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CLASSIFYING KEY RISK FACTORS IN CONSTRUCTION PROJECTS

BY

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Abstract. Risk management is an important step in project success. It is the process of identifying, classifying, analysing and assessing of inherent risks in a project. Due to the nature of the construction projects which consists of many related and none-related operations, many risk factors will contribute in a project. To have an effective risk management plan, at first step the key risk factors which have the most effect on project objectives should be identified and classified. This paper is an investigation of different risks which may be involved in construction projects. Project management functions which have the most effect on risk management plan are categorized and an analysis of key risk factors in every category is described. Finally a hierarchical risk classification to cover all the effective key risk factors in construction projects is suggested. Case studies have shown that this classification covers the most key risks that should be taken into consideration in a risk management plan.

Key words: risk analysis; risk classification; risk management; construction projects.

1. Introduction

A risk is defined as the potential for complications and problems with respect to the completion of a project and the achievement of a project goal

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(Mark *et al*., 2004) and as an uncertain future event or condition with the occurrence rate of greater than 0% but less than 100% that has an effect on at least one of project objectives (*i.e*., scope, schedule, cost, or quality, etc.). In addition, the impact or consequences of this future event must be unexpected or unplanned (Chia, 2006). It is well accepted that risk can be effectively managed to mitigate its' adverse impacts on project objectives, even if it is inevitable in all project undertakings. The source of risk includes inherent uncertainties and issues relative to company's fluctuating profit margin, competitive bidding process, weather change, job-site productivity, the political situations, inflation, contractual rights, and market competition, etc. (Karimiazari *et al*., 2011). It is important for the construction companies to face these uncertain risks by assessing their effects on the project objectives because a risk quantitative method allows deciding which of the project is more risky, planning for the potential sources of risk in each project, and managing each source during construction (Zayed *et al*., 2008). It is noteworthy that risk is distinguished from uncertainty. The one is measurable uncertainty; the other is immeasurable risk (Hillson, 2004; Olsson, 2007; Karimiazari *et al*., 2011).

Therefore, managing risks is involved in identifying, assessing and prioritizing risks by monitoring, controlling, and applying managerial resources with a coordinated and economical effort so as to minimize the probability and/or impact of unfortunate events and so as to maximize the realization of project objectives (Douglas, 2009). Project risk management, which has been practiced since the mid-1980s, is one of the nine main knowledge areas of the project management institute's project management body of knowledge (Tuysz *et al*., 2006). Effective risk management may lead the project manager to several benefits such as identification of favourable alternative course of action, increased confidence in achieving project objective, improved chances of success, reduced surprises, more precise estimates (through reduced uncertainty), reduced duplication of effort (through team awareness of risk control actions), etc. (Bannerman, 2008).

Systemic project risk management has an effect on the project success. It is found that there is a strong relationship between the amount of risk management efforts undertaken in a project and the level of the project success (Elkington & Smallman, 2002; Reza *et al*., 2002). Several project risk management approaches are proposed as follows; *i.e*., PRAM (Chapman, 1997), RAMP (Institute of Civil Engineering, 2002), PMBOK (PMI, 2008), RMS (Institute of Risk Management, 2002), etc. (Nieto *et al*. 2011). Existing approaches may be summarized into a four phase process for effective project risk management, *i.e*., identifying risks, assessing risks, responding risks, and monitoring and/or reviewing risks. Identifying risks is the first step which determines which risk components may adversely affect which project objectives and documents their characteristics (Karimiazari *et al*., 2011). Construction risks are classified in many ways by risk types (*i.e*., natures, and

magnitudes, etc.), the sources and/or origins, or project phase (Cooper & Chapman, 1987; Edwards & Bowen, 1998; Klemetti, 2006; Zhou *et al*., 2008). Some of the existing researchers propose a hierarchical structure of risks which classifies the risks according to their origin and the location which the risk impacts to the project (Tah *et al*., 1993; Wirba *et al*., 1996).

Table1

Key Expertise for Risk Analysis by Project Phase †

Discipline	Planning/ Programming	Preliminary Engineering	Final Design	Construction
Planning	●	●	O	
Environmental	●	●	O	O
Funding Approval	●	●	O	
Project Management	●	●	●	●
Engineering	●	●	●	●
Civil, Structural, Systems	O	O	●	●
Cost Estimating	O	●	●	●
Scheduling	O	●	●	●
Budgeting Controls	O	O	●	
Real Estate/Right of Way	O	●	●	O
Construction Management/ Oversight	O	O	●	●
Constructability /Contractor	O	O	O	●
Other Technical (*e.g*. Legal)		●	●	●
Risk Facilitation	●	●	●	O

● Highly Desirable;
O Desirable but optional depending upon circumstances.

Responding risks is involved in developing options and/or actions to enhance opportunities to achieve the project objectives. Finally, monitoring and reviewing risks revert to implementing a risk response plan, to keep tracking of the risks identified, to monitor residual risks, to identify new risks, and to evaluate the effectiveness of the project risk management process (Nieto *et al*., 2011). For this step, each engineering expertise should use specialized risk analysing tool as shown in Table 1 depending on project phase.

† Adapted from NCHRP 8-60, *Guidebook on Risk Analysis Tools and Management*, 2009.

2. Effective Project Elements on Project Risk Management

Project risk management is in collaboration with other project elements and an efficient risk management plan considerably increases the chance of gaining project scope. In Fig. 1 the effect of other project elements with project risk management is integrated. In Table 2 through 10 risk event and conditions of each project element is described.

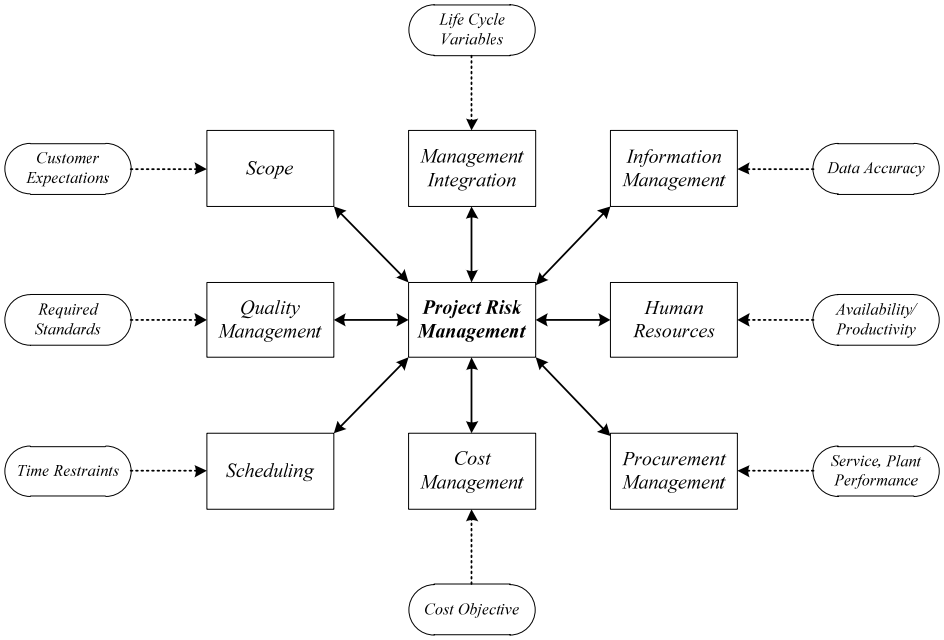

Fig. 1 – Integrating risk with other project management functions.

Table 2
Risk Event and Risk Conditions of Management Integration

Management Integration	
Risk event	Risk conditions
Incorrect start of integrated PM relative to project life cycle.	Inadequate planning, integration or resource allocation. Inadequate, or lack of post-project review.

Table 3
Risk Event and Risk Conditions of Information Management

Information Management	
Risk event	Risk conditions
Inaction or wrong action due to incorrect information or communication failure.	Carelessness in communicating. Improper handling of complexity. Lack of adequate consultation with project's "publics" (internal/external).

Table 4
Risk Event and Risk Conditions of Human Resources

Human Resources	
Risk event	Risk conditions
Strikes, terminations, organizational breakdown.	Conflict not managed. Poor organization, definition or allocation of responsibility, or otherwise absence of motivation. Poor use of accountability. Absence of leadership, or vacillating management. Consequences of ignoring or avoiding risk.

Table 5
Risk Event and Risk Conditions of Procurement Management

Procurement Management	
Risk event	Risk conditions
Contractor insolvency. Claims settlement or litigation.	Unenforceable conditions/clauses. Incompetent or financially unsound workers/ contractors. Adversarial relations. Inappropriate or unclear contractual assignment of risk.

Table 6
Risk Event and Risk Conditions of Cost Management

Cost Management	
Risk event	Risk conditions
Impacts of accidents, fire, theft. Unpredictable price changes.	Estimating errors, including estimating uncertainty. Lack of investigation of predictable problems. Inadequate productivity, cost or change control. Poor maintenance, security, purchasing, etc.

Table 7
Risk Event and Risk Conditions of Scheduling

Scheduling	
Risk event	Risk conditions
Specific delays, *e.g.*, strikes, labor or material availability, extreme weather, rejection of work.	Errors in estimating time or resource availability. Poor allocation and management of float. Scope of work changes without due allowance for time extensions/acceleration. Early release of competitive product.

Table 8
Risk Event and Risk Conditions of Quality Management

Quality Management	
Risk event	Risk conditions
Performance failure, or environmental impact.	Poor attitude to quality. Substandard design/materials/workmanship. Inadequate quality assurance program.

Table 9
Risk Event and Risk Conditions of Scope

Scope	
Risk event	Risk conditions
Changes in scope to meet project objectives.	Inadequacy of planning, or planning lead time. Poor definition of scope breakdown, or work packages. Inconsistent, incomplete or unclear definition of quality requirements. Inadequate scope control during implementation.

3. Risk Classification

3.1. Literature Review

PMBok (Version 2008) defines risk classification as a provider of a structure that ensures a comprehensive process of systematically identifying risks to a consistent level of detail and contributes to the effectiveness and quality of the risks process identification. Risk classification is an important step in the risk assessment process, as it attempts to structure the diverse risks that may affect a project. There are many approaches in literature for construction risk classification. Perry & Hayes (1985) give an extensive list of factors assembled from several sources, and classified in terms of risks retainable by contractors, consultants and clients. Abdou (1996) classified

construction risks into three groups, *i.e*. construction finance, construction time and construction design. Shen (1997) identified eight major risks accounting for project delay and ranked them based on a questionnaire survey with industry practitioners. Tah & Carr (2000) classified project risks by using the hierarchical risk breakdown structure (HRBS) and classified them into internal and external risks. Chapman (2001) grouped risks into four subsets: environment, industry, client and project. Shen (2001) categorized them into six groups in accordance with the nature of the risks, *i.e*. financial, legal, management, market, policy and political. Chen *et al*. (2004) proposed 15 risks concern with project cost and divided them into three groups: resource factors, management factors and parent factors. Assaf & Al-Hejji (2006) mentioned the risk factors as the delay factors in construction projects. Dikmen *et al*. (2007) used influence diagrams to define the factors which have influence on project risks. Zeng *et al*. (2007) classified risk factors as human, site, material and equipment factors.

3.2. Risk Breakdown

Generally risk factors in a project can be categorized based on their source and effect on project objectives and can be categorized in external, internal and legal categories. The following detailed figure (Fig. 2) and risk break down (Tables 10,...,14) provide convenient groupings of project risks generally classified according to source. The degree of predictability and ability to manage appropriate response varies but, in any case, is independent of the risk event status.

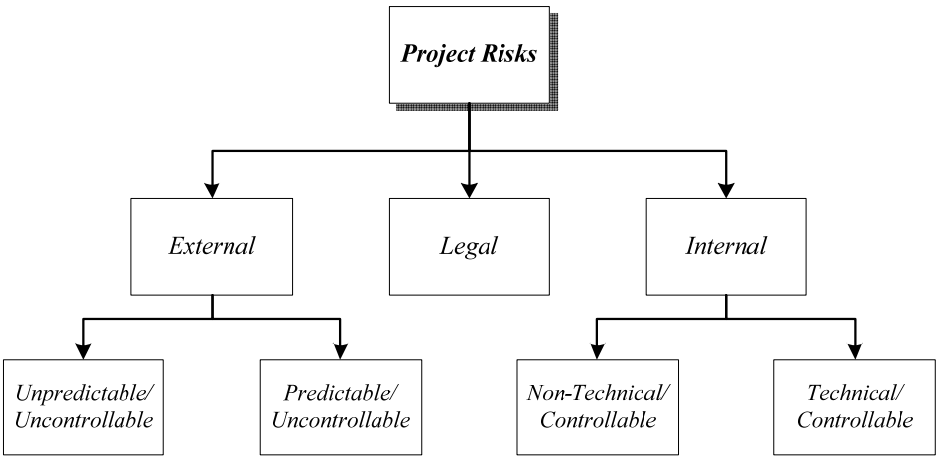

Fig. 2 – Specific project risks.

Table 10
"*External Unpredictable*" *Risk Break Down*

External Unpredictable/Uncontrollable				
Regulatory	Natural hazards	Postulated events	Indirect effects	Completion
Supply of raw materials. Environmental issues. Design standards. Production standards. Site location. Product or service sales or export. Pricing. Special requirements.	Location. Storm. Flood. Earthquake.	Vandalism. Sabotage.	Environmental. Social.	Failure of the supporting infrastructure as a result of others. Failure of design, execution or supply contracts due to bankruptcy or receivership, etc. Failure to provide financial support to the end of the project. Inappropriate project concept or configuration. Political unrest. Lack of final acceptance.

Table 11
"*External Predictable*" *Risk Break Down*

External Predictable/Uncontrollable						
Market Risks	Operational	Environmental impacts	Social impacts	Currency changes	Inflation	Taxation
Availability of raw materials. Cost of raw materials. Demand, including. customer/user rejection. Economics. Competition. End value in the market. Willingness of buyers to honor purchase agreements.	Maintenance needs. Fitness for purpose. Safety.					

Table 12
"*Internal Non-Technical*" *Risk Break Down*

Internal Non-Technical/Controllable				
Management	Schedule	Cost	Cash flow	Potential loss
Insincerity /lack of integrity. Incapacity. Inadequacies. Loss of control. Incompatibility of goals. Senior staff changes. Inappropriate or lack of organizational structure. Lack of appropriate policies and procedures. Inadequate planning. Unrealistic scheduling. Lack of coordination. Inadequate project management.	Delays due to management difficulties above. Regulatory approvals. Labor shortages. Labor productivity. Labor stoppages. Material shortages. Late deliveries. Unforeseen site conditions. Sponsor I user scope changes. Accident or sabotage. Start-up, turn-over or launch difficulties. Lack of access.	Any of the schedule delays listed. Inappropriate procurement strategy. Pay negotiations. Management and/or workforce inexperience. Lack of understanding how parts fit together. Contractor claims. Under-estimating. Any of the external factors listed previously.	Squeezing. Interruption. Insolvency.	Benefit. Profit.

Table 13
"Internal Non-Technical" Risk Break Down

Internal Technical/Controllable				
Changes in technology	Performance	Technology	Design	Complexity
Rendering parts of the project obsolete. Parts discontinued. Introduced by competitors, rendering the project obsolete, uncompetitive, or unacceptable. Complexity introduced as a result of new technology.	Quality. Rate of production. Reliability.	In creating the entity or product. In operating or marketing.	Inadequate data. Designer I detailer inexperience. Design inadequacies. Detail, precision and suitability of the specification. Likelihood of changes during the course of the project. Design *vs*. execution methods.	

Table 14
"Legal" Risk Break Down

Legal					
Licenses	Patent rights	Contractual	Outsider suit	Insider suit	Force majeure
		Misinterpretation. Misunderstanding. Inappropriate contracting. Strategy I contract type. Failure.			

3.3. Proposed Hierarchical Risk Breakdown

By summarizing and merging some of the above risk factors, following hierarchical risk breakdown structure for construction projects is proposed (Fig. 3).

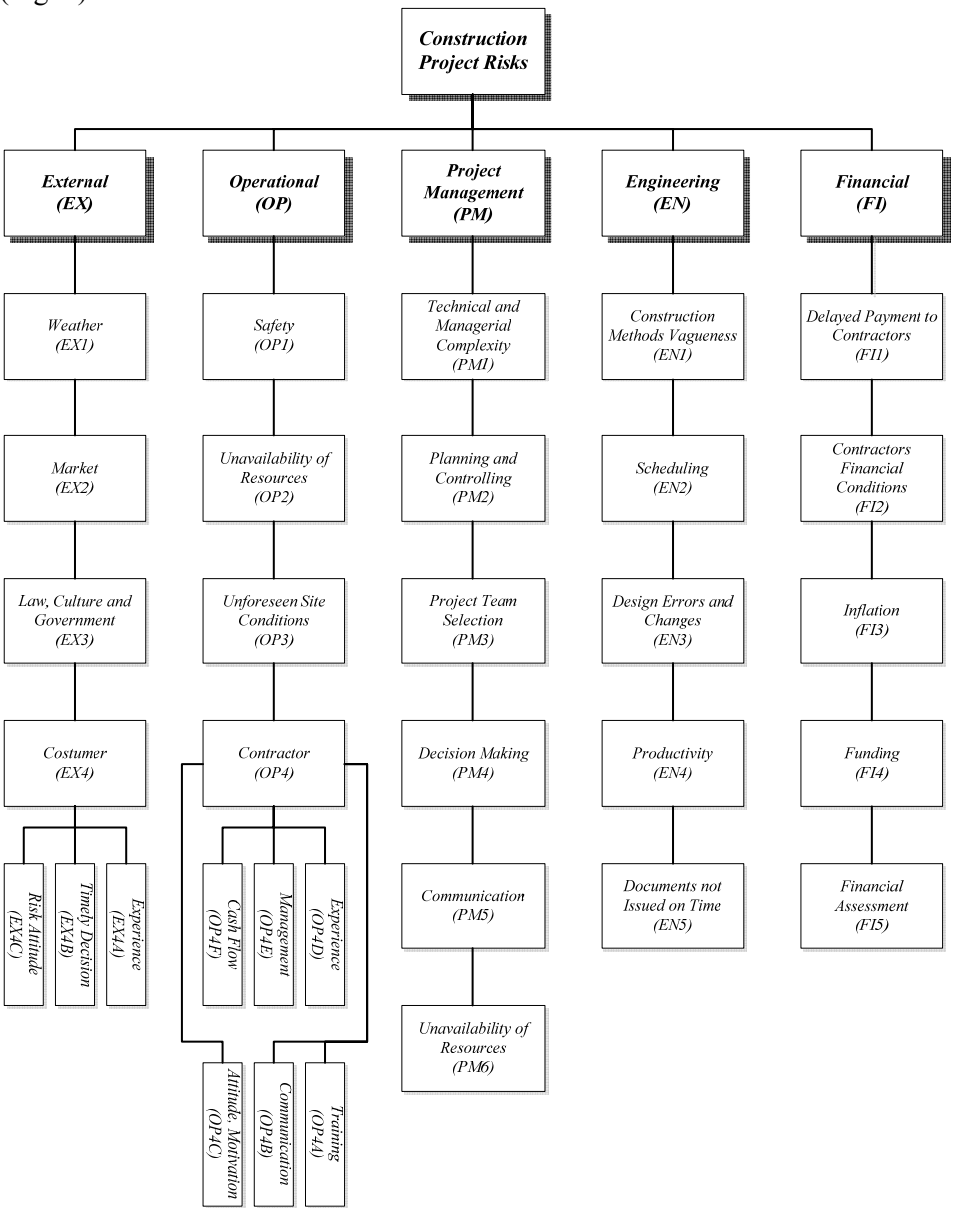

Fig. 3 – Suggested hierarchical risk breakdown structure for construction projects.

4. Conclusion

In this paper, the most effective key risk factors which have a significant effect on construction projects scope are identified and classified through a comprehensive literature survey and professional experiments of experts in construction management field. In proposed classification, effort is to cover the most effective risk factors. Case studies have shown that by utilizing proposed hierarchical risk breakdown, most of the risks in regular and complex projects are covered and as a result an effective risk management plan can be conducted.

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CLASIFICAREA FACTORILOR DE RISC PRINCIPALI ÎN PROIECTELE DE CONSTRUCȚII

(Rezumat)

Managementul riscului este un pas important în succesul unui proiect de construcții. Acesta implică procesul de identificare, analiză şi evaluare a riscurilor inerente într-un proiect. Datorită naturii, în proiectele de construcție sunt implicați mai mulți factori de risc. Pentru a avea un sistem eficient de gestionare a riscurilor, în primul rând trebuie identificați şi clasificați factorii principali de risc, cu cel mai mare efect asupra obiectivelor proiectului. Se analizează diferite riscuri care pot fi implicate în proiectele de construcții.

Sunt clasificate funcțiile de managemet ale proiectelor, care au cel mai mare efect asupra planului de gestionare a riscurilor. De asemenea este efectuată şi o analiză a factorilor de risc cheie din fiecare categorie. În cele din urmă se sugerează o clasificare care să acopere toți factorii esențiali de risc din proiectele de construcții. Studiile de caz au arătat că această clasificare acoperă riscurile cele mai importante care ar trebui luate în considerare într-un plan de gestionare a riscurilor.