

## Article

# Developing a Risk Management Process for General Contractors in the Bidding Stage for Design–Build Projects in Vietnam

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**Abstract:** Design–build (DB) projects have become increasingly popular for construction projects in developing countries due to the cost and scheduling advantages and their design optimization ability. As a result, much research has been conducted on improving DB efficiency in terms of cost, scheduling, risk management, etc. However, the existing studies have mainly focused on the owner's roles, whereas general contractors (GCs) must also take many risks on behalf of owners in DB projects. The adequate identification and assessment of risks before engaging a contractor can increase the likelihood of a project's success, at least from a DB contractor's perspective. Therefore, this study interviewed procurement experts to conduct a survey at the local level, then analyzed, developed, and proposed an additional risk management process (RMP) for use by GCs during the bidding process of DB projects. A case study was conducted with a large Vietnamese GC to evaluate the effectiveness of the process and find ways to optimize it in the future. The results of the study showed that risk management during a DB project is imperative. Nevertheless, preparing bids is time-consuming and increases the contingency costs, reducing the competitiveness of the bid prices for contractors. Therefore, depending on the specific project and risk management objectives, an RMP is recommended for adjusting the risk management target to reduce the risk, while still maintaining the competitiveness of the bid prices.

**Keywords:** risk management; tendering; bidding; design–build; Vietnam



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## 1. Introduction

A design–build (DB) system is a delivery system in which an owner assigns both the design package and the construction package to only one general contractor (GC), or a design–build team under a single DB contract [1]. The clear advantages for projects implementing the DB delivery system are not only a shorter project duration, but also being able to determine the project costs early, as well as the design/cost optimization ability, in comparison with other traditional project delivery systems [2–4]. These DB method advantages have been proven in both theory and practice through an increasing number of academic studies and DB projects in the international construction market [5–7]. As a result, the design–build (DB) project delivery method has continued to grow and is considered as a potential alternative to replacing the traditional project delivery method [8]. In the US, the FHWA's Design–Build Contracting Final Rule (2002) has allowed DB projects to move from an experimental status to the mainstream for federally funded projects [9]. During the last few years in Vietnam and in other developing countries, the number of projects

implementing a transfer to DB has increased significantly, and it has gained considerable attention from government, owners, and main contractors [10].

However, moving from traditional design–bid–build (DBB) procurement to DB procurement is not an easy task for many contractors [11]. Due to the low level of development (LOD) at the time of bidding and awarding of contracts, GCs experience more risks and uncertainties about increasing costs compared with DBB contracts [8], which impacts the success of both the GC and the whole project. In contrast to the traditional DBB delivery method, in which design activities are separated from construction activities and undertaken by different entities, the DB method requires contractors to integrate the design and construction in one contract [12]. As such, DB contractors are usually responsible for an appreciable proportion of the design risks, in which there is the potential for problems to arise from the design tasks [13]. Issues such as a lack of design expertise, design defects, or the design not adhering to the local regulations [14] can cause delays in design [8]. In some projects, the complexity in the design concept also increases the design risks and difficulties for DB contractors in sourcing and integrating the design team to ensure successful project delivery [15]. In other words, the design liability for errors and omissions in plans and the dispute risks of a DB project are transferred from the owners to the DB contractors [9,16,17]. Furthermore, these risks can greatly affect a GC's bid decision, bid price, and the overall success of DB projects [16].

Although construction is a very risk-inclined industry with a relatively poor ability to handle risk, risk management in the construction industry is still a comparatively new field, with no core system of risk management in developing countries [17]. In particular, the characteristics of DB projects, such as single-point responsibility, shorter project delivery duration, enhanced financial certainty, high levels of coordination, and risk transfer of design liability from designers/owners [2,4,5,8,18], have put GCs in a very hazardous position. On the other hand, a thorough understanding of design risk in DB projects and the effective management of this risk can significantly reduce barriers to entry for DB contractors into the DB market [16]. Furthermore, an adequate identification and assessment of the risks prior to engaging a contractor also increases the likelihood of project success—at least from a DB contractor's perspective [19]. In previous research, the risk management process (RMP) addressed several risk management problems, but not the risk management of contractors in the bidding phase. Understanding the potential for preventing the risk for GCs, this study inherits the results of previous studies, but focuses on risk assessment at the bidding stage when the decisions by the contractor contribute directly to their profits. Therefore, this study interviewed experts and conducted a survey to develop and propose an RMP for use by GCs during the DB project bidding phase. Although applying the add-on process can cause extra paperwork and increase redundancy costs, contractors can balance the risks and low-cost advantages for each specific project.

## 2. Literature Review

Research on DB methods has been popular since the 2000s, particularly as studies focusing mainly on the project owners, who benefit greatly from the DB system and have the decision-making rights. One example is the research of Molenaar, et al. [20], which proposed a framework for appropriately allocating risk in a request for proposals (RFP) in DB bidding. Another is the proposal of an automated tool, namely the Stochastic Quality Function Deployment (SQFD) system, to measure the quality performance of a DB contractor in the study by Lee, et al. [18]. To limit bias in contractor evaluation, Asmar, Lotfallah, Whited and Hanna [11] proposed the application of mathematical models to evaluate contractor selection in DB projects, and Xia, et al. [21] suggested an evaluation of design–builder qualifications. On the other hand, some studies have proposed assisting owners to select appropriate procurement methods for use under DB systems to eventually improve future project performance [6,17,22]. Although limited in number, some studies focusing on GC issues have also been conducted. These studies suggested solutions for

several issues, such as the presentation of contractor risks and their impact on the DB project (Liu and Xie [16]). In addition, Ling, et al. [23] proposed a model for assisting contractors to select design consultants for DB projects. Overall, previous studies have made significant contributions to suggestions for RFPs, selecting DB contractor methods, deciding a suitable procurement method, and so on. However, there is a very limited amount of research focusing on solving the problems that arise from GCs taking excessive risks [24], especially in developing countries [17].

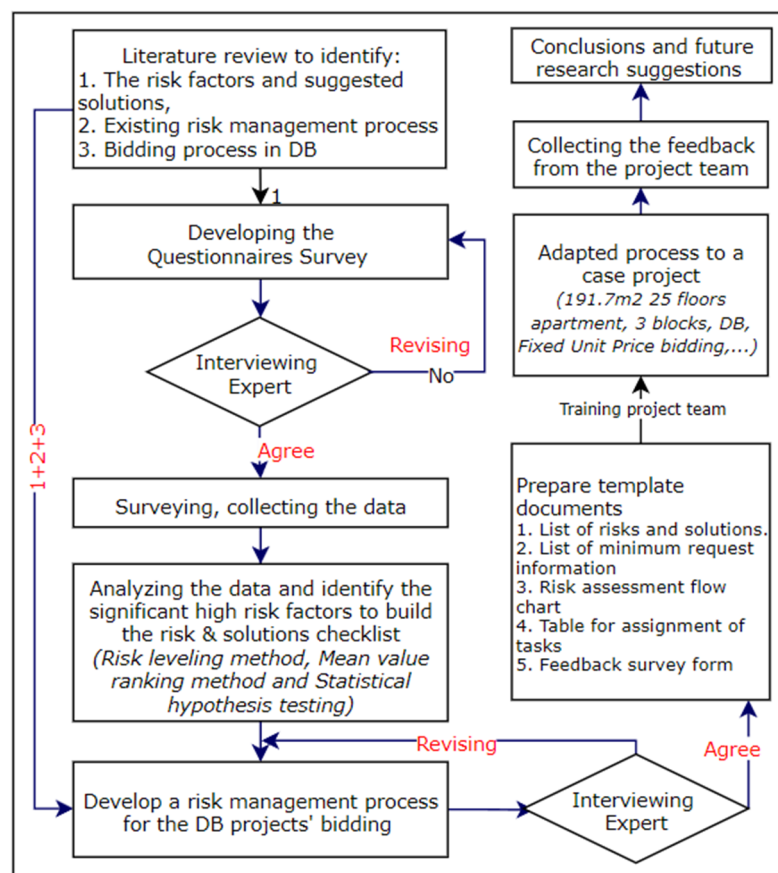
The characteristics of most construction projects are large-scale, high spending of capital on resources, long duration, and the concealment of risks from the parties involved. As a result, both industry and academic research focus on risk management solutions to prevent or reduce the impact of the risks to the project. These risk management studies involve risk identification, risk estimation, risk evaluation, risk response, and risk monitoring [25]. Furthermore, many risk management frameworks have been developed as a result of the efforts of various researchers [17]. Among the existing studies on the risks in DB projects, two fields have been the main focus: the risk identification and assessment (estimation and evaluation) field, and the risk response/treatments field. The most common is a group of studies that identify the risk factors to develop risk assessment models to support the decision-making process, such as the simplified schedule and risk analysis model by El-Gafy [22], a risk assessment from the perspective of an owner in the research by Tsai and Yang [26], the critical factors list for contractor bidding decisions in the Jarkas, et al. [27] study, the risk comparison of public owners and design-builders in choosing DB delivery [8], the classification study on three risk groups (cost, time, and quality) by Ogunsanmi [28], Yuni, et al. [29] list unacceptable risk factors and undesirable risk factors along with risk mitigation, the critical risk factors that influence the private sector's investment decisions on Publish Private Partnership transportation projects in Vietnam [10], the contractor perspective related to risk factors in a design-build project in Rostiyanti, et al. [30], and so on. Although targeting many different research objects, these studies all identify risks and their relationships through the analysis of interview and survey results, thereby building risk assessment models to support the decision-making process. On the other hand, some studies have focused on addressing risks through a risk management and analysis process (Öztaş and Ökmen [31]), a risk monitoring system ([32]), and risk management tools in DB projects (Adnan, Jusoff and Salim [3]).

In general, the previous studies fulfilled the demands of the risk management field within the research by identifying risks, developing decision-making models, and finding the corresponding response solutions for DB projects [3]. However, although GCs must take on many risks from the owner in DB projects, there is minimal research on supporting GCs, especially for developing countries such as Vietnam [27]. Due to a gap in the existing research regarding risk management by GCs and the increasing demand for DB projects in Vietnam, it is important to fill this gap with further research on developing an RMP to assist contractors, particularly in the bidding phase of new projects when the information about the contract, cost, schedule, and design has a clear influence on the success of the project and the profit of the contractor [9,16,17]. Therefore, this study investigated the potential risks and analyzed a survey to develop an RMP for GCs during the bidding phase of DB projects.

### 3. Research Methods

To develop an RMP for GCs when bidding on DB projects in developing countries such as Vietnam, this study consisted of three main steps. Step 1 investigated and identified the potential risk factors in a DB project by conducting a literature review of previous studies and literature. These identified risk factors formed the basis of a questionnaire survey that was delivered to a suitable target group. The main purpose of this phase was to collect data to identify the risk factors specific to GCs in DB projects by analyzing the results of the survey, as per the method in the previous studies by Tran et al. [8], Sy, Likhitrungsilp, Onishi and Nguyen [10], and Yuni, Norken, Sudarsana and Adnyana [29]. At step 2, an

RMP (including a workflow, rules, risk factors checklist, and assessment) was designed for use during the bidding phase of DB projects, based on a synthesis of the bidding process, the risk management process mentioned in previous studies by Öztaş and Ökmen [31] and Adnan, Jusoff and Salim [3], and the analysis results from the survey in this study. In step 3, the developed RMP was adapted and examined during the bidding phase of a DB project in Vietnam. Subsequently, an interview was conducted with the participating project team to collect feedback and evaluate the results of the study. In addition, the research team was consulted by a group of seven experts during the development of this study. The workflow of the results is presented in Figure 1.



**Figure 1.** Workflow of the research.

### 3.1. Methods to Identify Risk Factors, Build Questionnaires and Conduct Surveys

A total of 51 risk factors were compiled from existing research and documents during the literature review. After the list of identified risk factors was considered by the expert team, some factors were removed due to duplication, and 4/7 experts said that some risk factors rarely occurred in the projects in Vietnam. Several risk factors were also added at the request of the expert team, and the final list of 41 qualified risk factors was established as the foundation of this study. The final list of 41 risk factors were categorized as general risk factors [33] and bidding-specific risk factors [34]. Most risk factors originated from local political characteristics, the economic situation, the environment, and inevitable issues [33]. Bidding-specific risk arises from the contract, and includes poor contract clarity, an insufficient definition of the lines of communication, and untimely contract administration [35]. When divided into bidding-specific risk factors, the following products were found to be the elements of risk: bidding package obtainment, bidding package review, and bidding proposal submission. The specific trends in risk allocation during the bidding phase in DB projects are presented in Table 1.

**Table 1.** List of 41 risk factors and reference sources used in the study questionnaire.

|             | Risk Factors  | References         |
|-------------|---|--------------------|
| <b>I</b>    | <b>General risk factors</b>   |                    |
| <b>I.1</b>  | Politics and law  |                    |
| 1           | Change of laws and regulations  | [3,8,10,26,28,35]  |
| 2           | Unstable political transition period  | [35]               |
| <b>I.2</b>  | Economy/finance   |                    |
| 3           | Fluctuation of price, inflation rate, and interest rate for projects with an extended bidding stage   | [10,26,28,31]      |
| <b>I.3</b>  | Environment   |                    |
| 4           | Weather effect on quality and schedule of construction work   | [25,28,30,31]      |
| <b>I.4</b>  | Inevitable risks  |                    |
| 5           | Conflicts between landowners  | [30]               |
| 6           | Natural phenomenon (earthquake, fire, high winds, disease) during the construction period   | [26,28]            |
| <b>II</b>   | <b>Bidding-specific risk factors</b>  |                    |
| <b>II.1</b> | Bidding package obtainment  |                    |
| 7           | Inadequate information in the bid package   | [3,26–29,31]       |
| 8           | Disadvantage of down payment and payment schedule in the contract   | [8,10,27,28,31]    |
| 9           | The client holds the bid bond even after the project is awarded to other bidder   | [27]               |
| 10          | Financial stability of owner  | [25–27]            |
| 11          | Insufficient concept design drawing and document  | [26,29,31,35]      |
| 12          | Project with unclear construction approval and land rights  | [30,31]            |
| 13          | Unclear priority order in bidding package   | [35]               |
| 14          | Bidding package not following laws and policies   | *                  |
| 15          | Inconsistency between information provided by the owner and the actual conditions of the bidding package                                    | [29,30]            |
| 16          | Incorrect evaluation of the owner's financial stability, identity, reputation, strength, and position in the industry                       | [26,27,35]         |
| 17          | Bidding period is too short   | [35]               |
| <b>II.2</b> | Bidding package review  |                    |
| 18          | Incompatibility between geotechnical on-site condition and surveying document that is provided in the bidding package to support the design | [8,25,30,31]       |
| 19          | Construction process affects adjacent buildings and underground utility   | [8,27,30,35]       |
| 20          | Construction delays due to approval documents, urban planning, and land right conflict  | [3,8,28,30,35]     |
| 21          | Owner's requirement for concept design changes during tender stage  | [3,10,25,26,28,31] |
| 22          | Owner's requirement for construction schedule changes during tender stage   | [3,10,25,26]       |
| 23          | Design team's lack of experience, capability, and supervision skills  | [26,29,30]         |
| 24          | Delay schedule of the bid team in bidding proposal preparation  | [25,28,31]         |
| 25          | Insufficient collaboration of design–builder team   | [3,26,29]          |
| 26          | Quotation delay from subcontractors and suppliers   | [25]               |
| 27          | Quotation from subcontractors and suppliers is wrong  | [29]               |



Table 1. Cont.

|      | Risk Factors   | References |
|------|--|------------|
| 28   | Quoted materials are not available in the market   | [28,29,31] |
| 29   | Bid rigging by subcontractors and suppliers  | [36]       |
| 30   | Construction method cost is too high because of the design's complex constructability        | [28]       |
| 31   | Contractor's financial capability is insufficient  | [26]       |
| 32   | Availability of equipment required   | [26–28,31] |
| 33   | Bid proposal information leakage   | *          |
| II.3 | Bidding proposal submission  |            |
| 34   | Late submission of bidding proposal  | *          |
| 35   | Missing or incorrect information in bidding proposal   | [29]       |
| 36   | Bidder's initial design does not meet owner's requirement                                    | *          |
| 37   | Bidding proposal not following legal regulation  | *          |
| 38   | Design document, bill of quantities, scope of work, and quotation templates are inconsistent | [29]       |
| 39   | Construction method is not suitable  | [26,29]    |
| 40   | Capability of subcontractors and suppliers are inadequate                                    | [26,27,29] |
| 41   | Unfair bidder selection process  | [10]       |

\* Recommended by experts.

After finalizing, the risk factors list was translated into Vietnamese and used to develop a questionnaire to identify the high-level risk factors. The questionnaire contained the list of the 41 qualified risk factors (Google form) with the survey guideline attached and was sent via email to the major target respondents. The respondents were asked about their level of agreement for each risk agent in the following two statements: “Risk factor [A] influences the GC in the DB project” and “Risk factor [A] often occurs in the DB project”. To collect the frequency and extent of influence measurements of each risk factor in DB projects in Vietnam from surveyors, this study used a five-point Likert scale, similar to that used in the Adnan, Jusoff and Salim [3] and Sy, Likhitrungsilp, Onishi and Nguyen [10] studies. The five-point Likert scale is defined as follows: “A type of psychometric response scale in which responders specify their level of agreement to a statement typically in five points: (1) Strongly disagree; (2) Disagree; (3) Neither agree nor disagree; (4) Agree; (5) Strongly agree” [11]. It was recommended that respondents not respond to the survey if they had experience in DB projects or referred it to their colleagues if they had related experience. There were three major target respondent groups in this study. The first group was an email list of construction management master's students, proposed by one member of the expert team who works as a professor in a large university in Vietnam. The second group was found through the search engine results of LinkedIn, and the survey links and descriptions were sent directly through the messaging tool of this application. The third group was surveyed directly from the Procurement and Tendering Department staff of three companies that are members of a large main contractor group in Vietnam, who also supported this study. The determined minimum sample size required for the significance of the survey was 62 (a relatively high standard deviation of 4 and a minimum error factor of 1), calculated by the following Equation (1):

$$n = (Z \cdot s / E)^2 \quad (1)$$

where:  $n$  = minimum sample size;  $S$  = sample standard deviation;  $E$  = error factor; and  $Z = 1.96$ , equal to 95% of the confidence.

At the end of the survey, a total of 109 surveys were completed after 1 month of survey implementation, which is greater than the minimum number of survey samples of 62. The results showed that 100% of survey respondents had university degrees, 37% had a master's degree, and 70% worked for GCs.

### 3.2. Methods to Analyze Survey Results, and Development of RMP

The results obtained from the survey, according to the five-point Likert scale on the influence and probability of each risk factor, were converted to a scale of 0–1 as (0) Strongly disagree; (0.25) Disagree; (0.5) Neither agree nor disagree; (0.75) Agree; and (1) Strongly agree. To assess the risk levels of these factors, the combined risk level (RL) of each specific risk multiplier was calculated based on the following Equation (2) [10]:

$$RL = P + I - P \times I \quad (2)$$

where: RL = the combined risk level; P = risk probability measured on a scale of 0 to 1; and I = impact measured on a scale of 0 to 1.

The risk factors were classified into three different groups based on their calculated risk level (RL) value. Specifically, the factors will be in the high-risk group if the RL value of that factor is >0.8, the medium-risk level if the RL value is between 0.45 and 0.8, and the low-risk level if the RL value is <0.45 [10] (Figure 2). One important thing to note is that the mean value cannot accurately reflect the statistical results of the survey data, so further statistical techniques needed to be employed to evaluate the data from the survey [37]. In particular, the (1) mean value ranking, (2) Kolmogorov–Smirnov test, and (3) one-sample t-test techniques were used to identify the significant risk factors that influence GCs in developing an RMP for the bidding process. First, the mean value ranking technique was used to rank the risk factors based on their risk leveling value and the standard deviation [37]. Second, the Kolmogorov–Smirnov test ( $n > 50$ ) [38] was used to test the normality of the collected data distribution for further statistical hypothesis testing [39]. The null hypothesis H1 “The data are normally distributed” was used for the Kolmogorov–Smirnov test with a confidence index of 95%. The null hypothesis H1 was rejected if the sig value of the Kolmogorov–Smirnov test was less than 0.05. Next, a one-sample t-test identified the high-risk factors and prevented the statistics type I error [38]. The null hypothesis H2 “Risk factor not in the high-risk group (RL is significantly smaller than 0.8)” was accepted when  $\text{sig} > 0.05$ .

### 3.3. Methods to Evaluate the RMP

Based on the results of survey data analysis, this study proposed a checklist of risk factors that contractors need to consider during preparation for DB project bids. The list also clarified the prioritization of risk factors based on the mean value of RL values and highlighted the risk factors of the high-risk level group. By referencing previous studies on the bidding process [11,17,30,31,39,40], existing research on risk management [3,8,18,19,27,28,36], and a team of consulting experts, this study proposed an RMP for use by GCs during the DB project bidding process. The document package included a working flowchart, member responsibility, and a checklist of risk factor management reports. The expert team evaluated and revised the process before it was applied to a case project. A training session was held to guide and answer questions about applying this additional process for members participating in the case project bidding team. The total contract value was about USD 75 million, and the detail information is presented in Table 2. After the bidding process was completed, members of the project team were interviewed to collect feedback on the application of the add-on process during the bidding process.

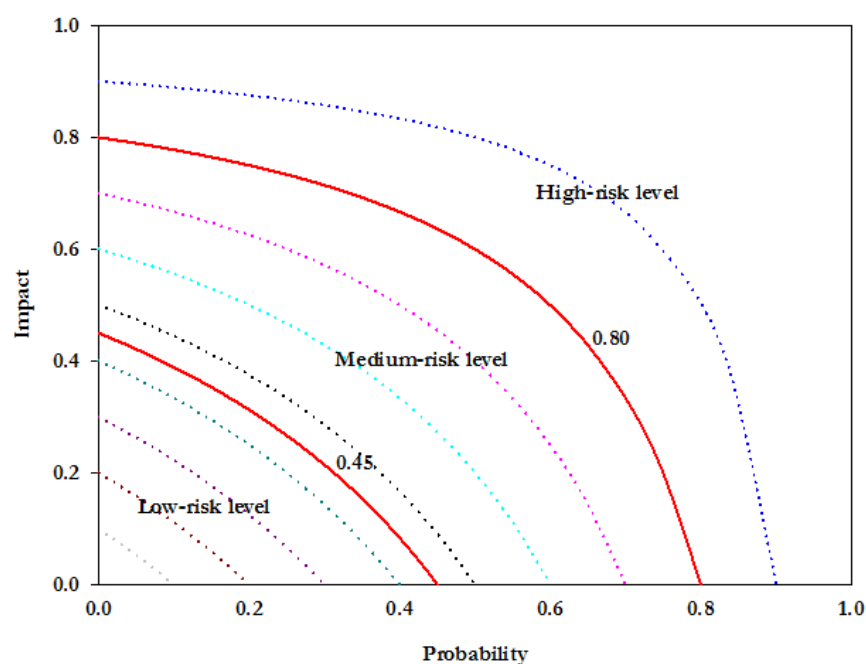


Figure 2. Risk level groups based on impact and probability in risk leveling [10].

Table 2. The case project information.

|                        |  |
|------------------------|--|
| Case project           | Private section, 25-floor apartment  |
| Project name           | Confidential   |
| Owner                  | Confidential   |
| Bid packages           | Design and build (MEP included) for CT1 tower  |
| Location               | Hanoi city, Vietnam  |
| Type                   | Apartment and commercial   |
| Conceptual design      | Total GFA 191,774 m <sup>2</sup>   |
|                        | 3 Blocks of 20-floor apartment – GFA 123,652   |
|                        | 5 floors of podium – GPA 8623 m <sup>2</sup> , include<br>+Landscape, swimming pool, garden – 2440 m <sup>2</sup><br>+Commercial – 6183 m <sup>2</sup> |
|                        | 1 sharing basement – GFA 16,270 m <sup>2</sup>   |
| Contract type          | Fixed-price contract   |
| Bidding type           | Public   |
| Duration               | 16 months  |
| Estimated project cost | VND 1,730,880,000,000~USD 75,882,506   |
| Bid security           | 20% project cost after tax   |
| Guarantee duration     | 60 months  |

#### 4. Results and Discussion

##### 4.1. List of Identified Risk Factors for GCs in DB Projects

The results of the data analysis collected from the survey are presented in Table 3, including mean value, standard deviation, results of the Kolmogorov–Smirnov test, and the one-sample *t*-test. Table 3 shows the order of risk levels of risk factors and the 12 factors belonging to the “high-risk level” group, according to the results of the mean value calculation. The Kolmogorov–Smirnov test results accepted hypothesis H1 for most of the risk factors, showing that the survey data obtained were mostly in a normal distribution.



Therefore, the *t*-tests were not severely affected by moderate differences of the basic assumptions about the standard and homogeneity of the collected data set [38]. In addition, hypothesis H2 (“Factors not in the high-risk level group”) was rejected for the top 29 factors. Therefore, the top 12 factors were identified by mean value, and the next 17 risk factors were also considered as being at the high-risk level in developing the RMP. The high-risk level factor results mainly arise from a lack of information cooperation with the owner, the contractor’s design team, and the bidding team, leading to an underestimated value or a lack of clear constraints in the contract. This shows that it is possible to develop a contractor clearance process by clarifying information, thereby adding contingencies and contract constraints.

**Table 3.** The collected data analysis results.

| Rank | Risk Factor No. | Mean of RL         | Std.  | Sig. Value <i>t</i> -Test | Sig. Value SW Test | Rank | Risk Factor No. | Mean of RL | Std.  | Sig. Value <i>t</i> -Test | Sig. Value SW Test |
|------|-----------------|--------------------|-------|---------------------------|--------------------|------|-----------------|------------|-------|---------------------------|--------------------|
| 1    | RF 30           | 0.834 <sup>c</sup> | 0.149 | 0.019 <sup>b</sup>        | 0.014 <sup>a</sup> | 23   | RF 15           | 0.783      | 0.168 | 0.286 <sup>b</sup>        | 0.001              |
| 2    | RF 25           | 0.833 <sup>c</sup> | 0.131 | 0.010 <sup>b</sup>        | 0.236 <sup>a</sup> | 24   | RF 8            | 0.78       | 0.15  | 0.17 <sup>b</sup>         | 0.573 <sup>a</sup> |
| 3    | RF 12           | 0.828 <sup>c</sup> | 0.137 | 0.036 <sup>b</sup>        | 0.181 <sup>a</sup> | 25   | RF 17           | 0.779      | 0.15  | 0.148 <sup>b</sup>        | 0.178 <sup>a</sup> |
| 4    | RF 24           | 0.825 <sup>c</sup> | 0.134 | 0.054 <sup>b</sup>        | 0.051 <sup>a</sup> | 26   | RF 11           | 0.777      | 0.162 | 0.132 <sup>b</sup>        | 0.052 <sup>a</sup> |
| 5    | RF 23           | 0.823 <sup>c</sup> | 0.135 | 0.076 <sup>b</sup>        | 0.011 <sup>a</sup> | 27   | RF 40           | 0.776      | 0.151 | 0.102 <sup>b</sup>        | 0.004              |
| 6    | RF 21           | 0.813 <sup>c</sup> | 0.156 | 0.392 <sup>b</sup>        | 0.075 <sup>a</sup> | 28   | RF 5            | 0.776      | 0.174 | 0.149 <sup>b</sup>        | 0.118 <sup>a</sup> |
| 7    | RF 36           | 0.811 <sup>c</sup> | 0.147 | 0.451 <sup>b</sup>        | 0.791 <sup>a</sup> | 29   | RF 39           | 0.775      | 0.15  | 0.09 <sup>b</sup>         | 0.677 <sup>a</sup> |
| 8    | RF 38           | 0.810 <sup>c</sup> | 0.163 | 0.511 <sup>b</sup>        | 0.992 <sup>a</sup> | 30   | RF 3            | 0.765      | 0.133 | 0.007 <sup>b</sup>        | 0.131 <sup>a</sup> |
| 9    | RF 35           | 0.810 <sup>c</sup> | 0.147 | 0.499 <sup>b</sup>        | 0.635 <sup>a</sup> | 31   | RF 31           | 0.762      | 0.181 | 0.028                     | 0.113 <sup>a</sup> |
| 10   | RF 22           | 0.808 <sup>c</sup> | 0.132 | 0.526 <sup>b</sup>        | 0.386 <sup>a</sup> | 32   | RF 13           | 0.759      | 0.162 | 0.01                      | 0.693 <sup>a</sup> |
| 11   | RF 10           | 0.808 <sup>c</sup> | 0.178 | 0.652 <sup>b</sup>        | 0.258 <sup>a</sup> | 33   | RF 28           | 0.757      | 0.136 | 0.001                     | 0.383 <sup>a</sup> |
| 12   | RF 33           | 0.802 <sup>c</sup> | 0.17  | 0.928 <sup>b</sup>        | 0.040 <sup>a</sup> | 34   | RF 32           | 0.749      | 0.186 | 0.005                     | 0.609 <sup>a</sup> |
| 13   | RF 34           | 0.798              | 0.181 | 0.899 <sup>b</sup>        | 0.031 <sup>a</sup> | 35   | RF 6            | 0.742      | 0.158 | 0                         | 0.192 <sup>a</sup> |
| 14   | RF 7            | 0.797              | 0.132 | 0.817 <sup>b</sup>        | 0.292 <sup>a</sup> | 36   | RF 19           | 0.741      | 0.176 | 0.001                     | 0.019              |
| 15   | RF 18           | 0.796              | 0.168 | 0.785 <sup>b</sup>        | 0.274 <sup>a</sup> | 37   | RF 29           | 0.724      | 0.193 | 0                         | 0.670 <sup>a</sup> |
| 16   | RF 14           | 0.794              | 0.19  | 0.747 <sup>b</sup>        | 0.772 <sup>a</sup> | 38   | RF 4            | 0.712      | 0.186 | 0                         | 0.075 <sup>a</sup> |
| 17   | RF 20           | 0.794              | 0.167 | 0.697 <sup>b</sup>        | 0.254 <sup>a</sup> | 39   | RF 9            | 0.704      | 0.182 | 0                         | 0.811 <sup>a</sup> |
| 18   | RF 26           | 0.793              | 0.16  | 0.667 <sup>b</sup>        | 0.910 <sup>a</sup> | 40   | RF 2            | 0.691      | 0.182 | 0                         | 0.575 <sup>a</sup> |
| 19   | RF 41           | 0.793              | 0.188 | 0.684 <sup>b</sup>        | 0.024 <sup>a</sup> | 41   | RF 1            | 0.665      | 0.194 | 0                         | 0.963 <sup>a</sup> |
| 20   | RF 16           | 0.791              | 0.163 | 0.573 <sup>b</sup>        | 0.749 <sup>a</sup> |      |                 |            |       |                           |                    |
| 21   | RF 27           | 0.790              | 0.151 | 0.494 <sup>b</sup>        | 0.918 <sup>a</sup> |      |                 |            |       |                           |                    |
| 22   | RF 37           | 0.786              | 0.161 | 0.355 <sup>b</sup>        | 0.513 <sup>a</sup> |      |                 |            |       |                           |                    |

a: > 0.05, accepted the H<sub>a</sub> hypothesis. b: Sig value > 0.05, accepted the H<sub>b</sub> hypothesis. c: Mean value > 0.8, the threshold of high-risk factors.

#### 4.2. Proposed RMP during DB Project Bidding Phase

The results of the mean value ranking were highlighted in the risk factors checklist to support the contractor’s risk management in the case project. Based on the investigation of risk factors, we proposed an RMP to be carried out in parallel with the preparation for the bid process. The templates and documents included: (1) a work assignment sheet; (2) a list of minimum required information; (3) a risk assessment report; and (4) a list of risks and suggested solutions created to lead the execution of the RMP. The integration workflow of the RMP and the bidding process is summarized in Figure 2. First, when a GC receives a bid invitation letter, the Board of Directors makes a preliminary assessment of the bid package and guidelines for procurement to decide whether to bid or not. If it progresses, the bid is transferred to the Procurement and Tendering Department and a bid preparation team is set up with the support of specialists from other departments. Next, based on

(2), the list of minimum required information, the bidding team requests a clarification of the missing information from the owner. Once the required information is collected adequately, the bidding team (4) lists the risk factors and proposes solutions to establish (3) a risk assessment report specific to the project based on the specific information collected. At the end of the design and quotation phase, (3) the risk assessment report is updated based on the information from the design department and the procurement specialist. It is finally qualified by the bid managers and submitted to the Board of Directors to decide the final proposal and bid prices for the project.

#### 4.3. Evaluating the RMP through the Case Project Results

The additional RMP was applied throughout the bidding process of the case project, and the important results of the case project are presented in each step (presented in Figure 3) below.

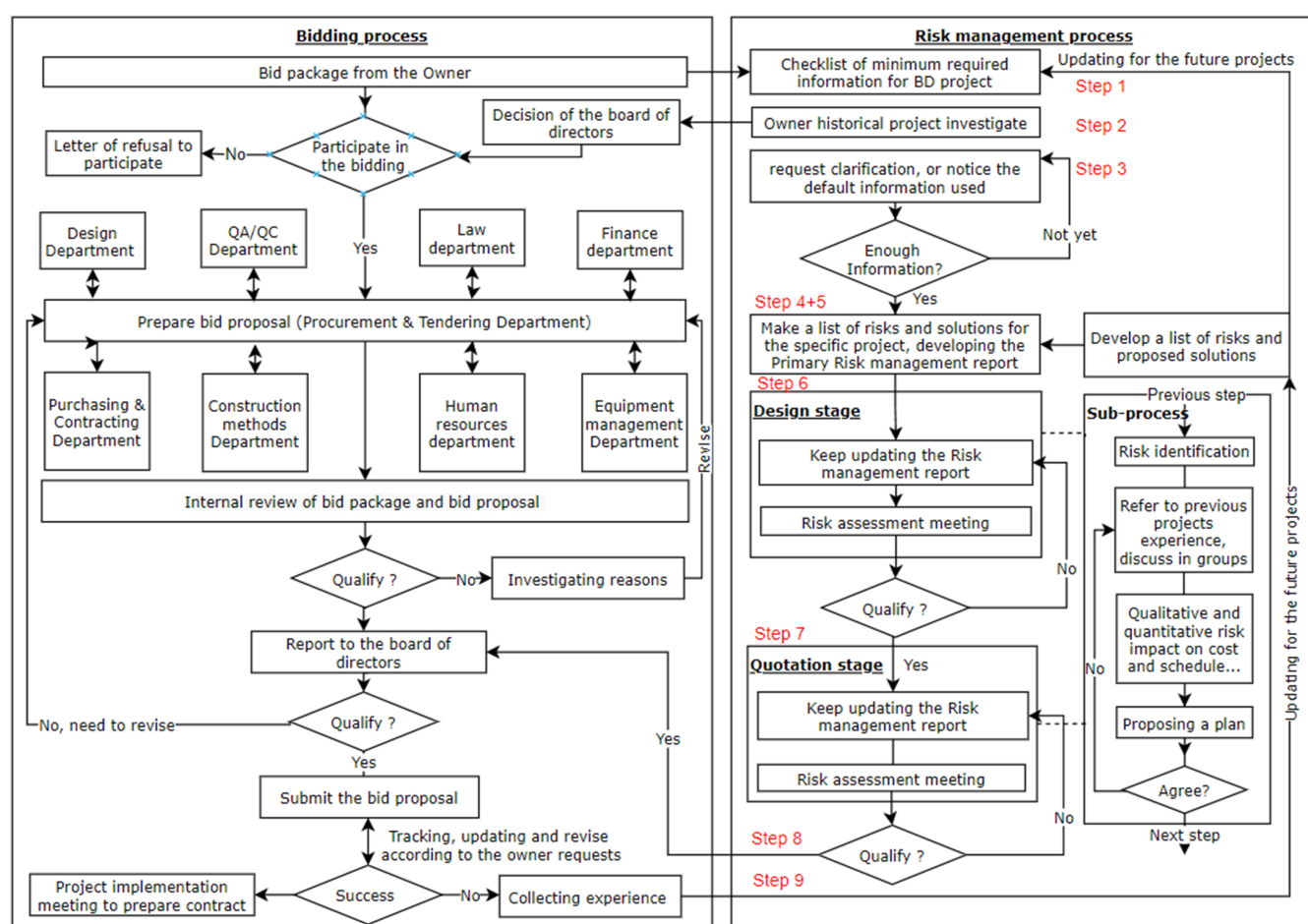


Figure 3. The risk management workflow for bidding stage.

Step 1. The project's bid package, received by the GC, includes conceptual design drawings (3D rendering, ground floor plan, podium floor plan for each story, and typical floor plan), geotechnical surveying documents, the owner's expected material specifications, and documents describing the scope of the GC's work (for both the design phase and the construction phase). The project team commented that the project's bid package was incomplete and needed clarification (compared with the minimum information list and based on experience in previous projects).

Step 2. Conduct primary risk management report to the Board of Directors. The information collected to support the Board of Director's decision-making to participate in the bid or not includes the owner's refinancing ability, land fund, and legal documents

for future projects, history of past projects, product segmentation, and feasibility of the bidding package.

Step 3. Clarify more information from the owner. In the specific case project, the information that needed to be clarified included legal information on the project, a sample apartment sale contract, payment conditions, temporary responses, settlement, etc. In addition, the scope of work and concept drawings are also required to be clarified. Specifically, this information is clarified through a direct meeting with the owner, and all clarified information is confirmed by the minutes.

Step 4. Project's risk management objective assessment. Based on the expected price, design, and construction plan of the project, the team discusses and sets the management objectives and project-specific risks. The project team concluded that this step is important to properly evaluate the risk management target because it ensures a balance between risk prevention and maintaining the competitive advantage of the bid prices. The case project had no special design requirements, the project team focused on the risks caused by the owner's cash flow problems.

Step 5. Develop detailed risk lists for the specific project. Based on the information collected and clarified from the owner, the project's risk management target, and a proposed checklist of risks, the project team clarified a checklist of risks, the causes, the solutions (from proposed solutions, or based on specific experiences), and their order of priority.

Step 6. Update the risk list in the design phase. This stage collects the risks from the design team that arise due to the owner's design requirements. Based on the risk management report developed in the previous stage, the design team and the bid manager continue to update more identified risks if available. The risks and response plans are implemented in the project, such as the risk of incurring design costs (suggested solution for re-clarifying the scope with the owner), the risk of incurring costs with the floor stress (suggested solution: apply unit price for suitable flooring method), and so on. At the end of the design phase, a meeting is held to review the risks in the design process and develop a response plan.

Step 7. Update the risk list during the quote execution phase. The price experts update the risk portfolio as per step 6. At the end of the period, members of the procurement team update and finalize the revised version of the package risk report with a list of risks, project-specific solutions, and their priorities. In general, most risks arose in the case project due to unclear requirements of the owner in the design and scope of work, and most of them were able to be resolved through information exchange with owners.

Step 8. Report to the Board of Directors. The final revision of the risk assessment report, the response plan, and the bid documents are submitted to the Board of Directors for the bid decision-making. The report should be revised if the Board of Directors has any conflict or asks for more information on risks and solution plans. Specifically, in the case project, the risk assessment report presented the owner's cash flow and progress risk due to the land plot's legal status. Therefore, the Board of Directors agreed to adjust the bid price to cover the refinancing costs due to the potential for schedule delay and late payment risks.

Step 9. Risk control during bid proposal submission. The risks in this phase are mainly due to the transfer, inspection, and printing of documents, or disclosure of bid price information due to illegal interference. Since this project conducted a direct bid submission, these risks were low. However, the project team still took some low-cost solutions to prevent these risks.

#### 4.4. Discussion

After completing the interview with the project team for the case project, the research team and the expert group drew out several important discussions on the risk management of the bidding phase of DB projects in Vietnam. Applying the additional RMP seems to reduce the duplication of work, conflicting information between these teams, and the blame between these groups. However, the project team also recommended additional

training and prepared forms for future projects to reduce the time spent on the RMP. While additional work was involved, having enough information about the project could have limited the rework and boosted the project's overall progress. Most subjective risks can be clarified and resolved by applying a risk assessment process during the bidding phase. Identifying and assessing the potential risk factors and formulating a response plan are time-consuming during the bidding phase but implementing a response plan may affect the project schedule and cost. This means that the cost of provision for the case project significantly increased (based on the experience of previous projects), thereby reducing the competitive advantage of the contractor. The proposed RMP guides GCs in assessing possible risks and clarifying input data for decision-makers, instead of relying solely on previous project experience. The process pointed to the risks that need to be considered and proposed suggestions for each risk, limiting the risks ignored during the bidding process. However, the results show that Vietnamese GCs tended to trade off the risks for development opportunities in new projects. In summary, most of the risks affecting Vietnamese GCs are mainly related to a lack of project information and owner's requirements, leading to inappropriate bids. The main contractor can handle this issue by communicating and clarifying the requirements with the investor during the bid preparation. Applying the proposed RMP to the case project increased the workload and required more effort from the project team, but it provided the necessary information for the contractor to make a bid decision. Preparing precise RMP forms, instructions, and training can make it easier for the procurement team to apply RMP in future projects.

## 5. Conclusions

This study achieved a collection of risk factors by compiling the risk factors found in the literature on relevant studies in the past, and using them as items in a questionnaire specifying the high-risk factors for Vietnamese GCs, with the support of statistical techniques. The list of specific factors and the RMP were also qualified by interviews with professionals and case study project team members. The study presented a step-by-step application of the RMP into a project bid and discussed the problems/results that the project team encountered during the application of the RMP. The application of the process caused additional work and should only be considered for use on highly complex projects. The interviewed experts and the case project team reached a consensus about the necessity and feasibility of risk assessment in the bidding process for GCs. Furthermore, the bidding stage is the best time for GCs to assess the risks from the investor and the project in order to make the appropriate decisions. The study also showed that a lack of information with regard to the owner's requests poses a significant risk to design-builders, and that these problems should be solved by clarifying information at the bidding stage. For academics, this study summarized the risk factors for GCs during the bidding phase from existing studies and contributes to building a preliminary foundation to fill the research gap on the risk assessment of construction projects in developing countries such as Vietnam. For industry, the proposed RMP applies to Vietnamese GCs to ensure that they understand project risks and to prevent them from experiencing serious financial implications due to project delays, especially in the case of unusual owner projects.

One of the limitations of the study is that there is not yet a quantitative formula to support a decision to participate in a bid, due to the various input data that are necessary. Even the actual process of how contractors and their clients negotiate and agree to prices is complex and not clearly articulated in the literature of any formal or analytical risk models [40]. Proposing a clear quantitative formula is necessary and possible with further research based on the data collected from applying this process to future projects. Although the survey respondents were spread over the territory of Vietnam, the interviewed experts came from a group of only a few companies and universities, leading to an unexpected result bias. It will take a great deal of effort to optimize the process to apply to other cases and objects (different in size, mode of operation, and so on). Thus, further study aimed

at testing more case projects to collect data to optimize the process is needed to make the process more widely applicable.

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