

## Improve a Human Resource Allocation Guide in Construction Management based on Case study

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**Abstract :** The object of this paper is to analyze difference Human Resource allocation Guide, and suggest improved Human Resource allocation Guide to meet the owner's needs. This paper analyzed the present situation of Human Resource allocation Guide by announcement and law through case study of construction management service about public office awarded by Public Procurement Service (PPS) from 2011 to 2013, and considered proper Human Resource allocation Guide in design process, during and after construction process. Based on the findings of current study, the following problems were identified; difference between announcement and legal Human Resource allocation, Human Resource allocation problem during the whole phase of project, and Human Resource allocation problem of work types. For the improvement, this paper suggests specifying minimum Human Resource requirement in RFP (Require For Proposal) so that it is available to manage flexible Human Resource allocation, proper Human Resource allocation Guide, in design process, to reduce the workload in construction process, and Human Resource allocation in construction process for appropriate compensation package. This study is anticipated to help the next following study to improve inefficient Human Resource allocation Guide.

**Keywords:** Construction management, Construction management of public works, Human Resource, Resource allocation strategy, RFP.

### 1. Introduction

In general, the meaning of construction management is the construction manager with professional knowledge and experience for the purpose of reducing construction cost, improving quality, and reducing time. It is a new contract ordering method or specialized management technique that entrusts and manages all or part of the construction management work. The construction management (CM) system in Korea is

① the need for systematic and professional management capabilities to effectively achieve the goals of quality, cost, and time according to the trend of large-sized, complex, and specialized construction projects. ② Existing based on the domestic construction technology management law Systems such as design supervision and responsibility supervision, (The term "supervision" means any service of managing construction works, to manage construction works for appropriate execution in conformity with the relevant statutes, standards, design documents, or other related documents, or to give technical guidance with respect to the management of execution, quality, safety, etc.; Written in Construction Technology Promotion Act Article 2 (Definitions), [1] have achieved partial results as a management system focusing on quality and safety at specific phases of the construction project, but they can comprehensively manage not only quality and safety, but also cost and period throughout the entire construction project. Necessity of a system that exists ③ In order to prepare for the opening of the construction market, it was introduced through the background of the necessity of diversification and internationalization through the introduction of a construction project execution system that is common in advanced countries.

Such CM is due to difficulties in communication and coordination between participants of each construction project such as planning, design, and construction, delays due to inadequate planning in the initial phase, increased project costs, concerns about poor quality, and insufficient contract management. Communication and management among multi-participant participants in existing construction projects, such as concerns about claims from construction project participants, insufficient administrative processing due to dispersion and complexity of laws and regulations related to authorization and permits, and insufficient review of VE and constructability due to insufficient design review. In order to solve the problem caused by the problem, the necessity is emerging. With the recent revision of the Construction Technology Promotion Act (May 22, 2014), the work and future direction of construction service companies needs to be changed from manpower management, which is divided into existing CM and supervision, to a direction that can be used comprehensively. This necessity is also a part that has been constantly suggested by academia and research institutes even before the entire amendment of the Construction Technology Promotion Act [1] came to the surface. Responsible supervision including construction supervision (Construction supervision refers to

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technical guidance and construction supervision for quality control, CM, safety management, etc.) and inspection (Inspection supervision refers to confirming whether the construction work is constructed according to the contents of design documents and other related documents and related laws.) refers to the supervision of construction and supervision as an order-based supervisory authority in accordance with related laws and regulations. It is not easy for service providers to respond due to the diversification of services ordered by public institutions and private sectors, as well as securing and operating technicians that meet the requirements of projects that require further specialization.

In addition, the Ministry of Land, Infrastructure and Transport plans to integrate the supervision system limited to the construction phase into CM (2014. 5. 23) in order to strengthen the project management capability of the ordering office and activate the overseas expansion of related companies. There was a process of inquiring opinions by preparing the revision of all considerations for “CM (draft)” in order to integrate and reorganize the consideration standards in a fixed-income method. When the CM consideration standard is integrated and reorganized in the actual cost fixed amount addition method, it is expected that manpower allocation and calculation of the consideration standard will become clear. Therefore, in order for construction service companies to become specialized CM companies (hereinafter referred to as CM companies), amendments to the legislation that can promote appropriate improvement in their skills should also be supported.

In Korea, CM orders from the Public Procurement Service began in earnest from 2006 after the commercial introduction in 1996, and many prior studies have been conducted on the service-type CM project. The research dealt with is incomplete. This study analyzes the differences between the two standards by comparing the public announcement standard and the legal standard (suggestions) among public construction CM services ordered by the Public Procurement Service from the PPS from 2011 to 2013. Based on the problems derived through this, we intend to pursue a plan to improve the manpower arrangement that can satisfy the needs of the client[15].

This study analyzed the status of manpower distribution and legal manpower distribution on public notices through the analysis of the case of public office construction project management ordered by the PPS, and analyzed and considered manpower distribution by project phase and by type of construction. Based on this, an alternative for each problem was presented. The method of study is shown in Figure 1.

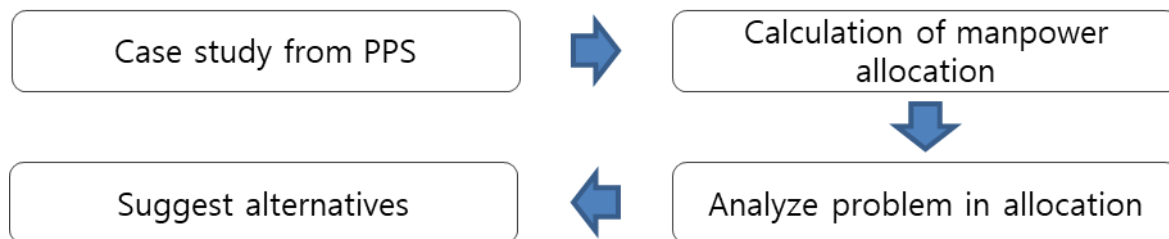


Figure 1 Research process

## 2. Literature review

The previous studies have been conducted to suggest various development plans and trends for the domestic construction project management system. Among them, major studies that dealt with problems related to manpower and improvement measures are summarized in Table 1 below.

Table 1 Previous study from Korean researchers

Author	Context
Choi and Jang [2]	System improvement to apply the CM method to the domestic public sector
Kim, Choi, and Lee [3]	Impact of project management on productivity of construction site
Kim [4]	System improvement for the development of CM companies
Oh and Han [5]	Presenting improvement plans by analyzing the current CM system and environmental issues
Kwon, et al [6]	A Study on the Factors Influencing the Productivity of Construction Site Managers
Lee, et al [7]	Realization of construction project management cost level, securing elasticity of personnel assigned to the initial phase of the project
Ahn and Kim [8]	Calculation and input of appropriate management personnel size

Previous studies have consistently presented the manpower problem as a matter to be improved in the construction project management system and market. Oh and Han [5] analyzed the current CM system and

environmental issues that need to be improved as shown in Table 2 to revitalize the CM system for public works.

**Table 2** Classification of improvement items necessary to vitalize the CM market

Category	No.	Item
Internal factor	1-1	Evaluation method by service scale and basis of allocation of bidding price
	1-2	Quantity of proposals by service scale
	1-3	Criteria for evaluating project performance ability
	1-4	Composition and evaluation method of joint supply and demand body
	1-5	Based on the score for selecting eligible persons by service scale
	1-6	Composition and content of evaluation of technical proposal
	1-7	Presentation evaluation method centered on responsible business managers
	1-8	Evaluating method on proposal
	1-9	Composition of evaluation committee
External factor	2-1	Overlap of housing law supervision and CM market
	2-2	Realization of CM masters
	2-3	Enhancement of client's expertise
	2-4	Market expansion of new and small businesses
	2-5	Nurturing professional and new technicians
	2-6	Establishment of CM performance plan
	2-7	Integrated management of the Supervisory Association and CM Association
	2-8	CM company verification plan
Internal factor	Items related to the bidding/successful bid system currently applied (based on the PPC) to select successful bidders in the CM market for public works	
External factor	Necessary items for which a base environment should be created for the development of the CM market for public works services	

Several prior studies have been conducted dealing with the problem of manpower input in the construction project management system. Among them, Lee et al [7] proposed realistic consideration standards based on domestic construction project management cases and operational plans in a study to improve the construction project management cost standard. In particular, in the process of re-estimating the level of consideration for the construction project management specific work based on the actual work experience, the realistic number of inputs was presented as shown in Table 3 through an expert questionnaire, but it is believed that additional analysis on manpower allocation is necessary.

**Table 3** Construction project management specific tasks (excluding VE) re-estimation of personnel input

Work	Existing workforce (a)	Survey results							
		Mean			Median(e)			Maximum	Minimum
		Mean (b)	Difference (c=b-a)	Ratio (d=c/a)	Median (b)	Difference (f=e-a)	Ratio (g=e/a)		
Cost Planning	1.0	1.88	0.88	88.00%	1.55	0.55	55.00%	3.60	1.00

EVMS	1.4	2.24	0.84	60.00%	1.65	0.25	17.86%	4.20	1.40
PMIS	1.9	3.88	1.98	104.21%	2.95	1.05	55.26%	7.0	1.70
Claim	1.4	2.11	0.71	50.71%	1.60	0.20	14.29%	5.50	0.30
Design Interface	0.8	1.53	0.73	91.25%	1.25	0.45	56.25%	3.40	1.00
Total	6.5	11.63	5.13		9.00	2.50			
Mean				78.92%				4.78	1.08

Note) Design period 12 months, construction period 38 months, construction cost 40 billion won

Previous studies have suggested various development plans and trends in domestic construction project management, but research on improvement measures such as the problem of the consideration criteria for efficient manpower allocation and the problem of order status of public construction projects is insufficient. This study analyzes the problem of manpower allocation by project phase and type of work and presents improvement plans, which is expected to be helpful for rational manpower allocation and efficient work performance by presenting quantitative basic data for improving manpower allocation for construction project management in the future.

### 3. Public Sector Construction Project Management Service Order Status

#### 3.1. PPS Technical Service Bid Standard

CM in Korea is managed in planning, feasibility study, analysis, design, procurement, contract, CM, supervision, evaluation or follow-up management, etc. for construction work in the Framework Act on Construction Industry [9] in effect after revised on December 30, 1996 Was defined as performing. The Construction Technology Promotion Act [1] regulates construction works in the public sector.

In addition, the PPS started the CM contract service for the first time in April 2006, so that ordering agencies of public works can also receive total services from planning to follow-up management, improving the quality of public works and enhancing the technological competitiveness of the construction industry. PPS has operated 'Detailed evaluation criteria for project performance capability and for construction project managers in PPS' and has been carrying out construction project management contracts through evaluation of technical proposals. The detailed evaluation criteria for the construction project management performance capacity of the PPS were established in 2005 and are currently being evaluated according to the revised criteria in 2013 after a total of six revisions.

It is a service for public sector construction works specified in the process of selecting successful bidders and establishing contracts using the national electronic procurement system (Korea ON-Line E-Procurement system [10]) is shown in Figure 2.

First, demand arises from the demanding institution and requests a procurement contract to the PPS. The technical review team of the PPS receives the request and discloses it to the general public through the website, and at the same time, after reviewing the preliminary specifications, the purchase decision is made. Next, when the criteria for selecting a successful bidder through a bidding announcement, a bid process is conducted after the proposed price, which is the maximum amount of the contract, is disclosed.

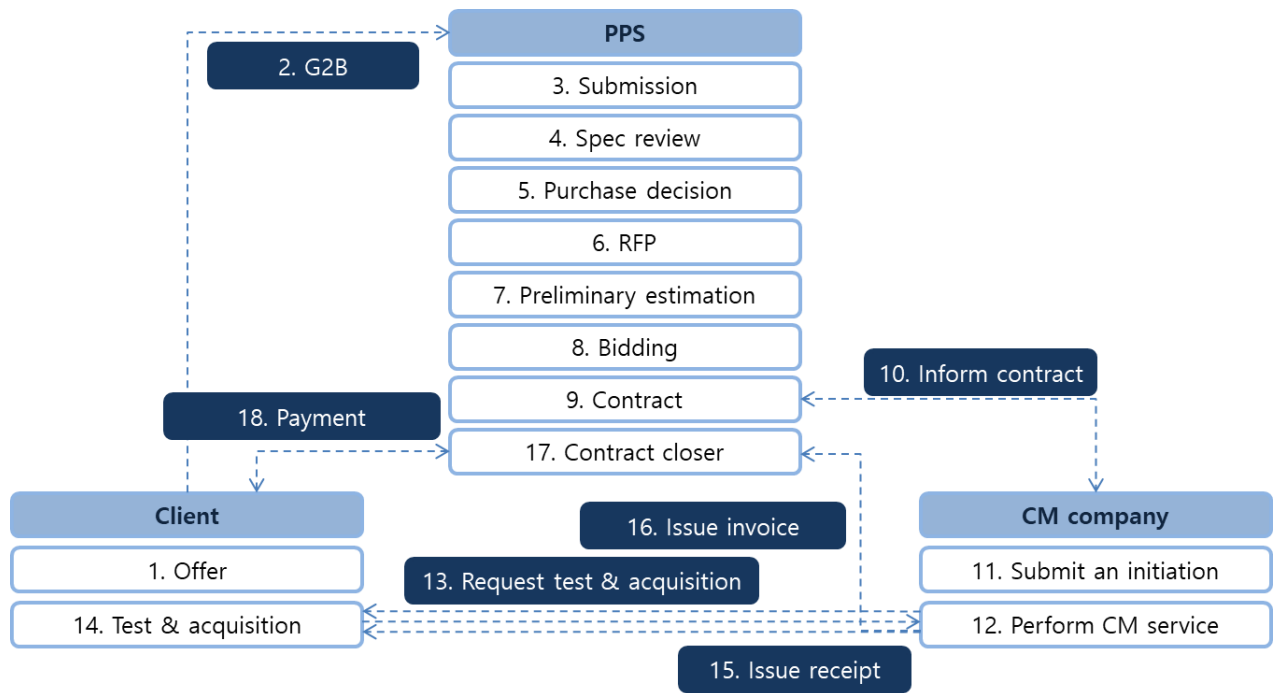


Figure 2 PPS Processing procedure

3.2. PPS Order status

The scope of CM services for public works ordered by the PPS is in the design phase and during and after construction.

The number of orders for CM services from the PPS for public buildings and offices was 7 in 2011, 11 in 2012 and 7 in 2013. The average service amount was 22.24 billion won in 2011, 23.32 billion won in 2012, and 15.21 billion won in 2013.

3.3. CM service manpower allocation standard

For this study, the criteria for manpower allocation and consideration for CM services were investigated as shown in Table 5. Looking at the criteria for calculating consideration for each service, services are calculated in the M/M method for each construction amount, and most other services are calculated based on the construction cost rate.

Table 4 Construction work service cost calculation standard

Category	Standard	Calculation method
Architectural work (Architecture, Civil, Mechanical, Landscape)	<ul style="list-style-type: none"> <li>· Construction supervision consideration standard</li> <li>· Design supervision consideration criteria</li> <li>· Construction project management consideration standard</li> </ul>	<ul style="list-style-type: none"> <li>· M/M method</li> <li>· construction cost rate</li> <li>· construction cost rate</li> </ul>
Electric work	<ul style="list-style-type: none"> <li>· Electric technology management act [11]</li> </ul>	<ul style="list-style-type: none"> <li>· construction cost rate</li> </ul>
Communication work	<ul style="list-style-type: none"> <li>· Enforcement decree of the information and communications construction business act [12]</li> </ul>	<ul style="list-style-type: none"> <li>· construction cost rate</li> </ul>
Fire-fighting work	<ul style="list-style-type: none"> <li>· Fire-fighting system installation business act [13]</li> </ul>	<ul style="list-style-type: none"> <li>· Total floor area, number of floors</li> </ul>

The standards for manpower allocation for CM follow the standards for supervisory assignments pursuant to the Certified Architects Act [14] and the Construction Technology Promotion Act (Article 27).[1] When responsible supervision is included, the consideration is determined by a fixed fee method (direct personnel expenses, direct expenses, overhead expenses, technical fees, additional work expenses, VAT and insurance (deduction) fees are summed to calculate consideration). In the case of design supervision in the detailed design phase or construction phase, the “design supervision consideration criteria” shall be followed. It is stipulated

that compensation for work other than design supervision or responsible supervision can be additionally accrued in the cost plus fee contract in Article 4 of the “CM Consideration Criteria”. The definition of each consideration standard calculation method is shown in Table 5 below.

**Table 5** Definition of consideration standard

Consideration standard	Definition
Cost plus fee	Direct labor costs, direct expenses, overhead expenses, technical fees and VAT are converted to calculate consideration
Construction cost rate	Calculation of consideration by summing additional work costs and VAT to the amount calculated by multiplying the construction cost by a certain rate

Therefore, if you know the construction cost, you can calculate the price. The construction project management fee rate is shown in Table 7 below, and the rate in case the construction cost exceeds 200 billion won is presented by a regression equation.

**Table 6** Example of method by construction cost rate (construction project management fee rate)

Construction cost (Billion won)	Pre-design (%)	Design and Construction			Post-construction (%)
		Design development (%)	Detailed design (%)	Construction (%)	
10	0.206	0.275	0.549	10.383	0.156
20	0.170	0.227	0.453	8.193	0.123
30	0.156	0.208	0.416	7.083	0.106
40	0.147	0.196	0.391	6.396	0.096
50	0.140	0.186	0.373	5.893	0.088
70	0.134	0.179	0.358	5.299	0.079
100	0.130	0.173	0.345	4.724	0.071
150	0.125	0.167	0.333	4.214	0.063
200	0.122	0.162	0.323	3.787	0.057
Interpolation	<p>* Rate when it is in the middle of the construction cost</p> $y = y_1 - \frac{(x - x_2)(y_1 - y_2)}{x_1 - x_2}$ <p>* Rate of construction cost exceeding 200 billion won</p> <p>Pre-design: <math>y = 0.0042 \times x^{-0.1637}</math>                      Design development: <math>y = 0.0047 \times x^{-0.1392}</math>                      Detailed-design: <math>y = 0.0094 \times x^{-0.1399}</math>                      Construction: <math>y = 0.3894 \times x^{-0.3066}</math>                      Post-construction: <math>y = 0.0059 \times x^{-0.3066}</math></p>				

Electric work, communication work, and fire-fighting work refer to Electric technology management act [11], Enforcement decree of the information and communications construction business act [12], and Fire-fighting system installation business act [13], and it is prescribed to follow the standards of each. According to

the manpower allocation standard, the total input manpower to perform construction project management work is calculated, but the consideration standard and manpower allocation do not necessarily form a proportional relationship.

**4. Analysis of manpower allocation for CM through case analysis**

*4.1. Case Analysis Overview*

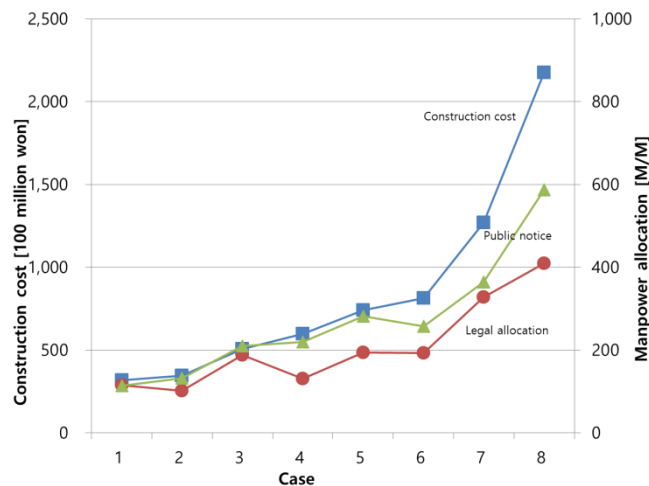
For this study, the cases of legal arrangement of the status of deployment were collected and investigated for eight projects currently undertaken or undertaken by major domestic CM companies among public government building construction project management services ordered by the PPS. Eight business cases are summarized in order of construction cost and are shown in Table 7 below.

**Table 7** Case study summary

No.	Year	Construction cost (Billion won)	Total floor area (m <sup>2</sup> )	Duration (month)	M/M	
					Public notice	legal standard
Case 1	2016	31.8	17,407	27	115.42	113.68
Case 2	2016	34.6	50,133	17	101.80	132.74
Case 3	2017	50.8	23,600	31	188.26	210.63
Case 4	2018	59.9	25,350	22	131.25	219.63
Case 5	2018	74.1	40,971	32	193.93	281.60
Case 6	2018	81.3	42,421	30	192.58	257.16
Case 7	2018	127.0	66,250	33	327.95	364.15
Case 8	2018	217.6	116,780	33.5	408.97	586.80

The construction cost of the case selected in this study ranged from 30 billion won to 220 billion won, and the average construction cost was 84.6 billion won. The total floor area was 17,000 to 16,000m<sup>2</sup>, and the average floor area was 47,800m<sup>2</sup>. Among the target cases, only Case 1 satisfies the legal standard number of months, and Cases 2 to 8 were analyzed to be at a level that did not satisfy the legal standard.

Figure 3 shows the layout of the public notice and the legal standard according to the construction cost. Figure 3 shows that the increase in construction cost and the increase in manpower allocation are irregularly proportional, but the increase in the number of legally-based manpower assignments is slowing down from about KRW 70 billion in construction costs. In addition, it can be seen that when the construction cost is high compared to the case where the construction cost is low, the gap between the legal standard arrangement and the arrangement of the public notice appears a little larger.



**Figure 3** Comparison of public notice and legal standard manpower allocation compared to construction cost

The reason why the manpower allocation in the public notice is lower than that of the legal standard is that ① orders are made by organizing the execution budget reduced based on the average budget three years ago, and ② about 76% of the public notice amount based on the execution budget. It is believed that this is because the price for applying the successful bid rate is calculated, and ③ the assigned manpower is planned based on the calculated price.

In most cases of selection, it can be seen that the legal standard amount is higher than the public notice amount, and this shows that there is an overall correlation with the situation in which the arrangement of the public notice is formed lower than the legal standard arrangement. This situation was compared and analyzed with the ratio of the case rate to the CM consideration standard. Table 8 shows the service costs according to the legal standard CM rate and the service costs in the public notice.

**Table 8** Comparison between public notice and legal standard

Cases	Pre-design			Design development			Detailed design			Construction			Post-construction			Total		
	P	L	ratio	P	L	ratio	P	L	ratio	P	L	ratio	P	L	ratio	P	L	ratio
1	0.247	0.154	1.600				1.028	0.617	1.665	3.698	7.023	0.527	0.280	0.105	2.660	5.253	7.900	0.665
2							0.228	0.759	0.301	4.375	6.925	0.632	0.301	0.104	2.900	4.04	7.788	0.630
3	0.111	0.140	0.797	0.162	0.186	1.435	0.511	0.372	1.372	3.631	5.869	0.619	0.411	0.088	4.689	4.826	6.655	0.725
4							0.134	0.692	0.194	4.127	5.600	0.737	0.613	0.084	7.338	4.874	6.376	0.765
5							0.127	0.651	0.196	3.410	5.220	0.653	0.085	0.078	1.092	3.623	5.949	0.609
6							0.178	0.657	0.271	5.782	5.083	1.138	0.300	0.076	3.942	6.260	5.816	1.076
7							0.167	0.637	0.262	3.560	4.449	0.800	0.184	0.067	2.756	3.911	5.153	0.759
8							0.101	0.600	0.168	3.201	3.709	0.863	0.125	0.056	2.240	3.427	4.365	0.785

Note) P : public notice, L : Legal standard

Compared to the legal standard rate, the public notice amount is about 75% on average, and the successful bid amount is about 57% on average. Since the successful bid price of about 76% of the public notice amount on average is the average price considering the successful bid rate at the planned price, the appropriateness of the successful bid price is a value that satisfies the legal standard CM rate, not the public notice amount, which is the level of the average public notice of the cases analyzed in this study. Therefore, it can be seen that in order to obtain an appropriate level of successful bid price, it is possible to maintain the public notice amount at the legal standard.

**Table 9** Comparison between public notice and legal standard based on successful bid

Cases	Cost [billion won]			Ratio [%]		
	P	L	Successful bid (S)	P/L	S/L	S/P
1	1.655	2.489	1.313	0.665	0.528	0.793
2	1.662	2.639	1.298	0.630	0.492	0.781
3	2.580	3.558	1.972	0.725	0.554	0.764
4	2.875	3.760	2.265	0.765	0.602	0.788
5	2.881	4.731	2.223	0.609	0.470	0.772
6	3.424	3.181	2.522	1.076	0.793	0.737
7	4.964	6.541	3.630	0.759	0.555	0.731
8	6.255	7.967	4.533	0.785	0.569	0.725



Average	3.287	4.358	2.469	0.752	0.570	0.761
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Note) P : public notice, L : Legal standard

Table 9 shows the ratio of the public notice rate and the successful bid rate for the legal standard rate. When eight cases were analyzed, the winning bid rate was an average of 57% of the legal standard rate. The reason why CM companies have no choice but to win orders despite the fairly low amount is that construction orders have decreased due to the recent downturn in the construction business. In addition, from the perspective of CM companies, it cannot but be seen as the ultimate choice for management maintenance. Therefore, it is deemed necessary to apply realistic public notice amount and successful bid amount.

#### 4.2. Analysis of manpower allocation by each phase

##### 4.2.1 Design phase

It can be seen that the ratio of manpower allocation in the design phase among the entire phases of carrying out the case of construction project management in this study is 8.41% on average, lower than 11.49% of the consideration standard, as shown in Table 10.

**Table 10** Manpower allocation ratio following construction phases

Cases	M/M based on public notice			Ratio [%]		
	Design	Construction	Total	Design	Construction	Total
1	11.952	103.467	115.419	10.36	89.64	100
2	3.850	97.953	101.803	3.78	96.22	100
3	38.328	149.928	188.256	20.36	79.64	100
4	7.595	123.651	131.246	5.79	94.21	100
5	12.742	181.184	193.926	6.57	93.43	100
6	10.548	182.034	192.582	5.48	94.52	100
7	30.825	297.124	327.949	9.40	90.60	100
8	22.752	386.220	408.972	5.56	94.44	100
Average	17.324	190.190	207.520	8.41	91.59	100

##### 4.2.2 During and post construction phase

Table 11 shows the details of the actual rates for the detailed design and during and post construction among all cases. It shows the distribution of consideration during and after the design and construction of the six cases provided.

**Table 11** Comparison between public notice and legal standard based on successful bid

Cases	Case analyzed				Legal standard			
	Construction cost rate (%)		Ratio(%)		Construction cost rate (%)		Ratio(%)	
	Design	During and post construction	Design	During and post construction	Design	During and post construction	Design	During and post construction
2	0.228	4.676	3.78	96.22	0.759	7.029	9.75	90.25
4	0.134	4.740	5.79	94.21	0.692	5.684	10.85	89.15
5	0.127	3.495	6.57	93.43	0.651	5.298	10.94	89.06
6	0.178	6.082	5.48	94.52	0.657	5.159	11.30	88.70
7	0.167	3.744	9.40	90.60	0.637	4.516	12.36	87.64

8	0.101	3.326	5.56	94.44	0.600	3.765	13.75	86.25
Average			6.10	93.90			11.49	88.51

Table 12 shows the analysis of the ratio of consideration distribution in the design phase and during and after construction, and the ratio of the design phase and during and after construction to legal standards. In the design phase, the average value of the proportion of cases relative to the legal standard is about 23.18%, and the average value of the proportion of cases compared to the legal standard during and after construction is about 84.17%.

Cases	Manpower allocation					
	Design (%)			Construction (%)		
	Case	Standard	ratio	Case	Standard	ratio
2	0.228	0.759	30.04	4.676	7.029	66.52
4	0.134	0.692	19.36	4.740	5.684	83.39
5	0.127	0.651	19.51	3.495	5.298	65.97
6	0.178	0.657	27.09	6.082	5.159	117.89
7	0.167	0.637	26.22	3.744	4.516	82.91
8	0.101	0.600	16.83	3.326	3.765	88.34
Average	0.156	0.666	23.18	4.344	5.242	84.17

## 5. Improvement plan for manpower allocation for CM

### 5.1. Improvement for CM public notice amount

The ultimate goal is to achieve the successful execution of the project by making full use of the capabilities of the management organization for efficient performance of CM, and to satisfy the needs of the client. In this respect, an efficient management organization must be formed, and appropriate labor costs corresponding to manpower input must be accompanied. The project cost based on the successful bid rate of about 57% of the legal standard cannot be a necessary and sufficient condition to inject professional management personnel with abundant technology and experience. The improvement plan for the public notice amount compared to the legal standard derived in this study is presented as follows.

- 1) In the case, the manpower presented in the assignment matrix in the public notice does not satisfy the legal standard manpower as the minimum manpower. It can be seen that the construction project management system itself is a technology-intensive service that requires a high level of professional manpower input. The way to efficiently arrange such professionals is to adopt the Two-Envelope Bidding System method. The factor of price by adopting the Two-Envelope Bidding System method, which is a method of opening the standard/price or technology/price bidding at the same time. Rather, it is suggested to select a project manager based on technology. Therefore, if the contract is made at the predetermined price level, it is expected that professional manpower input will be easier and the project will be successfully executed.
- 2) It is a method of flexible manpower management for successful business. A certain percentage (eg, 30%) of the total number of months of input is assigned to residents and non-residents at the request of the client, considering the characteristics of the project. According to Kim et al [15], an average of 3.243 design changes are made per public project, and construction cost increases by 17.8% compared to the contract amount. In addition, if there are many reasons for design change, the request of the client, basic plan change, lack of completeness of the design document due to unclear/missing/error/contradiction of the design document, lack of consultation and design management of project participants due to lack of work capability It was said to be a problem that occurs. Therefore, it is judged that the cause of design changes occurring in the construction phase can be prevented by securing the elasticity of the assigned personnel by utilizing non-resident personnel in the design phase.

### 5.2. Input of CM experts according to the needs of the client

Incorporating professional manpower to perform CM tasks such as contract management, cost management, scope management, quality management, safety management, and communication management by each phase

of construction, taking into account the outline of the relevant construction work, performance conditions, and characteristics of the project. As a method that can be appropriately implemented at the request of this client, the client assigns only the minimum required manpower to the Require For Proposal (RFP), and is flexible considering the different manpower for each company and the grade, qualification and number suitable for the characteristics of the business. It is desirable to establish and evaluate an optimal input plan for operation.

## 6. Conclusion

Appropriate manpower input is important to successfully complete in CM project. In this study, the following problems were identified as a result of reviewing the cases of public government building CM ordered by the Public Procurement Service and analyzing the status of manpower allocation by project phase.

1) The service rate on the public notice based on the legal standard rate corresponds to an average of 75%, and the successful bid amount considering the successful bid rate of about 76% is about 57% in the legal standard rate. If a manpower suitable for the assignment is put in, it is inevitable to assign a low-wage manpower.

2) The assignment of personnel that does not meet the consideration standard cannot increase the degree of completion of project execution, and provides a fundamental cause of disruption in the time management and cost management performance work due to design changes.

3) However, there are difficulties in reality due to problems such as lack of competence and institutional preparation of evaluation standards due to the few experiences of public clients with many one-time orders. It is necessary to continuously improve the institutional standards for manpower allocation for flexible manpower management and optimal placement, and to improve the capacity of clients.

To improve this problem, designate only the minimum number of manpower required by the client in the RFP (Require for Proposal), raise the manpower allocation in the design phase to the standard rate of about 11.49%, and the ratio of project expenses by construction type. It was suggested to allocate personnel according to the following. In order to implement such improvement measures, manpower must be allocated according to the project cost that meets the consideration criteria, and specialized training to improve the capacity of the client and systematic improvement of manpower allocation standards for flexible manpower management and optimal distribution is necessary. In future studies, research on generalized improvement plans should be conducted continuously through the analysis of not only public construction but also private construction cases.

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