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Original Research Article

WORK ACCELERATION STRATEGY DEVELOPMENT ON DESIGN-BUILD PROJECT TO IMPROVE RISK BASED QUALITY PERFORMANCE

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ABSTRACT

Design-build method has become a more popular procurement method in Indonesia. This method differs from other conventional procurement methods because the design and construction is one entity. All responsibilities are taken over by contractors so that the project outcome expected becomes more comprehensive. Design -build applies fast-track system. The work acceleration implemented during the construction will potentially generate risks on the performance, in this case quality performance. The implementation of risk management is expected to significantly reduce the impact of the risk on the quality performance of a project. The objective of this study is to analyze risks (the frequency and the impact) by identifying factors affecting the success of work acceleration, and thus work acceleration strategy can be developed for design-build project in order to improve risk based quality. This study is a qualitative research with literature study on factors of risks affecting quality performance and questioners given to experts and respondents who are experienced in design-build procurement. Risk factors analyzed in this study are competence of project owner, team leader, and project manager, planning and execution ability, procurement process, scope and nature of the project, work relationship among project teams, project owner's information, physical factors, and social economy environment. The result of this study is work acceleration strategy on design-build project in order to improve risk based quality performance.

Keywords: Work acceleration; quality performance; risk based; design-build

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1. INTRODUCTION

There are two main stages of a construction project [1]. First is designing and the second is the execution of the construction based on the design. In conventional procurement method, both of these stages, commonly known as design – bid – build, are separated. In design-build method, design and construction is one entity. This method has been widely used in numerous countries.

Accorrding to Molenaar et al. [2], design-build method was getting more popular in public sector and reached its peak in 1990-an. The advantage of this method is that all responsibilities are taken over by contractors so that the outcome of the project is more comprehensive [1]. The following is project organization structure for design and build method according to Ghadamsi [3].

This organization structure shows that a project owner / client only coordinates with an entity which is a designer or a contractor. Consultants, subcontractors, and suppliers are under the coordination of a designer or a contractor. This will be beneficial for clients who do not have either adequate ability or experience in delivering their own project [4]. Another advantage of design-build system compared to conventional system is obviously timing. This is known as fast-track system, a system where a pre-contract and contract stages are executed simultaneously [5].

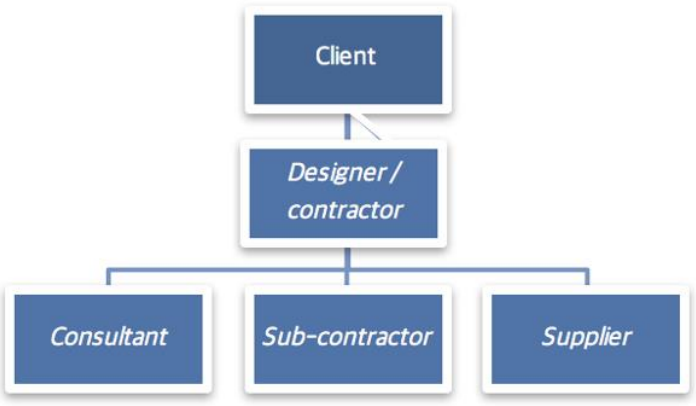

Figure 1. Organization Structure of Design-Build Method

Potter and Sanvindo [6] conducted a study on the use of proper design-build method. This study shows that the system is preferred if the

scope of the project is defined well, the design is standard or rather complicated, the completion time and project cost are a vital target, performance quality is standard or quite higher, and project risk is low or medium.

Work acceleration during design-build construction generates risk on the outcome of the project. According to Azizan & Ibrahim [7] design-build project is the most risky project. One of the reason is because the combination between design and construction activities. However, good knowledge of risk management applied may significantly reduce its impact on project performance. There is an additional job in the initial stage into the design, thus quality risks appear. The factor of quality risk caused by the owner's inability to control during the design and the build becomes one of risk identifications on project performance [8].

Project owner's inability to determine specifically the requirements for the quality regarding construction work is caused by the owner's full dependency on the contractor [1]. In addition, compared with the conventional system, in Design-Build system the contractor is the sole party in charge of the project, the risk taker, and the design and construction management in deciding project cost as well as the use of sources which are not economical [5]. Ashworth [9] confirmed that the disadvantage of design-build method is higher project cost and lack of flexibility in variation [10, 11].

Each construction project is unique, consisting of complexity and risks which emerge during the delivery of the construction. However, contractor responsibilities, roles, and client involvement in the initial stage are very crucial [5]. Factors of success for design-build project include project quality fulfilling user's requirement and function, and fulfilling timing and cost target which have been decided [5]. The objective of this study is to analyze risks (frequency and impact) by identifying factors affecting the success of work acceleration so that work acceleration strategy can be developed in order to improve risk based quality. It is expected that by implementing of risk based work acceleration strategy on design-build project, project quality performance can be achieved.

2. Literature Review

Design and Build system can be defined as a procurement system with one contract between a project owner and a constructions delivery team who is in charge of executing the process of planning and construction simultaneously and efficiently [2]. In order to ensure the success of design-build project, the parties involved in the design-build project must have mutual understanding about financial and technical work needed [12].

The existing negative perception regarding design-build project may be the reason for stakeholders to avoid implementing it. Design-build contractors are assumed to not be able to give an independent professional advice, to not be able to adopt architect recommendation, and to limit their power. The responsibility of design is transferred from the owner organization to Design-Build contractor who is responsible for the management of design and construction process. Design-Build contractor becomes the main role in the management of design of Design-Build project. This does not occur because Design-Build contractor has a better qualification, but because it reflects the reality of risk allocation in the mind of project participants [13].

Construction process has a target of time that must be reached. The lack of project scheduling technique, unfulfilled commitment, and delayed tasks affect productivity [14]. According to Dipohusodo [15] and Ervianto [16], it is a big challenge for project manager to complete the project on time. It is important to previously know the overall project duration concerning its critical tract. During project scheduling, in order to anticipate the lateness, one of the ways that can be done is by implementing fast track [17]. The following figure is the comparison of project stages between a conventional or normal project and fast track project [18].

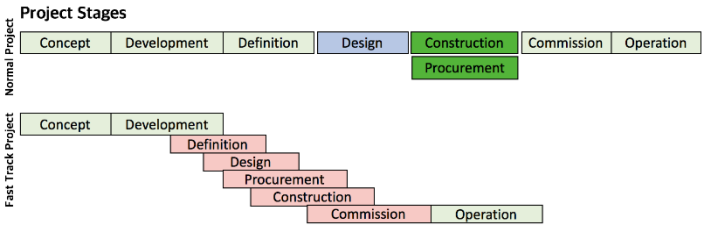

Figure 2. The Comparison between Conventional Project and Fast Track Project

In general, conventional system illustrates in detail the approaches and methods as well as standard specification used in construction filed. In design-build project, the owner has opportunity to let the designer apply a particular construction method in order to distinguish among their competition and to show efficiency which may not be questioned by the project owner. Nevertheless, this may generate risks that the particular method does not reach the same quality as determined in Design Build Contract. One of the main decisions is to articulate the number of flexibilities of infrastructure and method of construction possessed by the design maker [19].

Risk is the combination of probability of an event and its cause or consequence [20]. According to PMBOK [21] risk is seen as an uncertain event or condition. When it occurs, it may have either positive or negative effects on the project goal. This method covers three aspects as follows:

• Risk identification

According to Darmawi [22] the stage of risk identification must be done carefully and comprehensively so that there are no risks which are missed. The technique of risk identification consists of brainstorming, questioners, benchmarking, scenario analysis, audit, checklists, and so forth [23].

• Assessment or risk analysis

Risk analysis is a method of measuring and identifying risks, development, selection and management program to face the risks in a more organized way [24]. The analysis is done to evaluate the risk impact thoroughly using risk evaluation matrix and plotting to the probability impact matrix. The matrix shown on Figure 3 [23]. Scale used in measuring risk potential on frequency and risk impact is likert scale with number ranging from 1 to 5 as follows:

1 = very unlikely
2 = unlikely
3 = possibly
4 = likely
5 = very likely

Risk impact measurement:
1 = very low
2 = low
3 = medium
4 = big
5 = very big

• Risk management

Risk management is a systematic process of planning, identification, analysis, giving responses, and supervising of project risks [24]. Risk management involves technique, equipment, and process that will help

the manager to minimalize negative consequences and maximize consequence derived from positive events [25]. The figure below illustrates systematics of risk management occurring during a project according to Ronald [25].

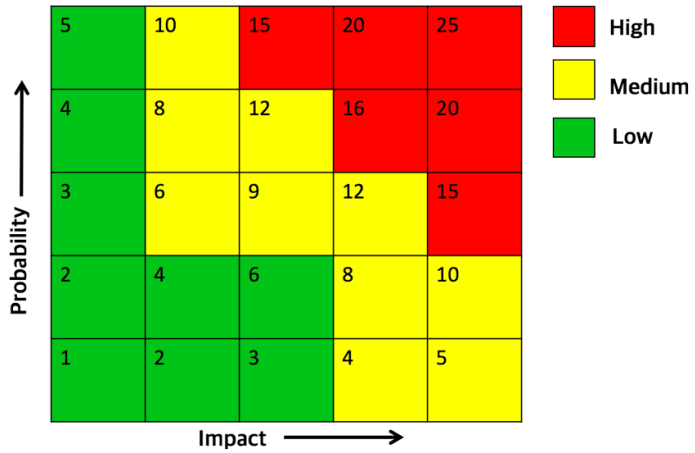

Figure 3. Probability Impact Matrix

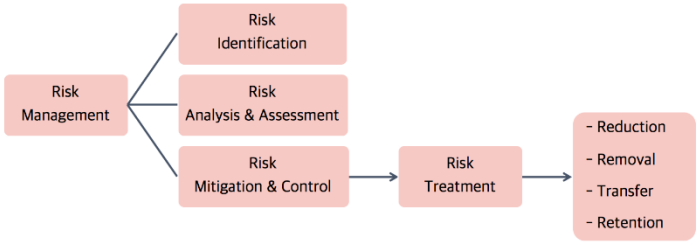

Figure 4. Stages of Risk Management

3. Research Method

Operational model of this study based on variables examined are as follows:

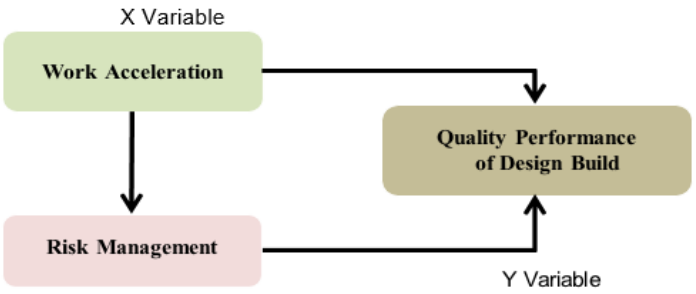

Figure 5. The Operational Model of Study

Operational model in Figure 5 is the relation between the variables. "Work Acceleration" and "Risk Management" are X variables affecting the performance of Y variable which consists of Quality Performance of Design and Build Project. After identifying variables in Work Acceleration, the researcher measured how big the risk affecting quality management system was, so that it was expected that the quality of design build project can improve.

This research was qualitative. The research instrument used was questioners. The following is a flow chart of this study.

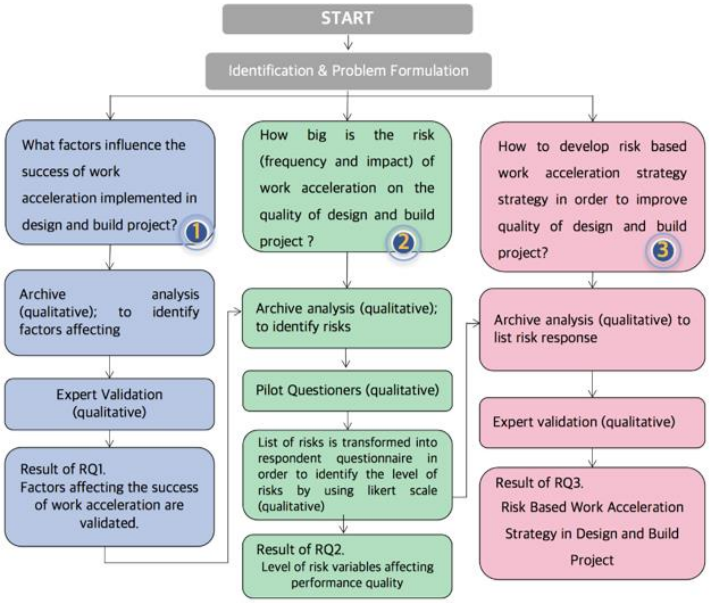

Figure 6. Study Flow Chart

In addition, the sources of research data are summarized in the following table:

Table 1. The Source of Research Data

Data Soures	RQ1	RQ2	RQ3
Data Result of questionnaire	√	√	√
Literature Survey	√	√	√
Archive analysis	√	√	√

4. Results

In the first stage, archive analysis was done, and from this factors affecting based on the previous studies were obtained. The factors are as follows:

a) According to Lam et al. [26], there are 12 main factors affecting the success of design build project in Hongkong;
b) According to Modupe et al. [8], there are 31 factors affecting the success of design build project in terms of quality performance and time in Nigeria;
c) According to Saaidin et al. [27], there are 64 factors affecting the success of design build project in Malaysia;
d) According to Tarigan et al. [28], there are 6 factors affecting the success of design build project in Total Rehabilitation Project of Gedung Pendidikan (education building) in Jakarta;

Those data were collected to be analyzed afterwards. From the analysis of the data, 10 main factors affecting the success of design build project were obtained.

This stage was conducted by distributing questioners to experts. The experts involved in these validation variables were 10 people. These 10 experts have ever delivered or are delivering a building project using design build method. The experts have background as project owners (Ministry of Public Works and Public Housing of Republic of Indonesia)

and Service providers (construction management consultants, planning consultants, and contractors).

Table 2. The Result of Modus Assessment on Stage I Questioner

VARIABLE	Experts Agreement										Modus	Status
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10		
X1	1	1	1	1	1	0	1	1	1	1	1	accepted
X2	1	1	1	1	1	1	1	1	1	1	1	accepted
X3	1	0	0	1	0	1	1	1	1	1	1	accepted
X4	1	1	1	1	1	1	1	1	1	1	1	accepted
X5	1	1	1	1	1	1	1	1	1	1	1	accepted
X6	1	1	1	1	1	1	1	1	1	1	1	accepted
X7	1	1	1	1	1	1	1	1	1	1	1	accepted
X8	1	1	1	1	1	1	1	1	1	1	1	accepted
X9	0	0	1	1	0	1	1	1	1	1	1	accepted
X10	1	1	1	1	1	1	1	1	1	1	1	accepted

On the second stage is with pilot survey. Data collecting used data from previous related journals and the result of expert validation. The response of expert validation which becomes one of the variables is related to permit. This factor is a variable derived from X10 variable, which is physical and social economy factor. After the questioners were distributed, there are feedback on respondent scoring format and sentences.

The third stage is collecting data from respondents' questioners. The number of respondents answering the questioners was 41 persons. The result of the questioners shows that there are 4 categories of company, namely: project owner, planning consultant, construction management consultant, and contractor.

Table 3. The Characteristics of Respondents Based on Company

No	Company Category	Frequency	Percentage
1	Project owner	16	39%
2	Consultant of Construction Management	13	32%
3	Planning Consultant	2	5%
4	Contractor	10	24%
	Total	41	100%

Table 4. Characteristics of Respondents Based on Work Experience

No	Category of Work Experience	Frequency	Percentage
1	< 5 years	10	24%
2	6-10 years	17	41%
3	11-15 years	6	15%
4	16- 20 years	6	15%
5	> 20 years	2	5%
	Total	41	100%

Table 6. Characteristics of Respondents Based on Last Education

No	Category of Last Education	Frequency	Percentage
1	Associate Degree	2	5%
2	Bachelor's Degree	30	73%
3	Master's Degree	9	22%
	Total	41	100%

After all data were collected from respondents, the data were then analyzed. Respondents' scores concerning the scale of the risk (frequency and impact) affecting work quality were obtained from the data collected from respondents questioners. After obtaining the data of 41 respondents, the researcher used mean calculation for frequency and impact. Mean was formulated as follows:

Mean = $X = \sum xi/n$

Remarks:

X = mean
n = the number of respondents
xi = the score given by respondents

After the calculation of respondents mean for frequency and risk impact, the value was plotted into probability and impact matrix. There are three categories of probability and impact, low, medium, and high. Based on the result of probability and impact matrix plotting, there are only two categories, high risk and medium risk. There are 4 risk variables under high risk categories as shown in the following table:

Table 7. Recapitulation of High Risk Category

CODE	RISKS AFFECTING PERFORMANCE QUALITY	RISK CATEGORY
X1	**Risk Factors of project owner**	
X1.1	The project owner's lack of project management and technical skill as well as experience in design and build project	High
X5	**Risk factor of delivery ability**	
X5.5	Discrepancy between the number of labors/ workforces, eqipment, and material with the jobs available	High
X5.7	Negligence and delay from subcontractor	High
X10	**Risk factor of physical and social economy environment**	
X10.3	Duration of permit issuance which is unpredictable	High

Based the result of risk analysis aforementioned, it is necessary to have risk response to the factors affecting the success of work acceleration to improve quality of design build project. Risk response can be done to mitigate or eliminate the risk. Risk response is especially conducted on high risk level category. The reference for this risk response uses archive and study case analysis which then is followed by experts validation. Risk response in this study is only for category with high risk level.
Remarks:
Project A : A 5 stars Hotel Project in Bali
Project B : An Apartment building project in Jakarta with > 24 storeys.
Project C : A School package project in Jakarta consisting of 14 schools
Project D : Office building project in Jakarta with > 50 storeys

Table 8. Risk Response of High Risk Category

CODE	RISK VARIABLE	RISK RESPONSE	REFERENCE
X1	**Risk factor of project owner's competence**		
X1.1	The lack of project management and technique skill in design build project	Selecting MK consultant which is representative and experienced	Project A,B, D
		Hiring internal personnel or selecting experienced professional experts	Project D
X5	**Delivery Ability Risk Factor**		
X5.5	Discrepancy of the number of labors/workforce, equipment and material with the jobs available	Preparing WBS in detail so that the resources needed can be identified	PMBOK, Project B
X5.7	Negligence and Delay of the Subcontractor	1. Detail explanation of project milestone requirement and schedule in contract agreement to subcontractor	PMBOK
		2. Applying reward and punishment to subcontractor	Project A
		3. Having routine meeting agenda with subcontractor	PMBOK, Project B
		4. Clarification with subcontractors and improving work method. If there is no change, subcontractor may be changed.	Project C
X10	**Physical Risk Factor and social economy environment**		
X10.3	Unpredictable duration of permit issuance	1. Having an expert of permit issuance to give guidance the design process from the initial stage until final stage to ensure that all the stages are following the existing regulation	Project D
		2. Design Build contractor leads design team from initial stage	Project A
		3. Looking for design team which can communicate well across fields of knowledge	Project C

5. Discussion

Based on the analysis of risk scales, there are high risk category factors of acceleration of work. The factor of unpredictable duration of permit issuance becomes the dominant risk factor. In addition, the third high risk variable is discrepancy of the number of human resources, equipment, and material. According to Saaidin [27], risk on design and build project can be caused by several reasons such as the uncertainty of permit issuance, the uncertainty of project location condition, the lack of project manager and experience in design and build project, and the lack of human resources and labor productivity.

The second risk variable in high risk category is negligence and delay from subcontractors. According to Modupe [8], worker error or negligence emerging during the construction is the most obvious quality risk factor which may affect the performance of design and build project. Subcontractors are one way to accelerate the work done by the main contractors. This work acceleration using the addition of this source is called crashing method. Crashing is a technique that can be used to shorten the schedule duration of projects by adding resources [21]. By implementing crashing work acceleration, interface between a subcontractor with another subcontractor is necessary to be done.

The fourth risk variable in high risk category is the lack of project management and technique ability as well as lack of experience of the project owner in design and build project. According to Lam [26], the more effective a project management will increase the rate of success of design and build project. An effective project management can shorten the project timing starting from the right planning so that it will enable optimum overlaps between design phase and construction phase. These overlaps are described as fast tracking work where work overlap is done without shortening the duration of initial work, but the level of risk increases [21].

Based on the analysis on the research result, it is indicated that work acceleration such as fast track or crashing in design build project can be either a solution or a risk. It is necessary to adjust this strategy with the sequence of the overall work and to update regularly. This strategy is expected to improve risk based quality in design and build project. The following is the comparison of fast track project stages by Anjali (2018) and design-build project based on the research:

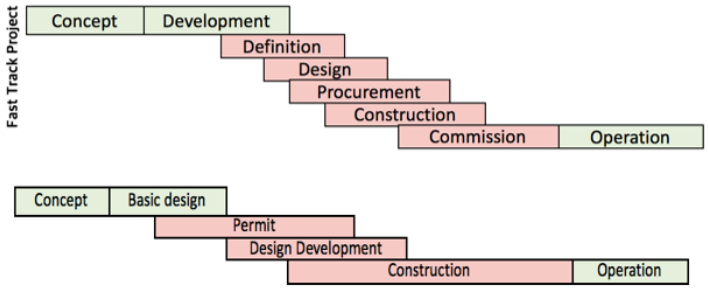

Figure 7. Comparison of Stages in Design Build Project with fast track project

Design team's lack of knowledge concerning current regulations and design change have become one of risk factors affecting quality. Risk factors in this study affected each other in order to create design build project products with good quality performance. The success of design build project which is different from the conventional one is that the stage of design process includes permit duration. Work Acceleration strategy in design build project that can be implemented is intensive concerning permit issuance. The duration of permit stages was carefully arranged, and super imposed was applied with schedule master obtained from the total of realistic project duration.

6. Conclusions

After the analysis, it can be concluded that:

1. There are 10 main variables of risk factors for work acceleration affecting quality in design-build project:
   a) Risk factors of project owner
   b) Risk factors of team leader competence
   c) Risk factors of procurement
   d) Risk factors of planning skill
   e) Risk factors of delivery ability
   f) Risk factor of contractor 's Project Manager (PM) ability
   g) Risk factor of the scope and the nature of project
   h) Risk factor of work relation among project teams
   i) Risk factor of project owner information regarding the project
   j) Risk factor of physical and social economy environment
2. Based on probability of risk impact in this study, there are two categories consisting of high and medium. From 40 variables, 4 variables are categorized as high risk and 36 are categorized as medium. The sequence of the categories from the highest risk is as follows:
   a) Unpredictable duration of permit issuance;
   b) Negligence and delay of the subcontractor;
   c) Discrepancy of the number of human resources, equipment, and material with the available jobs;
   d) The lack of project management and technical ability as well as the lack of project owner experience in design and build project.
   e) The unpredictable duration of permit issuance has become the most dominant risk factor in this study.
3. Fast track in design work, permit and construction can be done to improve quality of design and build project. Crashing can be done during the construction. However, it is necessary to consider the interface with other jobs and the conformity of the number of human resources, equipment, and material. This result can become a strategy of developing risk based work acceleration in order to improve work quality in design and build project.

7. Recommendations

Recommendation given in this study are:

1. Future researches will not only focus on the improvement of performance quality, but also on fulfilling cost and time performance in design and build project.
2. This study can be extended to not only for buildings, but also for infrastructures such as highway.
3. This work acceleration strategy can be developed by implementing duration on activity list so that the result can be more accurate.

Conflict of Interests

The authors declare that there is no conflict of interest related to the publication of this article.

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APPENDIX

Table A1. Recapitulation of Medium Risk Category

CODE	RISKS AFFECTING PERFORMANCE QUALITY	RISK CATEGORY
X1	**Risk Factors of project owner**	
X1.2	Lack of project owner's and building users' involvement during the construction	Medium
X1.3	Work Sequence planning is not well organized	Medium
X1.4	Lack of project owner's experience in making Term of Reference (TOR) and in contributing in stage design of design and build project	Medium
X1.5	The quality of project owner's communication with design team during design development is poor.	Medium
X1.6	Lack of Experts supervising or Constructrion Management Consultants in assisstinng the Project Owner during the delivery of the project	Medium
X1.7	High demand of request from project owner to change the work durinng the construction	Medium
X2	**Risk factor of team leader competence**	
X2.1	Team leader's lack of project management and technical skill as well as experience	Medium
X2.2	lack of support from constraction management head office for the team leader in the project	Medium
X2.3	Team leader's lack of knowledge of work scope and quality of coordination among multi disciplines	Medium
X3	**Risk factor of procurement**	
X3.1	lack of the availability of experienced design and build companies	Medium
X3.2	Technical specification such as material which will be used in design and build project is not addressed clearly during the auction process	Medium
X3.3	delay in the process of contract document making	Medium
X3.4	lack of time available in tender process, from the bidding stage to the evaluation stage	Medium
X3.5	Price begotiation process which does not quite consider the reasonability of the bidding price	Medium
X4	**Risk factor of planning skill**	
X4.1	Design team's lack of experience and technical ability, particularly experts in design and build project	Medium
X4.2	Design team's lack of knowledge on the needs stated in TOR	Medium
X4.3	Design team's lack of knowledge on existing regulations and design change requested by project owner during DED	Medium
X4.4	Lack of communication among personnels either among design team or physical work delivery team	Medium
X4.5	Delay in reaching agreement on design during design development caused by difference in perception between project owner and design team	Medium
X5	**Risk factor of delivery ability**	
X5.1	Contractors's lack of experience and competence in delivering design and build work	Medium
X5.2	Contractors' lack of cash flow ability to complete design and build project	Medium
X5.3	Contractor team's lack of innovation and knowledge in implementing work acceleration of design and build project	Medium
X5.4	Contractors' lack of ability to manage the project and to control performance quality of design and build project	Medium
X5.6	Lack of coordination and communication among divisions inside the contractor work organization	Medium
X5.8	Error in design causing alteration in the work	Medium
X6	**Risk factor of contractor 's Project Manager (PM) ability**	
X6.1	PM's lack of experience and project management ability to deliver the work of design and build project	Medium
X6.2	PM's lack od ability to select personnels involved and to execute tasks/ responsibilities sharing in design and build project	Medium
X6.3	PM's lack of ability to communicate and coordinate with stakeholders during the delivery og the project	Medium
X6.4	PM's lack of ability to encourage the whole team to committ to performance quality and time of design and build project	Medium
X7	**Risk factor of the scope and the nature of project**	
X7.1	Discrepancy of design specificatio standard and the clarity of the definition of project scope in TOR	Medium
X7.2	Complexity and design and build project's lack of interest	Medium
X8	**Risk factor of work relation among project teams**	
X8.1	inharmonic work relation amongn project teams	Medium
X8.2	lack of solidity of project teams.	Medium
X9	**Risk factor of project owner information regarding the project**	
X9.1	Project owenr's requests are not well informed	Medium
X10	**Risk factor of physical and social economy environment**	
X10.1	Project's condition and environment are beyond the predistion	Medium
X10.2	Change of situation or political policy and government economy	Medium