Risk Management in Engineering and Construction

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Risk Management in Engineering and Construction - A Case Study in Design-Build Projects in Vietnam

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***Abstract*—The constant demand for construction in developing countries like Vietnam causes Project Management Units (PMUs) more and more challenges and difficulty in carrying projects to completion on schedule, with quality assurance and fewer costs. In order to do this, PMUs need to have better and tighter management tools and forms. However, in order to minimize risks to the parties during project implementation, the binding terms in contracts are also becoming stricter with more and more new forms of contracts. One of them is the design-build (DB) contract form. This paper presents the critical risk factors for design-build projects in the construction industry. Good identification and management of these risk factors will help the projects succeed and increase the confidence of owners and contractors who seek to use the design-build form.**

Keywords-design-build (DB); risk management; project manager; construction management; Vietnam

I. INTRODUCTION

Vietnam's construction industry conducts projects mainly based on the traditional design-bid-build (DBB) method (Ling & Hoang, 2009). In particular, the project is broken down into packages and assigned to independent units to coordinate with the owner for implementation . The preparation of investment reports, surveys and construction design drawings, bidding to select construction contractors, and/or equipment suppliers is carried out. Work is assigned by the owner to each individual contractor. Accordingly, the risks during the process of project implementation from the commencement to the construction, acceptance, and delivery of the work will be shared equally by the parties involved in the project (Do, Veerasak, Masamitsu, & Phong, 2016; Hong Pham & Hadikusumo, 2014; P. T. Nguyen, Likhitruangsilp, & Onishi, 2018; Nguyen Thanh Phong, Likhitruangsilp, & Onishi, 2017). The owner, who is responsible for the quality, progress, and costs of the project is the focal point (P. T. Nguyen, Nguyen, Cao, et al., 2018). However, the fact that individual contractors deploy to construction at the site only after carrying out a survey, design, cost estimate increases the project duration due to complicated legal procedures (Huynh, Nguyen, Nguyen, Nguyen, & Nguyen, 2019). In addition, the construction units spend too much time studying design drawings, and work arising at the site requires cooperation between the owner, construction unit and design consultant. This may affect the overall progress of the project. The fact that independent contractors are only in charge of their tasks fails to promote their initiative, flexibility, and creativity and makes them become dependent on the consultant.

Recently, many owners from different economic sectors have chosen the design-build (DB) general contractor form for their projects. This has brought great benefits to the country. In addition, it has also helped domestic construction enterprises, and consultants have access to a new form of project

management with high professionalism because of their ownership in all aspects of consultancy and construction services. This paper presents overview of design-build approach and also points out the critical risk factors for design-build (DB) projects in the construction industry.

II. RESEARCH BACKGROUND

Normally, the design-build (DB) method is often compared to the traditional project implementation method, design-bid-build (DBB), in which the owner hires two separate units to perform the design and construction activities (Hale, Shrestha, Gibson Jr, & Migliaccio, 2009; Ling, Chan, Chong, & Ee, 2004). In other words, for DBB approach, owners employ independent contractors to carry out the design and construction of a work. In this form, the relationship between design, bid, and construction activities are conducted sequentially so the design must be completed before bidding and contractor selection. After construction contractors are selected, the construction of the work begins. In DBB form, the relationship between the design contractor and the construction contractor is completely independent. However, the contractors must always exchange information and coordinate with each other during the process of project implementation through the owner, the focal point. There is also the participation of subcontractors to assist the contractors in project implementation (see figure 1) (Veerasak Likhitruangsilp, Malvar, & Handayani, 2016). Meanwhile, the design and construction tasks are assigned to the same contractor.

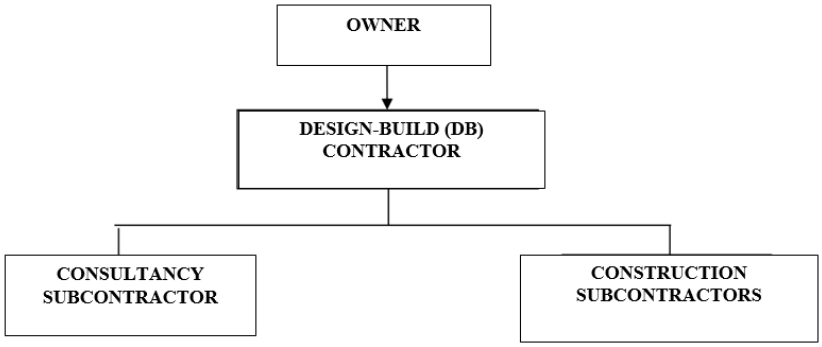

Figure 1. Design-Build project management model

The design-build contractor may hire consultancy subcontractors and/or construction subcontractors to share part of the workload. However, the main contractor is still responsible for all design and construction activities of the design-build project including the work done by subcontractors. It helps owner to simplify management interface throughout the project life cycle (Songer & Molenaar, 1996). As a result, the possibility of design changes, delayed completion time, as well as risks caused to owners will be limited. In addition, the construction design is implemented by a unit; therefore, the construction contractor will be exposed earlier to the design drawings. Accordingly, the contractor can deploy the construction even if the design is not completed which makes it possible to shorten the implementation time so that owner can soon put the project into operation (Linda, Phong Thanh, Lydia, & Shankar, 2019; Soomro, Memon, Chandio, Sohu, & Soomro, 2019). Moreover, this limits the incrimination and complaints between the design and construction contractors or between two or more subcontractors. Thanks to the continuity from design to construction, errors in the project implementation process are reduced significantly. Due to being in the same organization, the design and construction units coordinate better and make design adjustments more easily even during the construction process.

Basically, risk factors can be classified into groups including risks related to politics and laws, economics and finance, design, contracts and bidding, construction, owners and contractors (Öztaş & Ökmen, 2004). Among those, common risks are divided into two groups, namely politics and laws, economics & finance. Project risks are specifically divided into four main groups of factors, including design; contract and bidding; construction; owners and contractors.

(i) Group 1 - Politics and laws

Political risks affect all actions at the central, provincial, and local levels by state agencies. Political risks also affect the attraction of project investment and for ensuring that the project investment is advantageous without being stopped because of trade wars or protests (Ling & Hoang, 2009; Voelker, Permana, Sachs, & Tiong, 2008). More specifically, political risks include corruption; government intervention; delays in approving projects and licenses; differences in regulations due to regional differences. Bureaucracy and harassment of local authorities also cause trouble for project owners as well as contractors. Legal risks arise from deficiencies in the legal and institutional framework, namely: incomplete legal and supervisory system; conflicts between laws, decrees, and circulars; changes in laws and decrees; risks due to tax policy changes (Nguyen & Likhitruangsilp, 2017; P. T. Nguyen, Nguyen, Ha, & Nguyen, 2017). If the policies and laws of the State are altered too much from the time of project planning through to the time of construction, the owners often have to change the design to fit the new policies or adjust the goals that were set initially. This makes it difficult for contractors to adjust the design and construction methods of the works.

(ii) Group 2 – Economics and finance

The assessment of the financial feasibility of a project is the most common method for measuring the ability to achieve the financial goals set by stakeholders (Huynh, Nguyen, Nguyen, & Nguyen, 2018; Huynh, Nguyen, Van Nguyen, & Nguyen, 2018; Likhitruangsilp & Ioannou, 2005; Phuc, Phong, Vy, & Quyen, 2017). Financial market risks and exchange rate fluctuations are unfavorable factors that were identified in previous projects. Moreover, inflation and interest rates are also quite common risk variables. Indeed, the fluctuation of inflation and interest rates has also affected the uncertainty in the construction industry. Unfortunately, these risk factors are related to macroeconomics and are unavoidable. Inflation can have a strong impact on the price of materials, equipment, and labor costs in a project (Sohu, Abdullah, Nagapan, Rind, & Jhatial, 2019). At that time, the project must have appropriate solutions and the ability to change materials, equipment, labor costs, and machine shifts which are more relevant than the actual time of construction deployment. Unstable interest rates are undesirable for most project participants as they lead to concerns about profitability and return on equity (Xenidis & Angelides, 2005). Another possible barrier is whether private investors are able to access the projects' capital through loans from financial institutions. In addition, they will also have to pay additional interest in case they are unable to pay on time. When an economy is not stable, investment capital mobilization for projects faces many difficulties and investors may have to suspend projects because of the lack of investment capital.

(iii) Group 3 – Design

The design risks of design-build projects often stem from the roles (main or indirect) of the project participants (Liu, Xie, Xia, & Bridge, 2017). Design experts will face design risks, of course, but those involved in the projects such as owners or contractors will also face general design risks depending on their roles and their responsibility. This is because, in design-build projects, design units no longer work exclusively for the owner but work in the same team with the construction units, resulting in less communication with the owner. The likely result is that there will be misunderstandings or untimely

adjustments with the owner. The main design risks are changes or deficiencies in a design; inadequate design, designers who do not know how to engineer well can make design errors (in the planning, specifications, estimates), and difficulties in following instructions (standards).

Since a project's objectives and scale are not clear, it may be necessary to adjust them during the project implementation process. This results in changes in design, the length of document preparation and submission, leading to project delays and excess costs. Further, construction contractors may have to change or adjust construction methods, machinery, and types of materials that are used (Likhitruangsilp & Harinthajinda, 2008; Nguyen & Likhitruangsilp, 2017).

Difficulties in following instructions (standards). The design-build form is usually applied to projects with large scale and complex technical properties. Therefore, few domestic companies in Vietnam can meet the project requirements, and thus, the cooperation of foreign contractors is very common. However, foreign contractors face many difficulties in organizing project implementation because they do not clearly understand the weather, hydrogeology, customs, as well as Vietnam's regulations, standards, and legal provisions because the applicable standards are outdated and inappropriate. Therefore, using foreign standards or converting from foreign standards to Vietnamese standards is often difficult and takes much time, which further slows down the implementation progress of the project design.

Group 4 – Contracts and bidding

This group of issues includes the lack of transparency in bidding (the breakdown of packages, projects not yet approve but bidding has proceeded), conflicting or incomplete contracts, signing contracts improperly, unfair allocation of responsibilities and risks, inappropriate contract quotes related to the bidding process and the project evaluation.

The lack of transparency and fraud in bidding leads to the selection of incompetent and inexperienced contractors who cannot ensure the design and construction work in accordance with specified requirements, easily causing problems during construction. In addition, a negative situation in the work of bidding and collusion in bidding increases the total investment costs.

In addition, a design-build contract is a lump-sum contract (Lines, Shalwani, & Smithwick, 2011). Therefore the contractor is the only one responsible to the owner for the whole project. In the contract, thus, it is necessary to clearly indicate the criteria, such as ensuring the work quality, specifying the scope of work, the standard system applicable to the work, identifying specific timelines, and penalties in the contract's terms, control of expenses incurred during the implementation process, bind responsibility upon the parties for risks occurring to the project etc. Accordingly, the lack of experience in contract drafting or loose contractual terms in the contract can cause a lot of controversy during project implementation. Especially if potential risks (fluctuations in material and equipment prices, instability in the world, etc.) are not anticipated and are tightly bound into the contract. The project's progress will be prolonged and there often excess contract estimates.

Group 5 – Construction

Construction risks are adverse factors in the construction phase of a design-build project. These include unavailable labor/ materials/ equipment or delays; owners' requirements on special or monopoly equipment; limited supply in the market; exorbitant requirements on the quality of the work; force majeure risks (abnormal events such as earthquakes, storms, floods, natural disasters); and accidents (Khahro & Memon, 2018; Nguyen; Phong, Phuc, & Quyen, 2017; Sy Tien, Veerasak, Tran, & Phong, 2017).

During the construction process, the contractor will face many difficulties if the project's quality is not guaranteed, leading to incidents of subsidence, cracking and waste of recovery costs (Nguyen Thanh Phong & Quyen, 2017). Therefore to minimize risks, the management and the inspection of the rationality of the design documents compared to the geological documents, the quality of supervision, control and assurance, as well as the construction method proposed by the contractor, are critical (Long, Tran, & Nguyen, 2019). The schedule prepared by the contractor and approved by the owner is the basis for implementing the project. However, during the implementation process, it may be overlapped due to the weak coordination between the main contractor, subcontractors, and suppliers of specialized equipment, machinery, and construction materials (Nguyen et al., 2016). Some contractors must wait for the other contractors to be able to do their duties, causing problems for the contractors themselves as well as delaying the overall progress of the project. Therefore, the management of project progress must be paid special attention by the owner and the contractor to ensure the overall progress of the project (Nguyen, Vu, Nguyen, Le, & Vo, 2019; Sy, Likhitruangsilp, Onishi, & Nguyen, 2017). Therefore, unforeseen force majeure risks often have a great impact on the construction project, may cause damage to the work or lead to designs arising out of the original design proposed by the contractor. This is costly and can impact an enterprise's prestige and brand.

The contractor for a DB project is not only responsible for construction techniques, means, and methods, but also for the design, accuracy, and performance. The owner's responsibility is also partially reduced while they can still follow the project quickly. As a result, contractors not only take more responsibility but are also responsible for their own specialties (Perkins, 2009). That contractors are not familiar with this can cause a lot of problems, including accuracy in assessing the feasibility of the project, an investor's incompetent supervisor. changes in project scope, contractors chasing maximum profit and ignoring project specifications, using inferior materials or using replacement materials to get profit because it is a fixed price contract, insufficient capacity and experience of the staff on the design-build project, lack of reliable support from subcontractors, unsuitable allocation of resources to the project, and ineffective communication between owner and stakeholders in the project implementation process.

III. RESEARCH METHODOLOGY

To determine risk, we need to know two dimensionalities, namely occurring probability and consequence levels. Risk is often expressed in terms of a combination of the consequences of an event and the associated likelihood of occurrence. In short, a risk factor (RF) in this study is then calculated by using the formulas (P. T. Nguyen & Likhitruangsilp, 2017; Sy et al., 2017; Sy Tien et al., 2017):

$$RF = C + L - C.L \quad (1)$$

where

RF: risk factor or level of risk

C: consequence measure, on a scale 0 to 1 = average of consequence factors

L: likelihood measure, on a scale 0 to 1 = average of likelihood factors

Mathematically, this formula (1) derives from the probability calculation for disjunctive events: prob (A or B) = prob (A) + prob (B) - prob (A) x prob (B). The risk factor value from 0 (low) to 1 (high), reflects the likelihood of a risk arising in the element and the severity of its consequences. The risk factor will be high if the likelihood L is high, or the consequence C is high, or both.

It is important to remember that risk analysis rates consequences first, and then likelihoods, not the other way round. Events may have many kinds of outcomes that could range from quite small to quite large, so the sequence of rating likelihood before a consequence is fraught with difficulty - which of the many consequences should be selected when rating a risk? In practice, people who used this approach often selected the likelihood of an event occurring irrespective of the level of consequence, and then selected a conservative or worst-case consequence; this generated likelihoodconsequence pairs that could never arise in practice and levels of risk that were far too high. We now rate the consequence first, usually a 'most-likely' or characteristic consequence, and then the likelihood of that level of consequence is arising. This ensures that likelihood consequence pairs are coherent, could actually occur and describe the risk in a meaningful way (Cooper et al., 2014).

IV. RESULTS AND DISCUSSION

Based on the results in the literature review and in-depth interviews with experts, we identify a total of 28 risk factors in design-build projects in Vietnam. After using formulas (1), we can conclude that the top three most important risk factors have been identified, including delays in project approval and licensing, interest rate fluctuations, and design or technical specification deficiency and change. These leading risks are analyzed as follows:

(i) *Delays in project approval and licensing:*

In Vietnam, project approval often is delayed and sometimes even a previous approval is canceled. The project approval process is prolonged for several reasons, including the lack of capacity and professionalism of the approval department, and complex project approval procedures. Different departments often have different laws and regulations of their own with which contractors must comply. For example, environmental agencies, land offices, electricity, water and irrigation authorities often also cause delays in design-build projects. In addition, the amendment of some applicable laws and regulations in a short time makes contractors always face the application of changing regulations, which also takes a lot of time at the beginning of the project. Moreover, the complex legal hoops, prolonged submission procedures, and changes in the legal policies of the government of Vietnam also cause difficulties for owners, contractors, and design-build projects in the project implementation process as well as payment and final settlement.

(ii) *Interest rate fluctuation:*

Interest rate fluctuation can have a positive or negative effect on both owners and contractors.(Giang & Pheng, 2014; P. T. Nguyen, Nguyen, Pham, et al., 2018). Normally, owners and contractors have the need to use more than 50% of the capital borrowed from banks, with the interest rate depending greatly on the policies of the State Bank. Low interest rates will attract investors and motivate them to pay more attention to the construction market. On the other hand, when interest rates are volatile, there are problems with potential profit or return on equity. Moreover, getting access to loans from financial institutions in the private sector also is difficult.

(iii) *Design or technical specification deficiency and change*

The design or technical specification deficiency and change risk are unavoidable, particularly in large-scale design-build projects, because most of the design elements are not completed during the contracting period. This results in disputes between owners and contractors. The bigger the inaccuracy creates higher risks for the contractors because they bear the costs for their misunderstandings (Luong, Tran, & Nguyen, 2018; P. T. Nguyen, Van Nguyen, To Nguyen, & Huynh, 2016; T. A. Nguyen & Nguyen, 2015). In design-build projects, the investor regularly brings only an original idea about the

project that they wish to build, but it is the contractors when bidding that prepare the proposals including the preliminary design and estimated costs for the project based on the owner's requirements. The bid price from the contractors is often fixed. Therefore, if the design-build project contractors have incurred further costs for shortcomings in design as well as construction, they cannot have a claim against the owner. However, if an owner changes the requirements for the design or the project specifications, the contractors do require an additional amount from the owner, which comes out of his pocket (Handayani, Likhitruangsilp, & Yabuki, 2019; Likhitruangsilp, Handayani, Ioannou, & Yabuki, 2018).

One of the major reasons there are omissions in the design is due to unconditional surveying and measuring by the contractors (Do et al., 2016). Or if the contractor conducts an improper geologic survey on the construction site where there are complicated geologic conditions, this results in inconsistency in the course of construction and uneconomical in the design, thus being required to bring out a more appropriate design solution. It also can cause serious problems in the quality of the structure if it is not detected quickly. Further, three contractors may need a long time to carry out resurveying and design revisions. Besides, the costs for troubleshooting during construction caused by unsatisfactory geologic survey works will be very high. Thus, surveying and measuring of terribly significant for ensuring the project do not encounter difficulties.

V. CONCLUSION

This paper investigates the risk factors affecting the implementation of design-build projects in construction industry in Vietnam. The results showed that the top three critical risk factors in descending order of importance are delays in project approval and licensing, interest rate fluctuations, and design or technical specification deficiency and change.We expect that the research results will support researchers and project managers in design-build contract approach in project management.

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