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Analysis of Risk Assessment Techniques Used By Top Construction Firms in United States

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ABSTRACT
Risk continues to be an issue of concern in the construction industry. Regardless of size, all construction firms are faced with risks in the implementation of their projects. While risks cannot be totally eliminated in the course of doing business, attempts should be made to minimize them. Although various studies have been conducted in the area of construction risk management, the majority of these studies were limited in scope and often focused on international firms. This study was conducted to assess the risk management techniques often used by major contractor firms in United States. Using a structured survey questionnaire for data collection, a random sample of 200 study participants was selected from the list of top 400 contractors published by the Engi neering News Record. The findings revealed that the majority of contracting firms use some forms of risk management techniques to mitigate project risks. However, the traditional methods of using intuition, judgment or experience were still the most commonly used risk analysis techniques. Qualitative risk analysis methods are also widely used. Furthermore, the respondents perceived the top three project risks to be Safety, Defective Design, and Quality of Work. Further statistical analysis revealed correlates among various risk management techniques.

Keywords: Project Risks, Risk Analysis, Risk Management

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I. INTRODUCTION

The construction industry plays a significant role in the economy of most countries. In the United States, the industry accounts for over 7.2 million employees—more than 5% of the total non-farm workforce and around 8% of GDP, making it one of the largest sectors of the economy [1]. The industry, as any other business, has its own risks and challenges arising from change, which is inherent in construction. The construction industry is widely associated with high degree of risk due to the nature of construction, business activities, process, environment and organization [2]. Construction work involves risks and uncertainties regardless of its size, but as the size and complexity of a project increase, the risk involved also increases.

Risk has been defined in many ways and assessed in terms of fatalities and injuries, probability of reliability or in terms of the likely effects on a project depending on particular industry[3]. Within the project context, project risk is defined as an uncertain event or condition that, if it occurs, has a positive or negative effect on at least one project objective such as time, cost, scope or quality [4]. Risk exists when a decision is expressed in terms of a range of possible outcomes and when known probabilities can be attached to the outcome. On the other hand, uncertainty exists when there is more than one possible outcome of a course of action but the probability of each outcome is not known [3].

The construction industry is inherently affected by changes in nature and human imperfection. Therefore, the application of risk management allows for effective management of these factors. In addition, since all risks involved in a construction project cannot be eliminated, there is a need for a risk management process to manage all types of risks and to obtain the maximum degree of elimination or control of risks. Furthermore, the increase in size and the complexity of projects have made the ability to manage risks throughout the construction process a central element in preventing unwanted consequences [5].

II. BACKGROUND

1.1 Risk and Risk Management

Risk management is a systematic approach intended to provide decision makers with a scientific method to create the desired variation from an unexpected outcome or risk [6]. It leads to increased confidence in decision-making by providing a realistic and systematic approach to obtain more information on the risk inherent in the project [7]. Risk management is carried out by all parties involved in a construction project, but each party has different reasons or concerns. For instance, clients are concerned with the best use of their capital resources, the likely cost of procuring the facility and their return of capital. On the other hand, contractors are concerned with the decision whether to bid for a given project, the desired competitiveness of their bid and the most profitable way of constructing. Although opinions vary as to what constitutes the stages in the process of risk management, experts generally agree on the intended objective, content and outcome of the total process.

Traditional risk management in the construction industry includes the perception, evaluation and management of risks by measures of assumption, reduction, transfer and insurance [8]. According to Williams [9], risk management is "the development of the methodology or quantitative procedures necessary to control the level of risk and the mitigation of their effect" (p. 202).

1.2 Construction Project Risk

Risk in construction can be described as a variable in the process of a construction project whose variation results in uncertainty of the final cost, duration and quality of the project [10]. Many project risks can be broadly identified as generic, but their precise nature on a given project is project specific [11]. Different approaches exist for classifying and categorizing project risk in groups. Risks can be categorized as internal or external. Internal risks include local and global risks, such as availability of labor and material, productivity, design, site conditions and others. External risks include economic, physical, political and technological change risks [12]. El-Sayegh [13] categorizes risks similarly. A survey of top 100 U.S. construction contractors and other project participants found the five most important risks to be safety, quality of work, defective design and, labor and equipment productivity [14]. The study also found that risks related to labor, equipment and material availability, labor and equipment productivity and quality of work are risks that have always been allocated to the contractor. Hence, contractors perceive them as the most important risks. In addition to these risks, safety and labor disputes were found to be important risks by contractors [14]. The study also attempted to identify risk responsibilities that have traditionally been shifted to the contractor. The study showed risks related to quality of work, quantities of work and defective material have come to be considered as the contractor's responsibility.

Tang et al.'s [15] research found that the five most important risks common to all participants of projects in the Chinese construction industry were poor quality of work, premature failure of the facility, safety, inadequate or incorrect design and financial risk. Beyond the five common risks, contractors also ranked risk associated with claims and disputes and force majeure as fifth and sixth important risks, respectively. Another survey of the United Arab Emirates (UAE) construction industry showed that the highest rated risks for both local and international companies surveyed were inflation and sudden change in price [13].

1.3 Overview of Risk Management Process

Risk management involves certain steps or process. Two approaches to risk management include informal or formal. Any firm, depending on choice, can adopt any of these two approaches [3]. The informal approach views the risk in a subjective manner and the organizations that are implementing it do not realize that they are operating any kind of risk management procedure. The most widely used techniques to this approach are provision of contingency funds and consulting experts to assess and review the possible risks in a project. On the other hand, the formal approach consists of a set of procedures laid down by the organization for risk management process, which ensures that the process is more objective. Tang et al. [15] argued that risk management systems applied in the Chinese construction industry tended to be informal, which are inadequate to effectively manage project risks.

Different studies and sectors often have different approaches or strategies to manage project risks. As a result, different models or methodologies expressed in terms of the different steps to be followed in risk management process have been developed. The use of models or a formal procedure for risk management sets up a framework for the risk management procedures and allows the user to choose appropriate techniques depending on the project. The Project Management Institute [4] lays out the risk management process in four stages including risk identification, risk quantification, risk response development and risk response control. In the 2004 edition, the stages increased to six steps including: risk management planning, risk identification, qualitative risk analysis, quantitative risk analysis, risk response planning and risk monitoring and control. Mills [16] applied risk management in three stages as risk identification,

risk analysis and risk response. Tah and Carr [12] used a five-phase risk management software system as a framework to risk management, including risk identification, risk assessment, risk analysis, risk handling and risk monitoring. As discussed earlier in this paper, several different steps or models are used in the process of risk management. While these steps may be different in name, order and organization, the underlying principles remain the same. For this study, the risk management process was modeled after the following five stages: risk identification, risk assessment, risk analysis, risk response and risk monitoring. However, this paper focuses on risk assessment techniques used by the study respondents as well as barriers to risk management.

1.4 Barriers to Implementing Risk Management

There are several barriers to implementing risk management, depending on the project environment and the firm undertaking the project. These barriers can be dealt with in such a way that they do not hinder effective management of risks. One of the major obstacles to application of risk management in the construction industry is the amount of time required; a scarce resource in construction projects. Akintoye and MacLeod [17] found this to be true in their study. In addition, their study found that even though people are aware of what is involved in risk management, they often use few formal techniques of risk analysis due to lack of familiarity. The findings by Lyons and Skitmore [18] are consistent with other studies that concluded that lack of time and lack of familiarity with the techniques are very highly rated as limiting factors of risk management. Lack of expertise in the techniques, lack of dedicated resources and difficulty in seeing the benefits of risk management were ranked next on the list of limiting factors.

Tang et al. [15] list a lack of the following elements of risk management as possible barriers: joint risk management by parties, knowledge of risk management techniques, agreement on risk control strategies, effective implementation of risk control strategies, a formal risk management system, risk consciousness and appropriate risk allocation. The respondents in the Chinese construction industry study rated the first three of these factors as top three barriers to risk management. However, Kim and Bejaj [8] found in their study that the main reason most Korean contractors make decisions based on intuition/judgment/experience is a lack of familiarity with the concepts and methods of risk management techniques.

III. METHODOLOGY

The primary purpose of this study was to assess the current risk management practices of major contractor firms in the United States. One of the key objectives of the study was to investigate the extent to which study participants practice selected risk management techniques. The population for the study consisted of top Engineering News Record (ENR) 400 contractors listed in the ENR publication. From this population, a sample of 200 participants was randomly selected to participate in the study. A structured survey questionnaire was used to gather all the necessary data needed to conclude the study. The practices evaluated included: risk identification, risk assessment, risk response and risk monitoring. Respondents were also asked to indicate what they perceived to be major barriers to implementing risk management system in their organizations. Forty (40) completed questionnaires were returned, yielding a response rate of 20 percent.

The collected data was analyzed using SPSS 17 software. Descriptive statistics was employed in calculating the mean rating and for ranking the importance of project risks, frequently used risk management practices, and major barriers to implementation of risk management. One-way Analysis of Variance (ANOVA) was used to test for significant differences in the perceptions of project risk importance and perceptions of barriers to implementation of risk management among contractors with differing work specialty. One-way ANOVA was also used to test for significant differences in the practice of risk management techniques among contractors with differing work specialty. For the purpose of this paper, findings related to risk assessment and barriers to risk implementation are reported.

IV. RESULTS

4.1 Demographic Background

To gather their background information relative to the types of construction work performed, respondents were asked to identify their top two work specialty areas. The result revealed that 50% of the respondents engage in commercial and residential work, with 30% in industrial and Highway and Heavy construction. The rest are engaged in commercial and industrial work. When asked if they implement any form of risk management practices, an overwhelming majority (95%) indicated affirmatively. They also indicated that their companies have a formal written procedure for risk management. In order to assess the degree of importance placed on construction risks, respondents were asked to rank 14 identified project risks based on their importance or severity on a scale of 1 to 5; where 5 represents extreme risk, 4 represents high risk, 3 represents moderate risk, and 2 and 1 represent low risk and negligible risk, respectively. Table 1 presents the mean rating value for each of the risk factors.

It is evident from the Table that the top 5 project risks identified to be very important or severe include Safety, Defective design, Quality of work,

Financial risk, and Incompetence of Subcontractors. The top three ranked construction project risks in this study were consistent with the top three rankings of construction project risks reported in a study conducted by Kangari [14] in a 1995 survey of top 100 U.S. contractors. These similar findings have serious implications for construction industry. This means that safety, defective work, and quality of work will continue to be important risk factors in construction business. Therefore contracting firms must continue to employ appropriate strategies to mitigate those risks [19]. Further analysis was performed to assess how contractors of differing work specialty ranked the top 5 project risks. Table 2 shows high level of consistency among the three major contractor groups. Again, safety was ranked number 1 project risk by respondents who identified their construction specialties as commercial/residential, industrial/Highway/Heavy, and commercial/Industrial construction, respectively. A One-way ANOVA was performed to test for differences in the perception of the three contractor groups, using 0.05 level of significance. The results did not show any statistical significant differences in the perception of the top five construction project risks among the groups (Table 3). However, significant differences were found between the contractor groups relative to their perceptions of Delayed Payment (F=3.384, p=0.045,) and Labor, Equipment and Material Availability (F=3.842, p= 0.030).

Table 1. Ranking of Identified Construction Project Risks

Project Risk Description	Mean Rating	Rank
Safety	4.52	1
Defective work	3.90	2
Quality of work	3.87	3
Financial risk	3.78	4
Incompetence of subcontractors	3.77	5
Claims and disputes	3.40	6
Inflation and sudden changes in prices	3.33	7
Delayed payment	3.33	7
Defective materials	3.23	8
Differing site condition	3.12	9
Labor and equipment productivity	3.12	9
Labor, equipment. & material availability	2.98	10
Force majeure/Acts of God	2.93	11
Site access/Right of way	2.79	12

Table 2. Ranking of top five construction project risks based on contractor classification

Project Risk	**Overall (n=40)**		**Commercial & Residential Cont. (n=20)**		**Industrial & Highway/ Heavy Cont. (n=12)**		**Commercial & Industrial Cont. (n=8)**	
	Mean	**Rank**	**Mean**	**Rank**	**Mean**	**Rank**	**Mean**	**Rank**
Safety	4.53	1	4.60	1	4.50	1	4.38	1
Defective design	3.90	2	3.80	5	4.00	2	4.00	2
Quality of work	3.88	3	4.05	2	3.67	3	3.75	3
Financial risk	3.78	4	4.00	3	3.58	5	3.50	5
Incompetence of Subcontractors	3.77	5	3.90	4	3.67	3	3.57	4

Table 3. One-Way ANOVA on top five ranking of construction project risks based on contractor classification

Project Risk		**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
Safety	Between Groups	.300	2	.150	.156	.856
	Within Groups	35.675	37	.964		
	Total	35.975	39			
Defective Design	Between Groups	.400	2	.200	.171	.843
	Within Groups	43.200	37	1.168		
	Total	43.600	39			
Quality of Work	Between Groups	1.258	2	.629	.474	.626
	Within Groups	49.117	37	1.327		
	Total	50.375	39			

Financial risk	Between Groups	2.058	2	1.029	1.091	.347
	Within Groups	34.917	37	.944		
	Total	36.975	39			
Incompetence of Subcontractors	Between Groups	.742	2	.371	.266	.768
	Within Groups	50.181	36	1.394		
	Total	50.923	38			

Table 4 presents the respondents' mean ratings on risk assessment techniques. Among the ten listed risk assessment factors, the top three factors commonly used to assess the importance of risks by contractors were insurance coverage, financial capability (to bear the risk) and allocation of risk. These findings parallel those of Tang et al. [15] who argued that contractors have less capability to bear risk because they bid for jobs with narrow margins, which often makes it difficult for them to deal with risks related finance. Similarly, Kangari [14] found that contractors tend to give importance to risks that are allocated to them and are much more willing to assume risks as the use of insurance increases. Further analysis (Table 5) showed that the contractor group did not differ in their use of the identified risk assessment techniques, except in the use of "economic condition of the country" (F=6.097; p=0.005).

Certain barriers prevent general contractors from engaging in risk management practices [6]. To assess what the study respondents perceived to be barriers to their risk management efforts, they were asked to rank nine identified risk barriers based on their level of significance. The results showed that all the barriers presented were rated with moderate to low significance (Table 6). Lack of joint risk management was found to be the most significant barrier to risk management implementation followed by lack of time and shortage of knowledge.

Table 4. Mean rating for risk assessment techniques.

Risk Assessment Techniques	Overall (n=40)		Commercial & Residential Cont. (n=20)		Industrial & Highway/ Heavy Contr. (n=12)		Commercial & Industrial Cont. (n=8)	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
Insurance coverage	4.35	1	4.60	1	4.00	4	4.25	2
Financial capability	4.28	2	4.30	3	4.25	1	4.25	2
Allocation of risk	4.28	3	4.45	2	4.25	1	3.88	8
Likelihood of risk occurrence	4.05	4	4.00	7	4.00	4	4.25	4
Extent of the impact	3.95	5	3.75	9	4.00	4	4.38	1
Quantity of work	3.95	6	4.15	5	3.42	9	4.25	4
Location of project	3.93	7	4.05	6	3.67	7	4.00	6
Contract method	3.90	8	3.75	9	4.08	3	4.00	6
Duration of the work	3.80	9	3.95	8	3.58	8	3.75	9
Economic condition of the country	3.73	10	4.20	4	3.00	10	3.63	10

Table 5. One-Way ANOVA for risk assessment technique among contractors with differing work specialties.

Risk assessment		Sum of Squares	Df	Mean Square	F	Sig.
Financial capability	Between Groups	.025	2	.012	.015	.985
	Within Groups	29.950	37	.809		
	Total	29.975	39			
Allocation of risk	Between Groups	1.900	2	.950	2.497	.096
	Within Groups	14.075	37	.380		
	Total	15.975	39			
Duration of the work	Between Groups	1.033	2	.517	.512	.604
	Within Groups	37.367	37	1.010		
	Total	38.400	39			
Quantity of work	Between Groups	4.933	2	2.467	2.947	.065
	Within Groups	30.967	37	.837		
	Total	35.900	39			
Economic condition of the country	Between Groups	10.900	2	5.450	6.097	.005
	Within Groups	33.075	37	.894		
	Total	43.975	39			
Insurance coverage	Between Groups	2.800	2	1.400	1.970	.154
	Within Groups	26.300	37	.711		
	Total	29.100	39			
Location of project	Between Groups	1.158	2	.579	.541	.587
	Within Groups	39.617	37	1.071		
	Total	40.775	39			
Contract method	Between Groups	.933	2	.467	.370	.693
	Within Groups	46.667	37	1.261		
	Total	47.600	39			
Likelihood of risk occurrence	Between Groups	.397	2	.199	.304	.739
	Within Groups	23.500	36	.653		
	Total	23.897	38			
Extent of the impact	Between Groups	2.275	2	1.138	1.181	.318
	Within Groups	35.625	37	.963		
	Total	37.900	39			

Table 6. Mean rating for barriers to risk management implementation.

Risk Management Barriers	Overall (n=40)		Commercial & Residential Contr. (n=20)		Industrial & Highway/ Heavy Contr. (n=12)		Commercial & Industrial Contr. (n=8)	
	Mean	**Rank**	**Mean**	**Rank**	**Mean**	**Rank**	**Mean**	**Rank**
Lack of joint risk management	3.10	1	3.25	1	3.17	1	2.63	2
Lack of time	3.00	2	3.10	2	3.17	1	2.50	3
Shortage of knowledge	2.90	3	3.00	3	2.75	5	2.86	1
Lack of risk consciousness	2.75	4	2.60	6	3.17	1	2.50	3
Inappropriate risk allocation	2.65	5	2.50	7	3.00	4	2.50	3
Unavailability of sound data	2.60	6	2.65	5	2.58	7	2.50	3
Ineffective risk control and monitoring strategies	2.50	7	2.45	8	2.75	5	2.25	8
Lack of formal risk management	2.45	8	2.70	4	2.17	8	2.25	8
Lack of expertise in risk management	2.20	9	2.15	9	2.17	8	2.38	7

Further statistical analysis was performed to assess any correlation between barriers to risk management and risk assessment techniques. Among the risk assessment technique factors, duration of work (r= -0.412; p=0.008), quantity of work (r= -0.394; p= 0.012), and location of project (r= -0.374; p= 0.017) were found to be correlated with lack of consciousness to risk. These findings suggest that an increase in lack of consciousness to risk management is associated with a decrease in the use of duration of work, quantity of work, and location of project for assessing the impact or importance of risk. Quality of work was also correlated with unavailability of sound data (r= 0.316; p= 047). This suggests that lack of available sound data for risk management will more likely encourage contractors to use quality of work as an alternative in assessing construction risks.

V. CONCLUSIONS

This study was conducted to investigate and assess the risk management practices of selected major contracting firms in the United States. However, this paper only focuses on the assessment techniques used by the study participants in their risk management practices. Also discussed are the barriers that often prevent these firms from practicing certain risk management techniques. The study found that an overwhelming majority of contractors practice some form of risk management. These contractors also have formal written procedures for risk management. Having a formal written risk management program is an indication of an awareness of the importance of risk management in their construction business. Also, it can be deduced that safety, defective work, and quality of work are important risk management factors in the construction industry. These three areas will more likely continue to be focus areas of risk management discussion in the industry due to variation and complexity of construction project. While contractors of differing work specialties had similar perceptions towards the importance of project risks, there were no statistically significant differences in the way they practice major risk management techniques.

Contractors use a wide variety of techniques in their risk management practices. The most important risk assessment techniques commonly used by most contractors include insurance, financial capability, and risk allocation. Insurance also happens to be a technique widely used by the contractors in responding to any potential risk. Contractors also respond to project risks by trying to reduce the likelihood of such risk occurring. When feasible, they simply find ways to transfer the risk to someone else who is perhaps able to bear the risk.

While there was no single dominant barrier to risk management implementation, lack of joint risk management, risk consciousness, expertise in risk management, and lack of time seem to be the major barriers to risk management practices among the contracting firms. In order to improve risk

management practices, these areas must be addressed. Further studies are needed to support our findings and to improve risk management practices in the construction industry. Thus, it is recommended that an investigation of the perceptions of other construction project stakeholders relative to project risks be conducted.

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