



CONSTRUCTION RISK MANAGEMENT

Assistance Professor Mr. Zuhair M. Saco,

Abbas M. Burhan

Civil Engineering, College of Engineering,
University of Babylon.

ABSTRACT

In most of the construction projects, there are many events or risks may occur during the execution of project. These risks (e.g. the excess of project cost or the expected time, increasing the prices of material and labor, accidents, changes, engineering errors or omissions, bad quality, delay in reaching the facilities to the site, etc.) may effect negatively on the project and the parties. Therefore, these risks must be identified and assessed accurately to avoid or reduce the negative effects for these risks. The concept of risk is used to assess and evaluate uncertainties associated with an event or a process. A construction process includes many uncertainties, therefore, the construction project's parties are becoming aware of the construction process and thus the risks within this process are seeking more and more clarification that all is being done to remove foreseeable risk and minimize unforeseeable risk. It is also becoming clear that generic approaches to the management of risk are maturing and becoming easier to apply.

الخلاصة

في أغلب المشاريع الإنشائية يتوقع حدوث الكثير من الأحداث أو المخاطر أثناء التنفيذ. تلك المخاطر (مثل زيادة كلفة المشروع أو الزمن المتوقع لإنهائه، زيادة أسعار المواد أو العمال، الحوادث، التغييرات، الأخطاء والأهمالات، النوعية السيئة، الخ) ممكن أن تؤثر بصورة سلبية على المشروع وأطراف المشروع. لذا فإن تلك المخاطر يجب أ، تكون محددة ومقيمة بصورة دقيقة من أجل تجنب أو تقليل التأثيرات السلبية لتلك المخاطر. أن صناعة الإنشاء هي محاولة خطيرة مع العديد من الشكوك المرتبطة بأحداث أو ظروف. تلك الأحداث ممكن أن تكون مخاطر منظورة (مثل تأخيرات، أضرابات، إصابات، أخطاء وأهمالات، الخ) أو قد تكون مخاطر غير منظورة (مثل فيضانات، زلازل، حروب، الخ). أن مفهوم المخاطر يكون مستخدم لتقييم تلك الشكوك المرتبطة بحدث أو عملية. ولما كانت تلك الصناعة تتضمن الكثير من الشكوك (أو عدم التأكيد) فإن أطراف المشروع أصبحوا قلقين من تلك العملية الإنشائية التي فيها كل الأطراف يحاولون أن يتجنبوا المخاطر المنظورة ويقللوا من المخاطر غير المنظورة. كذلك أصبح واضح بأن مداخل كثيرة لإدارة المخاطر أصبحت مدروسة وسهلة التطبيق.

KEY WORDS

Risk, Risk Management, Project Management, Risk analysis

DEFINITION OF RISK AND RISK MANAGEMENT

Risk can be defined as the possibility of losses, injuries, damages, and/or delays arising during the execution of a project which may adversely affect its success. While risk management can be defined as a technique that helps to identify the elements that could potentially have a major negative impact on a project. Risk management process is a system that enables the management to evaluate the level of impact of a risk and then develop a plan or contingency for his eventuality and reducing this impact (Simmons,1998).

POTENTIAL AREAS OF RISK

When focusing on risk, it has been traditional to focus on the following items:

Cost

The focusing on cost generally means failure to keep the project within the budget, cost forecast, initial estimate, or the original tender.

Time

The focusing on time means failure to keep the project within its schedule or the time in which the project must complete.

Quality

This generally means a lack of focus on meeting the standards for function, fitness for purpose and the environment (Latham,1999).

Generally, risks encountered throughout a construction project can include:

- 1- Failure to complete within the time.
- 2- Failure to get the right planning and building regulations approval within the time.
- 3- Unforeseen ground conditions.
- 4- Exceptionally bad weather delaying a project.
- 5- Strike by labor force.
- 6- Unexpected price rises for labor and material.
- 7- An accident to an operative causing physical injury.
- 8- Latent defects through poor workmanship.
- 9- The occurrence of fire, flood, earthquake, etc.
- 10- Loss and expense claim which caused by late delivery of design by design team.
- 11- Failure to complete project within client's budget allowance.

THE TYPES OF RISK

There are risks to all projects and risk management is the process of identifying and containing them to ensure a project success. The following are some types of risk that are inherent in most construction projects (Bent & Thuman,1990):

Engineering Risk

The engineer is responsible for any engineering errors and omissions resulted from his negligence that can result in costly change orders, damage to equipment, or injury to persons.

Construction Risk

Almost, the contractor is responsible for many of the risks occurred during the execution of project. These risks may effect on the amount of contractor's profit or may lead to the loss. The contractor's risk can be minimized and that depends directly on the contractor's perceived abilities to forecast, assess, and manage those elements of exposure that are directly under its control. Normally, construction cost overruns are attributable to inaccurate estimation of construction requirements.



Inaccurate estimates result from inadequate scope of the project. For example, design or specifications may be inadequate; or contingency, allowances, engineering changes, inflation, or site conditions may not have been adequate foreseen.

Schedule Risk

Delays in the completion of a project result in increased overhead expenses and a general escalation of construction costs. Delays can result from such conditions as poor design or construction management, inadequate scheduling estimates, labor strikes or slowdowns, unexpected site conditions, delays in delivery of equipment, or defective equipment.

THE FIVE STEPS IN RISK MANAGEMENT PROCESS

Risk management is the identification, measurement, and treatment of property, liability, and personnel risk exposures. The process includes five steps (Williams & Heins,1985):

- 1- The risk of project must be identified. Risk identification is the first and perhaps the most difficult function that the project management must perform. Risk identification can be defined as determining which risks are likely to affect the project and documenting the characteristics of each. Failure to identify all the risks of the firm means that the management will have no opportunity to deal with these unknown risks intelligently. Identifying project risks should start early in the conception phase. The emphasis at that time is on identifying the high risk factors that might make the project difficult to execute or destine it to failure.
- 2- After risk identification, the next important step is the proper measurement of the losses associated with the risk. This measurement includes a determination of the probability or chance that the risk will occur, the impact of risk, and the ability to predict the losses that will actually occur during the budget period. The measurement process is important because it indicates the exposures that are most serious and consequently most in need of urgent attention.
- 3- Once the risk had been identified and measured, the various tools of risk management should be considered and a decision made with respect to the best combination of tools to be used in attacking the problem. These tools include primarily avoiding the risk, reducing the chance that the loss will occur or reducing its magnitude if it does occur, transferring the risk to some other party, and retaining or bearing the risk.
- 4- After deciding among the alternative tools of risk treatment, the project management must implement the decisions made.
- 5- The results of the decisions made and implemented in the first four steps must be monitored to evaluate the wisdom of those decisions and to determine whether changing conditions suggest different solutions.

THE RELATIONSHIP BETWEEN RISK AND OTHER TERMS

The term "Risk" is related to other engineering terms such as reliability and PERT (Project Evaluation and Review Technique) as illustrated:

Reliability

Reliability concerns with what can go right and how to maximize the likelihood that things will go right. But the risk concerns with what can go wrong, what happens if some things go wrong, what are the risks inherent to a project, and how could the project parties protect themselves from the consequences of something going wrong.

The reliability of an item (or an activity in the project) is the probability that the item will be performed successively under specified operational and environmental conditions throughout a specified time. The reliability of an item for a project can be calculated from the equation (1) (Kales,1998):

$$R(t) = e^{(-\lambda t)} \quad \text{Eq. (1)}$$

Where: $R(t)$ = the reliability at the time t .

λ = constant failure rate.

Where:

$$0 \leq R(t) \leq 1$$

$R(t) = 1$ implies certainty of success.

$R(t) = 0$ implies certainty of failure.

$R(t) + Q(t) = 1$, where $Q(t)$ is the unreliability or the risk at the time t ; so $Q(t) = 1 - R(t)$.

λ can be estimated from test of field data as shown in equation (2):

$$\lambda = C / T \quad \text{Eq. (2)}$$

Where C is the number of failures during total time T (e.g. number of injuries, number of delays of arriving materials, or number of change orders).

Consider a simple example, a project has a target completion time. The project manager expected that delays will occur during the execution. Over 12-weeks period (84 days), 5 delays were reported. What is the probability of occurrence the risk of delays for 3-weeks? Hence:

$$C = 5$$

$$T = 84 * 24 = 2016 \text{ hours}$$

$$t = 3 * 7 * 24 = 504 \text{ hours}$$

$$\lambda = C / T = 5 / 2016 = 0.00248 \text{ per hours}$$

The project reliability over 3-weeks (504 hours) period:

$$R(t) = e^{(-\lambda t)} = e^{-(0.00248)(504)} = 0.287$$

Which is the probability that the project will be performed for 3-weeks without delays. Hence, the risk of delays for 3-weeks is:

$$Q(t) = 1 - R(t) = 1 - 0.287 = 0.713$$

PERT Method

The PERT method (Project Evaluation and Review Technique) was devised to take account of the difficulty of estimating the duration of activities which can not be established conclusively from past experience. It was intended by its originators to account for risk and uncertainty in project scheduling. It is a way to warn managers of the need to compensate for the consequence of a risk on project duration.

The PERT method incorporates risk into project schedules by using three estimates for each project activity (a , m , and b) which enter in equation (3) to account the average time (t_e) as shown (Pilcher, 1976):

$$t_e = (a + 4m + b) / 6 \quad \text{Eq. (3)}$$

Where:

t_e = the average time or the mean of the *Beta* distribution. Wherever, the originator of PERT method assumed that the plots of duration of the activities almost fitted a *Beta* distribution curve.

m = the most likely duration of the activity.

a = the optimistic time that is the shortest time which could be anticipated for the activity.

b = the pessimistic estimate of the time, that is, the duration of the activity assuming that everything goes at its worst

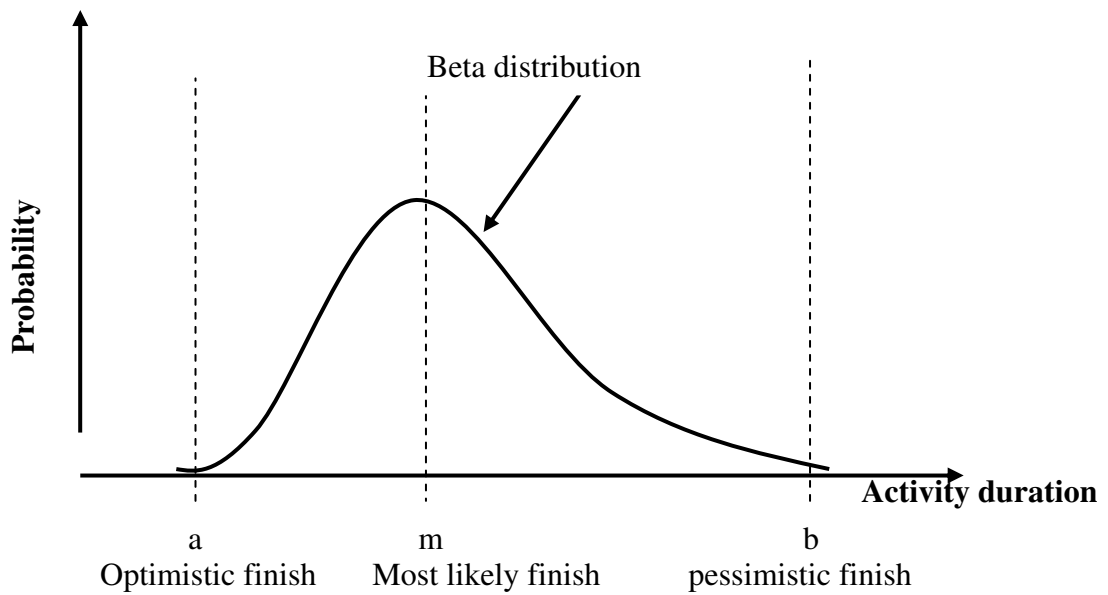


Fig. (1), An Activity Times in PERT Related to the Beta Distribution.

Greater risk in an activity is reflected by a greater spread between m and b , as shown in **Fig. (1)**. For an activity with no perceived risk, a , m , and b would be identical. If, however, hazards are identified, the way to account for them is to raise the values of b and m . In general, the greater the perceived consequence of risk hazards on time, the further b is from m . Thus, for a particular activity with given optimistic and most likely values (a and m), using a large value of b to account for greater risk will result in a large value of t_e , which logically would allow more time to complete the activity and compensate for things that might go wrong (risks). In addition, however, the larger value of b also results in a larger time variance for the activity because variance is:

$$V = (b - a) / 6 \tag{Eq. (4)}$$

This larger V will result in a larger variance for the project completion time, which would spur the cautious project manager to add a time buffer to the project schedule (Nicholas,2001).

Consider a simple example, an activity within a project has a target completion time of (8 months). Suppose the activity has little risk and the values of (a , m , and b) are estimated as (5, 6, and 7 months), respectively. From equation (3) and (4), the values of t_e and V are thus (6 months) and (0.33 months). Using a normal approximation values for project duration, we can compute the probability of completing the project in (8 months), thus:

$$Z = (D - t_e) / \sqrt{V} \tag{Eq. (5)}$$

$$Z = (8 - 6) / \sqrt{0.33} = 3.46$$

Where:

Z = a normal approximation value for calculating the probability.

D = the target completion time.

From the table of normal distribution, this Z -value yields a probability of over 99 percent. Assuming management trusts the time estimates, they would likely proceed with the project without worry.

Now, take the same one-activity project and suppose a major risk is identified that would increase the estimate of the pessimistic value from 7 to 12 months. In that case, t_e and V would be (6.83 months) and (1.167 months), and Z would be:

$$Z = (8 - 6.83) / \sqrt{1.167} = 1.08$$

and from the table, this Z-value yields a probability of about 86 percent. Given the lower probability of meeting the (8 months) target time, management might add a time buffer to the schedule (extend the target time), or take action to reduce the risk (which would allow a lower value for b). In short, assuming that the estimates for a, m, and b are credible, the PERT method provides a way for measuring the consequence of risk on project completion times.

RISK RESPONSE PLANNING

Risk response planning addresses the matter of how to deal with risk. In general, the ways of dealing with an identified risk include transferring the risk, altering plans or procedures to avoid or reduce the risk, preparing contingency plans, or accepting the risk.

Transferring the Risk

Risk can be transferred partly or fully from the owner to the contractor, or vice versa, using contractual incentives, warranties, or penalties attached to project performance, cost, or schedule measures. The contractor and the owner may decide to split the risk through a contractual agreement in which each manages the risks they can handle best. Different types of contracts split the risks in different ways. For example, in fixed price contract (e.g. lump sum contract), the contractor assumes almost all of the risk for cost overruns, while in cost plus fixed fee, the owner assumes almost all of the risk.

Of course it is impossible to entirely transfer the risk to one party or another. Even with a fixed price contract, where the contractor takes all the risk, the owner still incur damages or hardship should the project exceed the target schedule or the contractor declare bankruptcy. The project still must be completed and someone has to pay for it. Coming along with the transfer of risk usually is a transfer of authority, so that an owner agreeing to a cost plus fixed fee contract also will almost certainly argue for a large measure of management oversight on the project (Nicholas,2001).

Avoiding the Risk

Risk can be avoided by eliminating risky activities, minimizing the complexities, changing contractors, incorporating redundancy and safety procedures, and so on. Even though many risk factors can be avoided, not all can be eliminated, especially in large or complex projects. Attempting to eliminate risk usually entail adding innumerable management controls and monitoring systems that increase system complexity and introduce new sources of risk. Research projects and innovative, new product development projects are inherently risky, but they offer potential for huge benefits later on. Because the potential benefits of such a project is proportionate to the size of the risk, it is better to reduce risk to an acceptable level rather than completely avoid risk.

Reducing the Risk

Key elements, which can reduce the risks, include (Office of Financial Management,1998):

- 1- Early establishment of project definition.
- 2- Clear and coordinated project responsibilities.
- 3- Adequate construction administration services are included in the contract with consultants.
- 4- The necessity of experience of project staff.
- 5- Project scope, schedule, and budget are balanced and determined at outset and reviewed regularly during the project.
- 6- Differences and disputes are resolved immediately.
- 7- A systematic and thorough review of construction documents is performed before bidding the project.

Risks can be reduced through many ways associated with technical performance, meeting schedules, and meeting project cost target as illustrated (Nicholas,2001):



❖ The ways of reducing risk associated with technical performance are:

- 1- Employ the best technical team.
- 2- Base decisions on models and simulations of key technical parameters.
- 3- Use mature, computer-aided system engineering tools.
- 4- The technical team need incentives for encouraging the success of work .
- 5- Hire outside specialists for critical review and assessment of work.
- 6- Perform extensive tests and evaluations.
- 7- Minimize system complexity.

❖ The ways of reducing risk associated with meeting schedules are:

- 1- Create a master project schedule and strive to adhere to it.
- 2- Schedule the most risky tasks as early as possible to allow time for failure recovery.
- 3- Maintain close focus on critical and near-critical activities.
- 4- Put the best workers on time-critical tasks.
- 5- Provide incentives for overtime work.
- 6- Organize the project early and be careful to adequately staff it.

❖ The ways of reducing risk associated with meeting project cost targets are:

- 1- Identify and monitor the key cost drivers.
- 2- Use low-cost design alternative reviews and assessments.
- 3- Verify system design and performance through modeling and assessment.
- 4- Maximize usage of proven technology.

Contingency Planning

Contingency is the amount of money (or time) that should be added to the base estimate in order to predict the total installed cost and the accurate completion time for the project. Contingency may also be interpreted as the amount of money that must be added to the base estimate to account for work that is difficult or impossible to identify at the time a base estimate is being prepared. Sometimes, contingency is intended to cover known unknowns. That is, the estimator knows there are additional costs, but the precise amount is unknown (Oberlender,2000).

So, contingency is a necessary component of an estimate. Engineering and construction are risk endeavors with many uncertainties, particularly in the early stages of project development. Contingency is assigned based on uncertainty and may be assigned for many uncertainties, such as pricing , escalation, schedule, omission, and errors.

Traditional Methods of Assigning Contingency

There are many methods of assigning contingency, and the estimator must select the method considered most appropriate for each project, based on information provided by the project management team.

1- Percentage of Base Estimate:

Contingency may be assigned based on personal experience. A percentage is applied to the base estimate to derive the total contingency. Although this is a simple method, the success depends on extensive experience of the estimator and historical cost information from similar projects.

Contingency may be determined as a percentage of major cost items rather than as a percentage of the total base estimate. This method typically relies on the personal experience and judgement of the estimator, but the percentage can also be from established standard percentage based on historical data. This method has the advantage of considering risk and uncertainty at a lower level than that used when contingency is based on a percentage of the total base estimate (Oberlender,2000).

Generally, many companies use this method to assign contingency needed to be added to the base estimate. Since, after the estimator estimates the costs of items of a project such as civil works, electrical works, mechanical works, etc., he adds contingency as a percentage of each major cost

item about depending on the type of item and the personal experience of estimator. Therefore, the personal experience and judgement of the estimators and engineers should not be overlooked in the process of assigning contingency. Even the most advanced computers are not substituting for the knowledge and experience of the human mind. Estimators with many years of experience with a particular type of facility can often be quite accurate in assigning contingency based on how they feel about the level of uncertainty and risk associated with a project, the cost data used in preparing the estimate, and the thoroughness of the effort in preparing the base estimate.

2- Expected Net Risk:

The estimator may determine contingency based on expected maximum risk and likelihood. The expected value for risk is a function of the risk impact (or outcome) and likelihood of occurrence as shown below:

$$\text{Expected value} = \sum [(\text{outcome}) \times (\text{likelihood})]$$

This method is used if the project was repeated many times. The risk consequence on project duration is called the risk time, RT. It is the expected value of the estimated time required for risk correction, computed as (Nicholas,2001):

$$\text{RT} = (\text{corrective time}) \times (\text{likelihood}) \quad \text{Eq. (6)}$$

The risk consequence on project cost is called the risk cost, RC. It is the expected value of the estimated cost required for risk correction, computed as:

$$\text{RC} = (\text{corrective cost}) \times (\text{likelihood}) \quad \text{Eq.(7)}$$

For example, suppose the base time estimate (BTE) for project completion is (26 weeks) and the base cost estimate (BCE) is (\$71,000). Assume that the risk likelihood for the project as a whole is (0.3), and should the risk materialize, it would delay the project by (5 weeks) and increase the cost by (\$10,000). Hence,

$$\text{RT} = (5) \times (0.3) = 1.5 \text{ weeks}$$

$$\text{RC} = (\$10,000) \times (0.3) = \$3000$$

These RT and RC would be included as contingency or buffer amounts in the project schedule and budget to account for risk and must be added to the base estimate to result the final estimate. The final estimate for time and cost is computed as:

$$\text{ET} = \text{BTE} + \text{RT} = 26 + 1.5 = 27.5 \text{ weeks}$$

$$\text{EC} = \text{BCE} + \text{RC} = \$71,000 + \$3000 = \$74,000$$

Where ET and EC are the expected project completion time and cost respectively.

The above way is used for risk factors that affect the project as a whole. Another way to determine the expected net risk value is to estimate the risk likelihood and corrective time (and cost) for each element of the project. For example, a project has eight work packages, and for each the base cost estimate (BCE), risk likelihood, and corrective cost have been estimated. The **Table (1)** lists the information for each work package and gives EC, where EC is computed as:

$$\text{EC} = \text{BCE} + [(\text{corrective cost}) \times (\text{likelihood})] \quad \text{Eq. (8)}$$

For the same eight work package project, assume the base time estimated (BTE), risk likelihood, and corrective time have been estimated for each work package. The **Table (2)** lists the information for each work package and gives ET, where ET is computed as:

$$\text{ET} = \text{BTE} + [(\text{corrective time}) \times (\text{likelihood})] \quad \text{Eq. (9)}$$



Table (1), Expected Net Risk Analysis for Cost.

| Element | BCE | Corrective cost | Likelihood | Expected net risk | EC |
|---------|----------|-----------------|------------|-------------------|----------|
| A | \$10,000 | \$2,000 | 0.2 | \$400 | \$10,400 |
| B | \$8000 | \$1,000 | 0.3 | \$300 | \$8,300 |
| C | \$16,000 | \$4,000 | 0.1 | \$400 | \$16,400 |
| D | \$10,000 | \$6,000 | 0.2 | \$1,200 | \$11,200 |
| E | \$8000 | \$2,000 | 0.3 | \$600 | \$8,600 |
| F | \$9000 | \$2,000 | 0.1 | \$200 | \$9,200 |
| G | \$5000 | \$1,000 | 0.3 | \$300 | \$5,300 |
| H | \$5000 | \$1,500 | 0.3 | \$450 | \$5,450 |
| Total | \$71,000 | | | \$3,850 | \$74,850 |

Table (2), Expected Net Risk Analysis for Time.

| Element | BTE (week) | Corrective time (week) | Likelihood | Expected net risk | ET |
|---------|------------|------------------------|------------|-------------------|------|
| A | 6 | 1 | 0.2 | 0.2 week | 6.2 |
| B | 4 | 1 | 0.3 | 0.3 | 4.3 |
| C | 6 | 2 | 0.1 | 0.2 | 6.2 |
| D | 10 | 3 | 0.2 | 0.6 | 10.6 |
| E | 2 | 1 | 0.3 | 0.3 | 2.3 |
| F | 8 | 1 | 0.1 | 0.1 | 8.1 |
| G | 1 | 1 | 0.3 | 0.3 | 1.3 |
| H | 1 | 1 | 0.3 | 0.3 | 1.3 |

Suppose the **Fig. (2)** represents the network for the project of the above example. In this example, without considering the risk time, the critical path would be [A-B-D-E-G-H], which gives a project BTE of (24 weeks). Accounting for risk consequences, the critical path does not change but the duration is increased to (26 weeks). This is the project ET. Although activities on critical and near critical paths should be monitored carefully, in general, any activity that poses a high risk consequence (high likelihood and/or high impact) should also be monitored carefully, even if not on critical path.

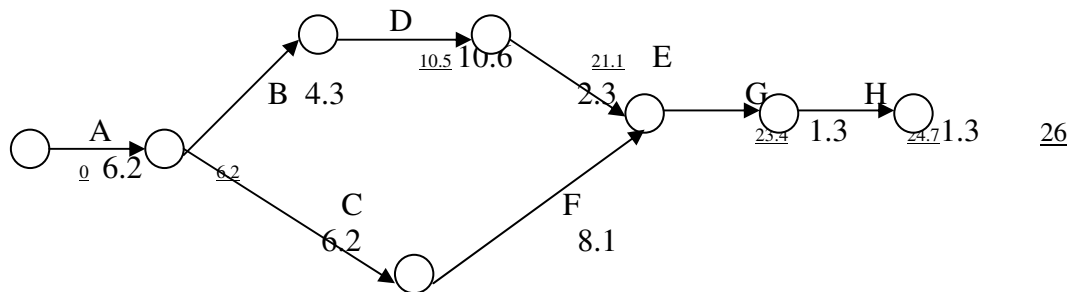


Fig. (2), Project Network, Accounting for Risk Time.

Accept Risk (Do Nothing)

Not all impacts are severe or fatal, and if the cost of avoiding, reducing, or transferring the risk exceeds the benefit, then “do nothing” might be advisable. Of course, this response would not be chosen for risks where the impacts or consequences are potentially severe.

RIGHTS AND RESPONSIBILITIES OF PROJECT PARTIES

The contract includes many rights and responsibilities for the project's parties, especially those for the owner and the contractor, and there are many conditions that effect on those parties and may lead to disputes or differences between them. Therefore, it must identify the rights and the responsibilities for each party and who must bear the risks that occur during the execution of contract.

Rights and Responsibilities of Owner

The owner, as a contracting party, has several rights especially reserved for him. Depending on the type of contract and its specific wording, he may be authorized to award other contracts in connection with the work, to require contract bonds from the contractor, to approve the surety proposed, to retain a specified portion of the contractor periodic payments, to make changes in the work, to carry out portions of the work himself in case of contractor default or neglect, to withhold payments to the contractor for adequate reason, and to terminate the contract for cause. The right of the owner to inspect the work as it proceeds, to direct the contractor to expedite the work, to use completed portions of the project before contract termination, and to make payment deductions for uncompleted or default work are common construction contract provisions (Clough,1975).

By the same token, the contract between owner and contractor imposes certain responsibilities on the owner. For example, construction contracts make the owner responsible for furnishing or arranging financing, providing site and access, acquiring permits and licenses, contracts for all necessary services, and making periodic payments to the contractor. The owner must assume all risks that have not been assigned to or assumed by others. He is required to make extra payment and grant extensions of time in the event of certain risks provided for in the contract. When there are two or more prime contractors on a project, the owner has a duty to coordinate them and synchronize their field operations.

Generally, the owner is responsible for the following exceptional risks (Ministry of Planning,1988):

- 1- War (whether war be declared or not), invasion, act of foreign enemies, or civil war.
- 2- Riot, commotion, or disorder by persons other than the contractor's personnel and other employees of the contractor and subcontractors.
- 3- Ionizing radiation or contamination by radio-activity, except as may be attributable to the contractor's use of such radiation or radio-activity.
- 4- Use or occupation by the owner of any part of the permanent works, except as may be specified in the contract.
- 5- Design of any part of the works by the owner's personnel or by others for whom the owner is responsible.
- 6- Any operation of the forces of nature which is unforeseeable and against which an experienced contractor could not reasonably have been expected to take precautions.

The owner must protect himself from exposure to risks. One key in the protection of owner from risk is the type of contract. The owner must select the appropriate type of contract depending on the circumstances that prevail. For example, the "lump-sum" contract affords the owner some protection against cost overruns by placing responsibility for construction on the contractor. While, the "cost-plus" contract may expose the owner to the risk of increasing prices of materials and labors.

Rights and Responsibilities of Contractor

The contractor has few rights and many obligations under the contract. His major responsibility, of course, is to construct the project in conformance with the contract documents. Although some casualties and risks are considered as justification for allowing him more construction time, only severe contingencies such as impossibility of performance can serve to relieve him from his obligations under the contract.



The contractor is expected to give his personal attention to the conduct of the work, and either he or his representative must be on the job site at all times during working hours. The contractor is required to conform with laws and ordinances concerning job safety, licensing, sanitation, and other aspects of the work. The contractor is also responsible for and warrants all materials and workmanship whether put into place by his own forces or those of his subcontractors. Contracts typically provide that the contractor shall be responsible for the work until its final acceptance (Clough,1975).

The expertise of contractor may play an important role in protecting him from the risks that may occur during the execution of the project. The contractor must be able to predict the risk, assess it, and add the contingency amount for his bid to cover this risk. For risks that are within the contractor's control, contingency amount will be at a minimum. For risks that are beyond the contractor's control, contingency amount will be at a maximum. The owner pays for the risk whether it occurs or not. If the risks do not occur, the contractor realizes more profit. In the reality of the marketplace, however, a contractor who prices each and every risk into a bid will not win the job. Since, other contractors may be willing to accept some risks in order to secure the work.

The most important contractor rights concern progress payments, termination of the contract for cause, right to extra payment and extensions of time for reason, and appeals from decisions of the owner or the architect engineer.

Duties of Architect-Engineer (The Designer)

The architect-engineer provides preliminary engineering and detailed design, specifies and may procure engineering items, and may provide construction management services. The architect-engineer is not a party to the construction contract, and no contractual relationship exists between him and the contractor. He is a third party who derives his authority and responsibility under the contract from the owner. However, the jurisdiction of the architect-engineer to make determinations and render decisions is limited to and circumscribed by the terms of the construction contract. The architect-engineer represents the owner in the administration of the contract and acts for him during day-to-day construction operations. The architect-engineer advises and consults with the owner, and communications between owner and contractor are made through the architect-engineer.

The architect-engineer's risks are usually mistakes "errors and omissions". These can lead to costly change order, damage to equipment, or injury to persons. For example, the engineer's fees will usually not exceed (5 – 8)% of the total project cost, while the damages resulting from an engineering errors may exceed the total project cost. Mistakes can occur even though the engineer is not negligent. This has been the owner's risk because the engineer is obligated only to perform with ordinary engineering skill and diligence. Therefore, the owner should determine whether the engineer would be willing to guarantee the work. If so, the remedy to the owner is clear. In most cases, however, engineers will limit responsibility reperforming the defective engineering only. They will not assume liability for any resulting loss or damage (Bent & Thuman,1990).

CONTRACTUAL RISK

The construction industry is notoriously risky. Much of the preparatory paperwork that precedes construction projects can be viewed as the formulation of risk allocation between the owner, the contractor, and the designer.

The owner is taking the risk that his project will not get built on schedule, that it will not get built for what he has budgeted, and that it will not be of the quality he expected. The owner naturally seeks to insure that these three factors will be satisfied, and he often thinks he can accomplish this through the contract language. In the investment projects, the owner is also taking the risk that his project will not give the appropriate returns according the preliminary studies. In some cases, the owner has other risks beyond these, for example, building a nuclear power plant or some other project subject to public protest or environmental and regulatory delays. Typically, however, an

owner will seek to control whatever risks he can through his contract documents. On other hand, the contractor faces a multitude of risks. Among them are inflation, bad weather, strikes and other labor problems, shortage of materials, accidents, and unforeseen conditions at the construction site. Ultimately, the contractor faces the possibility of losing a great deal of money or of being forced out of the business. Naturally, he too would like the contract wording to be protective of his interests. Many owners still view the obligatory contract as consummate protection. In reality, such contracts often turn out to be bad business, for the following reasons (Rubin, Guy, Maevis, and Fairweather,1983):

- 1- Obligatory contracts discourage responsible bidders. The only way a responsible contractor can protect himself from a high risk situation is to include a high contingency in his bid. If the risk and the contingency are sufficiently high, his bid will not be competitive, and probably not within the owner's budget.
- 2- Ambiguous language or exculpatory clauses through which the owner hopes to escape responsibility almost result in conflict. When the conflict escalates to the courtroom, judges almost rule against the party who drew up the ambiguous contract (the owner).
- 3- Such contracts attract those bidders willing to take any kind of chance or those who expect from the outset to make up their money via claims.

CONTRACTUAL ALLOCATION OF RISK FOR PROJECT'S PARTIES

Owners use contract language to assign some or all of the risks to the contractor. But, fundamentally, regardless of the contract language, contractors can not and do not assume the risk for some conditions, and continue to expect owners to share the risk. Contractors do not accept the idea that the responsibility for some risks belongs to them or can be assigned to them (Halligan, Hester, and Thomas,1987).

There is no fixed rule to help answer the question that who should bear what risks, but the chart in **Table (3)** suggests a starting position for determining who should bear what risks. In this chart, the types of risks and allocation of those risks for each party are showed (Fisk,1988).

Risk allocation form, as shown in table 3, is not a standard state for all types of contracts, however, some risks can be transferred from one party to another according the type of contract. For example, the design-built contract may transfer the engineering risks (errors and omissions, conflicts in documents, defective design and drawings) from the owner to the contractor. While, cost plus contract may expose the owner to the risk of increasing prices of material and labor.

Table (3), Construction Risk Allocation to Participants

| Type of risk | contractor | owner | engineer |
|---------------------------|------------|-------|----------|
| Site access | | * | |
| Subsurface conditions | | * | |
| Quantity variations | * | * | |
| Weather | * | | |
| Acts of God | | * | |
| Financial failure | * | * | * |
| Subcontractor failure | * | | |
| Accidents at site | * | | |
| Defective work | * | | |
| Management incompetence | * | * | * |
| Inflation | * | * | |
| Materials and equipment | * | | |
| Labor problems | * | | |
| Owner-furnished equipment | | * | |
| Delays in the work | * | * | * |
| Environmental controls | | * | |
| Regulations | | * | |
| Safety at site | * | | |
| Public disorder | | * | |
| Errors and omissions | | | * |
| Conflicts in documents | | | * |
| Drawings | | | * |



Site access is obviously an early risk and one that the owner should retain.

Subsurface conditions of soils, geology, or ground water can be transferred to the contractor, who is in a better position to assess the impact of these conditions on the project cost and time. However, as an essential party of the transfer process, the owner has the responsibility to undertake pre-contract exploration measures and the designer has the responsibility to design for the conditions expected. The extent that this is not feasible should determine the degree to which the owner retains a portion of the risk under an “unforeseen conditions” clause.

Weather, except for extremely abnormal conditions, is a risk for the contractor to assume, as its impact on construction methods can be better assessed by the contractor.

Acts of God, such as flood or earthquake are owner’s risks.

Quantity variations are another form of risk frequently encountered. Within reasonable tolerances, quantities of work can be reasonably estimated and any variances assumed by the contractor for all quantities in excess of, for example, 15 to 25 percent. Where quantities are dependent upon subsurface or other less known conditions, significant variations should be shared only to the extent that exploratory information is available. Quantity changes triggered by late changes in the owner’s requirements, should be at the owner’s risk.

Defective design is a risk usually associated with the engineer. The tremendous expansion of construction has placed great burdens upon the design professions. Maintaining performance standards in the face of this is quite difficult, and occasionally, design and specification defects occur that create construction problems. Unfortunately, it is usually the owner and the contractor who suffer the consequences of such failures instead of the engineer who creates the problem in the first place. Design failures are becoming more and more apparent, and the engineer should bear the true cost of such failures.

Subcontractor failure is a risk that is properly assumed by the contractor except where it arises from one of the other listed risks attributable to the owner or the engineer. The general contractors are in the best position to assess the capacity of their subcontractors.

Defective work of construction, to the extent that the problem is not caused by a design defect, should be the contractor’s risk.

Accident exposures are inherent to the nature of the work and are best assessed by the contractors. Furthermore, the contractors have the most control over site conditions that can increase or decrease accident exposure.

Management incompetence is a risk that must be shared by each party. It is an ongoing challenge for each organization to assign personnel according to their respective competence levels.

Financial failure is a risk not frequently mentioned, and can happen to any of the parties to a contract. Although infrequent, the order of magnitude of such failure should be considered. It is a shared risk, as the parties need to look at the financial resources of themselves.

Inflation is one of the world’s realities. Every owner is conscious of its impact on the viability of the project. It is important that the owner retain the true cost. The government experts in finance have so far been unable to predict where the country will be a few years from now, so it is unfair to expect the contractor to do better than the so-called government experts.

Labor, materials, and equipment involve considerable risks. The availability and productivity of these resources necessary to construct the project are risks that it is proper for the contractor to assume. The expertise of the contractor should follow the assessment of cost and time required to obtain and apply these resources. This is the basic service that the owner is paying for.

Delays in the work are common risk in most of the construction projects, and can happen by any of the parties to a contract.

Environmental risks rightfully belong to the owner alone and should be retained by the owner except to the extent that they are influenced by construction methods determined by the contractor, or created by suppliers controlled by the contractor.

Regulations by government in the social area, such as safety and economic opportunity are the rules under which the contractor rightfully must operate.

Public disorder and war are political catastrophes of such impact that their risk is best retained by the owner, lest it becomes necessary to pay an unusually high price for transferring the risk to another party.

CONCLUSIONS

There are group of conclusions can be summarized by the following points:

- 1- The experience of project team may play an important role in reducing the risks. Since from their experience, they could anticipate the risks of a project and know the procedures required to reduce the negative impacts of these risks.
- 2- The accuracy of bid price depends on the acquaintance level of owner (or contractor) for anticipation, assessment, and management of risks that may lead to excess in the project cost; and then included the costs of these risks in the bid.
- 3- Some of owners attempt to transfer the risks to the contractor by adopting a specific contractual form. This manner sometimes decreases from the owner cost because of decreasing his risks. On other hand, it is impossible to entirely transfer the risks to the contractor. Even when the contractor takes all the risks, the owner still incur damages or hardship should the project exceed the target schedule or the contractor declare bankruptcy. Also, the contractor may put a high price for his bid to cover the risks.
- 4- The owner, who selects the appropriate type of contract according to the prevail conditions, may gain some of protection against the risks that may occur. For example, the “lump-sum” contract affords the owner some protection against cost overruns by placing the responsibility of construction on the contractor. While, the “cost-plus” contract may expose the owner to the risk of increasing prices of material and labor.
- 5- Some of owners attempt to use an ambiguous contract language to protect themselves from the risks. This manner is not correct and may cause problems and differences between the parties.
- 6- The contractor, who prices each risk in his bid, will not win in the bidding because of existence other contractors willing to bear some of risks in order to win in the bidding.
- 7- The risk and the responsibility on it can be identified in the contract clauses, and this manner can avoid the parties any disputes or differences between them as that risk occurs in the future.
- 8- The owner must bear any engineering risk resulted from errors, omissions, or changes in design, plans, or specification; especially when is responsible on furnishing these documents. On other hand, the contractor is responsible on the engineering risks resulted from his errors and omission during the execution.

APPENDIX.-REFERENCES

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