Chapter 3

Risk Management in Construction

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Additional information is available at the end of the chapter

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Abstract

Construction industry have several different sectors producing heterogeneous products, which are immobile, unique, heavy and large, complex, durable and costly. Site conditions in a construction project can be unpredictable and unexpected natural events can negatively affect construction programs and schedules. Weather conditions constitute the most important and unpredictable handicap for the production process of construction. Construction projects usually executed over a long period and have large budgets. Because of this, demand for a construction project is volatile. Unpredictable site conditions and demand volatility bring high level of risk. Because of this, risk management is very important in construction. Construction insurance, surety bonds, contracts and subcontracting are the main affective solutions for the risk management. This study consists of two main sections. In the first section, characteristics of construction industry defined in detail. Secondly, the importance of risk management evaluated. In the second section, the focus of the study is the evaluation of risk management studies in construction with a broad literature review of previous researches.

Keywords: construction industry, risk management, insurance, surety bond, contract, subcontract

1. Introduction

Construction industry is a sector, which, in many ways, different from all others fields of economic endeavor. Loosely organized firms do non-repetitive work with handcraft methods, and use a contract system involving a serious of subcontractors. The products of the construction industry are immobile, unique, heavy and large, complex, durable and expensive. Characteristics of products changes project to project. Construction products not only takes long time to produce, but also produced and coordinated on-site; and this requires different schedules, programs and temporary solutions for each project.

Since, beginning with unpredictable site conditions and demand volatility, construction process bring high level of risk, a careful management of risks is very important in construction. Risk management is not only important for successfully completing the production process in construction industry, but also for achieving sustainability. Sustainable construction defined as creating a healthy built environment based on ecologically sound principles, and aims to create and operate a healthy built environment based on resource efficiency and ecological design [1]. A careful risk management means an effective using the resources and responsible management of a healthy built environment based on ecologically sound principles. Success lies in the details mean in sustainable construction all details require a careful design and production management.

The objective of this study is emphasizing the importance of risk management and defining affective risk management tools in construction. This study consists of two main sections. In the first section, characteristics of construction industry and construction risks are defined in detail. In the second section, the importance of risk management in building construction and risk management tools are evaluated. In this section, the focus of the study is the evaluation of risk management studies with a broad literature review of previous researches.

2. Construction industry characteristics

Construction has many characteristics common to both service and manufacturing industries. Although, construction is more like a service industry in some ways, because it does not accumulate significant amounts of capital when compared with industries such as steel, mining, transportation and petroleum; there are physical products, and often these are of overwhelming size, cost and complexity as the manufacturing industry. Success or failure in construction industry is by far more dependent on the qualities of its people than it is on technologies protected by patents out by the sheer availability of capital facilities as in service industries [2].

2.1. On-site production

In construction industry, the product is immobile and produced at the point of consumption. Each project is site specific, produced and coordinated on-site, the contractor sets up the factory on-site. Besides, all the complexities inherent in different construction sites. Subsoil conditions, weather, surface topography, transportation, material supply, utilities and services, local subcontractors, available technologies and labor conditions are an innate part of construction. Execution of the project is influenced by social, natural and other locational conditions such as weather, labor supply and local building codes. The anticipation of future requirements is inherently difficult, since the service life of a facility is long. Changes of design plans during construction are uncommon, because of technological complexity and market demands [3, 4]. In a construction project, since site conditions can be unpredictable, unexpected natural events can negatively affect construction programs and schedules. Weather conditions, for the production process of construction, are the most important and unpredictable handicap [5]. One of the two different side effects of weather conditions is unexpected changes in weather might stop, slow down or destroy production. Confining the production process to mild seasons is the other side effect of changes in weather. Construction activities

show a trend of seasonality, since it is difficult to execute outdoor activities in winter. Summer is the most active and highest season for all the projects in a contractor's portfolio. Most of the production required to complete before winter, since winter is a problematic season [6].

2.2. Properties of the product

The product is changeable in construction industry. It is one-of-a-kind, large, complex, durable and long lasting. There may be big value differences among the products. Production depends on a project and construction projects typified by the non-standardized nature by their diversity and complexity. The construction process is sometimes subject to the influence of highly variable and unpredictable factors. Nearly every facility requires a long time to complete and custom designed and constructed. To some degree, each construction project is unique and two projects cannot be the same. The vagaries of the construction site and the possibilities for creative and utilitarian variation combine to make each construction project a new and different experience. Both the design and construction of a facility required to satisfy the conditions peculiar to a specific site [3, 4].

2.3. Uncertainty and high level of risk

Construction projects usually executed over a long period and have large budgets. In construction industry, demand is not regular; it is both seasonal and volatile. Construction industry is one of the industries, which is the most effected by the economic crisis. During economic crisis, demand decreases. Because of this, demand for a construction project is volatile. Irregular demand in construction leads construction firms that have difficulty in keeping their overhead down in the case of low demand. In the case of high demand, responding to the load of irregular demand forces the contractor to search for other organizational forms than the traditional forms used in manufacturing [6]. It brings uncertainty in decision-making when different production methods required or the project executed in different parts of the country or the world. Different types of products, such as dam, highway and high-rise building, executed at the same time is a source of uncertainty. Every project requires different design study and production results, which brings both uncertainty and high level of risk.

2.4. Labor specialties

Construction is an industry that involves many different participants from different fields. Owner, design professional, contractor, subcontractors and material suppliers are vital elements of the construction project. A successful project can only achieved if interrelated roles of the participants coordinated effectively. During the life cycle of the project, beginning with the owner's first contemplating a construction project to the completion, there are different types of works, vary in type and intensity, which makes the process complicated. A large number of labor specialties required in construction projects such as electrical installation, sanitary installation or thermal insulation. Cooperation of experts from different fields required, since most of these trades demand the knowledge and experience of experts and it is hard and long way for a contractor to gain this expertise through project experiences. When a problem arises, the solution will be different in a highway project, compared to a solution in a building project. Therefore, outside assistance is needed, such as consultants and subcontractors [6].

2.5. Non-routine production system

Production process in construction industry is less amenable to routinize, because products have diverse characteristics and executed over a long period. A construction firm can execute different types of projects, all of which require different production schedules and systems all at the same time. Hence, this makes the decisions of labor and machinery investments uncertain. Not only coordination of resources among different projects becomes a major problem, but also new schedules and programs are required for each new project. Since the industry requires short-term project objectives and flexibility, construction named a casual industry [6].

3. Method

The specific characteristics of construction industry make the production process risky. Construction projects are time-consuming and intricate undertakings. There are several phases requiring a diverse range of specialized services during a total development of a project. Beginning with the planning phase, the process continues passing typical jobs through successive and distinct stages to project completion. The project demand input from such disparate areas, such as governmental agencies, financial organizations, architects, engineers, lawyers, contractors, material manufacturers and suppliers, insurance and surety companies and building tradesmen [3]. These various parties from different fields have to work together in harmony for successfully completing the project. The high performance green building delivery system requires close collaboration among the parties, much more than in conventional construction delivery system [1].

This study focuses on risk management in construction through the view of sustainability. For this purpose, in the first place a broad literature review of previous studies completed. After evaluation of the previous studies, specific characteristics of construction industry identified. Since, the characteristic of the industry form the basics of risk management in construction industry, risks of construction industry are analyzed. In the last section, the study focuses on the four different tools of risk management in construction.

4. Risks of construction industry

Construction is often a hazardous undertaking work. Risk, as a multi-facet concept [11], is an uncertain event or condition [7] and can defined as the "probability that an adverse event occurs during a stated period of time" [8]. If risk occurs, it has either positive or negative effects on project objectives [7]. In the context of construction industry, according to Faber [9], it could be the likelihood of the occurrence of combination of events/factors or a definite event/factor, which occur during the whole process of construction to the detriment of project. Hertz and Thomas [10] defined construction risks as a lack of predictability about structure outcome or consequences in a decision or planning situation. It is the uncertainty associated with estimates of outcomes—there is a chance that results could be better than expected as well as worse than

expected [11]. A risk means, for a construction contractor, an event that will cause costs that were not planned and from which no profit will result [12]. Risk may result substantial cost and time overruns that are detrimental the project objectives, and inherent to any construction project. Arising from delays and additional costs in particular if it comes to public construction projects, not only could project owners [clients], construction contractors but also community at large suffer from losses. Not only the contractor, but also the client's role can be critical to the success of construction projects [13]. Clients do not pay on time or dispute claims for change orders or file for bankruptcy. Contractors cannot or do not reduce fixed overhead fast enough in rough times or their cash runs short. Sometimes, subcontractors do not perform as required, or go broke [14]. It is a common fact among the participants within the construction industry continually faced with a variety of situation, involving many unknown, unexpected, frequently undesirable and often unpredictable factors [15].

The most common and well-known risks embedded in construction are the health and safety issues, delivery scheduling and aspects related to finances. The sector is full of risks that relate to planning, execution, communication and interaction with the surrounding society [16]. A primary classification of construction industry risks are natural and human risks. Natural risks occur outside human agencies or systems, while human risks arise within humanly organized systems. The sub categories of human risks relating to construction and project risks include social, political, economic, financial, legal, health, managerial, technical and cultural risks [8].

4.1. Natural risks of construction

4.1.1. Weather systems

Weather risks covers, adverse weather conditions, the probability of hurricane, typhoon, tornado, flood, tidal wave and lightning strike [8]. If it rains for 2 months while the job is coming out of the ground, meeting the schedules can be impossible [14]. Pollution is a risk factor, because dust, harmful gasses, noise, solid and all of the liquid wastes are harmful to nature and affect final quality of the construction [17].

4.1.2. Geological systems

Geological risks covers, discrepancy in geology and topographic conditions, the probability of earthquake, volcanic eruption and geotechnical fault [8]. Physical risks, such as subsurface conditions, are among the geological system risks of construction. Subsurface condition, different from anticipated, can lead to excavation costs, which is greater than expected [12]. Although, geological investigation reports provide information on the type of soil that contractors can expect to deal with, the contractor still has to rely on experience of the relative occurrences of 'adverse ground conditions' among different soil types, site conditions and site history to make judgments about the risk of adverse ground conditions on any site [18]. Site conditions, particularly subsurface conditions, can create an even greater degree of uncertainty for facilities with heretofore-unknown characteristics during operation [4]. Sometimes it can be possible that non-documented site conditions present themselves mid-project [14].

4.2. Human risks of construction

4.2.1. Social risks

This type of human risks covers criminal acts, such as sabotage and arson, civil torts, such as trespass, damage to fences, unauthorized graffiti and similar acts of vandalism, and substance abuse. While such indices are likely to result in the project proponent appearing as plaintiff or as witnesses for the prosecution, these can also lead to risks of counterclaims by the perpetrators. Social risks in construction industry are becoming a more frequent occurrence on projects vulnerable to militant protest lobbies [8]. According to Chicken [19], social risks are one of the "soft" factors in risk management for major projects, largely because of the difficulty of dealing with them quantitatively.

4.2.2. Political risks

War, civil disorder, industrial relations action are among the political risks of construction. This type of risks can arise from actions of the organization's government against other countries, such as trade embargoes. Another probability of political risks can arise from action within the home country, such as statutory amendments made to industrial relations legislation after a change in government [8]. Disapproval of the required project permits one of the other political and public risks [12]. According to Chicken [19], political risks are the other "soft" factors in risk management for major projects. Political risks are also defined by Ashley and Bonner [20] as foreign government interference with the normal conduct of business, and written mainly in the context of multinational construction firms and developers operating in foreign countries [8].

4.2.3. Economic risks

This type of risks can occur due to unexpected changes in supplying materials and labor, availability of equipment, inflation, tariffs, fiscal policies and exchange rates. Cost escalation is another economic risk of construction [12]. Warszawski [21] considered inflation as a risk factor for cost control, profit planning and other managerial decision-making aspects of construction projects [8]. Economic conditions of the past decade have negative effect on the climate of uncertainty with high inflation and interest rates. The deregulation of financial institutions, related to the financing of construction, can cause unanticipated problems [4]. Inflation is an important risk factor, because the price of construction materials rises with inflation. Sometimes, inaccurate cost estimate, underestimation of construction costs due to lack of information [22], that when many unforeseen factors may occur in construction activities causing the estimated cost to deviate from the real cost is another risk factor. Long-term investment can be a risk factor, especially when the project delivery approach requires the contractor to make large endowments in advance [17].

4.2.4. Financial risks

This type of risks are about funding of the project and national and international impacts [23] can result unexpected changes in interest rates, credit ratings, capital supply, cash flows and rentals. Jaafari et al. [24] concluded at the end of their research that a prudent pre-construction risk

evaluation of the project in real life would have revealed its financial feasibility [8]. Sometimes the cost certain materials spikes unexpectedly. Other times, suppliers can cut off credit [14]. Unavailability of funds, which means client's poor management of funding in the development of construction projects, is another risk factor [17].

4.2.5. Legal risks

Risk allocation through the contractual aspect of building procurement covers contract clauses, regulations, code and changed labor's safety laws or regulations. Legal risks, since the processes and remedies of subcontractor default, are widely found in the construction contract literature [8]. Contractual risks, such as risks assigned by contract over which the contractor has no control, are among the legal risks [12]. Amphibious contract, which means when the clauses of the contract are hard to understand because of the loose or awkward way in which they written, is an another important risk factor. Governmental bureaucracy, which means excessive approval procedures in government departments, is another source of risk [17]. Since inability to know what will be required and how long it will take to obtain approval from the regulatory agencies, the environmental protection movement has contributed to the uncertainty for construction. When the problems continue, after re-evaluation of the problems, additional costs can occur. Public safety regulations, which have been most noticeable in the energy field involving nuclear power plants and coal mining, have similar effects. As projects move through the stages of planning to construction, new dimension of uncertainty is added, can make it virtually impossible to schedule and complete work at budgeted cost [4].

4.2.6. Health risks

A construction site is an environment vulnerable to viruses and infectious diseases. Health risks of construction are occurrence and impact of epidemic on construction projects [8]. Construction accidents resulting from operating errors or carelessness [22] and the occurrence of safety failures in construction forms an important health risk. When resulted with accidents, safety failures, may lead to surgeries, which is the other health risk category for construction projects.

4.2.7. Managerial risks

Inefficiency of owner supervisors, productivity of labor, productivity of equipment and labor disputes [23] can lead to problems with the productivity on-site, quality assurance, cost control and human resource management. Labor availability and labor productivity, strikes and safety risks, such as worker injury or an injury to a member of the public, are the other managerial risks of construction [12]. Managerial strategies, which form managerial risks, can affect negatively or positively worker safety behavior and can make important contributions negatively or positively to occupational health and safety knowledge for construction [8]. Deregulation of safety, which means poor safety awareness of project managers and inaccurate safety measures, is an important risk factor. On the other hand, lack of insurance, in other words, if major equipment and employees are not insured, it is another risk factor. Design variations, which may result from issues such as changes by the client or defective

designs is another source of risk. Communication is very important for the sake of project, and poor communication, lack of effective communication among project partners can lead important problems. Theft is a risk factor, because employees can steal construction materials and equipment [17]. Organizational relationships are the other source of risk, since strained relationships may develop between various organizations involved in the design/construction process. When the problems occur, although the focus should be on solving the problems, discussions often center on responsibilities rather than project that needs at a time [4].

4.2.8. Technical risks

Late drawing and instructions, defective design, availability of resources, suitability of materials, defective work [23] can result in design failure, equipment and systems failure, estimation error, collision and accident. Faulty design not detected by contractor in tendering process and contraction errors due to faulty design but not checked in time by contractor are among the other technical risks [22]. A project design that is not constructible, construction-related risks such as the inability of a subcontractor to perform, construction vehicle accidents are among the technical risks of construction [12]. Reworking or delay of work, poor workmanship of subcontractor and material overuse by subcontractor with poor technique or working habits are the other technical risks [22]. Lack of high-quality staff is a risk factor that poorly trained laborers may lead to poor quality outcomes for the project. Defective construction materials that do not meet the building requirements are another risk factor [17]. Site location, and access, equipment and system failure, new technology failure, and collisions and accidents are the other technical risks. The risk associated with the introduction of new technology is an important risk factor, particularly with regard to information technology and the building procurement process. Construction technical risks can also be tracked from the bidding phase to the estimating process, and thus, to the planning and scheduling of a project [8]. The machinery break down is one of the essential technical risks inherent in all types of construction projects. The maintenance program, equipment life and haul road condition are the three input factors influence the probability of machinery breakdown. Cost overrun and project delay are the major negative impacts on project objectives are the results of machinery breakdown risk [22].

4.2.9. Cultural risks

This type of risks can occur when there are religion or/and cultural differences. Cultural issues can be relate to the risks of major international projects, but can also be found on home ground [8]. Liu et al. [25] intended to understand project risks as perceived by contractors from a perspective of culture how culture influences contractor's risk management. According to their findings, project risks perceived and managed differently in different national cultures. Risks are extended when the host country cultures differs from a contractor's expectation. International projects are inevitable that contractors could make effective plans to manage project risks, minimize the influences of cultural shock and develop a more realistic way of understanding and managing the differences. Where the host culture is similar to the contractor, risks are fewer and easier to manage than when the host culture is different [25].

The project success usually depends on the combination of all risks, although some of the individual risk factors may be more significant. Respond strategies used to mitigate risks

and a company's ability to manage them is fundamental [26]. Sound management of risk is a crucial determinant of the success of a project due to an increased attention to the variations in actual quality, time and cost performance compared to the expected ones, as a consequence of a growing pressure on reducing time and costs. Carborne and Tippett [27] demonstrated that failure to deal with risk is one main cause for exceeding budget, falling behind schedules and missing performance targets.

5. Managing construction risks

Risk is difficult and inherent to deal with, and this requires, both of theoretical and practical meanings a proper management framework [11]. It has demonstrated that failure to deal with risk is one main cause for missing performance targets, exceeding budget and falling behind schedules [27]. According to Guofeng et al. [28] in construction industry, this situation is exacerbated because, project is characterized by long execution processes, huge investments, many resources and stakeholders and unstable economic and political environments bring a high level of complexity [29]. In responding the risks and uncertainty, Ranasinghe [30] showed that the engineering construction industry should not allocate contingency at a predetermined probability of success for global variables such as project cost or duration, but rather at the input level. A suitable predetermined probability of success value to allocate contingency at the input level is about 70% and with at least 70% probability of success for bill items, work package costs and durations, or activity costs and durations, then contingency available for project cost and duration can ensure a high probability of success in successful completion of the project [30].

In the past, claims for damages were regularly presented subject to the precondition that an actual or rather obvious damage or loss at the structure occurred. However, in the meantime the claim increasingly asserted in the case of defects that have not yet led to damage or loss at the structures [31]. In building construction projects, probability of risks is difficult to assess, since each project has unique characteristics. Buildings are too dissimilar and it makes impossible to say what effect any one project will have on the firm providing it. It becomes easier to generalize about probabilities, when a series of building is repetitive [32]. The benefits of risk management are tremendous in construction projects. Risk management can improve the quality of cost estimate and decision-making, help projects completed on time and within budget, lower transaction costs and facilitate better risk allocation [33].

Risk management emphasized and implemented in construction projects, regardless of the project size to assure the achievement of project objectives; however, small projects are prone to more risks. Since, they face more challenges than large projects due to their innate characteristics such as resource constraints, tight project schedule, competition and low profit margin, small projects should managed diligently to prevent schedule and cost overruns. The benefits of risk management in small project and the impact of risk management on project performance are different from those in larger projects. Actually, risk management implementation in small projects would bring about benefits that outweigh the costs in the end [33].

Project complexity, the property of a project which makes it difficult to understand, foresee, and keep under control its overall behavior, even when given reasonably complete information

about the project system [34], can contribute toward the failure of projects, in terms of cost and time overruns. Qazi et al. [35] consider the decision problem of identifying critical risks and selecting optimal risk mitigation strategies at the commencement stage of a project, taking into account the utility function of the decision-maker with regard to importance of project objectives and holistic interaction between project complexity and risk [35].

5.1. Construction insurance

Construction is hazardous and the risk is significant, injury to individual workers and damage to property [14]. In any risk management program, insurance forms a major option to shift designated risks to a financially strong party, willing to assume some or all of the financial responsibility for the loss, for an agreed premium amount [2]. In construction industry, both the project owner and the contractor seek to control risk. One way project owners manage their risk requiring contractors to have certain types of insurance. Insurance protects contractors against certain events. Since, builder's risk insurance protects the owner, the general contractor, the subcontractors and the material suppliers against fire, theft and wind, while the facility is under construction; it is an "all risk" policy [12].

An insurance policy is a contract between the two parties and spells out obligations, responsibilities, benefits available and policy exclusions [14]. Purchasing insurance, to cover specific events that would result in a loss if they occur, is the primary way to manage risks. When a key piece of equipment is lost and can cause the contractor additional unplanned costs, insurance can cover the loss. If a contractor who owns and operates only one bulldozer, the loss of the bulldozer would be a risk that would put the contractor out of business. Insuring the bulldozer is a way for the contractor to manage that risk [12].

Odeyinka [36] identified the sources of insurable construction risks perceived to encounter in the Nigerian construction industry, and the types of insurance policy employed in managing them, examined how they managed through insurance premiums and investigated the effectiveness of the use of insurance. If there is any damage to the work, the risk bearing responsibility transferred to the insurance company by the contractor. The results of his study showed that great importance placed on-site security, construction risks, and health and welfare requirements, and the use of an all-risk insurance policy is the most prominent method for managing the identified risks. He found a correlation between insured sum and actual replacement cost when there are losses or damages. All-risk policies cover all the risks in construction except those specified by exclusion clauses. Odeyinka [36] concluded that actual replacement cost had a significant relationship with the claim settled. He concluded also that there was a significant correlation between the actual cost of replacement and the claim settled and the use of insurance was effective in managing construction risks [36].

Song et al. [37] investigated the possibility of using insurance for alternative dispute-resolution implementation and then subjective loss to represent the risk-averse attitude of project participants and quantify the effect of alternative dispute-resolution implementation costs in monetary terms. One approach to reduce the negative influence of uncertain alternative dispute-resolution implementation costs is to structure and price potential financial consequences of the cost losses as an insurance product. Thus, it becomes possible to transfer the risk of unexpectedly high alternative dispute-resolution costs from the project participant to

insurance company. The insurance company receives a premium that covers the company's underwriting expenses and targeted profit, in return. However, the risk transfer process does not directly eliminate the possibility that a dispute will occur. Compared to the uneven occurrence of alternative dispute-resolution implementation costs in the traditional self-funded model, periodic payout of premiums helps maintain a stable cash flow and thus makes it easier to budget and plan for insurance expenditures. The risk transfer process reimburses any alternative dispute-resolution implementation costs associated with that dispute [37].

There are a number of the more common and usual types of insurance, of the general interest to owners, contractors, subcontractors, construction managers and design professionals.

5.1.1. Workers' compensation insurance

This type of insurance designed to provide the statutory benefits required by state law to an employee hurt or killed because of employment [2]. This type of insurance protects workers, injured on the job, covering medical and hospitalization expenses, plus a percentage of the hourly wage during the time the employee out of work. The worker's compensation insurance protects contractor by limiting the workers' remedy from the employer to the amount that covered by the worker's compensation law [12]. Employers required by law, maintain statutory worker's compensation insurance for their employees, and in exchange relieve of direct liability for an injured worker's claims [14].

5.1.2. Employer's liability insurance

They are the contractor safety programs that form another example of risk management. If the contraction company has a high accident rate, the company will have a high experience modifier rating. A high experience modifier rating increases the cost of worker's compensation insurance and therefore makes the contractors less competitive. A good contractor works very hard at reducing the occurrence and severity of accidents [12].

5.1.3. Comprehensive general liability insurance

This type of insurance protects against third-party liability claims for property damage or personal injury that arise from the contractors' operations and acts, and the operations of subcontractors or representatives and tailored to protect against other claims [14]. The basic policy endorsed to include coverage for contractor's and owner's protective insurance, products and completed operations, personal injury (libel, slander, etc.) blanket contractual and coverage for liability arising from the insured's automobiles. This type of insurance is against liability imposed by law for negligent acts occurring in the conduct of the business, which result in bodily injury or damage to the property of others [2].

5.1.4. Contractual liability insurance

When the contractor assumes the legal liability of the owner, designer or other designated party, *contractual liability insurance* protects him. Since, the contractor is required to assume the potential liabilities of others, most contracts contain in some form of indemnification clause or hold-harmless provision [2].

5.1.5. Professional liability insurance

This type of insurance protects architects and engineers from liability based upon professional errors or omissions in performing design, construction management or other services [2].

5.1.6. Builder's risk insurance

The aim of this type of insurance is providing protection to the insured party or parties against physical damage. Destruction of the project or temporary buildings on the job site by external causes such as fire and storm, and the insurance should include not only physical damages, but also coverage for materials stored in transit to job site waiting for incorporation into the project [14]. Builder's risk insurance is against the cost of damage of a physical nature to a building or other component of a construction project. This type of insurance covers material and equipment not yet incorporated into the work when located on site or in transit to the site. Generally it include the interests of the owner, the general contractor and material supplies [2].

5.1.7. The equipment floater policy

They protect damages to mobile and stationary construction equipment, which is not generally subject to vehicle registration. It is coverage for damage to the equipment whether located at the job site, in transit, or at the contractor's yard, but not liability and property damage insurance for cars, trucks and other equipment subject to the motor vehicle licensing laws, since they covered under other liability policies [2].

5.1.8. Wrap-up insurance

This type of insurance is established by the owners to cover the owner, contractors, subcontractors, construction managers and the designers. Basic policies generally cover comprehensive general liability insurance, excess general liability, builder's risk, worker's compensation and occasionally errors and omissions insurance. Equipment floaters, and the deductible or self-insured retention and automobile liability insurance normally continue to be the responsibility of the individual injured [2].

5.2. Construction surety bonds

A surety is a company that guaranties for a fee the obligations of one party to another party. When the surety, usually an insurance company, guaranties to a project owner that his contractor will perform as required by the construction contract between the owner and the contractor, this is a bond made in writing. The surety is obliged to the owner to see that the contract completed—up to the face amount of the bond, if the contractor defaults on his obligations under the construction contract [14]. Surety bonding is an effective risk mitigation approach to avoid the possible risk of contractor default, in the construction industry. The surety company carries the risk of contractor pre-qualification and quarantines the project completion according to the contractual obligations, when a surety company agrees to bond a contractor for a construction project. The surety company, through a surety underwriter, conducts an evaluation of the contractor to estimate contractor competency for performing a specific project [38].

A construction owner is under the risk that the general contractor will not be able to complete the project on schedule, within budget, and in compliance with plans and specifications. It is the same for the general contractor; similarly, a general contractor runs the same risk against subcontractors. A surety bond is a financial instrument used to guarantee the completion of an obligation. The oblige turn to the bonding company, step in and, on behalf of the principal, accomplish the work according to contract terms, if the principal fails to perform [39].

Kangari and Bakheed [40] identified and classified quantitative and qualitative risk factors that impact construction bond underwriting, to improve the quality of the evaluation analysis and to reduce the highly unstructured environment and the subjectivity of the bond evaluation in underwriting. The objective of their paper was, based on a set of surveys and interviews with surety companies, to identify major factors impact surety-bond evaluation. The results showed that, contractor's financial strength was the first important factor. The second one was contractors past experience or character attributes such as the quality of contractor's people and their experience, contractors past work, contractor's business plan and trust with agents. Contractor's capacity, work schedule to analyze job's consistency and potential project characteristics; and contractor's continuity that came as the least important factor among the others [40].

There are three types of common and usual construction surety bonds of the general interest to owners, contractors and subcontractors.

5.2.1. Performance bonds

Construction surety bonds, for the performance of construction contract obligations that provide a third-party guarantee. Performance bonds are one of them that guarantee performance of contract obligations to the owner as set forth in the contract, but it is not insurance. The amount of the performance bond guaranteed to make available by the surety to complete the contract in the event of default by the contractor, which represents total contract price. The surety is obligated either complete the work or to arrange with the owner to pay for the cost of completion of the work less, in the event of default [2].

5.2.2. Bid and proposal bonds

They provide guarantee for the contractor's surety that the contractor contracts and provides required bonding if selected. If the bid or proposal is successful, surety remuneration comes from furnishing the performance and payment bonds and the contractor normally does not pay any premium for bid bonds [2].

5.2.3. Labor and material payment bonds

They provide prompt payment to all those furnishing labor and/or materials to the job. Although payment is made to the subcontractor by the general contractor, this type of clause cover unpaid bills to the same subcontractor [2]. This assures the owner that the vendors do not cause to place liens on his property [14].

In some circumstances, utilizing a combination payment and performance bond, under the amount of total contract price, can be preferred [2].

5.3. Construction contract

In the construction business, contracts are the vehicles used for the procurement of everything, both services and goods. A contract is an agreement between two parties that is enforceable by law, and protects parties such as contractors against risks. When the site subsurface conditions might not be exactly what the contractor anticipated or any changes in conditions occur, examining the contract language addressing these changes makes possible to protect against risks [12]. Successful project execution requires a proper contractual foundation and construction contracts have a key role with fair, clear and comprehensive allocation of risks [23]. Construction contract risks are qualitative, based on analyst's knowledge and experience of the risks and the process by which the analyst selects and organizes such knowledge and experiences into meaningful patterns [41]. Contracts for today's extended and interconnected enterprise have growing importance. Contracts are management tools in terms of risk, opportunities for value creation, successful inter-firm collaboration, profitability and competitive advantage. Contracts can help enabling companies to share, minimize and manage risks; preventing problems; and keeping problems from developing into disputes. In a situation where a dispute is unavoidable, contracts provide evidence of what agreed and an effective means to control and resolve dispute [42]. Many countries have develop standardized conditions contract to be used in construction projects. All contracts based on the general conditions of contract that formalize risk allocation in Sweden. They assign liabilities and responsibilities of each contracting party regarding job performance, organization, timeframes, guaranties, insurances, errors and payments [43].

5.3.1. Basic requirements for an effective risk management in the content of contract

Misunderstandings, delays, claims or disputes can be unexpected losses or other negative outcomes of contracts. Including goodwill and reputation a lot is at stake and contract disputes are expensive. If contracts fail, business performance will suffer, in terms of money, management and staff time that used for productive work. Language risks and contract wording is one of the sources of contract risk. The parties seldom concur on the terms of agreement, what those terms mean, when a dispute arises. Perceptions, growing complexity and communication failures are the other sources of contract risks and help to understand the true causes of contract risk. Contracts are a record of what agreed and communicate the deal and its terms clearly, so that future disputes over their meaning avoided. Gaps in the contracting process or lack of contract management are the next contractual risk. When several organizations and supply chain are added, the process becomes more complex and delivering the promises made in documents is not easy [42].

According to Rahman and Kumaraswamy [44], appropriate, clear and equitable conditions of contract are invaluable for successful projects. Appropriate contract conditions are important to meet the specific requirements and objectives of the project. Contract conditions should be clear to define the rights and duties of project participants and unequivocally allocate risks or future uncertainties to the different contracting parties. Contract conditions also expected to be equitable, apart from merely following the often-espoused principle of assigning the risks to those best equipped to deal with them [44].

Since any construction project involves risk, eliminating all the risks associated with a specific project is impossible. Regulating the risk allocated to different parties and then properly

managing the risk is all that done. The language of the construction contract can achieve this. Serving as a framework between the parties to establish which one has assumed which risk is one of the objectives of the contract. Risk sharing or risk shifting decisions made within the context of the contracting policy an owner [45]. Construction contracts not only serve as a means of pricing construction, they also structure the allocation of risk to the various parties involved.

5.3.2. Risk management with contract types

In a *lump-sum contract* [*single fixed-price contract*], all risks removed from the owner and assigned to the contractor [4] and the contractor entitled to a fixed amount of payment from the owner. It believed that lump-sum contracts can make the contractor accountable for all cost overruns and thus gives the contractor the strongest incentive to improve efficiency [46]. Under *unit-price contracts*, the contractor, in the absence of changes or impacts unforeseen by either party, takes all of the construction risk [2] and follow a strict sequential planning and design, procurement [tendering or bidding] and construction [23]. The risk of inaccurate estimation of uncertain quantities for some key tasks removed from the contractor in a unit-price contract [4]. Although the contractor may pass on much of the risk to lower tier specialty contractors when feasible, usually bears the economic risk of unusual weather conditions, strikes or other external factors that influence a contractor's cost, but which may not be directly under its control [2]. In a *cost plus fixed percentage contract*, the owner sometimes forced to assume all risks of cost overruns, especially types of construction involving new technology or extremely pressing needs. Under *cost plus fixed fee contract*, the owner assumes the risks of direct job cost overrun, while the contractor may risk the erosion of its profits if the project dragged on beyond the expected time. In *cost plus variable percentage contract*, the contractor takes the risk on its own estimate, agreeing to a penalty if the actual cost exceeds the estimated job cost, or a reward if the actual cost is below the estimated job cost. Cost plus variable percentage contract allocates considerable risk for cost overruns to the owner. Under *guarantied maximum cost contract* the contractor takes all the risks, both in terms of actual project cost and project time [4]. In this types of contracts, although the contractor may bear risks for items not under his control, eliminated the risk inherent in lump sum contracting as a trade-off for a lower guarantied fee [2]. There are possible options for improved contracting methods and better risk allocation processes such as collaborating/alliances, risk sharing/reward systems, incentive-based contracts and others. *Target cost contracts* are one of the construction contracts, often practiced in the projects with a high level of risk [47].

5.3.3. Various dimensions of contract risk management

Since the owners interested in knowing which risk factors will generate significant impacts on the projects, the identification of risks is a significant test for all major contracting parties across all building and civil engineering projects [47]. Risk allocation is the definition and division of responsibility associated with a possible future loss or gain and its objective is seeking to assign responsibility for a variety of hypothetical circumstances, if the project does not proceed as planned. Risk allocation is a part of risk management strategy, through the contractual documents. The owner generally has a tendency to pass the responsibility for most of the risks to the contractor contractually, under traditional procurement processes. A contract indicates willingness of the contractor for undertaking the work and his accepting both the

controllable and uncontrollable risks. The principles behind the allocation in the documents of model or standard sets of general conditions have not clearly stated, although model or standard sets of general conditions of contract are available. Any problems can occur using any of the model or standard sets of general conditions of contract, if additional clauses affecting risk applied to them. Moreover, in today's high-risk scenarios and multiparty complex projects, the nature and extend of risks tend to be project specific that adoption of tailor-made contract strategies is more desirable [48]. According to Zaghloul and Hartman [45], with the absence of trust in business relationships, the success of any project or business relationship is always questionable. Their findings identify the relationship between trust and risk allocation practices in construction contracts. How a strong relationship can reduce the final cost of any specific project by improving the risk allocation method between the contracting parties [45].

The aim of the Chang's [46] study is to make a case for the need of incorporating the consequence of contract breakup into risk allocation decisions, and analyzed the modeling of the post-contract hazard. A compelling reason for taking this factor seriously is that contract breakup may result in contracting parties incurring substantial additional costs. Although owners have a larger stake and hence have a stronger incentive to stay in the project; contractors' staying in or leaving the project depend on their risk bearing capacity. Beginning with an analyzation of standard pain-gain sharing arrangement in construction contracts, Chang [46] found that taking no account of contract breakup hazards result in underuse of incentives. When the outturn cost also depends on the contractor's effort high-powered incentives offered to the contractor when cost variations expected to be modest, contractor's distaste for risk taking is low, and contractor's disutility does not rise steeply. According to Chang [46], contract breakup potential is an important factor and incentives more intensively used to harness the contractor's potential in cost reduction because the efficiency savings stimulated by stronger incentives can serve as a buffer for downside risks and thus reduce the expected loss of contract breakup [46].

Contract choice decisions are central to the management of risk and uncertainty. Chapman and Ward [49] indicated that the starting position has to be a best practice approach to risk management in terms of the whole project life cycle. Fully integrating a balanced incentive and risk sharing approach to contracting is of central concern for a successful risk management. A two-dimensional view of risk and uncertainty, a linked risk efficiency view of choices and addressing both expected outcomes and potential departures from expectations, is essential for this integration to work. A concern for all sources of uncertainty, including ambiguity and lack of knowledge and addressing dependence and feedback is essential for an effective contract choice decision. Clients need to choose an appropriate form of contract from available common options and facilitating appropriate choices usefully addressed within a balanced incentive and risk sharing contract framework. According to Chapman and Ward [49], comparative measurement and related comparative assessment of assumptions is the key to effective choices. They indicated that the key overall conclusion is that full integration of contract choice decisions with a best practice approach to risk management is both practical and advantageous [49].

5.4. Subcontracting

Subcontracting is outsourcing a part of the job to another group and it is widely used in construction. Demand volatility, high level of risk and uncertainty are some special conditions of construction industry that causes subcontracting and enables some advantages to

general contractor, even if the size of the firm and capacity of work increase. The construction industry traditionally uses the method of subcontracting to fulfill the need for flexibility and short-term project objectives. According to Eccless [5], since bounded rationality of the general contractor in highly uncertain conditions, market contracting is preferred over vertical integration [6]. Subcontracting is another form of risk management. There is a great risk for a company performing in construction industry; a contractor can reduce project risk by hiring qualified subcontractors. The cost may be increased, but an unqualified subcontractor is a greater risk. The return justifies the cost by reducing the constructor's exposure to risk [12].

Unstable market conditions are the overriding reason for general contractors to conduct transactions with subcontractors, since subcontracting out work packages enables general contractors to be flexible in responding to potential market difficulties. The construction industry hosts an unstable and seasonal demand [i.e. market volatility] because construction firms to split into autonomous units and to rely on subcontractors to undertake some of the work packages. As construction firms prefer being flexible, general contractor-subcontractor relationship emerges as a rational response to the instability of demand in construction markets and to problems caused by seasonality. Uncertainty and asset specificity are the two dimensions of general contractor-subcontractor transactions. Uncertainty in general contractor-subcontractor transactions can both stem from the nature of the construction process and from the potential partner's performance during the course of the construction process. One of the sources causing uncertainty in the construction process is that construction operations carried out on sites, which present uncertainties regarding weather and soil conditions. Each project requires a new design and generates new production problems regarding the coordination and integration of the outputs of specialized task groups which carry out interdependent tasks; and the contracting system itself is a recipe for uncertainty since cost estimation is not an exact science are the other ones. General contractors and subcontractors also face difficulties in assessing each other's performance, which means poor performance on the part of either party, can have profound effects on the other one [50].

5.4.1. Importance of subcontracting in construction

Subcontracting is widely used much more extensively on housing and building construction projects than on engineering projects and industrial projects. Regardless of the general contractor's skills, especially building projects, it is common for subcontractors [39] perform 80–90% of the work. In spite of the benefits of subcontracting, there are some inherent risks. Quality is a critical issue and the cost of quality rectification problems is high. The contractor enters into contractual arrangements with the subcontractors in the traditional procurement arrangement option. Coordinating and controlling the works to ensure that the project delivered to time, cost and quality targets are the responsibilities of contractor. It is more risky when the main contractor in managing subcontractors, especially where the value of the subcontractors' work is significant in relation to the main contractor's work. The main contractor's performance and reputation may depend on the performance of the subcontractors. The control and coordination of the subcontractors and their works become problematic, and could result in unsatisfactory project outcomes. In this context, the main contractor becomes a construction manager and need to have sufficient construction management skills [51].

General contractor-subcontractor transactions involve a 'high human asset specific investment' and high human asset specificity is a direct result of the production technology used in the construction process. Interdependence among work groups is high, and its predecessors in the construction process define the workplace of a group. General contractors and subcontractors restrict access to transaction relationships increases the frequency of transactions between existing parties and enables them to learn from one another to overcome problems caused by newness. Learning new roles, coordination problems, developing trust and communication routes are some of these problems [50]. While main contractors do not depend on subcontracting alone, they support construction activities with their own resources, including equipment and labor. When the main contractors use their own resources, main contractors' control of the overall quality of construction is vastly improved. The control will be more affective, when the employment is direct. Contractors may get a better quality job, by having direct control on work. There is a looser relationship between employer and employee in subcontracting, and the client and main contractor have very little control over who carries out the specialist work under a subcontract [52].

5.4.2. Managing construction risks with subcontracting

Subcontracting is another way of managing risks; however, arbitrary passing down risk can create problems, relating to unequal risk allocation. Sometimes, risks not allocated to the party in the best position to manage them. People have less decision power toward the end of the construction supply chain. Increased subcontracting enables the re-distribution of risks between a numbers of subcontractors. In this process, rather than formal quantification and evaluation, perceptions of risk play an important role in determining the allocation of risk between contractual parties [53].

Mbachu [54] analyzed the various ways in which the subcontractor could contribute to the contractor's payment risks and cash flow problems. The results showed that cost management and subcontractor project implementation were the two broad classifications of risk sources. The key issues related to a lack of risk management and administration skills were the results of the evaluation of the various risk factors attributed to the subcontractor have cost management issues. Poor productivity, poor documentation and taking too many jobs at the same time were the three subsets of risk factors under the subcontractor's project implementation role. The major solution overcoming these problems was that using head contractor his/her key skills in risk management, administration and coordination to assist the subcontractor in overcoming these problems [54].

Risk commonly transferred to the subcontractor in the construction industry. According to Arditi and Chotibhongs [39], broad form indemnity, which entirely relieves the general contractor and/or owner from covering losses related to the subcontractor's performance of work, regardless of the cause or type of risk is the least balanced approach for a subcontractor. The additional insured endorsement is another risk, which is independent, but can have the same effect. The owner and/or general contractor named as insured under the subcontractor's commercial general liability policy. The waiver of subrogation is a third method of risk transfer that makes the subcontractor responsible for losses controlled by other parties. Signing a waiver, asked by the general contractor and/or owner, protects the subcontractor's insurance

carrier from making any claim to recover funds from the general contractor that the carrier paid out to cover a loss [39].

6. Conclusion

The construction industry has a dynamic, challenging and high risky business environment. Since the characteristics of the industry is specific and resources used for the production are diverse and at a high rate, the process directly related with sustainability. Sustainable development movement has evolved worldwide for almost two decades and caused significant changes in construction delivery systems. Since sustainable development requires an affective and carefully consuming the resources of the earth, an effective risk management is a key for achieving sustainability in construction projects, in particular building projects, not only to secure work, but also to make profit. In construction industry, uncertainty contributes to most of the problems related to contractual, client and commercial issues. Construction projects are prone to more risk and uncertainty than any other industries, such as production or service industries. Sometimes lack of close collaboration among the stakeholders can enough to lead higher levels of risk for success of the project. A collection of different risk factors occurs for risk management consideration by the Construction Company or contractor. Uncertainty may lead to changes in the performance of the task relating to productivity, work method, supply and quality of labor and materials can affect the construction projects' time and/or cost. It is possible that sometimes uncertainty can lead to the inflated prizing or the deflated pricing in the tendering phase. There are different tools to manage risks of construction. A construction company with a well-prepared contract can overcome the difficulties of uncertainty and achieve low cost by optimizing the cost effectiveness of risk allocation. Construction insurance, surety bonds and subcontracting are the other main affective solutions for the risk management in building construction projects.

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