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# Relationships of construction project manager, engineer, and foreman skills

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**Abstract.** Understanding the relationships of construction project manager, engineer and foreman skills can be used by contractors to develop project performance. Although there are widely discussed on construction individual skills, the relationships between individual skills having on others' skills have not been examined in previous studies. Thus, this study examined such relationships. The questionnaire was used to collect data on the important range of skills of the individual to evaluate the relationships among them. The data were then analyzed using structural equation modelling (SEM) to determine the relationships of construction manager, engineer and foreman skills. The final SEM model shows regression weights in parenthesis that construction manager skills have influence on engineer skills (0.65) and engineer skills have influence on foreman skills (0.84). Additionally, the regression weight presents that knowledge management is the most important skill for a construction manager (0.64). Problem-solving is the most important to engineer (0.59). Regarding foreman, physical skill is the most important (0.67). The findings can be used as a guideline for contractors in developing their staffs to increase project performance.

## 1. Introduction

Today, the changes in construction technique, economy and social condition are factors bring the construction industry to become difficult to survive. These changes cause a competition environment to become fiercer. Thus, contractors have to decide whether they will be outmoded and leave their business or take competitive advantage from technology changes.

Construction is a project-based business which consisted of many functions working under the limited time and resources. In old fashion, a construction project may depend on individual effort; however, to respond with high competition environment, participants need to engage in work through multidisciplinary teams. Contractor executes work through project members who decides which technique and technology should be used. With skilled project members, contractors are easier to adapt to the change in technology. Based on construction project organization structure, the key members of the construction project consist of the construction manager, engineering, and foreman. These key members work under the hierarchical structure. [1] mentioned that a construction manager is responsible for the overall success of delivery the owner's physical development within the constraints of cost, time, quality and safety requirements. An engineer is professional in the knowledge of mathematics and physical sciences, who judges to develop ways to economically utilize resources through design, planning, material selection and workforce management [2]. A construction foreman has a role in overseeing labor production, construction and maintenance of construction facilities (e.g. tools, equipment) under guideline from engineers or managers. A review of the previous literature show the roles of construction project managers, engineers, and foremen. However, the



relationships among their skills have not been examined. Hence, the study aim was to examine such relationships.

## 2. Literature review

### 2.1. Construction manager skills (MS)

Most of the construction tasks and resources are distributed from a construction manager to every function in order to achieve and deliver the project development under limited resources. Also, a construction manager is responsible for the overall success [1]. Thus, many researchers studied about manager's skills. Also, [3] surveyed the case study from Gas Tank Establishment (GTE) project and suggested that the knowledge and decision-making skills of the project manager have a contribution to project success. Regarding construction manager soft skills that were pointed by [4], these skills are negotiation skill, construction management skill, strategically thinking skill, risk management skill, project organizing skill, and training skill.

### 2.2. Engineer skills (ES)

Most of the project resources are always utilized by engineers through design, planning, material selection and activities management. To increase project efficiency, an engineer needs to develop economically way to use resources following the guide from the construction manager. Thus, their skills were discussed by many researchers. [5] pointed out the importance of problem-solving skill for a construction engineer, and created construction problem-solving application to assist project participates to execute the project. [6, 7] also determined necessary skills for engineer such as resource management skill, task organization skill, communication skill, technical skill, knowledge applying skill and behavior control skill. [8] mentioned project problem can arise from human factors such as poor interpersonal skills, poor communication, unprofessional interaction and unethical behavior.

### 2.3. Foreman skills (FS)

A foreman has a role to supervise labors and control their production including maintenance construction tools and equipment in order to keep project acceptable production rate under instruction from an engineer. There are many studies on foremen skills. For example, [9] discussed foremen as persons who are treated as a critical labor function, and have to face the on-site problems frequently. The result from [2] pointed out that not only physical construction skill but also learning skill, problem responding skill, systematic working skill, self-control and work cooperation skill are important characteristics of foremen.

From the analysis of the literature review, the proposed conceptual framework for the study is stated as follows:

- H1: Engineer skills have a positive and direct influence on foreman skills.
- H2: Construction manager skills have a positive and direct influence on engineer skills.

## 3. Research method

In the construction literature, content analysis regarding skills of construction manager, engineer and foreman have been reviewed. Then, to better understand the influence and importance of construction participants' skills, a structural framework was developed to investigate how construction manager skills affect engineer skills, and how engineer skills affect foreman skills. Then, the structural equation modeling (SEM) was used to test the framework.

A total of 300 copies of the questionnaire were distributed by hand, and 216 were received (a return rate of 72%). According to [10], the return rate is considered as excellent, which is sufficient for SEM analysis. From the survey's Part 1 results (Table 1), 55.55% of the respondents identified themselves as civil engineering. This is in agreement with the 80.10% which indicated they had 10 or more years' experience, and the entire sample who told they participated in the construction field. It

was noted that a large majority of the respondents (62.20%) were associated with infrastructure project. There are 88.89% engage with large project with average project value over 30 million USD. In questionnaires part 2, each item about construction manager skills, engineer skills and foreman skills is assessed using a 5-level Likert type agreement scale.

**Table 1.** Respondent characteristics (N=216).

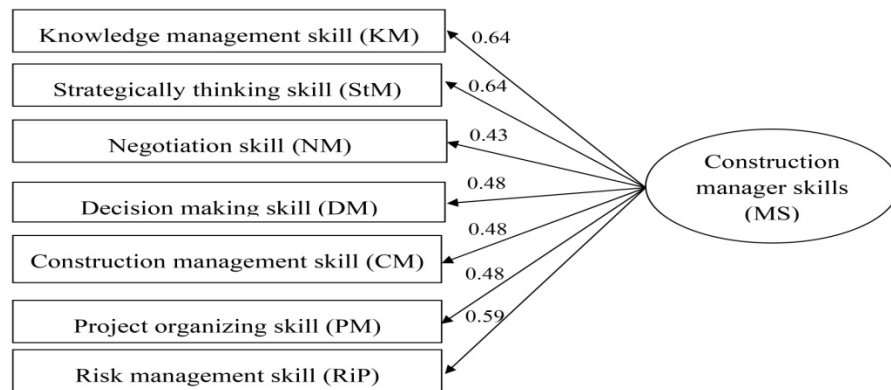
<b>Position</b>	<b>Frequency</b>	<b>%</b>
Construction senior manager	14	6.49
Construction project manager	82	37.96
Civil engineer	120	55.55
<b>Experience</b>		
Less than 5 years	15	6.94
5-10 years	28	12.96
10-20 years	91	42.14
Over 20 years	82	37.96
<b>Work characteristics</b>		
Strategic management	21	9.73
Construction project management	175	81.02
Construction control	20	9.25
<b>Range of average project value per year</b>		
0.3–3 million USD	22	10.18
3–30 million USD	41	18.98
Over 30 million USD	153	70.83
<b>Project characteristics</b>		
Infrastructure	135	62.20
Low-rise building (< than 8 stories)	9	4.16
High-rise building (> than 8 stories)	72	33.36
<b>Total employees</b>		
500-1000 individuals	24	11.11
Over 1000 individuals	192	88.89

**Table 2.** Likert type agreement scale.

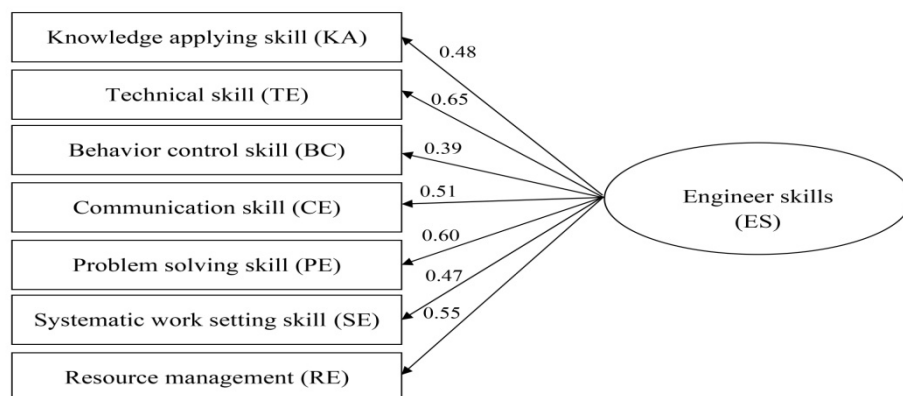
<b>Level of important</b>	<b>Measurement scale</b>
Less important	1
Little important	2
Medium Important	3
Important	4
Very important	5

Before distributed, the questionnaire was tested to confirm its reliability and validity. Cronbach's alpha was used to test the internal consistency reliability of the scale. The questionnaire's reliability returned results with an average value of 0.904, which a Cronbach's alpha value of 0.7 is considered as acceptable [11]. In addition, construct validity was tested to confirm that latent variables and observed variables are consistent by confirmatory factor analysis (CFA) method. This was determined by the overall fit index of each measurement model of construction manager skills (MS), engineer skills (ES) and foreman skills (FS) as shown in Figures. 1, 2, and 3, respectively. The recommended criteria [13] were used to justify construct validity. In the test, the values of overall goodness-of-fit indices satisfy all recommended criteria values as shown in Table 3; therefore construct validity exists.

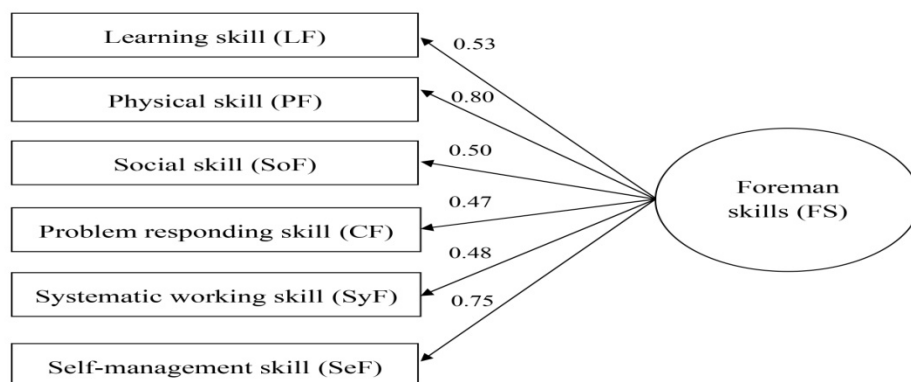
In addition, discriminant validity can be measured by analyzing relationships between latent variables [12]. Individual item was examined by looking at the loadings or correlations of each indicator on its respective construct (Table 4). In the table, all the latent variables are highly correlated; thus, the discriminant validity is confirmed.



**Figure 1.** Result of measurement model for construction manager skills.



**Figure 2.** Result of measurement model for engineer skills



**Figure 3.** Result of measurement model for foreman skills

**Table 3.** Criteria and theory of the value of goodness-of-fit for measurement models.

Criteria Index	Recommended criteria values	GoF values of measurement models		
		<i>MS</i>	<i>ES</i>	<i>FS</i>
Chi-square ( $X^2$ )	$0.05 < p \leq 1.00$	0.197	0.392	0.169
Relative $X^2$ $\chi^2/df$	$0 \leq \chi^2=df \leq 2$	1.322	1.056	1.453
Goodness of Fit Index (GFI)	$0.09 \leq GFI \leq 1.00$	0.980	0.988	0.982
Root Mean Square Error of Approximation (RMSEA)	$0 \leq RMSEA \leq 0.08$	0.039	0.016	0.046
Comparative Fit Index (CFI)	$0.09 \leq CFI \leq 1.00$	1.000	1.000	1.000
Incremental Fit Index (IFI)	$0.9 \leq IFI \leq 1.00$	1.000	1.000	1.000
Tucker-Lewis Index (TLI)	$0.9 \leq TLI \leq 1.00$	1.000	1.000	1.000
Results		passed	passed	passed

**Table 4.** Correlation coefficients between latent variables.

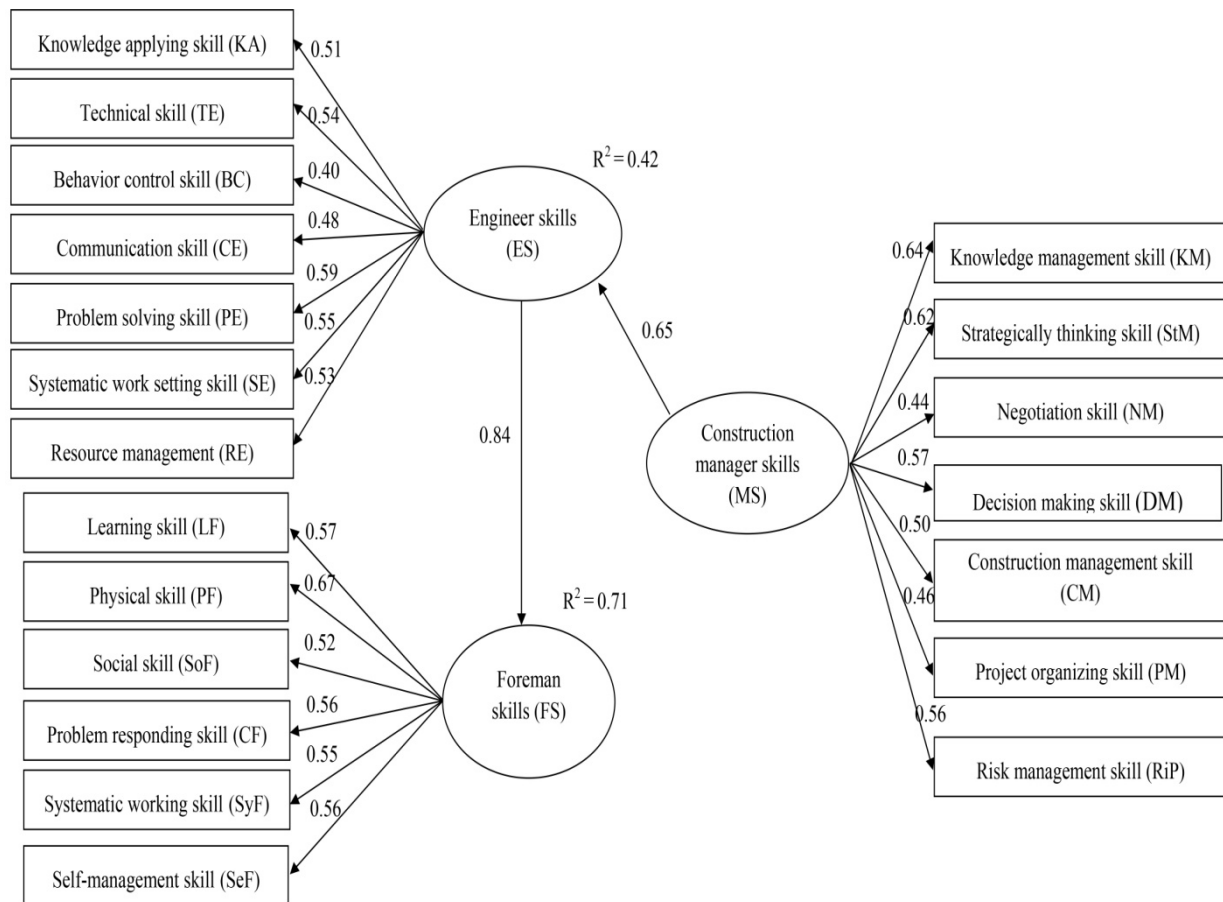
Latent variables	Influence	Latent variables		
		<i>MS</i>	<i>ES</i>	<i>FS</i>
Manager skills (MS)	DI	-	0.65*	-
	II	-	-	0.55
	TI	-	0.65	0.55
Engineer skills (ES) ( $R^2 = 0.42$ )	DI	-	-	0.84*
	II	-	-	-
	TI	-	-	0.84
Foreman skills (FS) ( $R^2 = 0.71$ )	DI	-	-	-
	II	-	-	-
	TI	-	-	-

#### 4. Result

To develop SEM for testing the relationships of the latent and observed variables of the respective hypotheses, IBM SPSS AMOS (version 20) software was used. Criteria index and the recommend index values [13] were shown in Table 5. All indices showed satisfaction value which means the model fit the data well. The SEM result was shown in Figure 4.

**Table 5.** Criteria and theory of the value of goodness-of-fit for SEM.

Criteria index	recommended values	GoF values
Chi-square ( $X^2$ )	$0.05 < p \leq 1.00$	0.211
Relative $X^2$	$\chi^2/df$ $0 \leq \chi^2=df \leq 2$	1.095
Goodness of Fit Index (GFI)	$0.09 \leq GFI \leq 1.00$	0.937
The Root Mean Square Error of Approximation (RMSEA)	$0 \leq RMSEA \leq 0.08$	0.021
Comparative Fit Index (CFI)	$0.09 \leq CFI \leq 1.00$	0.989
Incremental Fit Index (IFI)	$0.9 \leq IFI \leq 1.00$	0.990
Tucker-Lewis Index (TLI)	$0.9 \leq TLI \leq 1.00$	0.985
Results		passed



**Figure 4.** Result of final structural equation modeling for influence among construction project participant's skills

SEM analysis shows the results of hypothesis testing. The p-values of all hypotheses are less than 0.01, indicating statistical significance, so H1 and H2 were accepted. Table 6 additionally shows the relationships among the latent variables and their direct influence (DI), indirect influence (II), and total influence (TI) of each construct, with the sum of DI and II referred to as TI. This table also shows that engineer skills (ES) had a direct influence on foreman skills (FS) (DI = 0.84). Project manager skills (MS) were also shown to have a direct influence on engineer skills (DI = 0.65). This results reflect that project manager skills (MS) had an indirect influence on foreman skills (FS) (II = 0.546).

## 5. Discussion and conclusion.

The model of participant skills can be arranged into a hierarchical structure of construction manager skills, engineer skills, and foreman skills corresponding to most of project organization structure. However, few research works have explored the relationships, showing a knowledge gap. To fill this knowledge gap, this study aimed to find the relationships among construction manager skills, engineer skills, and foreman skills. The results show that construction manager skills significantly influence engineer skills (a regression weight of 0.65) and engineer skills significantly influence foreman skills (a regression weight of 0.84). This is likely because in working environment supervisor need to train their subordinates. This result is consistent with [4]. In addition, the result shows that knowledge management skill is the most important for construction manager skill (0.64). However, unexpected problem can occur during construction. This may be the reason for problem-solving skill is the most important for an engineer (a regression weight of 0.59), which complies with [5]. Physical

skill is the most important for foreman (a regression weight of 0.67). Also, [9] mentioned that a foreman has the main role in field construction to supervise labors, which considerably depends on his/her physical skill.

Understanding the relationships among project participants' skills and the importance level of their indicators can guide contractors to improve the project participants' skills, leading to increasing project performance.

## 6. Limitation and further study.

This study should be interpreted with limitations in some aspects. Firstly, the SEM framework model was based on international literature but the statistical survey was collected within the Thai construction industry. Secondly, project members and their related skills may vary, depending on the differences in each environment in different culture. Thus, future study needs to investigate or compare skills of project members in different types of various construction environments. Different construction environment may have different opinions on skills and circumstances.

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