EVALUATION OF THE RISK CRITERIA IN BUILDING CONSTRUCTION COST MANAGEMENT

A NEW APPROACH IN INCREASING THE EFFICIENCY OF COST MANAGEMENT BY ASSISTANCE OF RISK MANAGEMENT

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ABSTRACT

Cost is the most important matter in construction industry because of the great dimensions of the projects and the mass capitals invested in the business. The profitability of any investment absolutely depends on the proper control of costs from the feasibility phase to the operation phase.

There are many factors effecting the construction process where they may cause serious problems. The reason for unsuccessfully completion of any scheduled and planned construction project is that the most likely schedules to successfully complete the projects can not be selected properly, and the risk factors cannot be foreseen before they cause the problem. In view of the uncertain nature of the construction industry, Risk Management has taken an important place.

The objective of this research is to evaluate the effects of the risk management over the cost management. i.e. to forecast the processes of the production under the uncertainty, to determine the potential problems and risks, to quantify the risks, to determine the possible causes of the risk and taking the evasive action either by preventing or minimizing the problem in the viewpoint of cost.

In order to achieve the objective of the research, forecasting, decision making, risk management and cost management systems and methods will be evaluated.

As every construction project is unique, each project has its own problems and risks. In most cases, there are no past data exist. That is why the determination of the risks should be based on a subjective forecasting method.

One of the main problem in risk management for construction industry is that the risk management methods are very complex and requires special education or training.

However the need for the risk management is vital. The main purpose of the model developed in this research is to make the risk management process easy and for everyone in the building construction industry.

For the model of the research, a group of methods will be used. For the source data of risk i.e. risk identification, Delphi Method is appropriate. And output data of the Delphi Method can be best analysed with Cross Impact Method where the interrelations of the risk factors can be reviewed. The quantified data can be brought into life by analysing and applying them to the Cost Information, in other words Cash Flow. One of the easiest and most appropriate method for this purpose is the Risk Adjusted Discount Rate Method, where the uncertainties could be brought into reality.

This research can be beneficial for the private sector as well as public sector and educational purposes.

ÖZET

İnşaat endüstrisinde, projelerin ve yapılan yatırımların büyüklüğü nedeniyle en önemli konulardan birisi maliyettir. Herhangi bir yatırımın da kârlılığı, maliyetlerinin fizibilite aşamasından işletme aşamasına kadar geçen süreçte etkin şekilde kontrolü ile mümkündür.

İnşaat sürecini etkileyen çeşitli faktörler vardır ve bu faktörler ciddi problemlere sebep olabilirler. Planlaması yapılmış bir inşaat sürecinde dahi başarısızlıklarla karşılaşılabilir. Bunun nedeni, projenin tamamlanması için farklı planlamalar yapılabilir ve süreçte karşılaşılabilecek olan problemler ortaya çıkıncaya kadar görülemezler. Bu nedenle Risk Yönetimi İnşaat Sektöründe önemli bir yer tutmaktadır.

Bu araştırmanın hedefi, inşaat risk yönetiminin maliyet yönetimi üzerindeki etkilerini değerlendirmek ve belirsizlik altındaki üretim sürecinde ortaya çıkabilecek risk faktörlerinin etkilerini saptamak ve karşı-önlem alarak zararlarını minimize etmektir.

Bu hedefe ulaşabilmek için öngörüleme, karar verme, risk yönetimi ve maliyet yönetimi alanları ile ilgili sistem ve yöntemler değerlendirilecektir.

Yapı projelerinin herbirinin kendine özgü olması nedeniyle, her proje kendine has problem ve riskler barındırır. Kesin anlamda geçmiş istatistiki bilgiler elde etmek mümkün değildir. Çünkü bir seri üretim sözkonusu değildir. Bu nedenle riskler üzerine öngörüleme yapılırken sübjektif öngörüleme metodlarından yararlanılacaktır.

İnşaat sektöründe risk yönetimi açısından en önemli problemlerden birisi, risk yönetim yöntemlerinin çok karmaşık ve ileri seviyede eğitim gerektiriyor olmasıdır.

Bununla birlikte, risk yönetimine olan ihtiyaç çok yüksektir. Bu araştırmada geliştirilen modelin en önemli özelliklerinden birisi de herkesin uygulayıp kullanabileceği kadar kolay yöntemler içermesidir.

Bu modelde bir grup metod kullanılmıştır. Risk konusunda kaynak bilgiler yani riskin tanımlanması için Delphi Öngörüleme yönteminden faydalanılmaktadır. Delphi yönteminin çıktılarının analizi için en uygun yöntem olarak Cross Impact (Çapraz Etki) yöntemi kullanılmaktadır. Böylece risk faktörleri arasındaki ilişkiler de değerlendirilebilmektedir. Bu yöntemle sayısallaştırılan bilgiler Maliyete olan etkileri veren Risk Primi olarak karşımıza çıkmaktadır. Risk primlerinin ise maliyete yansıması Risk Adjusted Discount Rate (Riske Göre Düzeltilmiş İndirim Oranı) yöntemi kullanılmaktadır.

Bu araştırma, hem özel sektör, hem kamu kurumları, hem de eğitim açısından faydalı olabilecek bir araştırmadır.

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CHAPTER 1

INTRODUCTION

In a building construction project, one of the most important concept is the "cost" which have close connections with the "time, quality & scope" of the aimed production. Especially in the construction industry, cost is one of the most important elements that should be carefully studied. As the huge amounts of capital is tied for a long time span, it is inevitable to control the cost of the construction in as much detail and care as possible. There are many factors affecting the cost of the project and most of them should be determined at the beginning and be controlled during the project development.

In every project, it is known that there may always be some unexpected situations and uncertainties during the project life cycle which affects either one or all of the "cost – time – quality - scope" components. These uncertainties can cause a loss of capital, quality, reputation and so on. These unpredictable factors are called as the Risk Factors in the project. In order to make profit and to achieve the aimed results, the clients or contractors would want to know about the probability of the success of the project and quantify the predicted results as accurately and far as possible before the project is undertaken. It is the most important matter for the investor to make profit on his capital by undertaking the project. At this point of view, knowing the possibility of completion with success is vital for the investor, in order to make a decision on whether to undertake the project or not.

It is a common sense that as the risk increases, the more profit should be expected on the investment. There is no point to invest in a project with a high risk level where the profit margin is very low. The investor should foresee the possible risks which could be faced during the operation of the project, and eliminate the possible obstacles and bottlenecks which could affect the course of the project. Any unpredictable and unavoidable bottleneck will cause a loss during the project. It is responsibility of the

Project Manager to determine these possible risks and obstacles in order to avoid any unplanned cost during the project.

To accomplish a project successfully at aimed purposes, proper project management is vital. A proper project management can only be achieved by effective and efficient application of the 9 knowledge areas of project management which are defined in the PMBOK (Project Management Body Of Knowledge) by Project Management Institute. (PMBOK, 1996, p.6, 7). Cost management is one of the most important knowledge area and one of the most important component of any project. Because it is inevitable to evaluate the total cost, planned cash flows, expected revenues, planned expenses, overall costs, the expected profits and so on. That is the reason the cost management is the key component of project management.

The risk management is another component i.e., another one of the 9 knowledge areas but it is not really concerned about or applied often. Actually there can be many alternative schedules and programs lead to the success of a project but all of them have their own risks and uncertainties. The aim of the risk management is to determine the most likely or the least risky schedule and programs and to foresee the possible risk factors long before they happen in order to avoid them from the inception phase until the completion of the project.

The construction projects are subject to more risk and uncertainty than many other industrial projects. The process of taking a project from initial investment appraisal to completion and into use is complex, time and cost consuming. Because of the nature of the construction process, there are various interdependent entities, processes and services which are quite difficult to coordinate and which may cause the cost management applications to be complex and frequently modifying. The aim of this research is to increase the efficiency of cost management of a construction project by applying a risk analysis & management method and process in order to foresee and eliminate any possible bottlenecks which could cause unplanned cost and loss.

Following chapters will provide information on Cost Management and Risk Management definitions & principles. Then the model will be built by Delphi and Cross Impact Methods by applying the forecasting and data analysis in order to determine and

quantify the risks in construction project. Lastly, the quantified risk factors will be contributed to the cost management processes by "Risk Adjusted Discount Rate Method".

1. 1 The Motivation of the Research

In the new economy, the competition is rival, while the time and the resources are limited. In these conditions, it is absolutely necessary for an investor to strictly control the resources, the production, quality and time. Especially in the construction industry where the high capitals are tied up for a long time and the expected profit will return after a long time and there are high fixed and variable costs. In such a condition, every investor needs to forecast the probable risks and to take the necessary action on time before losing capital.

In view of the risky nature of the construction industry, it is surprising that the managerial techniques used to identify, analyze and respond to risk have been applied in the industry only during the last decade. In developed countries, Risk Management has taken an important place in construction industry. Universities, private consulting and investment corporations, public and government associations are making in-depth researches about risk & risk management and trying to widen the application areas of this component of PM.

In Turkey, as a developing country, it is highly necessary to do researches in these areas, in order to avoid the possible risk factors that could cause serious loss and waste of time, quality, money and other resources.

Risk plays a crucial role in business decision-making. It can manifest itself in numerous ways, varying over time and across activities. Uncontrolled or unexpected risks may cause hazardous results for the investor. When the risks are known at the planning phases of the investment, it is easier to control them. Also it is easier to forecast the uncertain situations before the problems occur. That is the reason, cost management should not be separated from the risk management.

Studies show that the most of the projects can not be completed on aimed cost, duration and quality even though they were scheduled and planned in detail. This is because there are many alternative schedules to be chosen for the course of project and there are many

risk factors affecting the schedules. The reason for unsuccessfully completion of any scheduled and planned project is that the most likely schedules to successfully complete the projects can not be selected properly, and the risk factors cannot be foreseen before they cause the problem. Even with the most likely figures, schedules have 50% of probability to be completed on time given the fact of normal distribution curve. When the risk factors effects the schedule, generally it is too late to evade or take the necessary action. But in order to take control of the succeeding risk factors, it is inevitable to apply the risk management processes.

As a chain reaction, when the various minor risk conditions impact each other sequentially, they can cause more serious impacts on the course of the project and sometimes they can cause more destructive effects than expected. At this point of view, it is inevitable not only determining the risk factors independently, but also determining the interrelations and cross impacts of each factor on the others. It is highly necessary to determine the risk factors independently in order to predict their possible effects to the schedule and cost respectively. On the other hand it is inevitable to determine interdependent effects and accumulated rates of the effects in order to evaluate the possible results which might occur when many minor risk factors effects the schedule sequentially. The motivation of this research arises from this fact.

Numerous studies and texts have dealt with the Risk Management and Cost Management for construction industry. Most of them deal with the underlying theoretical concepts of cost management and risk management and with techniques used to identify and manage them. There is a gap between the theory and the techniques proposed to manage risk and cost of the project, but it is not likely to find research about how to combine these two PM knowledge areas. This research is intended to be a first step in this direction.

There is also another fact that many forecasting and risk management methods are based on the complex and advanced mathematical models. Most of the time, these models are far from being used by the many project managers and other responsible personnel who haven't got a degree or training on the related sciences. Because of this problem, many companies or managers are reluctant to apply risk management processes. That is because,

an easier and attractive risk management process should be developed. This is also another motivating point for this research.

1. 2 The Objective of the Research

The objective of this research is to develop a model to evaluate the effects of the risk management over the cost management. i.e. to forecast the processes of the production under the uncertainty, to determine the potential problems, risks, and uncertain situations before they actually happen during the construction stages, to quantify the risks, to determine the possible causes and combined effects of the risk factors to the cash flows and cost management processes, and taking the evasive action either by preventing or minimising the problem in the terms of cost.

In order to achieve the objective of the research, forecasting, decision making, risk management and cost management systems and methods will be evaluated and utilised.

The use of such a model will help developing more effective process where there are many risk factors with high risk rates. In order to build such a model effectively, a proper project management is vital. The application of proper project management will also help the undertaking parties to be in a strict work discipline.

The proposed model may help private and government companies and associations to take control of the uncertainties and possible effects on the cost of the contract as well as on the country's economy.

Also the proposed model will be easier to apply for managers and responsible personnel who haven't got a degree or training on complex and advanced risk related areas. This is especially important for the developing countries for making widespread use of risk management methods. It also makes for any small-scale enterprise, company or project manager possible to apply the risk management process to their project management applications even if they are more simple efforts.

CHAPTER 2

COST AND RISK MANAGEMENT IN CONSTRUCTION INDUSTRY

2. 1 Introduction to Construction Cost Management and Risk Management

Cost is the most important matter in construction industry because of the great dimensions of the projects and the mass capitals invested in the business. The profitability of any investment absolutely depends on the proper control of costs from the feasibility phase to the operation phase. Any individual enterprise needs to make profit in order to survive and continue its existence.

The inevitable increase in size and complexity of construction projects forces any participating party in the business to give much care and attention to the strict control of every phase of the project. Especially the managers of projects, whether acting on behalf of an owner, a designer or a contractor, are faced with the need to have a greater understanding of all the relevant and associated economic aspects of their work. Project managers must be able to implement a high degree of control, not only in respect of the day-to-day progress, cost and quality of the work, but also over the influences arising from the total external environment in which the project is being constructed. This can be achieved by the application of a proper project management effort.

Project management has been described as "...to plan, coordinate, and control the complex and diverse activities of modern industrial and commercial projects." (Lock, 1992, p.1) by Dennis Lock, and "...managing the activities that lead to the successful completion of a project." (Pyron, 1994, p.2) by Tim Pyron. So, project management can be described as the application of management principles and methods to organise, plan,

control and direct resources of an organisation for a temporary and specific goal. The difference of the project management from conventional management is that a project has limited goals and more narrowly focused concepts. It is temporary and success or performance depends on the objectives like time, quality and budget.

"Construction Management" can be described as the application of project management methods and principles to a construction project. The main knowledge areas in order to carry out the proper project management have been determined and described by the PMI (Project Management Institute) (PMBOK, 1996, p.6, 7). which is a non profit association who aims to support project management activities and professionals by educating, training and sharing information. These main knowledge areas are listed as;

1. Project Integration Management
2. Project Scope Management
3. Project Time Management
4. Project Cost Management
5. Project Quality Management
6. Project Human Resource Management
7. Project Communication Management
8. Project Risk Management
9. Project Procurement Management

The construction projects with their complexity and dimensions, are the ones that require all of the above knowledge areas to be applied during all stages.

Increasing productivity and finding rational and economical solutions have become the new goals of building sector as in all other industrial sectors. And one of the key concept is Project Management in order to achieve these goals. A proper project management can beneficially affect building sector probably the most but it is not applied widespread in Turkey yet.

Modern projects are not necessarily great in scale. But economical pressures of the industrialied world made the competition rival between sponsors, contractors and companies. That is the reason, achieving the project goals on time, on budget and on quality become more important and inevitable. The aim of planning and managing the project is to achieve the most economic investment within the minimum duration and with

the highest possible quality. This gives the most cost efficient solution. It is very hard to achieve these 3 goals at the same time but with the help of some quantitative methods, it is possible to optimize them successfully. The aim for the final result is to satisfy the sponsor or purchaser, within the promised time-scale, without using more money or resources, bearing the risks in mind. At this stage, accuracy of the project schedules and efficiency of the project management can only be achieved by managing the risks properly.

In construction business, there are many internal and external factors that can affect the advance of the project which are called as risk factors. These risk factors and bottlenecks which can affect the smooth advance of the project, should be foreseen and determined long before they occur and the necessary action should be taken on time in order to evade them or to reduce their negative effect. This determination can be done by properly analyzing the project environment, and the application of a risk management process.

2. 2 Construction Cost Management

All around the world, every company or individual entrepreneur works for making profit in order to live, gain better life standards, develop the economy, science and technology, create employment, etc. On the other hand there are some private or governmental organisations who works for non profit purposes such as charities, social services and meeting basic public needs. In both cases, every enterprise or service can be considered as a project even it's size is small or huge.

In a project, maybe the most important concept is the "project cost" which is inevitable to determine at the beginning and to control during the project development. No matter it is for profit or non-profit purposes, the cost should be under control at every phase of a project. Especially in the key industries of all economies such as construction industry, where huge amount of capitals are tied. Whether it is for profit purposes or public services, cost should be known in order to finance and launch the project.

2.2.1 Definition and the Need for the Cost Management

The Cost Management can be described as estimating, budgeting and controlling the resources and costs of the elements or processes of a project. Then, "Construction Cost

Management" can be described as estimating, budgeting and controlling the resources and costs of the elements and processes of a construction project.

"Project Cost Management includes the processes required to ensure that the project is completed within the approved budget....

... Project cost management is primarily concerned with the cost of the resources needed to complete project activities. However, project cost management should also consider the effect of project decisions on the cost of using the project product. For example, limiting the number of design reviews may reduce the cost of the project at the expense of an increase in the customer's operating costs. This broader view of project cost management is often called life-cycle costing.

In many application areas predicting and analysing the prospective financial performance of the project product is done outside the project. In others (e.g., capital facilities projects), project cost management also includes this work. When such predictions and analysis are included, project cost management will include additional processes and numerous general management techniques such as return on investment, discounted cash flow, payback analysis, and others.

Project cost management should consider the information needs of the project stakeholders—different stakeholders may measure project costs in different ways and at different times. For example, the cost of a procurement item may be measured when committed, ordered, delivered, incurred, or recorded for accounting purposes." (PMBOK, 1996, p.73).

The decision to invest capital in construction industry or a project which needs a construction work inside, is taken on the basis of an estimate of capital cost together with the need for the associated working capital (for raw materials, labor, work-in-progress, product stocks, etc.) and some other items such as future replacement, repair and maintenance costs. These investment costs are expected to be returned over the life of the asset plus an additional profit margin by way of return for the investment. Therefore, it is important, that the capital cost of the facilities is controlled during design, construction and installation so that the basis of the investment appraisal can be sustained during this phase

of the creation of capital assets. Once the capital is invested in physical assets almost nothing can be done to reduce it and its effect on the economic appraisal of the investment. It is important that needless capital investment is therefore avoided and that control rather than monitoring of expenditure is undertaken during both design and construction.

If the capital cost of a facility escalate during design and/or construction beyond that level where the asset being provided the cease of work can be financially inevitable. In that case, work can be stopped. At the design point, with probably almost no direct financial commitment to physical construction, the relative penalty costs will not be too severe. However, if construction is underway, with a major part of the facility already constructed, the choices between alternatives at this stage are not attractive. On the one hand, there is a partly-finished facility probably incapable of performing any useful function and difficult to dispose of; on the other, the prospect of a total capital investment in excess of that originally envisaged and a project that is no longer economically acceptable.

A construction contractor will have objectives for his own cost control which will differ from those of an owner's project management. Essentially, a contractor is controlling against his anticipated margin on the work for the well being of his own organization. So he needs to be in a position to pinpoint inefficient and uneconomic areas of his operations with a view to their investigation and correction. However, through these cost control procedures and the information flows between himself and an owner's project management, a contractor will become the first source of warning for possible variations in the total cost of the works which will affect the subsequent return on the investment project. It is important, therefore, to recognize that all the parties to an investment project involving construction activity have a role to play in controlling the construction costs.

2.2.2 Factors Affecting the Cost of Construction

Construction is an industry where the architect's designs and ideas are brought into reality. Architect makes the complete designs and drawings with the technical details and contracts in the most economic conditions with the acceptable quality. The architect should define the construction method, cost decisions and information on his project.

The aim of planning and managing the project is to achieve the most economic investment within the minimum duration and with the highest possible quality. This combination gives the most cost efficient solution. It is very hard to achieve these 3 goals at the same time but with the help of some quantitative methods, it is possible to optimise them successfully.

A builder requires strict information such as cost estimates, present machine-equipment reports and man-hour records so that he can decide his estimating policy, together with existing cash and material statements to see present resources and financial conditions in order to regulate his production or undertake a new job.

In order to evaluate the financial conditions, all the costs of contributing elements should be listed and considered in detail. Mainly these costs are listed below: (Cartlidge & Mehrtens, 1982, p.98)

1. *The cost of the site – a purchase price (a capital sum), or an annual rent (annual sum)*
2. *Cost of construction and associated professional fees (a capital sum)*
3. *Annual running costs, for example, heating and annual maintenance (an annual sum)*
4. *Periodic expenditure, for example boiler replacements, renewal of roof coverings (capital sums to be met at regular internals)*
5. *A further costs may be a premium paid to a landlord every xth year. Such a premium means that a lower rent is asked and, therefore, the annual equivalent is already taken into account as a deduction from the full market rent.*

Considering the above determinations, in the construction industry, the factors affecting the cost of construction can be listed as below in detail:

General Costs:

- Fixed Site Costs
- Regular Site Costs
- Unproductive Personnel

Charge of Central (HQ)Expenses

- Overheads

Plants and Permanent Equipment

- Service Buildings etc.
- Amortization

Direct Costs

- Sub- contractors
- Laboring and workmanship expenses

Materials Costs

- Consumed or Mounted Materials
- Stocks

Advance Payments

- Work Advance Payments
- Materials Advance Payments
- Advance Tax Payments

Special Costs

- Bank Credit Interests
- Representation Costs
- Insurance & Taxes
- Others

All above costs contribute the total cost of the investment and should be taken into consideration. This list covers all the stages of the construction process. Depending on this list, the estimating can be prepared and the control can be made during the construction phase based on this cost information.

2.2.3 Major Processes of Cost Management

The major processes of the Cost Management has been described as below by the PMI;

*"**Resource Planning**—determining what resources (people, equipment, materials) and what quantities of each should be used to perform project activities.*

***Cost Estimating**—developing an approximation (estimate) of the costs of the resources needed to complete project activities.*

***Cost Budgeting**—allocating the overall cost estimate to individual work items.*

***Cost Control**—controlling changes to the project budget."* (PMBOK, 1996, p.73).

Figure 2.1 shows the components and processes of Cost Management

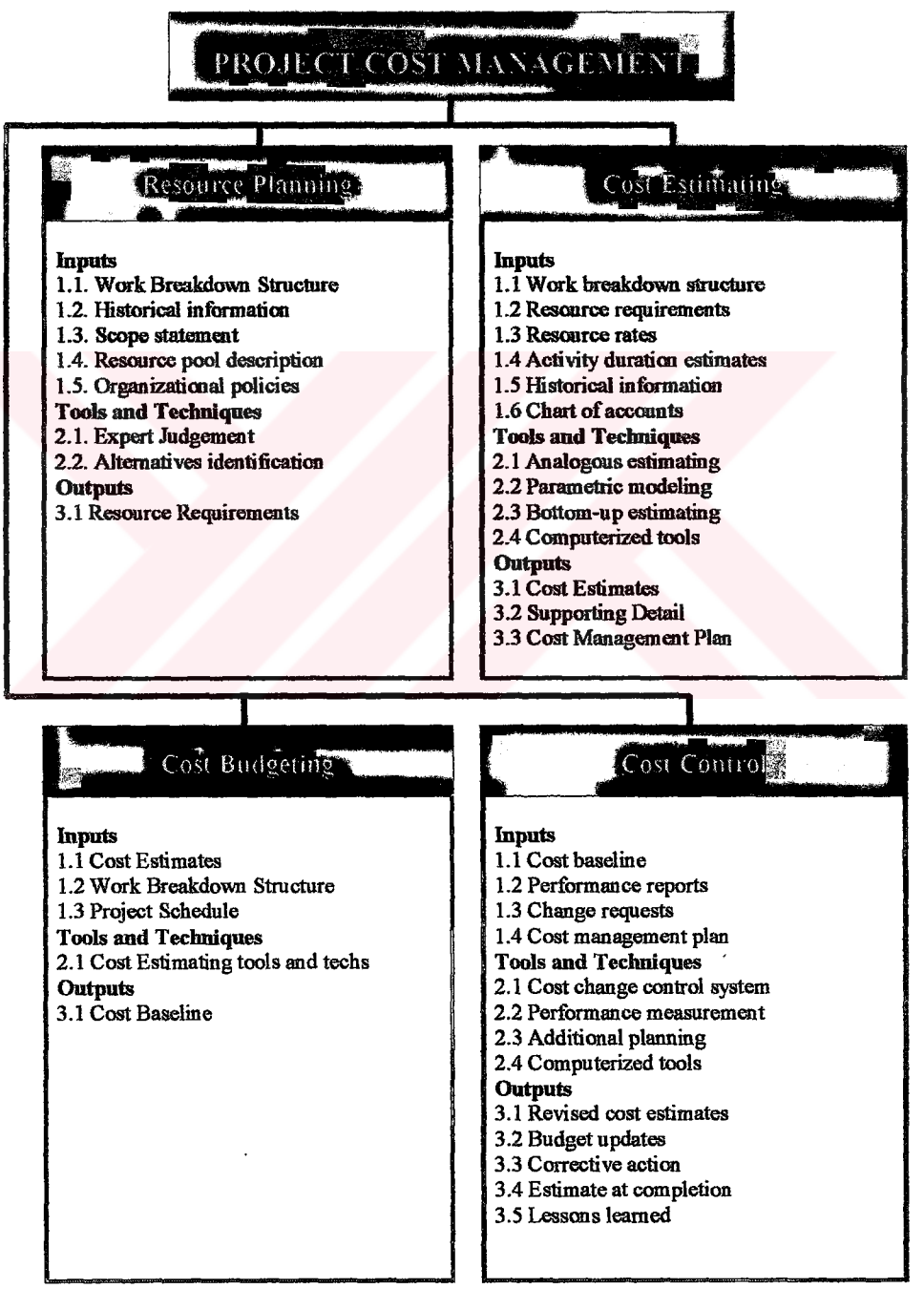

Figure 2.1 Project Cost Management Overview (PMBOK, 1996, p.74)

These processes interact with each other and with the processes in the other knowledge areas as well. Each process may involve effort from one or more individuals or groups of individuals based on the needs of the project. Each process generally occurs at least once in every project phase. Although the processes are presented here as discrete elements with well-defined interfaces, in practice they may overlap and interact in ways not detailed here.

2.2.3.1 Resource Planning

Construction is a high labour-dependent industry. Employing, assigning and managing the staff and key personnel can be very important in most cases, especially in the countries where the labouring costs are low. All contracting firms employ staff from unskilled labours to skilled and experienced site or office managers. No construction firm can exist for a long time unless they have a proper personnel policy.

Labor and personnel are not the only resources needed in construction industry. Materials and equipment are also the resources that should be planned carefully.

There is always a conflict of demand among resources required for construction work. Resource allocation is a means of determining within the constraints of the float available an optimum combination of activity schedules which will best achieve contract completion. By rescheduling activities within certain limits it may be possible to reduce the peak demand. The aim is to achieve a reasonably constant demand for a particular resource during construction.

Whenever a project has to be accomplished according to a time, then it is useful to have at least some idea of the relationship between the time allowed and the time needed. Any plan, drawing or specification which is to be read by more than one person must be regarded as a means of communicating information. There are several methods developed for time-scale planning from simple charts to more complex estimation calculations. The ideal project plan requires careful cooperation between the key participants in the proposed work, all striving to meet the needs of the customer and balancing these with the capabilities of the project organization. To be really effective, the constituent elements of the plan must be reliably estimated and arranged in their most logical sequence.

Basically, resource planning consists of the following stages;

- Identify and estimate resource requirements and make the resource pool
- Determine the quantities for the use of each resource
- Determine the duration of their use
- Perform the scheduling and planning activities

2.2.3.2 Cost Estimating

Construction planning is generally concerned with completing a project in the shortest possible time with the most economical method. The scientific approach to production begins with a complete analysis of the job, down to its smallest component parts. The production of each component is planned in terms of the optimum material usage, and the effective assigning of resources in labour and plant. All components are then fitted together in a program of production. The main goal here is that each component should be ready on time, in the correct balance of quantities and at the right place. The work flow should be programmed and carried out very carefully.

Estimation is the key phase of cost management. Winning the tenders rely on the accurate cost estimations. When the cost estimates are accurate, it is easier to win the contract and the increase the profitability,

Efficiency in the construction means a shorter contract period where a huge amount of capital is tied up, with less costs and lower overheads, so that the total cost is effectively decreased. This kind of programs also provide a useful basis for ordering materials, and a reference for assessing progress.

When the tender is won, the real task of construction planning begins. It is vital that every project, should be properly planned from this point on regardless of its size or duration. Intense attention is necessary in this phase. Spending time on this work avoids later blockings of the work.

Before starting the site operations, a program of work is essential. The most common way of doing such a program is a Gantt chart which could be supported with a Critical Path Analysis. It is also useful to prepare a financial graph based upon the master program. The

work program is essential in any kind of project. However the scale of the program can be determined depending on the scale of the project.

2.2.3.3 Cost Budgeting

Monthly programming is very important especially for companies doing long term business and large scale projects. Accuracy of the monthly data is vital. The liquidity of the company's funds depends on the valuation of work done and control of outgoings. The monthly data to be analysed is generally collected from weekly reports that are prepared by different departments of company such as site engineers, foremen, purchasing manager etc.

A better control of production may be achieved by preparing weekly programs. It is still necessary to take a forward view each month. The operations to be started or done during the coming week, and checking the requirements exactly is the key operations of weekly programming. The program chart should be drawn up as before but for one week ahead only which indicates crew and perhaps work hours.

Achievement analysis: Proper project planning can have an important influence on labour costs and overall costs and the duration of a job. During the construction process, the achievement should be checked regularly in order to control the costs or the time schedule determined for each task of the project. The timing of these checks can be programmed either by time or by task. In order to make proper comparisons between the planned progress and actual achievement, it is also desirable that some standard of physical measurement be applied to each item. Quantities by weight, volume, area, length or number can be calculated or estimated. The data for the calculations can be obtained from the weekly or monthly reports. The analysis of the achievement can be simply done by a percentage. This may be the comparison of the materials usage, the man-hour calculations or the timing of the work etc.

Detailed planning and achievement analysis can also help to eliminate idle and non-productive usage of materials, labour and plant. Once a non-productive element determined, corrective action can be taken at once.

One of the main elements of the cost budgeting is the cash flow. A cash flow is the movement or transfer of money into or out of a company. Contractors should be alert to the timing of both payments and receipts for work done. In construction work there is a disparity between timing of payments that may distort the true financial position.

The conditions of contract usually indicate when payments will be made to the contractor for work done and also the amount of retention both during and after the contract. On most projects the contractor is entitled to payment based on an interim valuation usually on a monthly basis. From this valuation would be deducted a mutually agreed percentage retention value.

When preparing the cash flow, a 5 step procedure should be followed;

1. Using the estimate and project plan (bar chart), develop a time-scaled plan for payments (cash out) for labour, materials, plant and subcontractors. Include direct costs only in this calculation.
2. Add to this plan the expected expenditure on preliminaries and general overheads for each project.
3. Establish expected receipts in the form of payments from clients and other sources for each project.
4. Prepare a cumulative statement indicating the next requirements for cash.
5. Compare actual expenditure and receipts on an ongoing basis, and revise each plan if necessary.

The main purpose of cash flow planning may be summarised as follows:

1. It ensures that sufficient cash is available to meet demands.
2. It provides a reliable indicator to lending institutions that advances made can be repaid according to an agreed program.
3. It ensures that cash resources are fully utilised to the benefit of the owner and investor in the company.

Cash flow forecasting

The three main ingredients in the determination of cash flows are:

1. Payments (cash outflow): This is the aggregate of the payments which a contractor will make over a period of time for the resources he uses in a project, e.g. labour, plant, materials, subcontractors.

2. Receipts (cash inflow): This is the receipts which a contractor will receive over a period for the work he has completed.

3. Timing of payments: In cash flow analysis we are interested in the timing of payments so that the size of deficiency can be estimated and the time period over which this deficiency applies can be assessed.

The timing of payments and receipts is related to the work done by the contractor. In contract work, the conditions of contract indicate when interim and final receipts may be expected. The size of these receipts reflects progress to date and the project plan is the principal source of these data. The project plan which may be prepared in a network form and then converted to bar-chart format indicates the starting and finishing date of each operation. An examination of these operations indicates what payments will be made and received over a period of each operation. While the project plan indicates, in physical terms, the program for construction, the estimate is used to expand this to give the data for each element.

2.2.3.4 Cost Control

One of the principal objectives of most organizations is the achievement at minimum cost. Because all business enterprises are in business to make profit. Profit in simple terms is what is left after all the costs or outgoings have been paid and deducted from the total income has been received. For all construction projects, costs must be controlled and optimized if necessary, whether from the point of view of owner, designer or a contractor.

"Cost control, whatever the industry; may be defined as the regulation, by executive action, of the cost of carrying out the various activities which go to make up a project or a contract." Pilcher, Roy (1994)

It is necessary to carry out cost control, analysis, and cost optimization methods at all stages of activity during the construction process. Cost control and analysis applications are necessary for detection of favourable and unfavourable variances of performance and

expenditure. On the other hand, cost optimization is concerned with the establishment, usually by analysis, of the methods, resources and the program of work which should be adopted so that a project will be carried out at minimum total cost.

The analyses of progress can not be separated from the management of the project. The effective project management decisions depend on the accurate information and communication. Collecting, sorting and analysing the information for large and complex projects can not be done without the use of the computer. Highly developed and complicated computer programs makes loads of data storing, calculations and analysis at the same time. That is the reason, the use of computer programs will not be separated from the project management any more to get the most effectiveness and the best performance.

Actually there are no projects carried out same as they were planned. Some can be finished earlier and some can be finished a later. But the primary objective of a project plan is to carry out the project as close as the original planned one. If this is achieved, the project can be considered as successful.

2.2.4 The Time Value of Money

The value of the money changes in time mainly depending on the inflation which also determines the interest rate. If a sum of money put in a bank today, it would be earning interest each year and in the future, this would be a much higher amount of money than today, depending upon the interest rates.

Conversely, we can see that a sum of money at some time in the future will always be worth less than the same amount of money today, and the difference will depend upon:

- the length of time involved
- the probable interest rate
- future risks

In the past, the time value of money was not considered to be important, because:

- interest rates were 3% or lower in most countries and inflation was non-existent or discarded
- buildings were comparatively simple and construction times were quick

- the techniques of cost estimating were crude.

But today the situation is quite different:

- Interest rates will continue to be a major factor, especially as rates tend to go up during expansionary periods when large programs of building work are being undertaken.
- Inflation is far from negligible.
- With the increasing complexity of large buildings it is not uncommon for some years to elapse from the start of expenditure on the project to the time when an income is produced or the building is available for use.
- Clients now expect a sophisticated cost planning service in developed countries.

In construction business, it is now inevitable to analyse the time value of costs of construction activities as well as the income. This means that the cash flows should be prepared considering the time value of the money.

There are several methods to determine the time value of money. The basic method to determine the future value of the capital invested in now. This is the compound interest formula which is;

$F = P * (1+i)^n$ (Pilcher, Roy (1994) p.50)

Where,

F is the Future Compound Amount,

P is the Present Compound Amount (i.e. Original Sum),

i is the rate of interest per period

n is the number of periods

The reverse process of compounding is known as discounting, i.e.

$$P = \frac{F}{(1+i)^n}$$

This discounting formula gives us the Net Present Value of a future payment (either income or outcome)

2. 3 Construction Risk Management

All around the world, every company or individual entrepreneur works for making profit in order to live, gain better life standards, develop the economy - science and technology, create employment, etc. On the other hand there are some private or governmental organisations who works for non profit purposes such as charities, social services and meeting basic public needs. In both cases, every enterprise or service can be considered as a project even it's size is small or huge.

In a project, maybe the most important concepts are the "cost and time" which have close connections with the "quality" of the aimed production and which are inevitable to be determined at the beginning and to be controlled during the project development. No matter it is for profit or non-profit purposes, the cost, time and quality should be under control at every phase of a project. Especially for the key industries of all economies such as the construction industry where huge amount of capitals are tied. Whether it is for profit purposes or public services, they should be known in order to launch and carry out the project.

In every project, it is known that there might always be faced with some unexpected situations and uncertainties during the project which affects either one or all of the above components. That is the reason, the sponsors or contractors would want to be informed about the probability of the success of the project and quantify the predicted results as accurately and far as possible before they undertake the project. However, there are always uncertainties and problems effecting the smoothly proceeding of a project. This is called as the Risk Factor in the project.

Construction is considered to be a high risk industry. The risks not only arise from financial activities but also from physical activity on the site. Many construction activities are concerned with the future. All estimates of cost at the design and tendering stages contain a degree of uncertainty because they always have to be prepared on incomplete information and the actual outcome cannot be predicted accurately. Each type of contract contains a different amount of risk.

Clearly risk analysis is becoming increasingly important as an aspect of construction to be investigated at all stages of a project. With new approaches and differing views becoming available, risk analysis will become a standard acceptable aspect of project management's work. Because it is better to undertake such studies as early as possible in the investment and preferably before any of the parties to a project are committed to the expenditure of hard money.

The risk management is one of the 9 knowledge areas but it is not concerned about or applied often. Actually there can be lots of different schedules and programs lead to the success but all of them have their own risks and uncertainties. The aim of the risk management is to determine the most likely or the least risky schedule and programs and to foresee the possible risk factors long before they happen in order to avoid them from the beginning.

2.3.1 Risk and Construction

The profit is the key achievement in any industry in order to continue the existence of any enterprise. Profit and risk are the inseparable and directly related elements of the economy. As a principle in economy, as the risk is higher, the expected income (profit) should be more. If the risk is low, than the profit will be low. This principle is highly applicable in construction industry.

Because of the huge amounts of capital invested in the sector, and many internal and external factors effecting the industry, construction business is always a high risk sector. On the other hand, the sector is not in the control of a few giant companies as it is in hi-tech industry and so. In computer peripherals business, the CPU production can be in control of very few individual companies. So it is in the software sector. But for the construction industry, there are many competitors who have the same or very similar know-how and technology. When this problem is combined with the many external and internal factors effecting the investment, the competition becomes rival between the competitors. The number of competitors makes it impossible for the companies to make high profits from the contracts. At this point, the idea of efficiency becomes more important. Thus, the efficiency can be reached by only an effective cost management supported with risk management theories.

Construction projects have an abundance of risks, where the owners pay for it and the contractors cope with it. Undertaking a project from initial investment appraisal to completion and into use is a process which is complex and entails time-consuming design and production processes. Many people with different skills and interests participate the process, and a coordination of a wide range of disparate and interrelated activities is needed. This complexity is compounded by many external, and internal uncontrollable factors.

The managerial techniques used to identify, analyse and respond to risk have been applied in the industry only during the last decade when so many risks in construction is considered. Most people agrees that risk plays an important role in business decision-making. On the other hand, there is not much agreement about what causes risk. Risk can be faced in numerous ways, varying over time and across activities. The source of the risk is uncertainty, which is caused by a lack of information.

Even though the research studies about risk have been carried out since last decade, there are still gaps between the theory and the techniques proposed to manage risk especially in construction industry. Forecasting, expert skills and judgement may influence decision-making, but some other tools are also needed which will enable risk management techniques to be applied in the construction industry. This research is intended to be useful at this point.

The concept of risk can be applied to nearly every decision-making action where the consequences are uncertain. The uncertainty arises from an essential characteristic of decision-making that it is about the future. The future itself by nature is uncertain. Therefore time is an important variable to be considered when dealing with risk. For the construction industry, there are many other variables to be considered. Because of the nature of the industry, there are two main groups participating the construction business. The principals who commission the construction such as government or a development company or an individual householder, and the agents who undertake the activities to produce the construction such as architects, engineers, contractors and a wide range of professionals.

Construction projects have many involving parties and it is an organization where many activities and processes are carried out. Combining them is a very complex and difficult effort considering so many internal and external factors affecting the industry. Intuition, expert skills and judgements can not be enough to undertake the project in such a risky environment. That is the reason, construction business needs more efforts to identify, quantify and analyse the risk factors in a project.

"Risk management aims to ensure that all that can be done, will be done to ensure the project objectives are achieved. Once a risk is identified and defined, it ceases to be a risk, it becomes a management problem." (Flanagan, R. & Norman, G., Risk Management and Construction, 1993, p.5)

2.3.2 Definitions

"Project Risk Management includes the processes concerned with identifying, analyzing and responding to project risk." (PMBOK, 1996, p.111). Then, "Construction Risk Management" is to determine, analyze and respond to the risk factors affecting the progress of a construction project.

In practice risk is mostly known as an unknown threat. But the environment where decision-making takes place can be divided into three parts: (Flanagan, R. & Norman, G., Risk Management and Construction, 1993, p.22)

- certainty
- risk
- uncertainty

"Certainty exists only when one can specify exactly what will happen during the period of time covered by the decision. This does not, of course happen very often in the construction industry.

Many writers go to great lengths to explain difference between risk and uncertainty, while others consider the terms to be synonymous. There is a general consensus that a decision is made under risk when a decision maker can assess, either intuitively or rationally, the probability of a particular event occurring. Risk has its place in a calculus

of probability and lends itself to quantitative expression. For instance, past performance indicates that a 60 storey office building can be built in the UK in 30 months; there is an element of risk in this estimated duration, but past data tell the decision-maker that it can be achieved with at least some degree of certainty. The risk of success and the cost of failure can be calculated by using the probability of failure.

Uncertainty, by contrast, might be defined as a situation in which there are no historic data or previous history relating to the situation being considered by the decision-maker. In other words it is one of a kind." (Flanagan, R. & Norman, G., Risk Management and Construction, 1993, p.22)

Construction projects involve many interacting activities, each with a time, cost, quality, and sequencing problem. The costs and duration are generally uncertain and a common approach to respond the risk is to ignoring the uncertainty and hoping for the best. Another way to respond uncertainty is to apply expert judgement, experience, and analysing the uncertainty.

"Risk and uncertainty need to be identified in a structured way to try and remove the fog of uncertainty. Building models of uncertainty in projects is not difficult. The hardest part is not finding the techniques or the tools to analyse risk and uncertainty, but accepting that life is uncertain and that it is better to grasp it rather than ignoring it." (Flanagan, R. & Norman, G., Risk Management and Construction, 1993, p.23)

The source of the risk is the uncertainty of the future events that can also be called as ignorance. However there are four ways to remove ignorance: Analysis, Synthesis, Simulation and Test. This approach is the base of risk management structure. Figure 2.2 shows this structure. (Flanagan, R. & Norman, G., 1993, p.22)

Identifying the risk management is not the only problem. The risk should be quantified. At this point, Probability is an important concept in quantifying risk and also decision making.

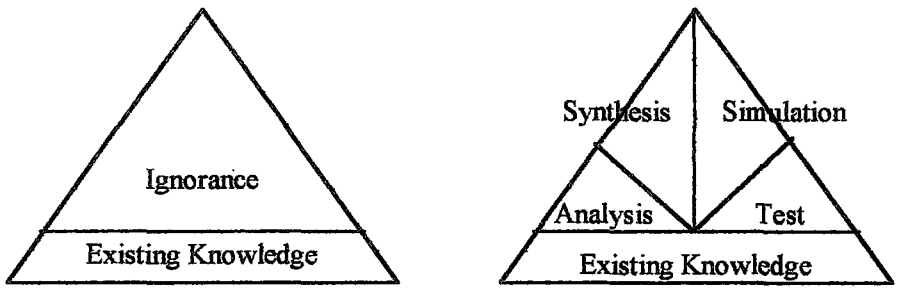

Figure 2.2 The Base of the Risk Management Structure (Flanagan, R. & Norman, G., 1993, p.28)

Probability theory deals with random events (or stochastic) events, whose outcomes are affected by chance. In decision-making process, probability means certainty.

"There are two schools of thought about probability theory:

- *Objective probabilities - The objectivists believe that probabilities must relate to long term frequencies of occurrence. In other words, only events that can be repeated over a large number of trials may be governed by probabilities. Therefore, only after repeated observations can we speak of the relative frequency of events and the associated probabilities;*
- *Subjective probabilities - According to this concept, the probability of an event is the degree of belief or confidence placed in its occurrence by the decision-maker on the basis of the evidence available. Hence, if the decision-maker feels an event is very unlikely to occur, he will assign a probability value of its occurrence close to zero; if he believes the event is very likely to happen he will assign a probability value close to one. Subjective probabilities represent the degree of belief that a person believes is correct, based on the information available to him. In order to use subjective probabilities in decision-making, they have to be accurate, reliable, calibrated and coherent."* (Flanagan, R. & Norman, G., Risk Management and Construction, 1993, p.28)

In the construction industry, generally the decisions are likely to be determined by subjective probabilities. All construction projects are unique; construction is not a routine and repetitive process like factory production line. In most cases in construction industry, decision-makers must decide the frequencies of occurrence from experience and samples.

All objective and subjective data currently available should be used in the assignment of subjective probabilities. These probabilities should reflect the decision-maker's beliefs.

Probability theories can also be used at the risk analysis and response stages.

Taking action against risks depends on an accurately evaluation of the uncertainty and a proper decision making process. Decision making tools are the important components of risk management process. The goal of the decision making techniques is to define the probabilities, consequences and alternative financial options.

Decision making process generally depends on the forecasting techniques. In order to evaluate the alternatives and to make the correct decision, the forecasting techniques are needed. Forecasting methods help decision maker to foresee possible consequences of future events by evaluating past data. This is valid for most cases. But as mentioned before, construction projects are all unique. Very rarely two projects are have same or similar risks. Thus, only a few past data can help to forecast the possible risk consequences such as weather conditions. At this point, the decision maker needs expert judgement and intuition in order to forecast risk probabilities.

"In principle regardless of how good the decision making process and tecniques are, there are some basic rules for taking risk; (Flanagan, R. & Norman, G., 1993, p.24)

- *Never risk a lot for a little.*
- *Always plan ahead*
- *Always analyze both the sources and the consequences of risks*
- *Devise alternative options as a contingency measure*
- *Don't use other people as an excuse for inaction*
- *Don't take risks purely for reasons of principle*
- *Don't take risks to avoid losing face*
- *Never risk more then you can afford to lose*
- *Be prepared to seek advice from the experts*
- *Consider the odds and what your experience and intuition tells you*
- *Consider the controllable and the uncontrollable parts of the risk"*

2.3.3 Risk Factors Affecting the Construction Industry

Industrial projects like a construction project, may have it's common or special risks and problems of organisation or communication or some uncertainties caused by natural, social, economical or political events.

Some of the special risk criteria for construction industry is determined at the Sample Contract by Bayındırlık Bakanlığı. It includes: the situations caused by the sponsor, damages caused by natural phenomenon, social events like strikes – contagious diseases - local or general mobilisations etc. There are also some common risks or uncertainties faced at scheduling, cost estimating, budgeting, or some other problems occur during the progress of the project.

Project managers may face with some unexpected expenses that might be originated from various outer factors. The important thing is to forecast these unexpected situations before they occur in order to prevent the serious problems they might cause and take the necessary action at once. This is why the proper project risk management is needed.

As mentioned before, there are many factors effecting the construction industry, so there are various risk factors. Some of the risk factors are defined by Akintoye & Mc Leod (1997, Vol.15 p.31-38) as following:

- Environmental (e.g. weather)
- Political, Social & Economical (e.g. inflation)
- Contractual Arrangement (e.g. responsibilities
- Financial
- Construction (Productivity, Injury & Safety)
- Market/Industry (Availability of workload)
- Company (Corporate)
- Development in IT
- Project (Design Information)

The Risk factors in Construction industry are grouped by Lewis & Zimmerman as following: Financial, Contractual, Operational, Organizational and Insurable Risks. (Lewis & Zimmerman, 2000)

Financial Risks & Exposures Project Financing (Debt, Equity)

- Labor and Material Costs (FTE's, Contract, Outsourced)
- Earnings Volatility (Revenue Recognition, EPS Growth)
- Currency Fluctuation (Foreign Exchange, Arbitrage)
- Interest Rate Changes (Credit Risks, Bonding)
- Commodity Price Fluctuations (Options, Derivatives)
- Regulatory Exposures (IRS, FASB)
- Funding Risks (Government Contract Funding, Allocations)
- Employee Stock Options (Pension Funds, Dividends)

Contractual Risks & Exposures Contractual Liability (Breach, Third-Party Actions)

- Indemnification (Hold Harmless Clauses)
- Indemnification Forms (Limited, Intermediate and Broad)
- Design Responsibility (Design Delegation, Assumption of Risk)
- Warranties (Express, Implied)
- Waivers of Subrogation
- Liquidated, Consequential and Punitive Damages Clauses
- Force Majeure Clauses (Schedule Delay)
- Subcontractor Default

Operational Risks & Exposures

- Operations Failure Risk
- Construction Defect
- Weather Volatility (Seasonality, Cat Risk)
- Political Risk (Domestic, International)
- Reputational Risk (Company, Product/Service Defamation)
- Regulatory Risk
- Operational Leverage Risk
- Material / Labor Price Risk
- Supplier Provisioning Risk

Organizational Risks & Exposures (Project Delivery Methods)

- General Construction Contracts (Design-Bid-Build)
- Design-Build Contracts (Self-Performed or Subcontracted Design)
- EPC Contracts (Engineering, Procurement and Construction)
- Construction Management Contracts (CM At-Risk or Agency CM)
- Fast Track Contracts (Phased Design and Construction)
- Joint Venture or JV / Design-Build Contracts

Insurable Risks & Exposures Workers Compensation and Employers Liability

- Commercial General Liability
- Commercial Property and Builders Risk
- Professional Liability (E&O Coverage)
- Environmental Liability (Pollution Coverage)
- Contractors Professional Liability
- Directors and Officers Liability (D&O Coverage)
- Employment Practices Liability (EPL)
- Project Specific Coverages (OCP, RRP, PMPL)
- Owners and Contractors Protective Liability (OCP)
- Railroad Protective Liability (RRP)
- Project Management Protective Liability (PMPL)
- Subcontractor Default Liability (Bonding Alternative)

The above mentioned risk factors are grouped and listed depending on the legal and industrial needs and conditions. In Turkey, Typical risks on a construction project include:

- failure to complete within the stipulated design and construction time;
- inaccuracy of drawings, details, estimates & schedules
- failure to obtain the expected outline planning, detailed planning or building code regulation approvals within the time allowed in design program;
- failure to obtain necessary equipment or material on time & budget,
- unforeseen ground conditions delaying the project
- strike by the labor
- exceptionally inclement weather delaying the project;

- unexpected prices rises for labor and materials;
- failure to let a tenant upon completion;
- problems caused by the suppliers and subcontractors,
- changes and/or inadequacy in the contract,
- an accident to an operative on site causing physical injury;
- latent defects occurring in the structure through poor workmanship;
- force majeure (flood, earthquake etc.);
- a claim from the contractor for loss and expense caused by the late production of design details by the design team;
- failure to complete the project within the client's budget allowance
- inaccuracy in management, ineffective use of labor & materials, waste…
- others

It is important to distinguish the sources of risk from their effects. Ultimately, all risks encountered on a project is related to one or more of the following:

- failure to keep within cost budget/forecast/estimate/tender;
- failure to keep within the time stipulated for the approvals, design, construction and occupancy;
- failure to meet the required technical standards for quality, function, fitness for purpose, safety and environment preservation.

In most situations, effects of adverse events will be financial loss. The task of the professional advisers, contractors, specialist contractors and suppliers is to identify the discrete sources of risk which cause failure to occur, and to develop a risk management strategy that provides for the most appropriate organization to carry that risk.

Risk and uncertainty do not only occur on major projects. Whilst size is an important consideration, factors such as location, complexity, buildability and type of building can all contribute to the risk. It is no accident that a complex, high serviced $5 million hospital operating theatre is going to carry more risk of a construction cost and time overrun than a $5 million warehouse building.

Furthermore it is rare for two construction projects to be exactly alike. By their nature they are different, which means every project has to be considered one of a kind. Fortunately however, an effective risk management system contains a set of techniques that can be applied to any project.

In the view of Global and Turkish perspective of the Construction industry, specifically for this thesis model, the Risk factors affecting the Construction Process can be summerized as below:

- **Problems Arising from Project & Design Conditions**

  Complexity of Design, Completion Level of Design, Drawings and Details, Accuracy of Drawings, Schedules, Estimates, & Calculations.
- **Problems Arising from Site Conditions**

  Location, Access & Traffic, Size of Site, Ground Conditions, Site Organization, Safety & Security Matters.
- **Problems Arising from Construction Technology and Materials**

  Construction Method, Required Special Equipment, Technology Level of Building, Delivery, Quality and such matters of Ordinary and Special Materials,
- **Problems Arising from Construction Team and Involved Parties**

  Suppliers – Subcontractors – Labor Type, Labor Quality and Labor Experience
- **Problems Arising from Contract Conditions**

  Duration to Completion, Type of Contract, Nature & Magnitude of Work, Difficulty of Activities, Laws & Regulations, Changes in Client's Needs,
- **Occurrence of External Factors & Unpredictable Risks**

  Changes in Economical Conditions, Changes in Political Conditions, Labor Problems (Strike etc), Extreme weather conditions, Other Hidden Obstructions.
- **Problems Arising from Management, Unproductivity & Waste**

  Inaccuracy in Project Management, Communication Between Involved Parties, Waste, Ineffective use of Labor and Materials (productivity).

2.3.4 Major Processes of Risk Management

The risk management system structure can be summarised as follows:

- *"risks have to be identified, classified and analyzed before any response is made;*
- *an identified risk is not a risk, it is a management problem;*
- *beware of using solely the intuitive approach or 'gut feel' to manage risk;*
- *risk management needs to be continuous from the moment the project starts to the moment it ends;*
- *a poorly defined risk structure will breed more risk;*
- *use both a wide angled lens and a zoom lens for your vision of what could happen in the future;*
- *use both creative and negative brainstorming, don't use the ostrich approach;*
- *always have a contingency plan to cope with the worst eventuality;*
- *risk management systems should not be complicated or burdensome, they need to be integrated into a firms daily operations."* (Flanagan, R. & Norman, G., Risk Management and Construction, 1993, p.67)

Risk Management contains the processes of identifying, analyzing and responding to project risk, where the aim is to maximizing the results of positive events and minimizing the consequences of adverse events. There are 4 major processes of risk management defined by PMI in PMBOK:

*"**Risk Identification**—determining which risks are likely to affect the project and documenting the characteristics of each.*

***Risk Quantification**—evaluating risks and risk interactions to assess the range of possible project outcomes.*

***Risk Response Development**—defining enhancement steps for opportunities and responses to threats.*

***Risk Response Control**—responding to changes in risk over the course of the project.*

These processes interact with each other and with the processes in the other knowledge areas as well. Each process may involve effort from one or more individuals or groups of individuals based on the needs of the project. Each process generally occurs at least once in every project phase.".(PMBOK, 1996, p.73).

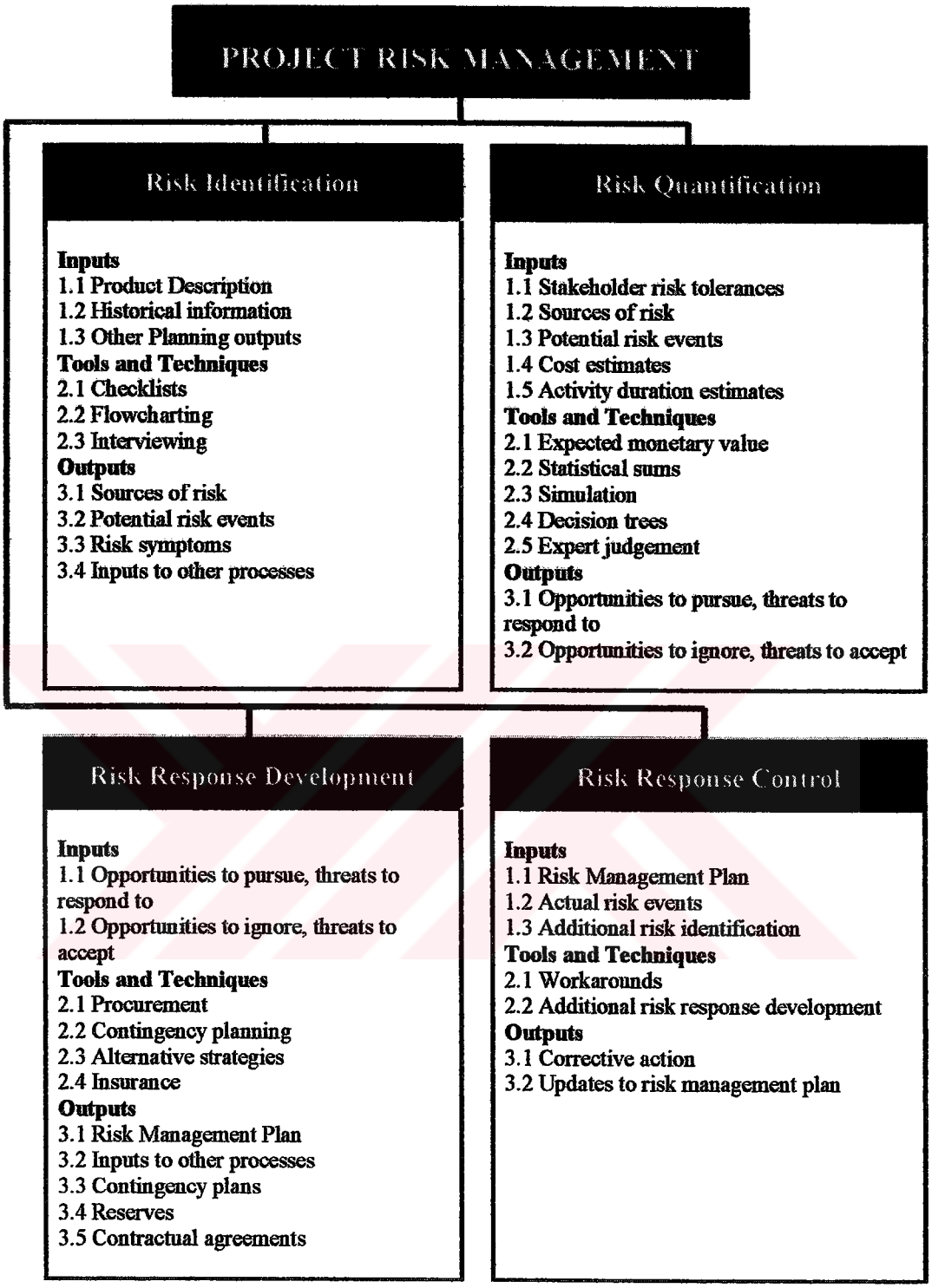

Figure 2.3 Project Risk Management Overview (PMBOK, 1996)

These processes may have different names depending on the applications. For example:

- Risk identification and risk quantification can be applied as a single process sometimes, and the combination of these processes may be called risk analysis or risk assessment.
- Risk response development is sometimes called risk mitigation.
- Risk response development and risk response control are sometimes treated as a single process, and this process is sometimes called risk management or risk response.

For every process of the risk management, there are some inputs, tools and techniques to analyse and some outputs. Figure 3.1 shows these components of the Project Risk Management.

2.3.4.1 Risk Identification

Identification of the risks and sources are the first step and start point of the risk management structure.

"*Risk identification consists of determining which risks are likely to affect the project and documenting the characteristics of each. Risk identification is not a one-time event; it should be performed on a regular basis throughout the project.*

Risk identification should address both internal and external risks. Internal risks are things that the project team can control or influence, such as staff assignments and cost estimates. External risks are things beyond the control or influence of the project team, such as market shifts or government action.

Strictly speaking, risk involves only the possibility of suffering harm or loss. In the project context, however, risk identification is also concerned with opportunities (positive outcomes) as well as threats (negative outcomes).

Risk identification may be accomplished by identifying causes-and-effects (what could happen and what will ensue) or effects-and-causes (what outcomes are to be avoided or encouraged and how each might occur)." (PMBOK, 1996, p.111-113)

In the process of risk identification, there are some necessary and useful tools and techniques. The inputs and outputs of these techniques are defined by PMI in PMBOK as follows:

"Inputs to Risk Identification:

1. Product description. The nature of the product of the project will have a major effect on the risks identified. Products that involve proven technology will, all other things being equal, involve less risk than products which require innovation or invention.

Risks associated with the product of the project are often described in terms of their cost and schedule impact.

2. Other planning outputs. The outputs of the processes in other knowledge areas should be reviewed to identify possible risks. For example:

- *Work breakdown structure—non-traditional approaches to detail deliverables may offer opportunities that were not apparent from the higher-level deliverables identified in the scope statement.*
- *Cost estimates and duration estimates—aggressive estimates and estimates developed with a limited amount of information entail more risk.*
- *Staffing plan—identified team members may have unique skills that would be hard to replace or may have other commitments that make their availability tenuous.*
- *Procurement management plan—market conditions such as a sluggish local economy may offer opportunities to reduce contract costs.*

3. Historical information. Historical information about what actually happened on previous projects can be especially helpful in identifying potential risks. Information on historical results is often available from the following sources:

- *Project files—one or more of the organisations involved in the project may maintain records of previous project results that are detailed enough to aid in risk identification. In some application areas, individual team members may maintain such records.*
- *Commercial databases—historical information is available commercially in many application areas.*
- *Project team knowledge—the individual members of the project team may remember previous occurrences or assumptions. While such recollections may be useful, they are generally less reliable than documented results.*

Tools and Techniques for Risk Identification:

1. Checklists. Checklists are typically organised by source of risk. Sources include the project context , other process outputs the product of the project or technology issues, and internal sources such as team member skills (or the lack thereof). Some application areas have widely used classification schemes for sources of risk.

2. Flow charting. Flow charting can help the project team better understand the causes and effects of risks.

3. Interviewing. Risk-oriented interviews with various stakeholders may help identify risks not identified during normal planning activities. Records of pre-project interviews (e.g., those conducted during a feasibility study) may also be available.

Outputs from Risk Identification:

1. Sources of risk. Sources of risk are categories of possible risk events (e.g., stakeholder actions, unreliable estimates, team turnover) that may affect the project for better or worse. The list of sources should be comprehensive, i.e., it should generally include all identified items regardless of frequency, probability of occurrence, or magnitude of gain or loss. Common sources of risk include:

- *Changes in requirements.*
- *Design errors, omissions, and misunderstandings.*
- *Poorly defined or understood roles and responsibilities.*
- *Poor estimates.*
- *Insufficiently skilled staff.*

Descriptions of the sources of risk should generally include estimates of the probability that a risk event from that source will occur, the range of possible outcomes, expected timing, and anticipated frequency of risk events from that source. Both probabilities and outcomes may be specified as continuous functions (an estimated cost between $100,000 and $150,000) or as discrete ones (a patent either will or will not be granted). In addition, estimates of probabilities and outcomes made during early project phases are likely to have a broader range than those made later in the project.

2. Potential risk events. Potential risk events are discrete occurrences such as a natural disaster or the departure of a specific team member that may affect the project. Potential risk events should be identified in addition to sources of risk when the probability of occurrence or magnitude of loss is relatively large ("relatively large" will vary by

project). While potential risk events are seldom application-area-specific, a list of common risk events usually is. For example:

• Development of new technology that will obviate the need for a project is common in electronics and rare in real estate development.

• Losses due to a major storm are common in construction and rare in biotechnology. Descriptions of potential risk events should generally include estimates of the probability that the risk event will occur, the alternative possible outcomes, expected timing of the event, and anticipated frequency (i.e., can it happen more than once). Both probabilities and outcomes may be specified as continuous functions (an estimated cost between $100,000 and $150,000) or as discrete ones (a patent either will or will not be granted). In addition, estimates of probabilities and outcomes made during early project phases are likely to have a broader range than those made later in the project.

3. Risk symptoms. Risk symptoms, sometimes called triggers, are indirect manifestations of actual risk events. For example, poor morale may be an early warning signal of an impending schedule delay or cost overruns on early activities may be indicative of poor estimating.

4. Inputs to other processes. The risk identification process may identify a need for further activity in another area. For example, the work breakdown structure may not have sufficient detail to allow adequate identification of risks. Risks are often input to the other processes as constraints or assumptions." (PMBOK, 1996, p.114)

2.3.4.2 Risk Quantification

Quantification of the risk is the second stage of risk management structure and based on the evaluating the risk factors and their interactions and determining the possible consequences.

This process is complicated in nature because of several factors including:

"....

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

- *Opportunities for one stakeholder (reduced cost) may be threats to another (reduced profits).*
- *The mathematical techniques used can create a false impression of precision and reliability.*" (PMBOK, 1996, p.115)

In the process of risk quantification, the inputs and outputs of the tools and techniques are described by PMI on the PMBOK as follows and accepted as a base information among the project management professionals:

"*Inputs to risk quantification:*

1. Stakeholder risk tolerances. Different organisations and different individuals have different tolerances for risk. For example:

• A highly profitable company may be willing to spend $500,000 to write a proposal for a $1 billion contract, while a company operating at break-even is not.

• One organisation may perceive an estimate that has a 15 percent probability of overrunning as high risk, while another perceives it as low risk.

Stakeholder risk tolerances provide a screen for both inputs and outputs to risk quantification.

2. Sources of risk.

3. Potential risk events.

4. Cost estimates.

5. Activity duration estimates.

Tools and Techniques for Risk Quantification

1. Expected monetary value. Expected monetary value, as a tool for risk quantification, is the product of two numbers:

• Risk event probability—an estimate of the probability that a given risk event will occur.

• Risk event value—an estimate of the gain or loss that will be incurred if the risk event does occur.

The risk event value must reflect both tangibles and intangibles. For example, Project A and Project B both identify an equal probability of a tangible loss of $100,000 as an outcome of an aggressively priced proposal. If Project A predicts little or no intangible effect, while Project B predicts that such a loss will put its per-forming organisation out of

business, the two risks are not equivalent. In similar fashion, failure to include intangibles in this calculation can severely distort the result by equating a small loss with a high probability to a large loss with a small probability.

The expected monetary value is generally used as input to further analysis (e.g., in a decision tree) since risk events can occur individually or in groups, in parallel or in sequence.

2. Statistical sums. Statistical sums can be used to calculate a range of total project costs from the cost estimates for individual work items.

The range of total project costs can be used to quantify the relative risk of alter-native project budgets or proposal prices.

3. Simulation. Simulation uses a representation or model of a system to analyse the behaviour or performance of the system. The most common form of simulation on a project is schedule simulation using the project network as the model of the project. Most schedule simulations are based on some form of Monte Carlo analysis. This technique, adapted from general management, "performs" the project many times to provide a statistical distribution of the calculated results.

The results of a schedule simulation may be used to quantify the risk of various schedule alternatives, different project strategies, different paths through the net-work, or individual activities. Schedule simulation should be used on any large or complex project since traditional mathematical analysis techniques such as the Critical Path Method (CPM) and the Program Evaluation and Review Technique (PERT) do not account for path convergence and thus tend to underestimate project duration. Monte Carlo analysis and other forms of simulation can also be used to assess the range of possible cost outcomes.

4. Decision trees. A decision tree is a diagram that depicts key interactions among decisions and associated chance events as they are understood by the decision maker. The branches of the tree represent either decisions (shown as boxes) or chance events is an example of a decision tree.

5. Expert judgment. Expert judgement can often be applied in lieu of or in addition to the mathematical techniques described above. For example, risk events could be de-scribed as having a high, medium, or low probability of occurrence and a severe, moderate, or limited impact.

Outputs from Risk Quantification:

1. Opportunities to pursue, threats to respond to. The major output from risk quantification is a list of opportunities that should be pursued and threats that require attention.

2. Opportunities to ignore, threats to accept. The risk quantification process should also document those sources of risk and risk events that the project management team has consciously decided to accept or ignore and who made the decision to do so." (PMBOK, 1996, p.117)

2.3.4.3 Risk Response Development

This process is the key stage in Risk management based on the reliable and accurate outcomes of the Risk Identification and Risk Quantification stages.

On the other hand, according to PMI, risk response development consists of 3 steps as following:

"*Risk response development involves defining enhancement steps for opportunities and responses to threats. Responses to threats generally fall into one of three categories:*

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

• *Mitigation—reducing the expected monetary value of a risk event by reducing the probability of occurrence (e.g., using proven technology to lessen the probability that the product of the project will not work), reducing the risk event value (e.g., buying insurance), or both.*

• *Acceptance—accepting the consequences. Acceptance can be active (e.g., by developing a contingency plan to execute should the risk event occur) or passive (e.g., by accepting a lower profit if some activities overrun).*" (PMBOK, 1996, p.119)

The structure of the Risk Response Development Process is defined and described by PMI on PMBOK as follows:

"...*Inputs to Risk Response Development:*

1. Opportunities to pursue, threats to respond to.

2. Opportunities to ignore, threats to accept. These items are input to the risk response development process because they should be documented in the risk management plan.

Tools and Techniques for Risk Response Development

1. Procurement. Procurement, acquiring goods or services from outside the immediate project organisation, is often an appropriate response to some types of risk. For ex-ample, risks associated with using a particular technology may be mitigated by contracting with an organisation that has experience with that technology.

Procurement often involves exchanging one risk for another. For example, mitigating cost risk with a fixed price contract may create schedule risk if the seller is unable to perform. In similar fashion, trying to transfer all technical risk to the seller may result in an unacceptably high cost proposal.

2. Contingency planning. Contingency planning involves defining action steps to be taken if an identified risk event should occur.

3. Alternative strategies. Risk events can often be prevented or avoided by changing the planned approach. For example, additional design work may decrease the number of changes which must be handled during the implementation or construction phase. Many application areas have a substantial body of literature on the potential value of various alternative strategies.

4. Insurance. Insurance or an insurance-like arrangement such as bonding is often available to deal with some categories of risk. The type of coverage available and the cost of coverage varies by application area.

Outputs from Risk Response Development

1. Risk management plan. The risk management plan should document the procedures that will be used to manage risk throughout the project. In addition to documenting the results of the risk identification and risk quantification processes, it should cover who is responsible for managing various areas of risk, how the initial identification and quantification outputs will be maintained, how contingency plans will be implemented, and how reserves will be allocated.

A risk management plan may be formal or informal, highly detailed or broadly framed, based on the needs of the project. It is a subsidiary element of the overall project plan.

2. Inputs to other processes. Selected or suggested alternative strategies, contingency plans, anticipated procurements, and other risk-related outputs must all be fed back into the appropriate processes in the other knowledge areas.

3. Contingency plans. Contingency plans are pre-defined action steps to be taken if an identified risk event should occur. Contingency plans are generally part of the risk management plan, but they may also be integrated into other parts of the overall project plan (e.g., as part of a scope management plan or quality management plan).

4. Reserves. A reserve is a provision in the project plan to mitigate cost and/or schedule risk. The term is often used with a modifier (e.g., management reserve, contingency reserve, schedule reserve) to provide further detail on what types of risk are meant to be mitigated. The specific meaning of the modified terms often varies by application area. In addition, use of a reserve, and the definition of what may be included in a reserve, is also application-area-specific." (PMBOK, 1996, p.120)

2.3.4.4 Risk Response Control

Last stage of Risk Management process is Risk Response Control. Risk response control involves in carrying out a risk management plan in order to respond to risk factors over in the project.

The structure of Risk Response Control has been described by PMI as follows:

"*...Inputs to Risk Response Control:*

1. Risk management plan.

2. Actual risk events. Some of the identified risk events will occur, others will not. the ones that do are actual risk events or sources of risk, and the project management team must recognise that one has occurred so that the response developed can be implemented.

3. Additional risk identification. As project performance is measured and reported potential risk events or sources of risk not previously identified may surface.

Tools and Techniques for Risk Response Control

1. Workarounds. Workarounds are unplanned responses to negative risk events. Workarounds are unplanned only in the sense that the response was not defined in advance of the risk event occurring.

2. Additional risk response development. If the risk event was not anticipated, or the effect is greater than expected, the planned response may not be adequate, and it will be necessary to repeat the response development process and perhaps the risk quantification process as well.

Outputs from Risk Response Control

1. Corrective action. Corrective action consists primarily of performing the planned risk response (e.g., implementing contingency plans or workarounds).

2. Updates to risk management plan. As anticipated risk events occur or fail to occur, and as actual risk event effects are evaluated, estimates of probabilities and value, as well as other aspects of the risk management plan, should be updated." (PMBOK, 1996, p.121)

2.3.5 Risk Analysis In Investment Appraisal

Investment appraisal almost invariably deals with events that will occur in the future. Cash flows of many kinds, arising from a wide variety of causes, need to be predicted in order that potential returns may be evaluated. A major risk here is that, in practice, the chances are that things may not turn out as expected. There may be difficulties in forecasting that lead to an uncertainty about the outcome of taking a decision between two or more alternatives. Methods of risk analysis have been developed to provide a variety of ways of examining problems that involve uncertainty. These provide a clearer and more detailed understanding of the risks that are involved in decision making, that is making the choice between alternatives.

Risk is concerned with the chances or probability of a loss being made. The loss may not necessarily be directly financial; the risk of physical injury (or death), collapse of a building structure, having a car accident, falling into a river, loosing a golf ball off the tree, etc., are all situations where someone or something is at risk-probably as a result of making a decision, whether after due consideration or not, to take some specific action.

Prominent writers have drawn a distinction in the past between risk and uncertainty. In essence, with modest variations, the distinction has been based upon a concept that risk is concerned with situations in which statistical data are available concerning the variability of the environment in which a decision problem exists, and uncertainty is concerned with situations in which no such data are available. In the former case it is assumed to be possible to postulate, for example, a distribution showing the variation in the probability of particular outcomes resulting; in the latter case there are insufficient or no data available to define such probabilities. Where such data are not available, decision makers need to resort to subjective probability assessments.

While much emphasis has been placed on risk analysis as a tool to assist with decision making concerning financial investments, it must not be overlooked that the theories involved are capable of application to most decision problems, whether they involve alternative financial investments or not. For example, in construction, it is likely that risk analysis can have beneficial results from its application in special areas of insurance where unusual risks are being undertaken on new or difficult methods, in assessing situations where opportunities for alternative contractual arrangements are available involving different allocations of risk and reward among the construction organizations involved, in assisting with the deliberations on the circumstances in high competitive or other types of bids should be made or not as the case may be, and for generally enhancing the processes of design and construction as a result of assessing the risk to achieving rapid, accurate, and true construction. In this chapter risk will be dealt with in the context of financial appraisal.

Risk analysis is based upon applying probability and other theories to cash flow models so that a broader, more complete, treatment can be undertaken of an economic evaluation by providing a quantitative expression of the chances or probabilities that certain outcomes will be achieved given the data concerning the problems.

2.3.6 Risk Management Tools and Techniques

There are many ways of analyzing risk and making decisions under risk. From the fairly simple to those which require a computer as a minimum tool. As we shall consider easy to use and widespread technique which can be applied to cash flows of the project, on the other hand, some other techniques with varying degrees of complexity concentrating upon

the principles of the various methods rather than their detailed application will be summarized.

Risk management is one aspect of management science. There are two broad categories of management science techniques: deterministic, and probabilistic or stochastic. Deterministic techniques assume that the values of the decision variables are known with 100% certainty, which is rarely the case with construction.

Probabilistic or stochastic techniques on the other hand, are concerned with factors that cannot be estimated with certainty, such as most data associated with construction.

For the most part decision-makers tend to concentrate on single values of outcomes, such as profit, which have been calculated from single value estimates of the variables. This approach does not distinguish between high and low risk projects. A decision-maker may or may not be in a position to control the uncertainties, but he should be in a position to make a quantitative estimate of the risk involved in any estimate.

Whilst most of the tools and techniques discussed here provide quantitative solutions, they will incorporate some subjectivity. However, the analyst should rely more heavily on the output of a quantitative forecast rather than on intuitive judgement.

There is no doubt that judgement stimulates thought and explores new relationships but, where possible, quantitative techniques should be incorporated to test and support assumptions. Most importantly, always recognize what the statistical technique is doing with the data.

The tools and techniques of risk management help us to determine a decision. Determining has two senses; finding out and assuring. Once a situation has been determined it requires action. The tools cannot make the decision, only humans can initiate the course of action. When we make decisions we need to have clear objectives, goals, plans and strategies. We need two types of camera in our mind; one with a broad angle lens that can see the breadth of the whole problem, but not in great detail, the other with a zoom lens that can zoom in on specific risk areas which require more in-depth analysis.

A number of decision making techniques can be used in risk management and investment appraisal, shown in the list below;

Decision Making Techniques	Where They Are Used
The Risk Premium	Risk response
Risk-adjusted discount rate	Risk response
Subjective probability	Risk response
Decision Analysis	Risk Analysis
Algorithms	Risk classification
Means-end Analysis	Risk Analysis
Decision Matrix	Risk Analysis
Decision Trees	Risk Analysis
Bayesian theory	Risk classification
Sensitivity Analysis	Risk Analysis
Monte Carlo simulation	Risk Analysis
Portfolio theory	Risk Analysis
Stochastic dominance	Risk Analysis

2.3.7 The Risk Premium

A discount rate reflects the investor's time value of money and the rate of return the properly must earn to justify the investment. Some projects are almost risk free, such as the case of a tenant prepared to sign a long term lease on a building at the early design stage, whereas a project which is considered risky will attract a premium to the discount rate.

The investor in land and property will balance the costs and the revenue of the investment over a period of time by using a discount rate. Similarly the contractor and specialist contractor are looking at the investment of their resources and effort into a construction project: there is a risk of loss which is tempered by the possibility of gain. They might use discounted cash flow techniques (or a non-discounted approach) in order to evaluate the project. The risk premium will be added to the risk free discount rate. The risk premium will vary with each project, depending upon attendant risk and the attitude towards risk taking. For example, building an office block in the Balçova area in Izmir is likely to be a safer investment than building the same block in Alsancak. A discount rate to

be used for the future cash flows for the Balçova project might be 11% whereas for the Alsancak project the rate might be 15%. The additional 4% is a reflection of the risk premium the investor feels is appropriate.

There are no formula which derive an appropriate risk premium; each investor will have his or her own requirements as to the risk premium for each project. The difficulty in choosing the appropriate risk free discount rate is rooted in the inaccuracy of the term risk free. Financial commitments always carry certain risks which can be neither eliminated nor transferred. The term risk free is intended to imply not absolute absence of all risk, but virtual absence of default risk. In financial terms, the risk free rate is taken as that which would apply if lenders viewed a borrower's credit and collateral so favourably that they were absolutely certain of repayment at the scheduled time.

A contractor or a specialist contractor will also add a risk premium to a project, although they might not identify it as such. When pricing an estimate for a tender, if there is information or a party to the contract they are unsure about, they will add an additional margin for unforeseen eventualities.

The determination of the appropriate risk premium is based upon the trade off between risk and return. Unfortunately the concept of discounting embodies the precept that the further into the future the risk premium is applied, the greater is the impact on the present value of an investment. In other words, future risk is discounted more heavily than is near-term risk. A single risk-adjusted discount rate, therefore, is a poor proxy for the impact of risk on value over the project's lifetime, because risk does not increase exponentially with the passage of time. Arguably, the greatest uncertainty surrounds the initial construction period. Once the project has been built and tenants have been found, the risk for a client starts to diminish. Obviously, running costs are still a concern but after a period of occupancy they are easier to forecast. One way of solving this difficulty is to make appropriate adjustments to the risk premium for the varying risks at different stages of the project. This approach is similar to varying the allowance for inflation in the discount rate for differing time periods.

The issue of risk is thus very important for profitability in the industry. But how do decision-makers decide on the risk premiums and the riskiness of earnings and costs? That

depends upon their attitudes to risk and upon the probabilities associated with an event. What we are concerned with here is the framework within which these variables can be handled. And what we are proposing in the model is to determine and evaluate the risk premiums more efficiently rather than a blind estimate of the project manager.

2.3.8 Risk Management Efforts In Construction Industry

Construction professionals need to know how to balance the contingencies of risk with their specific contractual, financial, operational and organizational requirements. In order to achieve this balance, proper risk identification and risk analysis is required. The risk management process entails identifying construction risks and exposures, and formulating an effective risk management strategy to mitigate the potential for loss.

There have been many studies and researches on Risk Management in Construction Industry but surprisingly not as many as other industries. Many of these efforts are using different methods to identify, analyse and manage the risks.

Early studies and applications on construction risk management was only covering the necessary actions which were obligatory such as legal aspects, safety issues etc. These early efforts were generally solved by on site actions and insurance etc.

Later on, especially after the Project Management Science has been started to become widespread in the Construction Industry, researchers have made many researches and developments in the Construction Risk Management Area.

The Construction Risk Management approaches and models have been developed in mainly 2 scientific concepts. Some researchers preferred to use objective statistical and/or probabilistic methods, and some preferred subjective methods.

Some researchers like Al-Momani developed models about the risks of specific areas of the project such as construction delays. (Al-Momani, 1999) He used a quantitative approach to determine the risk factors affected the duration of the project.

Tony Baxendale & Owain Jones have made a study on the construction design and management safety regulations, where they focus on safety and regulatory risks and implementation of the safety issues at the design, planning and application phases. (Baxendale & Jones, 2000)

Similarly, there are more studies on the specific areas of Construction Management such as the research by Ramy Zaghloul & Francis Hartman, which they specialised on contract risks of a construction project. (Zaghloul & Hartman, 2002)

Descriptive statistics for the PRM tools

Tool	Description	Group	Mean	Standard deviation	Ranking
T1	Checklists[8]	Identification	2.20	0.98	36
T2	Brainstorming[9,10]	Identification	3.74	0.79	8
T3	Risk documentation form[4]	Identification	2.65	0.94	29
T4	Periodic risk reporting[4]	Identification	2.88	1.12	24
T5	Risk probability assessment[2,11,4,8,12]	Analysis	3.57	1.01	14
T6	Risk impact assessment[2,11,4,8,12]	Analysis	3.86	0.98	3
T7	Risk time frame assessment[4]	Analysis	2.58	1.25	30
T8	Risk classification[13,4,14,15]	Analysis	2.38	1.17	33
T9	Ranking of risks[2,11,4,8,12]	Analysis	3.29	0.91	17
T10	Graphic presentation of risk information	Analysis	1.82	1.24	38
T11	Responsibility assignment[4]	Planning	3.99	0.84	2
T12	Planning for risk mitigation[4,14]	Planning	3.61	0.99	12
T13	Time-limited action-item lists	Planning	3.70	0.82	9
T14	Cost-benefit assessment during risk planning[10,16]	Planning	2.69	1.08	26
T15	Cause and effect analysis during risk planning[9,10,17]	Planning	2.33	1.14	34
T16	Project replanning for risk mitigation[4]	Planning	3.17	1.05	21
T17	Revision of risk assessments[4]	Tracking	3.30	0.77	16
T18	Periodic document reviews[4,8]	Tracking	3.18	1.01	20
T19	Periodic risk status reporting[4]	Tracking	3.20	1.05	19
T20	Periodic reporting of risk mitigation plans[4]	Tracking	2.90	0.93	25
T21	Periodic trend reporting[4]	Tracking	2.58	1.01	31
T22	Critical risk reporting to senior management[4]	Tracking	3.75	0.99	6
T23	Analysis of trends, deviations and exceptions[4]	Control	2.69	0.92	27
T24	Project replanning[8]	Control	2.94	1.02	23
T25	Procedure for closing risks[4]	Control	2.20	1.27	37
T26	Contingency plans for risk mitigation failure[4]	Control	2.43	1.14	32
T27	Cost-benefit analysis during risk control[10,16]	Control	2.68	1.10	28
T28	Cause and effect analysis during risk control[9,10,17]	Control	2.27	0.99	35
T29	Prototyping	Background	3.75	1.03	7
T30	Simulation	Background	4.00	0.85	1
T31	Benchmarking	Background	3.58	0.87	13
T32	Requirements management[18]	Background	3.69	0.89	10
T33	Subcontractor management[18]	Background	3.77	0.96	5
T34	Configuration control[18]	Background	3.83	0.70	4
T35	Quality control[18]	Background	3.69	0.76	11
T36	Quality management[18]	Background	3.39	0.76	15
T37	Training management[18]	Background	3.18	0.82	22
T38	Customer satisfaction surveys	Background	3.27	0.96	18
	Average across all tools		2.72	0.84	

Figure 2.4 Project Risk Management Tools Comparison, (T. Raz & E. Michael., 2001)

From many risk assessment methods & models, the most commonly used ones are determined by the research of T. Raz & E. Michael. They have determined the use and benefits of tools for project risk management. (T. Raz & E. Michael., 2001) According to their research, the most widespread use of the risk management tools are determined at figure 2.4 above.

Risk Management studies not only developed new methods but also contributed to the strategies and processes.

According to Lewis & Zimmerman (Lewis & Zimmerman Assoc., 2000), Risk Management Strategies in construction industry include; ***Risk Avoidance, Risk Abatement, Risk Retention, Risk Transfer, Risk Allocation.***

"Risk Avoidance is just that, avoiding the risk associated with a specific task, activity or project. Often, following the review of a contract, it is determined that a project is just too risky. The client may decide not to bid the work at all, or remove that element of the work from their bid, sometimes using an alternate deduct to delineate the exclusion. Risk avoidance is strictly a business decision, and sometimes a very good strategy if construction documents are unclear, ambiguous or incomplete.

Risk Abatement is the process of combining loss prevention or loss control to minimize a risk. This risk management strategy serves to reduce the loss potential and decrease the frequency or severity of the loss. Risk abatement is preferably used in conjunction with other risk management strategies, since using this risk management method alone will not totally eliminate the risk.

Risk Retention is a good strategy only when it is impossible to transfer the risk. Or, based on an evaluation of the economic loss exposure, it is determined that the diminutive value placed on the risk can be safely absorbed. Another consideration in retaining a risk is when the probability of loss is so high that to transfer the risk, it would cost almost as much as the cost of the worst loss that could ever occur, i.e., if there is a high probability of loss, it may be best to retain the risk in lieu of transferring it.

Risk Transfer is the shifting of the risk burden from one party to another. This can be done several ways, but is usually done through conventional insurance as a risk transfer mechanism, and through the use of contract indemnification provisions.

Risk Allocation is the sharing of the risk burden with other parties. This is usually based on a business decision when a client realizes that the cost of doing a project is too large and needs to spread the economic risk with another firm. Also, when a client lacks a specific competency that is a requirement of the contract, e.g., design capability for a design-build project. A typical example of using a risk allocation strategy is in the formation of a joint venture." (Lewis & Zimmerman Assoc., 2000)

Geoff Conroy and Hossein Soltan have developed an approach called ConSERV which they claim is a project specific Risk Management Approach which uses knowledge based non probabilistic tool. In this approach , they use a graphical presentation of possible project risks and develop a decision support system to response to the risks. Figure 2.4 shows the basic process of the model.

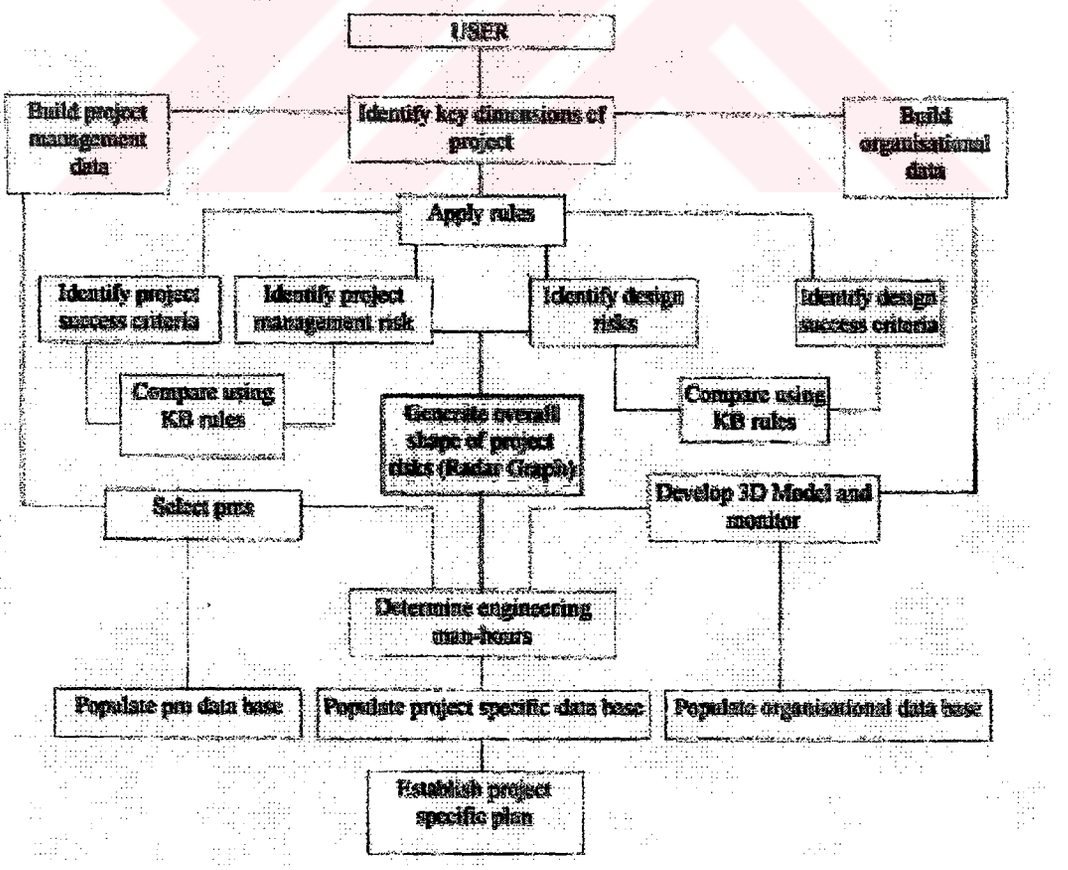

Figure 2.5 Basic Process of the ConServ Consept (Conroy & Soltan, 1998)

Some researchers categorise the Risk Response Action in 4 groups which are, risk retention, risk transfer, risk reduction and risk avoidance. (Akintoye & McLeod, 1997, p.31-38). According to Williams and Heims (Risk Management & Insurance, 1989), the risk retention becomes the only option where risk prevention or transfer is impossible, avoidance is undesirable, possible financial loss is small, probability of occurrence is negligible and transfer is uneconomic. Risk avoidance in Construction is generally recognised as impractical, as it may lead to projects not going ahead or a contractor submitting an excessively high bid for a project. Risk reduction techniques in terms of potential impact or probability of occurrence including the use of alternative contract strategies, different method of construction, project redesign, etc. Risk Transfer is made by the companies in different ways such as subcontracting, contractual terms, arrangements of clients, insurance and surety.

While many researches are depended on the quantitative methods such as statistics and/or probability for risk response development, some others consider to define a Risk Premium for both quantifying and response developing. As the risk factors influence the projects' performance in terms of time, quality and cost, a risk premium can be placed in each of them.(Akintoye & Mc Leod, 1996). One of the most common way of risk premium strategy is contingency allowance. This allowance is determined by the facts of the experience of construction team, probability of occurrence, etc. However, generally the risk premium is determined by the individual judgement of the project/risk analyst or manager. This point is the most criticised fact of the risk premium approach.

As the importance of the risk management becomes more obvious, the researches, methods and strategies will develop much faster. However risk management is considered difficult, complex and unattractive because of the use of some complex statistical and probabilistic methods. Among the many approaches for risk management very few ones claim to be easy to be used by any project manager. This thesis research is aimed to be an easy approach for project managers to understand and apply.

CHAPTER 3

THE METHODOLOGY

3. 1 Introduction

As mentioned before, all the Risk Management processes are tightly related and interact with each other. In the risk management procedure, the outputs of some processes are the inputs for some others. Mainly, the risk management procedures are applied to time management (schedules) and cost management areas. Because it is more accurate to quantify them.

The necessity of risk management is clear in the construction industry. The investments are high and they are tied up for a long time. Every sponsor or investor would like to know what are their chance to succeed, what is the quantitative probability of their success and in what conditions they will succeed. They also should take the urgent decision or necessary action when they face with problems during the project. The key to these matters is the risk management.

In this study, increasing the efficiency of cost management is aimed to be done by the assistance of risk management procedures. Cashflows are the key components of the cost management procedure. The risk effects should be reflected to the cashflows.

For this purpose, a series of procedures and methods should be applied. The series of procedures are as following:

Step 1: In order to determine the risk effects, a forecasting method should be used. As the construction projects are never the same and have no past data, then a subjective forecasting method should be used. Under the light of the comparisons between subjective

judgement methods Delphi method determined to be appropriate for this purpose. The comparison of the subjective judgement and decision making models have been listed by Robert Chapman (Chapman, Robert, 1998)

Characteristics	Identification techniques Nominal group technique	Brain-storming	Delphi
GROUP			
Group Size			
• equality of participation/ participation inhibited/member dominance	member equality	member dominance	respondent equality
• degree of cohesion	contribution and participation reduces with an increase in group size affecting cohesion	cohesion reduces with group size	sense of belonging, strength of commitment and cohesion reduced by isolation of respondents
Member Characteristics			
• degree of group compatibility	social needs of members may affect members responses	social needs of members may affect members responses	unaffected
• emotional 'blocks'	inhibited participation, but likely to be less than brainstorming	inhibited participation	uninhibited participation, not self conscious
• level of experience/professional training	inhibited participation	inhibited participation	no reticence to fully participate
• personality characteristics	self conscious participation but less than brainstorming	self conscious participation	unaffected
• company position imbalance/ status incongruities	inhibited participation	inherent pressures	freedom not to conform
Individual Objectives and Roles			
• potential for task orientated effort to be drained by pursuit of hidden agendas	affected	affected	unaffected
• potential for task orientated effort to be drained by pursuit of social needs	affected	affected	unaffected
• interpersonal behaviour	affected, participation directly encouraged by the sequence of steps in the technique	affected if long meeting participants may be distracted, lose interest	unaffected
Stage of Development			
• informational pressure	affected	affected	unaffected
• normative pressure	may arise	may arise	unaffected
THE TASK			
Nature of the Task			
unclear criteria for effectiveness	group meetings directly affected by clear explanation of determinates	group meetings directly affected by clear explanation of determinates	effectiveness entirely dependent on the content of the questionnaires
salience of the task	dependent on clear and persuasive argument at the outset	dependent on clear and persuasive argument at outset	dependent on clear and persuasive argument at the outset
poor definition of the task	meeting preparation time required	meeting preparation time required	no opportunity for clarification, maximum preparation time
• written material needs to be created and or considered	structure required	minimal preparation	extensive preparation
• requires a high level of technical expertise	discipline skill required	discipline skill req.	discipline skill req.
ENVIRONMENT			
norms and expectations—unstructured method of working	structured	strong direction required	highly structured
leader position—poor morale	strong leader required for group sessions	strong leader required	unaffected
poor inter-group relations	affected	affected	unaffected
physical location	affected	affected	unaffected

Step 2: In order to analyze the quantified risk effects, an analysis method should be used. In this study, our aim is to determine the cross effects of risk factors to each other risk factor and also to each phase of the construction on the cashflow. For this purpose, the Cross Impact Method is chosen. Cross impact matrix method is generally used for decision theories at construction project options/decision. (Alarcon, L.F, Ashley, D.B., 1998). However this method is appropriate for this thesis research in order to determine the cross effects of risk factors.

During the analysis process, a Monte Carlo Simulation will be applied in order to simulate the effects in random occurrence, which simulates the real life. The results of this analysis will indicate compound risk effect in percentage, i.e. the difference of the cash flows at each phase of construction in percentage. This difference can be considered as the Risk Premium.

Step 3: After cross effects of risk factors and risk premiums are determined, risk premiums should be reflected to the cash flow. For this purpose, the Risk Adjusted Discount Rate Method will be used.

Before building the mathematical model, the mentioned methods will be discussed in detail.

There are various applications that the Delphi, Cross-Impact Matrix and Risk Adjusted Discount rate methods are used. However very few or none of the researches are carried out to determine the combined risk effects as a chain reaction. This determination also leads to the risk premium which used to be criticised because of being inaccurate information. Cross Impact method was used in the models generally to make decisions and/or to develop strategies. In this research, this method is also used to quantify the risk effects during the construction process.

3. 2 The Delphi Method

3.2.1 Definitions and Historical Background

Delphi is one of the best-known forecasting method uses group judgement. The objective of most Delphi applications is the reliable and creative exploration of ideas or the production of suitable information for decision making.

It is Developed by Helmer (1977) and other mainly for Technological forecasting. according to Helmer (1977), Delphi Method is a communication device among a group of experts in order to formation of a group judgement which is based on a structured process for collecting knowledge & information from a group of experts. This process is in terms

of a series of questionnaires evaluated with feedbacks. The Delphi method has been widely used to generate forecasts in technology, education, and other areas (Cornish, 1977).

The first applications of the Delphi method has been carried out at the RAND Corporation by Gordon and Helmer (1964). The aim was to assess the long range time span forecasting of trends on science and technology, and their probable effects on society.

Since the first applications of the method, several researchers used the Delphi method at their studies, especially in public health issues and education areas.

3.2.2 The Basics of Delphi Method

The Delphi technique allows experts to make a forecast systematically. The process of the system comprises a series of questionnaires sent either by mail or via computerized systems, to group of experts. These questionnaires are designed to collect individual responses to the problems. After receiving the questionnaires, the experts refine their views as a group according to the group's judgement.

"The major point behind the Delphi method is to overcome the disadvantages of conventional committee action. According to Fowles (1978) anonymity, controlled feedback, and statistical response characterize Delphi. The group interaction in Delphi is anonymous, in the sense that comments, forecasts, and the like are not identified as to their originator but are presented to the group in such a way as to suppress any identification."(Gunaydin, M. 1999)

In the Delphi process, the key principles are structuring of information flow, feedback to the participants, and anonymity for the participants. These principles have many advantages over the conventional face-to-face review as a communication tool. A panel director manages the questionnaires without the influence of other experts. So the problem of group dynamics is eliminated .

According to Fowles (1978) the ten steps of the Delphi method is described as follows:

1. Formation of a team to undertake and monitor a Delphi on a given subject.

2. Selection of one or more panels to participate in the exercise. Customarily, the panelists are experts in the area to be investigated.
3. Development of the first round Delphi questionnaire.
4. Testing the questionnaire for proper wording (e.g., ambiguities, vagueness).
5. Transmission of the first questionnaires to the panelists.
6. Analysis of the first round responses.
7. Preparation of the second round questionnaires (and possible testing).
8. Transmission of the second round questionnaires to the panelists.
9. Analysis of the second round responses (Steps 7 to 9 are reiterated as long as desired or necessary to achieve stability in the results).
10. Preparation of a report by the analysis team to present the conclusions of the exercise.

The most important matter of this process is the understanding of the aim of the Delphi method by all participants. Otherwise the experts may answer inappropriately and the results may be far from the group judgement.

The minimum number of participants depends on the study design. Brockhoff (1975) claims that the under ideal circumstances, groups as small as four can perform well.

The result of a Delphi application is nothing but a group opinion. The accuracy of the results are only as good as the opinions of the experts who contributed to the panel (Martino, 1978).

Delphi method has taken critics from some researchers like Makridakis for being not as accurate as the quantitative methods. "An improvement in forecasting reliability over the Delphi method was thought to be attainable by taking into account the possibility that the occurrence of one event may cause an increase or decrease in the probability of occurrence of other events included in the survey (Helmer, 1978). Therefore cross impact analysis has developed as an extension of Delphi techniques." (Gunaydin, M.,1999)

3. 3 Cross Impact Matrix Method

3.3.1 Definitions and Historical Background

As the most criticised matter of the Delphi method is it' accuracy for obtaining the experts' opinion about the desired problem, a quantitative method could be used to compare and analyse results. There were several efforts to solve the above problem. One of those techniques is Cross Impact Analysis.

The Cross Impact Analysis can be used as a forecasting tool It can be used in the development of a particular new product or the occurrence of a particular scientific discovery.

"The cross-impact concept originated with Olaf Helmer and Theodore Gordon in conjunction with the design of a forecasting game for Kaiser-Aluminum (Helmer, 1977). It represented an effort to extend the forecasting techniques of the Delphi method. In 1968, Gordon and Hayward developed a computer-based approach to cross-impact analysis and they published their findings in the paper titled "initial experiments with the cross-impact matrix method of forecasting" (Gordon and Hayward, 1968). In this approach, events were recorded on an orthogonal matrix and at each matrix intersection the question was asked: If the event in the row were to occur, how would it affect the probability of occurrence of the event in the column? The judgements were entered in the matrix cells. Allen (1977) states that most forecasting methods may not consider many reactions between forecasted events: Cross-impact analysis, however, attempts to reveal the conditional probability of an event given that various events have or have not occurred.

According to Alter and Enzer (1978), cross-impact analysis differs from both probability theory and mathematical statistics; a cross-impact analysis is concerned with the identification of possible outcomes rather than with an understanding of what is or what was. They define cross-impact analysis as a systematic way to examine possible future developments and their interactions.

Helmer (1977) developed the causal cross-impact approach. Duperrin and Godet (1975) have considered the rather different notion of correlational cross-impacts. The main problem associated with this was stated by Helmer (1977) as being the difficulty of obtaining consistent estimates of the conditional probabilities of A given B and of B given A. Later Enzer and Alter (1978) illustrated two versions of conditional probability as used in a cross-impact analysis, one based on correlation and one based on causation, and showed that the latter is much better suited to the study of alternative futures. A sequential

approach to cross-impact analysis was developed by Sarin (1978). The proposed approach sequentially solicits information from the expert and checks it for consistency. "(Gunaydin, M.,1999)

3.3.2 The Basics Of Cross Impact Analysis Method

The first step of the Cross Impact Analysis is to specify the problem or events that effects the future events which are called trends. This step is one of the critical procedures in the Cross Impact Analysis. The events can be defined by the face-to-face group or from the Delphi exercise.

When the events are determined, the user should estimate the event occurrences according to the period of the specified time. This set of estimates are called "Overall Probabilities". However, the user must perform some averaging process taking into account the time dependence as well as casual effects from other potential occurrence because their estimates may change according to the changing of time period.

The third step of the Cross Impact Analysis procedure is to determine the changes of estimates according to some changed condition. These estimates are called "Conditional Probabilities".

The next step of the Cross Impact Analysis procedure is to use analytical model to calculate the outcome result, which called the Cross Impact Table. The application will generate the result according to this table.

The major steps in the use of cross-impact analysis for evaluating future situations are described by Helmer (1977) and Fowles (1978) as:

a. Define the events and trends to be included in the analysis.
b. Define the planning interval and sub-intervals, "scenes".
c. Develop cross-impact matrices to define the interdependencies between events and trends.
d. Estimate the entries in the cross impact matrix, i.e. information on how the occurrence of an event Ei or how the deviation of a trend Tj from its expected value

in a given scene would affect other event probabilities and trend values in later scenes.

e. Estimate the initial occurrence probabilities of each event in each scene.
f. Estimate the value of each trend at the beginning of each scene.
g. Perform a calibration run
h. Define the policies actions or sensitivity tests to be run with the matrix.
i. Perform cross-impact calculations.
j. Evaluate results.

The initial occurrence probabilities of events, values of trends, and the magnitude of impacts between the variables may be estimated by individual experts but more commonly estimated by groups containing experts from the various disciplines covered by the events (Fowles, 1978). Delphi questionnaires or interviews also can be used to collect these judgements.

Once a cross-impact model has been put together, it should be run a number of times in order to test the computer program's performance.

In general, the scale developed for Cross Impacts is as following:

Table 3.1 Scale Developed for Cross Impact Method

Transformed Coefficient	Coefficient	Scale	Meaning
1	+3	SIG	Significantly High Impact
0,8	+2	MOD	Moderate Impact
0,5	+1	SLI	Slight Impact
0	0	NO	No Impact
-0,5	-1	- SLI	Slight Negative Impact
-0,8	+2	- MOD	Moderate Negative Impact
-1	+3	- SIG	Significantly High Neg.Impact

There are several methodologies developed for different applications by various researchers.

One of these methodologies was provided by Gordon and Hayward (1968) and applied for the decision to deploy Minuteman missile project. For this project a set of 28 events was obtained from historical data and through personal interviews with experts. The 28x28 event pairs are entered into a program. The computer selected an event from among the predecessor group, and using random numbers, decided whether the event occurred or not. If it did, the probabilities of the other events were effected and thus adjusted. The application repeated for the next item and the process was repeated 1000 times in order to produce new probability estimates for the items.

Another approach was developed by Enzer and Alter (1978) by criticising that application of correlative conditions of Bayes' theorem to a causative cross-impact analysis is not suitable. They presented two versions of conditional probability, one based on correlation and one based on causation, and show that the latter is much better suited for cross-impact analysis. The difference is explained by an example: In cross-impact analysis, one is concerned about the probability that "a" will happen if "b" happens first. In classical probability, one asks for the probability that "a" has happened conditional on the fact that "b" has happened.

Helmer (1978) developed another approach which develops a casual cross-impact method with the time dimension introduced as scenes. He introduced the scenes as a planning interval for the casual cross-impact analysis. In addition to events, he also introduced trends, whose fluctuations, from expected values in one scene affect trend levels and event probabilities in subsequent scenes.

According to Helmer (1977), as the cross-impact matrix is large, than the information in each of its cells should be as simple as possible. Helmer (1977) also developed the concept of the "carryover" effect, as follows: *"If a trend, for whatever reason (a random fluctuation or a cross-impact), deviates from its predicted value, then some fraction, d, of this deviation (where 0 =< d =< 1) carries over to the next scene. Similarly in the case of an event, if the event fails to occur, then some fraction of the deviation of the probability carries over to the probability of occurrence in the next scene. It should be noted that, in the case of a trend, the carryover is precisely in the nature of a cross impact of the trend upon itself, and computationally it is handled as such."* However, Helmer (1977) argues

that these differential effects appear to be small, and ignoring them is justified in the interests of simplicity.

Helmer (1977) developed a scale for an intuitive interpretation of the actual cross-impact coefficients to be inserted in the matrix which is very close to Gordon and Hayward's (1968) definition of "S" that is the measure of the strength of connection and Fontela and Gabus (1975) definition of impact factors. This approach has later been used by several other researchers (Stover and Gordon, 1978; Wissema and Benes, 1980).

A cross impact upon an event or trend causes the event probability or the trend value for the next scene to be raised (or lowered) by a certain amount. Several impacts, if applied additively, might cause these quantities to fall below the lower or rise above the upper limit.

A scale transformation method is proposed by Helmer (1977) to prevent this from happening; a rational function is defined which translates the lower limit, 0, into-∞; the upper limit, U, into + ∞; and the central value, C, into 0.

Since a cross-impact upon a trend, resulting either from the occurrence of an event or from the unexpected fluctuation of another trend, also represents some form of "surprise", Helmer (1977) introduced the usage of "s" (the surprise threshold associated with the trend) as the unit in which to measure the cross-impact effect on it. Thus, for example, a cross impact of 2 represents an effect comparable to twice the median deviation caused by unexpected exogenous influences.

After this scale transformation, Helmer (1977) added the cross-impact effect. If p is the probability of occurrence, and x is the cross-impact coefficient, then X, the cross-impact effect is $X=(1-p)x$. There are other methods developed by Fontela and Gabus (1975) which are very close with different quadratic functions to determine the cross-impact effect on the impacted event's probability.

3. 4 Risk Adjusted Discount Rate Method

3.4.1 Definitions and Historical Background

The risk-adjusted discount rate approach attempts to handle the problem of risk in a more direct and thoughtful way. The risk-adjusted discount rate is the outcome of an analytical and carefully-specified model, the approach dealt with here handles the issue on a more casual and intuitive basis.

It is tempting to consider the risk premium as the requirement for an additional rate of return. In other words, it has been suggested that one way of taking risk into account in investment appraisal is to use risk-adjusted discount rates. A real discount rate used in say, life-cycle costing calculations, may be viewed as composed of three parts: a time value of money; an adjustment for expected inflation; and a risk premium.

3.4.2 The Basics of Risk Adjusted Discount Rate Method

To use a risk-adjusted discount rate for investment appraisal, the company simply adds to the current risk-free rate an additional premium, the size of which is determined by the estimated riskiness of the project being appraised. On the assumption that investors are risk-averse, the greater the perceived risk of a project the greater will be the risk premium and therefore the greater will be the resulting discount rate used to appraise the project. Thus the risk-adjusted discount rate takes the commonsense approach to handling risk in investment appraisal of adjusting the `height' of the `acceptance hurdle' to correspond to the project's risk level.

For example, a company's management may judge that the current rate of return on government long-term bonds is an adequate reflection of the risk-free interest/discount rate. Suppose this rate is 8 %. Management may also decide to classify investment proposals into three broad categories, low, medium and high risk, and assign risk premiums of 3 %, 5 % and 9 % respectively. Therefore the cash flows of low-risk projects would be discounted to present value using a discount rate of 8 % + 3 % =11 %, whilst projects of medium or high risk would be evaluated by discounting their cash flows to present value using 13 % and 17 % discount rates respectively.

In one very important way, the risk-adjusted discount rate approach to the problem of uncertainty is much more useful to the decision maker than sensitivity analysis in that it does actually produce decision advice, in the form of a risk-adjusted net present value. In addition, the method is easily understandable and appears to be intuitively correct: investors do require a higher expected return on riskier investments.

The two main problems are the allocation of project's into risk classes and the identification of the risk premiums. In terms of the first of these problems we know that projects should be allocated on the basis of their systematic risk. In this rather casual and judgemental approach, the allocation of projects to risk classes is much more likely to be made on a project's total variability (its total risk) as it is this that management would perceive to be the risk of the project, if they did not have the insights into risk that the CAPM gives. The second point here is that the allocation of particular projects to particular risk classes will also be at the mercy of the individual managements' personal attitudes towards risk and, in particular, be viewed in relation to how a particular project will affect the firm's risk (as opposed to the risk of the shareholders' own investment portfolios).

The second problem concerns the allocation of the risk premium. Once again, this is likely to be unsatisfactory because it is done on the basis of a personalized analysis and without any more knowledge of the market's actual risk-return trade-off than that of casual observation. Further there may well be a temptation for management to determine risk premium on the basis of achieved rates of return, by projects in particular risk categories. The obvious danger here is that there are likely to be differences (and considerable differences when more risky projects are concerned) between.

The risk premium is added to reflect the investors view of the degree of sensitivity of the project to risky factors. The size of the premium depends upon the degree of risk associated with the project and the attitude to risk by the investor. The greater the risk, the greater the premium. In practice, a single risk-adjusted discount rate is added to the discount factor: (Flanagan & Norman, 2000, p.72)

RA $= (RF+I+RP)^t$ or (RP can sometimes be replaced with a coefficient of "k")

$= (RF+I+k)^t$

RA = Risk-adjusted discount rate

RF = Risk free rate

I = Allowance for inflation (Discount for time value of money)

RP = (k) Risk premium (or risk coefficient) which is the adjustment for extra risk above the normal risk

The potential disadvantages of this approach has already been noted. Since the discount factor is part of a compounding function, the discount factor grows with increases in the value of t. This implies a special assumption that the risks associated with future costs and revenues increase geometrically with time. This assumption is usually justified on the grounds that the accuracy of our forecasting decreases with time.

A procedure for evaluating such projects is to separate timing and risk adjustments using the concept of certainty equivalent value (CEV). The CEV of a cash flow in a given year is simply its risk adjusted value in that year. Hence, if all future cash flows were converted to CEVs, they could then be discounted to the present using a single risk free discount rate. With the timing and risk adjustments separated, the risk adjustments can then be viewed more analytically.

If a company uses the same discount rate for all projects regardless of their different risks, it will tend to reject low risk projects that are profitable and invest in some high risk projects that are unprofitable. For this reason, many companies use different discount rates for different kinds of assets depending upon their risks.

An alternative is to discount cost and benefit streams separately, each with a unique risk-adjusted discount rate (RA). As future benefits become more uncertain into the future, the RA is adjusted upwards as perceived risk increases. However, for cost streams, the RA is adjusted downwards as perceived risk increases, which means as future costs become more uncertain, so this is reflected with the lower rate.

A practical example of this might be in the construction of a bowling alley. Bowling has been undergoing a renewal of interest over the past five years. Over a 10 year time horizon

it is difficult to know how the revenue streams will be maintained in the later years; hence the later years have a higher risk associated with them. Similarly, the cost streams may be affected by the need for additional refurbishment to cater for changes in taste over the later years, adding to the risk in the later years of the time horizon.

Most companies using risk-adjusted discount rates employ a risk classification scheme. Typical projects are classified into, say, four categories. Each has a different level of risk and a different risk premium. If there are only four risk classes, there are only four discount rates used at a time.

Figure 3.1 shows a graphical representation of a typical relationship between required rates of return and risk classes. (Flanagan & Norman, 2000, p.72)

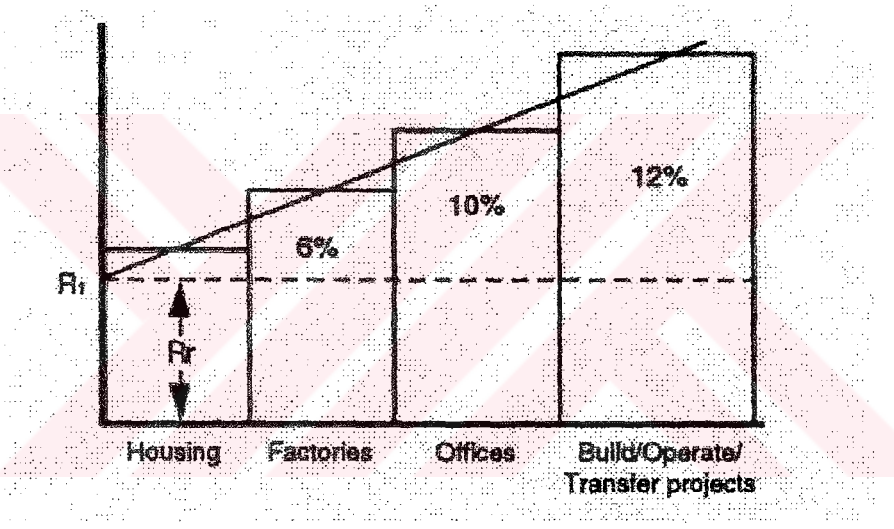

Figure 3.1 Rates of Return and Risk Classes

Another example for risk classes could be as following:

Table 3.2 Risk Classes

Risk Class	RADR (k*)	Project Type
1	12%	Replace equipment, Expand current business
2	14%	Related new products
3	16%	Unrelated new product
4	24%	Research & Development

The reason for using risk classes is that it minimizes bias in project evaluation. We need to identify why we are assigning a much higher premium to a build/operate/transfer project compared with a housing scheme.

For an investment, especially in the construction industry, the cash flows should reflect the Net Present Value of the money considering the inflation affect and also the risk premium as well. In summary, some of the properties of the Risk Adjusted Discount Rate method are as follows:

1. This approach involves varying the discount rate to reflect risk perception; the higher the perceived risk, the greater is the size of the discount rate.

2. The risk-adjusted discount rate is composed of a risk-free rate plus a risk premium.

a. The difficulties in specifying a riskless rate of discount lead most analysts to accept the expedient of using the rate available on short-term federal securities as a proxy. Because they are short-term and highly secure, interest rates on treasury bills are nearly devoid of premiums for default risk and interest rate risk.

b. Adjustments for perceived risk, the *risk premium*, should be based on an investor's risk-return trade-off function. In practice, real estate analysts who use this approach have generally chosen a risk premium that embodies their perception of the risk and their personal risk-return trade-off function.

In spite of its problems, the risk-adjusted discount rate is probably the most commonly used approach among analysts. The approach is, nevertheless, fatally flawed.

a. Since attitude toward risk is determined by such factors as financial ability to sustain loss, the extent of existing risk exposure, and personal psychological preferences, there is no reason to suppose that the analyst's attitude will ever exactly match the clients.

b. In separating riskless and risk premium portions of the discount rate, the risk-free rate is intended to represent the time value of money, with no associated risk. But when an additional discount factor is introduced for risk, it also incorporates an adjustment for time. As a consequence, future risk is discounted more heavily than near-term risk. Yet near-term risk is often greater than far-distant risk.

c. An equally serious shortcoming is the impracticality of expressing risk-adjusted discount rates as policy statements. Because risk premiums must be determined individually for each project, they are not well suited to a policy of delegating preliminary investment decisions.

The RADR method assumes that risk is a constant amount per period of time. If risk changes over time (eg. when uncertainty is resolved) then an incorrect capital budgeting decision may be made on the basis of the RADR. In this case there should be a better analysis or a supplementary method or combinations of methods should be used in order to remove this disadvantage. These combinatory methods are proposed in this Thesis.

The basic approach should be as following:

As the main problem of RADR method is that it assumes that risk is a constant amount per period of time, then the risk rates which are changing by time should be determined depending on time or the stages of the project. As there are interdependencies of stages of the project, the risk premium or coefficient of each stage can be unique and can be determined by a Cross Impact Matrix method.

The forecasting data needed for each stage of the project for the Cross Impact Method can be collected from the experienced professionals by a Delphi Forecasting Method. These combinations of methods could eliminate the known disadvantage of Risk Adjusted Discount Rate and could help risk management to be applied easier and more, as it will be an easy to use application for all professionals in construction industry.

3. 5 The Model For Proposed Method

Before getting into the process of the model, first of all the aim of the research should be reviewed. As the aim of the research is to increase the efficiency of the Cost Management by assistance of Risk Management, the method is based on the basic principles of the cost management and risk management processes and their interrelations. Thus, the steps of each management process should be followed sequentially and interrelated.

The main frame of the model depends on an effective cost management process. At this stage, the phases of cost management should be reviewed.

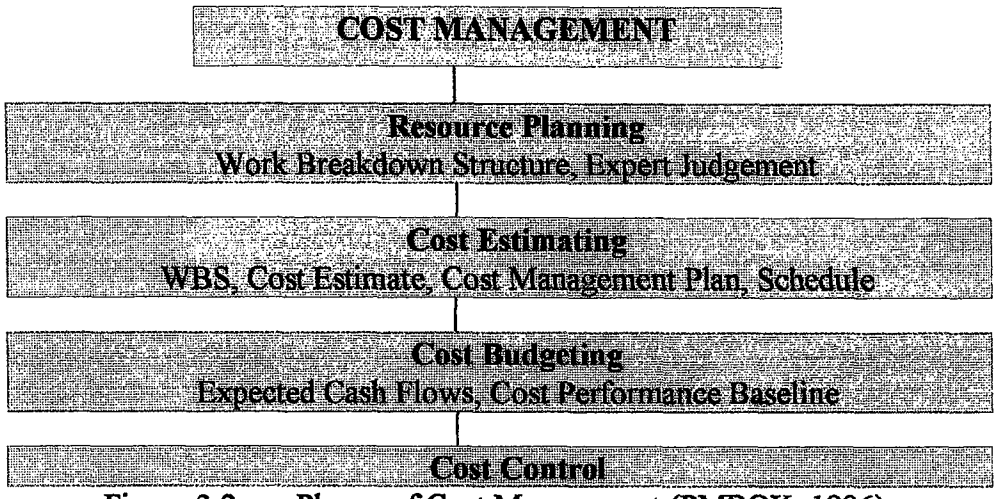

Figure 3.2 Phases of Cost Management (PMBOK, 1996)

As the effects of risk management process is aimed to be evaluated on the cost management process, the phases of risk management should also be reviewed.

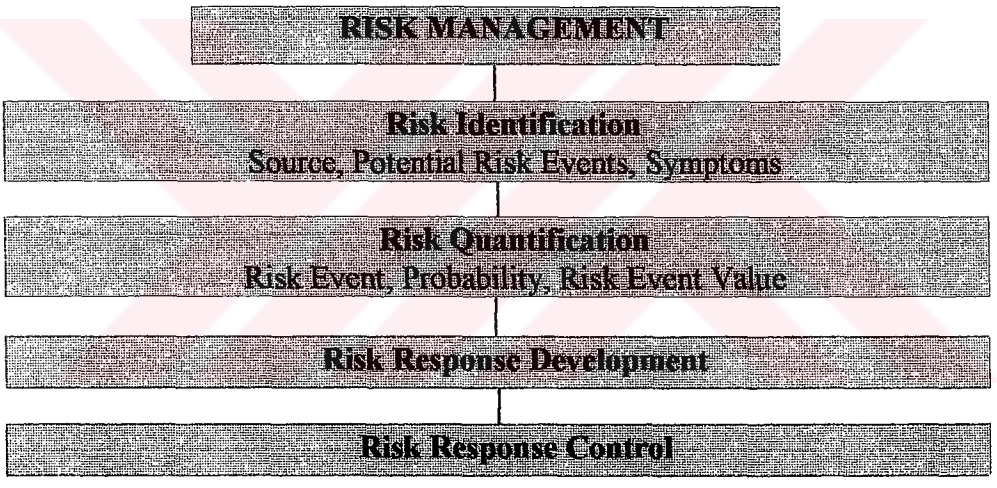

Figure 3.3 Phases of Risk Management (PMBOK, 1996)

Depending on these phases, the data flow and inter-relations between the phases of Cost management and Risk management can be defined and depending on these definitions, the data flow, interrelations and the methods required to quantify the interrelations of the two management areas can be put forward. These concepts and components helps us to constitute the model.

In order to build the model for the proposed method, quantifying and analyzing the data is required and a series of procedures by separate methods will be used sequentially.

We can make a deduction i.e. backward process from result that we need to achieve, to the data that we can obtain at the beginning of the process, in order to determine the procedure for the model. The goal at the end of the study is to determine the Risk Premium to adjust the cashflow. So how is the Risk Premium determined? As we know that the most serious critic on Risk Premium is that it is the subjective judgement of the project manager. In order to make the judgement more objective and precise rather than being subjective, we need to mathematically analyze the risk factors and inspect their relationships in the view of their effect rates and their probabilities of occurrence.

Cross Impact Method is appropriate for this aim, as the method uses both probabilistic data and the relationship effect coefficients, i.e. impacts of the other risk criteria on each criterion, as well as the impacts on the phases of construction. During the analysis process, a Monte Carlo Simulation will be applied in order to simulate the effects in random occurrence, which simulates the real life. The results of this analysis will indicate compound risk effect in percentage, i.e. the deviations of the cash flows at each phase of construction in percentage. This deviation can be considered as the Risk Premium.

Now the necessary data required for the Cross Impact Method, should be obtained. At this point, we need to consider again that, every construction project is unique and there are no definite past data like a serial production line, such as the past production and demand figures, faced risks or precise productivity analysis. Because there are many external factors affecting the construction process more than any other industry. So determining the data required for the Cross Impact Method is collected by a subjective forecasting method and the Delphi Method is appropriate for this purpose, where the raw data for the Delphi Method is obtained from the Resource Planning, Scheduling and Cost Estimating Phases.

Now the mainframe of the model , the data flow and the stages of the methodology can be summerized as shown in Figure 3.4.

3.5.1 The Process of the Model

First stage is to make the necessary resource planning, preparing the work breakdown structure and schedules. Depending on these information, the cost estimates should be prepared.

Next is to identify the risk factors effecting the cost estimates and schedules. The DELPHI method will be used at this stage to determine the possible risk factors and the probability rates of each factor.

Another Stage is to quantify the risk and evaluate the cross impacts of each individual risk to each other and to the phases of construction. I.e. there might be accumulated risk factors which could normally be underestimated individually, but when combined, these risk criteria can cause more serious problems than they look individually. The quantification and cross impacts of the risk factors with the phases will be evaluated with the CROSS IMPACT METHOD.

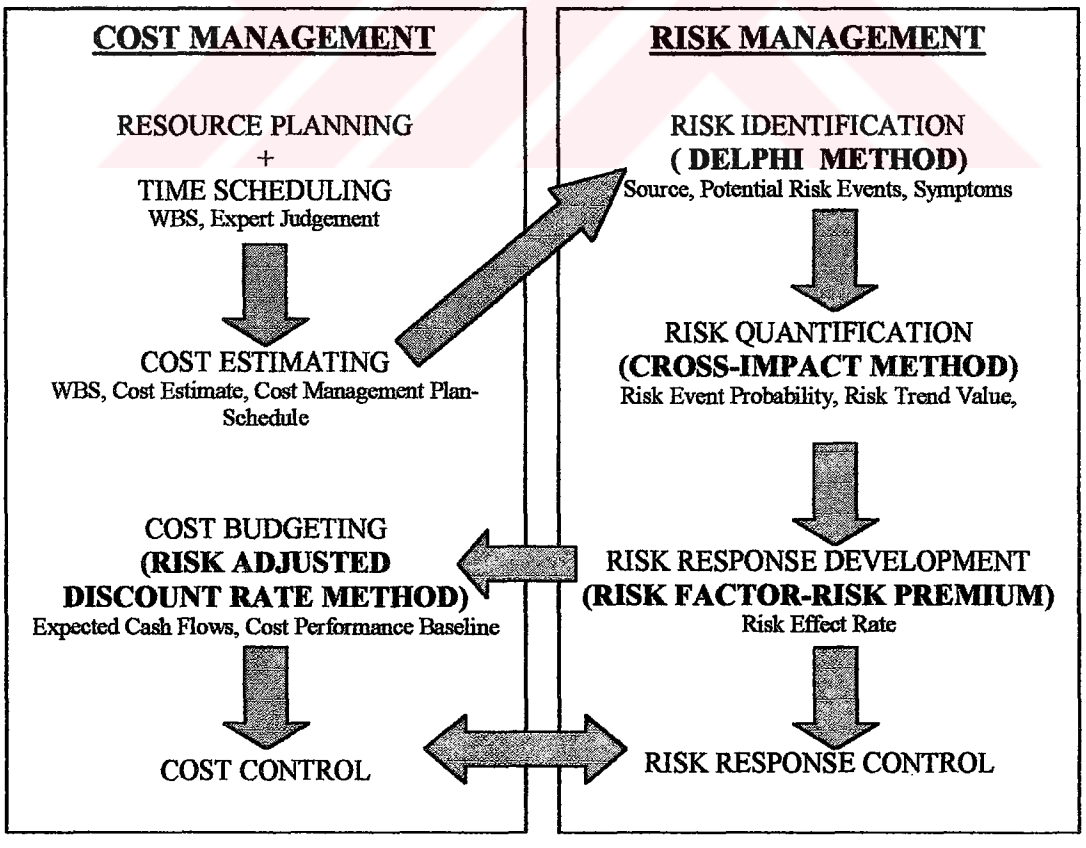

Figure 3.4 Mainframe of the Proposed Model

Once the Cross Impact analysis is completed, the possible discount rates of individual and combined risk criteria will be determined. Depending on these probability rates, the cash-flows will be modified. In order to modify the Cash-Flows with the risk discount rates, "Risk Adjusted Discount Rate" method will be used. Later stages will be the control stages including both cost control and risk control.

The findings of the Cross Impact Matrix will give us the Combined Risk effects after the risk factors impacting to each other and impacting the construction phases. This combined risk effect can be described as the Risk Premium, in other words the Risk Discount Rates needed for adjusting the cash flow at each construction phase.

To start from the beginning, the complete procedure to be followed during the model application can be defined in detail as below (Figure 3.5):

Step 1: Prepare the detailed and accurate Resource Plans containing all the Resources like the Labor, Materials and Equipment.

Step 2: Prepare the detailed and accurate Cost Estimates containing all the costs like fixed costs, variable costs, etc. These will be the data for the Risk Identification phase.

Step 3: Define the Events and Trends i.e. Identify the Risk Factors and Phases of Construction. Then Forecast the Event (Risk) Effects on other Events and also the (Risk) Event Effects on Trends (Phases of Construction). Also Forecast the Probability of Occurrence for each Risk Factor (i.e. event). These will be the data for the Risk Quantification phase.

Step 4: Quantify the Risks, i.e. Place the data in the Cross Impact Matrix and by the necessary formulation of Cross Impact Method, analyze the interrelations (Impacts) of Risk Factors (Events) and Phases of Construction (Trends) with the occurrence probabilities of the Risk Factors. This is the data for the Risk Reponse Development phase.

Step 5: Develop the Risk Response i.e. Determine the Compound Probability Rate for each risk factor. Then Simulate the occurrence of risk factors randomly (like the real life) by a standard Monte Carlo Simulation, and check the average results of the impacts on the

each construction phase as a chain reaction in order to evaluate the variation from the original cost values. This Simulated Compound Probability Rate Averages can also be called as Risk Premium required to adjust the cash flows which is the data for the cost budgeting.

Step 6: Prepare the Cost Budgets adjusting the Cash Flows with the Risk Premium by the Risk Adjusted Discount Rate Method.

Step 7: Do the cost control during the construction.

Step 8: Do the Risk Response control by adjusting the actual cost changes during the construction.

By combining these models within the Risk Management and Cost Management Processes, more accurate results & data will be gathered for the for risk quantification and risk response development phases. A new method for defining the Risk Premium will also be developed.

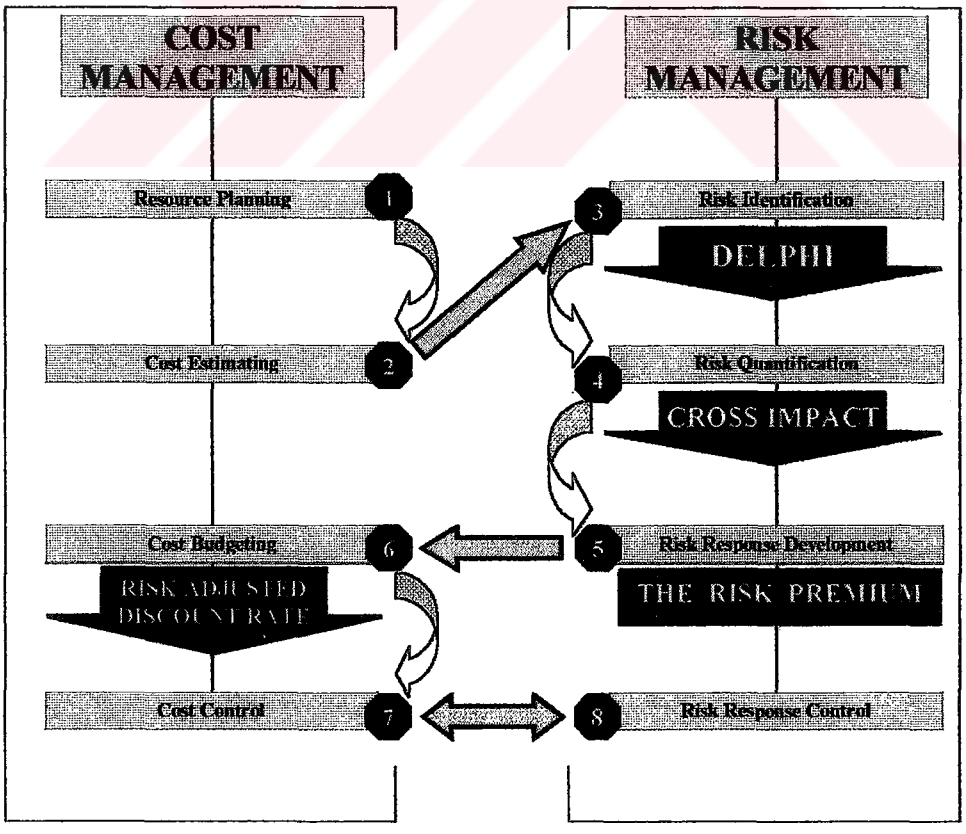

Figure 3.5 Step by Step Process of the Proposed Model

3.5.2 Definitions of Events and Trends

There are many Risk Factors (i.e. Events) effecting the Construction Phases (i.e. Trends). The interrelations between the Events and Trends are shown in Figure 3.6 .

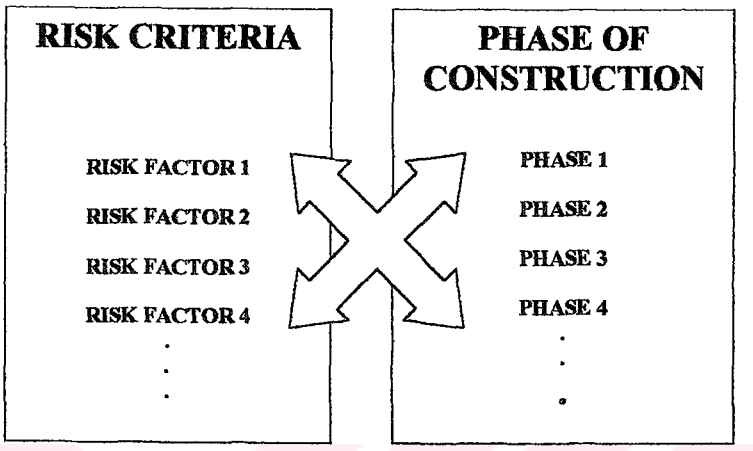

Figure 3.6 The interrelations between the Events and Trends

If the effects of these Risk Factors are taken individually in the method, the Delphi Questionnaire would be too long for the experts to judge and respond. Also the Cross Impact Matrix would be too large.

Todays technology makes the matrix calculations very easy in a short time but the judgement still depends on the human factor. That is the reason The Risk Factors i.e. Events are Grouped under 7 main titles. The Trends in this model is the Total Costs of each Construction Phase.

Followings are the data tables and charts necessary for the cross impact matrices determined for this model:

Table 3.3 List of Events (Risk Factors) and Trends (Phases of Construction)

EVENTS RISK FACTORS	TRENDS (COSTS OF THE PHASES OF CONSTRUCTION)
- Problems Arising from Project & Design Conditions Complexity of Design, Completion Level of Design, Drawings and Details, Accuracy of Drawings, Schedules, Estimates, & Calculations. **- Problems Arising from Site Conditions** Location, Access & Traffic, Size of Site, Ground Conditions, Site Organization, Safety & Security Matters. **- Problems Arising from Construction Technology and Materials** Construction Method, Required Special Equipment, Technology Level of Building, Delivery, Quality and such matters of Ordinary and Special Materials, **- Problems Arising from Construction Team and Involved Parties** Suppliers – Subcontractors – Labor Type, Labor Quality and Labor Experience **- Problems Arising from Contract Conditions** Duration to Completion, Type of Contract, Nature & Magnitude of Work, Difficulty of Activities, Laws & Regulations, Changes in Client's Needs, **- Occurrence of External Factors & Unpredictable Risks** Changes in Economical Conditions, Changes in Political Conditions, Labor Problems (Strike etc), Extreme weather conditions, Other Hidden Obstructions. **- Problems Arising from Management, Unproductivity & Waste** Inaccuracy in Project Management, Communication Between Involved Parties, Waste, Ineffective use of Labor and Materials (productivity).	**Foundation** **Structural System Works** **Elevation & Separating Works** **Roofing** **Insulation Works** **Windows and Doors** **Floor & Wall Coverings** **General Fittings & Finishings (Contingencies)** **Rough Mechanical Installations** **Mechanical Fittings & Finishings** **Rough Electrical Installations** **Electrical Fittings & Finishings** **Elevator Works**

Probability of Problem Occurrence of the Risk Factors which affects the Cost During the Construction Phase can be grouped as in Table 3.4.

Table 3.4 Table of Scenes

RISK FACTORS	SCENE 0 Current Scene Before The Launch of Construction	SCENE 1 The Construction Phase
Problems Arising from Project & Design Conditions Complexity of Design, Completion Level of Design, Drawings and Details, Accuracy of Drawings, Schedules, Estimates, & Calculations.	0	P_{01}
Problems Arising from Site Conditions Location, Access & Traffic, Size of Site, Ground Conditions, Site Organization, Safety & Security Matters.	0	P_{02}
Problems Arising from Construction Technology and Materials Construction Method, Required Special Equipment, Technology Level of Building, Delivery, Quality and such matters of Ordinary and Special Materials	0	P_{03}
Problems Arising from Construction Team and Involved Parties Suppliers – Subcontractors – Labor Type, Labor Quality and Labor Experience	0	P_{04}
Problems Arising from Contract Conditions Duration to Completion, Type of Contract, Nature & Magnitude of Work, Difficulty of Activities, Laws & Regulations, Changes in Client's Needs,	0	P_{05}
Occurrence of External Factors & Unpredictable Risks Changes in Economical Conditions, Changes in Political Conditions, Labor Problems (Strike etc), Extreme weather conditions, Other Hidden Obstructions.	0	P_{06}
Problems Arising from Management, Unproductivity & Waste Inaccuracy in Project Management, Communication Between Involved Parties, Waste, Ineffective use of Labor and Materials (productivity).	0	P_{07}

3.5.3 Steps of the Delphi Method

In Delphi process, Two types of data will be collected from the experts:

Predictions for the Future Scenes: Event (Risk Factor) Occurrence probabilities and Predictions for the possible effects of risk factors to other risk factors and also the risk factors to the construction phases i.e. Impact Rate Values in the Cross Impact Matrix.

The following steps for the Delphi Process are defined to be followed during the application of the model

1. Selection of the team of experts from the individuals connected or unconnected to the sample construction project who have experiences in local or global construction industry.
2. Development of the Delphi Survey in 2 parts. First Part contains 8 Questions including the Effects of Risk Factors on Other Risk factors with the Probability of Occurrence of the risk Factors, and second part contains 8 questions including the effects of risk factors on the costs of each construction phase.
3. Testing the Delphi Questionnaire for wording etc.
4. Transmission of first round questionnaires to the experts.
5. Collection and Analyses of first round responses.
6. Transmission of second round questionnaires to the experts.
7. Collection and Analyses of second round responses.
8. Preparation of a report for the analysis results.

After the development and application of Delphi Survey, The analysis results will be placed in the Cross Impact Matrix as source data.

3.5.3.1 Profile of the Experts contributing the Delphi Questionnaire

The experts who are contributing the questionnaire are chosen by their location of the business they conduct, their area and level of expertise, their knowledge or understanding of the project management and risk management principles. The reason for determining

these selection criteria is to make the best contribution to the project by getting appropriate and efficient answers and results.

Because of the uniqueness of each project, some experts should be localised to that area where the project is undertaken. Local contractors have the best knowledge about the local site conditions and legal liabilities and the best expertise in local practise.

Experienced Project managers, engineers and architects are another professional group who can contribute to the research. Because of their technical knowledge and local experiences, they are more likely to understand the project and risk management principles, which also helps appropriately contribute to the questionnaire.

The project/site manager of the sample project is another contributing professional who must join the questionnaire because of his deep knowledge about every phase of this specific project.

Other contributing professionals like experts on economics and politics, and other knowledge areas can also contribute to the questionnaire.

3.5.4 Steps of the Cross Impact Method

After the Delphi analysis results are obtained, Cross Impact Matrix should be formed. The following steps for the Cross Impact Method are defined to be followed during the application of the model:

1. Defining the Events and Trends to be Included in the Analysis
2. Formation of the Cross Impact Matrix.
3. Defining the Scenes and planning horizon. The Construction projects are not serial (continuous) productions, i.e. they are unique. That is the reason, there is no past data and the planning horizon is only the time interval that the construction processes are carried out. So as an assumption, there are 2 scenes in this method. Scene0 is the current scene which is before the launch of the construction, and Scene1 is the time interval during the construction phase.

4. Gather the data required for the estimations from Delphi analysis results, and enter the information on how the occurrence of an event E_i effects the other Events and/or Trends and with the probability of occurrence for each E_i Event.
5. Convert the Cross Impact Scale to the percentage scale over 100.
6. Estimate the Impacts of Events on the Events depending on the initial occurrence probabilities.
7. Estimate the impacts of Events on the Trends depending on the combined probability of occurrence.
8. Perform the calculation runs by a Monte Carlo Simulation
9. Evaluate results as Risk Premium.

The average values of results of the Monte Carlo Simulation gives us the variance of the trends i.e. Costs of Construction Phases from their initial estimate depending on their inter-relational impacts and probability of occurrences. As this variances are in percentage at a scale of 100, we can assume these values are the variances caused by the risk factors which is the Risk Premium).

One calculation run by a Monte Carlo Simulation follows the following steps:

1. Generate uniform random numbers between 0-1 in order to decide which events are occurring. The distribution of the random numbers is a normal distribution because the occurrence of Risk Factors does not depend on any other particular distribution.
2. Conduct Monte Carlo simulation: Determine the occurring and non-occurring events by comparing the random numbers with the forecasts of the experts in the Delphi process. If the random number is smaller then the experts' forecast, then the Risk Factor in question is assumed to occur. If it is higher, it is assumed that the Risk Factor has not occurred.
3. Adjust the probabilities of the events in the next scene according to inter-event impacts.
4. Go to the next scene, define occurring and non-occurring events with modified probabilities from the previous scene and random numbers.
5. Record the results and scenarios.
6. Repeat steps 2-6 until all scenes are covered.

This process can be repeated several times for the analysis of scenarios. Optimum repeat is around 10,000 times of run.

3.5.5 Mathematical Model

The mathematical model has been developed based on the previous researches in cross-impact analysis. First of all the Cross Impact Matrices have been formed as seen at Figures 3.7 and 3.8.

ESTIMATED PROBABILITY OF OCCURRENCE For each Risk Factor	IMPACTING RISK FACTORS (Problems : Consequences of Faults, Changes, Inadequacies, Problems or Occurrences of Certain Events) SCALE = 0 to 4	IMPACTING RISK FACTORS (Problems : Consequences of Faults, Changes, Inadequacies, Problems or Occurrences of Certain Events)						
		Problems Arise From Project & Design Conditions Design Complexity, Completion Level of Design Drawings and Details, Accuracy of Schedules, Estimates & Calculations	Problems Arise From Site Conditions Location, Access & Traffic, Size of Site, Ground Conditions, Site Organization, Safety & Security	Problems Arise From Construction Technology & Materials Construction Method & Technic, Required Special Equipment, Technology Level of Building, Ordinary & Special Materials	Problems Arise From Construction Team & Involved Parties Suppliers - Subcontractors - Labour Type, Quality & Experience	Problems Arise From Contract Conditions Duration to Completion, Type of Contract, Nature & Magnitude of Work, Activity Difficulty, Laws & Regulations, Changes in Client's Needs	Occurrence of External Factors & Unpredictable Risks Economical Conditions, Labor Problems, Extreme Weather Conditions, Other Hidden Obstructions, Political Conditions	Problems Arise From Management, Unproductivity & Waste Inaccuracy in Management, Communication Between Involved parties, Waste, Ineffective use of Labor & Materials (Productivity)
P_1	Problems Arise From Project & Design Conditions Design Complexity, Completion Level of Design Drawings and Details, Accuracy of Schedules Estimates & Calculations	EE_{11}	EE_{12}	EE_{13}	EE_{14}	EE_{15}	EE_{16}	EE_{17}
P_2	Problems Arise From Site Conditions Location, Access & Traffic, Size of Site, Ground Conditions, Site Organization, Safety & Security	EE_{21}	EE_{22}	EE_{23}	EE_{24}	EE_{25}	EE_{26}	EE_{27}
P_3	Problems Arise From Construction Technology & Materials Construction Method & Technic, Required Special Equipment, Technology Level of Building, Ordinary & Special Materials	EE_{31}	EE_{32}	EE_{33}	EE_{34}	EE_{35}	EE_{36}	EE_{37}
P_4	Problems Arise From Construction Team & Involved Parties Suppliers - Subcontractors - Labour Type, Quality & Experience	EE_{41}	EE_{42}	EE_{43}	EE_{44}	EE_{45}	EE_{46}	EE_{47}
P_5	Problems Arise From Contract Conditions Duration to Completion, Type of Contract, Nature & Magnitude of Work, Activity Difficulty, Laws & Regulations, Changes in Client's Needs	EE_{51}	EE_{52}	EE_{53}	EE_{54}	EE_{55}	EE_{56}	EE_{57}
P_6	Occurrence of External Factors & Unpredictable Risks Economical Conditions, Labor Problems, Extreme Weather Conditions, Other Hidden Obstructions, Political Conditions	EE_{61}	EE_{62}	EE_{63}	EE_{64}	EE_{65}	EE_{66}	EE_{67}
P_7	Problems Arise From Management, Unproductivity & Waste Inaccuracy in Management, Communication Between Involved parties, Waste, Ineffective use of Labor & Materials (Productivity)	EE_{71}	EE_{72}	EE_{73}	EE_{74}	EE_{75}	EE_{76}	EE_{77}

Figure 3.7 The Cross Impact Matrix Model Table (Impact of Events on Events)

IMPACTING RISK FACTORS (Problems : Consequences of Faults, Changes, Inadequacies, Problems or Occurrences of Certain Events) SCALE = 0 to 4	IMPACTED PHASES OF PROJECT												
	Foundation	Structural System Works	Elevation & Separation Works	Roofing	Insulation	Windows and Doors	Floor & Wall Coverings	General Fittings and Finishings	Rough Mechanical Installations	Mechanical fittings & Finishings	Rough Electrical Installations	Electrical fittings & Finishings	Elevator Installations
Problems Arise From Project & Design Conditions Design Complexity, Completion Level of Design Drawings and Details, Accuracy of Schedules Estimates & Calculations	ET_{11}	ET_{11}	ET_{11}	ET_{11}	ET_{11}	ET_{11}	ET_{11}	ET_{11}	ET_{11}	ET_{11}	ET_{11}	ET_{11}	ET_{11}
Problems Arise From Site Conditions Location, Access & Traffic, Size of Site, Ground Conditions, Site Organization, Safety & Security	ET_{21}	ET_{21}	ET_{21}	ET_{21}	ET_{21}	ET_{21}	ET_{21}	ET_{21}	ET_{21}	ET_{21}	ET_{21}	ET_{21}	ET_{21}
Problems Arise From Construction Technology & Materials Construction Method & Technic, Required Special Equipment, Technology Level of Building, Ordinary & Special Materials	ET_{31}	ET_{31}	ET_{31}	ET_{31}	ET_{31}	ET_{31}	ET_{31}	ET_{31}	ET_{31}	ET_{31}	ET_{31}	ET_{31}	ET_{31}
Problems Arise From Construction Team & Involved Parties Suppliers - Subcontractors - Labour Type, Quality & Experience	ET_{41}	ET_{41}	ET_{41}	ET_{41}	ET_{41}	ET_{41}	ET_{41}	ET_{41}	ET_{41}	ET_{41}	ET_{41}	ET_{41}	ET_{41}
Problems at Contract Conditions Duration to Completion, Type of Contract, Nature & Magnitude of Work, Activity Difficulty, Laws & Regulations, Changes in Client's Needs	ET_{51}	ET_{51}	ET_{51}	ET_{51}	ET_{51}	ET_{51}	ET_{51}	ET_{51}	ET_{51}	ET_{51}	ET_{51}	ET_{51}	ET_{51}
Occurrence of External Factors & Unpredictable Risks Economical Conditions, Labor Problems, Extreme Weather Conditions, Other Hidden Obstructions, Political Conditions	ET_{61}	ET_{61}	ET_{61}	ET_{61}	ET_{61}	ET_{61}	ET_{61}	ET_{61}	ET_{61}	ET_{61}	ET_{61}	ET_{61}	ET_{61}
Problems Arise From Management, Unproductivity & Waste Inaccuracy in Management, Communication Between Involved parties, Waste, Ineffective use of labor & Materials (Productivity)	ET_{71}	ET_{71}	ET_{71}	ET_{71}	ET_{71}	ET_{71}	ET_{71}	ET_{71}	ET_{71}	ET_{71}	ET_{71}	ET_{71}	ET_{71}

Figure 3.8 The Cross Impact Matrix Model Table (Impact of Events on Trends)

Then the Cross Impact Scale for the proposed method has been defined.

Table 3.5 The Scale Developed for Cross Impacts in this model

Transformed Coefficient	Coefficient	Scale	Meaning
1.00	+4	VHIG	Very High Impact
0.75	+3	HIG	High Impact
0.50	+2	MED	Medium Impact
0.25	+1	LOW	Low Impact
0.00	0	NO	No Impact
-1.00	-1	- NEG	Negative Impact

At the Delphi Survey, scale is presented to the experts in abbreviation mode such as MED for Medium Impact etc. Then this scale has been transformed into numerical coefficients between +1 and +1. These coefficients make the calculation and analysis easier.

For applying the method, necessary data are gathered from Delphi method. These data were the Event probabilities, Impacts of events on other events and Impacts of Events on Trends. The A cross-impact upon an event or trend causes the event probability or the trend value to be raised (or lowered) by a certain amount in the next scene. Several impacts, if applied additively, might cause these quantities to fall below the lower bound or rise above the upper bound, where the probability can only be in between 0 and 1. To prevent this from happening a scale transformation function, R(x), is adopted from Helmer's (1977) methodology. Figure 3.9 shows the graphic of transformation function.

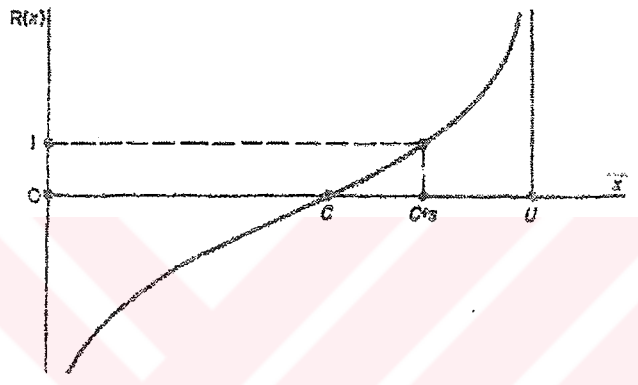

Figure 3.9 Graphic of Transformation Function

This Transformation Formula is:

$$R(x) = k * \frac{(x-c)}{x*(U-x)}$$ where,

X = cross impact coefficient to be transported in to R space

K = constant to be specified

U = Upper Limit

C = Central value

All of the trends have 0 as a natural lower bound. The parameter s is introduced as "surprise threshold", meaning that, we will or will not be surprised depending on whether the true value turns out to lie outside or inside the interquartile interval. Parameter "s" can be intuitively estimated by answering the following question: If estimated trend value is C,

what is the value s such that the true value of the trend has a %0.25 probability of lying between C and C+s?

Because of the stipulation that R(C+s)=l, k can be derived as follows:

$$R(C+s)= k \frac{s}{(C+s)(U-C-s)} = 1$$

$$k = \frac{(C+s)(U-C-s)}{s}$$

Table 3.6 shows some estimates of surprise thresholds and the corresponding R-transforms for events and trends used in this study:

Table 3.6 Estimates of Surprise Thresholds and R-transforms

	Upper bound U	Central value C	Lower bound L	Surprise threshold s	Scale transformation function R(x)
Events	1	0,5	0	0,25	0.75*((x-0.5)/(X*(1-x))
Trends	2	1	0	0,25	0.75*((x-0.5)/(X*(1-x))

It should be pointed out that if an event has a high probability of occurring then its actual occurrence is unsurprising, and any impact of its occurrence should be small. Conversely, a low-probability event, if surprisingly it does occur, has a high impact. To reflect this relationship, the impact of an event E; on another event or on a trend will be obtained by multiplying the cross-impact coefficient listed in the matrix by I p; where pT is the updated scene probability of E; in the scene of its occurrence.

According to Helmer's method (1977), cross impact of E_1 on $P(E_2)$ would be as follows:

Cross Impact Effect Value Formula (Occurrence of an event)

$X = (1-P_1)^* S_{11}$ where

X = Cross Impact Coefficient

P = Probability of Occurrence

S = Cross Impact Effect Value

On the other hand, to reflect the low probability – high impact relationship, the non-occurrence of an event has also an impact. Cross impact of non-occurrence is that

$X' = - P * S$ where

X' = Cross Impact Coefficient of nonoccurrence

P = Probability of Occurrence

When the probability of occurrence of an event is low, but that event happens, the effect of the event would be high. On the other hand, when the probability of occurrence of an event is high, and that event does not happen, still the effect of the event would be high.

These impacts would then be added to the impacted event's probability in R() Space.

The modified probability of multiple impacts is as following:

Cross Impact of E_1, E_4, and E_5 on $P(E_7) = (1-P_1)\ EE_{17} + (1-P_4)\ EE_{47} + (1-P_5)\ EE_{57}$

The Cross Impact Values would then be added to P(E7) in R() Space.

Similarly, the Cross Impacts of Events on Trends can be defined as following:

The Cross Impact of E_1 on $T_2 = (1-P_1)\ ET_{12}$

Cross-impact coefficient (ET_{12}) in this case is the impact coefficient of E_1 on T_2.

Again, If we assume that in the first scene E_1, E_4, and E_5 have occurred, the cross impact of these events on trend T_2 in the second would be calculated as follows:

Cross Impact of E_1, E_4, and E_5 on $T_2 = (1-P_1)\ ET_{12} + (1-P_4)\ ET_{42} + (1-P_5)\ ET_{52}$

Then again, Cross Impact Values would be added to the value of T2 in R() Space.

When building the Matrices for the Mathematical model, it should be considered that there are 4 main Matrix Structures in Cross Impact Method.

- Event – Event Matrix,
- Event – Trend Matrix,
- Trend – Event Matrix,
- Trend - Trend Matrix.

In this model, logically, trends can not affect the Events, for example, a phase of the construction cannot effect a risk factor, as it is not logical. That is the reason Trend – Event Matrix is Discarded. Although the Trends (Costs of Construction Phases) can effect the other trends, these effects are already reflected to the cash flow. In that case, It would be a repeated effect on the Trends. So the Trend-Trend Matrix will also be discarded. In that case the mainframe of the Mathematical methodology can be summarised as following:

1. Event Probabilities and Event-Event Cross Impacts should be entered.
2. Cross Impacts of Events on Events should be transferred to R(x) Space.
3. Modified Probabilities for the Events should be estimated.
4. Depending on the modified probabilities, the Impacts of Trends on other Trends should be estimated.
5. By using the R(x) transformation function again, the multiple trend impacts should be modified.
6. The results should be transformed into the normal space again.
7. These steps should be simulated by a Monte Carlo Simulation as real life situation by assigning random numbers to the model to simulate events and trends to occur or not.
8. The average of the outcomes of the simulation showes us the deviation from the original values of the trends (i.e. costs) by sequentially impacting various events i.e. risk factors. So the deviation of costs at each construction phase can be estimated.
9. These deviations can be called as Risk Premiums for each construction phase.

CROSS IMPACT EFFECTS OF EVENTS (1-p) * X		IMPACTED EVENTS (RISK FACTORS)									IMPACTED TRENDS (PHASES OF CONSTRUCTION)				
		PROBABILITY OF RISK OCCURRENCE SCBNE 1 VALUE	Project & Design Cond.	Site Conditions	Const. Tech & Materials	Constr. Team & Parties	Contract Conditions	Σ(Ep) In R Space	R(x) In R Space	R(x) + Σ(Ep) In R Space	Transformed (x) Value (Modified Probability)	Foundations	Structural Works	Elevations & Separating	Roofing	Insulations
EVENTS Risk Factors	Project & Design Cond.	0,25	0	x	x	x	x				Mod.P	x	x	x	x	x
	Site Conditions	0,85	x	0	x	x	x				Mod.P	x	x	x	x	x
	Const. Tech & Materials	0,15	x	x	0	x	x				Mod.P	x	x	x	x	x
	Constr. Team & Parties	0,25	x	x	x	0	x				Mod.P	x	x	x	x	x
	Contract Conditions	0,38	x	x	x	x	0				Mod.P	x	x	x	x	x
	Extrnl Fact. & Unpred. Rsk	0,76	x	x	x	x	x				Mod.P	x	x	x	x	x
	Mang. Unprod. & Waste	0,23	x	x	x	x	x				Mod.P	x	x	x	x	x
												Σ	Σ	Σ	Σ	Σ
TRENDS Phases Of Construction	Substructure (Foundations)	0,25	IMPOSSIBLE								The Effects of this Matrix will be existing in the Cash flow. Thus, in order to prevent double impact, this matrix will not be used in Analysis				
	Superstructure (Structural System)	0,85														
	Inor. & Exter Finishings (Walls, Etc.)	0,15														
	Fittings & Furnishings (Coverings etc.)	0,25														
	Services & Finishings Mech and Elect. Finishings	0,38														
										Σ(Ep) In R Space		0,000	0,000	0,000	0,000	0,000
										R(x) In R Space		#REF!	#REF!	#REF!	#REF!	#REF!
										R(x) + S(Ep) In R Space		#REF!	#REF!	#REF!	#REF!	#REF!
										Transformed (x) Value (Modified Trend Value)		#REF!	#REF!	#REF!	#REF!	#REF!
										Δ x		#REF!	#REF!	#REF!	#REF!	#REF!
												RISK PREMIUM !				

Figure 3.10 The Process of the model and the mainframe of the Excel Program

In order to make the calculations and do the simulation, a program is written in Excel 97 Spreadsheet and a VBA Macro is written in Visual Basic Applications. The modular design of the model makes the program flexible and easy.

3.5.6 Application of the Risk Adjusted Discount Rate Method

After the risk premiums for each construction phase are estimated, the cash flow can be adjusted and new realistic budgets can be prepared.

The main goal of the Risk Adjusted Discount Rate Method is to estimate the future value of the money invested considering the risk premium effect over the estimated future value of the money. For this aim, the RADR formula contains compound interest calculation figures and the additional risk premium.

However, according to the standard RADR formula, the risk premium is added to the inflation rate, and the total value is used in the formula to assess the future value of money. At this point, the risk premium addition increases the compound future value too much to be unrealistic. For example, if the monthly inflation rate is 2%, and the risk premium is 5%, then 12 months later the compound interest should be around 27% plus the risk premium 5%, result should be 32%. But if the original formula is used, the interest rate plus risk premium would be 7% (monthly) and after 12 months the compound rate would be 125%. This makes the formula unrealistic. So the RADR formula here should be amended as following

RA $= (RF+I)^t + RP$ or (RP can sometimes be replaced with a coefficient of "k")

$= (RF+I)^t + k$

RA = Risk-adjusted discount rate

RF = Risk free rate

I = Allowance for inflation (Discount for time value of money)

RP = (k) Risk premium (or risk coefficient) which is the adjustment for extra risk above the normal risk

To make the results of the model simple and understandable, the compound interest module of the formula will be discarded and to be simple, only the risk premiums will be added to the cash flow for adjustment. So the change and the effect of risk premium can be viewed easily.

3.5.7 Concluding Remarks

The Model has been developed to assess relative impacts of Risk Factors on the costs of construction phases of a building project. In this concept, methods that are easy to use are applied in order to make it easy for every construction professional to use it. The main goal here was to develop a model not consisting of very complex calculations that require specific training or education but something for everybody.

Indeed this makes the Model suitable for its purpose that is to analyze the impacts of different Risk Factors on the costs of phases of a building project.

This model may serve as a planning tool as well as a learning tool for construction professionals, construction managers and contractors in particular. Well-defined relationships between risks effecting the construction process and costs may help construction managers and contractors to prepare more reliable budgets and to be more competitive against others competing in the industry locally or globally.

The model has a modular design which makes it easy to modify the current model to be used for different purposes. Therefore the model can be modified to include other functions. Modules related to various aspects of construction and risk such as productivity, safety, quality, reliability, technology, equipment, human resources and, organizational structures, etc. can be designed and added to the model.

CHAPTER 4

FINDINGS AND ANALYSIS

4. 1 Description and Data of Sample Project Used in The Model

The sample project for the application of this model is chosen at Narlıdere Area of Izmir consisting of 3 x 8 Storey Apartment Blocks. Construction technic is conventional which gives us the opportunity to apply the model on more common system. Currently Structural System of 1 Block is finished and second block is half finished. Production is stopped because of financial problems of previous contractor caused by unplanned investment. New contractor knows the importance of the project management and scheduling. So he wants to see the risks affecting the process.

Following are the scheduling data planned on Microsoft Project. For this project, the risk assessment will be applied for only 1 block which has never been started at all. So the Cost and Scheduling data covers the complete process of the 8 storey apartment block.

Table 4.1 Summary of Work Breakdown Structure i.e. the Phases of Construction

ID		Görev Adı
2		Program Start
3		A Block
4		A Block Rough Structural Works
1		Foundation Works
23		Structural System Works
211		Elevation & Separation Works
281		Roofing
5		A Block Fitting works
1		Insulation
38		Windows & Doors
73		Floor & Wall Coverings
194		Fittings & Finishings
6		A Block Mechanical Works
1		Rough Mechanical Works
51		Mechanical Fittings
7		A Block Electrical Works
1		Rough Electrical Works
55		Electrical Fittings
77		Elevator
8		Program End

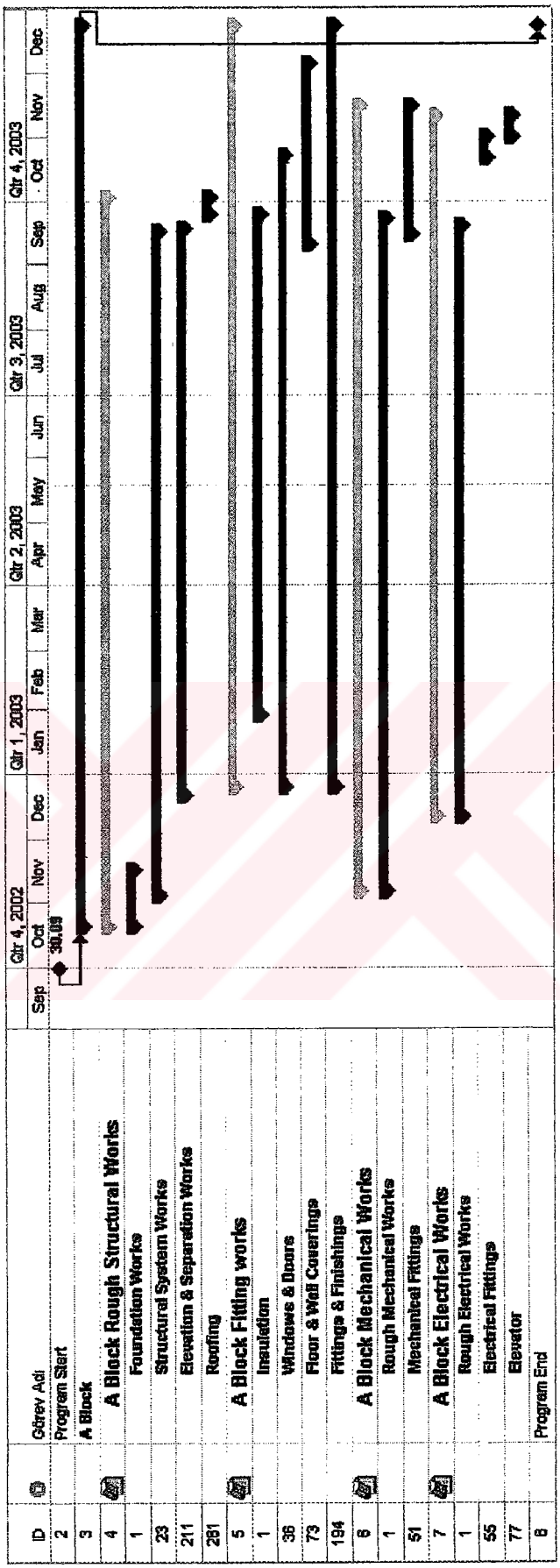

Figure 4.1 Summary of Work Scheduling

Table 4.2 Summary of the Costs for each construction phase

Program Start	
A Block	
Foundations	33.001.272.000,00 TL
Structural System Works	188.824.000.000,00 TL
Elevation & Separation	21.931.000.000,00 TL
Roofing	5.697.000.000,00 TL
Insulation	6.630.000.000,00 TL
Windows and Doors	48.339.513.000,00 TL
Floor and Wall Coverings	330.205.313.643,00 TL
Fittings & Finishings	63.031.365.000,00 TL
Rough Mechanical	16.716.000.000,00 TL
Mechanical Fittings	98.240.000.000,00 TL
Rough Electrical	2.400.000.000,00 TL
Electrical Fittings	9.200.000.000,00 TL
Elevator	25.000.000.000,00 TL
Program End	
Grand Total	849.215.463.643,00 TL

The above mentioned cost data is summarised from the estimated cash flows. These cost estimates are based on the private sector prices and special procurement proposals for this contract.

4. 2 Delphi Survey

The Model developed in this research demands data from the Work Breakdown Structure in order to form the Cross Impact Matrices and the Delphi Survey. Also the Cash Flow data are required for Cross Impact Analysis and RADR Method. After obtaining the

necessary data Delphi Survey has been prepared. The Delphi Survey Questionnaire is presented in Appendix A.

6 professionals accepted to participate the Survey.

The Delphi survey was conducted in two rounds. In the first round all the experts were invited to answer the survey. They were required to use their intuitive judgement when responding to the questions and were encouraged to refer to the definitions and ask questions if needed. As the participants are professionals with busy schedules, it took one week to complete the first round of the Delphi survey. Results of the first round were stored in an Excel sheet.

Median values were calculated for the questions that have discrete scales (i.e., cross-impact coefficients). Mean values were calculated for continuous scales (i.e., probabilities).

In the second round of the Delphi survey, all questions were asked again along with the feedback of median and mean values from the first round. The experts were also supplied with their own answers to the questions in the first round. Hence, experts were required to reconsider their answers in the light of the median/mean values of the first round. For doing this a separate form (web site) was designed and presented to each expert. Answers were gathered and analyzed.

Experts reached a consensus on all of the assessments in the second round. At the end of the second round of the Delphi survey, mean/median values were calculated for all of the answers. These values were tabulated for use in the model for simulation purposes.

Two rounds of Delphi survey is considered to be adequate for this study. Because after the second run the results were sufficient and satisfying for the Next Stage of the model, i.e. Cross Impact Analysis.

Following Figures and Tables Show the Delphi Results entered into the matrices.

Table 4.3 Delphi Survey Results (Impact of Risk factors on other Risk Factors)

IMPACTING RISK FACTORS (Problems : Consequences of Faults, Changes, Inadequacies, Problems or Occurrences of Certain Events) SCALE = 0 to 4	IMPACTING RISK FACTORS (Problems : Consequences of Faults, Changes, Inadequacies, Problems or Occurrences of Certain Events)						
	Problems Arise From Project & Design Conditions Design Complexity, Completion Level of	Problems Arise From Site Conditions Location, Access & Traffic, Size of Site, Ground Conditions, Site Organization, Safety & Security	Problems Arise From Construction Technology & Materials Construction Method & Technic, Required	Problems Arise From Construction Team & Involved Parties Suppliers - Subcontractors - Labour Type,	Problems Arise From Contract Conditions Duration to Completion, Type of Contract, Nature & Magnitude of Work, Activity Difficulty, Laws & Regulations, Changes in Client's Needs	Occurrence of External Factors & Unpredictable Risks Economical Conditions, Labor Problems,	Problems Arise From Management, Unproductivity & Waste Inaccuracy in Management, Communication
Problems Arise From Project & Design Conditions Design Complexity, Completion Level of Design Drawings and Details, Accuracy of Schedules Estimates & Calculations	0	3,25	2	2,5	1,25	0,5	1,5
Problems Arise From Site Conditions Location, Access & Traffic, Size of Site, Ground Conditions, Site Organization, Safety & Security	0,25	0	1,25	2,75	1,25	0	1,5
Problems Arise From Construction Technology & Materials Construction Method & Technic, Required Special Equipment, Technology Level of Building, Ordinary &	1,25	2	0	3	1,5	0,75	2
Problems Arise From Construction Team & Involved Parties Suppliers - Subcontractors - Labour Type, Quality & Experience	1	0,75	1,75	0	1,5	0	2,5
Problems Arise From Contract Conditions Duration to Completion, Type of Contract, Nature & Magnitude of Work, Activity Difficulty, Laws & Regulations, Changes in Client's Needs	1,75	1,5	2,25	1,25	0	0	1,5
Occurrence of External Factors & Unpredictable Risks Economical Conditions, Labor Problems, Extreme Weather Conditions, Other Hidden Obstructions,	1	2,5	1,25	1,75	2	0	1
Problems Arise From Management, Unproductivity & Waste Inaccuracy in Management, Communication Between Involved parties, Waste, Ineffective use of labor &	3,25	1,75	1,25	3,25	2,75	0,5	0

Table 4.4 Conversion Matrix

EVENTS - EVENTS MATRIX IMPACTING RISK FACTORS CONVERSION TO 0.00 - 1.00	IMPACTING RISK FACTORS						
	E1	E2	E3	E4	E5	E6	E7
E1	0,00	0,81	0,50	0,63	0,31	0,13	0,38
E2	0,06	0,00	0,31	0,69	0,31	0,00	0,38
E3	0,31	0,50	0,00	0,75	0,38	0,19	0,50
E4	0,25	0,19	0,44	0,00	0,38	0,00	0,63
E5	0,44	0,38	0,56	0,31	0,00	0,00	0,38
E6	0,25	0,63	0,31	0,44	0,50	0,00	0,25
E7	0,81	0,44	0,31	0,81	0,69	0,13	0,00

Table 4.5 Delphi Survey Results (Impact of Risk factors on Phases of Construction)

IMPACTING RISK FACTORS (Problems : Consequences of Faults, Changes, Inadequacies, Problems or Occurrences of Certain Events)	IMPACTED PHASES OF PROJECT												
	Foundation	Structural System Works	Elevation & Seperation	Roofing	Insulation	Windows and Doors	Floor & Wall Coverings	General Fittings and Finishings	Rough Mechanical Installations	Mechanical fittings & Finishings	Rough Electrical Installations	Electrical fittings & Finishings	Elevator Installations
Problems Arise From Project & Design Conditions Design Complexity, Completion Level of Design Drawings and Details, Accuracy of Schedules Estimates & Calculations	1	1,8	1,5	0,8	1	0,5	1	0,8	0,8	0,8	0,8	0,8	0,8
Problems Arise From Site Conditions Location, Access & Traffic, Size of Site, Ground Conditions, Site Organization, Safety & Security	1,3	1,3	0,8	0,5	0,5	0,3	0,3	0,3	0,8	0,3	0,5	0,3	0,3
Problems Arise From Construction Technology & Materials Construction Method & Technic, Required Special Equipment, Technical Level of Building, Ordinary &	1,3	2	1,3	0,5	0,5	0,5	0,5	0,8	0,5	0,5	0,5	0,5	0,5
Problems Arise From Construction Team & Involved Parties Suppliers - Subcontractors - Labour Type, Quality & Experience	1	1,3	1	0,5	0,8	0,5	0,8	0,5	0,5	0,8	0,5	0,8	0,8
Problems at Contract Conditions Duration to Completion, Type of Contract, Nature & Magnitude of Work, Activity Difficulty, Laws & Regulations, Changes in Client's Needs	0,5	0,8	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3
Occurrence of External Factors & Unpredictable Risks Economical Conditions, Labor Problems, Extreme Weather Conditions, Other Hidden Obstructions	1	1	0,5	0,5	0,8	0,5	1	0,5	0,5	0,5	0,5	0,5	0,5
Problems Arise From Management, Unproductivity & Waste Inaccuracy in Management, Communication Between Involved parties, Waste, Ineffective use of labor &	1,3	1,8	1,5	1,3	2	1,3	1,3	1	0,8	1	0,8	1	1

Table 4.6 Event – Trend Conversion Matrix

EVENTS - TRENDS MATRIX IMPACTING RISK FACTORS CONVERSION TO 0-1.00	IMPACTED PHASES OF PROJECT												
	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13
E1	0,250	0,438	0,375	0,188	0,250	0,125	0,250	0,188	0,188	0,188	0,188	0,188	0,188
E2	0,313	0,313	0,188	0,125	0,125	0,063	0,063	0,063	0,188	0,063	0,125	0,063	0,063
E3	0,313	0,500	0,313	0,125	0,125	0,125	0,125	0,188	0,125	0,125	0,125	0,125	0,125
E4	0,250	0,313	0,250	0,125	0,188	0,125	0,188	0,125	0,125	0,188	0,125	0,188	0,188
E5	0,125	0,188	0,063	0,063	0,063	0,063	0,063	0,063	0,063	0,063	0,063	0,063	0,063
E6	0,250	0,250	0,125	0,125	0,188	0,125	0,250	0,125	0,125	0,125	0,125	0,125	0,125
E7	0,313	0,438	0,375	0,313	0,500	0,313	0,313	0,250	0,188	0,250	0,188	0,250	0,250

Table 4.7 Probability of Event Occurrence table

PROBABILITY TABLE IMPACTING RISK FACTORS (Problems : Consequences of Faults, Changes, Inadequacies, Problems or Occurrences of Certain Events)	Probability of Event Occurrence
Problems Arise From Project & Design Conditions Design Complexity, Completion Level of Design Drawings and Details, Accuracy of Schedules Estimates & Calculations	0,70
Problems Arise From Site Conditions Location, Access & Traffic, Size of Site, Ground Conditions, Site Organization, Safety & Security	0,15
Problems Arise From Construction Technology & Materials Construction Method & Technic, Required Special Equipment, Technology Level of Building, Ordinary & Special Materials	0,11
Problems Arise From Construction Team & Involved Parties Suppliers - Subcontractors - Labour Type, Quality & Experience	0,46
Problems Arise From Contract Conditions Duration to Completion, Type of Contract, Nature & Magnitude of Work, Activity Difficulty, Laws & Regulations, Changes in Client's Needs	0,60
Occurrence of External Factors & Unpredictable Risks Economical Conditions, Labor Problems, Extreme Weather Conditions, Other Hidden Pobstructions, Political Conditions	0,18
Problems Arise From Management, Unproductivity & Waste Inaccuracy in Management, Communication Between Involved parties, Waste, Ineffective use of labor & Materials (Productivity)	0,68

As a result of the Delphi Survey, The following observations can be presented;

The risk factors caused by Problems Arise from Management, Unproductivity & Waste has the Highest impact on the other Risk Factors. Then the risks caused by Project and Design Conditions has the second highest impact on other risk factors. Oppositely the Problems arise from site conditions has the least impact on other risk factors.

The most impacted risk factors by the others are Problems arise from construction team and parties. Then the risk factors caused by the problems arise from the site conditions are the second most impacted event. The least impacted risk factors are the Occurrence of the external factors and unpredictable risks.

The Most Probable Risk factors to be occurred are Problems arise from project design and conditions, then Problems arise from Management, Unproductivity and Waste. The Least Probable risk is caused by the problems arise from the construction technology and materials.

Similarly, The risk factors caused by Problems Arise from Management, Unproductivity & Waste has the Highest impact on the Construction Phases. Then the risks caused by Project and Design Conditions has the second highest impact on the Construction Phases. Oppositely the Problems arise from Contract Conditions has the least impact on the Construction Phases.

The most impacted Construction Phases by the risk factors are Structural System Works. Then the Foundation and Elevation-Separation works are the second most impacted phases. Then comes the Insulation and covering works. Other phases of construction are the least impacted phases.

4. 3 Cross Impact Analysis

A cross-impact analysis uses the data that are elicited from experts by Delphi Method as described in the preceding sections.

The data gathered from Delphi is entered in the matrices of Cross Impact Model. As described in the Mathematical Model, the estimations are calculated in Excel 97 Worksheet. The results of the Delphi showed us the most impacting and impacted risk factors and construction phases. Cross Impact Analysis shows us the quantification of the interrelations and the simulation results.

A simulation run of 10,000 replications of the model produced the results.

Because of the nature of the study, the relationships between the variables are all positive, therefore the results of the Delphi survey are either positive (i.e., "signifcant", "moderate", and "slight") impacts or "no" impacts. If there were negative impacts, the model might have generated lower values than the estimated Delphi , results (in cases where the negative impacts overcame the positive impacts). For example if we assume that the events (impacting risk factors) are not occurring at all, then the model should and actually does present the original Delphi estimates (i.e., forecasted maturity levels and forecasted probabilities), since there are no impacts either positive or negative on the estimated trend and event values. The model's performance depends on the Delphi estimates. This underlines the importance of the Delphi process; the results of the model can be as good as the inputs. (Helmer 1977)

Table 4.8 Scenes Table

SCENES TABLE IMPACTING RISK FACTORS (Problems : Consequences of Faults, Changes, Inadequacies, Problems or Occurrences of Certain Events)	CURRENT Before the Launch of Construction	SCENE 1 During the Construction Phase
Problems Arise From Project & Design Conditions Design Complexity, Completion Level of Design Drawings and Details, Accuracy of Schedules Estimates & Calculations	0,00	
Problems Arise From Site Conditions Location, Access & Traffic, Size of Site, Ground Conditions, Site Organization, Safety & Security	0,00	
Problems Arise From Construction Technology & Materials Construction Method & Technic, Required Special Equipment, Technology Level of Building, Ordinary & Special Materials	0,00	
Problems Arise From Construction Team & Involved Parties Suppliers - Subcontractors - Labour Type, Quality & Experience	0,00	
Problems Arise From Contract Conditions Duration to Completion, Type of Contract, Nature & Magnitude of Work, Activity Difficulty, Laws & Regulations, Changes in Client's Needs	0,00	
Occurrence of External Factors & Unpredictable Risks Economical Conditions, Labor Problems, Extreme Weather Conditions, Other Hidden Obstructions, Political Conditions	0,00	
Problems Arise From Management, Unproductivity & Waste Inaccuracy in Management, Communication Between involved parties, Waste, Ineffective use of labor & Materials (Productivity)	0,00	

Table 4.9 Estimation of impacts (Impacts of Event on Event), i.e. Risk Factors on Risk Factors

		CROSS IMPACT EFFECTS OF RISK FACTORS ON OTHER RISK FACTORS								
			IMPACTED RISK FACTORS							
Probabilities	(1-P)	IMPACTING RISK FACTORS	E1	E2	E3	E4	E5	E6	E7	Transferred Event Probabilities in R Space
0,70	0,30	E1	0,00	0,81	0,50	0,63	0,31	0,13	0,38	0,71429
0,15	0,85	E2	0,06	0,00	0,31	0,69	0,31	0,00	0,38	-2,05882
0,11	0,89	E3	0,31	0,50	0,00	0,75	0,38	0,19	0,50	-2,91080
0,46	0,54	E4	0,25	0,19	0,44	0,00	0,38	0,00	0,63	-0,11314
0,60	0,40	E5	0,44	0,38	0,56	0,31	0,00	0,00	0,38	0,31250
0,18	0,83	E6	0,25	0,63	0,31	0,44	0,50	0,00	0,25	-1,68831
0,68	0,33	E7	0,81	0,44	0,31	0,81	0,69	0,13	0,00	0,59829

Table 4.10 Estimates of Constants, Coefficients, Surprise Tresholds and R-Transforms

Probability Transformation Function Constants and Coefficients & Assumptions									
EVENTS	P	(1-P)	U	C	L	s	k	d	R(x) Formula
E1	0,70	0,30	1,00	0,50	0,00	0,25	0,75		$\frac{0.75 * (x-0.50)}{x*(1-x)}$
E2	0,15	0,85	1,00	0,50	0,00	0,25	0,75		
E3	0,11	0,89	1,00	0,50	0,00	0,25	0,75		
E4	0,46	0,54	1,00	0,50	0,00	0,25	0,75		
E5	0,60	0,40	1,00	0,50	0,00	0,25	0,75		
E6	0,18	0,83	1,00	0,50	0,00	0,25	0,75		
E7	0,68	0,33	1,00	0,50	0,00	0,25	0,75		
T1	1,00		2,00	1,00	0,00	0,25	3,75		$\frac{3.75 * (x-1)}{x*(2-x)}$
T2	1,00		2,00	1,00	0,00	0,25	3,75		
T3	1,00		2,00	1,00	0,00	0,25	3,75		
T4	1,00		2,00	1,00	0,00	0,25	3,75		
T5	1,00		2,00	1,00	0,00	0,25	3,75		
T6	1,00		2,00	1,00	0,00	0,25	3,75		
T7	1,00		2,00	1,00	0,00	0,25	3,75		
T8	1,00		2,00	1,00	0,00	0,25	3,75		
T9	1,00		2,00	1,00	0,00	0,25	3,75		
T10	1,00		2,00	1,00	0,00	0,25	3,75		
T11	1,00		2,00	1,00	0,00	0,25	3,75		
T12	1,00		2,00	1,00	0,00	0,25	3,75		
T13	1,00		2,00	1,00	0,00	0,25	3,75		

The Trend Values for the model are assumed as 1,00. This is because, the variance of the Trend Values are expected to be in Percentage.

Table 4.11 Cross Impact Coefficients of Risk Factors on other Risk Factors Based on the Probabilities

		CROSS IMPACT COEFFICIENTS OF RISKS ON OTHER RISKS								
			IMPACTED RISK FACTORS							Compound Probability in (R) Space
Random Numbers	Event Probabilities	IMPACTING RISK FACTORS	E1	E2	E3	E4	E5	E6	E7	(∑)
0,34	0,70	E1	0,00	0,24	0,15	0,19	0,09	0,04	0,11	0,38694
0,91	0,15	E2	-0,01	0,00	-0,05	-0,10	-0,05	0,00	-0,08	-1,58773
0,51	0,11	E3	-0,04	-0,06	0,00	-0,08	-0,04	-0,02	-0,06	-2,73814
0,74	0,46	E4	-0,12	-0,09	-0,20	0,00	-0,17	0,00	-0,29	-0,17564
0,16	0,60	E5	0,18	0,15	0,23	0,13	0,00	0,00	0,15	0,09219
0,01	0,18	E6	0,21	0,52	0,26	0,35	0,41	0,00	0,21	-1,75628
0,79	0,68	E7	-0,55	-0,30	-0,21	-0,55	-0,46	-0,08	0,00	0,66548

Table 4.12 Transformed Cross Impact Effect Results in (R) Space

CROSS IMPACT EFFECT RESULTS IN (R) SPACE							
	E1	E2	E3	E4	E5	E6	E7
Total Cross Impact	-0,33	0,47	0,17	-0,06	-0,22	-0,07	0,07
Risk Probabilities	0,71	-2,06	-2,91	-0,11	0,31	-1,69	0,60
Cross Impact Effect	0,39	-1,59	-2,74	-0,18	0,09	-1,76	0,67

Table 4.13 Compound probabilities and transformed probabilities into Normal Space

Compound Probability in (R) Space	Transformed Probability into Normal Space	
(∑)	Root x1	Root x2
0,38694	0,62138	-1,55965
-1,58773	0,18321	1,28916
-2,73814	0,11854	1,15537
-0,17564	0,44224	4,82795
0,09219	0,53061	-7,66621
-1,75628	0,16984	1,25720
0,66548	0,68985	-0,81686

Compound Probability in Normal Space
0,62138
0,18321
0,11854
0,44224
0,53061
0,16984
0,68985

Table 4.14 Estimation of Impacts (Impacts of Events on Trends), i.e. Risk Factors on Phases of Construction

	CROSS IMPACT EFFECTS OF RISK FACTORS ON PHASES OF CONSTRUCTION													
		IMPACTED PHASES OF CONSTRUCTION												
Compound Probability in Normal Space	IMPACTING RISK FACTORS	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13
0,62138	E1	0,25	0,44	0,38	0,19	0,25	0,13	0,25	0,19	0,19	0,19	0,19	0,19	0,19
0,18321	E2	0,31	0,31	0,19	0,13	0,13	0,06	0,06	0,06	0,19	0,06	0,13	0,06	0,06
0,11854	E3	0,31	0,50	0,31	0,13	0,13	0,13	0,13	0,19	0,13	0,13	0,13	0,13	0,13
0,44224	E4	0,25	0,31	0,25	0,13	0,19	0,13	0,19	0,13	0,13	0,19	0,13	0,19	0,19
0,53061	E5	0,13	0,19	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06
0,16984	E6	0,25	0,25	0,13	0,13	0,19	0,13	0,25	0,13	0,13	0,13	0,13	0,13	0,13
0,68985	E7	0,31	0,44	0,38	0,31	0,50	0,31	0,31	0,25	0,19	0,25	0,19	0,25	0,25

Table 4.15 Cross Impact Coefficients of Risk Factors on other Risk Factors Based on the Probabilities

			CROSS IMPACT COEFFICIENTS OF RISK FACTORS ON PHASES OF CONSTRUCTION													
				IMPACTED PHASES OF CONSTRUCTION												
Compound Probability in Normal Space	Compound Probability in R(n) Space	(1-F')	IMPACTING RISK FACTORS	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13
0,621	0,387	0,378	E1	0,09	0,17	0,09	0,07	0,09	0,05	0,09	0,07	0,07	0,00	0,07	0,00	0,07
0,183	-1,593	0,817	E2	0,26	0,00	0,00	0,09	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,05	0,00
0,119	-2,738	0,881	E3	0,00	0,00	0,00	0,11	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
0,442	-0,170	0,553	E4	0,00	0,00	0,14	0,07	0,00	0,07	0,10	0,07	0,00	0,10	0,07	0,00	0,00
0,531	0,082	0,469	E5	0,06	0,09	0,03	0,03	0,00	0,03	0,03	0,03	0,00	0,03	0,03	0,00	0,03
0,170	-1,755	0,830	E6	0,00	0,00	0,00	0,10	0,00	0,10	0,00	0,00	0,00	0,00	0,00	0,00	0,00
0,690	0,495	0,310	E7	0,00	0,14	0,12	0,09	0,16	0,10	0,10	0,00	0,06	0,00	0,03	0,00	0,09

Table 4.16 Generation of Random Numbers for Monte Carlo Simulation

RANDOM NUMBERS FOR OCCURRENCE OF EVENTS(RISKS) AT EACH TREND (PHASE OF CONSTRUCTION)												
0,360	0,352	0,726	0,099	0,190	0,124	0,664	0,569	0,243	0,675	0,365	0,892	0,543
0,130	0,239	0,843	0,292	0,982	0,928	0,405	0,269	0,719	0,718	0,324	0,098	0,700
0,800	0,273	0,607	0,109	0,962	0,948	0,540	0,764	0,819	0,997	0,470	0,636	0,977
0,535	0,524	0,155	0,412	0,642	0,026	0,248	0,434	0,621	0,374	0,148	0,495	0,588
0,027	0,399	0,424	0,427	0,684	0,072	0,225	0,151	0,851	0,286	0,202	0,681	0,369
0,649	0,830	0,564	0,046	0,504	0,027	0,673	0,257	0,440	0,356	0,462	0,272	0,373
0,927	0,562	0,242	0,890	0,641	0,069	0,126	0,856	0,269	0,916	0,346	0,741	0,757

Table 4.17 Transformed Cross Impact Effect Results in (R) Space

TREND VALUES in R(x) Space	IMPACTING RISK FACTORS	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13
		CROSS IMPACT EFFECT RESULTS IN (R) SPACE												
		IMPACTED PHASES OF CONSTRUCTION												
0,000	E1	0,09	0,17	0,00	0,07	0,00	0,05	0,00	0,07	0,07	0,00	0,07	0,00	0,07
0,000	E2	0,26	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,05	0,00
0,000	E3	0,00	0,00	0,00	0,11	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
0,000	E4	0,00	0,00	0,14	0,07	0,00	0,07	0,10	0,07	0,00	0,10	0,07	0,00	0,00
0,000	E5	0,06	0,09	0,03	0,03	0,00	0,03	0,03	0,03	0,00	0,03	0,03	0,00	0,03
0,000	E6	0,00	0,00	0,00	0,10	0,00	0,10	0,00	0,00	0,00	0,00	0,00	0,00	0,00
0,000	E7	0,00	0,14	0,12	0,00	0,16	0,10	0,10	0,00	0,06	0,00	0,06	0,00	0,00
	Compound Impact on Trends :	0,41	0,39	0,29	0,38	0,26	0,35	0,23	0,17	0,19	0,13	0,23	0,05	0,10

Table 4.18 Compound Cross Impact Effects Transformed into Normal Space (RISK PREMIUM)

Roots													
X1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
X2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Variance of Trend in 0,100 Scale RISK PREMIUM	0,11	0,10	0,08	0,10	0,07	0,09	0,06	0,05	0,03	0,04	0,06	0,01	0,03

Table 4.19 Results of 10,000 run Monte Carlo Simulation (The Risk Premium)

	Foundation	Structural System Works	Elevation & Seperation Works	Roofing	Insulation	Windows and Doors	Floor & Wall Coverings	General Fittings and Finishings	Rough Mechanical Installations	Mechanical fittings & Finishings	Rough Electrical Installations	Electrical fittings & Finishings	Elevator Installations
	SIMULATION RESULTS (RISK EFFECTS AT EACH PHASE OF THE CONSTRUCTION)												
	0,070	0,113	0,102	0,018	0,094	0,075	0,072	0,018	0,081	0,027	0,041	0,032	0,049
	0,048	0,073	0,228	0,065	0,092	0,087	0,075	0,034	0,080	0,038	0,038	0,100	0,041
	0,045	0,072	0,124	0,039	0,075	0,106	0,025	0,039	0,040	0,069	0,047	0,096	0,025
	0,045	0,080	0,153	0,019	0,064	0,038	0,061	0,000	0,063	0,047	0,026	0,040	0,059
	0,062	0,127	0,062	0,089	0,062	0,033	0,054	0,035	0,062	0,101	0,040	0,016	0,027
	0,088	0,106	0,074	0,072	0,092	0,060	0,055	0,026	0,060	0,076	0,038	0,019	0,016
	0,013	0,067	0,142	0,055	0,148	0,040	0,089	0,084	0,051	0,021	0,015	0,048	0,034
	0,097	0,072	0,009	0,062	0,056	0,041	0,129	0,071	0,062	0,063	0,000	0,053	0,053
	0,161	0,083	0,044	0,040	0,099	0,037	0,086	0,079	0,034	0,028	0,084	0,037	0,042
	0,133	0,081	0,080	0,034	0,159	0,026	0,014	0,062	0,041	0,021	0,041	0,083	0,009
	0,034	0,144	0,000	0,055	0,114	0,034	0,071	0,034	0,028	0,055	0,081	0,083	0,055
	0,062	0,178	0,095	0,050	0,069	0,026	0,048	0,071	0,093	0,044	0,075	0,059	0,067
	0,059	0,103	0,050	0,105	0,029	0,064	0,059	0,027	0,052	0,083	0,039	0,090	0,064
	0,050	0,118	0,031	0,052	0,109	0,050	0,034	0,045	0,040	0,029	0,024	0,045	0,081
	0,108	0,103	0,076	0,101	0,066	0,092	0,061	0,045	0,034	0,036	0,081	0,014	0,027
RESULTS	0,081	0,111	0,079	0,052	0,072	0,046	0,061	0,047	0,047	0,050	0,045	0,050	0,050
RESULTS in % Scale	8,07	11,06	7,95	5,20	7,17	4,65	6,11	4,73	4,73	5,02	4,49	4,99	4,98

The results of the 10,000 run Simulation are presented below.

	SIMULATION RESULTS (RISK EFFECTS AT EACH PHASE OF THE CONSTRUCTION)												
	Foundation	Structural System Works	Elevation & Seperation Works	Roofing	Insulation	Windows and Doors	Floor & Wall Coverings	General Fittings and Finishings	Rough Mechanical Installations	Mechanical fittings & Finishings	Rough Electrical Installations	Electrical fittings & Finishings	Elevator Installations
RESULTS	0,081	0,111	0,079	0,052	0,072	0,046	0,061	0,047	0,047	0,050	0,045	0,049	0,050
RESULTS in % Scale	8,07	11,06	7,95	5,20	7,17	4,65	6,11	4,73	4,73	5,02	4,49	4,99	4,98

Table 4.20 Results of Monte Carlo Simulation (The Risk Premium)

These results show that the Risk Factors at this project are impacting mostly The Structural System Phase, then the Foundation Phase. Then the elevation and Separation Phase is the most impacted. The result also give us the quantification of the possible risks and their impacts.

These result figures can be considered as the Risk Premium to be added to the cost of each construction phase & cash flow.

Table 4.21 Risk Premium for Best Situation (No Risks Occurred)

X1	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
X2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Variance of Trend in 0,100 Scale RISK PREMIUM	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Results of the Best Situation (i.e. if no risk factor occurs) show that, then there is no risk premium needed to add to the costs of construction phases.

Table 4.22 Risk Premium for Worst Situation (All Risks Occurred)

X1	1,205	1,258	1,169	1,103	1,127	1,089	1,123	1,103	1,109	1,092	1,0[illegible]	1,[illegible]	1,[illegible]
X2	-9,[illegible]	-2,811	-3,010	-8,7[illegible]	-8,[illegible]	-10,[illegible]	-7,12[illegible]	-9,[illegible]	-4,211	-9,[illegible]	-3,21[illegible]	-9,[illegible]	-8,[illegible]
Variance of Trend in 0,100 Scale RISK PREMIUM	0,21	0,26	0,17	0,10	0,13	0,09	0,12	0,10	0,11	0,09	0,10	0,09	0,09

Results of the Best Situation (i.e. if all risk factors occur sequentially) show that, the cost of the Structural System Works Phase may be increased up to 26%, then Foundation phase 21% and Elevation Works phase 17% respectively. The least impacted phases i.e. Elevator Works, Mechanical & Electrical Fittinga & Finishings still have a premium of 9%.

Results of the 10,000 run Simulation (i.e. if some risk factors occur and some do not occur) show that, Structural Works Phase have 11,06% Risk Premium which is the highest Risky Phase and Rough Electrical Installations have 4,49% Risk Premium which is the lowest among all the phases.

Based on these results, in order to see the effects and adjustments of the risk premium on the cash flow,/Risk Adjusted Discount Rate Method should be applied.

4. 4 Risk Premiums and Adjusted Cash Flow

Obtaining the results of Simulation also given us the Risk Premium. These premium should be used to adjust the Cost of each Construction Phase on the cash flow. To give a more clear view, and not having the income data of the contractor because of contractor's privacy policy, the adjustments will be made on the Summary Cost table.

Table 4.23 Summary of the Costs for each construction phase and the premium adjustments without considering the Inflation.

Phases Of Construction	Base Estimated Cost	Risk Premium (%)	Risk Premium Adjustment	Total Adjusted Costs
Foundation	33.001.272.000,00 TL	8,07	2.663.202.650,40 TL	35.664.474.650,40 TL
Structural Works	188.824.000.000,00 TL	11,06	20.883.934.400,00 TL	209.707.934.400,00 TL
Elevation	21.931.000.000,00 TL	7,95	1.743.514.500,00 TL	23.674.514.500,00 TL
Roofing	5.697.000.000,00 TL	5,20	296.244.000,00 TL	5.993.244.000,00 TL
Insulation	6.630.000.000,00 TL	7,17	475.371.000,00 TL	7.105.371.000,00 TL
Window&Doors	48.339.513.000,00 TL	4,65	2.247.787.354,50 TL	50.587.300.354,50 TL
Coverings	330.205.313.643,00 TL	6,11	20.175.544.663,59 TL	350.380.858.306,59 TL
Fittings & Finishings	63.031.365.000,00 TL	4,73	2.981.383.564,50 TL	66.012.748.564,50 TL
Rough Mechanical	16.716.000.000,00 TL	4,73	790.666.800,00 TL	17.506.666.800,00 TL
Mechanical Fittings	98.240.000.000,00 TL	5,02	4.931.648.000,00 TL	103.171.648.000,00 TL
Rough Electrical	2.400.000.000,00 TL	4,49	107.760.000,00 TL	2.507.760.000,00 TL
Electrical Fittings	9.200.000.000,00 TL	4,99	459.080.000,00 TL	9.659.080.000,00 TL
Elevators	25.000.000.000,00 TL	4,98	1.245.000.000,00 TL	26.245.000.000,00 TL
Grand Total	849.215.463.643,00 TL	6,09	51.704.156.882,57 TL	908.216.600.575,99 TL

This adjustment and analysis indicates the most critical & risky stages of the project. Although the highest risk premium is adjusting the Structural Works phase, the cost of Coverings Phase is the highest, so the adjustment amount is almost the same as Structural Works Phase.

In order to find the future values of each cost of phase, the Risk Adjusted Discount Rate Method should be applied.

For this application, the interest rate plus the risk premium should be placed in the formula to find each adjustment. As the total duration of the project is 15 months, the adjustment should be made on monthly basis.

The Inflation is assumed to be 59.95% per year according to the government bond of 12 months, auction date on 18.03.2003. (www.tcmb.gov.tr/yeni/evds/piyasa.html). That means the expected inflation rate forecasted by government on 18.03.2003 is 59.95%. In this case, from the compound interest formula, expected monthly interest rate should be 3,992%

First of all the future values of the costs are determined monthly basis. Then the costs are adjusted by the Risk Premium of each Phase of the Construction.

The Results can be seen at tables 4.24 to 4.29 and also in Appendix C.

Table 4.24 Estimated Baseline Costs (a)

Estimated Costs	t	0	1	2	3	4	5	6	7	8
	Phases of Construction	01.09.2002	01.10.2002	01.11.2002	01.12.2002	01.01.2003	01.02.2003	01.03.2003	01.04.2003	01.05.2003
	Foundation	0 TL	14.347 TL	18.654 TL						
	Structural Works			79.313 TL	11.780 TL	11.470 TL	192 TL	11.662 TL	11.470 TL	11.854 TL
	Elevation				1.626 TL	2.340 TL		827 TL	1.513 TL	2.340 TL
	Roofing									
	Insulation					480 TL			480 TL	480 TL
	Window&Doors				706 TL	3.936 TL			3.936 TL	3.936 TL
	Coverings									
	Fittings & Finishings									
	Rough Mechanical			1.018 TL						
	Mechanical Fittings									
	Rough Electrical				120 TL	285 TL			285 TL	285 TL
	Electrical Fittings									
	Elevators									
	Grand Total	0 TL	14.347 TL	99.985 TL	14.232 TL	18.511 TL	192 TL	12.489 TL	17.684 TL	16.895 TL

Table 4.25 Time/Inflation Adjusted Costs (a)

Monthly Interest Rate	Risk Premium	t	0	1	2	3	4	5	6	7	8
		Phases of Construction	01.09.2002	01.10.2002	01.11.2002	01.12.2002	01.01.2003	01.02.2003	01.03.2003	01.04.2003	01.05.2003
%3,992	8,07	Foundation	0 TL	14.920 TL	20.173 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL
%3,992	11,06	Structural Works	0 TL	0 TL	85.772 TL	13.248 TL	13.414 TL	234 TL	14.749 TL	15.086 TL	16.213 TL
%3,992	7,95	Elevation	0 TL	0 TL	0 TL	1.829 TL	2.737 TL	0 TL	1.046 TL	1.990 TL	3.200 TL
%3,992	5,20	Roofing	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL
%3,992	7,17	Insulation	0 TL	0 TL	0 TL	0 TL	561 TL	0 TL	0 TL	631 TL	657 TL
%3,992	4,65	Window&Doors	0 TL	0 TL	0 TL	794 TL	4.603 TL	0 TL	0 TL	5.177 TL	5.383 TL
%3,992	6,11	Coverings	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL
%3,992	4,73	Fittings & Finishings	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL
%3,992	4,73	Rough Mechanical	0 TL	0 TL	1.101 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL
%3,992	5,02	Mechanical Fittings	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL
%3,992	4,49	Rough Electrical	0 TL	0 TL	0 TL	135 TL	333 TL	0 TL	0 TL	376 TL	390 TL
%3,992	4,99	Electrical Fittings	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL
%3,992	4,98	Elevators	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL
		Grand Total	0 TL	14.920 TL	107.046 TL	16.005 TL	21.649 TL	234 TL	15.795 TL	23.259 TL	25.843 TL

Table 4.26 Inflation and Risk Adjusted Costs (a)

Monthly Interest Rate	Risk Premium	t - time	0	1	2	3	4	5	6	7	8
		Phases of Constructio	01.09.2002	01.10.2002	01.11.2002	01.12.2002	01.01.2003	01.02.2003	01.03.2003	01.04.2003	01.05.2003
%3,992	8,07	Foundation	0 TL	16.124 TL	21.801 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL
%3,992	11,06	Structural Works	0 TL	0 TL	95.258 TL	14.713 TL	14.898 TL	259 TL	16.381 TL	16.754 TL	18.006 TL
%3,992	7,95	Elevation	0 TL	0 TL	0 TL	1.974 TL	2.954 TL	0 TL	1.129 TL	2.148 TL	3.455 TL
%3,992	5,20	Roofing	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL
%3,992	7,17	Insulation	0 TL	0 TL	0 TL	0 TL	602 TL	0 TL	0 TL	677 TL	704 TL
%3,992	4,65	Window&Doors	0 TL	0 TL	0 TL	831 TL	4.817 TL	0 TL	0 TL	5.417 TL	5.634 TL
%3,992	6,11	Coverings	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL
%3,992	4,73	Fittings & Finishings	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL
%3,992	4,73	Rough Mechanical	0 TL	0 TL	1.153 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL
%3,992	5,02	Mechanical Fittings	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL
%3,992	4,49	Rough Electrical	0 TL	0 TL	0 TL	141 TL	348 TL	0 TL	0 TL	392 TL	407 TL
%3,992	4,99	Electrical Fittings	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL
%3,992	4,98	Elevators	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL
		Grand Total	0 TL	16.124 TL	118.212 TL	17.659 TL	23.619 TL	259 TL	17.510 TL	25.388 TL	28.206 TL

Table 4.27 Estimated Baseline Costs (b)

Estimated Costs

Phases of Construction	01.06.2003	01.07.2003	01.08.2003	01.09.2003	01.10.2003	01.11.2003	01.12.2003	
Foundation								33.001 TL
Structural Works	12.646 TL	22.340 TL	11.657 TL	4.440 TL				188.824 TL
Elevation	4.680 TL	2.340 TL	2.340 TL	3.925 TL				21.931 TL
Roofing				2.046 TL	3.651 TL			5.697 TL
Insulation	480 TL	960 TL	480 TL	3.270 TL				6.630 TL
Window&Doors	3.936 TL	7.873 TL	3.936 TL	7.971 TL	12.105 TL			48.335 TL
Coverings				108.664 TL	137.625 TL	62.618 TL	21.296 TL	330.203 TL
Fittings & Finishings					9.108 TL	5.512 TL	48.411 TL	63.031 TL
Rough Mechanical				15.698 TL				16.716 TL
Mechanical Fittings				4.600 TL	44.240 TL	49.400 TL		98.240 TL
Rough Electrical	285 TL	570 TL	285 TL	285 TL				2.400 TL
Electrical Fittings					9.200 TL			9.200 TL
Elevators						25.000 TL		25.000 TL
Grand Total	**22.027 TL**	**34.083 TL**	**18.698 TL**	**150.899 TL**	**215.929 TL**	**142.530 TL**	**69.707 TL**	**849.208 TL**

Table 4.28 Time/Inflation Adjusted Costs (b)

Monthly Interest Rate	Risk Premium	t	9	10	11	12	13	14	15	
		Phases of Construction	01.06.2003	01.07.2003	01.08.2003	01.09.2003	01.10.2003	01.11.2003	01.12.2003	
%3,992	8,07	Foundation	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	35.093 TL
%3,992	11,06	Structural Works	17.987 TL	33.043 TL	17.930 TL	7.102 TL	0 TL	0 TL	0 TL	234.777 TL
%3,992	7,95	Elevation	6.656 TL	3.461 TL	3.599 TL	6.278 TL	0 TL	0 TL	0 TL	30.797 TL
%3,992	5,20	Roofing	0 TL	0 TL	0 TL	3.273 TL	6.073 TL	0 TL	0 TL	9.346 TL
%3,992	7,17	Insulation	683 TL	1.420 TL	738 TL	5.231 TL	0 TL	0 TL	0 TL	9.921 TL
%3,992	4,65	Window&Doors	5.598 TL	11.645 TL	6.054 TL	12.750 TL	20.136 TL	0 TL	0 TL	72.140 TL
%3,992	6,11	Coverings	0 TL	0 TL	0 TL	173.814 TL	228.927 TL	108.317 TL	38.309 TL	549.367 TL
%3,992	4,73	Fittings & Finishings	0 TL	0 TL	0 TL	0 TL	15.150 TL	9.535 TL	87.085 TL	111.770 TL
%3,992	4,73	Rough Mechanical	0 TL	0 TL	0 TL	25.110 TL	0 TL	0 TL	0 TL	26.211 TL
%3,992	5,02	Mechanical Fittings	0 TL	0 TL	0 TL	7.358 TL	73.589 TL	85.453 TL	0 TL	166.400 TL
%3,992	4,49	Rough Electrical	405 TL	843 TL	438 TL	456 TL	0 TL	0 TL	0 TL	3.376 TL
%3,992	4,99	Electrical Fittings	0 TL	0 TL	0 TL	0 TL	15.303 TL	0 TL	0 TL	16.303 TL
%3,992	4,98	Elevators	0 TL	0 TL	0 TL	0 TL	0 TL	43.245 TL	0 TL	43.245 TL
		Grand Total	**31.330 TL**	**60.412 TL**	**29.760 TL**	**241.371 TL**	**359.178 TL**	**246.650 TL**	**125.394 TL**	**1.307.746 TL**

Table 4.29 Inflation and Risk Adjusted Costs (b)

Monthly Interest Rate	Risk Premium	t - time	9	10	11	12	13	14	15	
		Phases of Constructio	01.06.2003	01.07.2003	01.08.2003	01.09.2003	01.10.2003	01.11.2003	01.12.2003	Total
%3,992	8,07	Foundation	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	0 TL	37.925 TL
%3,992	11,06	Structural Works	19.976 TL	36.698 TL	19.913 TL	7.888 TL	0 TL	0 TL	0 TL	260.744 TL
%3,992	7,95	Elevation	7.186 TL	3.736 TL	3.885 TL	6.777 TL	0 TL	0 TL	0 TL	33.245 TL
%3,992	5,20	Roofing	0 TL	0 TL	0 TL	3.443 TL	6.389 TL	0 TL	0 TL	9.832 TL
%3,992	7,17	Insulation	732 TL	1.522 TL	791 TL	5.606 TL	0 TL	0 TL	0 TL	10.632 TL
%3,992	4,65	Window&Doors	5.859 TL	12.186 TL	6.336 TL	13.343 TL	21.072 TL	0 TL	0 TL	75.495 TL
%3,992	6,11	Coverings	0 TL	0 TL	0 TL	184.434 TL	242.914 TL	114.936 TL	40.649 TL	582.933 TL
%3,992	4,73	Fittings & Finishings	0 TL	0 TL	0 TL	0 TL	15.867 TL	9.986 TL	91.204 TL	117.057 TL
%3,992	4,73	Rough Mechanical	0 TL	0 TL	0 TL	26.298 TL	0 TL	0 TL	0 TL	27.450 TL
%3,992	5,02	Mechanical Fittings	0 TL	0 TL	0 TL	7.727 TL	77.283 TL	89.742 TL	0 TL	174.753 TL
%3,992	4,49	Rough Electrical	424 TL	881 TL	458 TL	476 TL	0 TL	0 TL	0 TL	3.527 TL
%3,992	4,99	Electrical Fittings	0 TL	0 TL	0 TL	0 TL	16.067 TL	0 TL	0 TL	16.067 TL
%3,992	4,98	Elevators	0 TL	0 TL	0 TL	0 TL	0 TL	45.399 TL	0 TL	45.399 TL
		Grand Total	**34.176 TL**	**55.023 TL**	**31.384 TL**	**255.992 TL**	**379.592 TL**	**280.063 TL**	**131.853 TL**	**1.395.059 TL**

CHAPTER 5

CONCLUSIONS

5. 1 Conclusions

This research provides contributions in several areas. The following paragraphs itemize conclusions and major identifiable tasks that have been accomplished. At a global level, this dissertation developed a unique methodology for understanding Risks impact on the Construction Phases in the process of a building project.

This dissertation has presented the development of a methodology for the evaluation of Risk Factors' impact on the Costs of Phases of Construction in the building construction industry. For doing this, the interdependencies between Risk Factors and Phases of Construction are analyzed in the context of the process of a building project.

A model has been developed based on the Delphi method, cross-impact analysis and Risk Adjusted Discount Rate Method. The Intuitive judgements of the professionals in several disciplines have been obtained as input for the model. An investigation of the impacts of major Risk Factors on Construction Cost.

The following are the research findings, the conclusions and contributions:

1. The Delphi Survey showed that The risk factors caused by Problems Arising from Management, Unproductivity & Waste have the Highest impact on the other Risk Factors. Then the risks caused by Project and Design Conditions have the second highest impact on other risk factors. Oppositely the Problems arising from site conditions have the least impact on other risk factors.

2. The most impacted risk factors by the others are Problems arising from construction team and parties. Then the risk factors caused by the problems arise from the site conditions are the second most impacted event. The least impacted risk factors are the Occurrence of the external factors and unpredictable risks.

3. The Most Probable Risk factors to be occurred are Problems arising from project design and conditions, then Problems arise from Management, Unproductivity and Waste. The Least Probable risk is caused by the problems arise from the construction technology and materials.

4. Similarly, The risk factors caused by Problems Arise from Management, Unproductivity & Waste have the Highest impact on the Construction Phases. Then the risks caused by Project and Design Conditions has the second highest impact on the Construction Phases. Oppositely the Problems arise from Contract Conditions has the least impact on the Construction Phases.

5. The most impacted Construction Phases by the risk factors Structural System Works. Then the Foundation and Elevation-Separation works are the second most impacted phases. Then comes the Insulation and covering works. Other phases of construction are the least impacted phases.

6. These results show that the Risk Factors at this project are impacting mostly the The Structural System Phase, then the Foundation Phase. Then the elevation and Separation Phase is the most impacted. The result also give us the quantification of the possible risks and their impacts.

7. These result figures can be considered as the Risk Premium to be added to the cost of each construction phase & cash flow.

8. Results show that if the risk factors occur sequentially, the cost of the Structural System Works Phase may be increased up to 26%, where the least impacted phases have still a premium of 9-10 %.

9. Obtaining the results of Simulation also given us the Risk Premium. These premium should be used to adjust the Cost of each Construction Phase on the cash flow. To give a more clear view, the adjustments will be made on the Summary Cost table.

10. This adjustment and analysis indicates the most critical & risky stages of the project. Although the highest risk premium is adjusting the Structural Works phase, the cost of Coverings Phase is the highest, so the adjustment amount is almost the same as Structural Works Phase.

11. The main problem of the risk adjusted discount rate method was being unsatisfactory because it is done on the basis of a personalized analysis and without any more knowledge of the market's actual risk-return trade-off than that of casual observation. By this research the observation and the analysis of the RADR Method can be applied effectively and precisely.

12. The model can be used for comparative policy analyses. The testing of a variety of policies and their implementation through specific plans and appropriate budget allocations may identify several policies as potentially promising. Decision-makers of the companies involved in the process of a building project can simulate their decisions and compare the results. The integrated approach of this model both in terms of disciplines and in terms of phases helps professionals to develop robust strategies of Risk Management for their projects.

13. The methodology provides a model framework for capturing and formalizing the intuitive judgment of experts' knowledge. The methodology developed for knowledge acquisition in the modelling process eliminates one of the major difficulties found in practice for the development of this type of model. The knowledge is stored in modules that are self contained and independent. This facilitates isolation and capture of expertise. Experts can provide their expertise in a localized area. Also, the model can be easily updated without altering the model structure.

14. From a general perspective, conclusions cover methodological contributions that include the development of a conceptual and mathematical model; Risk Management related contributions that include evaluation, quantification and analysis of Risk

Factors and their interaction in different phases of construction, and their impacts on the other risk factors as well as the phases of construction. The concepts applied can be extended beyond the specific problem addressed in this dissertation.

15. The scope of the method can be widen very easily and can cover all the process starting from the feasibility anaysis to the operation phase.

16. The Results show that there are quite a big amount of variance on the costs when they are adjusted by the inflation rate and by the risk premium. This proves that how the requirement for the risk management and the cost management are serious and inevitable.

17. The risk quantification process should be repeated at each phase as the project continues and the risk effects at each phase should be updated in order to reflect the actual problems happened or not. If any risk has not occurred, the value of the risk effect should be entered as 0. Then the Cross Impact and adjustment processes should be calculated again i.e. updated. So, more realistic simulations could be made by ignoring the effects of non-occurred risks.

18. The risk factors can also be effected to the milestones instead of the phases of construction and monthly risk premiums could be calculated. This way could be a time dependent risk management process and could give more accurate monthly results.

19. The results also prove that assistance of risk management methods considerably increase the efficiency of budgets and cost management efforts.

Future studies may be carried out in order to develop the concept and applications of similar methods.

APPENDIX A

DELPHI SURVEY

Dokuz Eylul University

Institute Of Natural And Applied Sciences

Department Of Architecture

Structural And Constructional Design Program

DELPHI SURVEY FOR DETERMINING EFFECTS OF EACH RISK FACTOR ON OTHER RISK FACTORS

Please assess the impact of probable risk factors on each other risk factors, which might be occurred during the construction phases. The relevant risk factors are grouped under 7 main titles which could contain one or more sub-factors. Also at the last question, the forecasting of the probability of occurences for each risk factor is required. There are 8 questions. Please check the relevant "Assessment Rate Box" to assess the impact amount. If you think that there might be a negative impact, please check the "Negative Impact Box" together with the relevant "Assessment Rate Box". The time required to complete this form is approximately 14 minutes. Please note that your answers are based on your intuitive judgment, there are no correct or wrong answers.

Thank you.

Your Name:	

(Your name will not be revealed in any document, this is for feedback & communication purposes only)

Question I:

If a problem occurs at **Project & Design Conditions** (*Design Complexity, Completion Level of Design Drawings and Details, Accuracy of Schedules Estimates & Calculations)*, how are the following Risk Factors affected in the construction phase of the building project?

	Very High Impact	**On Risk of Problems Arise From Site Conditions** *Location, Access & Traffic, Size of Site, Ground Conditions, Site Organization, Safety & Security*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Problems Arise From Construction Technology & Materials** *Construction Method & Technic, Required Special Equipment, Technology Level of Building, Ordinary & Special Materials*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Problems Arise From Construction Team & Involved Parties** *Suppliers - Subcontractors - Labour Type, Quality & Experience*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Problems Arise From Contract Conditions** *Duration to Completion, Type of Contract, Nature & Magnitude of Work, Activity Difficulty, Laws & Regulations, Changes in Client's Needs*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Occurrence of External Factors & Unpredictable Risks** *Economical Conditions, Labor Problems, Extreme Weather Conditions, Other Hidden Obstructions, Political Conditions*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Problems Arise From Management, Unproductivity & Waste** *Inaccuracy in Management, Communication Between Involved parties, Waste, Ineffective use of labor & Materials (Productivity)*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

Question 2:

If a problem occurs at **Site Conditions** (*Location, Access & Traffic, Size of Site, Ground Conditions, Site Organization, Safety & Security)* how are the following Risk Factors affected in the construction phase of the building project?

	Very High Impact	**On Risk of Problems Arise From Project & Design Conditions** *(Design Complexity, Completion Level of Design Drawings and Details, Accuracy of Schedules Estimates & Calculations),*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Problems Arise From Construction Technology & Materials** *Construction Method & Technic, Required Special Equipment, Technology Level of Building, Ordinary & Special Materials*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Problems Arise From Construction Team & Involved Parties** *Suppliers - Subcontractors - Labour Type, Quality & Experience*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Problems Arise From Contract Conditions** *Duration to Completion, Type of Contract, Nature & Magnitude of Work, Activity Difficulty, Laws & Regulations, Changes in Client's Needs*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Occurrence of External Factors & Unpredictable Risks** *Economical Conditions, Labor Problems, Extreme Weather Conditions, Other Hidden Obstructions, Political Conditions*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Problems Arise From Management, Unproductivity & Waste** *Inaccuracy in Management, Communication Between Involved parties, Waste, Ineffective use of labor & Materials (Productivity)*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

Question 3:

If a problem occurs at **Construction Technology & Materials** (*Construction Method & Technic, Required Special Equipment, Technology Level of Building, Ordinary & Special Materials)* how are the following Risk Factors affected in the construction phase of the building project?

	Very High Impact	**On Risk of Problems Arise From Project & Design Conditions** *(Design Complexity, Completion Level of Design Drawings and Details, Accuracy of Schedules Estimates & Calculations),*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Problems Arise From Site Conditions** *Location, Access & Traffic, Size of Site, Ground Conditions, Site Organization, Safety & Security*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Problems Arise From Construction Team & Involved Parties** *Suppliers - Subcontractors - Labour Type, Quality & Experience*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Problems Arise From Contract Conditions** *Duration to Completion, Type of Contract, Nature & Magnitude of Work, Activity Difficulty, Laws & Regulations, Changes in Client's Needs*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Occurrence of External Factors & Unpredictable Risks** *Economical Conditions, Labor Problems, Extreme Weather Conditions, Other Hidden Obstructions, Political Conditions*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Problems Arise From Management, Unproductivity & Waste** *Inaccuracy in Management, Communication Between Involved parties, Waste, Ineffective use of labor & Materials (Productivity)*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

Question 4:

If a problem occurs at **Construction Team & Involved Parties** (*Suppliers - Subcontractors - Labour Type, Quality & Experience)* how are the following Risk Factors affected in the construction phase of the building project?

	Very High Impact	**On Risk of Problems Arise From Project & Design Conditions** (*Design Complexity, Completion Level of Design Drawings and Details, Accuracy of Schedules Estimates & Calculations)*,
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Problems Arise From Site Conditions** *Location, Access & Traffic, Size of Site, Ground Conditions, Site Organization, Safety & Security*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Problems Arise From Construction Technology & Materials** *Construction Method & Technic, Required Special Equipment, Technology Level of Building, Ordinary & Special Materials*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Problems Arise From Contract Conditions** *Duration to Completion, Type of Contract, Nature & Magnitude of Work, Activity Difficulty, Laws & Regulations, Changes in Client's Needs*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Occurrence of External Factors & Unpredictable Risks** *Economical Conditions, Labor Problems, Extreme Weather Conditions, Other Hidden Obstructions, Political Conditions*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Problems Arise From Management, Unproductivity & Waste** *Inaccuracy in Management, Communication Between Involved parties, Waste, Ineffective use of labor & Materials (Productivity)*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

Question 5:

If a problem occurs at **Contract Conditions** (*Duration to Completion, Type of Contract, Nature & Magnitude of Work, Activity Difficulty, Laws & Regulations, Changes in Client's Needs),* how are the following Risk Factors affected in the construction phase of the building project?

	Very High Impact	**On Risk of Problems Arise From Project & Design Conditions** (*Design Complexity, Completion Level of Design Drawings and Details, Accuracy of Schedules Estimates & Calculations),*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Problems Arise From Site Conditions** *Location, Access & Traffic, Size of Site, Ground Conditions, Site Organization, Safety & Security*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Problems Arise From Construction Technology & Materials** *Construction Method & Technic, Required Special Equipment, Technology Level of Building, Ordinary & Special Materials*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Problems Arise From Construction Team & Involved Parties** *Suppliers - Subcontractors - Labour Type, Quality & Experience*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Occurrence of External Factors & Unpredictable Risks** *Economical Conditions, Labor Problems, Extreme Weather Conditions, Other Hidden Obstructions, Political Conditions*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Problems Arise From Management, Unproductivity & Waste** *Inaccuracy in Management, Communication Between Involved parties, Waste, Ineffective use of labor & Materials (Productivity)*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

Question 6:

If a problem occurs as **External Factors & Unpredictable Risks** (*Economical Conditions, Labor Problems, Extreme Weather Conditions, Other Hidden Obstructions, Political Conditions)* how are the following Risk Factors affected in the construction phase of the building project?

	Very High Impact	**On Risk of Problems Arise From Project & Design Conditions** *(Design Complexity, Completion Level of Design Drawings and Details, Accuracy of Schedules Estimates & Calculations),*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Problems Arise From Site Conditions** *Location, Access & Traffic, Size of Site, Ground Conditions, Site Organization, Safety & Security*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Problems Arise From Construction Technology & Materials** *Construction Method & Technic, Required Special Equipment, Technology Level of Building, Ordinary & Special Materials*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Problems Arise From Construction Team & Involved Parties** *Suppliers - Subcontractors - Labour Type, Quality & Experience*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Problems Arise From Contract Conditions** *Duration to Completion, Type of Contract, Nature & Magnitude of Work, Activity Difficulty, Laws & Regulations, Changes in Client's Needs*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Problems Arise From Management, Unproductivity & Waste** *Inaccuracy in Management, Communication Between Involved parties, Waste, Ineffective use of labor & Materials (Productivity)*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

Question 7:

If a problem occurs at **Management, Unproductivity & Waste** (*Inaccuracy in Management, Communication Between Involved parties, Waste, Ineffective use of labor & Materials (Productivity)* how are the following Risk Factors affected in the construction phase of the building project?

	Very High Impact	**On Risk of Problems Arise From Project & Design Conditions** (*Design Complexity, Completion Level of Design Drawings and Details, Accuracy of Schedules Estimates & Calculations*),
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Problems Arise From Site Conditions** *Location, Access & Traffic, Size of Site, Ground Conditions, Site Organization, Safety & Security*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Problems Arise From Construction Technology & Materials** *Construction Method & Technic, Required Special Equipment, Technology Level of Building, Ordinary & Special Materials*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Problems Arise From Construction Team & Involved Parties** *Suppliers - Subcontractors - Labour Type, Quality & Experience*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Problems Arise From Contract Conditions** *Duration to Completion, Type of Contract, Nature & Magnitude of Work, Activity Difficulty, Laws & Regulations, Changes in Client's Needs*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On Risk of Occurrence of External Factors & Unpredictable Risks** *Economical Conditions, Labor Problems, Extreme Weather Conditions, Other Hidden Obstructions, Political Conditions*
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

Question 8:

What is the Probability of Occurrence for the following Risk Factors during the Construction Phase?

PROBABILITY (%)	RISK FACTORS
	Risk of Problems Arise From Project & Design Conditions *(Design Complexity, Completion Level of Design Drawings and Details, Accuracy of Schedules Estimates & Calculations),*
	Risk of Problems Arise From Site Conditions *Location, Access & Traffic, Size of Site, Ground Conditions, Site Organization, Safety & Security*
	Risk of Problems Arise From Construction Technology & Materials *Construction Method & Technic, Required Special Equipment, Technology Level of Building, Ordinary & Special Materials*
	Risk of Problems Arise From Construction Team & Involved Parties *Suppliers – Subcontractors - Labour Type, Quality & Experience*
	Risk of Problems Arise From Contract Conditions *Duration to Completion, Type of Contract, Nature & Magnitude of Work, Activity Difficulty, Laws & Regulations, Changes in Client's Needs*
	Risk of Occurrence of External Factors & Unpredictable Risks *Economical Conditions, Labor Problems, Extreme Weather Conditions, Other Hidden Obstructions, Political Conditions*
	On Risk of Problems Arise From Management, Unproductivity & Waste *Inaccuracy in Management, Communication Between Involved parties, Waste, Ineffective use of labor & Materials (Productivity)*

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Department Of Architecture

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DELPHI SURVEY FOR DETERMINING EFFECTS OF EACH RISK FACTOR ON COSTS OF EACH CONSTRUCTION PHASE

Please assess the impact of probable risk factors on each Phase of The Construction, which might be occurred during the construction phases. The relevant risk factors are grouped under 7 main titles which could contain one or more sub-factors and there are 13 Phases of Construction. There are 7 questions. Please check the relevant "Assessment Rate Box" to assess the impact amount. If you think that there might be a negative impact, please check the "Negative Impact Box" together with the relevant "Assessment Rate Box". The time required to complete this form is approximately 23 minutes. Please note that your answers are based on your intuitive judgment, there are no correct or wrong answers.

Thank you.

Your Name:	

(Your name will not be revealed in any document, this is for feedback & communication purposes only)

Question l:

If a problem occurs at **Project & Design Conditions** (*Design Complexity, Completion Level of Design Drawings and Details, Accuracy of Schedules Estimates & Calculations)*, how are the Costs of following Construction Phase affected?

	Very High Impact	**On the Costs of FOUNDATION PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of STRUCTURAL SYSTEM WORKS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ELEVATIONS & SEPARATIONS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ROOFING PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of INSULATION PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of WINDOWS & DOORS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs Of FLOOR & WALL COVERINGS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of GENERAL FITTINGS & FINISHINGS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ROUGH MECHANICAL INSTALLATIONS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of MECHANICAL FITTINGS & FINISHINGS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ROUGH ELECTRICAL INSTALLATIONS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ELECTRICAL FITTINGS & FINISHINGS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ELEVATOR INSTALLATIONS**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

Question 2:

If a problem occurs at **Site Conditions** (Location, Access & Traffic, Size of Site, Ground Conditions, Site Organization, Safety & Security), how are the Costs of following Construction Phase affected?

	Very High Impact	**On the Costs of FOUNDATION PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of STRUCTURAL SYSTEM WORKS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ELEVATIONS & SEPARATIONS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ROOFING PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of INSULATION PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of WINDOWS & DOORS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs Of FLOOR & WALL COVERINGS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of GENERAL FITTINGS & FINISHINGS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ROUGH MECHANICAL INSTALLATIONS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of MECHANICAL FITTINGS & FINISHINGS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ROUGH ELECTRICAL INSTALLATIONS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ELECTRICAL FITTINGS & FINISHINGS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ELEVATOR INSTALLATIONS**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

Question 3:

If a problem occurs at **Construction Technology & Materials** (*Construction Method & Technic, Required Special Equipment, Technology Level of Building, Ordinary & Special Materials)*, how are the Costs of following Construction Phase affected?

	Very High Impact	**On the Costs of FOUNDATION PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of STRUCTURAL SYSTEM WORKS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ELEVATIONS & SEPARATIONS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ROOFING PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of INSULATION PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of WINDOWS & DOORS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs Of FLOOR & WALL COVERINGS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of GENERAL FITTINGS & FINISHINGS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ROUGH MECHANICAL INSTALLATIONS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of MECHANICAL FITTINGS & FINISHINGS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ROUGH ELECTRICAL INSTALLATIONS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ELECTRICAL FITTINGS & FINISHINGS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ELEVATOR INSTALLATIONS**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

Question 4:

If a problem occurs at **Construction Team & Involved Parties** (*Suppliers - Subcontractors - Labour Type, Quality & Experience)*, how are the Costs of following Construction Phase affected?

	Very High Impact	**On the Costs of FOUNDATION PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of STRUCTURAL SYSTEM WORKS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ELEVATIONS & SEPARATIONS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ROOFING PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of INSULATION PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of WINDOWS & DOORS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs Of FLOOR & WALL COVERINGS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of GENERAL FITTINGS & FINISHINGS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ROUGH MECHANICAL INSTALLATIONS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of MECHANICAL FITTINGS & FINISHINGS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ROUGH ELECTRICAL INSTALLATIONS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ELECTRICAL FITTINGS & FINISHINGS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ELEVATOR INSTALLATIONS**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

Question 5:

If a problem occurs at **Contract Conditions** (*Duration to Completion, Type of Contract, Nature & Magnitude of Work, Activity Difficulty, Laws & Regulations, Changes in Client's Needs),* how are the Costs of following Construction Phase affected?

	Very High Impact	**On the Costs of FOUNDATION PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of STRUCTURAL SYSTEM WORKS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ELEVATIONS & SEPARATIONS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ROOFING PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of INSULATION PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of WINDOWS & DOORS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs Of FLOOR & WALL COVERINGS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of GENERAL FITTINGS & FINISHINGS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ROUGH MECHANICAL INSTALLATIONS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of MECHANICAL FITTINGS & FINISHINGS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ROUGH ELECTRICAL INSTALLATIONS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ELECTRICAL FITTINGS & FINISHINGS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ELEVATOR INSTALLATIONS**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

Question 6:

If a problem occurs as **External Factors & Unpredictable Risks** (*Economical Conditions, Labor Problems, Extreme Weather Conditions, Other Hidden Obstructions, Political Conditions*, how are the Costs of following Construction Phase affected?

	Very High Impact	**On the Costs of FOUNDATION PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of STRUCTURAL SYSTEM WORKS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ELEVATIONS & SEPARATIONS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ROOFING PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of INSULATION PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of WINDOWS & DOORS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs Of FLOOR & WALL COVERINGS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of GENERAL FITTINGS & FINISHINGS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ROUGH MECHANICAL INSTALLATIONS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of MECHANICAL FITTINGS & FINISHINGS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ROUGH ELECTRICAL INSTALLATIONS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ELECTRICAL FITTINGS & FINISHINGS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ELEVATOR INSTALLATIONS**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

Question 7:

If a problem occurs at **Management, Unproductivity & Waste** (*Inaccuracy in Management, Communication Between Involved parties, Waste, Ineffective use of labor & Materials (Productivity),* how are the Costs of following Construction Phase affected?

	Very High Impact	**On the Costs of FOUNDATION PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of STRUCTURAL SYSTEM WORKS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ELEVATIONS & SEPARATIONS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ROOFING PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of INSULATION PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of WINDOWS & DOORS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs Of FLOOR & WALL COVERINGS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of GENERAL FITTINGS & FINISHINGS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ROUGH MECHANICAL INSTALLATIONS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of MECHANICAL FITTINGS & FINISHINGS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ROUGH ELECTRICAL INSTALLATIONS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

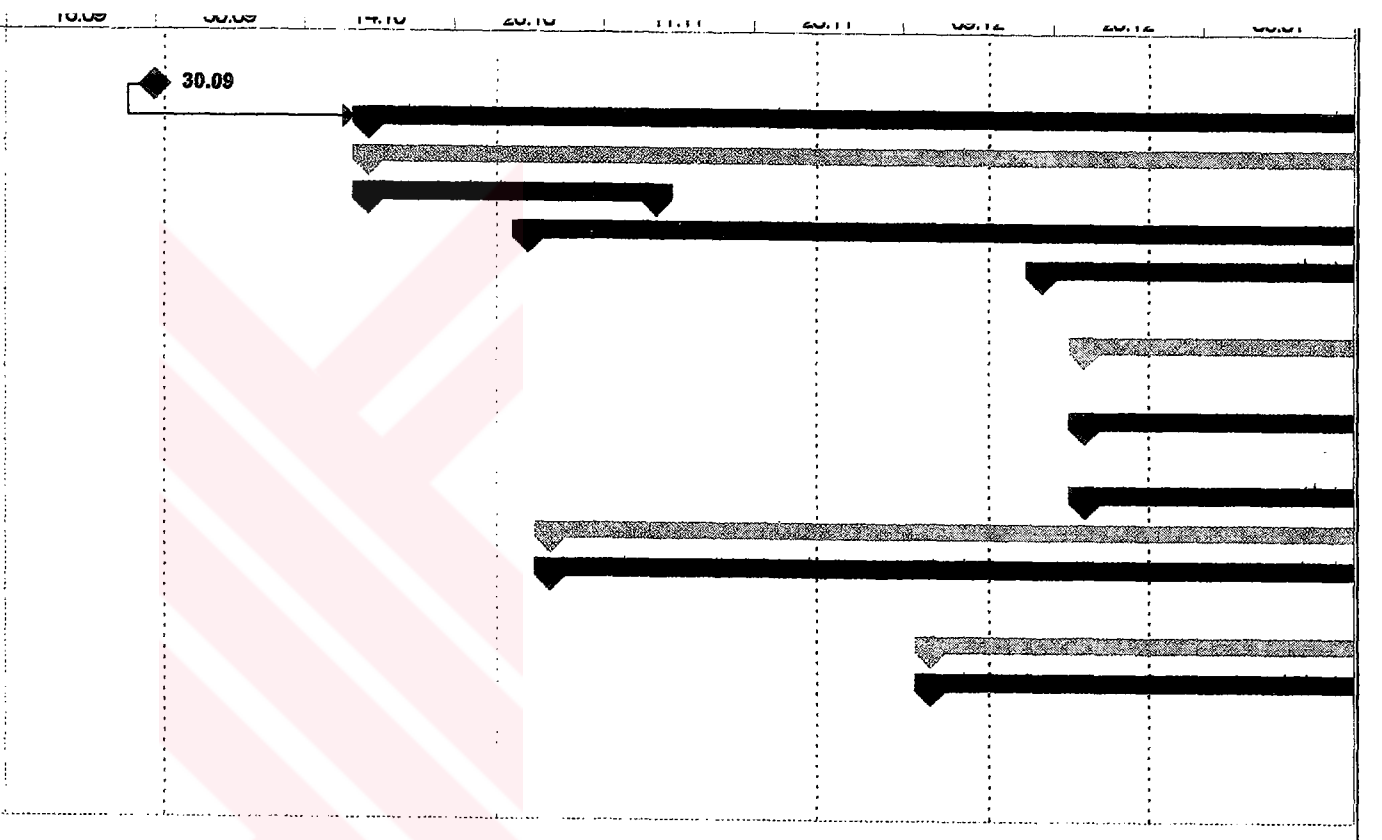
	Very High Impact	**On the Costs of ELECTRICAL FITTINGS & FINISHINGS PHASE**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

	Very High Impact	**On the Costs of ELEVATOR INSTALLATIONS**
	High Impact	
	Medium	
	Low Impact	
	No Impact	
	Negative Impact	

APPENDIX B

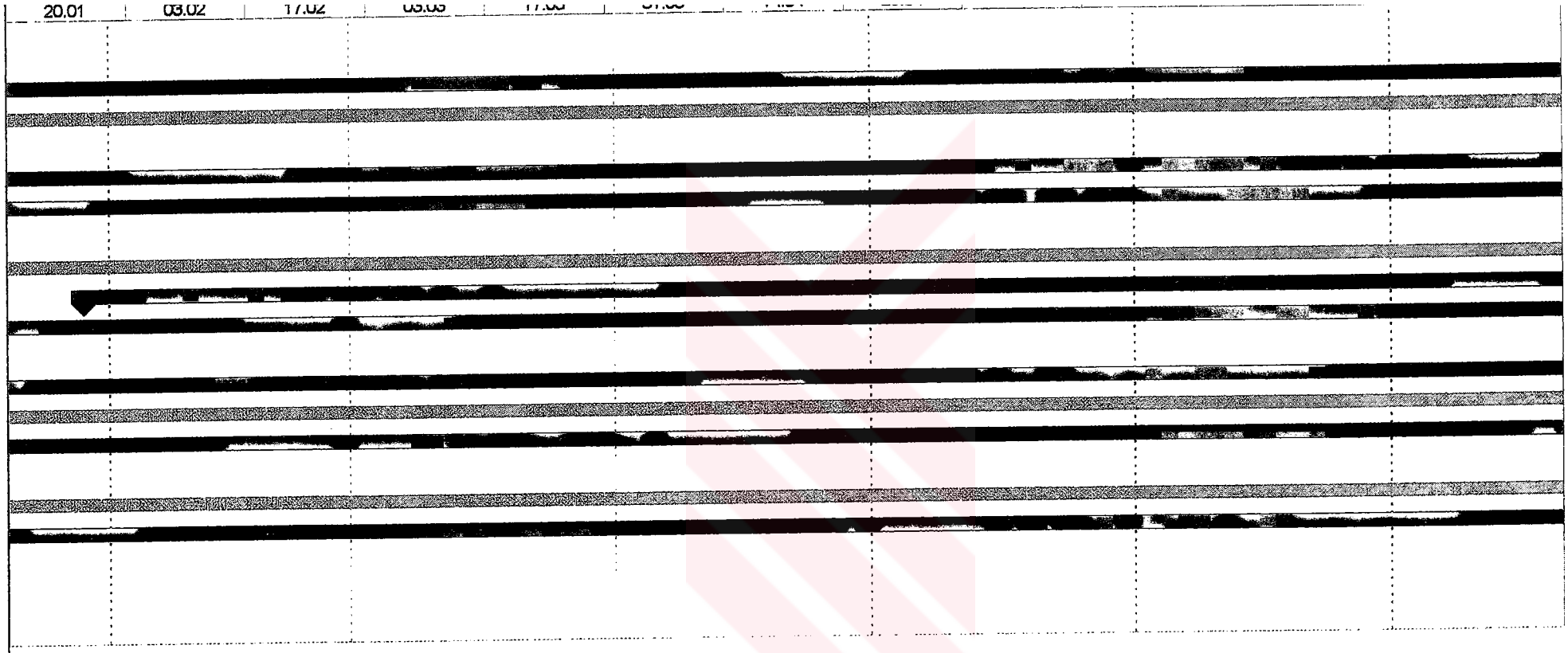
SAMPLE PROJECT DATA
WORK SCHEDULE, CASH FLOW AND COST SUMMARIES

ID	Görev Adı
1	**Site Kaynak Havuzu**
2	Program Başlangıcı
3	A Blok
4	**A Blok Kaba Yapı İşleri**
1	Temel İşleri
23	Strüktür İşleri
211	Elevasyon İşleri
281	Çatı İşleri
5	**A Blok İnce Yapı İşleri**
1	İzolasyon İşleri
36	Doğrama İşleri
73	Kaplama İşleri
194	Özel ve Müteferrik İşler
6	**A Blok Mekanik Tesisatı İşleri**
1	Kaba Mekanik İşleri
51	İnce Mekanik İşleri
7	**A Blok Elektrik Tesisatı İşleri**
1	Kaba Elektrik İşleri
55	İnce Elektrik İşleri
77	Asansör
8	Program Sonu



Project: Site Master
Date: Tue 17.12.02

Task		Rolled Up Task		External Tasks	
Critical Task		Rolled Up Critical Task		Project Summary	
Progress		Rolled Up Milestone		Group By Summary	
Milestone		Rolled Up Progress			
Summary		Split			



Project: Site Master
Date: Tue 17.12.02

Task		Rolled Up Task		External Tasks	
Critical Task		Rolled Up Critical Task		Project Summary	
Progress		Rolled Up Milestone		Group By Summary	
Milestone		Rolled Up Progress			
Summary		Split			

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Project: Site Master
Date: Tue 17.12.02

Task		Rolled Up Task		External Tasks	
Critical Task		Rolled Up Critical Task		Project Summary	
Progress		Rolled Up Milestone		Group By Summary	
Milestone		Rolled Up Progress			
Summary		Split			

HY İNŞAAT SİTESİ
MALİYETLER VE AYLIK NAKİT AKIŞI

Site Master	01.09.2002	01.10.2002	01.11.2002	01.12.2002	01.01.2003	01.02.2003	01.03.2003	01.04.2003
Program Başlangıcı	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL
A Blok								
Temel İşleri	0,00 TL	14.347.260.000,00 TL	18.654.012.000,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL
Strüktür İşleri	0,00 TL	0,00 TL	79.313.000.000,00 TL	11.780.000.000,00 TL	11.470.000.000,00 TL	192.000.000,00 TL	11.662.000.000,00 TL	11.470.000.000,00 TL
Elevasyon İşleri	0,00 TL	0,00 TL	0,00 TL	1.626.000.000,00 TL	2.340.000.000,00 TL	0,00 TL	827.000.000,00 TL	1.513.000.000,00 TL
Çatı İşleri	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL
İzolasyon İşleri	0,00 TL	0,00 TL	0,00 TL	0,00 TL	480.000.000,00 TL	0,00 TL	0,00 TL	480.000.000,00 TL
Doğrama İşleri	0,00 TL	0,00 TL	0,00 TL	706.713.000,00 TL	3.936.500.000,00 TL	0,00 TL	0,00 TL	3.936.500.000,00 TL
Kaplama İşleri	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL
Özel ve Müteferrik İşler	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL
Kaba Mekanik İşleri	0,00 TL	0,00 TL	1.018.000.000,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL
İnce Mekanik İşleri	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL
Kaba Elektrik İşleri	0,00 TL	0,00 TL	0,00 TL	120.000.000,00 TL	285.000.000,00 TL	0,00 TL	0,00 TL	285.000.000,00 TL
İnce Elektrik İşleri	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL
Asansör	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL
Program Sonu	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL
Monthly Total	0,00 TL	14.347.260.000,00 TL	98.985.012.000,00 TL	14.232.713.000,00 TL	18.511.500.000,00 TL	192.000.000,00 TL	12.489.000.000,00 TL	17.684.500.000,00 TL

HY İNŞAAT SİTESİ
MALİYETLER VE AYLIK NAKİT AKIŞI

01.05.2003	*01.06.2003*	*01.07.2003*	*01.08.2003*	*01.09.2003*	*01.10.2003*	*01.11.2003*	*01.12.2003*	
0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	
0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	33.001.272.000,00 TL
11.854.000.000,00 TL	12.646.000.000,00 TL	22.340.000.000,00 TL	11.657.000.000,00 TL	4.440.000.000,00 TL	0,00 TL	0,00 TL	0,00 TL	188.824.000.000,00 TL
2.340.000.000,00 TL	4.680.000.000,00 TL	2.340.000.000,00 TL	2.340.000.000,00 TL	3.925.000.000,00 TL	0,00 TL	0,00 TL	0,00 TL	21.831.000.000,00 TL
0,00 TL	0,00 TL	0,00 TL	0,00 TL	2.046.000.000,00 TL	3.651.000.000,00 TL	0,00 TL	0,00 TL	5.697.000.000,00 TL
480.000.000,00 TL	480.000.000,00 TL	960.000.000,00 TL	480.000.000,00 TL	3.270.000.000,00 TL	0,00 TL	0,00 TL	0,00 TL	6.630.000.000,00 TL
3.936.500.000,00 TL	3.936.500.000,00 TL	7.873.000.000,00 TL	3.936.500.000,00 TL	7.971.700.000,00 TL	12.105.600.000,00 TL	0,00 TL	0,00 TL	48.339.613.000,00 TL
0,00 TL	0,00 TL	0,00 TL	0,00 TL	108.664.000.000,00 TL	137.625.800.000,00 TL	62.618.813.643,00 TL	21.296.700.000,00 TL	330.205.313.643,00 TL
0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	9.108.000.000,00 TL	5.512.000.000,00 TL	48.411.365.000,00 TL	63.031.365.000,00 TL
0,00 TL	0,00 TL	0,00 TL	0,00 TL	15.698.000.000,00 TL	0,00 TL	0,00 TL	0,00 TL	16.718.000.000,00 TL
0,00 TL	0,00 TL	0,00 TL	0,00 TL	4.600.000.000,00 TL	44.240.000.000,00 TL	49.400.000.000,00 TL	0,00 TL	98.240.000.000,00 TL
285.000.000,00 TL	285.000.000,00 TL	570.000.000,00 TL	285.000.000,00 TL	285.000.000,00 TL	0,00 TL	0,00 TL	0,00 TL	2.400.000.000,00 TL
0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	9.200.000.000,00 TL	0,00 TL	0,00 TL	9.200.000.000,00 TL
0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	25.000.000.000,00 TL	0,00 TL	25.000.000.000,00 TL
0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL	0,00 TL
18.895.500.000,00 TL	22.027.500.000,00 TL	34.083.000.000,00 TL	18.698.500.000,00 TL	150.899.700.000,00 TL	215.930.400.000,00 TL	142.530.813.643,00 TL	69.708.035.000,00 TL	849.215.463.643,00 TL

Site Master

ID		Kaynak Adı	Tip	Malzeme Birimi	Kısaltmalar	Grup	Max.Birim
1		Kazı taşeronu	Work		HAF	Hafriyatçı	100%
2		Ekskavatör	Material	tp	EKS	Hafriyat	
3		Kalıp ekibi	Work		KLP	Kalıpçılar	1.000%
4		Demir ekibi	Work		DEM	Demirciler	800%
5		Beton ekibi	Work		BET	Betoncular	600%
6		Ekip düz işçisi	Work		EDZ	İşçiler	400%
7		Duvar ekibi	Work		DUV	Duvarcılar	600%
8		*kalıp,demir beton götürü Temel	Material	kt	KDB	Kabacı	
9		*kalıp,demir beton götürü normaller	Material	kt	KDB	Kabacı	
10		*kalıp,demir beton götürü çatı	Material	kt	KDB	Kabacı	
11		*duvar götürü zemin	Material	kt	DUG	duvarcı	
12		*duvar götürü normaller	Material	kt	DUG	duvarcı	
13		*duvar götürü makine dairesi	Material	kt	DUG	duvarcı	
14		İzolasyon taşeronu	Work		İZO	İzolasyoncu	400%
15		*izolasyon normaller	Material	kt	İZG	İzolasyon	
16		*izolasyon çatı	Material	kt	İZG	İzolasyon	
17		Ahşap doğrama taşeronu	Work		DGR	ahş.doğramacı	800%
18		*doğrama zemin	Material	kt	ADG	ahş.doğrama	
19		*doğrama normaller	Material	kt	ADG	ahş.doğrama	
20		PVC doğrama taşeronu	Work		PVC	pvc doğramacı	800%
21		*pvc zemin	Material	kt	PDG	pvc doğrama	
22		*pvc normaller	Material	kt	PDG	pvc doğrama	
23		Sıva ekibi	Work		SIV	Sıvacı	6.300%
24		*Dış sıva	Material	tp	SIG	Sıva	
25		*İç sıva zemin	Material	kt	SIG	Sıva	
26		*İç sıva normaller	Material	kt	SIG	Sıva	
27		*İç sıva makine dairesi	Material	kt	SIG	Sıva	
28		Seramik ekibi	Work		KAR	Karocu	1.600%
29		*seramik zemin	Material	kt	SEG	Karo	
30		*seramik normaller	Material	kt	SEG	Karo	
31		Parke ekibi	Work		PAR	Parkeci	1.600%
32		*parke normaller	Material	kt	PAG	Parke	
33		Boya ekibi	Work		BOY	Boyacı	1.800%
34		*boya dış cephe	Material		BOG	Boya	
35		*alçı+plastik zemin	Material	kt	BOG	Boya	
36		*alçı+plastik normaller	Material	kt	BOG	Boya	
37		*alçı+plastik makine dairesi	Material	kt	BOG	Boya	
38		*demir yağlı boya zemin	Material	kt	BOG	Boya	
39		*demir yağlı boya normaller	Material	kt	BOG	Boya	
40		*demir yağlı boya makine d.	Material	kt	BOG	Boya	
41		Mermer ekibi	Work		MEK	Mermerci	1.200%
42		*mermer zemin	Material	kt	MEG	Mermer	
43		*mermer normaller	Material	kt	MEG	Mermer	
44		*mermer makine dairesi	Material	kt	MEG	Mermer	
45		Mutfak taşeronu	Work		MUT	Mutfakçı	800%
46		*mutfak normaller	Material	kt	MUG	Mutfak	
47		Cam taşeronu	Work		CAM	Camcı	600%
48		*cam zemin	Material	kt	CAG	cam	
49		*cam normaller	Material	kt	CAG	cam	
50		*cam makine d.	Material	kt	CAG	cam	
51		Asansör taşeronu	Work		ASA	Asansörcü	400%
52		*asansör 9 duraklı	Material	as	ASG	Asansör	
53		Asma tavan taşeronu	Work		ASM	Asma Tavancı	400%
54		*asma tavan normaller	Material	kt	ASG	Asma Tavan	
55		Korkuluk taşeronu	Work		KOR	Korkulukçu	1.000%
56		*zemin merdiven	Material	tp	KOG	Korkuluk	
57		*korkuluk normaller	Material	kt	KOG	Korkuluk	
58		*makine d.merdiven	Material	kt	KOG	Korkuluk	
59		Tesisat ekibi	Work		TES	Tesisatçı	1.600%
60		*kaba tesisat zemin	Material	kt	TEG	Kaba tesisat	
61		*kaba tesisat normaller	Material	kt	TEG	Kaba tesisat	
62		*ince tesisat zemin	Material	kt	TEG	İnce tesisat	
63		*İnce tesisat normaller	Material	kt	TEG	İnce tesisat	
64		Elektrik ekibi	Work		ELK	Elektrikçi	1.600%
65		*kaba elektrik zemin	Material	kt	ELG	Kaba elektrik	
66		*kaba elektrik normaller	Material	kt	ELG	Kaba elektrik	
67		*ince elektrik zemin	Material	kt	ELG	İnce elektrik	
68		*ince elektrik normaller	Material	kt	ELG	İnce elektrik	
69		Kalorifer ekibi	Work		KAL	Kaloriferci	800%
70		*kaba kalorifer zemin	Material	kt	KAG	Kaba kalorifer	
71		*kaba kalorifer normaller	Material	kt	KAG	Kaba kalorifer	
72		*ince kalorifer zemin	Material	kt	KAG	İnce kalorifer	
73		*ince kalorifer normaller	Material	kt	KAG	İnce kalorifer	

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ID		Kaynak Adı	Tip	Malzeme Birimi	Kısaltmalar	Grup	Max.Birim
74		Çavuş	Work		ÇVŞ	Kaba Yapı	100%
75		*grobeton mlz	Material	tp	GRB	Beton	
76		*demir mlz.temel	Material	kt	NDE	demir	
77		*demir mlz.zemin	Material	kt	NDE	demir	
78		*demir mlz.normaller	Material	kt	NDE	demir	
79		*demir mlz.makine d. parapet	Material	kt	NDE	demir	
80		*temizlik betonu mlz	Material	tp	HBT	Beton	
81		*hazır beton mlz.temel	Material	kt	HBT	Beton	
82		*hazır beton mlz.döş+kir	Material	kt	HBT	Beton	
83		*hazır beton mlz.makine d.	Material	kt	HBT	Beton	
84		*tuğla mlz.zemin	Material	kt	TGL	Tuğla	
85		*tuğla mlz.normaller	Material	kt	TGL	Tuğla	
86		*tuğla mlz.makine d.	Material	kt	TGL	Tuğla	
87		*ocak taşı mlz	Material	tp	TAŞ	Taş	
88		*eleküstü agrega mlz	Material	tp	KUM	Agrega	
89		*kazı toprağı	Material	tp	KTP	toprak	
90		*rüberoit	Material	tp	RÜB	Rüberoit	
91		*kiremit mlz	Material	tp	KRM	Kiremit	
92		*çinko ve ekleri	Material	tp	ÇİN	Çinko	
93		*röğar	Material	tp	RÖG	Röğar	
94		*beton büz	Material	tp	BÜZ	Büzler	
95		*çatı süzgeci mlz	Material	tp	SÜZ	süzgeç	
96		*yağmur oluğu mlz	Material	tp	OLU	oluk	
97		*yağmur borusu mlz	Material	tp	YBO	y.boru	
98		*cephe iş iskelesi	Material	tp	İSK	İş iskelesi	
99		*kalıp mlz.temel	Material	tp	TKL	kalıp malzeme	
100		*kalıp mlz.kolon zemin	Material	tp	SKL	kalıp malzeme	
101		*kalıp mzl.kolon normaller	Material	tp	SKL	kalıp malzeme	
102		*kalıp mlz.kolon makine d.	Material	tp	SKL	kalıp malzeme	
103		*kal+isk.kir/döş.mlz.zemin	Material	tp	İKL	kalıp malzeme	
104		*kal+isk.kir/döş.mlz.normaller	Material	tp	İKL	kalıp malzeme	
105		*kal+isk.kir/döş.mlz.makine d.	Material	tp	İKL	kalıp malzeme	
106		*b kalıp,demir beton götürü normaller	Material	tp	KDB	Kabacı	
107		*b kalıp,demir beton götürü çatı	Material	tp	KDB	Kabacı	
108		*b duvar götürü zemin	Material	tp	DUG	duvarcı	
109		*b duvar götürü normaller	Material	tp	DUG	duvarcı	
110		*b duvar götürü makine dairesi	Material	tp	DUG	duvarcı	
111		*b izolasyon normaller	Material	tp	İZG	İzolasyon	
112		*b izolasyon çatı	Material	tp	İZG	İzolasyon	
113		*b doğrama zemin	Material	tp	ADG	ahş.doğrama	
114		*b doğrama normaller	Material	tp	ADG	ahş.doğrama	
115		*b pvc zemin	Material	tp	PDG	pvc doğrama	
116		*b pvc normaller	Material	tp	PDG	pvc doğrama	
117		*b Dış sıva	Material	tp	SIG	Sıva	
118		*b İç sıva zemin	Material	tp	SIG	Sıva	
119		*b İç sıva normaller	Material	tp	SIG	Sıva	
120		*b İç sıva makine dairesi	Material	tp	SIG	Sıva	
121		*b seramik zemin	Material	tp	SEG	Karo	
122		*b seramik normaller	Material	tp	SEG	Karo	
123		*b parke normaller	Material		PAG	Parke	
124		*b boya dış cephe	Material	tp	BOG	Boya	
125		*b alçı+plastik zemin	Material	tp	BOG	Boya	
126		*b alçı+plastik normaller	Material	tp	BOG	Boya	
127		*b alçı+plastik makine dairesi	Material	tp	BOG	Boya	
128		*b demir yağlı boya zemin	Material	tp	BOG	Boya	
129		*b demir yağlı boya normaller	Material	tp	BOG	Boya	
130		*b demir yağlı boya makine d.	Material	tp	BOG	Boya	
131		*b mermer zemin	Material	tp	MEG	Mermer	
132		*b mermer normaller	Material	tp	MEG	Mermer	
133		*b mermer makine dairesi	Material	tp	MEG	Mermer	
134		*b mutfak normaller	Material	tp	MUG	Mutfak	
135		*b cam zemin	Material	tp	CAG	cam	
136		*b cam normaller	Material	tp	CAG	cam	
137		*b cam makine d.	Material	tp	CAG	cam	
138		*b asma tavan normaller	Material	tp	ASG	Asma Tavan	
139		*b zemin merdiven	Material	tp	KOG	Korkuluk	
140		*b korkuluk normaller	Material	tp	KOG	Korkuluk	
141		*b makine d.merdiven	Material	tp	KOG	Korkuluk	
142		*b kaba tesisat zemin	Material	tp	TEG	Kaba tesisat	
143		*b kaba tesisat normaller	Material	tp	TEG	Kaba tesisat	
144		*b ince tesisat zemin	Material	tp	TEG	İnce tesisat	
145		*b ince tesisat normaller	Material	tp	TEG	İnce tesisat	
146		*b kaba elektrik zemin	Material	tp	ELG	Kaba elektrik	

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ID		Kaynak Adı	Tip	Malzeme Birimi	Kısaltmalar	Grup	Max.Birim
147		*b kaba elektrik normaller	Material	tp	ELG	Kaba elektrik	
148		*b ince elektrik zemin	Material	tp	ELG	İnce elektrik	
149		*b ince elektrik normaller	Material	tp	ELG	İnce elektrik	
150		*b kaba kalorifer zemin	Material	tp	KAG	Kaba kalorifer	
151		*b kaba kalorifer normaller	Material	tp	KAG	Kaba kalorifer	
152		*b ince kalorifer zemin	Material	tp	KAG	İnce kalorifer	
153		*b ince kalorifer normaller	Material	tp	KAG	İnce kalorifer	
154		*b demir mlz.normaller	Material	tp	NDE	demir	
155		*b demir mlz.makine d. parapet	Material	tp	NDE	demir	
156		*b hazır beton mlz.döş+kir	Material	tp	HBT	Beton	
157		*b hazır beton mlz.makine d.	Material	tp	HBT	Beton	
158		*b tuğla mlz.zemin	Material	tp	TGL	Tuğla	
159		*b tuğla mlz.normaller	Material	tp	TGL	Tuğla	
160		*b tuğla mlz.makine d.	Material	tp	TGL	Tuğla	
161		*b rüberoit	Material	tp	RÜB	Rüberoit	
162		*b kiremit mlz	Material	tp	KRM	Kiremit	
163		*b çinko ve ekleri	Material	tp	ÇİN	Çinko	
164		*b rögar	Material	tp	RÖG	Rögar	
165		*b beton büz	Material	tp	BÜZ	Büzler	
166		*b çatı süzgeci mlz	Material	tp	SÜZ	süzgeç	
167		*b yağmur oluğu mlz	Material	tp	OLU	oluk	
168		*b yağmur borusu mlz	Material	tp	YBO	y.boru	
169		*b cephe iş iskelesi	Material	tp	İSK	İş iskelesi	
170		*b kalıp mzl.kolon normaller	Material	tp	SKL	kalıp malzeme	
171		*b kalıp mlz.kolon makine d.	Material	tp	SKL	kalıp malzeme	
172		*b kal+isk.kir/döş.mlz.normaller	Material	tp	İKL	kalıp malzeme	
173		*b kal+isk.kir/döş.mlz.makine d.	Material	tp	İKL	kalıp malzeme	
174		*s.Ekskavatör	Material	tp	EKS	Hafriyat	
175		*s.eleküstü agrega mlz	Material	tp	KUM	Agrega	
176		*s.temizlik betonu mlz	Material	tp	HBT	Beton	
177		*s.kalıp mlz.temel	Material	tp	TKL	kalıp malzeme	
178		*s.demir mlz.temel	Material	tp	NDE	demir	
179		*s.hazır beton mlz.temel	Material	tp	HBT	Beton	
180		*s.ocak taşı mlz	Material	tp	TAŞ	Taş	
181		*s.kazı toprağı	Material	tp	KTP	toprak	
182		*s.grobeton mlz	Material	tp	GRB	Beton	
183		*s.kalıp,demir beton götürü Temel	Material	tp	KDB	Kabacı	
184		*s.kalıp mlz.kolon+perde	Material	tp	SKL	kalıp malzeme	
185		*s.kal+isk.kir/döş.mlz.sığınak tavan	Material	tp	İKL	kalıp malzeme	
186		*s.demir mlz.sığınak	Material	tp	NDE	demir	
187		*s.hazır beton mlz.döş+kir+perde	Material	tp	HBT	Beton	
188		*s.kalıp,demir beton götürü sığınak	Material	tp	KDB	Kabacı	
189		*s.duvar götürü sığınak	Material	tp	DUG	duvarcı	
190		*s.tuğla mlz.sığınak	Material	tp	TGL	Tuğla	
191		*s.izolasyon temelaltı sığınak	Material	tp	İZG	İzolasyon	
192		*s.izolasyon duvar+döşeme sığınak	Material	tp	İZG	İzolasyon	
193		*s.izolasyon dilatasyonlar	Material	tp	İZG	İzolasyon	
194		*s.Dış sıva sığınak	Material	tp	SIG	Sıva	
195		*s.İç sıva sığınak	Material	tp	SIG	Sıva	
196		*s.seramik sığınak	Material	tp	SEG	Karo	
197		*s.plastik badana sığınak	Material	tp	BOG	Boya	
198		*s.demir imalat	Material	tp	KOG	Korkuluk	
199		*s.demir imalat yağlı boyası	Material	tp	BOG	Boya	
200		*f.beton büz	Material	tp	BÜZ	Büzler	
201		*f.Ekskavatör	Material	tp	EKS	Hafriyat	
202		Taş işleri taşeronu	Work		TŞT	Taşçı	1.200%
203		*f.blokaj otopark	Material	tp	TŞG	Çevre	
204		*f.grobeton otopark	Material	tp	TŞG	Çevre	
205		*f.taş duvar bahçe	Material	tp	TŞG	Çevre	
206		*f.korkuluk bahçe	Material	tp	KOG	Korkuluk	
207		*f.korkuluk yağlı boyası	Material	tp	BOG	Boya	
208		*f.plak yaya yolu bahçe	Material	tp	TŞG	Çevre	
209		*m.kaba tesisat müşterek	Material	tp	TEG	Kaba tesisat	
210		*m.ince tesisat müşterek	Material	tp	TEG	İnce tesisat	
211		*m.kaba kalorifer müşterek	Material	tp	KAG	Kaba kalorifer	
212		*m.ince kalorifer müşterek	Material	tp	KAG	İnce kalorifer	
213		*m.kaba elektrik müşterek	Material	tp	ELG	Kaba elektrik	
214		*m.ince elektrik müşterek	Material	tp	ELG	İnce elektrik	

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Std.Ücret	Zamlı Ücret	Maly/Kullanım	Maly.Yüklem	Temel Takvim	Kod
OTL/h	OTL/h	OTL	End	Site Şantiye	000.06.00.11
604.800.000TL		OTL	End		000.06.00.11
OTL/h	OTL/h	OTL	Prorated	Site Şantiye	000.02.04.11
OTL/h	OTL/h	OTL	Prorated	Site Şantiye	000.02.04.11
OTL/h	OTL/h	OTL	Prorated	Site Şantiye	000.02.04.11
OTL/h	OTL/h	OTL	Prorated	Site Şantiye	000.02.04.11
OTL/h	OTL/h	OTL	Prorated	Site Şantiye	000.02.04.11
2.610.000.000TL		OTL	End		000.02.04.11
3.816.000.000TL		OTL	End		000.02.04.11
2.940.000.000TL		OTL	End		000.02.04.11
870.000.000TL		OTL	End		000.02.04.11
1.513.000.000TL		OTL	End		000.02.04.11
980.000.000TL		OTL	End		000.02.04.11
OTL/h	OTL/h	OTL	End	Site Şantiye	000.06.00.12
480.000.000TL		OTL	End		000.06.00.12
2.790.000.000TL		OTL	End		000.06.00.12
OTL/h	OTL/h	OTL	End	Site Şantiye	000.06.00.13
198.300.000TL		OTL	End		000.06.00.13
2.017.600.000TL		OTL	End		000.06.00.13
OTL/h	OTL/h	OTL	End	Site Şantiye	000.06.00.19
508.413.000TL		OTL	End		000.06.00.19
3.936.500.000TL		OTL	End		000.06.00.19
OTL/h	OTL/h	OTL	Prorated	Site Şantiye	000.02.05.11
12.101.500.000TL		OTL	End		000.02.05.11
11.184.000.000TL		OTL	End		000.02.05.11
17.501.000.000TL		OTL	End		000.02.05.11
2.189.000.000TL		OTL	End		000.02.05.11
OTL/h	OTL/h	OTL	Prorated	Site Şantiye	000.02.05.12
2.816.000.000TL		OTL	End		000.02.05.12
4.656.000.000TL		OTL	End		000.02.05.12
OTL/h	OTL/h	OTL	Prorated	Site Şantiye	000.02.05.13
3.564.000.000TL		OTL	End		000.02.05.13
OTL/h	OTL/h	OTL	Prorated	Site Şantiye	000.02.05.14
10.299.000.000TL		OTL	End		000.02.05.14
3.801.900.000TL		OTL	End		000.02.05.14
7.195.800.000TL		OTL	End		000.02.05.14
205.200.000TL		OTL	End		000.02.05.14
69.300.000TL		OTL	End		000.02.05.14
161.210.000TL		OTL	End		000.02.05.14
55.685.000TL		OTL	End		000.02.05.14
OTL/h	OTL/h	OTL	Prorated	Site Şantiye	000.02.05.15
4.625.000.000TL		OTL	End		000.02.05.15
1.776.000.000TL		OTL	End		000.02.05.15
1.924.000.000TL		OTL	End		000.02.05.15
OTL/h	OTL/h	OTL	End	Site Şantiye	000.06.00.14
4.592.000.000TL		OTL	End		000.06.00.14
OTL/h	OTL/h	OTL	End	Site Şantiye	000.06.00.15
390.000.000TL		OTL	End		000.06.00.15
1.230.500.000TL		OTL	End		000.06.00.15
26.700.000TL		OTL	End		000.06.00.15
OTL/h	OTL/h	OTL	End	Site Şantiye	000.06.00.16
25.000.000.000TL		OTL	End		000.06.00.16
OTL/h	OTL/h	OTL	End	Site Şantiye	000.06.00.17
310.500.000TL		OTL	End		000.06.00.17
OTL/h	OTL/h	OTL	End	Site Şantiye	000.06.00.18
118.000.000TL		OTL	End		000.06.00.18
1.798.000.000TL		OTL	End		000.06.00.18
118.000.000TL		OTL	End		000.06.00.18
OTL/h	OTL/h	OTL	Prorated	Site Şantiye	000.02.07.11
200.000.000TL		OTL	End		000.02.07.11
825.000.000TL		OTL	End		000.02.07.11
400.000.000TL		OTL	End		000.02.07.11
9.800.000.000TL		OTL	End		000.02.07.11
OTL/h	OTL/h	OTL	Prorated	Site Şantiye	000.02.08.11
120.000.000TL		OTL	End		000.02.08.11
285.000.000TL		OTL	End		000.02.08.11
200.000.000TL		OTL	End		000.02.08.11
1.125.000.000TL		OTL	End		000.02.08.11
OTL/h	OTL/h	OTL	Prorated	Site Şantiye	000.02.07.12
160.000.000TL		OTL	End		000.02.07.12
940.000.000TL		OTL	End		000.02.07.12
1.040.000.000TL		OTL	End		000.02.07.12
2.300.000.000TL		OTL	End		000.02.07.12

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Std.Ücret	Zamlı Ücret	Maly/Kullanım	Maly.Yüklem	Temel Takvim	Kod
OTL/h	OTL/h	OTL	Prorated	Site Şantiye	000.01.04.13
1.379.484.000TL		OTL	End		000.20.92.04
10.955.000.000TL		OTL	Start		000.20.75.11
8.681.000.000TL		OTL	Start		000.20.75.11
8.681.000.000TL		OTL	Start		000.20.75.11
1.102.000.000TL		OTL	Start		000.20.75.11
2.190.490.000TL		OTL	End		000.20.92.58
14.219.000.000TL		OTL	End		000.20.92.58
6.670.000.000TL		OTL	End		000.20.92.58
1.403.000.000TL		OTL	End		000.20.92.58
756.000.000TL		OTL	Start		000.26.18.11
827.000.000TL		OTL	Start		000.26.18.11
605.000.000TL		OTL	Start		000.26.18.11
235.000.000TL		OTL	Start		000.20.94.11
371.970.000TL		OTL	Start		000.20.24.06
210.528.000TL		OTL	End		000.20.24.01
473.000.000TL		OTL	Start		000.37.19.46
1.573.000.000TL		OTL	Start		000.48.32.11
3.651.000.000TL		OTL	Start		000.20.99.26
250.000.000TL		OTL	End		000.52.03.91
768.000.000TL		OTL	Start		000.50.70.17
118.000.000TL		OTL	Start		000.48.03.71
605.000.000TL		OTL	Start		000.48.03.64
495.000.000TL		OTL	Start		000.48.03.61
1.033.313.643TL		OTL	Start		000.16.12.11
225.000.000TL		OTL	Start		000.16.20.11
192.000.000TL		OTL	Start		000.16.20.11
192.000.000TL		OTL	Start		000.16.20.11
187.000.000TL		OTL	Start		000.16.20.11
992.000.000TL		OTL	Start		000.16.13.11
984.000.000TL		OTL	Start		000.16.13.11
97.000.000TL		OTL	Start		000.16.13.11
1.707.300.000TL		OTL	End		000.02.04.11
1.365.000.000TL		OTL	End		000.02.04.11
569.100.000TL		OTL	End		000.02.04.11
683.000.000TL		OTL	End		000.02.04.11
455.000.000TL		OTL	End		000.02.04.11
240.000.000TL		OTL	End		000.06.00.12
1.480.000.000TL		OTL	End		000.06.00.12
99.150.000TL		OTL	End		000.06.00.13
1.008.800.000TL		OTL	End		000.06.00.13
140.000.000TL		OTL	End		000.06.00.19
1.408.300.000TL		OTL	End		000.06.00.19
6.848.000.000TL		OTL	End		000.02.05.11
4.865.000.000TL		OTL	End		000.02.05.11
7.613.000.000TL		OTL	End		000.02.05.11
1.164.000.000TL		OTL	End		000.02.05.11
1.428.888.888TL		OTL	End		000.02.05.12
2.361.000.000TL		OTL	End		000.02.05.12
1.628.000.000TL		OTL	End		000.02.05.13
6.097.000.000TL		OTL	End		000.02.05.14
2.901.000.000TL		OTL	End		000.02.05.14
3.247.000.000TL		OTL	End		000.02.05.14
300.300.000TL		OTL	End		000.02.05.14
117.800.000TL		OTL	End		000.02.05.14
77.100.000TL		OTL	End		000.02.05.14
27.800.000TL		OTL	End		000.02.05.14
1.998.000.000TL		OTL	End		000.02.05.15
1.369.000.000TL		OTL	End		000.02.05.15
1.521.000.000TL		OTL	End		000.02.05.15
1.845.000.000TL		OTL	End		000.06.00.14
587.000.000TL		OTL	End		000.06.00.15
639.400.000TL		OTL	End		000.06.00.15
26.700.000TL		OTL	End		000.06.00.15
218.900.000TL		OTL	End		000.06.00.17
118.000.000TL		OTL	End		000.06.00.18
958.888.888TL		OTL	End		000.06.00.18
118.000.000TL		OTL	End		000.06.00.18
150.000.000TL		OTL	End		000.02.07.11
412.500.000TL		OTL	End		000.02.07.11
300.000.000TL		OTL	End		000.02.07.11
4.900.000.000TL		OTL	End		000.02.07.11
90.000.000TL		OTL	End		000.02.08.11

Std.Ücret	Zamlı Ücret	Maly/Kullanım	Maly.Yüklem	Temel Takvim	Kod
142.500.000TL		0TL	End		000.02.08.11
150.000.000TL		0TL	End		000.02.08.11
562.500.000TL		0TL	End		000.02.08.11
120.000.000TL		0TL	End		000.02.07.12
470.000.000TL		0TL	End		000.02.07.12
520.000.000TL		0TL	End		000.02.07.12
1.150.000.000TL		0TL	End		000.02.07.12
6.450.000.000TL		0TL	Start		000.20.75.11
1.102.000.000TL		0TL	Start		000.20.75.11
4.075.250.000TL		0TL	End		000.20.92.58
1.014.000.000TL		0TL	End		000.20.92.58
757.000.000TL		0TL	Start		000.26.18.11
428.000.000TL		0TL	Start		000.26.18.11
228.000.000TL		0TL	Start		000.26.18.11
242.250.000TL		0TL	Start		000.37.19.46
746.320.000TL		0TL	Start		000.48.32.11
2.693.000.000TL		0TL	Start		000.20.99.26
150.000.000TL		0TL	End		000.52.03.91
768.000.000TL		0TL	Start		000.50.70.17
118.000.000TL		0TL	Start		000.48.03.71
605.000.000TL		0TL	Start		000.48.03.64
495.000.000TL		0TL	Start		000.48.03.61
832.000.000TL		0TL	Start		000.16.12.11
78.258.000TL		0TL	Start		000.16.20.11
103.000.000TL		0TL	Start		000.16.20.11
531.250.000TL		0TL	Start		000.16.13.11
45.000.000TL		0TL	Start		000.16.13.11
2.232.000.000TL		0TL	End		000.06.00.11
390.000.000TL		0TL	Start		000.20.24.06
2.298.000.000TL		0TL	End		000.20.92.58
207.000.000TL		0TL	Start		000.16.20.11
1.923.000.000TL		0TL	Start		000.20.75.11
3.167.000.000TL		0TL	End		000.20.92.58
392.000.000TL		0TL	Start		000.20.94.11
644.000.000TL		0TL	End		000.20.24.01
2.281.500.000TL		0TL	End		000.20.92.04
961.000.000TL		0TL	End		000.02.04.11
727.200.000TL		0TL	Start		000.16.20.11
945.000.000TL		0TL	Start		000.16.13.11
9.400.000.000TL		0TL	Start		000.20.75.11
14.452.000.000TL		0TL	End		000.20.92.58
1.450.000.000TL		0TL	End		000.02.04.11
76.000.000TL		0TL	End		000.02.04.11
66.000.000TL		0TL	Start		000.26.18.11
7.698.000.000TL		0TL	End		000.06.00.12
15.040.000.000TL		0TL	End		000.06.00.12
378.000.000TL		0TL	End		000.06.00.12
1.093.000.000TL		0TL	End		000.02.05.11
6.348.500.000TL		0TL	End		000.02.05.11
11.111.000.000TL		0TL	End		000.02.05.12
1.175.600.000TL		0TL	End		000.02.05.14
1.754.000.000TL		0TL	End		000.06.00.18
505.750.000TL		0TL	End		000.02.05.14
656.000.000TL		0TL	Start		000.50.70.17
405.600.000TL		0TL	End		000.06.00.11
0TL/h	0TL/h	0TL	End	Site Şantiye	000.06.00.20
3.451.000.000TL		0TL	End		000.06.00.20
9.663.300.000TL		0TL	End		000.06.00.20
10.400.000.000TL		0TL	End		000.06.00.20
7.948.888.888TL		0TL	End		000.06.00.18
1.392.300.000TL		0TL	End		000.02.05.14
8.669.000.000TL		0TL	End		000.06.00.20
64.000.000TL		0TL	End		000.02.07.11
161.000.000TL		0TL	End		000.02.07.11
4.000.000.000TL		0TL	End		000.02.07.12
29.275.000.000TL		0TL	End		000.02.07.12
2.246.000.000TL		0TL	End		000.02.08.11
32.000.000.000TL		0TL	End		000.02.08.11

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