

Derivation and Implications of Digitalizing Key Construction Supervision Work:

Focusing on the Construction Supervision Work of the Domestic Construction Sites

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Abstract This study aims to derive key construction supervision work that can be digitalized among construction supervision work. The scope of the study includes domestic construction sites to which the Building Act of South Korea is applied. First, the construction supervision process was identified through extensive consultation of construction expert witnesses. Afterwards, the key construction supervision works for digitization were derived through survey results construction expert witnesses. Among the 24 supervision works throughout the pre-construction, construction, and post-construction stages, the proportion of supervision work manpower or cost, the type of data generated by supervision work and the urgency of introducing digital technology, and the impact on productivity and safety of supervision work were evaluated on a 5-point scale from "very low" to "very high" was investigated. The survey was conducted by t-test analysis, and as a result, it was possible to derive that the level of digitization was higher than average in "quality management," "safety management," and "collection and cooperation of maintenance instructions." It can be interpreted that digitization has been introduced on a pilot testing basis or has already been completed according to the needs of the site. On the other hand, it can be interpreted that the work that are obtained below the average score are considered to be realistically constrained at the construction site and that it is inevitable for the supervisor to proceed manually. Future studies include analyzing the quantitative impact of the key construction supervision work once digitalization is fully applied.

Keywords: Digitalization, Construction Site, Supervision, Process

1. INTRODUCTION

(1) Background and Purpose

The vast amount of data generated at construction sites such as location information, sensors, personal terminals, and CCTVs has not been effectively utilized, leading to inefficiency

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and decreased productivity throughout the construction process(Chan, Scott & Chan, 2004; Cha & Kim, 2008; Cha & Kim, 2011; Zavadskas et al., 2014; Sung et al., 2022). This is judged to be a phenomenon caused by the absence of an integrated building supervision platform that can collect, share, and analyze construction site data(Kang et al., 2015; Wang, Park & Choi, 2018). Therefore, there is a growing interest in developing an information circulation system by implementing a dedicated platform which collects, shares, and analyzes the vast amount of data generated in construction sites(Lee, Lee & Lee, 2015; Kim et al., 2019). Such platform for construction supervision has the advantage of enabling digitalization of construction supervision work, such as replacing conventional 2D drawings. Through this, a virtuous cycle of increased work productivity and efficiency at the construction site and shortened construction period can be created. Therefore, the purpose of this study is to first derive the key construction supervision work that can be digitalized.

(2) Scope and Method of Research

The study focuses on domestic construction sites, to which

the Building Act of South Korea is applied (National Law Information Center, 2020). Construction sites in the private sector, governed by the Building Act, are categorized into four types of supervision: court supervision, non-resident supervision, resident supervision, and responsible resident supervision. The responsibilities vary among these types of supervision. Non-resident supervision oversees the construction process by reviewing design documents and other relevant paperwork, while resident supervision and responsible resident supervision offer technical support for construction work, covering aspects such as quality management, construction management, and safety management(Sung et al., 2022).

To identify the key construction supervision work that can be digitalized, it is crucial to have a thorough understanding of the current supervision work practices in construction sites. Gathering input from workers, who have first-hand experience and insights into their job, can further enhance this understanding. This study begins by identifying the current processes of supervision work in construction sites within the specified scope. Using survey results from construction experts, the study then determines the key construction supervision works.

2. IDENTIFYING PROCESS OF CONSTRUCTION SUPERVISION WORK

(1) Definition of Terms

Terms consistently mentioned in this paper regarding identifying the process of construction supervision work are listed as below:

1. Unit: Each supervision work, including the review of design drawings, material selection, and contract management.
2. Mega: The combined total of all supervision works.
3. Process: A flowchart that encompasses inputs (required information) and outputs (generated information). A “unit process” is a specific flowchart for a unit of supervision work, including necessary documents for the work and generated documents. The “mega process” refers to the flowchart that encompasses all unit processes.

Aligning with the definitions above, identifying the process of construction supervision work can be achieved by creating both a 1) unit process for each work and a 2) mega process, which includes all the unit processes.

(2) Unit Process

The unit process consists of a flow chart, input/output documents, related management topic (e.g. contract management, safety management), and construction stage.

The flow chart outlines three key roles: the Client, the Supervisor, and the Contractor. The activities performed by each role are depicted on the same row, providing a clear indication of their involvement.

The “input documents” are those that are legally required by law to initiate the work, as well as documents necessary for smooth work progression. On the other hand, “output documents” refer to the documents generated after the completion of the work.

Each construction supervision work falls into one of the seven management topics delineated in this study.

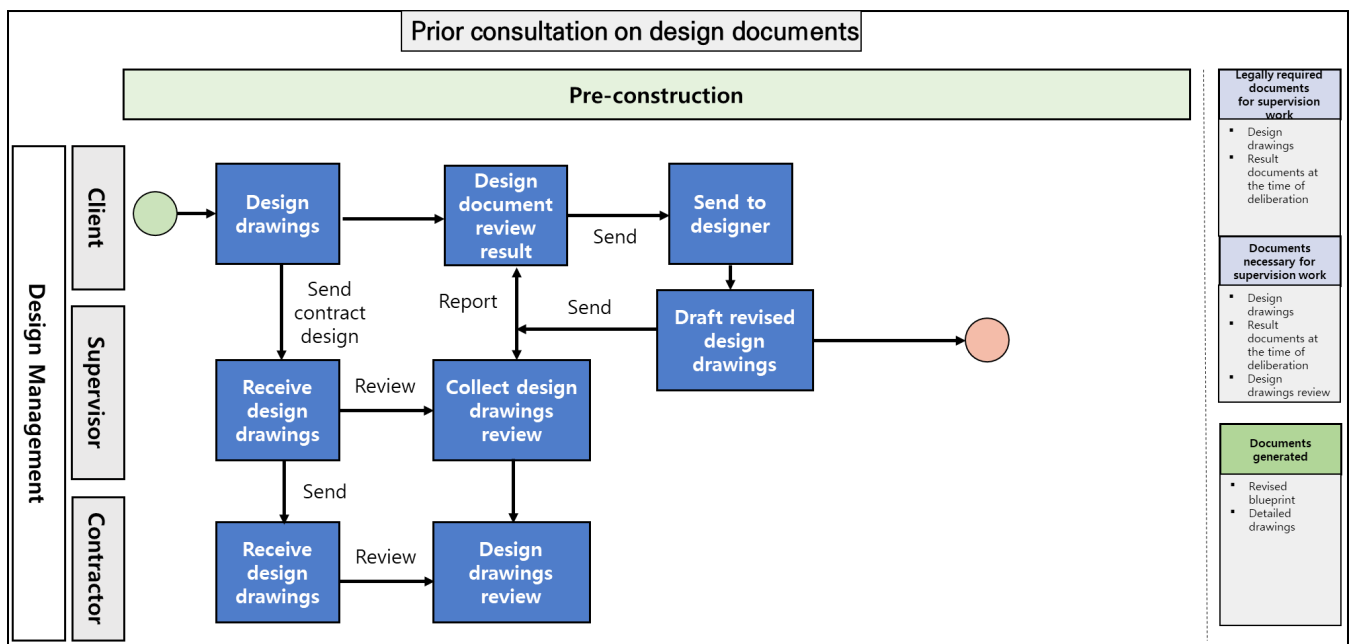


Figure 1. Unit Process of Prior Consultation on Design Documents

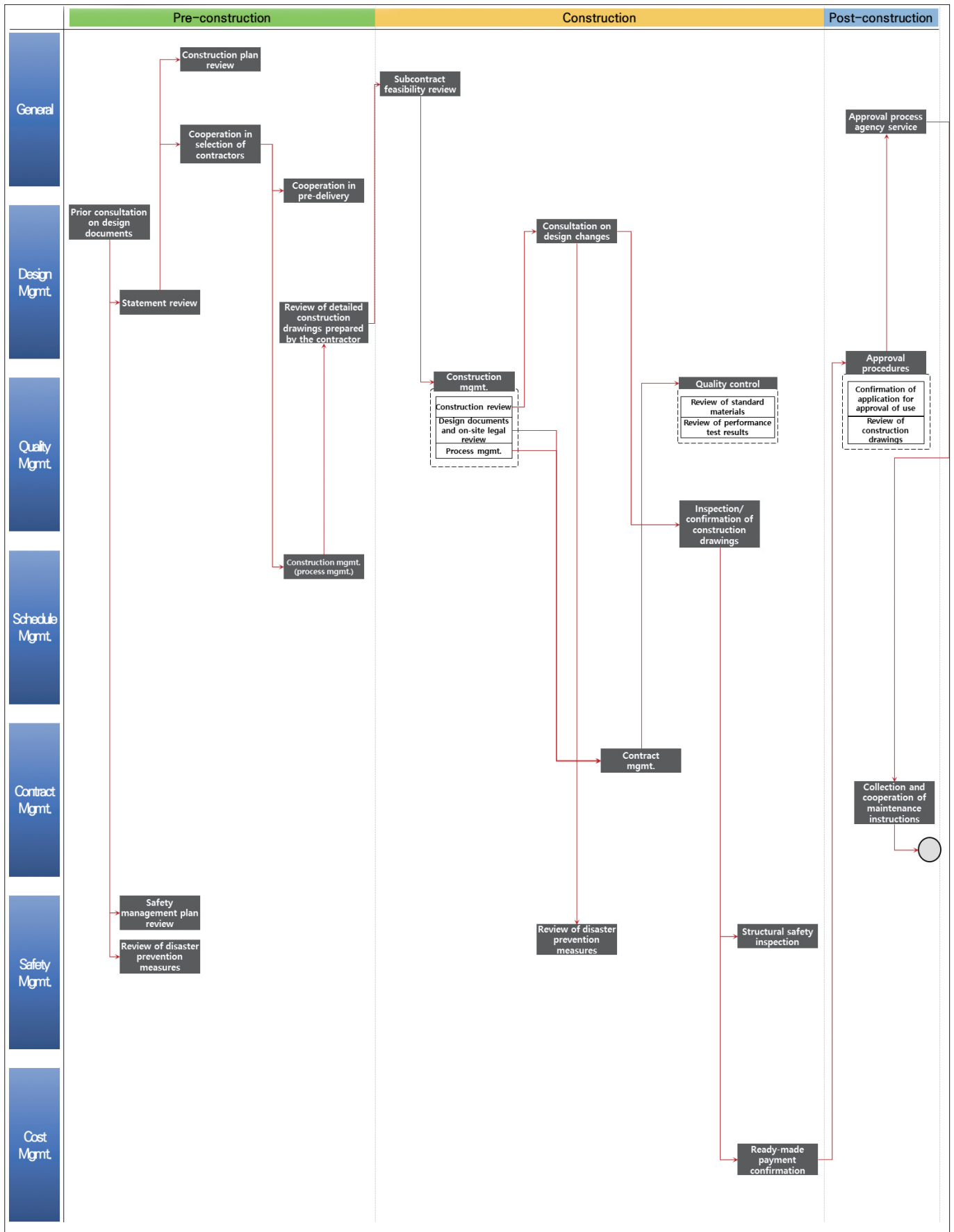


Figure 2. Mega Process of the Construction Supervision Works

Table 1. Summary of Supervision Work by Construction Stage

Construction Stage	Supervision Work	Classification of supervision work			Supervision work by construction stage – detailed standards for building construction supervision - (2020)			Related Laws
		Court Supervision	Non-resident Supervision	Resident Supervision	Responsibility Supervision	Input	Output	
Pre-construction	Prior consultation on design documents	○	○	○	○	Design drawings Result documents at the time of deliberation Design drawings review	Design drawings Result documents at the time of deliberation Design drawings review	Detailed standards for building construction supervision - 1.4.2.4
	Statement review	△	△	□	□	Estimated statement Quantity statement Itemized unit cost	Revised statement Unit price calculation review (itemized unit cost)	Detailed standards for building construction supervision - 2.4.3.6
	Cooperation in selection of contractors	△	△	△	△	Construction delivery plan (draft) Field manual	Construction delivery plan (draft) On-site special notes	Detailed standards for building construction supervision - 2.4.3 & 2.5.6.2
	Construction plan review	△	△	□	□	Construction plan	Construction plan review copy Client approval documents	Detailed standards for building construction supervision - 2.4.3 & 2.5.6.2
	Cooperation in pre-delivery	△	△	△	△	Foreign material design Government-supplied materials design Government construction design Construction design directly managed by the client	Foreign material order plan Government-supplied materials order plan Government construction plan Owner's direct construction plan	Detailed standards for building construction supervision - 2.5.2.3
	Construction management (process management)	△	□	○	○	Designer's scheduling table Revised scheduling table	Scheduling table (reviewed by supervisor and constructor)	Detailed standards for building construction supervision - 2.5.2.3
	Safety management plan review	△	□	○	○	Safety management plan (by constructor) Safety management guidelines	Safety management plan Safety management guidelines Supervisor review document	Detailed standards for building construction supervision - 2.4.3.5
	Review of disaster prevention measures	△	△	△	△	Disaster prevention plan	Revised disaster prevention plan	Detailed standards for building construction supervision - 2.5.6.3
	Review of detailed construction drawings prepared by the contractor	○	○	○	○	Construction contract conditions	Construction details by work type	Detailed standards for building construction supervision - 2.4.5.2
	Subcontract feasibility review	△	△	△	△	Subcontract selection approval request form Subcontract details	Subcontract review Subcontract details	Construction Contract General Conditions (Article 42) Framework Act on the Construction Industry (Articles 29, 34-38)
Construction	Construction management (design documents and on-site legal review)	□	○	○	○	Design drawings Site survey (cadastral) Investigation of the surrounding environment Various U/T investigations Review documents Detailed drawings	Modified design drawings Modified detailed drawings	Detailed standards for building construction supervision - 2.5.4.1 Detailed standards for building construction supervision - 2.5.5
	Construction management (construction review)	△	○	○	○	Construction plan Construction plan by work type Scheduling table	Modified construction plan Technical review report	Detailed standards for building construction supervision - 2.5.2.3
	Contract management	△	△	△	△	Construction contract Field manual On-site special notes	Implementation plan by work type and process	Detailed standards for building construction supervision - 1.4.3
	Inspection/confirmation of construction drawings	□	○	○	○	Construction drawings by construction type	Modified construction drawings by construction type Report of current state Technical review report	Detailed standards for building construction supervision - 2.4.5 Building Act - Article 25(5) Building Act Enforcement Decree - Article 19 Paragraph 4
	Ready-made payment confirmation	△	△	△	△	Ready-made application form Contract statement Subcontracting statement	Notice of advance payment request form	Detailed standards for building construction supervision - 2.5.8
	Quality control (review of standard materials)	△	□	○	○	Material/equipment order request form	Material/equipment order request form Technical review report	Detailed standards for building construction supervision - 1.4.2.2 & 2.5.4.2
	Quality control (review of performance test results)	△	□	○	○	Material selection review request form Performance test documents (ESS, storage battery, etc.)	Material selection review notice	Detailed standards for building construction supervision - 2.4.3.4
	Structural safety inspection	○	○	○	○	Construction plan approval request form Supplementary documents for disaster prevention measure implementation plan	Structural safety review Technical review report	Detailed standards for building construction supervision - 2.4.5
	Review of disaster prevention measures	△	△	□	□	Disaster prevention measure implementation plan	Disaster prevention measure implementation plan	Detailed standards for building construction supervision - 2.5.6.3
	Consultation on design changes	○	○	○	○	Report of current state (design change) request form	Report of current state review document Design change contract	Detailed standards for building construction supervision - 2.5.7
Post-construction	Approval procedures (confirmation of application for approval of use)	○	○	○	○	Application for approval of use Various certification materials by construction type Design drawings deliverables	Jurisdiction approval period document	Detailed standards for building construction supervision - 2.6.1.1
	Approval procedures (review of construction drawings)	□	□	□	□	Construction completion drawings (pre-sealed)	Design drawings deliverables	Detailed standards for building construction supervision - 2.6.1.1 & 2.6.1.2
	Approval process agency service	△	△	△	△	Approval process drawings (pre-sealed)	Approval process drawings and documents (post-sealed)	Detailed standards for building construction supervision - 2.6.1.3
	Collection and cooperation of maintenance instructions	△	△	△	△	Maintenance plan by construction type Commissioning plan Manual by construction type Catalog by construction type	Maintenance plan Commissioning results Certificate of education completion	Detailed standards for building construction supervision - 2.6.3

1. General Management
2. Design Management
3. Quality Management
4. Schedule Management
5. Contract Management
6. Safety Management
7. Cost Management

Lastly, according to the detailed standards listed in the Building Act of South Korea, construction supervision works are carried out in three stages: pre-construction stage, construction stage, and post-construction stage; the construction supervision works for each stage are identified to be 9, 11, and 4, respectively.

The unit process for “Prior consultation on design documents”---one of the construction works in the pre-construction stage---is shown in Figure 1. All 24 unit processes were created through extensive consultation with construction expert witnesses.

(3) Mega Process

The “mega process” encompasses the entire workflow of all unit processes for construction supervision works, from pre-construction to post-construction. This comprehensive process was established through consensus and extensive consultation with construction expert witnesses.

Construction supervision in the pre-construction stage starts with a consultation on design documents in the design management. This is followed by statement reviews, safety management plan, and disaster prevention measures. Upon conclusion of the statement review, the construction plan is reviewed and the selection of contractors is initiated. After the contractors have been selected, cooperation in pre-delivery and process management activities commence, culminating in a review of the detailed construction drawings prepared by the contractor.

Construction supervision activities in the construction stage start with a review of subcontract feasibility. This is followed by three concurrent construction management works: construction review, design document and on-site legal review, and process management. The latter two works culminate in contract management, while the construction review leads to consultation on design changes. The process also includes reviews of disaster prevention measures and inspection and confirmation of construction drawings. This results in simultaneous structural safety inspections and ready-made payment confirmations.

Finally, the construction supervision in the post-construction stage begins with approval procedures, where both the confirmation of application for approval of use and the review of construction drawings take place. The conclusion of such construction supervision works leads to an agency service approval process. Finally, the process ends with the collection and coordination of maintenance instructions.

The summary of the mega process throughout the entire construction stages is shown in Tables 1 and 2. The laws related to the construction supervision work are also listed.

Table 2. Summary of Supervision Work by Construction Stage: Supervision Target Size and Classification Code (Legend for Table 1)

Classification Code	Supervision Target Size
Court Supervision	- Residential buildings: Total floor area less than 661m ² - Other buildings: 495m ² or less
Non-resident Supervision	- Total floor area: buildings less than 5,000m ² - Total floor area: Buildings with less than 3,000m ² (less than 5 contiguous floors, excluding “court supervision”)
Resident Supervision	- Total floor area: buildings less than 5,000m ² - Total floor area: Buildings with less than 3,000m ² (less than 5 contiguous floors, excluding “court supervision”) - Construction supervision of apartments (less than 20 households)
Responsibility Supervision	- Construction supervision of multi-use buildings

○ - Basic work

□ - Additional tasks (basic tasks or optional performance depending on the use of the building)

△ - Additional work (work performed according to the contract at the request of the building owner)

3. DERIVING KEY CONSTRUCTION SUPERVISION WORK FOR DIGITALIZATION

(1) Construction Expert Witnesses Survey

In this study, a survey of construction expert witnesses was conducted to derive the key construction supervision work for digitalization. The survey attempted to examine the following information:

1. Proportion of supervision manpower or cost: The first survey item is the ratio of manpower or cost invested in each stage of construction. Its purpose is to derive a supervision work with a relatively high or low proportion of manpower or cost during the pre-construction stage, construction stage, and post-construction stage. Since the proportion of each construction supervision work may be different for each site, this study only records the proportion invested in each stage.
2. The urgency of adopting digital technology and type of data generated by supervision: The second survey item is the proportion of data types generated during supervision work, and the urgency of introducing digital technology and its potential impact on performance. Its purpose is to determine whether to apply digitization through the above survey items. The data type was classified into text/numerical/image/video, and the digitization level of the task,

the urgency of digitization, and the impact on performance during digitization were investigated on a 5-point scale ranging from “very low” to “very high”.

- Impact on productivity and safety of supervision work: The third survey item is the impact of major supervision tasks on productivity and safety. Furthermore, survey was conducted on cost efficiency, schedule efficiency, quality improvement, and client satisfaction, which are linked items. Each item was surveyed on a 5-point scale ranging from “very low” to “very high”.

Based on the average information of the above survey items, a t-test analysis method was adopted to test whether the

difference between the average of each construction supervision work and the average of all construction supervision works was significant. The t-test is a test method to find out the difference between the means of two populations using the variance or standard deviation estimated from a sample when the variance or standard deviation of the population is not known. Through t-test analysis, if the value of (1-p-value) is 0.05 or higher, a significant result is derived, and in this study, the level of digitization can be interpreted as above average.

$$t = \frac{\bar{X} - \mu}{\frac{S}{\sqrt{n}}} \tag{1}$$

Table 4. t-test on Survey Results for Construction Supervision Works

Construction supervision work	Avg.	Std. Dev.	Sample Size	Threshold (=normal level)	Significance Level	t _{calculated}	t _{0.05, 32}	1-(p-value)	Digitalization Status
Statement review	2.5	0.7	33	3	0.05	-3.76	1.697	0.001	Below Avg.
Prior consultation on design documents	2.7	0.8	33	3	0.05	-1.99	1.697	0.032	Below Avg.
Construction plan review	2.5	0.9	33	3	0.05	-3.34	1.697	0.002	Below Avg.
Cooperation in selection of contractors	2.4	0.9	33	3	0.05	-4.15	1.697	0.000	Below Avg.
Prior consultation on design documents	2.7	0.9	33	3	0.05	-2.23	1.697	0.020	Below Avg.
Scheduling Management	2.4	1.1	33	3	0.05	-3.33	1.697	0.002	Below Avg.
Construction management (construction review)	2.5	0.6	33	3	0.05	-4.56	1.697	0.000	Below Avg.
Inspection/confirmation of construction drawings	2.3	0.7	33	3	0.05	-5.45	1.697	0.000	Below Avg.
Quality Management	2.9	0.7	33	3	0.05	-1.06	1.697	0.153	Above Avg.
Safety Management	2.9	0.6	33	3	0.05	-0.82	1.697	0.212	Above Avg.
Consultation on design changes	2.4	0.7	33	3	0.05	-5.07	1.697	0.000	Below Avg.
Ready-made payment confirmation	2.4	0.6	33	3	0.05	-5.55	1.697	0.000	Below Avg.
Subcontract feasibility review	2.5	0.8	33	3	0.05	-4.07	1.697	0.000	Below Avg.
Construction management (design documents and on-site legal review)	2.7	0.8	33	3	0.05	-2.24	1.697	0.020	Below Avg.
Applying for approval procedures	2.6	0.6	33	3	0.05	-3.47	1.697	0.002	Below Avg.
Approval procedures	2.8	0.7	33	3	0.05	-2.03	1.697	0.029	Below Avg.
Collection and cooperation of maintenance instructions	2.8	0.7	33	3	0.05	-1.36	1.697	0.096	Above Avg.

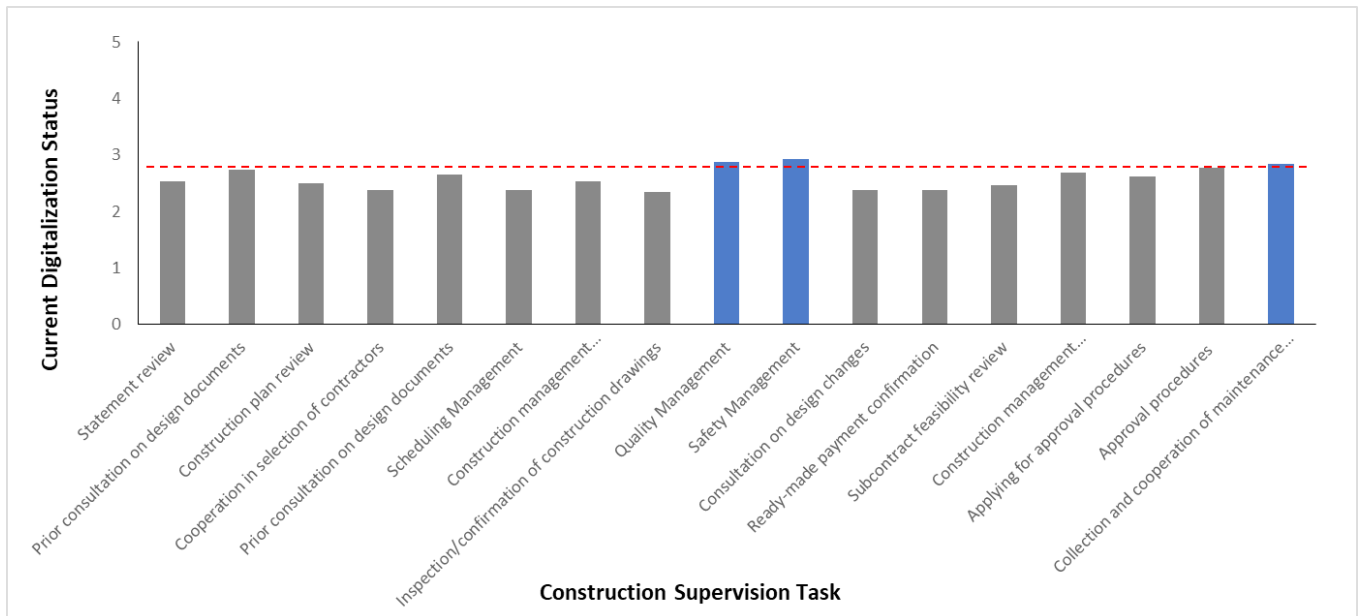


Figure 3. Digitalization Level Survey Results for Supervision Works

The survey was conducted on 33 executives and employees with experience in the construction industry and construction supervision. Such construction expert witnesses' work experiences in the construction field are summarized in Table 3.

Table 3. Expert Survey Results: Work Experience in the Construction Field

Expert Survey Results: Work Experience in the Construction Field	
Below 5 years	3
5~7 years	3
7~10 years	0
10~20 years	3
Above 20 years	24
Total	33

(2) Survey Results

As a result of analyzing the current level of digitization on a 5-point scale for the construction supervision works, "quality management," "safety management," and "collection and cooperation of maintenance instructions" scored an average of 2.9 points, 2.9 points, and 2.8 points, respectively. Such scores were the highest among the supervision works. Since each (1-p-value) recorded a significant average difference value of 0.05 or more, it was derived that the digitization level was above average. The standard deviation of those three supervision works ranged between 0.6 and 0.7. Meanwhile, "inspection/confirmation of construction drawings" yielded the lowest scores amongst all construction supervision works, with a standard deviation of 0.7. The results of the survey are summarized in Table 4 and Figure 3.

4. DISCUSSION

The above three construction supervision works that received above-average scores suggest either the high level of digitalization already introduced at the construction site due to its need, or the completion of the digitalization process. In other words, this high digitalization score can be attributed to the urgency of incorporating digital technology in the field or the significant impact it has on performance. The standard deviation scores of these supervision works, ranging between 0.6 and 0.7, suggest that workers generally hold a similar view on the level of digitalization. However, only the "Scheduling management" supervision work had a standard deviation score above 1.0, indicating a varying degree of understanding towards digitalization.

On the other hand, construction supervision works with lower average scores imply realistic limitations in digitalizing the work on the construction site, making manual performance by the construction supervisor unavoidable.

5. CONCLUSION

In this study, based on the various factors regarding digitalization, key construction supervision works for digitalization were

derived. For future research, this study aims to investigate the potential increase in productivity and efficiency of the key construction supervision works once digitalization is complete. Based on this analysis, the impact of digitalization on specific supervision work can be quantified, providing a valuable metric for construction site workers considering the implementation of digital technology.

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