Risk Management in Construction Projects

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1.1 Introduction

Risk management has become an important part of the management process for any project. Risk in construction has been the object of attention because of time & cost overruns associated with construction projects. While the importance of risk management is a matter of debate, it is generally accepted that best risk management practice, in combination with strong project processes, improves project quality, reduces costs & speeds up schedules. This report defines risk & explains the process of risk management, as well as reviews the literature concerning some of risks faced in the construction projects, some of analysis techniques, risk response practices and risk monitoring and control.

Figure 1: Risk Management Lifecycle

1.2 Risk Definition

Risk can be defined as an uncertain event or condition that, if it occurs, has a positive or a negative effect on a project objective.

1.3 Certainty and Uncertainty in Risks

There are arguments whether risk is the same as uncertainty. Some studies view risk and uncertainty as different concepts based on the fact that risk can be quantified in terms of its probabilities and impacts, while uncertainty is difficult to determine statistically especially in terms of probability. Other studies consider risk and uncertainty as so similar that they are synonymous (Ceric, 2003). Risk and uncertainty are invariably described in relation to one another and to differentiate between them may not be helpful. Accordingly, this study takes the view that risk and uncertainty is essentially the same thing.

1.4 Types of Risks

Risks can be associated to technical, operational or business aspects of projects. Technical risk is the inability to build a product that complies with the customer's requirement. An operational risk arises when the project team members are unable to work cohesively with the customer. Risks can be either acceptable or unacceptable. An unacceptable risk is one which has a negative impact on the critical path of a project. Risks can either have short term or long-term duration. In case of a short-term risk, the impact is visible immediately, such as a requirement changes in a deliverable. The impact of a long-term risk is visible in the distant future, such as a product released without adequate testing.

Risks can also be viewed as manageable and unmanageable. A manageable risk can be accommodated, example being a small change in project requirements. Unmanageable risk, on the other hand, cannot be accommodated, such as turnover of critical team members. Finally, the risks can be characterized as internal or external. An internal risk is unique to a project and is caused by sources inherent in the project; example can be the inability of a product to function properly. Whereas an external risk has origin in sources external to the project scope, such as cost cuts by senior management.

2.1 Risk identification

This is the preliminary step in risk management and it involves documenting of all the risks that may occur during the project. It is widely recognized that the greatest influence on the accuracy of any risk assessment is caused by the risk identification stage as part of the whole risk management process. The goal of this phase is to create a list of risks that could be significant for a specific project. This includes identifying where the risks may come from, potential negative scenarios, and their adverse impacts. To help with identifying risks, they can be generally divided into controllable and uncontrollable categories (Flanagan and Norman, 1993). Further, controllable risks are those risks which a decision maker undertakes voluntarily and whose outcome is, in part, within our direct control, and uncontrollable risks as those risks which we cannot influence. Risk identification should address both internal and external risks.

2.1.1 Internal risks

Internal risks are those which directly affect the project and are within the control of the project management team. These risks are again categorized based on the respective originator featured like client system, consultants, contractor, sub-contractors and suppliers.

2.1.2 External risks

Unlike internal control systems, which have a direct impact on external risk where social, natural, economic, political, and cultural factors are involved. Research has determined that each of these categories is also at risk of different events.

2.2 Risk identification techniques

According to Ceric (2003), how the project manager approaches risk identification will depend on his previous experience. If he is experienced and proficient in certain approaches, he will favor these methods; conversely, he will avoid any that he has had bad experiences with. There are various techniques for risk identification, including:

- **Brainstorming.**

- **Interviews.**

• **Questionnaires.**

• **Expert systems.**

These techniques are discussed in the following sections:

Brainstorming

Brainstorming is a collaborative discussion where participants share their thoughts on potential project risks, uncertainties, likelihood of risks, possible impacts, and strategies for addressing those risks (Ceric, 2003). Typically, the project manager or risk manager leads the discussion, and their experience can significantly influence the session's effectiveness— a domineering leader may prevent others from sharing their views. Additionally, the number of participants can impact the success of the brainstorming session; having too many people involved can result in wasted time and an unproductive conversation.

Interviews

Interviews provide respondents with the opportunity to respond to pre-prepared questions and explore the topic in depth (Ceric, 2003). The responses gathered serve as the foundation for analysis. Questions can be either structured or unstructured. Unstructured questions give respondents the freedom to answer in their own words, whereas structured questions require them to select from provided options. The project or risk manager tasked with formulating the questions and leading the interviews must possess a high level of knowledge and experience in the process.

Questionnaires

Just like interviews, questionnaires can be structured or unstructured. They serve as the quickest and most effective means of collecting opinions from all project members for analysis and comparison (Ceric, 2003). The questions must be formulated to ensure high quality answers, but the process is fundamentally limited by the inability of the questionnaire to allow respondents to discuss their answers or to present opinions that go beyond the scope of the questions. Thus, questionnaires may hinder creative thinking.

Expert systems

An expert system is created by leveraging the combined knowledge and experiences of all project participants. This system will draw on the insights of stakeholders from past projects, yet it may still miss some hidden risks. Importantly, expert systems explain how previous issues were addressed, they not only provide knowledge but also give an insight into how this knowledge was developed. Consequently, users often trust these systems and view them as dependable resources for identifying risks.

3.1 Risk analysis

Risk analysis is a key part of the risk management process, focusing on the causes and consequences of harmful events. The goal of this analysis is to provide a clear and objective assessment of risk. When done effectively, it enhances the certainty of the decision-making process. Essentially, risk analysis aims to explore all possible options and evaluate the different outcomes of any given decision. For building projects, clients are mainly interested in the most likely price, but projects do have cost overruns and, too frequently, the 'what if' question is not asked (Flanagan & Norman, 1993). Conducting risk analysis involves evaluating the identified risks, which first requires quantifying them in terms of their impact on costs, timelines, or revenues. They can be analyzed by measuring their effects on the economic parameters of the project or process. In terms of risk response, three general types of response can be identified:

- Risk avoidance or reduction.
- Risk transfer.
- Risk retention.

The use of risk analysis gives an insight into what happens if the project does not proceed according to plan. When active minds are applied to the best available data in a structured and systematic way, there will be a clearer vision of the risks than would have been achieved by intuition alone (Flanagan & Norman, 1993).

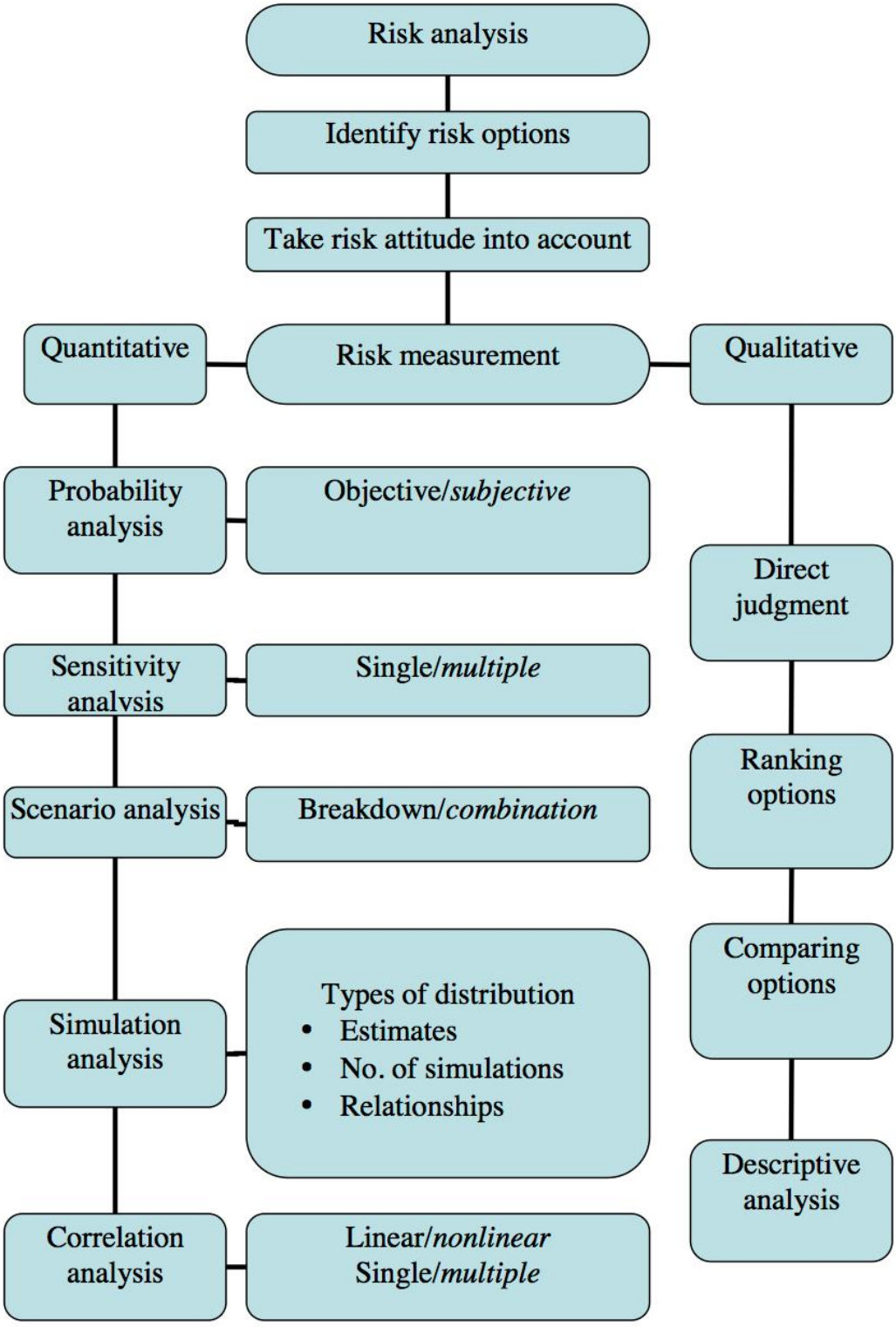

Figure 2: Risk analysis sequence

Figure (2), detailed by Flanagan and Norman (1993), shows the sequence in risk analysis. The traditional approach to forecasting construction price or construction duration at the design stage of a project is to use the available data and produce a single point best estimate. The risk analysis approach explicitly recognizes uncertainty that surrounds the best estimate by generating a probability distribution based upon expert judgment. Therefore, the understanding about the effects of uncertainty upon the project will be improved. Risk analysis must not be viewed as a stand-alone activity; any strategies developed must not be seen as cast in stone commandants. Rather, these should be seen as a component of all decisions made continually to respond to project dynamics. Risk analysis involves evaluating risks and risk interactions to assess the range of possible project outcomes. It is complicated by several factors including, but not limited to (PMI, 1996):

• Opportunities and threats can interact in unanticipated ways (e.g., schedule delays may force consideration of new strategy that reduces overall project duration).
• A single risk event can cause multiple effects, as when late delivery of a key material produces cost overruns, schedule delays, penalty payments, and a lower quality product.

• The mathematical techniques used can create a false impression of precision and reliability.

What is needed is an application of risk analysis to help project managers control cost that is relatively simple to apply, can be used throughout the life cycle of a construction project, accounts for the tendency of construction professionals to apply risk in linguistic terms, and apply their experience (Bender & Ayyub, 2001).

3.2 Methods of risk analysis

The analysis of risks can be quantitative or qualitative in nature depending on the amount of information available (APM, 2000). According to Chapman (2001):

• Qualitative analysis focuses on identification together with assessment of risk.

• Quantitative analysis focuses on the evaluation of risk.

3.2.1 Qualitative risk analysis

Qualitative risk assessment is the process of identifying a hierarchy of risks, their scope, factors that cause them to occur and potential dependencies. This hierarchy is determined by the likelihood of the event and its impact on the project. In qualitative risk analysis, risk management focuses on documenting the characteristics of each risk. Qualitative risk analysis evaluates the significance of identified risks and creates prioritized lists for further examination or immediate action. The management team evaluates each risk based on its likelihood of occurrence and its potential impact on project goals. Occasionally, specialists or functional units assess risks within their areas of expertise and communicate their findings to the team (Office of project management process improvement, 2003). the components of risk analysis are as follow:

• List activities, tasks, or elements that make up the project.

• Identify applicable risk factors.

• Develop risk-ranking scale for each risk factor.

• Rank risk for each activity for each risk activity.

• Document the results and identify potential risk-reduction actions.

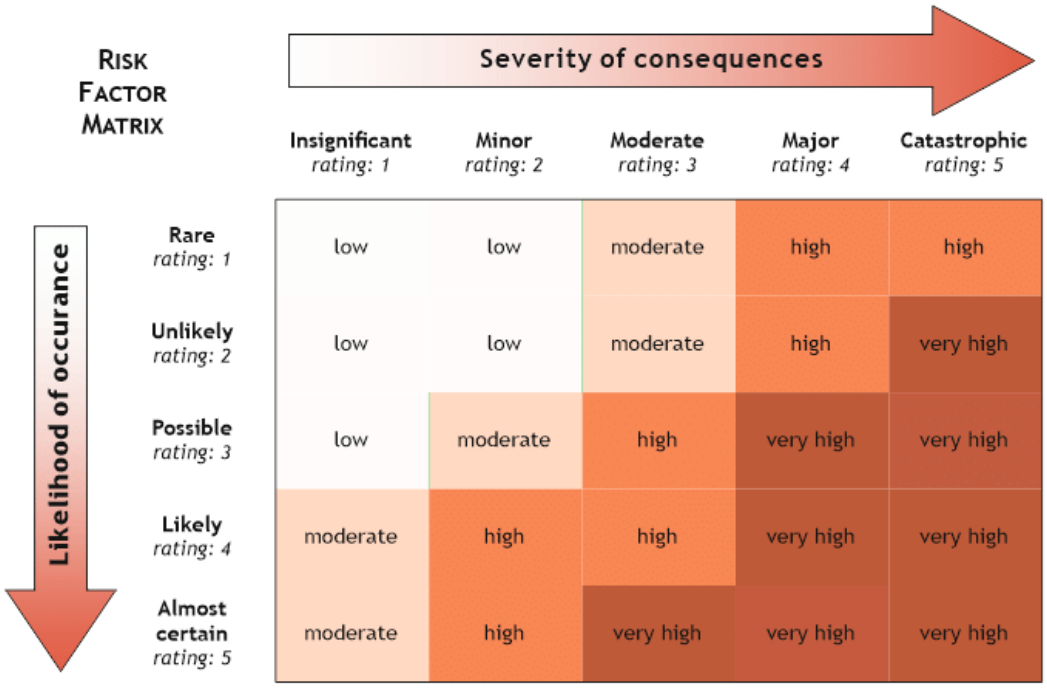

Figure 3: Risk factors score matrix for qualitative risk assessment

3.2.2 Quantitative risk analysis

Quantitative risk analysis involves numerically estimating the likelihood that a project will achieve its cost and time goals. This type of analysis evaluates the impact of all identified and quantified risks simultaneously. The outcome is a probability distribution that reflects the project's potential costs and completion dates based on these risks. Quantitative methods utilize probability distributions of risks and can provide more objective results compared to qualitative methods, provided there is enough current data available. In contrast, qualitative methods rely on the analyst's personal judgment and past experiences, which can lead to varying results among different individuals. As a result, many analysts prefer quantitative methods. Quantitative risk analysis examines the potential range of values for key variables and the likelihood of their occurrence. The simultaneous and random fluctuations within these ranges result in an overall probability that the project may be deemed unacceptable. Quantitative risk analysis involves statistical techniques that are most easily used with specialized software The goal of quantitative risk analysis is to assign probabilities or likelihoods to various factors, assess their impact, and

determine the severity of each factor. When thorough quantitative risk analysis is necessary it can take two alternative approaches:

1. Risks can be quantified as individual entities while looking at the big picture. This way can include the cumulative effects (to certain accuracy) into each individual risk and thus make more accurate estimations of the net value of the risks.

2. Alternatively modeling the mathematical properties of the interrelations from the bottom up can be started and then calculate the net impact of each risk including the effects of interrelations.

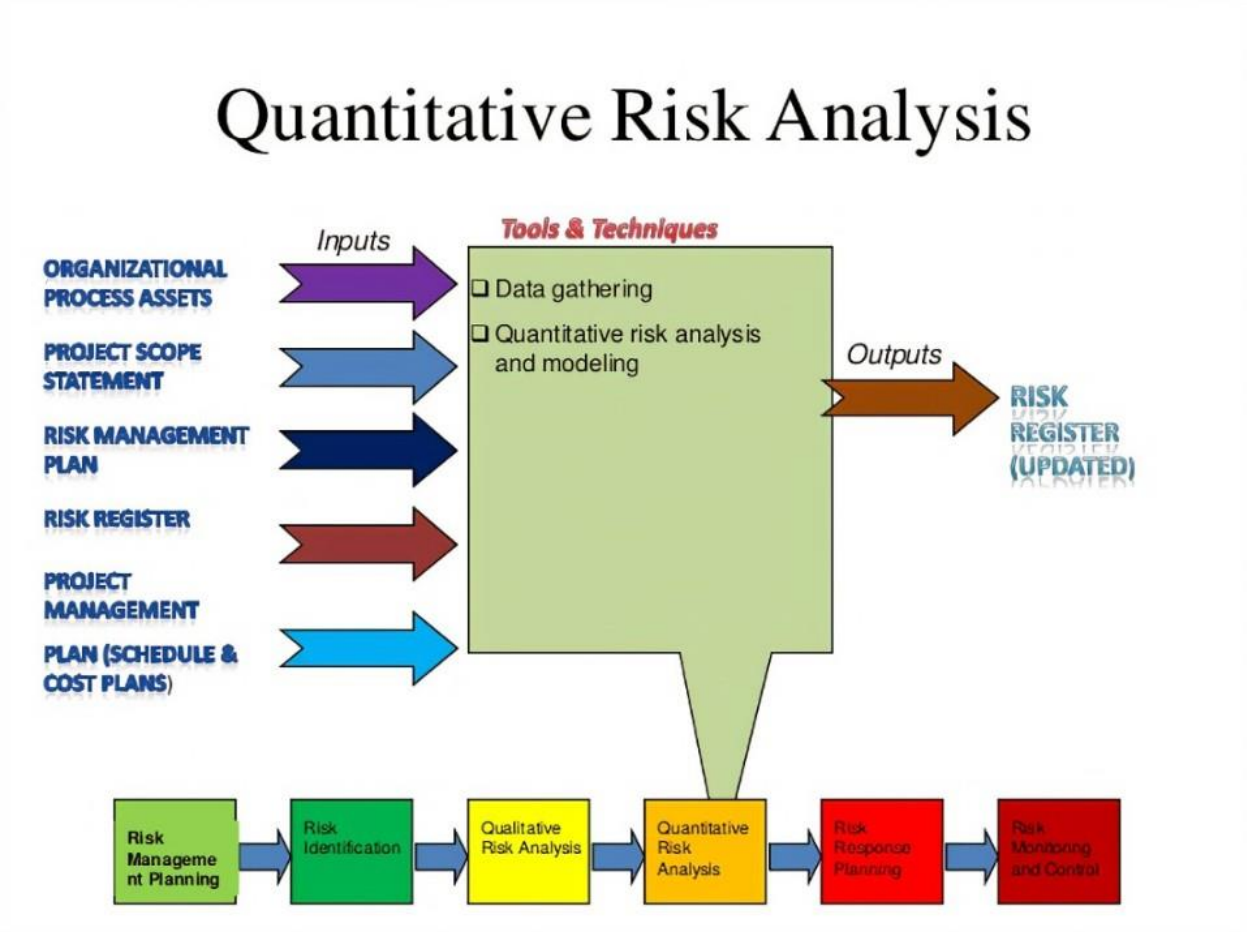

Figure 4: Quantitate Risk Analysis with Data

Basic Steps of Quantitative Risk Analysis

The goal of risk analysis is to assess the likelihood of an adverse event occurring and to understand the potential consequences if it does happen. When conducting quantitative risk analysis, the aim is to express risk in numerical terms. To do this, it should go through a few steps:

1. Define the consequence; define the required numerical estimate of risk.

2. Construct a pathway; consider of all sequential events that must occur for the adverse event to occur.

3. Build a model - Collect data; consider each step on the pathway and the corresponding variables for those steps.

4. Estimate the risk; once the model has been constructed and the data collected the risk can be estimated. Included in this estimation will be an analysis of the effects of changing model variables to reflect potential risk management strategies.

5. Undertake a sensitivity and scenario analysis; Undertaking a risk analysis requires more information than for sensitivity analysis.

Techniques of Quantitative Risk Analysis

Any specific risk analysis technique is going to require a strategy. It is best to begin by providing a way of thinking about risk analysis that is applicable to any specific tool might be used. There are various techniques of quantitative risk analysis, including:

• **Probability Analysis** is a tool in investigating problems which do not have a single value solution, Monte Carlo Simulation is the most easily used form of probability analysis.

• **Monte Carlo Simulation** is presented as the technique of primary interest because it is the tool that is used most often.

• **Sensitivity Analysis** is a tool that has been used to great extent by most risk analysts at one time to another.

• **Breakeven Analysis** is an application of a sensitivity analysis. It can be used to measure the key variables which show a project to be attractive or unattractive.

• **Decision trees** is method, which aims at determining an expected value for each response action, is particularly recommended when considering the cost implications of the various available construction methods.

• **Scenario Analysis (SA)** is a rather grand name for another derivative of sensitivity analysis technique which tests alternative scenarios; the aim is to consider various scenarios as options.

4.1 Risk response practices

PMI (1996) suggested three ways of responding to risk in projects, they are as follows:

• Avoidance: eliminating a specific threat, usually by eliminating the cause. The project management team can never eliminate all risks, but specific risk events can often be eliminated.

• Mitigation: reducing the expected monetary value at risk events by reducing the probability of occurrence (e.g., using new technology), reducing the risk event value (e.g., buying insurance), or both.

• Acceptance: accepting the consequences. Acceptance can be active by developing a contingency plan to execute should the risk event occur or passive by accepting a lower profit if some activities overrun.

Figure 5: Risk Response Categories

Abu Razek (2003) suggested some actions to be taken in response to residual risks. Actions can include:

• Reduce uncertainty by obtaining more information, this leads to re-evaluation of the likelihood and impact.

• Eliminate or avoid the risk factor through means such as a partial or complete redesign, a different strategy or method etc.

• Transfer the risk element by contracting out affect work.

• Insure against the occurrence of the factor.

• Abort the project if the risk is intolerable and no other means can be undertaken to mitigate its damages.

Generally, its argued that there are four distinct ways of responding to risks in a construction project, namely, risk avoidance, risk reduction, risk retention and risk transfer. Those ways are discussed in below briefly.

- **Risk avoidance**

Risk avoidance is often called risk elimination. In construction, risk avoidance is typically seen as impractical because it can result in projects being canceled. For instance, a contractor might choose not to submit a bid, or an owner might decide against funding a project to eliminate risks. There are several strategies to avoid risks, such as submitting an excessively high bid, placing specific conditions on the bid, engaging in pre-contract negotiations to determine which party assumes certain risks, and opting not to bid on the high-risk segments of the contract (Flanagan & Norman, 1993).

- **Risk transfer**

This essentially involves shifting the risk to another party. In the context of a construction project, while an insurance premium does not eliminate all risks, it does provide some advantages since potential losses are covered by fixed costs. Risk transfer can take two primary forms:

• The property or activity that carries the risk may be transferred, such as hiring a subcontractor to handle a hazardous process.

• The property or activity may be kept, but the financial risk is transferred, for example, through methods like insurance and surety.

- **Risk retention**

This approach involves managing risks internally, particularly for projects where avoiding risks isn't feasible, potential financial losses are minimal, the likelihood of occurrence is low, and transferring the risk uneconomical. The company or contractor takes responsibility for both anticipated and unanticipated risks, controlling and financing them. There are two methods of retention: active and passive.

A. Active retention, often known as self-insurance, is a proactive management approach that follows a careful assessment of potential losses and the costs associated with different risk management strategies.

B. Passive retention, on the other hand, arises from negligence, lack of awareness, or failure to make a decision. For instance, if a risk goes unrecognized, the contractor must deal with the repercussions of that risk.

- **Risk reduction**

This term generally refers to the process of minimizing the likelihood and/or impact of a negative risk event. In some cases, this can lead to complete elimination, as seen in the concept of "risk avoidance." However, when it comes to risk reduction, it's important to look beyond just the expected value. If the potential impact exceeds a certain threshold, the risk may still be deemed unacceptable. In such situations, it may be necessary to consider alternative strategies.

5.1 Risk monitoring and control

The risk management team is tasked with increasing productivity and minimizing the project's exposure to schedule delays and cost overruns. It's essential to monitor and control any risks associated with construction projects, starting with the creation of a comprehensive risk management plan.

Risk monitoring and control is required in order to:

1. Ensure the execution of the risk plans and evaluate their effectiveness in reducing risk.

2. Keep track of the identified risks, including the watch list.

3. Monitor trigger conditions for contingencies.

4. Monitor residual risks and identify new risks arising during project execution.

5. Update the organizational process assets.

Purpose of risk monitoring:

• To determine if risk responses have been implemented as planned.

• To determine if risk response actions are as effective as expected or if new responses
should be developed.

• To determine if project assumptions are still valid.

• To determine if risk exposure has changed from its prior state, with analysis of trends.

• To determine if a risk trigger has occurred.

• To determine if proper policies and procedures are followed.

• To determine if new risks have occurred that were not previously identified.

5.2 Inputs to risk monitoring and control

1. Risk management plan.

2. Risk Register. Contains outputs of the other processes: identified risks & owners, risk responses, triggers and warning signs

3. Approved Change Requests. Approved changes include modifications such as to scope, schedule, method of work, or contract terms. This may often require new risk analysis to consider impact on existing plan and identifying new risks and corresponding responses

4. Work Performance Information. Project status and performance reports are necessary for risk monitoring and control of risks.

5.3 Outputs from risk monitoring and control

1. Risk Register Updates. The risk register has been updated to reflect the outcomes of risk reassessments, audits, and reviews. These updates may influence the probability, impact, ranking, and response strategies associated with risks. The actual outcomes of risks and the effectiveness of risk responses will be documented as part of the project file for reference in future projects.

2. Corrective Action. Corrective action involves implementing the contingency plan or a workaround. Workarounds are unplanned responses to newly identified risks. It is essential to document these workarounds properly and integrate them into both the project plan and the risk response plan.

3. Recommended Preventive Actions. Used to direct project towards compliance with the project management plan

4. Project change requests. Implementing contingency plans or workarounds frequently results in a requirement to change the project plan to respond to risks. The result is issuance of a change request that is managed by overall change control.

5. Organizational Process Assets Updates. Information gained through the risk management processes are collected and kept for use by future projects: Templates for risk management plan, probability-impact matrix, risk register, lessons learned, updated RBS.

6. Project Management Plan Updates. Updates to the project management plan as a result of approval of requested changes.

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