A Study on the Enhancement of the Large-Scale Construction Project Capability of Project Management Boards

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ABSTRACT

This article analyzes the data collected from the general public and experts in the industry in order to assess the current situation and propose solutions to improve the capability of project management boards of large-scale construction projects in Vietnam. A dataset of 129 survey respondents, whose reliability has been validated with the Cronbach's alpha and the Exploratory Factor Analysis (EFA) test, was constructed. The remaining 24 factors were organized into 8 factor groups that influence the project management capability. Group I, which had the greatest impact, is the legal procedures group, followed by the project deployment process group, down to Group VIII, which is the project risk management group. The results of this study help large-scale construction companies find effective solutions to improve the quality of their projects and increase their competitive capacity in the domestic and international markets.

Keywords-project management board; project management capability; solutions; project quality; large-scale construction projects

I. INTRODUCTION

Project management capability refers to the ability to plan for not only the tasks that must be completed, but also the potential issues that may emerge as one is working through tasks. In a system constrained by organizational, legal, human, and resource issues, a strong project management capability allows completing the target tasks on time and thus meeting the requirements regarding cost of production, quality of products, and environmental impact [1-5]. The management of investment construction projects is becoming increasingly important, posing great influence on the economy. Ineffective project management can lead to serious consequences. To avoid this, we need to plan carefully on how to deal with all the emerging tasks throughout the whole project. This involves scheduling what needs to be completed, how to complete it and preparing backup solutions to tackle unexpected problems that may arise during the project. When dealing with investment construction projects, project management typically includes the work schedule, the construction quality, the expected time of completion, the construction costs, the construction safety, the environmental protection in construction, the selection of contractors, the contract agreement, and the management of risks. Information system management and other necessary contents are implemented in accordance with the provisions of the relevant laws in [6-9].

Authors in [10] conducted a study on the current state of the management of construction projects at the Construction Project Management Board (PMBs) and proposed several solutions to improve the Board's project management capacity. In particular, it was emphasized that investment in infrastructure development is one of the most important tasks that needs to be urgently performed. Investing in new construction projects and renovating old construction works can upgrade the overall infrastructure to achieve the following objectives: 1) maintaining the landscape of the surrounding area and 2) providing infrastructure that meets Class-2 urban criteria according to the regulations. Authors in [11] researched the theoretical aspects in the field of quality management of construction investment projects. The study evaluated the

performance of the PMB in managing their investment construction projects and then proposed solutions to improve their management capability. The authors recognized that the performance of the Board was poor at the time, and there was a strong need to reflect on what the shortcomings were in order to develop solutions to enhance the management performance. Authors in [12] developed several solutions to ameliorate the performance of managing investment construction projects for the PMB. They stated that construction project investors must be responsible for the overall management of construction projects involving budgetary capital. Effective project management not only yields high investment efficiency but also enhances the quality of the construction, minimizes risks, and improves the management skills of the project management team. The success of a project depends strongly on how the project is being managed. Authors in [13] examined the limitations and weaknesses of consulting and designing for a company. They proposed solutions to upgrade the quality of civil construction design for the 2018-2020 period. Scientific data were provided to improve the understanding of parties involved in construction activities. It was shown that there have been several construction recent incidents across the country that have led to the loss of life and property. These incidents were caused by design errors that affected the safety of the construction work.

Authors in [14] focused on the nature of project management, the management of budget, the employment of human resources that encourages creativity and innovation, the effective planning that allows the assigned tasks to be completed, and the integration of technology into the project where the project manager combines engineering, science, and management to enhance various aspects of the project, such as product design, process design, support design, project cost, work schedule, and resources. The success of a project strongly depends on the ability of a project manager to effectively utilize technology, supervise project progress, and manage risks from the early stage of the project to the final stage when the latter is completed. In [15], the principles and techniques of managing construction projects from the early stage were presented, whereas ideas are developed, through the design and construction stages, and finally to completion. It was stressed that the early stages of the project development are highly important as they can directly influence the quality, the cost, and the work progress of the whole project. For any construction project, project management is typically conducted after the scope of the work is fully defined, the budget is set, and the completion date is confirmed. Although each project is unique, there is information that must be identified at the beginning of the project.

For large-scale construction companies, the improvement in project management capability is essential to the company's ability to compete and survive in the construction industry. Currently, the product quality of these companies has been gradually enhanced to meet the standard customer requirements. However, as the economy develops and the demand for high-quality products increases, it is important to provide effective solutions to ameliorate project management capability. In addition, due to ineffective project management, there have been numerous construction accidents that have led to devastating consequences, such as the loss of life and property. Thus, this article proposes solutions that enhance the project management capability of the PMBs of large construction companies, helping them to be more competitive in the construction industry.

II. RESEARCH METHODS

A. Research Process

The research process is shown as a flowchart in Figure 1.

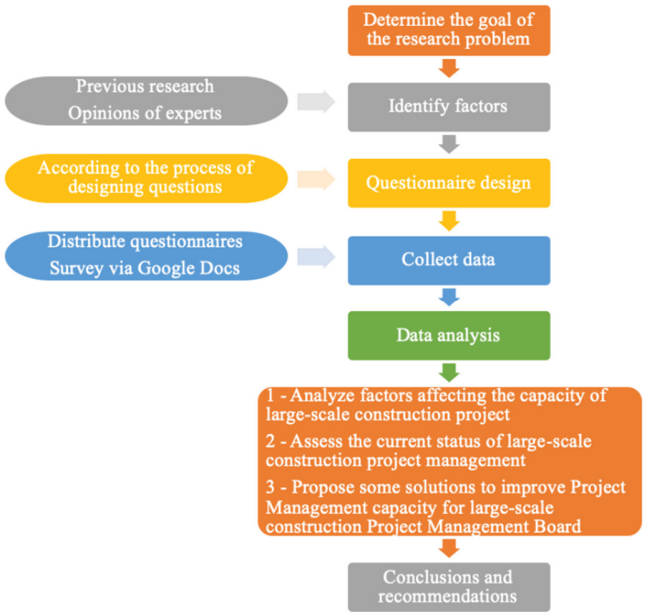

Fig. 1. Research propcess.

B. Data Acquisition

Based on previous studies, we identified 28 potential factors that influence project management capability. The factors are categorized into the following groups:

- Group I: Structure and organization of the PMB
- Group II: Concerns the technical aspects of the project
- Group III: Understanding and compliance with legal regulations
- Group IV: Cost management
- Group V: Work environment, occupational safety and health, and security
- Group VI: Concerns the project communication aspect
- Group VII: Risk management

To facilitate data acquisition and analysis, the factors were coded according to the groups of influencing factors, as can be observed in Table I.

TABLE I. ENCODING OF FACTORS AFFECTING PROJECT MANAGEMENT CAPABILITY

Code	Factors affecting management capability
I	**Aspects of structure and organization of the PMB**
F01	Structure and organization of the PMB
F02	Professional qualifications of the members of the PMB
F03	Execution skills of the members of the PMB
F04	Professional attitude of the members of the PMB
F05	Ability to coordinate work among different departments of the PMB
F06	Task allocation for members within the PMB
II	**Aspects of technical management**
F07	Quality of the construction project
F08	Quality of surveying and measuring equipment
F09	Organization and management by the PMB
F10	Construction drawing
F11	Planning and scheduling of the construction project
III	**Aspects of understanding and compliance with legal regulations**
F12	Compliance with current legal documents
F13	Understanding of the contractor selection process
F14	Monitoring and managing contracts
F15	Inadequate and unbinding contracts
IV	**Aspects of project cost management**
F16	Accuracy of the cost estimation
F17	Ability to manage project costs
F18	Extra work
F19	Changes in project design
F20	Design errors
V	**Aspects of managing the work environment, occupational safety, and security**
F21	Control of occupational safety during construction project
F22	Management of environmental sanitation during construction project
F23	Security management within and outside the construction area
VI	**Aspects of communication management**
F24	Ability to conduct regular internal communication within the company
F25	Ability to establish communication channels between stakeholders
F26	Ability to resolve conflicts among the participants of the project
VII	**Aspects of risk management**
F27	Ability to plan for project risk management
F28	Ability to respond to potential risks of the project during implementation

The constructed questionnaire aimed to collect data through multiple-choice questions, and respondents could answer based on their personal perspectives. Therefore, questions were strategically prompted in a way that allowed respondents to clearly understand the nature of the issues and evaluate them using their own perspectives. This is highly important as it greatly influences the research outcome. The data were collected applying two different methods. One involved distributing surveys via mobile telephone and the other entailed conducting interviews with the participants. The interviewing method was preferred over the survey method because interviewing the participants could give them a chance to thoroughly answer all the questions. The survey was sent to experts in the construction field, head supervisors, supervisors from the investing companies or PMBs, chief engineers, and construction engineers of various contracting companies. Additionally, it was sent to the PMBs of the investing companies and the consultants of several projects of Novaland Group, Hung Thinh Group, and Vingroup. To ensure reliability, questionnaires with uniform agreement levels for all items, questionnaires that were marked according to a fixed pattern, and questionnaires that had many missing data were discarded.

C. Research Tools

The research tools are shown in Table II.

TABLE II. RESEARCH TOOLS

Research content	Research tools
Analyzing factors that influence project management performance	- Overview of previous studies and consulting experts. - Testing the reliability of the Cronbach's alpha scale. - Descriptive statistical analysis.
Evaluating the current state of project management work.	Explatory Factor Anaysis (EFA)

III. RESULTS AND DISCUSSION

A. Analyzing Information from Survey Respondents

A total of 150 questionnaires were sent via Google Forms to head supervisors, supervisors of investing companies, PMB members, technical and supervisory consultants, chief commanders, construction engineers, and experts in the construction field in Vietnam. A total of 139 questionnaires were answered, of which 10 were deemed inappropriate and discarded, leaving 129 valid questionnaires for analysis.

1) Years of Work Experience

The pie chart that displays the respondents' level of experience is shown in Figure 2.

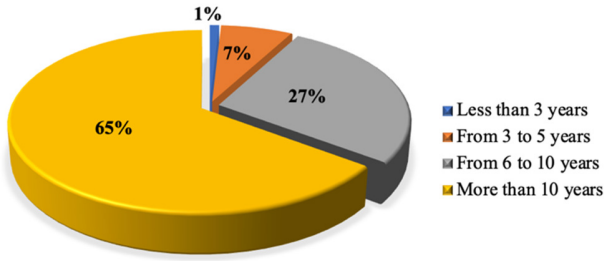

Fig. 2. Level of experience (measured by the number of years of working in the construction industry) of the respondents.

2) Job Positions

The majority of the survey respondents hold positions as head supervisors and supervisors, as can be observed in Figure 3.

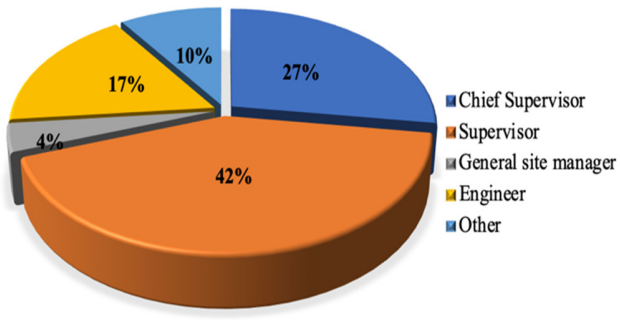

Fig. 3. Job positions of the respondents.

3) Job Roles

The majority of the surveyed individuals are investors and PMB members. Other respondents with different roles in the construction industry only make up 0.8% (Figure 4).

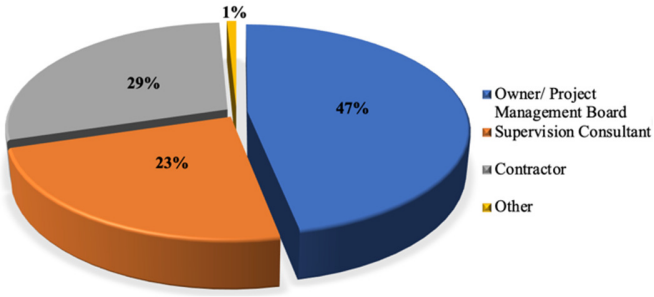

Fig. 4. Work roles of the survey respondents.

B. Testing Reliability with Cronbach's Alpha

Cronbach's alpha was used to test the reliability of the collected data. The total Cronbach's alpha value of the 28 factors that could affect project management capability was calculated to be 0.808 (which indicates a good scale), see Table III. Factors with Cronbach's alpha coefficient value greater than 0.6 were considered as important, and 2 factors were discarded. The Cronbach's Alpha coefficients of the remaining 26 factors are summarized in Table IV.

TABLE III. CRONBACH'S ALPHA COEFFICIENTS OF THE 28 FACTORS

Group	No of items	Cronbach's alpha
Group I	6	0.634
Group II	5	0.567
Group III	4	0.801
Group IV	5	0.755
Group V	3	0.693
Group VI	3	0.791
Group VII	2	0.674
Sum	**28**	**0.808**

TABLE IV. CRONBACH'S ALPHA COEFFICIENTS OF THE REMAINING 26 FACTORS

Group	No of items	Cronbach's alpha
Group I	5	0.658
Group II	4	0.636
Group III	4	0.801
Group IV	5	0.755
Group V	3	0.693
Group VI	3	0.791
Group VII	2	0.674
Sum	**26**	

C. Descriptive Statistics Ranking

The ranking of the 26 factors affecting project management capability is presented in Table V. The average value of the influence level ranges from 'high' to 'very high' for 15 of the 26 factors. The remaining ones have an average influence ranging from 'moderate' to 'high.' The column that exhibits the average value of the variable is one of the key columns in the Table. In the questionnaire, a 5-point Likert scale was used, with an average score of 3. If the average value of the variable falls between 3 and 5, it means that the respondents agree with the question statement. If the average value of the variable is between 1 and 3, the respondents disagree with the question statement. In the column that showcases the standard deviation of the variable, the smaller the value, the less variation in the response to the questionnaire is noticed. A high value indicates that the survey respondents have contradicting opinions regarding the variable. When the standard deviation of the factors is less than 1, or approximately equal to 1, there is an agreement among the respondents.

TABLE V. DESCRIPTIVE STATISTICS OF THE FACTORS AFFFECTING PROJECT MANAGEMENT CAPABILITY

Code	Factors affecting management capability	Average	Standard deviation	Rank
F11	Planning and scheduling of construction project	4.6124	0.5048	1
F07	Quality of the construction project	4.5116	0.5320	2
F20	Design errors	4.5116	0.6139	3
F26	Ability to resolve conflicts among the participants of the project	4.3953	0.6664	4
F03	Execution skills of the members of the PMB	4.2868	0.6637	5
F18	Extra works	4.2791	0.6612	6
F19	Changes in project design	4.2558	0.6408	7
F08	Quality of surveying and measuring equipment	4.2558	0.6529	8
F10	Construction drawing	4.2248	0.5895	9
F21	Control of occupational safety during construction project	4.1318	0.7539	10
F16	Accuracy of the cost estimation	4.1240	0.6375	11
F06	Task allocation for members within the PMB	4.1240	0.7396	12
F28	Ability to respond to potential risks that may occur during the project	4.1240	0.7290	13
F15	Inadequate and unbinding contracts	4.0775	0.6568	14
F02	Professional qualifications of members of the PMB	4.0620	0.7262	15
F17	Ability to manage project costs	3.9922	0.7126	16
F27	Ability to manage risk	3.9302	0.7201	17
F12	Compliance with current legal documents	3.9225	0.6448	18
F04	Professional attitude of the members of the PMB	3.8140	0.8548	19
F25	Ability to establish communication channels between stakeholders	3.7287	0.7980	20
F23	Security management within and outside the construction area	3.6589	0.9057	21
F22	Management of environmental sanitation during construction project	3.4186	0.8723	22
F13	Understanding of the contractor selection process	3.3798	0.7520	23
F05	Ability to coordinate work among the departments of the PMB	3.3798	0.8678	24
F24	Ability to conduct regular internal communication within the company	3.2868	0.8120	25
F14	Monitoring and managing contracts	3.2171	0.7067	26

D. Exporatory Factor Analysis (EFA)

The EFA was conducted to uncover the fundamental relationships among the 26 considered factors affecting project management capability. First, the correlation matrix between the factors was examined. Then this study checked the suitability of the factor analysis that was conducted for the data

(using the Kaiser-Mayer-Olkin (KMO) index where 0.5 < KMO < 1 and the Bartlett's test of sphericity with statistical significance sig. <0.05). Finally, the reliability of the factor model was verified through the commonalities of variance coefficients (> 50%) of the factors.

TABLE VI. RESULTS OF THE KMO AND BARTLETT'S TEST FOR 26 FACTORS

Kaiser-Meyer-Olkin measure of sampling adequacy		0.710
Bartlett's test of sphericity	Approx. Chi-Square	1131.286
	df	325.000
	Sig.	0.000

According to [18], the commonality of each factor should be equal to or greater than 0.5 to be sufficiently explanatory. The results in the component matrix of 26 factors (Table VII) indicate that the factor F06, which refers to the assignment of tasks to members of the PMB, has a load factor less than 0.5 and therefore should be excluded from the analysis. However, when running the EFA for the second time, the factor F04, which refers to the professional attitude of PMB members, also exhibited a load factor less than 0.5. Consequently, it was decided for both factors, F04 and F06, to be removed from the analysis before conducting the 2nd EFA with the remaining 24 factors. The factor analysis process was performed again using the EFA, and the results are illustrated in Table XI. The component matrix for the 24 factors with a load factor ≥ 0.5 revealed that all 24 factors resulted in a load factor > 0.5. These factors are divided into 8 new classes, as spotted in Table XIV.

The findings in Table XIII demonstrate that the component matrix reveals the relationship among the factors. Each factor consists of coefficients that are grouped together in one column. The eight extracted factors are renamed, as pinpointed in Table XIV. The results are:

Factor group I, which refers to legal procedures, project implementation processes, is the most important factor group in project management capability. Factor group I accounts for the largest proportion of variance at 12.565%, comprising five factors ranked in order of influence from 1 to 5 (weak to strong) in Table XIV. The most influential factor is monitoring and managing contracts, which has a loading factor of 0.803. The fifth most influential factor is the ability to coordinate work between the departments of the PMB, which has a loading coefficient of 0.527. In Group I, the capability of the PMB to manage legal procedures and project implementation processes is the weakest. There are many shortcomings and limitations in the legal procedures. Also, the implementation process must deal with requirements that are not appropriate for a project of such scale.

Factor group II represents project cost management, and is the second most influential factor in project management capability. Group II accounts for the second-largest proportion of variance at 11.027%, comprising five factors ranked in order of influence from 1 to 5 (weak to strong), as observed in Table XIV. The most influential factor is design error, which has a loading coefficient of 0.816, and the fifth most influential factor is arising work, which has a loading coefficient of 0.564. In Group II, the capability of the PMB to manage costs for the project is the second weakest due to the existence of many difficulties and limitations.

Factor Group III refers to project communication. It is the third most influential factor in project management capability. Group III accounts for the third-largest proportion of variance at 9.365%, comprising three factors ranked in order of influence from 1 to 3, as depicted in Table XIV. The most influential factor corresponds to the ability to establish communication channels between stakeholders with a loading coefficient of 0.853. The third most influential factor is the ability to resolve conflicts among the participants of the project, which has a loading coefficient of 0.771. In Group III, the capability of the PMB to manage project communication is the third weakest.

TABLE VII. COMMUNALITY RESULTS OF THE 26 FACTORS

No.	**Code**	**Factors affecting project management capability**	**Initial**	**Extraction**
1	F02	Professional qualifications of the members of the PMB	1.000	0.653
2	F03	Execution skills of the members of the PMB	1.000	0.772
3	F04	Professional attitude of the members of the PMB	1.000	0.585
4	F05	Ability to coordinate work among the departments of the PMB	1.000	0.705
5	F06	Task allocation for members within the PMB	1.000	0.555
6	F07	Quality of the construction project	1.000	0.661
7	F08	Quality of the surveying and measuring equipment	1.000	0.684
8	F10	Construction drawing	1.000	0.572
9	F11	Planning and scheduling of the construction project	1.000	0.706
10	F12	Compliance with current legal documents	1.000	0.629
11	F13	Understanding of the contractor selection process	1.000	0.725
12	F14	Monitoring and managing contracts	1.000	0.693
13	F15	Inadequate and unbinding contracts	1.000	0.578
14	F16	Accuracy of the cost estimation	1.000	0.592
15	F17	Ability to manage project costs	1.000	0.582
16	F18	Extra work	1.000	0.519
17	F19	Changes in project design	1.000	0.648
18	F20	Design errors	1.000	0.740
19	F21	Control of occupational safety during project construction	1.000	0.683
20	F22	Management of environmental sanitation during construction project	1.000	0.715
21	F23	Security management within and outside the construction area	1.000	0.638
22	F24	Ability to conduct regular internal communication within the company	1.000	0.739
23	F25	Ability to establish communication channels between stakeholders	1.000	0.784
24	F26	Ability to resolve conflicts among the participants of the project	1.000	0.658
25	F27	Ability to manage risks	1.000	0.733
26	F28	Ability to respond to potential risks that may occur during the project	1.000	0.730

TABLE VIII. TOTAL VARIANCE FOR THE 26 FACTORS

Component	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.074	19.514	19.514	5.074	19.514	19.514	3.210	12.345	12.345
2	2.445	9.404	28.919	2.445	9.404	28.919	2.660	10.230	22.576
3	2.136	8.217	37.135	2.136	8.217	37.135	2.330	8.960	31.536
4	1.991	7.658	44.793	1.991	7.658	44.793	1.992	7.661	39.197
5	1.707	6.566	51.360	1.707	6.566	51.360	1.878	7.222	46.419
6	1.510	5.807	57.167	1.510	5.807	57.167	1.794	6.901	53.320
7	1.255	4.829	61.996	1.255	4.829	61.996	1.780	6.845	60.165
8	1.158	4.455	66.451	1.158	4.455	66.451	1.634	6.286	66.451
9	0.901	3.466	69.917						
10	0.782	3.009	72.926						
11	0.752	2.892	75.818						
12	0.726	2.793	78.611						
13	0.669	2.574	81.185						
14	0.619	2.382	83.567						
15	0.552	2.124	85.691						
16	0.476	1.830	87.521						
17	0.455	1.750	89.271						
18	0.442	1.699	90.970						
19	0.394	1.515	92.485						
20	0.381	1.467	93.952						
21	0.346	1.330	95.282						
22	0.315	1.213	96.494						
23	0.275	1.059	97.553						
24	0.221	0.849	98.402						
25	0.217	0.834	99.237						
26	0.198	0.763	100						

TABLE IX. THE COMPONENT MATRIX OF THE 26 FACTORS WITH LOAD FACTOR ⩾ 0.5

No	Code	Factors affecting project management capability	Component							
			1	2	3	4	5	6	7	8
1	F13	Understanding contractor's selection process	0.802							
2	F14	Monitoring and managing contracts	0.782							
3	F12	Compliance with current legal documents	0.717							
4	F15	Inadequate and unbinding contracts	0.692							
5	F05	Ability to coordinate work among the departments of the PMB	0.508							
6	F06	Task allocation for members within the PMB								
7	F20	Design errors		0.812						
8	F17	Ability to manage project costs		0.749						
9	F19	Changes in project design		0.709						
10	F16	Accuracy of cost estimation		0.593						
11	F18	Extra work		0.562						
12	F25	Ability to establish communication channels between stakeholders			0.851					
13	F24	Ability to conduct regular internal communication within the company			0.796					
14	F26	Ability to resolve conflicts among the participants of the project			0.771					
15	F22	Management of environmental sanitation during project construction				0.788				
16	F21	Control of occupational safety during the construction of the project				0.728				
17	F23	Security management within and outside the construction area				0.708				
18	F03	Work execution skills of the members of the PMB					0.855			
19	F02	Professional qualifications of members of the PMB					0.733			
20	F04	Professional attitude of the members of the PMB					0.510			
21	F08	Quality of the surveying and measuring equipment						0.774		
22	F10	Construction drawing						0.666		
23	F11	Planning and scheduling of the construction project							0.808	
24	F07	Quality of the construction project							0.704	
25	F27	Ability to manage risks								0.835
26	F28	Ability to respond to potential risks that may occur during the project								0.833

TABLE X. RESULTS OF THE KMO AND BARTLETT'S TEST FOR 24 FACTORS

Kaiser-Meyer-Olkin measure of sampling adequacy		0.694
Bartlett's test of sphericity	Approx. Chi-Square	1016.592
	df	276.000
	Sig.	0.000

TABLE XI. COMMUNALITY RESULTS OF THE 24 FACTORS

No.	Code	Factors affecting project management capability	Initial	Extraction
1	F02	Professional qualifications of the members of the PMB	1.000	0.686
2	F03	Execution skills of the members of the PMB	1.000	0.800
3	F05	Ability to coordinate work among the departments of the PMB	1.000	0.681
4	F07	Quality of the construction project	1.000	0.727
5	F08	Quality of surveying and measuring equipment	1.000	0.582
6	F10	Construction drawing	1.000	0.741
7	F11	Planning and scheduling of the construction project	1.000	0.640
8	F12	Compliance with current legal documents	1.000	0.727
9	F13	Understanding of the contractor selection process	1.000	0.708
10	F14	Monitoring and managing contracts	1.000	0.589
11	F15	Inadequate and unbinding contracts	1.000	0.594
12	F16	Accuracy of the cost estimation	1.000	0.569
13	F17	Ability to manage project costs	1.000	0.524
14	F18	Extra work	1.000	0.630
15	F19	Changes in project design	1.000	0.739
16	F20	Design errors	1.000	0.683
17	F21	Control of occupational safety during construction project	1.000	0.726
18	F22	Management of environmental sanitation during the project construction	1.000	0.640
19	F23	Security management within and outside the construction area	1.000	0.744
20	F24	Ability to communicate regularly with different departments within the company	1.000	0.794
21	F25	Ability to establish communication channels between stakeholders	1.000	0.662
22	F26	Ability to resolve conflicts among the participants	1.000	0.754
23	F27	Ability to plan for project risk management	1.000	0.760
24	F28	Ability to respond to potential risks that may occur during the project	1.000	0.718

TABLE XII. TOTAL VARIANCE OF 24 THE FACTORS

Component	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.672	19.467	19.467	4.672	19.467	19.467	3.016	12.565	12.565
2	2.356	9.816	29.283	2.356	9.816	29.283	2.646	11.027	23.592
3	2.130	8.877	38.160	2.130	8.877	38.160	2.248	9.365	32.957
4	1.815	7.563	45.723	1.815	7.563	45.723	1.926	8.024	40.981
5	1.679	6.994	52.717	1.679	6.994	52.717	1.667	6.946	47.926
6	1.498	6.242	58.959	1.498	6.242	58.959	1.665	6.938	54.864
7	1.208	5.035	63.994	1.208	5.035	63.994	1.654	6.890	61.754
8	1.058	4.408	68.402	1.058	4.408	68.402	1.595	6.648	68.402
9	0.897	3.736	72.138						
10	0.777	3.236	75.373						
11	0.715	2.979	78.352						
12	0.660	2.750	81.102						
13	0.605	2.520	83.621						
14	0.527	2.196	85.817						
15	0.478	1.991	87.809						
16	0.448	1.867	89.676						
17	0.427	1.778	91.454						
18	0.394	1.642	93.096						
19	0.373	1.555	94.651						
20	0.335	1.396	96.046						
21	0.289	1.205	97.251						
22	0.233	0.969	98.221						
23	0.224	0.934	99.155						
24	0.203	0.845	100						

TABLE XIII. COMPONENT MATRIX OF THE 24 FACTORS WITH LOAD FACTOR ≥ 0.5

No	Code	Factors affecting project management capability	Component							
			1	2	3	4	5	6	7	8
1	F14	Monitoring and managing contracts	0.803							
2	F13	Understanding of the contractor selection process	0.801							
3	F12	Compliance with current legal documents	0.712							
4	F15	Inadequate and unbinding contracts	0.687							
5	F05	Ability to coordinate work among different departments of the PMB	0.527							
6	F20	Design errors		0.816						
7	F17	Ability to manage project costs		0.743						

8	F19	Changes in project design		0.709						
9	F16	Accuracy of the cost estimation		0.605						
10	F18	Extra work		0.564						
11	F25	Ability to establish communication channels between stakeholders			0.853					
12	F24	Ability to communicate regularly with different departments			0.799					
13	F26	Ability to resolve conflicts among the participants of the project			0.771					
14	F22	Management of environmental sanitation during the project				0.797				
15	F21	Control of occupational safety during construction project				0.724				
16	F23	Security management within and outside the construction area				0.708				
17	F11	Planning and scheduling of construction project					0.829			
18	F07	Quality of the construction project					0.741			
19	F03	Work execution skills of the members of the PMB						0.876		
20	F02	Professional qualifications of members of the PMB						0.764		
21	F08	Quality of surveying and measuring equipment							0.813	
22	F10	Construction drawings							0.674	
23	F28	Ability to respond to potential risks that may occur during the project								0.852
24	F27	Ability to plan for project risk management								0.849

TABLE XIV. RESULT OF FACTORS ANALYSIS

Group	Name	Old code	Brand	Ingredients							
				1	2	3	4	5	6	7	8
I	Legal procedures and project implementation processes	F14	Monitoring and managing contracts	0.803							
		F13	Understanding of the contractor selection process	0.801							
		F12	Compliance with current legal documents	0.712							
		F15	Inadequate and unbinding contracts	0.687							
		F05	Ability to coordinate work among different departments of the PMB	0.527							
II	Project cost management	F20	Design errors		0.816						
		F17	Ability to manage project costs		0.743						
		F19	Changes in project design		0.709						
		F16	Accuracy of the cost estimation		0.605						
		F18	Extra work		0.564						
III	Project communication	F25	Ability to establish communication channels between stakeholders			0.853					
		F24	Ability to conduct regular internal communication within the company			0.799					
		F26	Ability to communicate regularly with different departments within the company			0.771					
IV	Occupational safety and environmental hygiene	F22	Ability to resolve conflicts among the participants of the project				0.797				
		F21	Management of environmental sanitation during construction project				0.724				
		F23	Control of occupational safety during construction project				0.708				
V	Organization and quality control	F11	Planning and scheduling of construction project					0.829			
		F07	Quality of the construction project					0.741			
VI	Capability of PMB members	F03	Work execution skills of the members of the PMB						0.876		
		F02	Professional qualifications of members of the PMB						0.764		
VII	Surveying and designing the project	F08	Quality of surveying and measuring equipment							0.813	
		F10	Construction drawings							0.674	
VIII	Project risk management	F28	Ability to respond to potential risks that may occur during the project								0.852
		F27	Ability to manage risks								0.849

Factor Group IV, which represents occupational safety and environmental hygiene, is the fourth most influential group in project management capability. Factor IV accounts for the fourth-largest proportion of variance at 8.024%, comprising three factors ranked in order of influence from 1 to 3 in Table XIV. The most influential factor is the management of environmental sanitation during project construction, with a loading coefficient of 0.797. The third most influential factor is security management within and around the project construction area, with a loading coefficient of 0.708. The capability of the PMB to manage occupational safety and environmental hygiene is the fourth weakest. There is a lack of safety, environmental sanitation, and security controls.

Factor Group V, which refers to organization and quality control, is the fifth most influential factor in project management capability. Group V accounts for the fifth-largest proportion of variance at 6.946%, comprising two factors. The most influential factor is the project construction planning and scheduling, with a loading coefficient of 0.829 and the second most is the quality of the construction project, with a loading

coefficient of 0.741. The capability to manage organization and quality control is the fifth weakest.

Factor Group VI, which represents the capability of PMB members, is the sixth most influential factor in project management capability. Group VI accounts for the sixth-largest proportion of variance at 6.938%, comprising two factors ranked. The most influential factor is the work execution skills of PMB members, with a loading coefficient of 0.876, and the second is the professional expertise of PMB members, with a loading coefficient of 0.764. The capability to manage the capacity of PMB members is the sixth weakest. The PMB does not have highly enough skilled personnel.

Factor Group VII, which refers to the surveying and design of the project, is the seventh most influential factor in project management capability. Group VII accounts for the seventh-largest proportion of variance at 6.890%, comprising two factors. The most influential factor is the quality of surveying and measuring equipment, with a loading coefficient of 0.813, and the second is construction drawing, with a loading coefficient of 0.674. The capability to manage surveying and design of the project is the seventh weakest. There are problems with the outdated equipment and the delays in project design that affect the quality and schedule of construction.

Factor Group VIII, which represents project risk management, is the eighth most influential factor group in project management capability. Group VIII accounts for the eighth-largest proportion of variance at 6.648%, comprising two factors ranked. The most influential factor is the ability to respond to potential risks of the project during implementation, with a loading coefficient of 0.852 and the second is the ability to plan for project risk management, with a loading coefficient of 0.849. The capability in project risk management is the eighth weakest.

IV. SOLUTIONS TO ENHANCE THE CAPABILITY OF MANAGING CONSTRUCTION INVESTMENT PROJECTS

A. Solutions to Enhance the Capability of Managing Legal Procedures and Project Implementation Processes

1) Solutions for Contract Management

One needs to thoroughly check the operational capacity and professional competence of contractors before negotiating contract agreements and ask contractors to provide original invoices, certificates, and capacity profiles for verification, to avoid situations where contractors falsely declare their capabilities during the bidding process. One should also carefully review all terms in the contracts to ensure that all parties can rely on the contract to fulfill their responsibilities. The value of the contract must not exceed the bid price or the results of contract negotiations and agreements. Provisions related to advance payments, recovery of advanced funds, payment for completed work, and final settlement of the project should be clearly designated in the contract.

To ensure that the contractors will fulfill their responsibilities after signing the contracts, contract terms need to specify binding content regarding construction quality and contract execution timelines. Specific provisions for handling and penalizing non-compliance with the contract and corresponding penalty levels should be clearly stated. If a contractor repeatedly violates the contract without implementing corrective measures, the PMB should organize meetings to reassess the contractor's actual capabilities and consider terminating the contract. In cases where the contractor's violations are repetitive and significantly impact the project's schedule, quality, and safety, the PMB should consider contract termination without having to return the advance guarantee and the performance guarantee provided by the contractor.

2) Solutions for Contractor Selection and Compliance with Current Legal Documents

To accurately assess the professional level, work execution skills, and experience of contractors, the PMB needs to review the profile of each contractor participating in the bidding process. This includes examining their previous project involvement in terms of manpower, quality, schedule, and safety. Additionally, compliance with current legal documents that are still in effect is essential. From this, the PMB will establish proper and suitable criteria for contractor selection. The criteria include capability, construction progress, construction cost, and assurance of occupational safety.

3) Solutions for Coordinating Work Among the Departments of the Project Management Board

The PMB needs to address this issue by adopting the Building Information Modeling (BIM) approach in construction to coordinate work among various departments competently. Implementing BIM in project construction helps identify conflicts and coordinate their resolution efficiently. Regular collaboration among different departments, such as civil, infrastructure, surveying, design, business and administration, is essential to minimize revisions and changes, thereby ensuring the quality of various project packages.

B. Solutions to Enhance the Capability of Managing Project Costs

The PMB needs to select personnel who have the necessary competence, ethical integrity, and honesty to accurately review cost estimation files before submission for approval. Additionally, strict regulations and penalties must be established against any behavior that exploits positions to deliberately profit, make errors, or inflate estimates for personal gain. The PMB should also implement measures to establish a unit price system that reflects current market conditions. The system should be easy to use and provide accurate market conditions.

The contractor selection process at each stage must be conducted openly to choose the most experienced contractors. The PMB needs to plan for rigorous supervision, inspection, and acceptance control to avoid repeated surveys and excessive adjustments. The PMB must closely monitor the construction site, control the construction process, and push contractors to fulfill their tasks and meet the committed timeline. The aim is to ensure the quality of the project and effective cost management throughout the whole project, from surveying to construction and completion.

When contractors submit payment requests and settlement reports at each stage, the PMB requires them to present detailed explanations of the work volume. In case of any additional work, they must provide an adequate explanation, along with full signatures from all relevant parties. In addition, the construction diary must document in detail the work volume and any additional issues that arise.

C. Solutions to Enhance the Capability of Managing Project Communication

Regular internal meetings of the PMB and with relevant parties on a weekly and monthly basis to review work volume, quality, and progress, should be held. These meetings also serve to address any issues and timely resolve conflicts among the participants, thereby facilitating the project's progress. All participants should be notified about new regulations, complications, and conflicts that have occurred in other PMBs. This will ensure better coordination in construction activities.

D. Solutions to Enhance the Capability of Managing Occupational Safety and Environmental Hygiene

During the review and approval process of safety, environmental hygiene, and security plans for construction, the PMB needs to carefully scrutinize each construction item of the contractors to ensure all requirements have been met. The contractors must also possess all the necessary protective equipment. All machinery and equipment must have valid inspection documents to enhance the effectiveness of management and control. The PMB needs to enhance collaboration with contractors to inspect occupational safety, environmental hygiene, and security management systems of the contractors at work sites, living areas, and construction sites. Contractors must not employ workers who have not undergone training in occupational safety, environmental hygiene, and security.

E. Solutions to Enhance the Capability of Management and Quality Control

1) Solutions for the Planning and Scheduling of the Construction Project

Before construction begins, contractors are required to prepare a construction schedule that aligns with the approved project timeline. Contractors must regularly monitor the progress on the construction site and collaboratively work with the PMB and the supervisory team to respond to unexpected problems that may occur during the project. These problems may include the fluctuation in material prices, modifications to designs that turn out to be unsuitable for the actual construction conditions, and poor weather conditions. The goal is to keep the project on schedule.

2) Solutions for the Quality of the Construction Project

The PMB requires contractors to submit a plan for quality control before construction, including the inspection and assurance of the quality of materials and equipment. Contractors are required to constantly check the construction site and organize weekly meetings to address technical errors and propose solutions to solve these errors. During the construction process, there should be frequent monitoring and inspection so that the emergence of any error can be quickly resolved, ensuring a continuous workflow. Regular weekly meetings should be conducted to update on the quality and progress of the work, addressing any issues during construction to maintain the quality and progress of the project.

F. Solutions to Enhance the Capability of Project Management Board Members

The capability of PMB members can have a great effect on the work progress of a construction project. A professional PMB is established with the aim of enhancing the capability and quality of managing construction investment projects. It is always important to propose new training policies and organize appropriate training and coaching for the PMB members. Also, the members must have professional certificates relevant to the project that they are working on. The board should create a balanced working environment for members to learn, strive, and compete healthily. There should be a good reward system to encourage the members to work more efficiently. The board should annually reassess the capabilities of its members so that they can replace underperforming members with better suitable ones. The board must ensure that salaries, bonuses, and benefits are commensurate with capabilities, positions, and job responsibilities to guarantee a sufficient living standard for the members, helping them to focus on their work. Moreover, the board must have policies for recruiting experienced staff to meet the project's specific requirements and the company's overall needs. Recruiting capable project management members will enhance the project's quality and contribute to the company's growing reputation and development.

The PMB should organize weekly meetings at the project site with relevant parties and should require construction contractors to have plans for the tasks that need to be completed and plans for the acceptance and payment of completed work. Daily, weekly, and monthly reports serve as a basis for the PMB to review and resolve issues at the construction site. This also helps board members to develop their capabilities while closely monitoring their work progress. New construction regulations should be systematically updated by the board members, and follow-up meetings after inspection should be conducted to allow them to learn from shortcomings and draw lessons for future project management. Members of the PMB must continuously stay updated with the current legal documents and strictly adhere to the standard procedures to ensure that all construction work is carried out as planned.

G. Solutions to Enhance the Capability of Surveying and Designing the Project

The PMB ensures high quality utilizing its own and the contractor's surveying equipment. All equipment must be periodically inspected and replaced if old, damaged, or outdated. Based on the approved construction schedule, the Surveying Department of the PMB and the contractor need to plan for the use of each type of surveying equipment, to guarantee that the surveying processes can be conducted effectively to gather appropriate data and develop an accurate construction drawing for the project. Members of the PMB tend to be highly skilled engineers with many years of work experience. They use the surveying equipment to design

optimal construction drawing documents. The PMB needs to enhance the capabilities of its members in conducting accurate surveying, supervision, and inspection. In this way, the tasks will be completed with a high standard in terms of quality and scheduled progress. Good design drawing documents will minimize errors and unexpected adjustments, which, if they occur, would significantly hinder the progress of the construction project.

H. Solutions to Enhance the Capability of Project Risk Management

1) Solutions for Responding to Potential Risks of the Project

First, the PMB must provide the contractors with approved designs and drawings. Contractors are responsible for checking these designs and drawings and breaking them down before starting construction. The supervisor team must strictly monitor the construction work, ensuring that it aligns with the provided designs. All parties involved in the project must fully comply with the terms of the signed contract. It is imperative that all contract terms are followed and proper construction procedures are conducted. If not, the PMB needs to implement strong corrective measures or even consider terminating the contract. All technical regulations and procedures must be followed strictly during construction to avoid risks that could delay the project's progress.

2) Solutions for Risk Management Planning

PMB needs to develop an appropriate response plan for each potential risk. It should also clearly define who is responsible for risk management. In summary, to create a good plan, the Board must establish effective control methods and identify responsible individuals for implementation. Group leaders and head supervisors should regularly report on the project's progress to provide adjustments if necessary. This approach enables effective risk control to prevent any impact on the project's progress.

V. CONCLUSIONS

Based on previous studies on the factors that can influence project management capability, 28 factors that can affect the project management capability for the PMBs of large construction companies were determined in this paper. However, the data collected from the survey questionnaires, after being processed by the EFA, revealed that only 24 factors could influence project management capacity. These factors were reorganized into 8 new factor groups. This result aligns with the conclusions derived from previous studies. Practically, this study helps both the investors and the PMBs to recognize the factors that can impact project management capability. The former can be further extended in future research to assess and improve the administration of project management capabilities of the PMB members.

The study has established the relationship among the influencing factors and provided managers with a comprehensive list of factors that can potentially affect project management capability. From this, the managers can come up with solutions to improve project quality in the long run.

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