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Japan Theme Paper
- Smart Construction for Sustainable Development-

Introduction

While construction investment in Japan has remained steady, the number of workers in the construction industry has continued to decline, and the labor shortage has become increasingly severe.

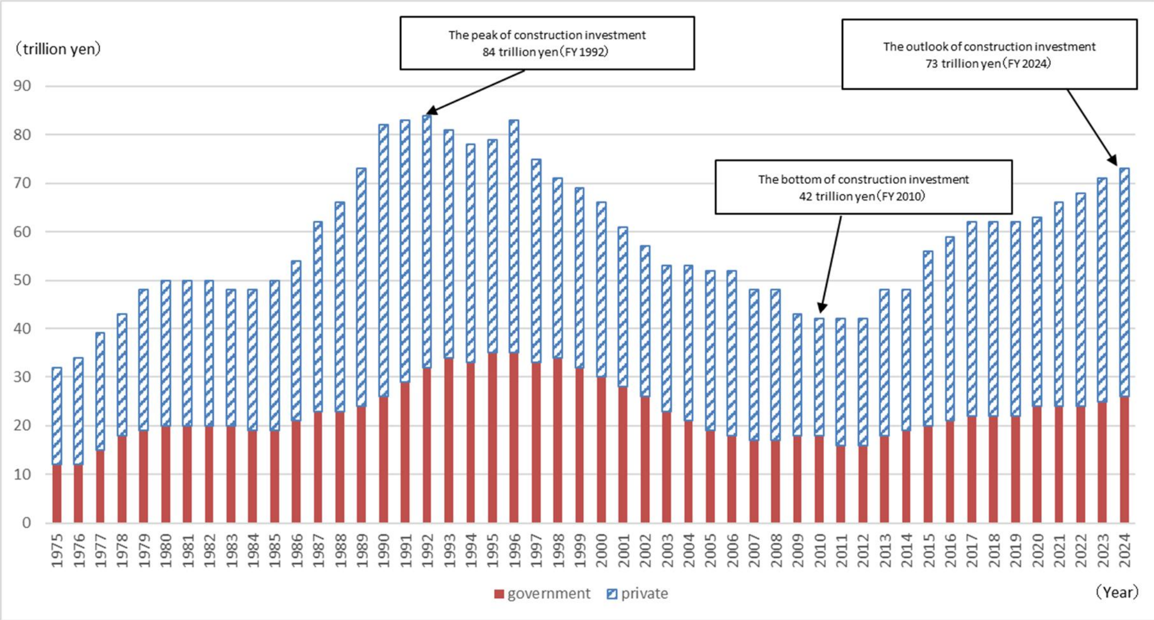
This report introduces national policies and initiatives by construction companies aimed at improving productivity and labor-saving to ensure sustainable development in the face of the worsening labor shortage. We hope that Japan's efforts in smart construction will serve as a reference for other countries and that the issues Japan faces on smart construction will be shared.

Chapter 1. Current Situation and Issues of the Construction Labor Market in Japan

1. Construction Investment

Construction investment in Japan peaked at approximately 84 trillion yen in FY 1992 and has continued to decline, falling to approximately 42 trillion yen in FY 2010, which is half of the peak level. However, it has shifted to an upward trend and has remained steady due to the Tokyo Olympics and Paralympics in 2021, and construction investment expected to reach approximately 73 trillion yen in FY 2024.

Figure 1: Construction Investment



Source: Created by RICE based on the data retrieved from Ministry of Land, Infrastructure, Transport and Tourism "Construction Investment Outlook"

2. The Current Situation Surrounding Social Infrastructure Development in Japan and Issues Facing the Construction Industry

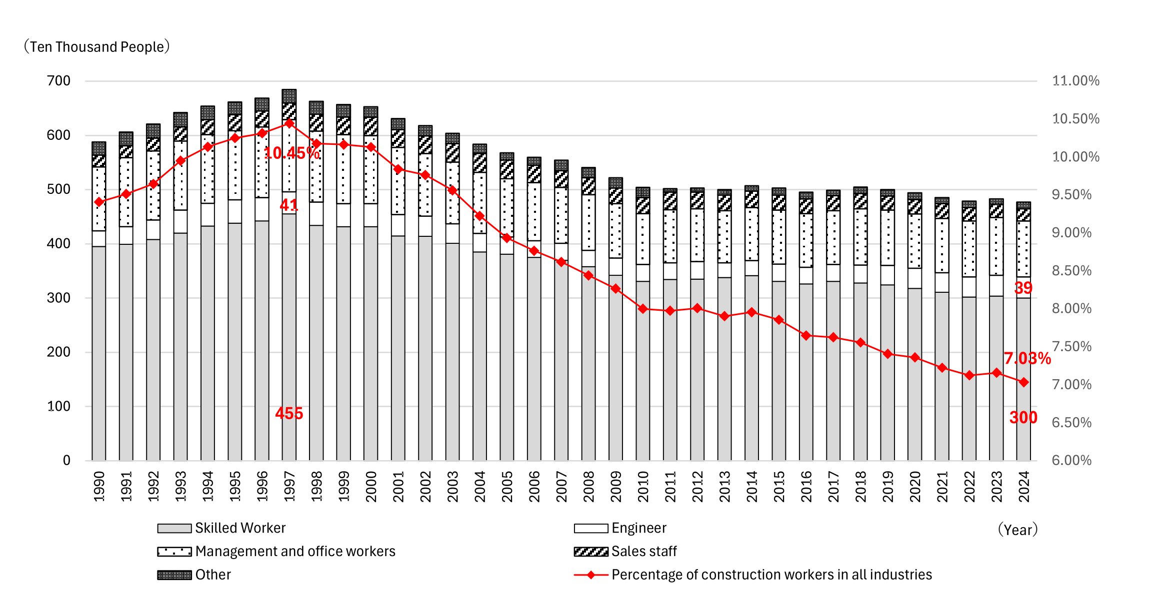
2.1. Decline in the Number of Construction Workers and Aging of the Workforce

While construction investment has remained steady, the number of construction workers has continued to decline since peaking at approximately 6.85 million in 1997. Even after construction investment began to increase in 2011, the number of construction workers has not increased, and as of 2024, it stands at approximately 4.77 million. This represents 30.4% decrease from the peak.

Looking at the breakdown by occupation, the number of engineers in the construction industry peaked at approximately 410,000 in 1997, dropped to approximately 270,000 in 2013, but it has increased, to approximately 390,000 in 2024, a decrease of approximately 4.9% from the peak.

In contrast, the number of skilled workers has continued to decline. There were approximately 4.55 million skilled workers in 1997 as a peak, but this number has decreased to approximately 3 million in 2024, representing a decrease of approximately 34.1%.

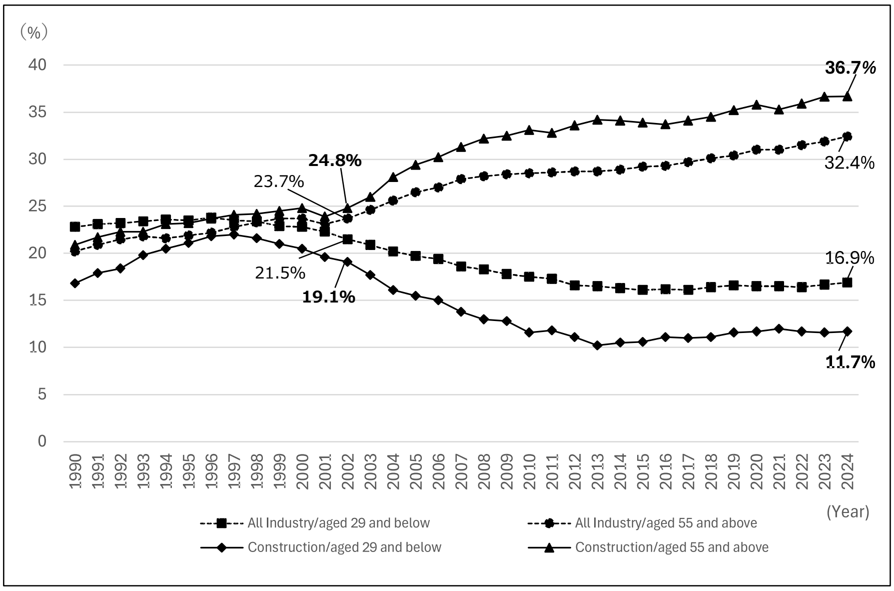
Figure 2: Number of Construction Workers



Source: Created by RICE based on the data retrieved from Ministry of Internal Affairs and Communications "Labor Force Survey"

The aging of the construction workers is also progressing. In 2002, in all industries, the ratio of workers aged 29 and below was 21.5%, and the ratio of workers aged 55 and above was 23.7%. In contrast, in the construction industry, the ratio of workers aged 29 and below was 19.1%, and the ratio of workers aged 55 and above was 24.8%. In 2024, in all industries, the ratio of workers aged 29 and below was 16.9%, and the ratio of workers aged 55 and above was 32.4%. In contrast, in the construction industry, the ratio of workers aged 29 and below was 11.7%, and the ratio of workers aged 55 and above was 36.7%. This indicates that the aging of the workforce is more severe in the construction industry compared to other industries.

Figure 3: Age Structure of Construction Workers



Source: Created by RICE based on the data retrieved from Ministry of Internal Affairs and Communications "Labor Force Survey"

2.2. Intensification and Frequent Occurrence of Disasters

In Japan, disasters such as earthquakes and floods occur annually in various regions. In particular, regarding earthquakes, major disasters such as the Great East Japan Earthquake (2011), the Kumamoto Earthquake (2016), the Hokkaido Eastern Iburi Earthquake (2018), and the Noto Peninsula Earthquake (2024) have occurred nationwide within the past 15 years. Additionally, earthquakes such as the Nankai Trough Earthquake and the Tokyo Metropolitan Earthquake are expected to occur with a high probability in the near future.

Figure 4: Damage caused by the Noto Peninsula Earthquake

Source: Ishikawa Prefecture website

2.3. Aging Infrastructure

Regarding infrastructures (roads, bridges, tunnels, rivers, water supply systems, sewerage systems, ports, etc.) constructed in and after the period of high economic growth, the proportion of facilities over 50 years old increases at an accelerating rate. Accidents caused by aging infrastructure have also occurred. A recent example is the road collapse accident in Yashio City, Saitama Prefecture, which occurred in January 2025. It is believed to have been caused by the rupture of a sewer pipe buried beneath the road.

3. Analysis of Labor Productivity in Japan

As mentioned above, while construction investment remains steady in Japan, the construction industry faces a wide range of issues, including natural disasters and aging infrastructure. The industry also faces labor shortages due to a declining and aging workforce, and these will make it difficult to meet demand. To address these issues, it is essential to secure a workforce and improve productivity through labor-saving construction methods and operational efficiency.

3.1. Definition of Productivity

Productivity is an indicator that measures the amount of output relative to the amount of input in production activities. It can be expressed as follows, and the larger this indicator is, the more efficiently production activities are carried out.

$$\text{Productivity} = \frac{\text{Output amount}}{\text{Input amount}}$$

While various quantities can be used as the input in the denominator, given the expected decline in the number of construction workers and the implementation of overtime work limits, labor productivity - defined as the output per worker per hour - has become a critical indicator.

$$\text{Labor productivity} = \frac{\text{Output amount (Added value)}}{\text{The number of workers} \times \text{Working hours}}$$

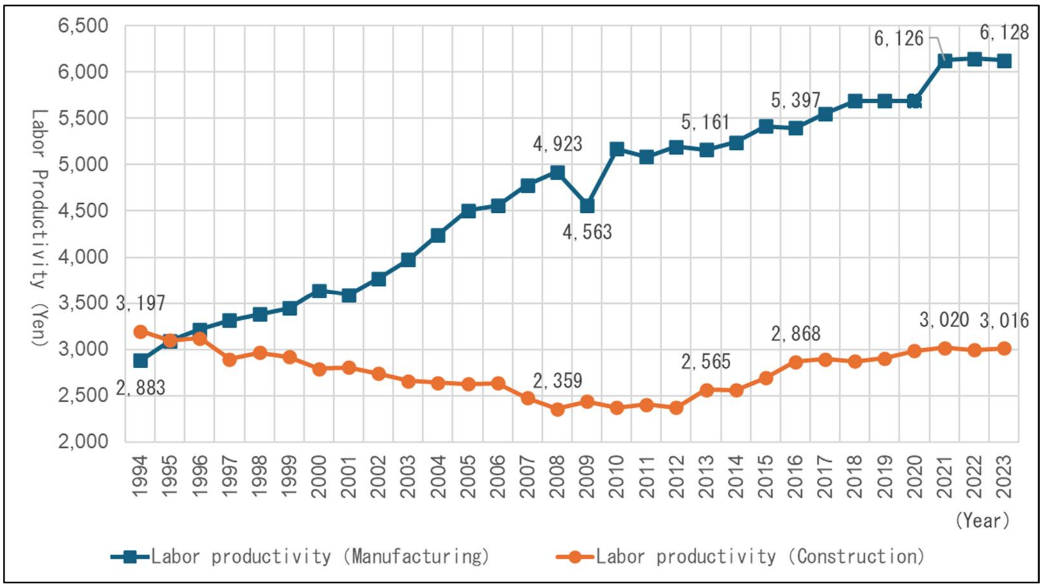
In addition, various quantities can be used as the output in the numerator, but the value added is calculated by subtracting the amount paid externally from the production value (sales).

3.2. Comparison of Labor Productivity in the Construction and Manufacturing Industries

Labor productivity in the manufacturing industry has generally continued to rise, except in 2009, the next year of the financial crisis of 2007–2008, and as of 2023, it stands at 6,128 yen per hour per worker, more than double that of 1994.

In contrast, labor productivity in the construction industry was 3,197 yen in 1994, but declined from the late 1990s to the 2000s, and reached 2,359 yen in 2008 – its lowest level of its period –. After that, it reached 3,020 yen in 2021, the highest level in the past 20 years, and has remained at almost the same level through 2023. When comparing 1994 and 2023, there has been little change.

Figure 5: Labor Productivity in Manufacturing and Construction Industry



Source: Created by RICE based on the data retrieved from Cabinet Office "National Accounts of Japan", Ministry of Internal Affairs and Communications "Labor Force Survey", Ministry of Health, Labour and Welfare "Monthly Labor Survey"

In the current situation where construction investment remains steady, further efforts toward "labor-saving" and "efficiency improvement" are necessary to complete construction projects with fewer workers and within limited time frames. The next chapter will introduce initiatives for ICT and DX aimed at achieving labor-saving and efficiency improvement, using examples.

Chapter 2. Smart Construction Initiatives in Japan

1. "i-Construction" promoted by the Ministry of Land, Infrastructure, Transport and Tourism

1.1. The Background of the Government's Digitalization Policies

The origins of digitalization policies in Japan date back to the 2000s. First, the IT Strategy Headquarters was established within the Cabinet and the "e-Japan Strategy" was released, which is based on IT Basic Law enforced in 2001. This set the goal of becoming the world's leading IT nation within five years, driving initiatives such as the digitization of administrative processes, the development of network infrastructure, and the establishment of laws and regulations. Then in 2003, the "e-Japan Strategy II" was released.

In 2006, the "IT New Reform Strategy" was formulated and set goals that an online utilization rate of 50% or more for application and notification procedures for national and local government by FY 2010.

However, this goal was not met by the 2010 fiscal year, and the "Declaration on the Creation of a World-Leading IT Nation" in 2013 emphasized the importance of designing user-centric services and providing convenient electronic administrative services. In addition, the "Digital Government Implementation Plan," decided by the Cabinet meeting in January 2018, included not only constructing information systems but also reforming business processes and reviewing systems themselves, and set the goal of enabling all administrative services to be completed digitally to achieve user-centered administrative services.

Against this backdrop, the Act on the Promotion of Administrative Services Utilizing Information and Communications Technology (Digital Procedures Act) was enacted in December 2019, and decided basic principles for the digitalization of government and the principles for digitizing administrative procedures. Furthermore, alongside the vision for the future of a digital society and revisions to the IT Basic Law, the government outlined its policy on the establishment of a Digital Agency, and it was established in 2021.

1.2. Overview of "i-Construction"

As mentioned in Chapter 1, while the shortage of workers in the construction industry in Japan is expected to become increasingly severe due to the declining and aging workforce, construction investment remains steady. Additionally, the country faces various issues such as the intensification and frequent occurrence of disasters, and the aging of infrastructure. To address the anticipated shortage of future workforce, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has been advancing the "i-Construction" initiative since FY 2016. This initiative aims to enhance productivity at construction sites by leveraging ICT and other technologies across all stages of the construction production process - surveying, measurement, design, construction, inspection, and maintenance/renewal.

The initiative was launched in 2016 and aims to increase productivity at construction sites by 20% by FY 2025. As a result, ICT construction has been implemented in 87% of directly managed civil engineering projects with an average reduction in working hours of approximately 21% compared to 2015.

In 2024, as part of efforts to further reduce labor, "i-Construction 2.0," a more advanced version of "i-Construction," was established. By 2040, when the working-age population is expected to decrease by 20%, the goal is to achieve 30% labor-saving at construction sites, equivalent to a 1.5-fold increase in productivity compared to 2023, by shifting from the previous "use of ICT, etc." to "automation." Efforts to achieve construction site automation will be carried out under three main pillars: "Automation of Construction", "Automation of Data Integration", and "Automation of Construction Management".

The first initiative, in "Automation of Construction," the goal is to improve the productivity per worker by using various sensors to collect information from the site, and having a single operator manage the operations of multiple construction machines based on construction plans that AI automatically creates. In addition, in construction sites where various systems are used, the initiative aims to promote the digitization and visualization of construction sites, and enable instant decisions on the optimal placement of construction machinery and achieving efficient construction, and automate the operation of work boats in offshore construction by smoothly acquiring and sharing real-time construction data even between different construction machinery manufacturers.

The second initiative, "Automation of Data Integration," aims to digitize and three-dimensionalize the entire construction production process, including surveys, measurements, design, construction, and maintenance, by utilizing BIM/CIM, and to build an environment where necessary information can be easily obtained in a format that can be processed as needed. A large amount of data is created and acquired in the construction production process, but at present, this data is not being fully utilized. Therefore, we will build an information sharing platform that allows the necessary information to be organized at each stage and easily shared among relevant parties, thereby promoting smooth data integration. In utilizing data, we will promote efficiency in field operations, such as directly utilizing design data as construction data and streamlining construction planning by creating digital twins, as well as improving back-office efficiency such as paperless by utilizing BI tools, for not making paper-documents and visualizing data, analyzing, and making decisions.

Finally, the third initiative, "Automation of Construction Management", involves not only the automation of construction processes and the utilization of digital data through BIM/CIM, but also the proactive adoption of new technologies that are useful in various stages such as material production, transportation, installation, management, and inspection. We will apply remote presence to inspections, and for the confirmation of the completed work of reinforcing steel in concrete structures, we will also apply measurement technology using image analysis of photos taken with digital cameras. Also, with regard to precast products, which have been primarily used for small and medium-sized structures, we will promote their introduction for large structures by establishing VFM (Value for Money) evaluation methods and others, thereby advancing remote and off-site operations. Furthermore, to effectively utilize large volumes of data, strengthening communication networks is essential. We will improve an environment that connects the entire country via high-speed, high-capacity networks and enable us to use large-volume data smoothly such as videos and 3D models.

2. Examples of DX Initiatives

We introduce examples related to ICT and DX aimed at achieving productivity improvements and labor-saving.

2.1. Automation in a Dam Construction Project

This section introduces the automated efforts in a dam construction project of a company (referred to as Company A). Company A has developed an automated construction system centered on autonomous construction machinery to address "labor shortages and a lack of skilled workers," "improve productivity," and "eliminate workplace accidents."

2.1.1. Automated construction system

The automated construction system developed by Company A is a system that automated general-purpose construction machinery receives work data based on an optimized plan and performs tasks autonomously and automatically.

This system consists of "technology for modifying general-purpose construction machinery automated," "automated driving technology that incorporates AI methods based on the operational data of skilled workers, and adapts to varying work conditions and situations," and "construction management technology that coordinates multiple machines to operate according to the most productive construction plans." This enables the automatic creation of optimized plans for machine placement and work sequences, allowing all machines to operate autonomously and automatically in coordination with each other, just like a factory.

Additionally, in 2021, the company successfully centralized control of automated construction machinery operating at multiple sites nationwide from a central control room at its headquarters in Tokyo, managed by a small number of controllers.

2.1.2. Introduction of efforts

At this dam construction site, the system was introduced for CSG placement starting in FY 2020, and automated construction machinery such as dump trucks, automated bulldozers, and automated vibrating rollers have been gradually deployed in accordance with site progress. Construction is also being carried out using a remote control system that operates the automated construction machinery from a control room approximately 400 km away.

Furthermore, from FY 2023, CSG can be directly and automatically supplied from the manufacturing plant to the dam body via long-distance belt conveyors and SP-TOM※. As a result, automatic dump trucks that receive CSG automatically transported to the dam body deliver them to the bulldozer's spreading points using optimal routes and driving methods, with high efficiency and precision. This has successfully automated all operations from material production to placement.

※ Cemented Sand and Gravel: A material made by mixing locally sourced materials (such as stones and gravel) with cement and water.

※ Special Pipe Transportation Method: A technique that continuously transports materials from high to low elevations using their own weight without separating them by rotating the pipes, thereby maintaining material quality.

2.2. Unmanned construction and digital twin utilization through collaboration with construction machinery manufacturer

This section introduces the efforts of a construction company (referred to as Company B) to ensure safety and improve labor productivity at construction sites through the use of a digital twin system leveraging ICT.

2.2.1 Efforts to improve productivity and ensure safety using a system developed by construction machinery manufacturer

Company B implemented initiatives to improve productivity and ensure safety by utilizing multiple systems provided by a construction machinery manufacturer (referred to as Company C). (Details of this system will be described later.)

As the first initiative, they introduced a system that they can monitor the real-time operation status and location of dump trucks. By equipping security guards and drivers with smartphones containing this system, security guards can immediately identify the arrival of vehicles, reducing waiting times in extreme heat and contributing to heatstroke prevention and improved work efficiency. Driver's safety awareness was improved and it led to accident prevention. Additionally, drivers have praised the system for providing visibility of oncoming vehicles and other vehicles when driving mountain roads with numerous curves.

As the second initiative, they introduced a system that enables the creation of high-precision 3D terrain data without ground control point by using drones with automatic takeoff and landing capabilities. Before the introduction of this system, it was necessary to stop work at the site during surveying, but with this system, they can now monitor daily progress without stopping work. In addition, they can easily check the amount of soil runoff and the scour caused by heavy rain based on data captured by drones, and this makes it easier to explain the situation to clients.

As the third initiative, they introduced a system that utilizes AI to consider construction plans. Previously, they determined the route and number of dump trucks by driving the vehicles actually and calculating based on past performance. With this system, they can determine the route and number of dump trucks by visualizing the route at the planning stage and performing dozens of simulations using AI. In addition, in the case of route overlaps due to other construction work during the construction period, they can flexibly respond by creating two types of routes and performing simulations.

2.2.2. This system

This system provided by construction machinery manufacturer C is a service which makes everything - from surveying to inspection - "visible" on-site and create a safe, productive, and smart "futuristic site" by connecting all data throughout the entire construction production process using ICT. With this system, digital data collected from construction machinery and IoT devices is centrally managed in the cloud, and realizing the digital twin and information is synchronized at any time in the cloud.

In addition to the three systems that we introduced in this case, there are various other systems that provide ICT-based support across the entire construction production process, including surveying, design, construction planning, construction, and inspection.

2.3 Utilization of BIM/CIM for management and inspection

This article introduces efforts to utilize BIM/CIM for management and inspection in mountainous excavation work for river improvement construction.

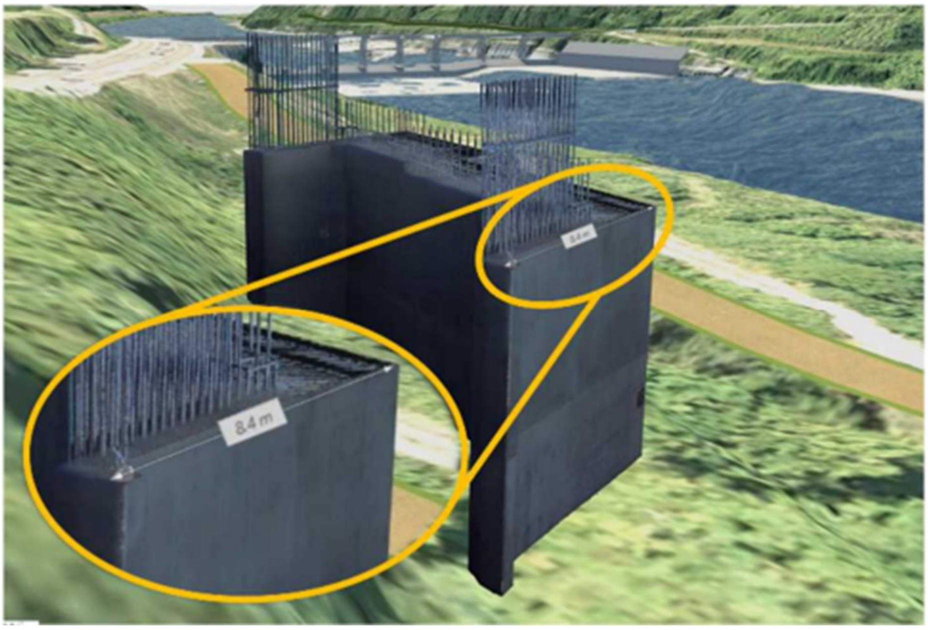
First, we will introduce the use of 3D data and VR technology for completed work inspections. When inspecting the completed work, inspectors must visit the site, and inspect the object in accordance with standards, and contractors must make arrangement and prepare necessary documents for inspection. However in this project, the structures were measured using a 3D laser scanner, integrated into a unified CIM model, and VR (virtual reality) technology was applied to the model space and conduct a trial of the quality inspection. Inspectors wore VR goggles in the office and measured the length and width of the completed work and counted the number and space of reinforcing bars by placing the cursor of the measurement tool over the 3D model of the structure displayed on the goggles.

The second, we introduce remote on-site inspections using wearable cameras and web conference. At the site, construction contractors wearing wearable cameras visited the construction area, and at the office, inspectors and construction contractors conducted on-site inspections via web conference under the instruction of inspectors. This allows inspectors to conduct inspections without visiting the site, and reduces travel time, and construction contractors can undergo inspections without halting work at the site, and reduce the number of personnel and inspection time required for inspections.

Figure 6: A picture of VR-based inspection

Source: Ministry of Land, Infrastructure, Transport and Tourism Hokuriku Regional Development Bureau "Report on the Implementation Status of BIM/CIM in the Excavation of the Ohkouzu Branch Canal Mountainous Area"

Figure 7: 3D model of the inspection target displayed in the virtual space



Source: Ministry of Land, Infrastructure, Transport and Tourism Hokuriku Regional Development Bureau "Report on the Implementation Status of BIM/CIM in the Excavation of the Ohkouzu Branch Canal Mountainous Area"

2.4 Business Efficiency Improvement Using a Cloud-Based Construction Project Management Service

This section introduces business efficiency improvements using a cloud-based construction project management service developed by Company D. This service manages various information and data related to construction sites on the cloud, and enable diverse stakeholders such as clients, general contractors, subcontractors, site supervisors, and site workers to share and utilize necessary information. Originally developed for the residential sector, it is now used in construction projects of office buildings, commercial buildings, and so on, and is adopted by a wide range of companies including general contractors, subcontractors, and specialist construction companies. The service has over 216,000 client companies and 550,000 users.

Functions for construction management include paperless and prevention of miscommunication by management and sharing of the latest work schedules, materials, drawings, and other documents in digital format, information sharing using chat functions, organization of photos taken with smartphones in the cloud and creation of ledgers, and creation of 3D data on-site using smartphones and sharing of the created data with related parties in remote locations.

Additionally, the system offers functions applicable for business management, design, and sales, besides construction management, and enables seamless integration from business management to construction on a single platform.

A certain city conducted a pilot project with this system aimed at reducing the burden on construction contractors and improving the efficiency and sophistication of various operations in construction projects. By enabling the submission of construction documents online, the pilot project aimed to reduce the burden on contractors, centralize information related to construction projects, and optimize construction schedule management. The pilot project achieved several outcomes, including a reduction in the time required for contractors to organize construction photos, the paperless of regular meetings, and a reduction in the time required to review construction documents.

2.5 Utilization of human augmentation technology and improvement of network environments

As previously stated, in the situation of a declining and aging workforce in the construction industry, there is a need to advance "labor-saving" and "efficiency improvements". However, it is also necessary to maintain or increase the number of workers. Therefore, by utilizing power assist suits, drones, XR technology, etc., it is expected that the workload will be reduced, thereby increasing opportunities for women and the elderly to participate in the workforce. Additionally, visual augmentation technology will enable non-construction skilled workers to perform on-site work at the same level as construction skilled workers, regardless of their skill level, thereby improving the efficiency and productivity of human power labor.

In addition, we will introduce the use of "local 5G" for improving network environments. Local 5G is a method whereby companies and local governments that are not telecommunications carriers build dedicated 5G networks in certain areas or buildings/premises, it enable them to build and use their own 5G systems even in areas where public 5G coverage is not yet available. Furthermore, unlike Wi-Fi or public 5G, Local 5G is not affected by interference from other radio waves or other users, it enable Local 5G users to use stable high-speed, high-capacity communication. It also offers a wider coverage area compared to Wi-Fi and enhanced security through user restrictions. In practice, a certain construction company has built a Local 5G environment for concrete pouring in dam construction and achieved the automated and autonomous operation of cable cranes.

Conclusion

This report has introduced efforts toward ICT and DX in the Japanese construction industry. However, while the adoption of ICT technologies and the promotion of DX are essential for improving productivity and reducing labor, many issues remain in their implementation. Finally, this report concludes by discussing the issues and solutions for ICT and DX initiatives.

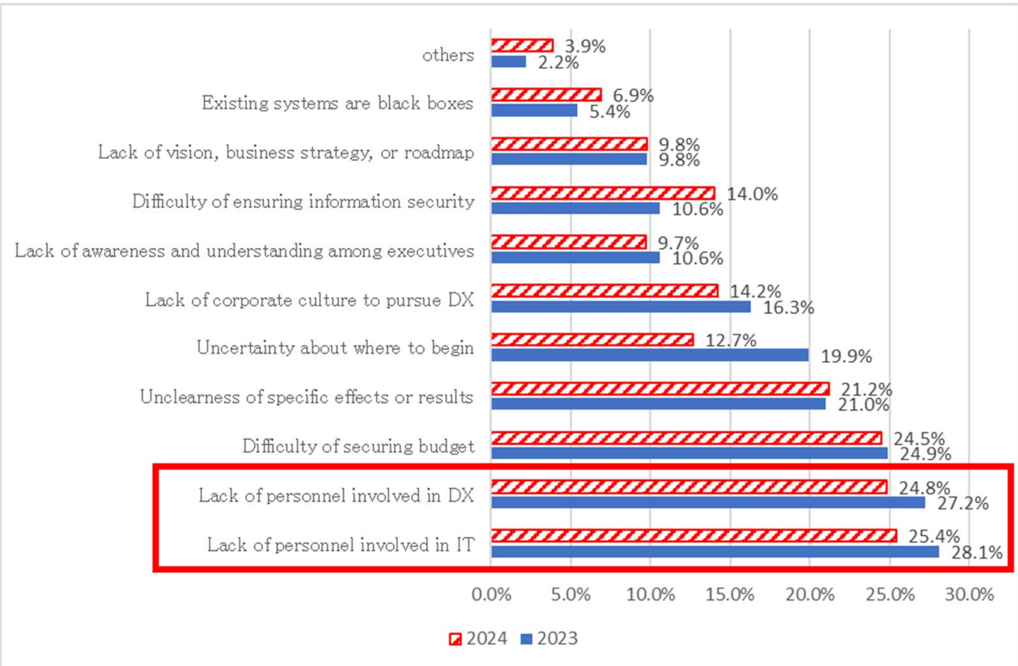
1. Capital Investment

One of the main factors making DX implementation difficult for small and medium-sized enterprises is the difficulty of capital investment. According to the 2024 Edition of the White Paper on Small and Medium-Sized Enterprises, many companies cited "cost burdens" as an issue in advancing DX initiatives, and many companies requested "grants and subsidies" as the support measures they expect.

2. Securing and Developing ICT/DX Talent

As mentioned earlier regarding the shortage of construction workers, the following charts also highlight the significant issue of insufficient personnel involved in DX and IT.

Figure 8: Issues in Implementing DX



Source: Created by RICE based on the data retrieved from Organization for Small & Medium Enterprises and Regional Innovation, JAPAN " Survey on DX Promotion in Small and Medium-Sized Enterprises (2024)"

3. Strengthening Communication Networks

Building a stable communication environment is essential for advancing ICT and DX, but construction sites often face situations where radio waves do not reach satisfactorily, such as in mountains or tunnels. In Chapter 2, we introduced the use of local 5G, but for its implementation, there are issues such as high costs, the difficulty of licensing, and the difficulty of constructing and maintaining the network in-house. In situations where the rapid and stable transmission of large volumes of data is required for ICT and DX initiatives, the importance of strengthening networks at construction sites is expected to grow significantly.

4. Response from the client (government)

One issue is that the methods of conducting work and specifications for deliverables requested by clients have not changed. Clients, including the national government, are reluctant to adopt new technologies such as ICT construction, and there are cases where local governments, particularly prefectures and municipalities, lack understanding of the technology and refuse to permit increased construction costs resulting from ICT construction. Additionally, the "Survey on Digitalization in Public Works" conducted last year revealed that over half (66.6%) of municipalities have not yet digitized their bidding procedures. Furthermore, while cutting-edge technologies such as AI are evolving rapidly, laws and regulations have not kept pace with these advancements. Revising analog-based rules could pave the way for the widespread adoption of DX and significant improvements in operational efficiency.

5. Multi-tiered subcontracting structure

The Japanese construction industry is characterized by a multi-tiered subcontracting structure consisting of prime contractors and subcontractors. This structure requires a large member of companies to introduce systems, and it takes a long time for the widespread system adoption. When introducing a new system, whether the system selected by the prime contractor is suitable for subcontractors depends on each company's business processes, systems, and corporate culture. Additionally, if the prime contractor's system support or instructions are insufficient, it may take time for subcontractors to understand how to use the system and its benefits. For example, to improve the efficiency of a safety document system, it is essential that all subcontractors use the same system. However, if some subcontractors don’t use the same system, centralized processing through the system becomes impossible, and the prime contractor must manually correct data output from the system. This hinders overall efficiency. Some general contractors have voluntarily implemented "tier restrictions," but since the national-level effectiveness of these measures has not been verified, institutional revision and fundamental solutions are expected.

While construction investment remains steady in Japan, the construction industry faces a wide range of issues, including natural disasters and aging infrastructure. At the same time, the industry is also facing labor shortages due to a declining and aging workforce. In this situation, efforts to improve productivity and reduce labor are unavoidable, and the national government is strategically promoting ICT and DX, but these initiatives haven't taken root in the construction industry. Given the multi-tiered subcontracting structure of the construction industry, individual company initiatives alone are unlikely to yield significant results, and the costs are also substantial. Therefore, it is considered necessary for the industry as a whole to collaborate and advance these efforts.