Delay in the Construction of Public Utility Projects in Saudi Arabia

by

Mohammed Ahmed Al-Ghafly

A Thesis Presented to the

FACULTY OF THE COLLEGE OF GRADUATE STUDIES

KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

DHAHRAN, SAUDI ARABIA

In Partial Fulfillment of the
Requirements for the Degree of

MASTER OF SCIENCE

In

CONSTRUCTION ENGINEERING & MANAGEMENT

June, 1995

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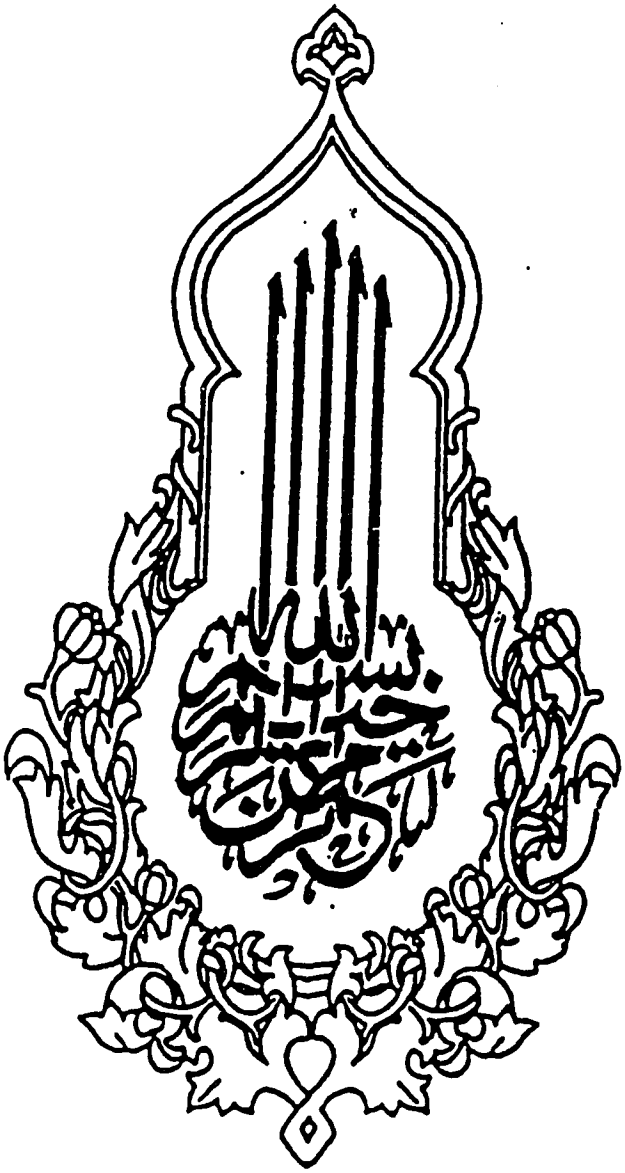

﴿ وان أريد الا الاصلاح ما استطعت

وما توفيقى الا با لله عليه توكلت واليه أنيب ﴾

KING FAHD UNIVERSITY OF PETROLEUM & MINERALS
DHAHRAN, SAUDI ARABIA
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This thesis, written by MOHAMMED AHMED ABDULLMOHSEN AL GHAFLY under the direction of his Thesis Advisor and approved by his Thesis Committee, has been presented to and accepted by the dean of the College of Graduate Studies, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in CONSTRUCTION ENGINEERING AND MANAGEMENT.

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COLLEGE OF GRADUATE STUDIES

DEDICATION

I dedicated this thesis to my family, my wife and my children who encouraged me and supported my graduate program.

ACKNOWLEDGMENT

Acknowledgment is due to King Fahd University of Petroleum and Minerals for support of this research. Specially to those contribute in preparing this study.

The author would like to express his special thanks and appreciation to Dr. Mohammed Al Khalil, thesis advisor, for his continuous guidance and support throughout preparing this thesis, without his effective contribution this study would not have been successfully completed. The author also extends his thanks to Dr. Abdulaziz Bubshait and Dr. Ali Shash for their effective participation in the thesis committee and their advises and constructive comments.

Also, thanks are given to all those who participated in the survey, specially to the branch managers and project engineers of Water & Sewage authorities in the Eastern and Riyadh provinces for their participation in the survey and their comments.

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THESIS ABSTRACT

STUDENT NAME : **MOHAMMED AHMED ABDULMOHSEN AL GHAFLY**

THESIS TITLE : **DELAY IN THE CONSTRUCTION OF PUBLIC UTILITY PROJECTS IN SAUDI ARABIA**

MAJOR : **CONSTRUCTION ENGINEERING AND MANAGEMENT**

DATE OF DEGREE : **JUNE 1995**

This research discusses the delay in public water and sewage construction projects in Saudi Arabia. It studies frequency, extent, and importance of causes of delay in such projects. Sixty causes were identified and classified by source into 6 groups.

A field survey was conducted through a structured questionnaire including 23 contractors, 12 consultant engineers, and 10 water & sewage authorities in the Eastern Province and Riyadh Province. Frequency and extent of delay were determined. SAS was used to analyze the data to present statistical measures and to calculate the importance index and ranking of the causes for each individual party and as an aggregate (standard) importance.

A hypothesis that the parties generally agree on the importance ranking of the causes of delay was tested. It was concluded that the contractor disagrees with the consultant and the owner in the importance ranking of the causes.

The research concluded that the delay occurred frequently in such projects, specially in medium and large size projects, and that the extent of delay is severe, specially in small projects. The study concluded that there are many important causes of delay related mainly to owner involvement, contractor performance, and the early planning and design of the project. Among these important causes are financial problems, changes in the design and scope of the projects, delay in making decisions and gaining approvals by the owner, difficulties in obtaining work permits, and coordination and communication problems.

MASTER OF SCIENCE DEGREE

KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

DHAHRAN, SAUDI ARABIA

JUNE 1995

خلاصة الرسالة

اسم الطالب : محمد احمد عبد المحسن الغافلي

عنوان الرسالة : التأخير في تشيد مشاريع المرافق العامة بالمملكة العربية السعودية

التخصص : برنامج هندسة وإدارة التشييد

تاريخ الشهادة : يونيو ١٩٩٥م

تناقش هذه الرسالة التأخير في تشيد مشاريع المياه والصرف الصحي باعتبارها احد المرافق العامة بالمملكة . تدرس الرساله تكرار ومدى و أسباب التأخير في مثل هذه المشاريع. لقد حدد ستون سببا للتأخير تم جمعها في ستة مجموعات تبعا لمصدرها.

تم القيام بمسح ميداني من خلال استبيان منظم شمل ٢٣ مقاول, ١٢مهندس استشاري, و١٠ إدارة لمصالح المياه والصرف الصحي بالمنطقة الشرقية ومنطقة الرياض . تم إيجاد التكرار ومدى التأخير و حساب مؤشر الأهمية وترتيبها لهذه الأسباب وذلك باستخدام برنامج (SAS) لتحليل المعلومات وتقديم المعاير الاحصائية وذالك لكل طرف على حده وكذلك كمعدل لجميع الأطراف.

كما تم اختبار فرضية أن الأطراف موافقين بشكل عام على ترتيب أهمية أسباب التأخير, وقد استنتج أن المقاول غير متفق مع الاستشاري و المالك على ترتيب الأهمية لأ سباب التأخير.

وقد خلص البحث إلي أن هناك تأخير متكرر في مثل هذه المشاريع وخاصة المشاريع الكبيرة و المتوسطة كما وجد أن مدى التأخير كبير وخاصة بالمشاريع الصغيرة. أما أسباب التأخير فقد استنتجت الدراسة أن هناك العديد من أسباب التأخير المهمة والتي تتعلق بشكل رئيسي بمشاركة وادارة المالك, أداء المقاول , والتخطيط المبكر ودراسات و تصا ميم المشروع . ومن بين أهم أسباب التأخير هي المشاكل المالية, التغيرات في تصاميم و نطاق المشروع, التأخير باتخاذ القرارات والموافقات من قبل المالك, الصعوبة في الحصول على تراخيص العمل, ومشاكل التنسيق والاتصال بين الأطراف المعنيين .

درجة الماجستير في العلوم

جامعة الملك فهد للبترول والمعادن

الظهران, المملكة العربية السعودية

يونيو ١٩٩٥م

CHAPTER 1

INTRODUCTION

1.1 GENERAL

One of the main objectives and policies of the Government of Saudi Arabia is to upgrade public projects performance, through reduction of costs, completion of the projects within their assigned budget and time constraints, and improvement of quality.

Completion time is extremely important in construction: "Time is of the Essence", and "Time is Money". Execution time is one of performance measures of a construction project, which are time, cost, and quality. Project success is measured by these measures, which show the performance of the construction parties involved, mainly the owner and contractor. All the parties look for project completion by a specified time, in the most economical manner, with the required quality.

Time performance of a project is usually a particularly important consideration for the owner and the contractor. Often, the most troublesome

construction disputes involve delay and failure to complete the works in a timely manner. Time of delivery of a project is a key factor to the owner in terms of cost, and it is important also to the contractor (O'Brien 1976). Completion of a public project is in the interest of all construction parties and public citizens; all look forward to utilize the project in the shortest possible time.

The construction process is subjected to the influence of highly variable and sometimes unpredictable factors which could result from different sources. These sources include the performance of construction parties, resource availability, environmental conditions, involvement of other parties, and contractual relations. As a consequence of these sources, public construction project may face many problems which could cause delay in the project completion time (Clough 1972).

Delay is a relative term, in construction. It means the time overrun either beyond the completion date specified in the contract, or beyond the date that the parties agreed upon for delivery of the project; in both cases, the delay is usually a costly situation (O'Brien 1976). In simple terms, a

delay represents an act or event which extends the time required to perform or to complete a part of the works or all works under the contract (Leon 1987).

The delay which will be addressed in this research is the time overrun beyond the construction completion date as specified in the project contract, regardless of whether the owner allows a time extension, or a delay penalty and liquidated damages are applied in compensation for delay.

This research is an attempt to study the delay problem in water and sewage construction projects, as these projects are among public utility projects. It will identify the frequency, extent, and causes of delay in this type of project to give the necessary precautions to control and avoid those causes for future improvement in the performance of public construction projects.

1. 2 - PROBLEM STATEMENT

Delay used to be a mutually accepted condition in the construction process (O'Brien 1976). Construction projects, especially underground utility projects, face high uncertainty. This makes problems that could

obstruct the progress and cause delay in this type of project. There are many causes which must be identified in order to control them in the early stages of the project.

Delay could be a result of low contractor performance during construction, inadequacies or defaults in early planning & design, poor owner administration and involvement in construction, problems in supervision, restrictions in government laws and regulations, or obstructions at the site. Any of these factors could cause problems in the progress of a public project leading to delay.

The writer has worked for more than fourteen years in the Water And Sewage Authority in the Eastern Province of Saudi Arabia. The experience gained through supervising a good number of water and sewage projects, discussions with many contractors and project engineers, and reviewing some cases of delayed projects, all revealed that many projects were delayed due to many of above causes.

A preliminary survey has been done to identify the frequency and extent of delay in the construction of public water and sewage projects in the

Eastern Province. The projects which were completed in the last ten years, and had a contract value not less than one million SR, were collected. The delayed projects were identified by contacting the concerned authorities in the Eastern Province. It was found that about 60% of the projects (45 out of 76) were delayed.

A sample of 20 delayed projects was selected randomly. These 20 projects were selected from different cities in the Eastern province, completed by different contractors, and had varying contract values. It was found that the average extent of delay in these projects was about 110% of the original project duration. This means that the delay exceeded the original duration. The list of these projects cannot be revealed. The results of this preliminary survey support the problem statement.

In the Ministry of Housing and Public Works, through supervision of different public projects in the Kingdom, it was found that the delayed projects accounted for 70% of the total number of the projects executed by local contractors (Zain Al Abidien 1983). Al Sultan (1989) surveyed actual time performance of different types of public projects. He concluded that

approximately 70% of the public projects (101 out of 145) experienced time overrun, contractors requested time extensions in about 63% of these projects, and time extension was guaranteed for 84% of these requests. These statistics indicate the overall extent of delay in public projects in general. This interpretation could provide support to the problem statement.

So, it seems that delay is experienced in many public utility construction projects. Public authorities who suffer from delays in these projects, need to recognize the causes of delay, their frequency, and severity, which emphasizes the need to study the delay problem in these projects. Studies will help the government authorities concerned recognize frequency, and extent of delay, and the important causes of this problem. Then, this will help these authorities to take necessary precautions to control those causes in the early planning and design of the project, and improve their involvement in the construction phase, to avoid the causes of delay that may occur during construction of public utility projects.

Among those public projects are water and sewage construction projects, which have different construction environments and a different

nature of work that allow more chance for delay. The delay in construction of water and sewage projects could address several questions concerning the frequency, extent and the causes of delay in this type of project. These questions are:

* What is the frequency of delays in public water and sewage construction projects?
* What is the extent of these delays in the delayed projects?
* What are the causes of delay in public water and sewage construction projects?
* How frequent and how severe are these causes ?
* Which party is responsible for delay ?

So, the problem of this research is attempting to answer the above mentioned questions in order to identify the frequency, extent and important causes of delay in public water and sewage construction projects.

1.3 OBJECTIVES OF THE STUDY

The main objectives of the study can be summarized in the following points :

1- Identify the frequency and the extent of delay in construction of public water and sewage projects.

2- Identify the importance of the causes of delay in construction of public water and sewage projects based on the frequency of occurrence and severity of the causes.

3- Test the hypotheses that :

A) The owner, the contractor, and the consultant engineer generally agree on the ranking of the importance of the causes of delay.

B) The contractor is the first party responsible for the delay, then the owner and the consultant.

1.4 SCOPE & LIMITATION

As public underground utility projects, public water and sewage construction projects have their own nature of work and construction environments. Therefore, to distinguish them from other project construction environments, this research will be limited to the following :

1- Public water and sewage construction projects which have a value more than one million SR. each, excluding operation & maintenance projects.

2- Projects built in the Eastern and Riyadh provinces of Saudi Arabia.

3- Delay which occurs during the construction phase only, starting from the date of site delivery to the contractor to construction completion date specified in the contract.

1.5 SIGNIFICANCE OF THE STUDY

Delay means time which directly equals cost. A delay is a real cost item. It usually produces a costly situation for any project and may cost more for public projects. The delay problem is considered as one of the critical problems in the construction process, since it may lead to claims and disputes between the owner and the contractor. In a delay situation, there is not usually a winner or a loser, but rather two (or more) losers.

Consequently, it is to the benefit of construction parties to recognize the situation and identify the causes of delay in the early stages of the project. This will help them to take the necessary precautions to control these

causes before they occur and be aware of them when they occur during construction.

Delay in any project causes damages to the construction parties, specifically to the owner and to the contractor. In public projects, where the owner is the Government Authority, delay means that a building or a facility is not ready for use by the public on the specified time. This situation may cause disturbance in the national development plan, and the budget execution plan of the government authority. It may also cause loss of service revenues and public inconvenience. For the contractor delay means a longer construction period, which means higher overhead cost, other expenses, and tying up his working capital. Therefore, the contractor can not pursue other projects, and he may lose other opportunities for new projects (O'Brien 1976). For both parties delay is a costly problem; hence it is very significant. Moreover, the existing situation emphasizes the need to study this problem.

In general, and in short, studying the delay problem in this type of project will help diagnose the problem, and identify its extent and its most

critical causes. Identification will facilitate the control of those causes in the early stages of the project and improve the performance of public projects. The result of this study will be of benefit to all concerned parties: the government authorities, the contractors, and the consultant engineers.

1.6 THESIS ORGANIZATION

This research is divided into five chapters and include the following:

Chapter (1) presents an introduction to the research. It is intended to give an overview of the delay problem in public projects and includes the problem statement, the objectives, the scope limitation, and the significance of the study.

Chapter (2) presents the literature review of delay in public construction projects. It presents a general description of the construction environment of water and sewage projects, types of delay, causes of delay, government laws and regulations regarding delay, and previous studies of this problem in construction projects.

Chapter (3) discusses the research methodology which includes data collection, questionnaire development and design, sample size determination & selection, scoring system, and correlation.

Chapter (4) presents and discusses data analysis and results, and presents the major findings of the study.

Chapter (5) summarizes the results and major findings, to present the conclusions and recommendations of this research.

Throughout this thesis the following definitions are applied unless other wise stated:

The project: It means public water and sewage utility construction project within the defined scope of this research.

The owner: It means public water and sewage authorities within defined scope of this research.

The contractor: It means the classified contractor in the field of construction of water and sewage projects.

The consultant: It means the consultant engineer who supervised construction of water and sewage projects.

The government authorities: It means government water and sewage authorities.

CHAPTER 2

DELAY IN PUBLIC PROJECTS

2.1 GENERAL

Many literature has been reviewed which presents and discusses delay in construction projects. The outcome of this and the writer's experience will be described in order to present an overview of delay in public construction projects in general, and in water and sewage projects in Saudi Arabia in particular. This chapter includes a general overview of delay in public construction projects, types of delay, causes of delay, laws & regulations pertaining to delay, and previous studies pertaining to the delay problem in construction projects.

Many public projects have been constructed all over the Kingdom of Saudi Arabia as part of the national development plans in the last two decades, as result of utilizing the kingdom's huge capital resources. These projects form the basic development of the infrastructure facilities in the municipal and rural areas. Public water and sewage construction projects

are part of those projects for municipal services. These projects are very important utilities. They provide a basic service for environmental health and public safety and convenience.

One of the critical problems faced by government authorities is the delay in completion of construction projects due to many causes, which may occur during the construction phase.

The construction environment and the nature of the work in water and sewage construction projects play an effective role in the delay that may occur in this type of project. These projects could be subjected to different and difficult factors that could provide the chance for delay in construction progress, then in project completion. These factors could be summarized in the following points:

1- Water and sewage construction projects are horizontal construction, which take place mostly in public roads and streets in the municipal and rural areas. This needs special arrangements and precautions for the works.

2- These projects mainly include excavations and trenching works in different soil and site conditions. This makes these projects face high uncertainty. That may cause difficulties in the works, and may cause delay in their progress.

3- Work in these projects depends heavily on equipment, which needs continuous maintenance and efficient operation.

4- The contractor working in this type of projects must be experienced and able to perform the work, and cover risk that may exist at the site.

5- Other Government Authorities are involved in the project, where they frequently issue work permits to the contractor with restrictions in time and work area. This may obstruct the progress and cause delay in the work. Proper coordination between all parties involved should be done continuously to avoid obstructions in the work's progress.

6 - Special mechanical and electrical installations are required for pumping stations, as a part of these projects which are mostly imported, and may be subjected to unexpected delay in delivery. This delay may

cause delay in completion and operation of these stations and then utilization of a part or whole of the project.

So, these construction factors could provide more chance for delay in the construction of water and sewage projects, among other public utility projects.

2.2 TYPES OF DELAYS

A delay is the time during which some part of a construction project has been extended or not performed due to an unanticipated circumstance or other different causes. These causes could result from construction parties or by any other factors that influence the construction project's progress (Callahan 1992).

The construction delays can be classified in different categories, according to liability of the contractual parties, occurrence of the delays, or effect on the schedule of the project. According to the liability, the delays are classified as excusable / or nonexcusable delay. The excusable delay may be farther classified as compensable or noncompensable. According to the occurrence, the delay could be classified as concurrent/or independent

delay. In relation to the effect on the time schedule, the delays are classified as critical/or non critical delays.

In the following a brief description of these types of delays are presented, with the parties involved, and examples for each.

2.2.1 - Excusable & Nonexcusable Delays

Excusable or nonexcusable delays are based on the source of the causes. The main principle for establishing whether a delay is either excusable or nonexcusable is the contractor liability for the delay. Delays resulting from the fault or negligence and in the control of the contractor or his subcontractors, suppliers, or any party working in behalf of the contractor, all these causes of delay are nonexcusable, where the contractor is not entitled to any time extension for the project. The excusable delays are those causes which do not result from the contractor obligations according to the contract. The basis of this should be taken from applicable contract provisions and conditions of contract clauses (Callahan 1992 & Leon 1987).

2.2.1.1 Excusable delays

Excusable delays are delays that occur as a result of excusable causes. These causes excuse the contractor from meeting a contractual deadline, which is the project completion date. The delay will serve to justify an extension of the contract performance time. Excusable delays could be identified and represented by three major elements (Karim & Diekman 1987). They are:

1- Unforeseen events: Enforceable causes occur beyond the control of both parties: the owner, and the contractor.

2- Events beyond the contractor's control: Causes which may occur and the contractor cannot recover them in the schedule.

3- Events without faults or negligence: These events in which the contractor is blameless, such as an act of God, "Force Majeure" causes, and shortage of resources beyond what was expected at the time the contract was made.

Generally, the excusable causes are those which apply to the performance of the owner and his representatives or causes beyond the

contractor's control. The main element of the excusable delay causes is that the contractor cannot cover them in the schedule and should extend the project completion date (Karim & Diekman 1987, Callahan 1992).

Common excusable delays for the contractor include changes in design and the scope of work initiated by the owner or his representatives, late site handing over, late permits from government authorities concerned, and owner late decisions. If the contractor encounters an excusable delay, he is entitled to an extension of the project duration and may or may not ask for compensation according to the causes and the conditions of the contract. If the delay is deemed compensable, the party concerned will be entitled to additional compensation for the cost of the delay, as well as additional time for contract performance (Callahan 1992).

The following paragraphs will give a brief description for both types, and their classifications.

A- Excusable Compensable Delays: Excusable compensable delays are those delays which occur as a result of an owner or his representatives due to faults or negligence, and within the control of the owner.

Generally speaking, a delay that could have been avoided by due care of one party is compensable to the other party suffering injury or damages as a result of the delay. Both contract parties, the owner and the contractor, could claim for compensation. The contractor will be entitled to additional compensation for costs of delay to cover extra expenses generated by delay or obstruction to job progress, as well as additional time for contract performance. The owner can also get compensation for the costs which cover his losses of revenue and damages (Callahan 1992 & Leon 1987).

This compensation is restricted by conditions of contract under special cases. Normally the owner in the conditions of the contract states clauses to prevent any liability to compensate the contractor for this delay. These clauses are called "No- Damage" clauses. Such clauses attempt to place the entire risk for delay damages upon the contractor and limit the owner liability to a time extension only. The owner also could claim for compensation if the delay is attributable to the contractor. Owner compensation is covered by liquidated damage clauses in the conditions of contract. The owner normally states an

amount or a percentage of contract value withheld from contractor payments for each day of contractor - caused delay which results in late project completion (Karim & Diekman 1987).

This type of delay can occur under different causes. These causes can be the owner's failure to furnish and hand over the site to the contractor, faulty design or incomplete drawings and specifications, changes in design and scope of work, suspension of work, differing site conditions, late decisions that are necessary for work progress. The excusable compensable delays are not limited to those mentioned. Delay which arise from acts of the owner or the owner's failure in his obligations stated in the contract are all considered as excusable compensable delays (Karim & Diekman 1987, Callahan 1987, Leon 1987).

B- Excusable Nonecusable Delays: Excusable noncompensable delay are those which occur as a result of faults or negligence beyond the owner's or the contractor's control. These are normally defined in the contract. This kind of delay entitles the contractor to a time extension only, without recovery of associated delay damages cost (Leon 1987).

Examples of these causes of delay are new government laws and regulations, acts of God such as severe weather conditions, and late permits issued from concerned government authorities due to special requirements (Callahn 1992, Leon 1987).

2.2.1.2 Nonexcusable Delays

Nonexcusable delays are those caused by events or circumstances within the control or due to the fault or negligence of the contractor. In this type of delay, the contractor's own action and / or inaction have caused the delay. These delays could result from the contractor himself or from a subcontractor, a supplier, or any party who works for him. In this type of delay, the contractor is not entitled to either compensation or time extension from the owner. In fact, the owner could recover delay damages from the contractor through applying clauses of liquidated damages and delay penalties under the conditions of the contract (Karim & Diekman 1987, Callahn 1992).

There are many causes which result from the contractor's performance and his representatives. This could include but is not limited to, failure to

provide materials and manpower required; failure to finance the project; lack of technical and managerial staff; inefficient planning & scheduling and controlling of the project works; and subcontractor's problems.

2.2.2 Independent and Concurrent Delays

Delays can be classified according to their occurrence into two types, independent and concurrent delays. An independent delay is a delay which occurs as a result of causes related to one type of delays or one of the contractual parties, either the contractor or the owner. This could be a nonexcusable or excusable, compensable or noncompensable delay. The concurrent delays are two or more independent delays which occur at the same time as a result of different causes which could be excusable or nonexcusable, compensable and /or noncompensable (Leon 1987).

Concurrent delays are difficult to evaluate and to settle. Each party should keep full documentation of these delays, specially the concurrent delays which could result from both parties, the owner and the contractor. Measurement of concurrent delays is a complex issue. Concurrent delays may occur in one of the following cases (Karim & Diekman 1987):

1- If excusable noncompensable and nonexcusable delays are concurrent, then the delays will be considered excusable, where the contractor is entitled to a time extension only.

2- If excusable compensable and noncompensable delays are concurrent, the delays will be considered noncompensable and the contractor will be entitled to a time extension only.

3- If nonexcusable and excusable compensable delays are concurrent, the delay will be considered as an excusable delay, and the contractor will be entitled to a time extension only.

4- If excusable compensable, noncompensable, and nonexcusable delays are concurrent, the delay is to be evaluated according to as-built and as-planned schedules, and the contractor will be entitled to a partial time extension with or without compensation.

A "concurrent" delay means that more than one delay contributes to the project delay. It includes any delays that have contributed to the overall project delay (Karim & Diekman 1987). If the contractor and the owner have contributed to the delay, the contractor receives a time extension, but

not delay damages, and the owner does not receive liquidated damages (Callahn 1992).

2.2.3 Critical and Noncritical Delays

Delay causes could occur at any time during project construction duration. Those causes could affect any of the project activities on a critical or noncritical path in the project time schedule.

It is a basic principle in the scheduling of a critical path that delay which occurs on noncritical path does not extend the schedule until all of the floats along these paths are used or consumed. The delay incurred off the critical path would not delay ultimate project performance (Leon 1987).

Delays that affect the critical activities and result in an extended project completion date are known as "critical delays". Concomitantly, the delays that do not extend the project completion date are called "noncritical delays". It is a generally held that a contractor will not be entitled to a time extension for an excusable delay unless the delay extends the overall project completion date (Callahan 1992).

2.3 CAUSES OF DELAYS

There are many causes which could result in delay in public construction utility projects. Those causes could result from different sources and parties. Through the literature review, many interviews and discussions with some professionals in the field, and the writer's experience, many causes have been identified. There are sixty potential causes identified. Those causes could be combined in six major groups. These groups are classified according to sources of these causes. These sources are the following:

1- Contractor performance.

2- Owner Administration.

3- Early planning and design of the project.

4- Government regulations and policies.

5- Site and environmental conditions.

6- Supervision and field inspection.

Each one of the six sources are described briefly. The causes that result from these sources are identified to establish an overview for the reader of the causes of the delays in water and sewage construction projects

in particular, and public utility projects in general. These causes will be considered in the questionnaire to identify their frequency and severity. It is noticed that some of these causes could interface with, or could be a result of, other causes from other source. These causes are mentioned to relate them to their sources, in order to evaluate the relative importance of these causes and their sources.

2.3.1 Contractor Performance

The contractor in the construction process is the party who utilizes resources required to execute and complete the construction project. Normally, the contractor carries most of responsibility in the construction. He is responsible for delivering the completed project to the owner. The contractor's performance in construction plays an important role in the project performance. The contractor is obliged to complete the project, on the specified time, within the estimated cost, and with the required quality, according to specifications and conditions.

Contractor performance is based on his capabilities, which include administrative, technical, and financial capability. The contractor

capabilities are based on available resources and project management performance. The resources include materials, equipment, manpower, and money. The availability of these resources adequately on time as required is essential for the progress of the work and completion of the project by the time specified.

Many factors could cause delay in the project's completion as a result of low contractor performance. Shortage in contractor resources and low project management performance will affect the contractor performance which will affect construction progress and then completion. The effects of contractor resources and management which contribute in project time performance are presented and briefly described in the following sections. Contractor performance consists of many causes, so it is further divided into some groups.

2.3.1.1 Contractor Resources

A- Materials: Procurement of materials is one of the contractor tasks in the construction project. The materials required should be identified by a qualified planner and estimator from the shop drawings. Proper

scheduling has to be made to get the materials at the job site at the right time, especially, those materials imported from abroad or which need special manufacturing, to avoid delay in delivery which might lead to delay in progress of the work.

Materials used mostly in water and sewage construction projects are different types of pipes and fittings, valves, normal construction materials, and different types of mechanical and electrical installations, such as pumps, accessories, and other mechanical & electrical parts. These installations are used for construction of networks, house connections, and pumping stations.

Most pipes and fittings, and other normal construction materials are available from the local factories now, but the contractor needs to make arrangements for delivery time and payments. The factories normally request the contractor to pay an advance payment for materials orders. Piping installations for pumping stations are mostly ordered in special specifications and have to be imported from abroad, or from the local factories, and need time for manufacturing. Delivery of mechanical and electrical installations which are required for pumping stations are

very important in this type of project. These stations are very important in construction of these projects, since the operation and utilization of the project depend on the completion and operation of these stations. Most of these materials are imported from abroad, from special suppliers under special orders.

Shortage of any of the materials required could obstruct the progress of the construction and may delay the completion of the project. The contractor has to consider time for delivery of the materials, especially those imported from abroad. Delay in delivery of the materials required could delay the completion of a part of or a whole project. Delivery times should be matched with the time schedule of the project and according to the specifications and quantities required in the shop drawings. Also the contractor sometimes may not able to provide the materials due to financing and cash flow problems. This could make a shortage in the materials and may delay the progress.

Changes in material types and specifications may be required due to some defaults or mistakes in the design or specifications, or changes

ordered by the owner for improvement in the design and quality. Sometimes changes in the specifications require changes in the prices of work items, and it may take a long time to negotiate new prices and formal measures for approval of these prices. This time may delay parts of the work which sometimes are critical items in the schedule of the project, and may affect the completion of the project.

In general the contractor must deliver the required materials by the time needed, so he should make arrangements to order and deliver the materials in proper time.

B- Equipment: Procurement of equipment is a very important resource in construction, especially in horizontal heavy construction such as public water and sewage projects, since those projects are equipment intensive. Equipment plays the major role in the construction and completion of these projects.

The contractor can procure the equipment by utilizing one or all of the procurement methods: purchase, rent, or lease. Equipment

represents a major portion a contractor assets, so most of the contractors purchase equipment, which is regularly and economically utilized, such as standard equipment.

In water and sewage construction projects different types of equipment are used, mainly excavation and trenching equipment, loaders, cranes, trucks, compacting equipment, and other different equipment. The contractor also needs to provide temporary installations for supporting and shoring of trenches and excavations, specially when there are deep excavations and loose soil. Also the contractor needs to install a dewatering system when the water table is high at the site.

Most contractors own their standard equipment which is available in the local markets. The contractor obligates himself to provide all required equipment to execute the project according to the time schedule. Shortage or unavailability of the required equipment may slow the progress of the work and may delay the completion of the project. Equipment should be maintained properly to keep it in good condition and ready for efficient operation at all times.

Selection of adequate and proper equipment to perform the work is an important factor in the productivity. Inadequate or improper types of equipment and low skills of operators might reduce productivity and cause considerable delay in the progress of the project.

C- Manpower: Manpower is essential resource of the contractor, who also utilizes the other resources in the most efficient and productive manner. Manpower includes the different laborers, those directly performing the project work. They including skilled, semi - skilled, and unskilled laborers. Skilled laborers involve all craftsmen, such as pipe fitters, equipment operators, mechanics, carpenters, masons, and foremen who link between management staff and manpower. The foreman has an important role in the progress of the work, so normally the contractor assigns a trained foreman who has a good experience in the work with leadership skills and some management abilities. Semi-skilled laborers include the assistants of craftsmen and have medium skills, while unskilled laborers include ordinary laborers who perform normal jobs which do not require specific skills. Laborer availability,

skills, productivity, and experience play an important role in the progress of the work (Ubaid 1991).

In Saudi Arabia most contractors provide their manpower from abroad, most (if not all) laborers come from some of the Arab countries, and the west & south - east of Asia. Different laborers from different countries have various cost and different skills. There are many government policies and regulations concerning the importing of manpower. The contractor may face difficulties in importing required manpower for the project since it normally involves a long procedure to obtain visas, licenses, and work permits for them. This procedure may take a long time before the contractor can provide the manpower before the construction starts and may delay the progress of the project.

Productivity of the laborers is a function of their experience, convenience in the job, work operation and management, and many other factors which may decrease or increase the productivity.

Communication and coordination between the manpower and the project management staff affect the progress of the work. Lack of communication and coordination could cause delay in the progress of the project.

The contractor should make the arrangements of providing the required manpower for the progress of the work based on time schedules of the project. The shortage or unavailability of manpower during construction may cause delay in the progress of the works. Most contractors keep their most qualified and experienced manpower permanently with them to start new projects and train other, imported laborers.

D- Financial Resources: Financial resources are the most important element in the contractor capabilities. Funds are required to procure the other resources: materials, equipment, and manpower. Financing the project is the most important factor that affects the contractor's performance. The contractor could utilize different methods to finance the project. He could finance the project from his own financial resources, or by getting loans provided by commercial banks.

Most of the local contractors rely on commercial banks to finance their projects, but strong restrictions applied by those banks require contractors (especially financially weak firms) to depend on their own financial resources (Stevens 1989). During the boom construction in the early three national development plans (1970-1985), government was offering to the contractors involved in public projects advance payment which was equal to 20% of contract value to encourage those contractors to participate in the construction of a large number of public projects. This payment has stopped since 1987 with the decrease in the number of projects that awarded and increase in contractors financial capability (Stevens 1989). This situation affected the contractor financial capability which affects their ability to provide the required resources for the project.

Sometimes the contractors face difficulties in financing their projects due to financial problems: delay in progress payments, no advance payment, and cash flow problems. Cash requirement for procurement of materials and other expenses could lead the contractor into a very critical situation which could make delays in the progress of the work

and then the completion of the project. The contractor should manage his available financial resources, and plan his cash flow by utilizing progress payments.

2.3.1.2 Project Management Performance

The project management is very important in the contractor performance. The professional management staff can execute the project in the most efficient manners, within the time specified, with the best project performance level. Management staff include administrative personnel and engineering professionals. The contractor should assign administrative and technical staff as soon as the project is awarded to him, to arrange for procurement of resources, to manage the construction effectively, and to achieve project completion within the specified time with the required quality, and within estimated cost.

Administrative personnel perform administration activities concerning public and government relations, accounting, procurement, and labor affairs. Each of these should be done by qualified personnel to procure required resources for construction and to support the project management. Lack of

these personnel could create problems that may cause delay in delivery of resources and problems in communications and coordination with other parties involved.

The engineering professionals consist of all technical staff who perform technical and engineering tasks, and manage the construction. They involve project manager, site engineers in different fields, such as civil, mechanical, electrical, and architectural engineers, inspectors, draftsmen, surveyors, ...etc. Tasks include planning & scheduling, progress control, quality control, cost estimating, construction methods, and all other project management techniques. The professional staff are required to be qualified and experienced in the construction of the project. Lack of these professionals could cause difficulties in the progress which may lead to delay in completion of the project.

Project management involves many tasks that contribute to the project time performance. Among these important tasks are planning & scheduling, and progress control of the project. All these processes are very important for the project performance level, especially, time and cost performance.

So, planning & scheduling are considered to be among the most important measures of contractor performance, and project time performance.

The planning process is of paramount importance in the success of construction projects. Poor planning could create overruns in cost and time performance of the project. Planning is a process of selecting method and order of work to be used on a project from among all the various methods and sequences possible. This process provides details information for estimating and scheduling as well as a baseline for project control. Scheduling is the process of determining the timing and sequence of operations in the project and their assembly to give the overall completion time. The scheduling is very important in managing time. If proper planning and scheduling are not done, the probability of delay and cost overrun and disputes are higher. Schedules can control all the resources of the project, materials, equipment, manpower, and financing, and justify time extension claims. Planning should be matched with the resources and time to develop the work schedules (Callahan 1992).

Most local contractors normally use bar-chart scheduling techniques, and CPM (Critical Path Method) scheduling techniques for large, detailed,

complex projects. Revisions and updating of schedules should be done frequently to assure the completion of project in the specified time or the shortest possible time. Updating is required frequently in the schedules of projects facing high uncertainty, such as underground utility works in water and sewage construction projects. Planning and scheduling are continuous processes during the construction.

There are many factors resulting from the contractor's project management that could cause problems which might cause delays in the progress of the work and maybe in the completion of the project.

The contractor's head office has an important role in the project's success. The involvement of the head office during the construction will support the project management to complete the project at the specified time, with the best performance. The contractor head office will be involved in main administrative issues such as financing, procurement of resources, and main technical issues such as change of orders, technical conflict, and changes in the scope. Proper communication and coordination should be done by the contractor's head office to support project management.

The contractor should perform proper coordination and communication with all the parties involved: suppliers, subcontractor, supervision team, the owner, and other government authorities. Frequent meetings will improve communication, coordination, and cooperation between all parties involved to avoid any interface problems which may arise. This will save a lot of time solving these problems or conflicts that cause delays in the progress of the project.

Normally changes in a construction project are unavoidable in most cases. Changes may incur in design or scope. These changes may require changes in contract prices and specifications for some work items. These changes require the contractor to prepare new cost estimates with new detailed specifications and drawings for these work items. A contractor's late response to these changes, especially if these items are main items, may delay the progress and completion of the project.

Contractor quality control is an important factor in the project performance. This contributes to all performance measures: time, cost, as well as the quality of work performed. The contractor should perform self-supervision and field inspection to assure that works are done according to

specifications, drawings, and engineering standards. This will avoid any defects needing repairs, which require time and may cause some delays in the progress of the work.

In many projects, the contractor needs to subcontract part of his projects to a subcontractor who normally executes special work items in the project, such as mechanical & electrical work. The contractor has to assure that the subcontractor schedule should match with the project schedule and that the work is performed according to required specifications and drawings.

In the contract, the contractor is requested to prepare shop drawings for the work to be performed. These drawings provide all details needed for executing the work according to contract documents requirements. In water and sewage construction projects, the contractor is required to survey project areas to prepare detailed plans for networks to be constructed according to existent site conditions. Also he should prepare detailed drawings for pumping station works, which include architectural, structural, mechanical, and electrical work. Delay in preparation of these drawings

could delay starting execution of the work, which may delay the progress of the project.

Mobilization to start construction should take place as soon as the contract is awarded to the contractor. The mobilization includes all arrangements of the resources, management staff, site office, and preparation of all other requirements to start construction works. Late mobilization could cause delay in the progress of the project.

The contractor is required also to provide all necessary precautions of safety, by applying safety rules and regulations for safe site conditions and safe acts of the manpower. This will avoid injuries, which decrease productivity and may delay progress of the work.

2.3.2 Owner Administration

The role of the government authority who is the owner in the construction of public projects is an important role. Owner involvement is an effective factor in the construction process. The role of the owner includes many tasks. These tasks are very important for the progress of the

project. Failure of the owner to perform these tasks will cause problems that may cause delay in the progress then the completion of the project.

Owner involvement during the construction is very important to project performance. There are many tasks which they contribute to the project time performance. Delay in furnishing and handing over any part of the site to the contractor will cause a delay in starting some of the work of the project. This is especially true of those sites for some critical work in the schedule, such as pumping stations, or main trunk lines, which could make the contractor fail to complete the project on schedule.

Owner uncooperative with the contractor will create some complexity in the measures of owner administration. Cooperation between the parties will avoid the routine measures. Excessive bureaucracy in the owner organization will create some complexity in measures in the owner administration. This can be seen through lengthy and ineffective measures that could lead to delay in the decisions and approvals of contractor inquires, which could delay the progress of the project. Failure of the owner in making decisions within a reasonable time may hold back some of project work, and delay in settlement of contractor's claims by the owner,

such as approval of new work items, prices, and extra costs for changes in design, may obstruct project progress and then cause delay in the completion of the project.

Delay in the progress payments is one of the most critical problems for the contractor. It creates a very critical problem in his financial ability and cash flow. This problem makes the contractor unable to provide required resources and cover his expenses, which leads to delay in the progress of the work.

Delay in approval of contractor submittals for materials, shop drawings, schedules, etc., may cause delay in the progress which may lead to delay in completion. The owner's interference in the construction, such as changing the phases of the construction, may obstruct the progress of the work.

According to the conditions of the contract, the owner has the right to suspend any part of the work, if it is needed to restudy and redesign any part of the project to make necessary modification and corrections. Changes or change orders by the owner are one of the major factors alleged in most delay claims as a critical factor in delay (O'Brien, 1976). The procedure of

issuance of change orders may involve lengthy measures, which take a long time during construction, that could cause delay in the progress and then the completion of the project in the specified time.

The owner should make necessary coordination and communication with other government authorities to avoid any conflict that may cause delay in work progress and the completion of the project during construction. Lack of communications and coordination by the owner with other concerned government authorities, and with other parties involved during construction, is another problem in the owner administration that may cause problems affecting the project progress.

2.3.3 Early Planning and Design

Contract documents are the product of the early planning and design stages of the project. The contract documents normally include the conditions of the contract, the form of agreement, special conditions, standard and special specifications, the bill of quantities, drawings & plans, and addendum. In the contract documents, the owner states all scope,

requirements, conditions, specifications, quantities, and physical aspects of the project.

Normally during construction, the owner may order changes in scope, design, or quantities of work items. These changes could be as a result of inadequate or inapplicable design, or changes in the owner's requirements, such as improvement in the design and quality of the project. Differing site conditions, deficiencies and faults in the design are the most common reasons for changes in the design and scope of the project. It may take a long time to make necessary corrections in specifications and drawings, and for approval measures of prices of these changes. This could delay the progress of the project.

Inadequate early planning and design of the project are the main sources of problems in contract documents. This could be a result of changes in site conditions, mistakes in surveying, or inapplicable design standards and codes. These problems occur if the designer is not a professional in the field of the project.

Changes in the scope of the project could be ordered by the owner as changes in quantities of work items, new items, new areas, or added new requirements in the scope which were not considered in the contract documents. These changes need modifications in bill of quantities, in the form of modifications in quantities or the addition of new items, which need to be negotiated and approved by the owner. The procedure for this may take a long time, while part of the project is on hold. This could cause delay in the progress and completion of the project. Changes in scope of the project beyond the contract value also need approval of the owner for extra cost and time extension of the project.

In some contracts for public projects, the duration for the construction of the project is not well determined. The duration originally is not adequate for performing the project works. It is too short. This will not allow the contractor to execute the project on time and then the project will be delayed. The obligation of the contractor in the contract is executing the project in the specified duration or he will be subjected to a delay penalty, with or without liquidated damages. A delay penalty is limited to 10% maximum which could be applied within a short time, and then it remains

fixed. This could assure that some of the contractors are not worried about delay in completion if the delay time exceeds that time since the delay penalty has reached its maximum limit (Zain Abidien 1983). So, the delay penalty sometimes is not feasible and effective to urge completion of the project in the shortest possible time.

2.3.4 Government Laws and Regulations

In public utility projects many government authorities are involved in construction. Many laws and regulations should be considered in the contract and form a part of the contractor obligations. Long procedures and many measures must be applied in the government organizations, which normally take a long time, such as issuance of work permits, safety measures, and laborer and material importing measures.

Among the most important factors which affect progress of public water and sewage construction projects are work permits. The contractor should obtain work permits from all concerned government authorities. These authorities consist of the municipalities, telephone department, electricity company, traffic department, civil defense department, and road department.

Each of these authorities has its own laws and regulations regarding work permits. In many cases the contractor faces difficulties in obtaining work permits from some of these authorities mentioned, especially the municipalities if no proper coordination has been done in the early planning and design of the project, or the contractor performs poorly.

Work permits are issued with restrictions in work area and time period according to the municipalities regulations. These restrictions could affect work progress and may cause a delay in completion of the project. In general, restrictions in obtaining work permits may delay the work progress in this type of public utility project. The owner and the contractor should have continuous communications and coordination with concerned government authorities to avoid problems which may arise during construction. Both the owner and the contractor should coordinate with those authorities to apply their instructions and regulations.

The contract tendering system in government administrations allows for intense competition in most public projects, with a lack in prequalification and classification systems for the contractors. The government authorities are obliged to accept the lowest bidder. This situation sometime brings

unqualified contractors with shortage in resources and low capabilities, and then leads to low performance in construction, which causes delay in completion of the project.

Changes in some government regulations and laws, such as changes in costumes, restrictions in importing manpower from some countries, labor law, etc. could create problems for a contractor, making him unable to provide the required resources. This then may cause delay in the progress of the project.

2.3.5 Site and Environmental Conditions

In the construction process, especially in horizontal construction projects, such as water and sewage utility projects, environmental conditions at the site have some impact on project progress and completion. The environmental conditions include climate conditions, subsurface conditions, and social and cultural conditions.

The climate in most of Saudi Arabia is a hot dry desert climate, where the temperature could reach to around 49 degree Centigrade in the summer with a big variations in the temperature on the same day, while the winter

is a cool season with low rain. In the coastal areas the relative humidity becomes very high. Some of these climatic conditions sometime become very severe and the weather may affect the productivity of manpower and equipment, which could delay the work progress, if the contractor did not make the necessary arrangements and precautions.

In public water and sewage projects, subsurface conditions are the most important site conditions that affect work progress, because excavation works and trenching are the main work items in these projects. Excavations could be difficult work if the contractor does not provide adequate manpower and equipment for the work. Deep excavations for sewer lines and pumping stations need adequate equipment and implementation of proper excavation and construction methods. Failure of the contractor to provide complete installations may delay progress and completion of the project.

Subsurface conditions include soil conditions, water table, existent utility lines, and other obstructions. Hard rock or very lose soil require special equipment and temporary installations. A high water table needs continuous pumping to lower the water table for construction of utility lines

and structures. Existent utility lines could obstruct the progress, and in some cases, these lines need rerouting or repairing if they are damaged. In some cases where construction of utility lines takes place in narrow roads and streets with deep excavations, this could make difficulties in the work, which may delay progress. The contractor should investigate site subsurface conditions to make all necessary precautions to avoid obstructions that may cause delay in the progress of the work.

Some social and cultural conditions have some effect on the progress of the work; traditions, customs, and religion of the manpower play an effective factor in their productivity. Most manpower, if not all in the construction industry in Saudi Arabia, is imported from different countries, Arab and Non - Arab, Muslim and Non - Muslim. They have different social and cultural backgrounds which somehow effect their productivity. Familiarity of the manpower with the society and culture in the Kingdom will improve their productivity.

In some sites, special safety precautions are required to provide safety for citizens, and to prevent any accidents that may occur and delay the progress. Conflict between some projects constructed at the same site and at

the same time due to interfering in the construction area could cause delay in the progress. Proper coordination has to be made in the schedules to avoid any delay that could affect the completion of the project.

2.3.6 Supervision and Field Inspection

The supervision of public projects is an important element in project success. The supervisor has an important role in the construction performance. The project may be delayed if the supervisor does not perform his tasks efficiently, which will depend on his personnel qualifications and experience. The supervision of public projects are performed either by engineering department in house, or by consulting and engineering offices working as owner representatives. The supervisor responsibility is making sure that work is being performed as per requirements of contract documents and according to relevant engineering standards and codes.

The consultant office or the owner supervision team should manage the construction properly and efficiently. Any lack in their duties will cause

problems for the contractor and the owner, which may cause delay in the progress of the project.

Effective involvement in the supervision will help the contractor to complete the project on time. Unqualified and low experienced personnel will cause some problem which may cause delay in the progress. Delay in checking, review, and approval of contractor submittals, materials, shop drawings, schedules, payments, etc., all could delay progress of the work and may cause delay in the completion of the project. Progress payments should be checked and approved by the consultant engineer in proper time. The consultant has to keep full records for the work items performed and make proper coordination between personnel in the field and the contractor.

Coordination and communications between the consultant and the contractor will contribute to the progress of the project. Poor coordination could lead to conflict and problems that delay the progress. Continuous coordination and communications through regular meetings and organized work procedures for approvals, inspection and testing will improve coordination and communication between all parties. Clear inspection and testing procedures are very effective in the supervision in a good standard.

Those procedures should be designed as forms to fulfill the contract requirements. Improper or inadequate procedures will cause some difficulties in the work progress, which could lead to delay in completion. Changes in supervision level due to personnel attitudes or experience may cause late response to the contractor inquiries in the job site. Any of these factors may cause problems in progress and then delay in completion.

2.3.7 Summary of Potential Causes

The causes of delay in public utility projects as described previously could be summarized in groups according to their sources in the following:

I- Contractor Performance :

1- Shortage of materials required.

2- Delay in materials delivery.

3- Changes in materials prices.

4- Changes in materials specifications.

5- Shortage of equipment required.

6- Failure of equipment.

7- Shortage of supporting and shoring installations for excavations.

8- Inadequate equipment used for the work.

9- Shortage of manpower (skilled, semi-skilled, unskilled laborers).

10- Low skills of manpower.

11- Shortage of contractor's administrative personnel.

12- Shortage of technical professionals in the contractor's organization.

13- Poor communication by the contractor with the parties involved in the project.

14- Poor coordination by the contractor with the parties involved in the project.

15- Slow preparation of change order requests by the contractor.

16- Ineffective contractor head office involvement in construction of the project.

17- Delay in mobilization to start the project.

18- Loose safety rules and regulations within the contractor's organization.

19- Poor qualifications of the contractor's technical staff (engineers, inspectors, etc.).

20- Improper technical study of the project in the bidding stage by the contractor.

21- Ineffective planning and scheduling of the project by the contractor.

22- Delay in the field survey done by the contractor.

23- Ineffective control of the project progress by the contractor.

24- Ineffective quality control by the contractor.

25- Delay in the preparation of contractor submittals (e.g. shop drawings, materials sample, etc.).

26- Improper construction methods implemented by the contractor.

27- Difficulties in financing the project by the contractor.

28- Cash flow problems faced by the contractor.

29- Subcontractor problems with the contractor.

II- Owner Administration

30- Delay in furnishing and delivering the site to the contractor.

31- Delay in settlement of contractor's claims by the owner.

32- Suspension of work by the owner.

33- Delay in issuance of change orders by the owner.

34- Delay in making decisions by the owner within a reasonable time.

35- Interference by the owner in construction operation phases.

36- Uncooperative owner with the contractor.

37- Delay in progress payments by the owner.

38- Poor communication by the owner with the construction parties involved and with government authorities concerned during construction.

39- Insufficient coordination by the owner in the early planning and design stages with other government authorities concerned.

40- Poor coordination by the owner with the construction parties involved and government authorities concerned during construction.

41- Excessive bureaucracy in the owner administration.

III- Early Planning And Design

42- Changes in the scope of the project (e.g. quantities of work items, new items, new areas.).

43- Ambiguities, faults, and inconsistency of specifications & drawings.

44- Deferring site conditions.

45- Original contract duration is too short.

IV- Government Regulation And Policies :

46- Ineffective delay penalty.

47- Difficulties in obtaining work permits from the authorities concerned.

48- Low performance of lowest bidder contractor in the government tendering system.

49- Changes in government regulations and laws.

V- Site And Environmental Conditions :

50- Severe weather conditions on the job site.

51- Effect of subsurface conditions (soil, existent utilities, high water table, etc.).

52- Traffic control and restrictions on the job site.

53- Effect of social and cultural conditions.

54- Interference with other contractor's work.

VI- Supervision And Field Inspection :

55- Poor qualification of supervision staff of the consultant engineer.

56- Delay in the approval of contractor submittals by the engineer.

57- Poor communications by the consultant engineer.

58- Poor coordination by the consultant engineer.

59- Delay in performing inspection and testing by the consultant engineer.

60- Slow response to the contractor inquiries at the job site by the consultant engineer.

2.4 DELAY LAWS AND REGULATIONS

All public tendering in Saudi Arabia is governed by government laws and regulations, in particular by the "government procurement and project execution regulations and the rules for implementing them". The regulations document was issued by the royal decree in 1397H. corresponding to 1977 and the rules were issued later by the Ministry of Finance and National Economy in the same year. These regulations include 14 articles establishing the basic rules for government tendering systems. The rules consist of 40 articles explaining the basic requirements and procedures for the execution of public projects and procurement. Since the time these regulations and rules were issued, they have been valid with several changes, modifications, and clarification for articles, which have mainly

resulted from questions by government authorities and satisfaction of the current economic and construction environment.

The regulations contain an article related to the delay penalty applications for the delay in public projects. Article No. 9 describes the applications of the delay penalty, which consists of three clauses. Clause 9/A specifies the maximum limit for the delay penalty in each type of public project, including construction, procurement, operation & maintenance, and consulting contracts. This clause is applied to delay occurred as a result of forces, events, or causes beyond the contractor's responsibility. The maximum delay penalty for a delayed construction project should not exceed 10% of contract value.

Article No. 9/B identifies the authority of the concerned minister or the director of an independent department to extend contract duration when the delay results from one or both of the following cases:

1- Order for additional work that can not be executed within contract duration.

2- Suspension of the project work due to causes beyond the contractor obligations with the government.

Article No. 9/C states that if the delay results from other causes than those mentioned in Article 9/B, there is no excuse for the delay penalty unless coordinated with the Ministry of Finance & National Economy.

The rules for implementing the regulations describe the applications of those regulations. There are two articles which describe applications of the delay penalty. Article No. 26 states the conditions of time extensions, it states that "the contractor should execute his obligations in the specified project duration including additional work not exceeding 20% (modified to 10%), unless the order issued at the time does not allow the contractor to execute the project within the specified duration. In this case extension of the duration can be added to complete the project.

Article No. 37 defines the details of how to calculate the delay penalty as a function of the delay period and the average daily cost of the project contract value. The penalty value is calculated in two cases, the first case for short term projects (construction duration 300 days or less), and the

second for long term projects (construction period more than 300 days). The calculations of the penalty in both cases are according to the following formula (Zain Abidien 1983):

For short term project :

Delay penalty = $0.25\ C*D_1 + 0.50\ C*D_2 + C*D_3$

Where :

D = Delay period

$D = D_1 + D_2 + D_3$

$D_1 <= 15$ days, $15 < D_2 <= 30$ days, $D_3 > 30$ days

C = Average daily cost.

C = Project contract value / project duration (in days).

For long term project :

Delay penalty = $0.25\ C*D_1 + 0.50\ C * (D_2 - D_1) + C * D_3$

Where :

$D_1 </= 0.05\ P$, $0.05\ P < D_2 >= 0.10\ P$, $D_3 = D - 0.10\ P$

P = Project construction duration (in days).

It is noticed that the delay period is divided into three limits, and the delay penalty is calculated according to these limits as a function of average daily cost. The first limit is 25% of the daily average cost, the second 50%, and the third 100% of average daily cost. The result of the three limits are added together to compute the total delay penalty, which is limited to 10% of the contract value. The rate of increase in the penalty value reaches the maximum allowed in a short time, and the rate becomes less as the project duration increases. This means that for long term projects, the delay penalty reaches the maximum in a very short time, which does not give the chance to the contractor to complete the project in the shortest possible time. This situation could make infeasible and ineffective applications for the delay penalty, especially for long term projects (Zain Abidien 1983).

In projects such as water and sewage construction projects, which normally have long term duration, if the contractor is delayed, the period for maximum penalty becomes short, which makes the contractor unable to complete the delayed work. The contractor hence loss the incentive that drives him to enhance the work to accomplish it in a short time. Some contractors, therefore, expect before hand not to be able to complete the

project in its specified time, especially if the project duration is tight or/and the contractor expects some difficulties in the project progress or a risk in the project that he is obliged to carry. Then the contractor takes into consideration when tendering 10% increase in the project value to cover any loss that may happen in case of being subject to the delay penalty (Zain Abidien 1983).

On the other side, many government authorities used to change their decision to withdraw the project from the contractor and the execution of such a project at the contractor's expense, when he confirms his willingness to complete the work, exerts effort and provides the required resources in the hope of accomplishing the project without being obliged to withdraw it and then get entangled in the complexities of withdrawal and retendering. The delay penalty has to be more feasible and effective to encourage the contractors in executing public projects in the shortest time (Zain Abidien 1983).

In general laws & regulations pertaining to the applications of the delay penalty have an effect on the delay in public projects.

2.5 PREVIOUS STUDIES

Several studies and reports have been reviewed, which present the delay in construction projects, specifically the causes and types of delay in public projects. Among these studies and reports, the most relevant to this study will be presented briefly in the following paragraphs with their conclusions.

Al Hazmi (1987) presented causes of delay in large building construction projects. He introduced types and causes of delays that may occur in those projects. He mentioned fifty six significant factors that cause delays which are combined into nine major areas. He evaluated their degrees of importance and indicated the most severe factors. He concluded that the most important factors causing delays in large building construction projects are the following :

1- Financial problems which are given the highest ranking among the causes of delay. These problems result from delay in progress payments that are caused by the owner's or the consultant's late approvals. The delay in progress payments create cash flow problems for the contractor which cause financial problems.

2- Slowness of the decision making process and excessive bureaucracy in owner operation.

3- Design changes as a result of inadequate early planning of the project.

4- Difficulties in coordination and communications among various parties in the project. These are important factors and have effects on the completion of the project.

Finally, he concluded that the contractors, the consultants, and the owners generally agree on the severity rank of causes of delay.

Al-Awawdeh (1985) investigated delays and cost overruns in construction projects in general. He mentioned some factors of delay, and indicated 17 reasons of delay. He concluded his study by identifying the six most important reasons for delay in construction projects that occur frequently in Saudi Arabia. They are :

1- Inadequate early planning for the project.

2- Shortage or lack of construction management professionals.

3- Delays in contractor progress payments.

4- Difficulties in financing the project.

5- Changes in the different phases of the construction project.

6- Deficiencies in the organization of contracting companies.

Although this is a general study, it introduces helpful data concerning causes of delay in construction projects in general.

Al Mudlej (1984) presented causes of delay and overruns of construction projects in Saudi Arabia. He discussed generally types and causes of delays in the construction phase. He mentioned 21 causes of delay. He concluded that there are 5 causes considered very important by all parties concerned. They are :

1- Inadequate early planning.

2- Lack of professionals.

3- Poor communication.

4- Unavailability of a construction manager hired by the owners.

5- Shortage of skilled laborers.

Also, he mentioned other causes that each party thinks are important from his experience. They are changes in materials type and specifications,

changes in design drawings, shortage of equipment and manpower, and delays in progress payments. In general it seems that these causes are important causes.

Evans (1981) mentioned three major causes due to the owner. They are defective specifications, delay in furnishing and handing over the site to the contractor, and delays due to other acts of the owner, which result from difficulties or insufficient funding that prevent the owner from continuing construction progress. These causes are important causes of delay that relate to the owner.

Al-Subaei (1987) mentioned the causes of claims in the building construction. Since the delay in construction is related to claims, most of these causes are considered as causes of delay also. There are 29 causes which were identified, and combined into five major areas. He concluded that there are 4 main causes of claims referring to delay in payments, defective contract documents, poor early planning, and bad quality. These causes could be considered as important causes of delay.

Ubaid (1991) discussed the performance of building construction contractors. Contractor performance is one of major areas of causes of delay as described previously. He identified factors affecting contractor performance 13 major measures were considered. These measures related to contractor resources and capabilities. They influence the project's progress and are considered as factors for project time performance.

Al-Ojaimi (1989) reported a general study concerning delay in construction of public projects. He introduced some causes of delay. He concluded that there are six main causes of delay. They are:

1- Lack of organizational and administrational capabilities of some contractors.

2- Inadequate prestudy for the project in the bidding by the contractor.

3- Poor scheduling and planning of the project.

4- Unavailability of required equipment and manpower.

5- Experience of the contractor not considered in awarding of the project.

6- Weakness of supervision staff.

In general, the literature reviewed did not present any specific studies concerning the delay in public water and sewage construction projects, but the studies reviewed presented considerable data for the causes of delay in public projects in Saudi Arabia for the purpose of this research.

CHAPTER 3

RESEARCH METHODOLOGY

This research is a field survey study through a structured questionnaire which is directed to the owners (Water & Sewage Authorities), the consultant engineers, and the contractors within the defined scope limitations of this study in the Eastern and Riyadh Provinces of Saudi Arabia.

The survey will identify frequency and extent of the delay in water and sewage construction projects, and the importance of the causes of delay. This chapter will introduce the methodology of this research which includes the general study approach, the data collection, the survey, the scoring system, and correlation methods used. The survey includes questionnaire development & design, and sample size determination and selection.

3.1 - GENERAL STUDY APPROACH

The study approach will include the steps as shown in Figure 3.1 which can be summarized in the following points :

1- Perform a comprehensive review of literature relating to the topic of this study, in addition to interviews and discussions with some government authority representatives, contractor engineers, and consultant engineers. These are for collecting data concerned with identifying the types and causes of delay in water and sewage projects, and describing laws and regulations pertaining to delay in public projects.

2- Formulate data collected to develop and design a comprehensive questionnaire that covers the required data, and the causes of delay.

3- Conduct a field survey by mailing the questionnaire to the prospective respondents for collecting the field data.

4- Perform statistical analysis for data by using applicable statistical techniques.

5- Report and discuss results and major findings to introduce conclusions and recommendations.

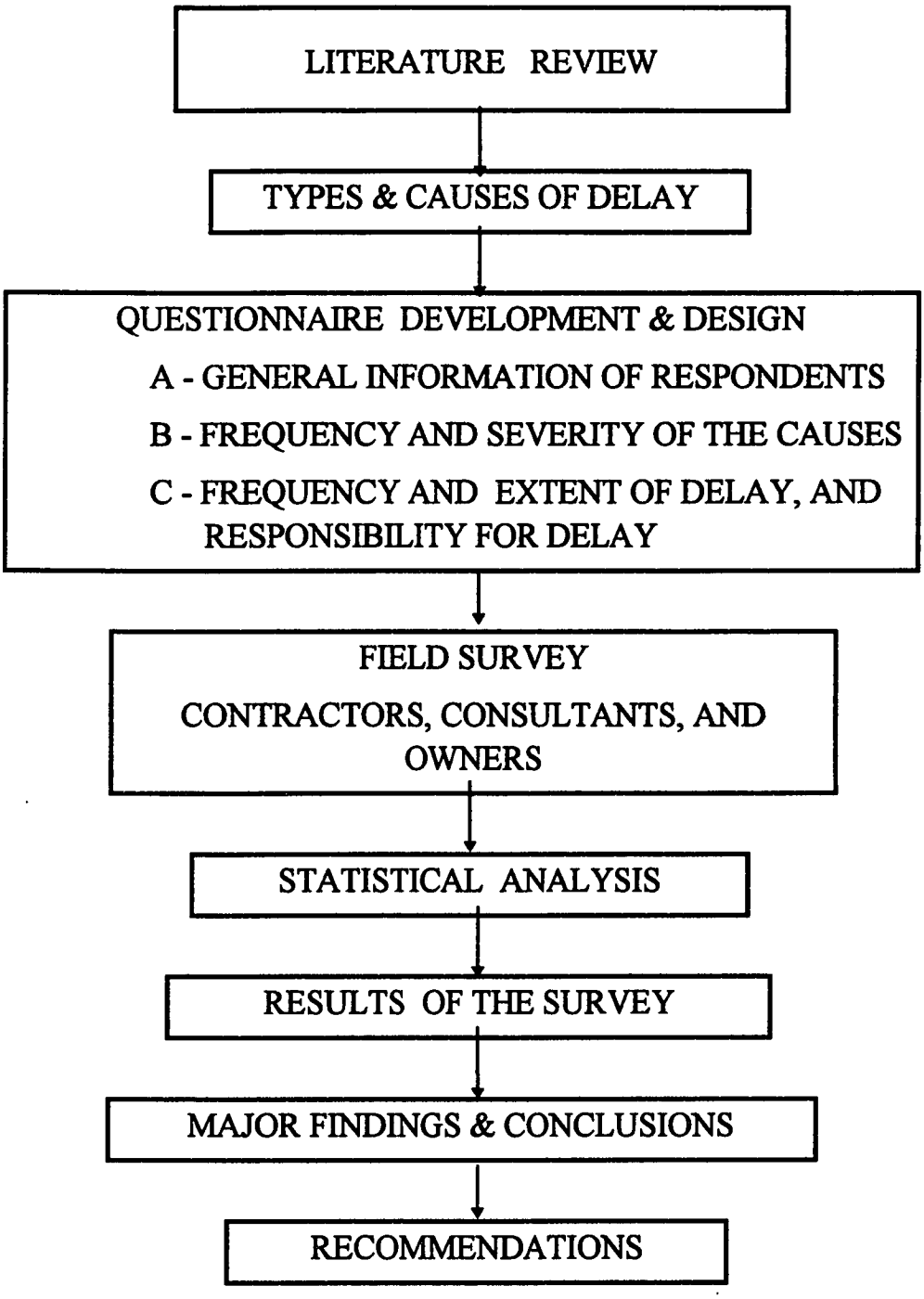


FIGURE 3.1 : STUDY APPROACH DIAGRAM

According to this study's objectives, the data required are of two types :

1- Data concerning the identification and description of the various types and causes of delay in the construction of water and sewage projects.

2- Data concerning identifying frequency and extent of delay and the important causes of delay measured by their frequency and severity, in water and sewage construction projects.

The first type of data will be gathered through a review of literature dealing with delay in construction projects, especially the causes of delay in water and sewage construction projects in Saudi Arabia. The second type of data will be obtained by a field survey for frequency and extent of delay and frequency and severity of the causes identified in the literature review to determine the importance of the causes.

3.2 THE SURVEY

3.2.1 Questionnaire Development and Design

The questionnaire was developed based on the research objectives for collecting the field data for this study. The literature review established the basis for the questionnaire development. Some questionnaire forms appropriate to this study from other studies were reviewed. Al-Hazmi (1987) developed a questionnaire for the importance of causes of delay, Al Mutauwaa (1988) developed a questionnaire for the causes of change orders, and Al Subaie (1987) developed a questionnaire for the importance of causes of claims. The questionnaire for this study was developed according to the required data from the field survey. The causes of delay identified in chapter (2) are considered in the questionnaire.

The questionnaire was carefully designed to achieve the research objectives. It consists of an introduction and three parts, A, B, and C. The introduction gives a description of the survey, its purpose and objectives, and provides basic definitions. Part (A) is related to general information

about only two of the parties, the contractors, and the consultant engineers only, since it is not applicable to government authorities. The respondents were requested to answer general information pertaining to their classification and experience in construction. A copy of the questionnaire is shown in appendix A.

Part (B) includes the list of the potential causes of delay in water and sewage construction projects. For each cause there are two main questions, one for measuring the frequency of occurrence and the other for measuring the degree of severity of each cause. Both the frequency and severity are based on a five - point scale.

Part (C) deals with the frequency and extent of delay in water and sewage construction projects to evaluate the frequency and extent of delay in this type of project. This part includes two groups of questions. The first group of questions is to the contractors and the second group will be for all parties, contractors, owners, and consultants. The first group of questions is concerned with the extent of delay experienced in the delayed projects. This will be to the contractors only, since they are more involved

and concerned in the delay problems, and to avoid duplication of data from the other parties for the same delayed projects. Also, it is easier to extract the data required from the contractors because of the limited number of projects for each contractor. The consultant engineers are requested to report their experience in delay for projects that they supervised, which are normally large and medium projects, to evaluate frequency of delay in these projects.

The first group of questions relates to the frequency of delay in the completion of water and sewage construction projects in the contractor's experience only. This includes four questions concerning overall frequency of delay in such projects, including number of projects completed, number of projects subjected to delay, number of projects for which time extensions were requested, and number of projects for which time extensions were approved.

The second group of questions is for all parties. This includes three questions concerning the overall extent of delay in this type of project, in the experience of the owner, the contractor, and the consultant.

The first question is for measuring the average percentage of delay time in the projects that experienced delay. The second is for measuring approximately the percentages of involvement of the parties in the delay. The third question asks the parties requested to list the five most important causes of delay in order of importance from their experience with delay.

In addition to part (C), in order to evaluate the actual extent of delay in those delayed projects, the contractor is requested to report the actual time performance for a random sample of some completed delayed projects. There is a table for project time performance. The contractors are requested to select randomly five delayed projects completed in the last ten years. In the time performance table, the actual duration will be compared with contract duration, time extension requested, time extension given, and contract value for these projects. This will be used to identify the actual extent of delay, and the type of delay, either excusable or nonexcusable according to the time extension requested by the contractor and the time extension approved for him.

The questionnaire was translated into Arabic to make it understood and clear. It was distributed by mail to the Water & Sewage Authorities concerned, consultant engineering offices, and contractors. The general managers or executive managers of the respondent's organization are requested to determine the most appropriate key personnel to answer the questionnaire. Also, the respondents are requested to write their comments concerning open questions at the end of each part.

3.2.2 Sample Size Determination & Selection

The total population covered in this research is composed of three stratums: the owners (Water & Sewage Authorities), consultant engineers (the supervisor), and contractors working in water and sewage construction projects within the defined scope of this study.

Selection of the sample from the total population will be as follows:

1- The owners. These are Water And Sewage Authorities which are located in the Eastern province and Riyadh province, and their

branches in the main cities of the two provinces. Since these authorities are of a limited number, their sample will be 100% used in this survey. These branches were identified by direct contact with the head offices of these authorities. There are 6 branches in the Eastern Province, and 4 different areas in Riyadh province.

2- The consultant engineering offices operating in the Eastern and Riyadh provinces classified by the Ministry of Municipal & Rural Affairs in water and sewage works, which performed supervision of such projects. These offices were identified by direct contact and in coordination with Water and Sewage Authorities in the two provinces. Since the number of these offices is limited also, the sample will be 100% used in this survey. There are 20 consultant engineering offices which were identified. Those performed supervision for projects in the two provinces.

3- The contractors operating in the Eastern and Riyadh provinces, classified in the construction of water and sewage works, according to the Government Classification System .

The contractors were identified from the Contractors Directory published by the chamber of commerce and the directory of classified contractors in the field of water and sewage works, that was published by the Ministry of Housing & Public works. The list of classified contractors in the water and sewage works includes about 450 contractors in different regions in Saudi Arabia classified in five grades. The highest grade is number one. In the contractor directories, there are about 200 contractors classified that are working in public water and sewage construction projects in the Eastern Province and Riyadh province. This will be the total sample population of the contractors. The sample size will be determined by using the following formula:

$$n = (t_s / d)^2 / (1 + (t_s / d)^2 / N) \qquad \text{Eq. 3.1}$$

Where :

n = sample size.

N = sample population = 200

t_s : $t\alpha/2$ is the abscissa of the normal curve that cuts off an area of $\alpha = 0.05$ at the tails.

$t\alpha / 2 = 1.96$ from statistic Table.

d : is the expected error in the estimate. The mount of accuracy (1 - α) % = 0.05 for 95% confidence interval.

S : pq , p = 0.50 and q = 1 - p = 0.50 ; maximum standard deviation in proportion of estimation.

Therefore, the sample size is calculated through the iteration process to determine a reasonable sample size for the survey as follows :

$n = (t_s/d)^2 / (1 + (t_s/d)^2 / N)$

$n = (1.96 * 0.50 / 0.05)^2 / (1+(1.96 * 0.50 / 0.05)^2 / 200)$

$n = 131.56$

$n = 131.56 / (1 + 131.56 / 200) = 79.35$

$n = 79.35 / (1 + 79.35 / 200) = 56.88$

$n = 56.88 / (1 + 56.88 / 200) = 44.30$

$n = 44.30 / (1 + 44.33 / 200) = 36.25$

$n = 36.70 / (1 + 36.70 / 200) = 30.70$

$n = 30.70 / (1 + 30.70 / 200) = 26.60$

$n = 26.60 / (1 + 26.60 / 200) = 23.48$

$n = 23.48 / (1 + 23.48 / 200) = 21.02$

Since the difference becomes smaller, the sample size is 21 contractors. Usually in such a study the response rate to the questionnaire

will not be high, so it is assumed that 30% of the questionnaires mailed will be replied to. Then the sample size will be about 70 contractors.

The questionnaire was actually sent to a sample of 80 deferent classified contractors selected at random as contractors in different classifications proportional to the total number of contractors in each classification according to the directory of classified contractors. In approximately two months, after sending the questionnaire for a second time to most of them, with follow up by telephone, a total of 23 contractors only replied by mail or through personal collection. This number is within the expected percentage of replies for such questionnaires. Also the questionnaire was sent to 20 consulting engineering offices, by direct contact with most of these offices. Only 12 consultant offices replies, which is a suitable number for this study. By direct contacts with Water and Sewage Authorities in the Eastern and Riyadh provinces, a total of 10 questionnaires were returned from different branches, 6 in the Eastern province, and 4 in Riyadh province. So, there are 23 contractors, 12

consultant engineers, and 10 water and sewage authorities that participated in the questionnaire.

3.3 SCORING SYSTEM

For part (B) of the questionnaire on causes, a 5 point scale is used to establish a quantitative measure of the frequency and severity of the causes.

The values in the scale for the frequency and the severity will be as shown in Table 3.1 and Table 3.2.

TABLE 3.1 : Frequency Scale

i_f	OPTION	Weight (A_{if})
1	Always	4
2	Often	3
3	Sometimes	2
4	Never	1
5	Do not know	--

$$N = X_1 + X_2 + X_3 + X_4 + X_5$$

TABLE 3.2 Severity Scale

i_S	Option	Weight (Ai_S)
1	Very severe	4
2	Severe	3
3	Somewhat severe	2
4	No effect	1
5	Do not know	--

The frequency index (F.I.) and severity index (S.I.) of each cause will be calculated by the following formula :

$$F.I. = \sum_{i=1}^{5} (Ai_f * Xi_f) / (n * 4) * 100 \qquad \text{Eq. 3.2}$$

$$S.I. = \sum_{i=1}^{5} (Ai_S * Xi_S) / (n * 4) * 100 \qquad \text{Eq. 3.3}$$

Ai = Constant expressing the weight assigned to option (i) on the frequency and the severity scales, as shown in Table 3.1 and Table 3.2.

Xi = Variable expressing number of respondents who selected option (i).

N = Total Number of respondents.

n = $N - X_5$

Then the importance index (IMP.IND.) will be calculated by the following formula:

IMP. IND. % = (F. I . * S. I .) * 100 Eq. 3.4

An example is given for illustration of this scoring:

Consider cause No 5 (Shortage of manpower). Assume the following answers:

Occurrence Frequency		Degree of Severity	
Option i_f	Respondents Xi_f	option i_s	Respondents Xi_s
Always	8	Very severe	4
Often	6	Severe	6
Sometimes	9	Somewhat	8
Never	4	No effect	12
Do not know	3	Do not Know	0

Total respondents N = 30

n = 30 - X_5

F.I. = (8*4 + 6*3 + 9*2 + 4*1 + 3*0) / (27* 4)*100 = 66.66%

S.I. = (4*4 + 6*3 + 8*2 + 12*1 + 0*0) / (30*4)*100 = 43.33 %

Then ;

IMP.IND.% = (F.I. * S.I.) * 100 = (00.6666 * 00.4333) 100 = 28.88%

Part (C) consists of the questions about frequency and extent of delay. No scoring is needed. In the first group, statistics for total projects in which the contractor experienced delays is to be obtained by calculation of percentages of projects delayed, projects where time extension was requested, projects where time extension was approved, and the average extent of delay in these projects. For the second group, there are general questions for the overall extent and causes of delay. No scoring is needed. Statistics with the respondent's comments on the extent, the involvement of the parties in the delay, and the most important causes of delay will be summarized.

3.4 CORRELATION

Correlation is a measure to express the relationship existing among different parties or factors and the strength and direction of the relationship. In this research it is used to show the degree of agreement or disagreement between the different parties, the contractors, the consultants, and the owners.

The correlation coefficient (r) varies between a value of +1 and -1, where +1 implies a perfect positive relationship (agreement), while -1 results from a perfect negative relationship (disagreement). It might be said then that sample estimates of correlation coefficient close to unity in magnitude imply good correlation, while values near zero indicate little or no correlation (Walpole & Myers 1978).

The rank correlation coefficient is used to provide a numerical index of the relation between two ranks for each party among the respondents. There are three rank correlation methods suitable for determining the relationship among the parties concerned in this study. These methods are Spearman's correlation, partial correlation, and multiple correlation. These

methods of correlation measure the extent to which two lists of ranks relate to each other. The results will indicate the degree of agreement or disagreement between the parties on the importance of the causes of delay. The rank correlation will be used also to test the hypothesis of agreement on the importance ranking of the causes between the parties.

1- Spearman's Rank Correlation: The Spearman's rank correlation coefficient is used to measure and compare the association between the ranking of two parties for a single cause of delay, while ignoring the ranking of the third party.

2- Partial Rank Correltion: Partial rank correlation is used to measure and compare association between two parties, while holding the third party constant. It is calculated as a function of the Spearman's rank correlation coefficient.

3- Multiple Rank Correlation: Multiple rank correlation is used to measure and compare the extent of association between one party and the other two. The multiple rank correlation is also calculated as a function of Spearman's rank correlation coefficient.

CHAPTER 4

DATA ANALYSIS AND RESULTS

This chapter presents and discusses the results of the survey data collected and its analysis. It consists of description of the respondents, descriptive statistics of the data, the results concerning delay in public utility projects and causes of delay, which present and describe frequency, extent, and responsibility of the delay, and frequency, severity, and importance of the causes and sources of delay. The ranking of the causes of delay will be determined, as well as the rank correlation, and the hypothesis of agreement on ranking between the parties will be tested. Then the most important causes and general comments reported by the respondents are presented.

4.1 DESCRIPTION OF THE RESPONDENTS

This section presents the description of the respondents who participated in the questionnaire which included 23 contractors, 12 consultant engineers, and 10 water and sewage authorities. These authorities are located in the Eastern Province and Riyadh Province. The questionnaire

was answered by project department managers, branch managers, or chief engineers in these authorities, who had a long experience in this type of project, mostly more than ten years experience.

The contractor's experience consists of two parts, the experience of the company, and the experience of the individual respondent. It is found that 65% of the contractor firms have experience of more than 10 years, but most of the respondents (95%) have experience of more than 10 years. Table 4.1 presents the contractor's experience.

The respondent contractors work in different regions, but mainly in the Eastern Province and the Riyadh Province. The contractor's regions of operation are shown in Table 4.2. Out of a total of 23 contractors, 20 contractors work in the Eastern Province, 9 work in Riyadh Province, and 13 work in other provinces. Most of the contractors work in more than one region.

The contractors are classified based on type of construction and grades. Table 4.3 presents the data related to the participating contractor grades in water and sewage construction. The classification in the

TABLE 4.1 CONTRACTOR'S EXPERIENCE IN CONSTRUCTION

EXPERIENCE IN YEARS	COMPANY EXPER.		RESPONDENTS EXPER.	
	NO. OF CONTRACTORS	%	NO. OF CONTRACTORS	%
< 5	3	13	0	0
5 – 10	5	22	2	5
10 – 15	7	30	8	36
> 15	8	35	13	59
TOTAL	23	100	23	100

TABLE 4.2 GEOGRAPHICAL AREAS FOR CONTRACTORS OPERATIONS

REGION OF OPERATION		
PROVINCE	NO. OF CONTRACTORS	% OF TOTAL
EASTREN WITH OTHERS	20	87%
RIYADH WITH OTHERS	8	35%
WESTERN	8	35%
NORTHERAN	2	9%
SOUTAHERN	2	9%

TABLE 4.3 CONTRACTOR'S CLASSIFICATION IN WATER AND SEWAGE CONSTRUCTION PROJECTS

CLASSIFICATION	CLASSIFICATION GRADE					TOTAL
	1	2	3	4	5	
NO. OF CONTRACTORS	2	5	6	3	7	23
% OF THE TOTAL	8.7	21.8	26.2	13.1	30.2	100

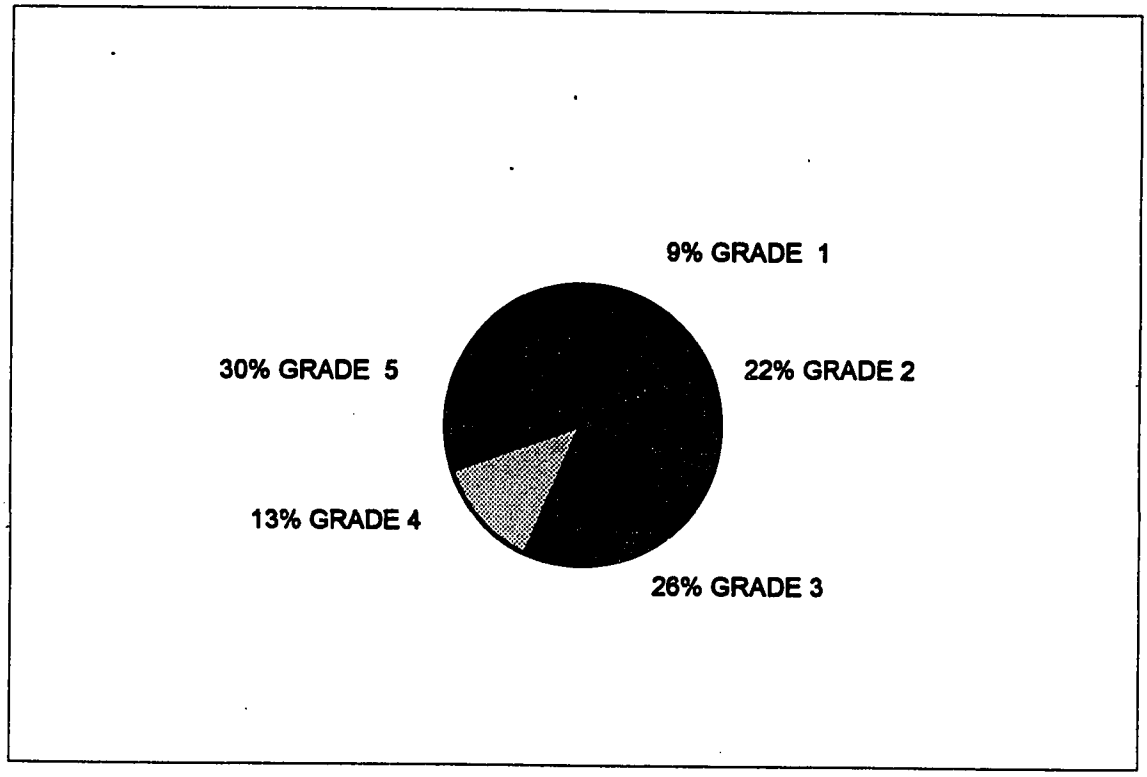


FIGURE 4.1 CONTRACTOR'S CLASSIFICATIONS

government classification system for contractors is divided into 5 grades. The highest grade is number one. The 23 contractors who participated in the questionnaire consist of two contractors in grade 1, five in grade 2, six in grade 3, three in grade 4, and seven in grade 5. This indicates a reasonable distribution of the sample. Twenty one of the contractors have classifications in the other construction fields, mainly buildings, roads, and mechanical & electrical work, as shown in Table 4.4.

Similarly the consultants also operate in the Eastern Province, Riyadh Province, and other regions 10 of them are operating in the Eastern Province, 6 in Riyadh Province, and 6 in other regions. Some of them work in more than one region. All the consultants had more than ten years experience and supervised different public utility projects.

4.2 DELAY IN PUBLIC UTILITY PROJECTS

In this section, the results concerning frequency, extent, and responsibility of delay in the construction of public utility projects are presented and discussed.

TABLE 4.4 CONTRACTORS CLASSIFIED IN OTHER TYPES OF CONSTRUCTION

OTHER TYPES OF CONSTRUCTION CLASSIFICATION	NO. OF CONTRACTORS					TOTAL
	1	2	3	4	5	21
GENERAL	2	1	3	0	3	9
BUILDINGS	2	4	6	2	2	16
ROADS	1	3	3	0	2	9
MECH. & ELEC.	2	4	5	1	3	15
DAMS	1	1	0	0	1	3
INDUSTRIAL	0	1	0	0	1	2

4.2.1 Frequency of Delay

Seventeen contractors reported to have completed a total of 161 projects. The contractors experienced delay in 60 of these projects. The projects were classified according to the contractor classification grades, as shown in Table 4.5. It was found that, the delayed projects were about 40%, 16%, 47%, 56%, and 24% for the contractor classification grades 1, 2, 3, 4, and 5 respectively, with an overall average of 37%. The variation in these percentages is probably due to a number of factors that are associated with the projects not to the contractors classification, since the contractors may construct different sizes of projects in different construction environments within their classification grade. These factors may include size of the project, site conditions, and the construction environment of the projects.

Time extension was requested in all the delayed projects reported, and the extension was approved partially or completely for 87% of the projects. This could indicate that the owner accepts at least partial responsibility for the delay.

TABLE 4.5 FREQUENCY OF DELAYS IN PUBLIC CONSTRUCTION PROJECTS

FACTOR	CONTRACTOR'S CLASSIFICATION GRADE					TOTAL
	1	2	3	4	5	
NO. OF CONTRACTORS	2	4	4	3	4	17
NO. OF PROJECTS COMPLETED	25	38	45	32	21	161
NO. OF PROJECTS DELAYED	10	6	21	18	5	60
% OF PROJECTS DELAYED	40	16	47	56	24	37
NO. OF PROJECTS EXTEN. REQUESTED	10	6	21	18	5	60
% OF PROJECT WERE EXTENS. REQUESTED	100%	100%	100%	100%	100%	100%
NO. OF PROJECTS WERE EXTENSIONS APPROVED	8	5	20	17	2	52
% OF PROJECTS WERE EXT. APPROVED	80	83	95	94	40	87

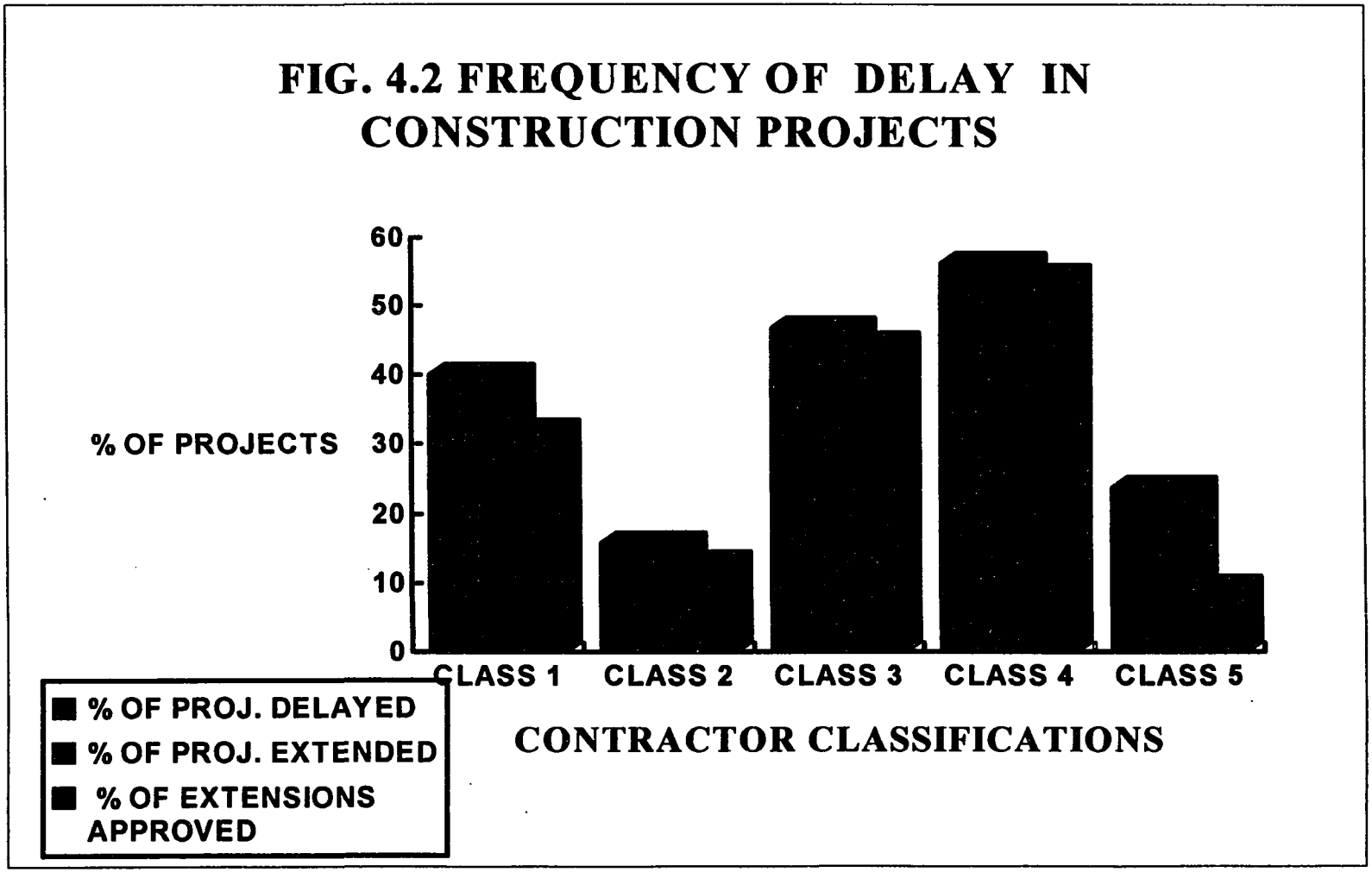


FIGURE 4.2 FREQUENCY OF DELAY IN CONSTRUCTION PROJECTS

The frequency of delay in the construction projects was reported also by the consultant engineers. Table 4.6 presents the frequency of delay in those projects. The consultants reported 89 projects, those they supervised in different regions. It was found that 84% of these projects were delayed; 88% in the Eastern province, 91% in Riyadh, 72% in other regions, indicating that frequency of delay in these projects is nearly the same in all the regions.

These projects normally are medium and large projects, since the government authorities assign consultant engineers to supervise only large and medium size projects, those normally have a contract value more than 10 Million S.R. Thus, it seems that there is a frequent delay in this type of project, especially in large and medium size projects. This delay is because the large and medium projects are associated with many problems that eventually cause delay in these projects.

It is noticed that there is big difference in the overall frequency for all projects reported by the contractors and the frequency for those projects supervised by the consultants. This difference is probably because different

TABLE 4.6 FREQUENCY OF DELAY BY THE CONSULTANT

FACTOR	SUPERVISION REGION			
	EASTERN	RIYADH	OTHERS	TOTAL
NO. OF PROJECTS SUPERVISED	41	23	25	89
NO. OF PROJECTS DELAYED	36	21	18	75
% OF DELAYED PROJECTS	88%	91%	72%	84%

projects reported by each, and the contractors may include some projects which are operation & maintenance projects or those small contracts have a value less than 1 Million S.R.

4.2.2 Extent of Delay

The extent of delay in public projects are presented as an overall extent of delay reported by all the construction parties and as actually reported by the contractors. Overall extent is presented in Table 4.7. The average extent of delay in a project reported was 35%, 41.66%, and 41.66% of the project duration in the opinion of the contractor, the consultant, and the owner respectively, with an overall average of 38.59% for all. The parties seem to agree to nearly the same percentage of extent of delay. The extent of delay is quite high, indicating generally that severe delays occurred in these projects. This finding supports the problem statement of this research.

The actual extent of delay was reported by 12 contractors for 35 completed projects that experienced delay. The projects had a construction duration from 6 to 49 months, and a contract value ranging from 3 million

TABLE 4.7 OVERALL EXTENT OF DELAY BY THE THREE PARTIES

PROJECT	CONTRACTORS		CONSULTANTS		OWNERS		ALL PARTIES	
EXTENT OF DELAY	NO.	%	NO.	%	NO.	%	NO.	%
LESS THAN 10 %	5	28	0	0	1	11	6	15
10 TO 30 %	4	22	6	50	1	11	11	28
30 TO 50 %	5	28	2	17	5	56	12	31
50 TO 100 %	3	17	4	33	2	22	9	23
OVER 100 %	1	5	0	0	0	0	1	3
TOTAL	18	100	12	100	9	100	39	100
AVERAGE EXTENT OF DELAY %	35%		41.66%		41.66%		38.59%	

Note: 5 contractors, and 1 owner did not answer this part.

SR. to 581 million SR. These projects were completed in the last ten years (from 1984 to 1993). Table 4.8 shows the actual extent of delay for these projects, classified according to their contract duration in to four categories: 12 months and less, 12 to 24 months, 24 to 36 months, and more than 36 months.

The results show actual duration compared with original contract duration to obtain the extent of delay, and the time extensions requested compared with time extension approved. Average extent of delay percentages calculated show an average of 57.77% for all projects reported. The small projects that had duration of 12 months and less experienced severe delay (143%), while large and medium projects experienced an average delay of 30.61 % to 42.97% of original duration. This indicates that the small projects experienced severe delay more than the other projects, because it seems that the duration time for construction of small projects is very tight and the projects face many problems that cause mostly certain long delay in construction of these projects.

TABLE 4.8 EXTENT OF DELAY FOR COMPLETED PROJECTS

CONTRACT DURATION	PROJECTS NO.	PROJECTS %	TOTAL DURATIONS	ACTUAL DURATIONS	AVERAGE % OF DELAY	EXTENTS. REQUESTED	AVER. % OF DELAY	EXTENTS. APPROVED	AVER. % OF EXTS.
0 - 12 M.	9	26	86	209	143	123	100	31*	25
13 - 24 M.	18	51	384	549	43	137	83	108	79
25 36 M.	7	20	234	366	56	132	100	118	89
> 36 M.	1	3	49	64	31	15	100	9	60
TOTAL	35	100	753	1188	58	407	94	266	65

NOTES :

ALL DURATIONS IN MONTHS.

AVERAGE % OF TIME EXT. REQUESTED = TIME EXT. REQUESTED / ACTUAL DELAY TIME

AVERAGE % OF TIME APPROVED = TIME EXT. APPROVED / TIME EXT. REQUESTED.

* IN SOME PROJECTS, TIME EXT. CASES NOT APPROVED AND STILL BENDING WITH THE OWNER.

12 CONTRACTORS REPORTED THESE PROJECTS MENTIONED ABOVE THAT HAVE BEEN COMPLETED DURING LAST TEN YEARS WITH A CONTRACT VALUE RANGE FROM 3 MILLIONS TO 581 MILLIONS S.R.

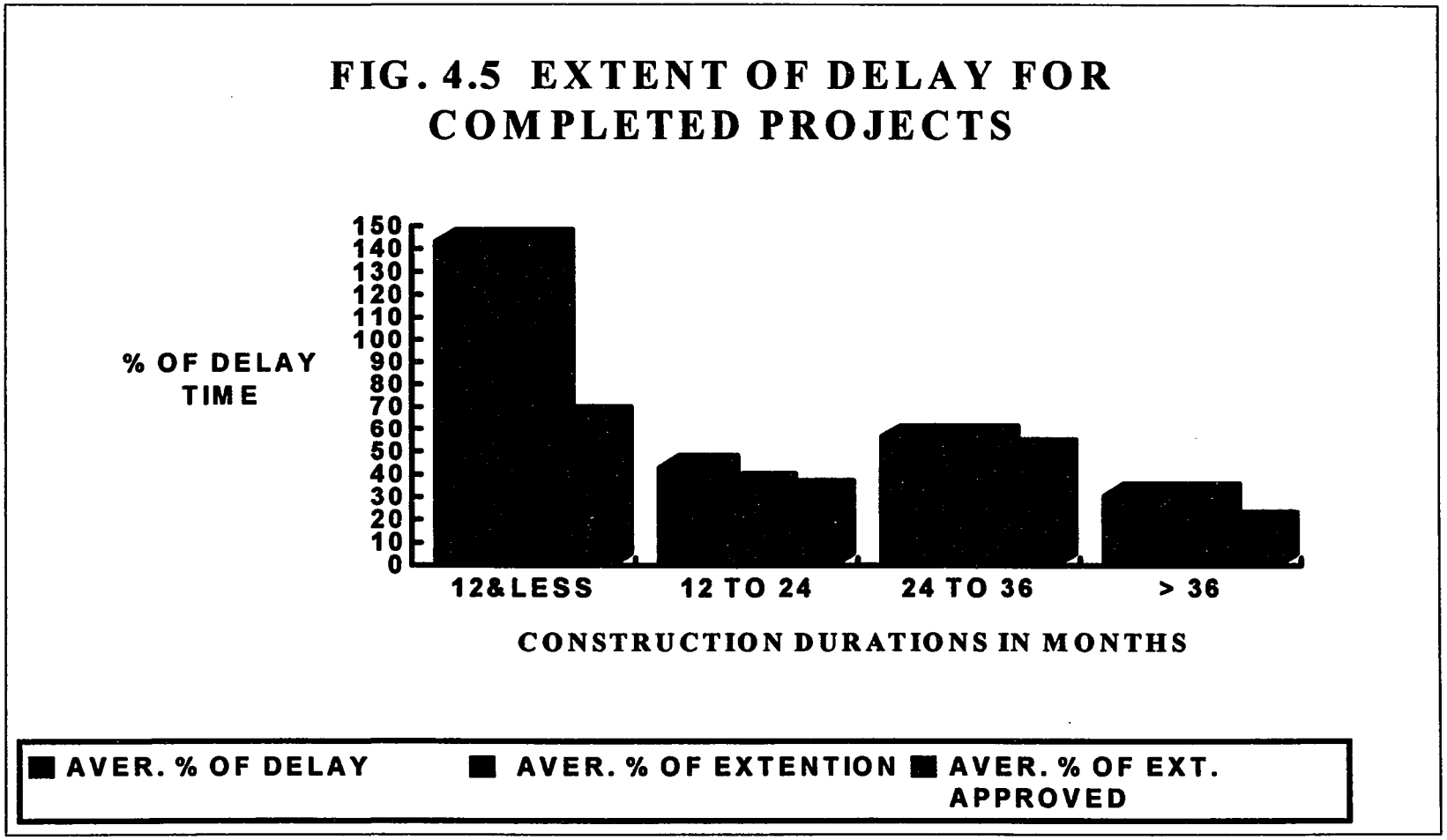


FIGURE 4.3 EXTENT OF DELAY FOR COMPLETED PROJECTS

A time extension was requested for the total amount of delay for almost all the delayed projects. It was found that 65% of the time extensions requested was already approved for the contractors, while some cases were still pending because the time extension takes a long time to approve according to Government formal procedures, and while awaiting the owner's decision. The high number of approved requests for time extension indicates that projects experienced mostly excusable delay. It is noticed that the actual extent of delay for completed projects was somewhat close to the overall extent of delay found in Table 4.6 by the three parties.

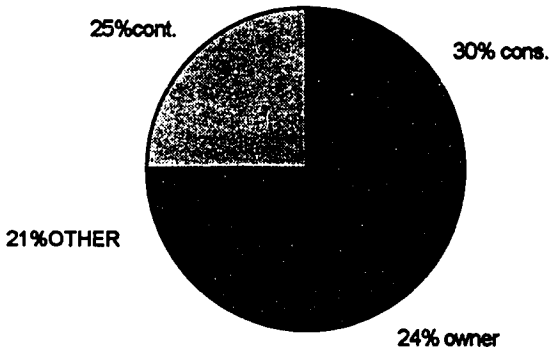
4.2.3 Responsibility for the Delay

Respondents were asked to assign to each of the parties a percentage of responsibility for the delay. The results are shown in Table 4.9. Each party assigned percentage of responsibility for each of the parties involved, then these parties were ranked according to these percentages. The contractor assigned the highest responsibility to the owner (30%), while the owner and the consultant assign the highest responsibility to the contractor (57% & 52%). The overall average of all parties shows that the contractor

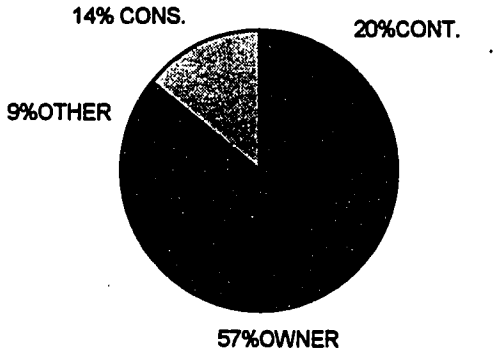
TABLE 4.9 AVERAGE RESPONSIBILITY OF THE PARTIES FOR PROJECT DELAY

RESPONSIBILITY OF	CONTRACTORS		CONSULTANTS		OWNERS		AVERAGE	
PARTIES IN DELAY TIME	%	RANK	%	RANK	%	RANK	%	RANK
OWNER	30	1	20	2	15	3	22	2
CONTRACTOR	24	3	57	1	52	1	44	1
CONSULTANTS	21	4	9	4	12	4	14	4
OTHERS	25	2	14	3	21	2	20	3
TOTAL %	100		100		100		100	

BY THE CONTRACTOR:



BY THE CONSULTANT:



BY THE OWNER:

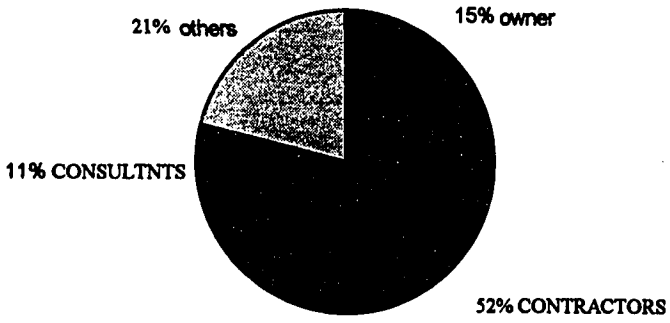


FIGURE 4.4 RESPONSIBILITY OF THE PARTIES IN THE DELAY

carries the highest responsibility (44%), second the owner (22%), then third others (20%), and finally the consultant (14%).

It is noticed that although the owner is ranked the second responsibility for the delay, the responsibility of the consultant and others actually transfers to the owner. So, the owner is considered as the prime party responsible for the delay in such projects, since he carries most of the responsibility.

4.3 CAUSES AND SOURCES OF DELAY

The questionnaire provided respondents with a set of causes of delay, for which they were to assign frequency of occurrence and degree of severity. The following sections presents and discusses the results concerning the frequency, and severity of the causes, then describes the importance of the causes and the sources groups of these causes based on their frequency and severity index. Ranking of the causes and the sources are described, as well as the rank correlation and the testing of the hypothesis of agreement on the ranking.

4.3.1 Frequency and Severity of the Causes

The frequency and severity of the causes are measured by the scores given to each cause by the respondents as described in Sec. 3.4 (Scoring system). Statistical techniques are used to analyze and interpret the collected data concerning the frequency and the severity scores of the causes of delay. Both of these scales are 5-point scale ranging between zero and four. These techniques will include calculations of weighted means, standard deviations, standard error, coefficient of variation, and confidence intervals. SAS on the mainframe computer at KFUPM was used to calculate these variables.

The results of the calculations of these statistical variables for the frequency and the severity scores are shown in Appendix (B). It is found that the mean of the frequency is in the range of 1.36 to 2.80 on the frequency scale, and the mean of the severity is in the range of 1.33 to 3.16 on the severity scale. The standard deviation is in the range of 0.56 to 1.20 for the frequency, and 0.64 to 1.47 for the severity. The standard error is in the range of 0.08 to 0.18 for the frequency, and 0.10 to 0.22 for the severity.

The confidence level used in this study is 95%. This means that 95% of the sample taken contains the actual mean of the universe population.

The coefficient of variation is in the range of 28% to 67% for the frequency, and in the range of 28.63% to 77.56% for the severity. It is noticed that the variability is somewhat large. The severity scores have larger variations than the frequency scores, and these variations are considered somewhat large. The data may be considered homogenous when the coefficient of variation is less than 10%, and acceptable if it is not more than 20%. So, the data concerning the frequency and severity of the causes for the three parties are considered somewhat unhomogenous.

The variability in the data collected for the frequency and severity of the causes is somewhat large because of differences in the nature and period of experience of the respondents, and the responsibility and interest of each party to the project, which affect their responses. The responsibility and the interest of the contractor is different from those of the other two parties, the owner and the consultant. The contractor is involved in construction of the project directly, while the consultant is involved in the supervision, and the

owner is involved in the administration. Each faces different problems in different projects. The variations in the responses of each party alone become slightly less than the variation for all the respondents of the three parties.

The frequency and severity of a cause is determined as an average of the reported frequency and severity of all the respondents. Specifically they are calculated as a frequency and severity index as shown in sec 3.4 (Scoring System). The frequency index and severity index are calculated for all the causes for each individual party, contractor, consultant, and owner. The frequency and severity indices are presented in Appendix C with the importance index of the causes for each party.

4.3.2 Importance of the Causes of Delay Within Each Group

The importance index of a cause of delay was calculated as the product of the frequency and the severity index of the cause. The importance index is translated to a standard form with a base of 100 for relative comparison in the ranking tables. The importance index of the causes are presented in Appendix C for each individual party; owner,

consultant, and contractor, and in aggregate form for all parties. This aggregate index was computed as the mean of the importance index of all parties for each cause.

It was found that the importance index of the causes by the contractor were in the range of 12.48 - 61.86%, by the consultant in the range of 9.03 - 60.94%, and by the owner in the range of 10.71- 61.63%. It is noticed that the three parties assign approximately same range for the importance index of the causes.

As shown in the importance index and ranking tables shown in Appendix C, each party considered many causes as important causes of delay; however, they agreed on the importance of some of those causes, and differed with regard to some other causes. Table 4.10 presents the standard importance index and ranking of the causes of delay as an average of the importance index of the causes assigned by the three parties.

The causes of delay are combined into six major groups related to their sources as presented and described in chapter two. The results of the importance index of these causes will follow the same organization of these

TABLE 4.10 STANDARD RANK AND IMPORTANCE INDEX

RANK	NO.	CAUSE OF DELAY	import index
1	28	Cash flow problems faced by the contractor.	56.62
2	47	Difficulties in obtaining work permits from the authorities concerned.	51.35
3	27	Difficulties in financing the project by the contractor.	49.85
4	37	Delay in progress payments by the owner.	45.72
5	48	Low performance of the lowest bidder contractor in the government tendering system.	45.71
6	21	Ineffective planning and scheduling of the project by the contractor.	42.01
7	51	Effect of subsurface conditions.	41.64
8	20	Improper technical study of the project in the bidding stage by the contractor.	41.61
9	17	Delay in mobilization to start the project.	40.52
10	42	Changes in the scope of the project	37.34
11	9	Shortage of manpower.	36.85
12	25	Delay in the preparation of contractor submittals	35.85
13	31	Delay in the settlement of contractor' s claims by the owner.	35.75
	41	Excessive bureaucracy in the owner administration.	
14			35.74
15	23	Ineffective control of the project progress by the contractor.	35.57
16	14	Poor coordination by the contractor with the parties involved in the project.	35.41
17	43	Ambiguities, defaults, and inconsistency of specifications, and drawings.	34.11
18	45	Original contract duration too short.	33.27
19	12	Shortage of technical professionals in the contractor's organization .	32.16

Continued .....

TABLE 4.10 STANDARD RANK AND IMPORTANCE INDEX

RANK	NO.	CAUSE OF DELAY	import index
20	34	Delay in making decisions by the owner within a reasonable time.	31.63
21	33	Delay in issuance of change orders by the owner.	31.16
22	2	Delay in materials delivery.	30.93
23	5	Shortage of equipment required.	30.36
24	29	Subcontractor problems with the contractor.	30.32
25	10	Low skills of manpower.	30.14
26	39	Insufficient coordination by the owner in the early planning & design stages of the project.	29.96
27	46	Ineffective delay penalty.	29.94
28	1	Shortage of materials required.	29.93
29	19	Poor qualifications of the contractor's technical staff	29.87
30	24	Inefficient quality control by the contractor.	29.72
31	56	Delay in approvals of contractor submittals by the engineer.	29.08
32	52	Trafic control and restrictions on the job site.	28.82
33	38	Poor communications by the owner with the construction parties involved	28.76
34	22	Delay in the field survey done by the contractor.	28.73
35	13	Poor communication by the contractor with the parties involved in the project.	28.59
36	6	Failure of equipment.	27.93
37	40	Poor coordination by the owner with the construction parties involved.	27.23
38	55	Poor qualification of supervision staff of the consultant engineer.	26.67
39	32	Suspension of work by the owner.	25.89
40	58	Poor coordination by the consultant engineer .	25.84

Continued .....

TABLE 4.10 STANDARD RANK AND IMPORTANCE INDEX

RANK	NO.	CAUSE OF DELAY	import index
41	57	Poor communication by the consultant engineer.	25.75
42	15	Slow preparation of change orders requests by the contractor.	25.43
43	26	Improper construction method implemented by the contractor.	25.39
44	60	Slow response to the contractor inquiries at the job site by the consultant engineer.	25.03
45	16	Ineffective contractor head office involvement in construction of project.	24.85
46	30	Delay in furnishing and delivering the site to the contractor by the owner.	23.93
47	35	Interference by the owner in the construction operation phases.	23.67
48	44	Differing site conditions.	23.43
49	54	Interference with other contractor's work.	32.21
50	59	Delay in performing inspection and testing by the consultant engineer.	22.90
51	7	Shortage of supporting and shoring installations for excavations.	21.83
52	4	Changes in materials specifications.	20.99
53	18	Loose safety rules and regulations within the contractor's organization.	20.89
54	11	Shortage of contractor's administrative personnel.	20.59
55	3	Changes in materials prices.	19.38
56	36	Uncooperative owner with contractor.	18.45
57	8	Inadequate equipment used for the works.	17.17
58	50	Severe weather conditions on the job site.	16.29
59	49	Changes in government regulations and laws.	13.35
60	53	Effect of social and cultural conditions.	12.91

groups to describe and discuss the importance of the causes in each individual group. It will focus on the important causes that each party considered, and describe and discuss the agreement and differences in the importance of these causes.

The causes are evaluated according to their importance index, it is considered that causes which have an importance index of more than or equal to 50 are considered very important, causes with 40 to 50 are important, causes with 30 to 40 are somewhat important, causes with 20 to 30 are slightly important, and those of less than 20 are not important.

1- Contractor's Performance

The contractor is an important party for project time performance. Many of the causes of delay relate to the contractor's performance. These causes are given high ranks in the importance index by the owner and the consultant, while the contractor considered them of low importance. Understandably, the contractor assigns low importance to those causes related to his performance, and tries to transfer the responsibility of these

causes to other parties involved, especially the owner. The causes number 1 to 29 presented in Table 4 . 10 are related to contractor performance.

The most important causes are the difficulties in financing the project by the contractor, and cash flow problems. The consultant and the owner agreed on the importance of these causes. The contractor also considered these problems as very important causes, but as a result of the delay in the progress payments, which he ranked highest in the importance index. The contractor claimed that delay in progress payments made difficulties in financing the project, and caused cash flow problems, while the other two parties agreed with him to some extent. Both claim that the contractor's financial capability is also a reason behind these problems.

Improper technical study of the project in the bidding stage by the contractor is considered also as a very important cause of delay by both the owner and the consultant, because this cause contributes mainly to the contractor's performance during the construction stage. The contractor should study the construction environment of the project, and plans for the

project and prepare estimates of resources required in the bidding stage, to assure the completion of the project on time.

Other important causes considered by the owner and / or the consultant are ineffective planning & scheduling and progress control of the project by the contractor, delay in mobilization to start construction, and shortage in manpower. Other causes considered as somewhat important with some variations in the importance index include delay in preparation of contractor's submittals, shortage of technical professionals, poor qualifications of the contractor technical staff, poor coordination with the parties involved, and delay in materials delivery respectively. These causes are a part of contractor resources, and project management, which form the contractor capabilities.

Other causes of delay related to the contractor's performance are considered as slightly or very low in importance by all the parties. Generally, financial problems faced by the contractor, low performance of project management, and shortage of manpower & materials are the important causes of delay that are related to the contractor.

2- Owner's Administration

The causes number 30 to 41 in Table 4.10 are related to owner administration. Among the most important causes related to owner administration is the delay in progress payments by the owner, which all the parties agree on, including the owner himself. The contractor assigns the highest rank to this cause, as mentioned above, while the owner considered it somewhat important, and the consultant considered it important. This difference is expected, because of the difference in the experience of the respondents and the responsibility and interest of each of these parties as mentioned previously, but in general all parties agreed that this cause is an importance.

Other very important causes are delays in settlement of contractor's claims by the owner, delays in issuance of change orders, and delays in making decisions by the owner within a reasonable time. It can be noticed that these causes interfere with each other, which is a result of the excessive bureaucracy in the Government Administrations. Excessive bureaucracy was also considered as a very important cause by the contractor, while the owner

considered this cause as somewhat important, and above three causes: delays in settlement of claims, issuance of change orders, and making decisions were all slightly important. This difference is also expected, because of the involvement of the owner in these causes due to the long and routine procedures that delay approvals, and decisions by the government authority, and then obstruct progress of construction, which may delay completion of the project.

Insufficient coordination in the early planning and design stages, and poor communications during construction by the owner, both are considered as important causes by the contractor. The owner and the consultant considered them low in importance. This is because both are involved in these problems, especially the consultant who is normally the planner and designer of the project, or works as a supervisor.

Other causes are given a lower important index by all parties as shown in the ranking tables in Appendix C, with some variations in importance ranking between the contractor and other two parties. Generally, delays in payments, approvals, and decisions due to excessive bureaucracy

in the government administration are important causes of delay. Poor coordination and communications are considered somewhat important.

3- Early Planning & Design

The planning and design of any project are very important. Both contribute to the project time performance, and to project performance in general. The planning and design of a project provide a sound basis for effective control.

For water and sewage construction projects, the routes of pipelines and locations of pumping stations should be approved by the municipalities and other concerned government authorities during the planning and design stages. This requirement is necessary to avoid any obstruction with regard to existing public utilities or private lands, to apply these authorities regulations and requirements concerning reinstatement of asphalt, and to provide protection of existing utilities. The owner and consultant engineer must coordinate, in the early planning and design stages, with these authorities to avoid problems that may occur during construction, especially those related

to work permits. The causes number 42 to 45 in Table 4 . 10 are related to the planning and design of the project.

Among the important causes related to poor planning and design of the project are changes in the scope, or changes due to ambiguities, faults, and inconsistencies in the specifications and drawings. The contractor considered changes in scope as an important cause, while all parties considered changes due to ambiguities, faults, and inconsistencies in specifications and drawings as somewhat important. These changes are important causes because they consume a long time for corrections and modifications during the construction, and then time is required for approval measures of change orders.

Other important causes related to the planning and design stage are short original duration, and differing site conditions. The contractor and consultant considered short duration as somewhat important. The owner considered it slightly important. The consultant and the owner considered differing site conditions not important. This is because they do not face this problem directly on the site as the contractor does. As mentioned in the

previous section, poor or absent coordination in the early planning and design stages with concerned authorities could create these problems, which need changes in scope, design and specifications and could make difficulties in obtaining work permits from these authorities.

Generally, changes in the project due to incomplete planning and design, and short original project duration are somewhat important causes of delay.

4- Government Regulations & Policies

The causes number 46 to 49 presented in Table 4.10 are related to government regulations and policies. The government regulations and policies are associated with bureaucracy in the procedures and measures for obtaining work permits from those authorities. As mentioned previously, difficulties in obtaining work permits from concerned authorities is one of the important causes related to other government authorities. It was considered as very important by the contractor and the owner, while the consultant considered it important. This is likely because both the contractor and the owner are involved more directly with obtaining work

permits from these authorities. This problem could be as a result of poor coordination in the early planning and design stages, as mentioned earlier, low contractor's performance, or restrictions and problems with the local municipalities.

All the three parties agree on the importance of the lowest bidder selection method in the government tendering system as a cause of delay. The contractor and the owner considered this cause as an important cause that affects project time performance. The consultant considered it as very important. This is expected. It is important because, as mentioned previously, the contractor performance is generally an important factor that affect project time performance, and may create delay problems.

Ineffective delay penalty is considered as an important cause by the owner, while the other two parties considered it as of slight important. This is because the government authorities suffer from long delayed projects. The delay penalty sometimes does not give incentive to the contractor to complete the project in the shortest possible time, especially for long delay

times. Changes in government regulations and laws is considered as slightly important by all three parties.

In general, difficulties in obtaining work permits is an important cause of delay. It is one of the major problems that the contractor faces during construction. So, there should be some control over those measures for obtaining work permits. Low performance of lowest bidder is also an important factor in project time performance, while the ineffective delay penalty is only somewhat important.

5- Site & Environmental Conditions

The causes number 50 to 54 presented in Table 4.10. are related to site and environmental conditions. Effects of subsurface conditions (existent utilities, high water table, etc.) is considered among the important causes by the contractor and the consultant, while the owner considered it somewhat important. Both the contractor and the consultant face many problems associated with excavations and trenching for pipelines and pumping stations. They face this problem on the site directly more than the owner. That is why they gave a higher importance index to this cause.

Other causes are considered as slightly or not important by the two parties. The contractor considered traffic control at the site only as somewhat important, because he is directly affected by this problem. The traffic control requires the contractor to provide safety precautions on site, in public roads and streets. Other causes are considered as slightly important causes by all the parties. Generally, the effect of subsurface conditions is an important cause of delay, especially if the contractor did not provide adequate temporary installations for excavations at the site.

6- Supervision and Field Inspection

Causes number 55 to 60 presented in Table 4.9 are related to supervision and field inspection. The contractor considers all causes related to the consultant engineer as somewhat important. Among those causes are delay in approvals of contractor's submittals, and poor qualification of supervision staff. Both the consultant and the owner considered these causes slightly important or not important. In general the contractor feels that he faces some problems with supervision staff, which may affect the work progress.

4.3.3 Importance of the Sources of Delay

There are six major groups related to the sources of delay as mentioned previously. The importance of the sources of delay are presented to evaluate the importance of these sources and their ranks. The overall importance index of these groups of causes are calculated according to their aggregate index to present the relative importance for these groups. These groups can be ranked according to the aggregate importance index of the causes in each group. Table 4.11 presents the importance index and ranks of these groups by each of the three parties. Generally, the cause groups are ranked as follows:

1- Early planning & design of the project.

2- Government regulations & laws.

3- Contractor performance.

4- Owner administration.

5- Supervision and field inspection.

TABLE 4.11 OVERALL IMPORTANCE INDEX AND RANKS OF GROUPS OF CAUSES OF DELAY

NO	CAUSES OF DELAY GROUP	IMPORTANCE INDEX AND RANK BY										
		CONTRACTOR			CONSULTANT			OWNER			AVERAGE	
		TOTAL	AVR. IMP.IND.	RANK	TOTAL	AVR. IMP.IND	RANK	TOTAL	AVR. IMP.IND	RANK	AVR. INDEX.	RANK
	CONTRACTOR'S PERFORMANCE SUBGROUPS :											
	A - Materials.	102.03	26	2	100.5	25	5	101.2	25	4	25	4
	B - Equipment.	77.42	19	5	111.5	28	4	102.8	26	5	24	5
	C - Manpower.	88.54	22	3	135.3	34	3	135.3	34	3	30	3
	D - Project Management.	290.62	19	4	556.3	37	2	547.3	36	2	31	2
	E - Financial & Cash Flow problems.	86.73	43	1	115.4	58	1	117.3	59	1	53	1
1	CONTRACTOR'S PERFORMANCE	645.34	22	6	1019	35	1	1004	35	2	31	3
2	OWNER ADMINISTRATION	493.67	41	1	266.3	22	5	313.8	26	4	30	4
3	EARLY PLANNING & DESIGN	142.35	36	4	118.7	30	3	159.3	40	1	35	1
4	GOVERNMENT REGULATIONS &LAWS	144.27	36	2	120.5	30	2	123.4	31	3	32	2
5	SITE ENVIROMENTAL CONDITIONS	145.65	29	5	114.8	23	4	108.2	22	6	25	6
6	SUPERVISION AND FIELD INSPECTION	213.88	37	3	102.7	17	6	149.3	25	5	26	5
	AVERAGE IMPORTANCE INDEX	2430.5	41		2760	46		2862	48		45	

6- Site environmental conditions.

As can be seen in Table 4.11, generally there are some variations in the importance index and the ranking of these groups, especially between the contractor and the other two parties. The owner and the consultant generally agreed on the importance of contractor performance, owner administration, and site and environmental conditions. Both are very close in their responses to some of these groups, while there are some variations in their responses to the importance of planning & design of the project, and supervision and field inspection, because the consultant is more involved in these tasks. Also, there are big variations in the importance index between the contractor and the consultant, mainly in the contractor performance, owner administration, and supervision & field inspection. These variations are because of difference in experience of respondents and responsibility and interest of each party as discussed previously.

The early planning & design group is considered generally as the most important group, because the causes of delay of this group contribute

effectively to project performance in general, and project time performance specifically.

Government regulations and the laws group of causes is considered the second important group of causes. This is because it includes, first, difficulties in obtaining work permits from concerned authorities, which is considered as a very important cause of delay, and second, low performance of the lowest bidder in the government tendering system, where it is considered as an important cause of delay. All three parties generally considered these causes as important causes of delay.

The contractor performance group was divided into subgroups as shown in the Table 4.11. Among the important causes related to the contractor are the financial and cash flow problems, as mentioned earlier. These causes are considered the highest important causes by the three parties, where they are given the highest ranks. There are some variations in the importance of the other causes. Generally, the other important subgroups according to their importance ranks are project management, manpower, materials, and equipment respectively.

The other groups, which include owner administration, supervision and field inspection, and site and environmental conditions, are ranked fourth, fifth, and sixth respectively, with wide variations between the contractor and other two parties. Although the owner administration is considered by the contractor as the most important group of causes, there is a big difference in the importance index and rank with owner and the consultant. This variation is also attributable to the difference in experience of the respondents, and the responsibility and interest of each party.

4.3.4 Ranking of the Causes and Sources of Delay

The causes were ranked according to their importance indices by each party. The importance and ranking tables in Appendix C present the ranking of the causes by each individual party. Table 4.12 presents the standard importance index and ranks of the causes by the three parties and Table 4.11 presents the importance index and ranks of the sources of delay.

It is noticed that there are big variations in the ranking of most of the causes and also in the sources of delay by the three parties as described in

TABLE 4.12 IMPORTANCE INDEX AND RANKS OF CAUSES OF DELAY

NO.	CAUSE OF DELAY	IMPORTANCE INDEX AND RANK BY					
		CONTRACTOR		CONSULTANT		OWNER	
		IMP.IND.	RANK	IMP. IND	RANK	IMP. IND.	RANK
1	Shortage of materials required.	25.99	30	30.99	25	32.81	24
2	Delay in materials delivery.	30.98	26	31.64	23	30.19	31
3	Changes in materials prices.	22.33	42	17.81	47	18.00	55
4	Changes in materials specifications.	22.73	41	20.05	43	20.19	52
5	Shortage of equipment required.	20.27	49	36.69	16	34.13	21
6	Failure of equipment.	22.87	39	29.30	28	31.63	26
7	Shortage of supporting and shoring installations for excavations.	20.20	50	27.23	32	18.06	54
8	Inadequate equipment used for the	14.28	59	18.23	46	19.00	53
9	Shortage of manpower.	25.99	31	39.06	14	45.50	7
10	Low skills of manpower.	23.55	36	35.24	19	31.63	25
11	Shortage of contractor's adminisrative personnel	17.01	56	21.01	40	23.75	44
12	Shortage of technical professionals in the contractor's organization.	21.99	43	40.10	12	34.38	19
13	Poor communication by the contractor with the parties involved in the project.	23.91	35	31.60	24	30.25	28
14	Poor coordination by the contractor with the parties invloved in the project.	24.31	33	44.41	9	37.50	11
15	Slow preparation of change orders by the contractor.	21.27	45	24.83	35	30.19	29
16	Ineffective contractor head office. involvement in construction of project.	17.66	55	23.87	36	33.00	22
17	Delay in mobilization to start construction of the project.	24.43	32	50.00	5	47.13	6
18	Loose safety rules and regulations within contractor's organization.	12.48	60	27.69	31	22.50	47
19	Poor qualifications of the contractor's technical staff.	17.72	54	41.71	10	30.19	30
20	Improper technical study of the project in the bidding stage by the contractor.	21.38	44	51.13	4	52.31	5
21	Ineffective planning and scheduling of project by the contractor.	23.16	38	48.44	7	54.44	4
22	Delay in the field survey done by the contractor.	20.27	48	29.17	29	36.74	13

Continued .....

TABLE 4.12 IMPORTANCE INDEX AND RANKS OF CAUSES OF DELAY

NO.	CAUSE OF DELAY	IMPORTANCE INDEX AND RANK BY					
		CONTRACTOR		CONSULTANT		OWNER	
		IMP.IND.	RANK	IMP. IND	RANK	IMP. IND.	RANK
23	Ineffective control of the project's progress by the contractor.	20.46	46	45.75	8	40.50	10
24	Inefficient quality control by the contractor.	16.95	57	36.46	17	35.75	16
25	Delay in the preparation of contractor submitals.	19.23	52	51.56	3	36.75	12
26	Improper construction method implemented by the contractor.	16.94	58	32.23	22	27.00	37
27	Difficulties in finanncing the project by contractor.	39.45	13	54.43	2	55.69	3
28	Cash flow problems faced by the contractor.	47.28	5	60.94	1	61.63	1
29	Subcontractor problems with the contractor.	22.73	40	35.24	20	33.00	23
30	Delay to furnish and deliver the site to the contractor by the owner.	29.35	28	20.46	42	22.00	50
31	Delay in the settelment of contractor's cliams by the owner.	53.02	3	29.30	27	24.94	42
32	Suspension of work by the owner.	32.35	24	19.35	45	26.00	40
33	Delay in issuance of change orders by the owner.	39.64	12	24.96	34	28.88	32
34	Delay in making decisions by the owner in a reasonable time.	41.84	10	28.13	30	24.94	43
35	Interference by the owner in the construction operation phases.	37.69	16	17.32	49	16.00	56
36	Uncooperative owner with the contractor.	28.35	29	11.57	58	15.44	57
37	Delay in progress payments by the owner.	61.86	1	39.06	13	36.25	14
38	Poor communications by the owner the construction parties involved	43.21	9	17.19	50	25.88	41
39	Insufficient coordination by the owner in in the early planning & design stages	44.62	7	16.41	54	28.88	33
40	Poor coordination by the owner with the construction parties involved	36.32	18	16.49	52	28.88	34

Continued .....

TABLE 4.12 IMPORTANCE INDEX AND RANKS OF CAUSES OF DELAY

NO.	CAUSE OF DELAY	IMPORTANCE INDEX AND RANK BY					
		CONTRACTOR		CONSULTANT		OWNER	
		IMP.IND.	RANK	IMP. IND	RANK	IMP. IND.	RANK
41	Excessive bureaucracy in the owner administration.	45.42	6	26.04	33	35.75	17
42	Changes in the scope of the project.	40.84	11	35.24	21	35.94	15
43	Ambiguities, defaults, inconsistency of specifications and drawings.	37.48	17	30.47	26	34.38	20
44	Differing site conditions.	30.89	27	16.90	51	22.50	48
45	Original contract duration is too short.	33.14	22	36.11	18	30.56	27
46	Ineffective delay penalty.	24.27	34	21.69	39	43.88	8
47	Difficulties in obtaining work permits from the authorities concerned.	57.04	2	39.02	15	58.00	2
48	Low performance of the lowest bidder in the government tendering system.	43.39	8	50.00	6	46.75	9
49	Changes in government regulations and laws.	19.57	51	9.77	59	10.71	60
50	Severe weather conditions on the job site.	20.35	47	16.49	53	12.04	58
51	Effect of subsurface conditions.	48.38	4	41.54	11	35.00	18
52	Trafic control and restrictions on the job site.	35.09	21	23.87	37	27.50	36
53	Effect of social and cultural	18.59	53	9.03	60	11.11	59
54	Interference with other contractor's work.	23.24	37	23.87	38	22.50	49
55	Poor qualification of supervision staff of the consultant engineer.	39.28	14	17.36	48	23.38	45
56	Delay in the approval of contractor submittals by the engineer.	38.28	15	20.83	41	28.13	35
57	Poor communication by the consultant engineer.	36.28	19	14.84	56	26.13	39
58	Poor coordination by the consultant engineer.	35.59	20	15.67	55	26.25	38
59	Delay in performing inspection and testing by the consultant engineer.	31.31	25	14.01	57	23.38	46
60	Slow response to the contractor at the job site by the consultant	33.14	23	19.97	44	22.00	51

the previous section, especially between the contractor and the other two parties, the consultant and the owner.

4.3.5 Rank Correlation

The rank correlation was calculated as a function of difference in ranks given to the causes by the parties. The formulas used and calculations of the Spearman's, the partial, and the multiple rank correlation are presented in Appendix D. Table 4.13 summarizes the rank correlation values.

TABLE 4.13 SUMMARY OF CORRELATION VALUES

SPEARMAN	PARTIAL	MULTIPLE
$r_{cs} = 0.01$	$r_{cs.o} = -0.27$	$r_{c.so} = 0.33$
$r_{co} = 0.20$	$r_{co.s} = 0.33$	$r_{s.co} = 0.84$
$r_{so} = 0.82$	$r_{so.c} = 0.84$	$r_{o.cs} = 0.84$

r_{cs} = The Spearman's rank correlation coefficient between the contractor and the consultant engineer.

r_{co} = The Spearman's rank correlation coefficient between the contractor and the owner.

r_{so} = The Spearman's rank correlation coefficient between the consultant engineer and the owner.

$r_{cs.o}$ = The partial rank correlation representing level of agreement between the contractor and the consultant.

$r_{co.s}$ = The partial rank correlation representing level of agreement between the contractor and the owner.

$r_{so.c}$ = The partial rank correlation representing level of agreement between the consultant and the owner.

$r_{c.so}$ = The agreement between the contractor and other two parties, the consultant and the owner.

$r_{s.co}$ = The agreement between the consultant and other two parties, the contractor and the owner.

$r_{o.cs}$ = The agreement between the owner and other two parties, the contractor and the consultant.

The rank correlation between the parties shows that the agreement between the owner and the consultant is high (r_{so} = 0.82), while the agreement between the consultant and the contractor approaches zero (r_{cs} = 0.01). There is only a little agreement between the contractor and the owner (r_{co} = 0.20) in the ranking of the causes. This is because of the adversarial nature of the relationship between owner and contractor, and the difference

in responsibility and interest of each party. As mentioned previously, each party has his own interest.

It is noticed that the agreement between the owner and the consultant is the highest because the consultant works as a representative of the owner, who carries no liability towards the owner as a result of this relationship. The agreement between the contractor and the other two parties is low, specially with the consultant. There is an almost total lack of agreement between the consultant and the contractor. This is because normally there is a conflict of interest between the two.

The partial correlation shows also that the agreement between owner and consultant when the contractor is held constant is the highest ($r_{so.c}$ = 0.84). The contractor and the consultant have a negative correlation ($r_{cs.o}$ = - 0.27), and agreement between the contractor and the owner is ($r_{co.s}$ = 0.33). Both the owner and the consultant have low agreement with the contractor.

The above correlation results are emphasized by the multiple correlation, where the highest correlation ($r_{o.cs}$ = 0.84) is when the owner is

considered with the two parties, while the contractor has the least ($r_{c.so}$ = 0.33) with other two parties.

4.3.6 Test of the Hypothesis of Agreement on Ranking

According to the objectives of the study, testing is required for the hypothesis that the contractor, the consultant engineer, and the owner generally agree on the ranking of the importance of the causes of delay.

The null hypothesis states that "the contractor, the consultant, and the owner do not agree on the ranking of importance of the causes of delay". The null hypothesis will be tested by comparing the calculated values of (t) with a critical (t) value. The following equation is used for calculating (t) values (Snedecor & Cochran 1980) :

$$t = \sqrt{r^2 (n - 2) / (1 - r^2)} \qquad \text{Eq. 4 . 1}$$

where :

t = calculated t - statistic

r = rank correlationcoefficient;Spearman's correlation partial correlation, or multiple correlation, found in Table 4 . 13.

n = number of observations = 60

Decision rule :

If the calculated (t) value is less than a critical (t) value, then the null hypothesis can be accepted. Otherwise it is rejected.

The critical (t) value is equal to 1.645 for a 95% confidence level and 58 degrees of freedom (n - 2).

Then calculated (t) values can be determined by applying equation 4.3 above, using the r values in Table 4.13. The results are presented in Table 4.14.

TABLE 4 . 14 t - TEST VALUES

SPEARMAN	PARTIAL	MULTIPLE
$t_{cs} = 0.06$	$t_{cs.o} = 2.15$	$t_{c.so} = 2.67$
$t_{co} = 1.52$	$t_{co.s} = 2.67$	$t_{s.co} = 11.58$
$t_{so} = 10.79$	$t_{so.c} = 11.59$	$t_{o.cs} = 11.91$

Conclusion:

According to the calculated values of (t) as shown in Table 4.14, it is noticed that the values are less than the critical value in Spearman's correlation when the contractor becomes one of the parties to the correlation, which means that there is no agreement between the contractor and the other two parties. The remaining values are all greater than the critical value. Therefore, the null hypothesis is accepted, and the hypothesis is rejected. So, the parties generally disagree on the ranking of the importance of causes of delay. Only the consultant and the owner generally agree on the importance ranking of the causes of delay.

4.4 MOST IMPORTANT CAUSES BY THE RESPONDENTS

The respondents were requested to list the 5 most important causes of delay in order of importance based on their experience in such types of projects. All the respondents mentioned many different causes, from their point of view and their experience of delay. The causes were ranked according to responses given for these causes by the respondents of each

party. Among the most frequent important causes reported by each party are the following:

Causes By The Contractor:

1- Delay in payments and cash flow problems.

2- Difficulties in obtaining work permits from concerned authorities.

3- Changes in specifications, design, and scope of the project.

4- Delay in decisions, and settlement of contractor claims by the owner.

5- Delay in materials delivery.

6- Poor coordination & communication by the owner in the early stages of the project.

7- Obstructions and difficulties in site conditions.

8- Low performance of some contractors.

9- Delay in furnishing and delivering the site to the contractor.

10- Short duration of some projects.

Causes By The Consultant:

1- Delay in payments and financial problems.

2- Low performance of the contractor.

3- Delays in obtaining work permits from concerned authorities.

4- Awarding to the lowest, unrealistic bidders.

5- Delay in material delivery, and shortage in manpower and equipment.

6- Changes in specifications and drawings.

7- Delay in decisions and settlement of contractor claims by the owner.

8- Poor planning and scheduling of the project by the contractor.

9- Poor coordination and communication between the parties involved.

10- Obstruction in subsurface conditions, and technical problems at the site.

11- Supervision problems.

12- Delay in mobilization.

13- Excessive bureaucracy and routine in owner administration.

Causes By The Owner:

1- Difficulties in obtaining work permits from concerned authorities.

2- Delay in payments and cash flow problems.

3- Delay in materials delivery, and shortage in contractor capabilities.

4- Changes in site conditions, and changes in design and specifications.

5- Poor coordination by the owner in the planning and design stages.

6- Poor coordination by the contractor .

7- Unprofessional technical staff of the contractor.

8- Improper technical study in the bidding stage by the contractor.

9- Short project duration in some cases.

10- Ineffective delay penalty.

Table 4. 15 summarizes these causes and their ranking by the three parties. It is noticed that all the three parties generally agree on most of these important causes, but differ in their ranking, and each did not mention some of these causes. These important causes are similar to those important causes mentioned in Sec. 4.3.2. The three parties agree only on 5 important

TABLE 4.15 SUMMARY OF MOST IMPORTANT CAUSES AND THEIR RANKS BY THE RESPONDENTS

SERIAL NO.	CAUSE OF DELAY	RANK BY		
		CONTR.	CONS.	OWNER
1	Delay in progress payments, financial, and cash flow problems	1	1	2
2	Difficulties in obtaining work permits from the authorities concerned.	2	3	1
3	Changes in the specs., drawings, site conditions, and scope of the project	3	7	4
4	Delay in making decisions, and settelement of contractor's claims by the owner	4	8	–
5	Delay in materials delivery.	5	5	3
6	Poor coordination by the owner in the early planning & design stages of the project.	6	–	5
7	Poor coordination and communications between the parties involved in the projects	–	10	6
8	Obstructions and difficulties at the site	7	11	–
9	Low performance of some contractors	8	2	–
10	Delay to furnish and deliver the site to the contractor by the owner.	9	–	–
11	Short duration for some projects.	10	–	9
12	Awarding to the lowest, unrealistic bidders	–	4	–
13	Poor planning and scheduling of the project by the contractor	–	9	–
14	Improper technical study of the project in bidding stage by the contractor.	–	–	8
15	Delay in mobilization to start the project.	–	13	–
16	Shortage of some contractor's resources	–	6	–
17	Excessive bureacracy in the owner adminis.	–	14	–
18	Shortage of technical professional staff of the contractor	–	–	7
19	Ineffective delay penalty.	–	–	10
20	Supervision problems	–	12	–

causes, and other causes were mentioned either by two or one of them with difference in their ranking.

At the end of Part (B), the respondents were requested to write any other important causes. Nine contractors mentioned other causes, but almost all of these causes were restatements of causes already in the questionnaire. Two consultants mentioned some important causes. These are involvement of the owner to complete the project on time, incomplete bids, and the past experience of the contractor. The owner did not mention any additional causes.

4.5 GENERAL COMMENTS BY THE RESPONDENTS

Some respondents commented in general at the end of the questionnaire. Many contractors, some consultants, and two government authorities wrote these comments. The contractor comments mainly confirm the most important causes in their experience, and refer to some important points, which should be taken into consideration by the parties concerned to avoid delay in such projects. These causes and points are summarized in the following list :

1- Award the project to a professional experienced contractor, not to the lowest bid even it is unrealistic or unstudied.

2- Assure obtaining work permits by the owner before site delivery and start the construction, and these permits should be issued with faster measures.

3- Assure handover of site to the contractor at start of construction.

4- Place water and sewage projects construction under one authority with road construction.

5- Contractor performance and his relations with other parties are considered as one of the main causes of delay.

6- Timely progress payments are very important for the contractor's financial capability and cash flow, and eventually contribute to project progress.

7- Lack of cooperation between the construction parties is an important cause of delay, and the owner decisions take a longer time than is necessary.

8- There should be a top government authority to coordinate between the Government Authorities concerned in public utilities to control issuance of work permits.

9- Excessive routine in government administration has a severe effect on project progress.

10- Planning & scheduling are important tasks that contribute to the time performance of the project. The contractor should take care about these tasks.

11- Assuring cooperation between the parties as a work team with direct coordination will contribute positively to the project progress.

12- One of the contractors mentioned this statement " The power of right should be stronger than the right of power between the owner and contractor". It seems that the contractor faces excessive bureaucracy with some of government authorities.

13- Preliminary studies and planning of the project are very important for the performance of the project. Considerations should be taken of the design and construction, especially those related to the site conditions and permits.

14- The causes mentioned do not occur in all projects. Each project has its environment, and there are some force majeur causes, so, each project is delayed by different causes.

15- Some respondents propose to announce the results of this research to the parties concerned to take necessary precautions to reduce and control causes of delay in such projects.

CHAPTER 5

SUMMARY, FINDINGS AND CONCLUSIONS, AND RECOMMENDATIONS

This chapter presents the summary of this research, with the major findings and conclusions from the results obtained and recommendations that could be given in light of the conclusions.

5.1 SUMMARY OF THE RESEARCH

This thesis discussed the delay in public water and sewage construction projects in Saudi Arabia. It studied the frequency and the extent of delay, and the importance of the causes of delay based on their frequency and severity. This research is a field survey research through a structured questionnaire directed to contractors, consultants, and owners who are the water and sewage authorities in the Eastern and Riyadh provinces. In the second chapter, types and causes of delay especially those related to utility projects were presented and described, with laws and regulations associated

with the delay and applications of delay penalties in public construction projects. Sixty causes were identified, described, and combined into six major groups related to their sources.

The field survey conducted included 23 contractors, 12 consultant engineering offices, and 10 water and sewage authorities. The questionnaire developed had three parts: one part for general information about the respondents, the second related to the respondent's opinion on frequency and severity of the causes, and the third related to the respondent's opinion on frequency and extent of the delay. The importance index was calculated for the causes as a function of their frequency and severity. SAS was used to calculate and present the importance index and ranking of the causes by the three parties according to their importance index.

A hypothesis that the parties generally agree on the ranking of the causes was tested by the rank correlation coefficient. It was concluded that the parties did not agree on the importance ranking of the causes. Only the owner and consultant generally agreed on the importance ranking of the causes.

The major findings related to the frequency and extent of delay, and the important causes of delay in such projects are presented in the following sections, then conclusions of the research are presented and the recommendations are given in the light of the major findings from the results obtained.

5 . 2 - FINDINGS AND CONCLUSIONS

In this section, the major findings and conclusions from the results are presented and discussed. The section will focus on the major findings related to frequency and extent of delay, and the important causes of delay in such projects.

5.2.1 - Frequency Of The Delay

Based on the results obtained and discussed, it was found that frequent delays in this type of project ocurr especially in large and medium size projects which have a contract value more than 10 million S.R. and which are normally supervised by the consultant engineers. It was also found that time extension was requested by the contractor in all those

delayed projects, and that time extensions were approved partially or completely in most of the delayed projects.

5.2.2 - Extent Of The Delay

The extent of delay obtained in the experience of all parties and by the contractors for actual delayed projects shows that the extent of the delay was severe, specially in small projects which have a construction duration of 12 month or less. It is also found that the time extension approved in those delayed projects was a high percentage of the time extension requested. Most of these delays are considered as excusable delays, and are granted by the owner. This shows that the owner is the prime party responsible for the delay in such projects.

It is noticed that the time extensions were more severe in small projects (duration 12 months and less) than medium and large projects (more than 12 months). It seems that the large and medium size projects normally experienced frequent delay more than small projects, while the small projects suffered a greater extent of delay than the other projects.

5.2. 3 - Important Causes Of The Delay

There are many causes that are considered important by one or more of the three parties. The important causes which have an importance index more than 30 according to the aggregate (standard) importance index assigned to these causes are presented to summarize the important causes. The causes are as follow :

1 - Difficulties in financing the project, and cash flow problems are given the highest importance among the other causes. These are caused mainly by delays in progress payments by the Government Authorities. These causes generally affect most of the other causes related to the contractor performance.

2 - Difficulties in obtaining work permits from the concerned authorities is considered a very important cause of delay, which obstructs the progress of such type of projects. This problem may arise due to low performance of the contractor, poor or no precoordination with concerned authorities, or difficulties and restrictions in procedures and measures required for obtaining work permits from these authorities, especially if no

coordination has been done in the planning and design stages of the project for approvals of routes and locations of utility lines.

3 - Effective government authority involvement and efficient administration during construction are very important to the project time performance and project performance in general. There are many causes that result from inefficient involvement and administration, especially those affecting directly contractor performance. Delay in making decisions, delay in settlement of contractor's claims, and delay in issue of change orders are the most important causes of delay. These causes a result of excessive bureaucracy and routine in the Government Authorities administration which is given very high rank in the importance index by all the parties with some difference to some extent.

4 - The early planning & design stages, and studies of the project are very important to the performance of the project. Most of changes that cause delays during construction result from poor planning and design of the project. The studies should take under consideration all the site conditions, avoid ambiguities, faults, and inconsistencies in

specifications and drawings, coordination with government authorities concerned, and determine a reasonable project duration. So, the project or engineering departments in Water And Sewage Authorities must be careful in planning and design stages about these matters to avoid delays that may occur and improve the project performance.

5 - In general, low contractor's performance in construction and management is a very important factor that effects the project time performance, which causes many problems that may lead to delay in progress and then in completion of the project. Among the most important measures of the contractor performance that contribute to the time performance are shortage in contractor resources, availability of professional technical staff, and planning, scheduling & control of work progress.

6 - Lack of or poor coordination and communications between the construction parties, and with other parties involved, are also important causes that create some problems, which lead to delay in progress. All the parties should make continuous coordination and direct

communication to avoid those problems that may arise during the construction.

7 - All parties refer to awording to the lowest bidder only as a very important factor that influences contractor performance and causes delay. In general, the lowest unrealistic and unstudied bid does not allow for a good project performance.

8 - Subsurface conditions, site obstructions, and traffic control have some effect on the progress of the project, and may cause delay, especially if incomplete precautions and temporary installations are not done for these existing conditions.

9 - Supervision by a consultant engineer with a non-professional technical staff could make some problems and create a conflict between the consultant and the contractor, which may obstruct the progress. Close involvement of the owner will avoid these problems.

It is noticed that the owner's involvement, planning and design of the project, and the contractor's low performance are the main sources of causes of delay in construction of water and sewage projects.

The correlation results and hypothesis testing show that generally there is agreement between the government authorities (the owner) and the consultant engineer (the supervisor) on the importance ranking of the causes, while there is almost no agreement between the contractor and the owner, nor the consultant engineer in the importance ranking of causes of delay. This could be expected due to the difference in the experience of the respondents and the responsibilities of the parties.

5.3 - RECOMMENDATIONS

5.3.1 - General Recommendations

Based on the conclusions identified previously, in the light of results obtained from this research, the following points can be recommended:

1 - It is strongly recommended that the Government Authorities consider the progress payments for the contractors according to project duration,

work progress, and thier being within the available budget for the project.

2 - It is recommended to restudy the Government Tendering System that is based on awarding to the lowest bidder only, awarding to be for a qualified contractor through a restricted prequalification system.

3 - It is suggested that the contractors give more attention to the planning and scheduling process, providing required resources, and control of work progress.

4 - It is recommended that the government authorities are advised to take care more in the planning and design stages of the project, give enough time for studies and design, define the scope accurately, investigate site conditions, review specifications and drawings, updating for the design if it is old, assign qualified consultant engineers to perform the design, be sure that the site is furnished and free of any obstructions or conflict with existing utilities, and coordinate with concerned government authorities, especially the municipalities, to avoid changes, and difficulties in obtaining work permits.

5 - It is recommended that the Government Authorities establish a set of standard procedures with clear measures, for effective project management and administration, to avoid the excessive bureaucracy and routine in government administration.

6 - It is recommended that the government authorities improve their involvement during the construction, follow up on the progress, and make necessary decisions, and approvals in a the reasonable time.

7 - It is recommended that care must be given by all construction parties to continuous coordination and direct communication between all the parties involved, and with other government aauthorities concerned during construction, to avoid those problems that may arise and take a long time to settle, which mostly cause delay in the progress and the completion of the project.

8 - It is suggested that the government authority consider the performance of the consultant engineer who supervise construction of projects.

9 - It is suggested that clear clauses be included in the conditions of contract to control delay, such as requesting planning and scheduling of the

project with the bid to conform the contractor capability to perform the project.

5.3.2 - Recommendtions For Further Studies

The following can be recommended for further studies in the field of this research:

1 - Similar type of research can be done for other parts of Saudi Arabia.

2 - Parallel research can be done for other types of public projects.

3 - Study methods for evaluating the time extensions in public projects can be done.

4 - A research can be done for analysis of actual delay cases.

5 - Actual causes of delay for completed projects can be investegted.

6 - The effect of the planning and scheduling process on the delay can be studied.

7 - The associated cost of delay in public projects can be studied.

APPENDIXES

(A) QUESTIONNAIRE FORM (ENGLISH & ARABIC VERSION)

(B) TABLES FOR STATISTICAL VARIABLES CALCULATIONS

(C) IMPORTANCE AND RANKING TABLES

(D) CORRELATION CALCULATIONS

APPENDIX (A)

QUESTIONNAIRE FORM (ENGLISH & ARABIC VERSION)

KING FAHD UNIVERSITY OF PETROLEUM & MINERALS
COLLEGE OF GRADUATE STUDIES

CONSTRUCTION ENGINEERING & MANAGEMENT DEPARTMENT

QUESTIONNAIRE

ON

" CAUSES OF DELAY IN PUBLIC UTILITY PROJECTS IN SAUDIA ARABIA "

Dear Mrs. :

I am a graduate student at king Fahd Univeristy of Petroleum & Minerals in Dhahran, I am now preparing a master thesis in the Construction Engineering and Management Program .
The title of the thesis is :

"CAUSES OF DELAY IN PUBLIC UTILITY PROJECTS IN SAUDI ARABIA "

The scope of this thesis will be limited to water and sewage construction projects . This questionniare is a survey of the frequency and severity of causes of delay and the extent of delay in public water and sewage construction projects in Saudi Arabia .

As you are one of the organizations working in this field, your participation in filling this questionnaire with the requied data is an important element in this research and offering valuable results for all .

We appreciate your cooperation in answering this questionnaire, which may take about 30 minutes of your valuable time .

All data will be analyzed as whole, and will be used for the purposes of scientific research only .

Please fill out this questionnaire and return it as soon as possible, but we would respectfully ask you to do that before 30 / 7 / 1994 .
Use either of the following addresses :

Dr. Mohammad A. AL khaleel . OR Eng. Mohammad A. Al Ghafly
KFUPM . P. O. 426 WASA. P.O. 4650
Dhahran : 31261 Dammam : 31198

Thanks for your cooperation .

Advising Professor Researcher

Dr. Mohammad A. Al Khaleel Eng. Mohammad A. Al Ghafly

Please read these notes before filling out this questionnaire :

INTRODUTION :

The objective of this questionnaire is to identify the frequency and severity of causes of delay in the completion of water and sewage construction projects .

The questionnaire consists of three parts , Part (A) includes general information relating to your experience, Part (B) includes a list of causes of delay. You are requested to choose a frequency of occurrence and a degree of severity for each of these causes, Part (C) includes questions for the overall extent of delay. You are kindly requested to answer the questions as reflected by your experience.

DEFINITIONS :

Delay: The time overrun beyond the construction completion date as specified originally in the contract of the project, whether or not the contractor was allowed a time extention .

Project: Project in this questionnaire refers to public water and sewage construction projects with a contract value of over one million Saudi Riyals, excluding operation & maintenance projects.

Frequency: The frequency of occurrence of a cause of delay throughout a construction project .

Severity: The severity of effect on the completion of a project when such a delay occurs.

RESPONSES :

For part (A), the responses are based on a 5- degree scale as follow :

Frequency of occurrence :

Always : occurs all the times and situations.
Often : occurs most of the times and situations.
Sometime : occurs from time to time.
Never : does not occur at all .
Do not know : no experience with the frequency of occurrence of this cause .

Degree of severity :

Very severe : cause has a greate effect on delay .
Severe : cause has an appreciable effect on delay .
Somewhat : cause has some effect on delay .
No effect : cause has negligible or no effect on delay .
Do not know : no experience with the severity of this cause .

For part (B), you are requested to choose an appropriate response or write a brief answer .

PART (A) :
GENERAL INFORMATION :

You are kindly requested to write or choose the appropriate answer for the following questions .

1- In which area in the kingdom does your firm perform construction operations ? Please , check one or more of the following :

Eastern province	( )
Centeral province	( )
Western province	( )
Southern province	( )
Northern province	( )

2 - How many years has your firm been constructing water and sewage projects ?

Less than 5 years	( )
5 to 10 years	( )
10 to 15 years	( )
over 15 years	( )

3 - What is your classification grade in the field of water and sewage construction works ?

Grade no. ----------

4 - Do you have any other classification in the construction field ?

Yes ( ) No ( )

5 - If your answer to question 4 " yes " , please check the appropriate answer below :

General construction	( )
Building construction	( )
Roads construction	( )
Mechanical & Electrical	( )
Dams construction	( )
Indesrerial works	( )

6 - How many years of experience have you had in the field of construction ?

---------- years.

PART (A):
GENERAL INFORMATION :

You are requested to write or choose the appropriate answer for the following questions :

1- In which area in the kingdom does your firm perform supervision of construction projects ?

Please , check one or more of the following :

Eastern province	**( )**
Centeral province	**( )**
Western province	**( )**
Southern province	**( )**
Northern province	**( )**

2 - How many water and sewage construction projects did your firm supervise in the kingdom ?

In the Eastern Provience, we supervise ---------- project .
In the Riyadh Provience, we supervise ---------- project .
In the other proviences, we supervise ---------- project .

3 - How many of these above mentioned projects were delayed ?

In the Eastern Provience, ---------- project were delayed .
In the Riyadh Provience, ---------- project were delayed .
In the other proviences, ---------- project were delayed .

PART (B) : CAUSES OF DELAY

The list below includes causes of delay . For each of these causes you are kindly requested to express your opinion by answering the following two questions and placing a check in the appropriate box :

In water and sewage construction projects :
What is the frequency of occurrance for each cause ?
What is the degree of severity for each cause ?

NO	CAUSE OF DELAY	frequency of occurrance					Degree of severity				
		Always	Often	Sometimes	Never	Do not know	very Severe	Severe	somewhat Severe	No Effect	Do not know
1	Shortage of materials required .	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2	Delay in materials delivery .	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
3	Changes in materials prices .	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
4	Changes in materials specifications.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
5	Shortage of equipment required .	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
6	Failure of equipment .	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
7	Shortage of supporting and shoring installations for excavations .	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
8	Inadequate equipment used for the works .	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
9	Shortage of manpower (skilled, semi - skilled, unskilled laborers) .	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
10	Low skills of manpower .	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

NO	CAUSE OF DELAY	frequency of occurrance					Degree of severity				
		Always	Often	Sometimes	Never	Do not know	very Severe	Severe	somewhat Severe	No Effect	Do not know
11	Shortage of contractor's adminisreative personnel .	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
12	Shortage of technical professionals in the contractor's organization .	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
13	Poor communication by the contractor with the parties involved in the project .	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
14	Poor coordination by the contractor with the parties invloved in the project .	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
15	Slow preparation of change orders requests by the contractor .	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
16	Ineffective contractor head office involvement in construction of the project .	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
17	Delay in mobilization to start the project .	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
18	Loose safety rules and regulations within the contractor's organization	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
19	Poor qualifications of the contractor's technical staff (engineers, inspectors,.....etc.)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
20	Improper technical study of the project in the bidding stage by the contractor .	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

NO	CAUSE OF DELAY	frequency of occurrance					Degree of severity				
		Always	Often	Sometimes	Never	Do not know	very Severe	Severe	somewhat Severe	No Effect	Do not know
21	Ineffective planning and scheduling of the project by the contractor.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
22	Delay in the field survey done by the contractor	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
23	Ineffective control of the project progress by the contractor.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
24	Inefficient quality control by the contractor.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
25	Delay in the preparation of contractor (e.g. shopdrawings, material samples, ...etc .)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
26	Improper construction method implemented by the contractor.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
27	Difficulties in finanncing the project by the contractor.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
28	Cash flow problems faced by the contractor.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
29	Subcontractor problems with the contractor.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
30	Delay to furnish and deliver the site to the contractor by the owner.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
31	Delay in the settelment of contractor' s by the owner.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

NO	CAUSE OF DELAY	frequency of occurrance					Degree of severity				
		Always	Often	Sometimes	Never	Do not know	very Severe	Severe	somewhat Severe	No Effect	Do not know
32	Suspension of work by the owner.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
33	Delay in issuance of change orders by the	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
34	Delay in making decisions by the owner a reasonable time.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
35	Interference by the owner in the operation phases.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
36	Uncooperative owner with the contractor.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
37	Delay in progress payments by the owner.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
38	Poor communications by the owner with the construction parties involved, and Government Authorities concerned during construction.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
39	Insufficient coordination by the owner in the early planning & design stages of the project with other Government Authorities concerned	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
40	Poor coordination by the owner with the construction parties involved, and Government Authorities concerned during constrcution.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
41	Excessive bureaucracy in the owner administration.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
42	Changes in the scope of the project (e. g. quantities of work items, new items, new areas.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

NO	CAUSE OF DELAY	frequency of occurrance					Degree of severity				
		Always	Often	Sometimes	Never	Do not know	very Severe	Severe	somewhat Severe	No Effect	Do not know
43	Ambiguities, defaults, inconsistancy of specifications and drawings.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
44	Diffiering site conditions.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
45	Original contract duration is too short .	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
46	Ineffective delay penalty.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
47	Difficulties in obtaining work permits from the authorities concerned.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
48	Low performance of the lowest bidder in the Government Tendering System .	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
49	Changes in Government regulations and laws.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
50	Severe weather conditions on the job site .	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
51	Effect of subsurface conditions (type of soil, existent utilities, high water table.....etc .).	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
52	Trafic control and restrictions on the job site	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
53	Effect of social and cultural conditions.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
54	Interference with other contractor's work.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
55	Poor qualification of supervision staff of the consultant engineer.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

NO	CAUSE OF DELAY	frequency of occurrance					Degree of severity				
		Always	Often	Sometimes	Never	Do not know	very Severe	Severe	somewhat Severe	No Effect	Do not know
56	Delay in the approval of contractor submittals by the engineer (materials samples, shopdrawings, schedules, payments request) .	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
57	Poor communication by the consultant engineer .	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
58	Poor coordination by the consultant engineer .	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
59	Delay in performing inspection and testing by the consultant engineer .	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
60	Slow response to the contractor inquiries in jobe site by the consultant engineer .	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Please write any other causes are not in this list which you think are important :										
61	----------	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
62	----------	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
63	----------	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
64	----------	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
65	----------	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

PART (C) DELAY EXTENT :

This part includes general questions pertainning to the overall extent of delay in water and sewage construction projects. You are kindly requested to answer the following questions :

1 - How many water & sewage projects, exceeding S.R. 1 milion contract value, were constructed by your firm in the last 10 years ?
---------- project(s).

2 - How many of these projects were subjected to delay ?
---------- project(s).

3 - In how many of these projects was time extension requested ?
---------- project(s).

4 - In how many projects was the time extension approved partailly or completely ?
---------- project(s).

5 - What was the average delay time in these projects relative to the original project contract duration ?

less than 10%	**( )**
10 to 30%	**( )**
30 to 50 %	**( )**
50 to 100 %	**( )**
over 100%	**( )**

6 - Based on your experience, what are the most important 5 causes of delay in order of importance in water and sewage construction projects ?

1 - ----------
2 - ----------
3 - ----------
4 - ----------
5 - ----------

7 - Based on your experience with projects which were actually delayed, how would you assign responsibility to each of the following parties for the delay (approximately) ?

Owner	**---------- %**
Contractor	**---------- %**
Consultant engineer	**---------- %**
Others	**---------- %**

Total should be equal to 100 .

PART (C) DELAY EXTENT :

This part includes general questions pertainning to the overall extent of delay in water and sewage construction projects . You are kindly requested to answer the following questions .

1 - Based on your experience with delayed projects, what was the average delay time of the delayed projects relative to the original project contract duration ?

less than 10%	( )
10 to 30%	( )
30 to 50 %	( )
50 to 100 %	( )
over 100%	( )

2 - Based on your experience, what are the most important 5 causes of delay in order of importance in water and sewage construction projects ?

1 - ----------
2 - ----------
3 - ----------
4 - ----------
5 - ----------

3 - Based on your experience with projects which were actually delayed, how would you assign responsibility to each of the following parties for the delay (approximately) ?

Owner	---------- %
Contractor	---------- %
Consultant engineer	---------- %
Others	---------- %

Total should be equal to 100 .

TIME PERFORMANCE OF COMPLETED PROJECTS:

Please fill the following table with 5 completed construction projects which were executed by your firm and were subjected to delay, Please, list projects of more than 1 million S.R. in cost and more than a year in duration.
An example is given in the table.

NO.	year of completion	contract value (.MillionSR.)	contract duration (Months)	actual duration (Months)	extra time requested by contractor	extra time given to contractor
EX.	1985	45	24	27	3	3
1						
2						
3						
4						
5						

Contract Value: rounded to the nearest million S.R.

Durations: Rounded to the nearest month.

Year of completion: Pls select projects completed during the last ten years

Comments : Please write any comment that would help us to understand your opinions on this questionnaire .

OPTIONAL :

The following information can be relevant to this study. However, if you do not want to provide information on any of these items, feel free to leave it blank.

Name of your firm :

Address :

Filled by :

Position :

بسم الله الرحمن الرحيم

جامعة الملك فهد للبترول والمعادن

كلية تصاميم البيئة

برنامج هندسة وادارة التشييد

استبيان

عن

" اسباب تأخير مشاريع تشييد المرافق العامة بالمملكة "

A - 16

بسم الله الرحمن الرحيم

وزارة التعليم العالي
جامعة الملك فهد للبترول والمعادن
كلية تصاميم البيئة
برنامج هندسة وإدارة التشييد

Ministry of Higher Education
King Fahd University of Petroleum & Minerals
COLLEGE OF ENVIRONMENTAL DESIGN
Construction Engineering & Management Program

سعادة مدير /

المحترم

السلام عليكم ورحمة الله وبركاته-:

اود ان افيدكم بأني احد طلاب الدراسات العليا بجامعة الملك فهد للبترول والمعادن بالظهران ومتقدم حاليا للحصول على شهادة الماجستير في برنامج هندسة و ادارة التشييد وقد تقدمت بالرساله التي عنوانها:

"اسباب تأخير تشييد مشاريع المرافق العامة بالمملكة"

وقد تحدد نطاق البحث لمشاريع تشييد اعمال المياه والصرف الصحي الحكوميه, ويهدف هذا الاستبيان الى مسح مرئيات العاملين بهذا المجال عن مدى التأخير و تكرار وشدة اسباب التأخير في اكمال تشييد مشاريع المياه والصرف الصحي بالمملكه.

وبصفتكم احد العاملين بمجال تشييد مشاريع اعمال المياه والصرف الصحي فأن مشاركتكم في تعبئة الاستبيان بالمعلومات المطلوبة تشكل عنصرا مهما في نجاح البحث وتقديم نتائج مفيدة للجميع.

نأمل تعاونكم بالاجابة على هذا الاستبيان الذي قد يأخذ ٣٠ دقيقة تقريبا من وقتكم الثمين كما نؤكد لكم ان جميع المعلومات التي سيتم الحصول عليها سوف يتم تحليلها بصورتها الاجمالية وسوف تستخدم لغرض البحث العلمي فقط.

نأمل تعبئة هذا الاستبيان واعادته بأقرب فرصه ممكنه وليكن في موعد اقصاه ٣٠/ ٢ / ١٤١٥هـ الى احد العنوانين التاليين:

دكتور : محمد ابراهيم الخليل
جامعة الملك فهد للبترول والمعادن ص.ب : ٤٢٦
الظهران : ٣١٢٦١

او م . محمد احمد الغافلي
ص.ب . ٤٦٥٠
الدمام : ٣١١٩٨

شاكرين لكم تعاونكمو وتقبلوا تحياتنا

الباحث

م/ محمد احمد الغافلي

الاستاذ المشرف

د/محمد ابراهيم الخليل

" مقدمة "

نأمل قراءة هذه الملاحظات قبل تعبئة الاستبيان :

يهدف هذا الاستبيان لتحديد مدى التأخير واسبابه الاكثر تكرارا في الحدوث والاكثر شدة في التأثير علي اكمال تشييد مشاريع المياه والصرف الصحي بموعدها المحدد .

يشمل الاستبيان ثلاثة اقسام , القسم الاول معلومات عامه تتعلق بخبرتكم في مجال تشييد المشاريع , القسم (أ) يشمل لائحة اسباب التأخير والتي سيطلب منكم اختيار مدى تكرار حدوث ودرجة شدة هذه الاسباب, اما القسم (ب) فيشمل اسئلة عن مدى التأخير بهذه المشاريع بشكل عام حيث سيطلب منكم الاجابة علي هذه الاسئلة من واقع خبرتكم بهذه المشاريع .

<u>تعريفات :</u>

التأخير : هو الوقت الزائد عن تاريخ الانتهاء المقرر لتشييد المشروع كما هو محدد اساسا بعقد المشروع سواء حصل المقاول على تمديد مدة تنفيذ المشروع ام لا .

المشاريع : المشاريع المشار اليها بهذا الاستبيان هي مشاريع تشييد اعمال المياه والصرف الصحي العامه فقط والتي لاتقل قيمتها عن مليون ريال سعودي ولا تشمل مشاريع التشغيل والصيانة .

التكرار : هو تكرار حدوث اسباب التأخير وتعني الي اي مدى تحدث هذه الاسباب اثناء تشييد المشاريع .

الشدة : هي درجة شدة اسباب التأخير وتعني الي اي مدى يؤثر هذه السبب في تأخير اكمال المشروع عن موعده المحدد .

<u>الاجابات</u>

للجزء (أ) الاول من الاستبيان وضعت خمس درجات لكل من تكرار الحدوث ودرجة الشدة لكل سبب . تتطلب الاجابة وضع علامة (✓) مقابل الاجابة المناسبه وهي كالتالي :

تكرار الحدوث :

١- دائما : السبب يحدث في جميع الاوقات والاحوال .

٢- عادة : السبب يحدث في معظم الاوقات والاحوال .

٣- احيانا : السبب يحدث في بعض الاوقات والاحوال .

٤- ابدا : لايحدث السبب اطلاقا .

٥- لا ادري : لااعرف جوابا لهذا السؤال من واقع تجربتي .

درجة الشدة :

١- شديد جدا :السبب له اعلى درجة من التأثير في تأخير المشروع .

٢- شديد : السبب له تأثير كبير في تأخير المشروع .

٣- الى حد شديد : السبب له تأثير في تأخير المشروع .

٤- لاتأثير : السبب ليس له اى تأثير يذكر في تأخير المشروع .

٥- لا ادري : لااعرف جوابا لهذا السؤال من واقع تجربتي .

اما الجزء (ب) فتتطلب الاجابه في معظم الاحيان الاشارة الى الاجابه المناسبة او كتابه الاجابة بشكل مختصر .

يوجد في نهاية كل من الجزء أ , ب سؤال عام لرصد وجهة نظركم ومقترحاتكم حول الموضوع نأمل كتابة ما ترونه مفيدا في موضوع البحث .

معلومـــــات عامـــة :

نأمل كتابة او اختيار الاجابة المناسبة للاسئله التالية :-

س١ - بأي منطقة من مناطق المملكة تقومون بأعمال التشييد ؟

(يمكن التأشير علي واحدة او اكثر من الاجابات التالية)

المنطقة الشرقية ( )

المناطق الوسطي ( )

المنطقة الغربية ( )

المناطق الشمالية ( )

المناطق الجنوبية ( )

س٢ - كم سنوات خبرة شركتكم في تنفيذ مشاريع المياه والصرف الصحي ؟

- اقل من ٥ سنوات ( )

٥ الي ١٠ سنوات ( )

١٠الي ١٥ سنه ( )

اكثر من ١٥ سنه ( )

س٣ - ماهي درجة تصنيفكم بتشييد اعمال المياه والصرف الصحي ؟

الدرجة :

س٤ - هل لديكم تصنيف اخر بمجالات التشييد ؟

نعم ( ) لا ( )

س٥ - اذا كانت اجابتكم على السؤال (٤) بنعم , فما هي مجالات التشييد الاخرى التى تعملون بها ؟

اعمال المقاولات العامه ( )

اعمال مقاولات المباني ( )

اعمال مقاولات الطرق ( )

اعمال المقاولات الميكانيكيه والكهربائيه ( )

اعمال مقاولات السدود ( )

اعمال المقاولات الصناعية ( )

س٦- كم عدد سنوات خبرتكم فى مجال تشييد المشاريع ؟

..... سنه

معلومـــــات عامــة :

تأمل كتابة او اختيار الاجابة المناسبة للاسئله التالية :-

س١ - بأي منطقة من مناطق المملكة تقومون بأعمال الاشراف على التشييد ؟
(يمكن التأشير علي واحدة او اكثر من الاجابات التالية)

المنطقة الشرقية ( )
المناطق الوسطي ( )
المنطقة الغربية ( )
المناطق الشمالية ( )
المناطق الجنوبية ( )

س٢ - كم عدد مشاريع المياه والصرف الصحي التى اشرفتم على تنفيذها بالمملكة ؟
فى المنطقة الشرقية اشرفنا على تنفيذ عدد ..... مشروع .
فى منطقة الرياض اشرفنا على تنفيذ عدد ..... مشروع .
فى مناطق المملكة الاخرى اشرفنا على تنفيذ عدد ..... مشروع .

س٣ - كم من المشاريع التى اشرفتم على تنفيذها قد تأخرت ؟
فى المنطقة الشرقية عدد ..... مشروع .
فى منطقة الرياض عدد ..... مشروع .
فى مناطق المملكة الاخرى عدد ..... مشروع .

الجزء (أ) : اسباب التأخير في مشاريع تشييد اعمال المياه والصرف الصحي :-

تشمل القائمة ادناه اسباب التأخير , لكل من هذه الاسباب , نأمل الاجابة بمرئياتكم عن المؤثرين التاليين :

بمشاريع تشييد اعمال المياه والصرف الصحي:

س١ : ما هو مدى تكرار الحدوث لكل سبب ؟

س٢ : ما هي درجة الشدة لكل سبب ؟

نأمل الاجابة بوضع اشارة ( ) في الخانة المناسبة لكل من الاسباب التاليه :-

	سبب التأخير	تكرار الحدوث					درجة الشدة				
		دائما	عادة	احيانا	ابدا	لا ادري	شديد جدا	شديد	الى حدما شديد	لا التأثير	لا ادري
١	نقص المواد المطلوبة .										
٢	التأخير في توريد المواد .										
٣	التغير في أسعار المواد .										
٤	التغير في مواصفات المواد .										
٥	نقص المعدات المطلوبة .										
٦	. العطل بالمعدات أثناء التنفيذ										
٧	نقص تركيبات السواقد والدعامات للحفريات .										
٨	استخدام معدات غير ملائمة للاعمال .										
٩	نقص القوى العاملة (العمال المهره, و شبه المهره, و الغير مهره) .										
١٠	انخفاض مهارة القوى العاملة .										

	سبب التاخير	تكرار الحدوث					درجة الشدة				
		دائما	عادة	احيانا	ابدا	لا ادري	شديد جدا	شديد	الي حدما شديد	لا التأثير	لا ادري
١١	نقص موظفي المقاول الاداريين .										
١٢	نقص الجهاز الفني بادارة المقاول .										
١٣	ضعف الاتصال من قبل المقاول مع الاطراف الاخرى اثناء التنفيذ .										
١٤	ضعف التنسيق من قبل المقاول مع الاطراف الاخرى اثناء التنفيذ .										
١٥	بطئ المقاول بتحضير طلبات اوامر التغير .										
١٦	عدم فاعلية اشتراك المكتب الرئيسي للمقاول باعمال المشروع .										
١٧	تأخر المقاول في التجهيزات لبدء العمل .										
١٨	ضعف انظمة وتعليمات السلامة بادارة المقاول .										
١٩	ضعف مؤهلات جهاز المقاول الفني.										
٢٠	خطأ المقاول بالدراسة الفنية للمشروع بمرحلة تقديم العروض الخاصه بالمناقصه .										
٢١	عدم كفاءة تخطيط وجدولة العمل بالمشروع من قبل المقاول .										
٢٢	تأخر المقاول باعمال المسح الميداني للموقع .										
٢٣	عدم فاعلية التحكم بسير العمل بالمشروع من قبل المقاول .										

	سبب التأخير	تكرار الحدوث					درجة الشدة				
		دائما	عادة	احيانا	ابدا	لا ادري	شديد جدا	شديد	الى حدما شديد	لا التأثير	لا ادري
٢٤	عدم كفاءة تحكم المقاول بجودة الاعمال .										
٢٥	تأخر المقاول في تحضير التقديمات (رسومات ومخططات , عينات المواد ..... الخ .)										
٢٦	استخدام المقاول طرق تنفيذ غير مناسبة.										
٢٧	الصعوبات فى تمويل المشروع من المقاول.										
٢٨	مشاكل السيولة النقدية لدى المقاول .										
٢٩	مشاكل مقاول الباطن مع المقاول .										
٣٠	تاخرالمالك فى تجهيز وتسليم المواقع الى المقاول .										
٣١	تاخر المالك فى تسوية مطالبات المقاول .										
٣٢	تعليق المالك للعمل بالمشروع.										
٣٣	تاخر المالك فى اصدار أوامر التغيير.										
٣٤	تأخر المالك باتخاذ القرارات بالوقت المناسب .										
٣٥	تدخل المالك فى مراحل عمليات التنفيذ.										

	سبب التاخير	تكرار الحدوث					درجة الشدة				
		دائما	عادة	احيانا	ابدا	لا ادري	شديد جدا	شديد	الي حدما شديد	لا التأثير	لا ادري
٣٦	عدم تعاون المالك مع المقاول .										
٣٧	تأخر المالك دفع المستخلصات الي المقاول .										
٣٨	ضعف الاتصال من قبل المالك مع الجهات الاخرى اثناء التنفيذ .										
٣٩	عدم كفاية التنسيق من قبل المالك مع الجهات الحكوميه الاخرى بالمراحل الاولى لتخطيط وتصميم المشروع .										
٤٠	ضعف التنسيق من قبل المالك مع الجهات الاخرى اثناء التنفيذ .										
٤١	زيادة الروتين بالاجراءات من قبل المالك .										
٤٢	التغيرات في نطاق عمل المشروع (كميات البنود . البنود الجديده و المناطق الجديده) .										
٤٣	الاخطاء و الغموض وعدم التوافق بمخططات ومواصفات المشروع .										
٤٤	الاختلاف في حالة موقع العمل .										
٤٥	قصر مدة التنفيذ الاساسيه بعقد المشروع.										

	سبب التاخير	تكرار الحدوث					درجة الشدة				
		دائما	عادة	احيانا	ابدا	لا ادري	شديد جدا	شديد	الي حدما شديد	لا التأثير	لا ادري
٤٦	عدم فاعلية غرامة التأخير .										
٤٧	الصعوبات والقيود بالحصول علي تراخيص العمل من الجهات المعنية.										
٤٨	ضعف اداء المقاول صاحب اقل العطاءات بنظام المناقصات الحكومية .										
٤٩	التغيرات بالقوانين والانظمه الحكومية .										
٥٠	تأثير حالات الطقس الشديدة بمنطقة المشروع.										
٥١	تأثير حالات ما تحت سطح الارض (التربة , وجودالمرافق , وارتفاع منسوب المياه ...الخ)										
٥٢	العوائق والقيود لحركة المرور بالموقع.										
٥٣	تأثير الاوضاع الاجتماعية والتقاليد.										
٥٤	التداخل مع اعمال مقاولين اخرين .										
٥٥	ضعف مؤهلات جهاز الاستشاري المشرف .										
٥٦	تأخر الاستشاري في الموافقه علي تقديمات المقاول (عينات المواد , المخططات , الجداول , و طلبات دفع المستخلصات) .										

	سبب التاخير	تكرار الحدوث					درجة الشدة				
		دائما	عادة	احيانا	ابدا	لا ادري	شديد جدا	شديد	الي حدما شديد	لا التأثير	لا ادري
٥٧	ضعف الاتصال من الاستشاري مع الاطراف الاخرى .										
٥٨	ضعف التنسيق من الاستشاري مع الاطراف الاخرى .										
٥٩	تأخر الاستشاري بأداء الفحوصات و الاختبارات اللازمه .										
٦٠	بطئ الاستجابه الي طلبات المقاول بالموقع من الاستشاري المشرف .										
	الرجاء كتابة اي اسباب اخرى والتي تروونها مهمه لم يتم ذكرها بهذه القائمه :										
٦١	----------										
٦٢	----------										
٦٣	----------										
٦٤	----------										
٦٥	----------										

الجزء ب : مدى التـــــأخير :

هذا الجزء يشمل اسئلة عامة تتعلق بمدى التأخير بشكل عام بمشاريع المياه والصرف الصحي .. نأمل الاجابة علي الاسئله التالية :

س١ – كم عدد مشاريع المياه والصرف الصحي التي قيمتها تزيد عن مليون ريال قمتم بتنفيذها خلال السنوات العشر الماضية ؟

..... مشروع

س٢ – كم العدد من هذه المشاريع قد تأخر تنفيذها ؟

..... مشروع

س٣ – كم العدد من المشاريع المتأخرة التي طلبتم لها تمديد مدة التنفيذ ؟

..... مشروع

س٤ –كم العدد من المشاريع التي طلبتم لها تمديد تمت الموافقة علي التمديد بكامل المدة المطلوب تمديدها او جزئ منها؟

..... مشروع

س٥ – كم كان معدل فترة التأخير لهذه المشاريع نسبة الي مدة عقد المشروع الاساسية ؟

اقل من ١٠ ٪ ( )

١٠ الي ٣٠ ٪ ( )

٣٠ الي ٥٠ ٪ ( )

٥٠ الي ١٠٠ ٪ ( )

اكثر من ١٠٠ ٪ ( )

س٦ – بناء علىخبرتكم ما هى اهم خمسة اسباب تؤدي الي التأخير في مشاريع المياه والصرف الصحي وترتيبها حسب اهميتها من الاهم الي الاقل اهميه ؟

١ – .....

٢ – .....

٣ – .....

٤ – .....

٥ – .....

س٧ – بناء علىخبرتكم الماضية بالمشاريع المتأخرة ما هي النسبة التقريبية التى ترونها لمسئولية كل من الاطراف التالية عن التأخير ؟

المالك.....٪

المقاول .....٪

الاستشاري المشرف.....٪

اطراف اخرين.....٪

(المجموع يجب ان يكون ١٠٠)

الجزء ب : مدى التـــــأخير :

هذا الجزء يشمل اسئلة عامة تتعلق بمدى التأخير بشكل عام بمشاريع المياه والصرف الصحي .. نأمل الاجابة علي الاسئله التالية :

س١ – بناءا على خبرتكم الماضيه بالمشاريع المتاخره ,كم معدل فترة التأخير للمشاريع المتأخرة نسبة الي مدة عقد المشروع الاساسية ؟

اقل من ١٠ ٪ ( )
١٠ الي ٣٠ ٪ ( )
٣٠ الي ٥٠ ٪ ( )
٥٠ الي ١٠٠ ٪ ( )
اكثر من ١٠٠ ٪ ( )

س٢ – بناء علىخبرتكم , ماهي اهم خمسة اسباب تؤدي الي التاخير في مشاريع المياه والصرف الصحي وترتيبها حسب اهميتها من الاهم الي الاقل اهميه ؟

١ – .....
٢ – .....
٣ – .....
٤ – .....
٥ – .....

س٣ – بناء علي خبرتكم الماضية بالمشاريع المتأخرة ما هي النسبة التقريبية التي ترونها لمسئولية كل من الاطراف التالية عن التأخير ؟

المالك.....٪
المقاول .....٪
الاستشاري المشرف.....٪
اطراف اخرين.....٪
(المجموع يجب ان يكون ١٠٠)

تقييم وقت الانجاز لمشاريع التشييد

وقت الانجاز لمشاريع مكتملة:

تأمل تعبئة الجدول ادناه بخمسة مشاريع تشييد اعمال المياه والصرف الصحي تم انجازها من قبل شركتكم وكانت متأخرة في حينها بحيث لاتقل قيمة الواحد منها عن مليون ريال سعودي ومدتها الاصلية عن سنه واحدة

مسلسل	سنة الانتهاء	قيمة العقد (مليون ريال)	مدة المشروع (شهر)	مدة التنفيذ الفعلية (شهر)	المدة الاضافية المطلوبة من المقاول (شهر)	المدة الاضافية الممنوحة الى المقاول (شهر)
مثال	١٩٨٥م	٤٥	٢٤	٢٧	٣	٣
١						
٢						
٣						
٤						
٥						

تأمل ملاحظة الآتي :

قيمة العقد الى اقرب مليون ريال.

المده الى اقرب شهر.

سنة الانتهاء : المشاريع المنتهيه خلال السنوات العشرة الماضية .

نأمل كتابة اي ملاحظات او تعليق لديكم والتي قد تساعدنا لمعرفة وفهم آرائكم عن هذه الدراسة .

.....

.....

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معلومات اختيـــاريه :

المعلومات التاليه يمكن ان تتعلق بهذه الدراسه , على كل حال اذا رغبتم بكتابة اي من هذه المعلومات اوتركها خاليه .

اسم الشركة : .....

العنـــوان : .....

تم تعبئة هذا الاستبيان من قبل : .....

الوظيفـــــه : .....

APPENDIX (B)

TABLES FOR STATISTICAL VARIABLES CALCULATIONS FOR FREQUENCY ND SEVERITY SCORES

TABLE B.1 STATISTICAL VARIABLES FOR FREQUENCY

TABLE B.2 STATISTICAL VARIABLES FOR SEVERITY

TABLE B-1 STATISTICAL TECHNIQUES FOR FREQUENCY INDEX

VARIABLE	MEAN	STD	CV	ERROR	CI95	LOWER	UPPER
QG1	2.00	0.56	28.20	0.08	0.1568	1.8432	2.1568
QG2	2.05	0.60	28.55	0.09	0.1764	1.9136	2.2664
QQ3	1.76	0.68	38.70	0.10	0.1960	1.5640	1.9560
QQ4	1.78	0.74	41.35	0.11	0.2156	1.5644	1.9956
QQ5	1.85	0.78	41.04	0.12	0.2352	1.6548	2.1252
QQ6	2.07	0.65	31.63	0.10	0.1960	1.8740	2.2660
QQ7	1.73	0.84	48.27	0.12	0.2352	1.4948	1.9852
QG8	1.45	0.63	42.05	0.09	0.1764	1.2136	1.6864
QQ9	2.22	0.82	37.02	0.12	0.2352	1.9848	2.4552
QG1C	1.98	0.84	42.42	0.13	0.2548	1.7252	2.2348
QG11	1.73	0.69	39.67	0.10	0.1960	1.5340	1.9260
QG12	1.96	0.77	39.24	0.11	0.2156	1.7444	2.1756
QG13	2.05	0.73	35.05	0.11	0.2156	1.8744	2.3056
QG14	2.20	0.79	35.74	0.12	0.2352	1.9648	2.4352
QG15	1.98	0.78	39.55	0.12	0.2352	1.7448	2.2152
QG16	1.85	0.80	42.57	0.12	0.2352	1.6548	2.1252
QG17	2.42	0.84	34.64	0.13	0.2548	2.1652	2.6748
QG18	1.80	0.84	46.78	0.13	0.2548	1.5452	2.0548
QQ19	1.93	0.81	41.85	0.12	0.2352	1.6948	2.1652
QG2C	2.05	0.97	46.57	0.15	0.2940	1.7560	2.3540
QG21	2.20	0.81	37.03	0.12	0.2352	1.9648	2.4352
QG22	2.00	0.80	39.85	0.12	0.2352	1.7648	2.2352
QG23	2.02	0.87	42.81	0.13	0.2548	1.7652	2.2748
QG24	1.85	0.75	39.46	0.11	0.2156	1.6744	2.1056
QQ25	2.05	0.87	41.66	0.13	0.2548	1.8352	2.3448
QG26	1.64	0.80	48.78	0.12	0.2352	1.4048	1.8752
QG27	2.51	0.87	34.62	0.13	0.2548	2.2552	2.7648
QG28	2.73	0.84	30.61	0.12	0.2352	2.4948	2.9652
QG29	2.00	0.85	42.64	0.13	0.2548	1.7452	2.2548
QG3C	1.76	0.74	41.35	0.11	0.2156	1.5644	1.9956
QG31	2.49	0.92	36.97	0.14	0.2744	2.2156	2.7644
QG32	1.44	0.92	63.58	0.14	0.2744	1.1656	1.7144
QG33	2.22	0.77	34.44	0.11	0.2156	2.0044	2.4356
QG34	2.16	0.85	39.51	0.13	0.2548	1.9052	2.4148
QG35	2.11	0.91	43.11	0.14	0.2744	1.8356	2.3844
QG36	1.45	0.84	56.60	0.13	0.2548	1.2352	1.7448
QG37	2.62	0.86	32.81	0.13	0.2548	2.3652	2.8748
QG38	2.11	0.91	43.11	0.14	0.2744	1.8356	2.3844
QG39	2.18	0.98	45.17	0.15	0.2940	1.8860	2.4740
QG4C	2.07	0.84	40.48	0.12	0.2352	1.8348	2.3052
QG41	2.42	0.81	33.50	0.12	0.2352	2.1848	2.6552
QG42	2.42	0.85	36.81	0.13	0.2548	2.1652	2.6748
QQ43	2.22	0.85	38.24	0.13	0.2548	1.9652	2.4748
QG44	1.80	0.76	42.04	0.11	0.2156	1.5844	2.0156
QG45	2.16	0.90	41.91	0.13	0.2548	1.9052	2.4148
QQ46	1.80	1.20	66.58	0.18	0.3528	1.4472	2.1528
QG47	2.80	0.92	32.84	0.14	0.2744	2.5256	3.0744
QG48	2.51	0.85	33.84	0.13	0.2548	2.2552	2.7648
QG49	1.36	0.68	50.12	0.10	0.1960	1.1640	1.5560
QG5C	1.64	0.65	39.23	0.10	0.1960	1.4440	1.8360
QG51	2.51	0.85	33.84	0.13	0.2548	2.2552	2.7648
QQ52	2.22	0.79	35.75	0.12	0.2352	1.9848	2.4552
QG53	1.38	0.78	56.41	0.12	0.2352	1.1448	1.6152
QG54	1.85	0.78	41.04	0.12	0.2352	1.6548	2.1252
QG55	2.00	0.64	31.98	0.10	0.1960	1.8040	2.1960

VARIABLE	MEAN	STD	CV	ERROR	CI95	LOWER	UPPER
SQ56	2.42	0.97	39.64	0.14	0.2744	2.1456	2.6944
SQ57	2.09	0.79	37.95	0.12	0.2352	1.8548	2.3252
SQ58	2.04	0.77	37.54	0.11	0.2156	1.8244	2.2656
SQ59	2.09	0.87	41.86	0.13	0.2548	1.8352	2.3448
SQ6C	2.22	0.90	40.58	0.13	0.2548	1.9652	2.4748

TABLE 8.2 STATISTICAL TECHNIQUES FOR SEVERITY INDEX

VARIABLE	MEAN	STD	CV	ERROR	CI95	LOWER	UPPER
SQ1	2.20	0.89	40.66	0.13	0.2548	1.9452	2.4548
SQ2	2.38	0.96	40.39	0.14	0.2744	2.1056	2.6544
SQ3	1.76	0.86	48.81	0.12	0.2548	1.5052	2.0148
SQ4	1.84	0.88	47.60	0.13	0.2548	1.5852	2.0948
SQ5	2.24	0.96	42.65	0.14	0.2744	1.9656	2.5144
SQ6	2.04	0.71	34.52	0.11	0.2156	1.8244	2.2556
SQ7	1.93	0.91	47.30	0.14	0.2744	1.6656	2.2044
SQ8	1.76	0.83	47.28	0.12	0.2352	1.5248	1.9952
SQ9	2.40	0.89	37.06	0.13	0.2548	2.1452	2.6548
SQ10	2.20	0.84	38.28	0.13	0.2548	1.9452	2.4548
SQ11	1.80	0.79	43.68	0.12	0.2352	1.5648	2.0352
SQ12	2.38	0.94	39.38	0.14	0.2744	2.1056	2.6544
SQ13	2.09	0.79	37.95	0.12	0.2352	1.8548	2.3252
SQ14	2.33	0.88	37.67	0.13	0.2548	2.0752	2.5848
SQ15	1.96	0.64	32.63	0.10	0.1960	1.7640	2.1560
SQ16	1.82	0.81	44.23	0.12	0.2352	1.5848	2.0552
SQ17	2.33	0.90	38.77	0.13	0.2548	2.0752	2.5848
SQ18	1.62	0.83	51.39	0.12	0.2352	1.3848	1.8552
SQ19	2.11	0.88	41.91	0.13	0.2548	1.8552	2.3648
SQ20	2.56	1.24	48.33	0.18	0.3528	2.2072	2.9128
SQ21	2.51	1.12	44.62	0.17	0.3332	2.1768	2.8432
SQ22	2.02	0.89	44.09	0.13	0.2548	1.7652	2.2748
SQ23	2.33	1.07	45.65	0.16	0.3136	2.0164	2.6436
SQ24	2.16	0.98	45.28	0.15	0.2940	1.8660	2.4540
SQ25	2.33	0.93	39.83	0.14	0.2744	2.0656	2.6044
SQ26	2.02	0.99	48.87	0.15	0.2940	1.7260	2.3140
SQ27	2.98	0.97	32.41	0.14	0.2744	2.7056	3.2544
SQ28	3.16	0.90	28.63	0.13	0.2548	2.9052	3.4148
SQ29	2.16	0.90	41.91	0.13	0.2548	1.9052	2.4148
SQ30	2.18	1.11	51.14	0.17	0.3332	1.8468	2.5132
SQ31	2.53	1.04	40.88	0.15	0.2940	2.2360	2.8240
SQ32	1.89	1.47	77.56	0.22	0.4312	1.4588	2.3212
SQ33	2.38	0.96	40.39	0.14	0.2744	2.1056	2.6544
SQ34	2.40	1.07	44.77	0.16	0.3136	2.0864	2.7136
SQ35	2.00	0.83	41.29	0.12	0.2352	1.7648	2.2352
SQ36	1.89	1.19	63.07	0.18	0.3528	1.5372	2.2428
SQ37	3.02	0.97	31.93	0.14	0.2744	2.7456	3.2544
SQ38	2.38	0.94	39.38	0.14	0.2744	2.1056	2.6544
SQ39	2.38	1.01	42.33	0.15	0.2940	2.0860	2.6740
SQ40	2.22	0.90	40.58	0.13	0.2548	1.9652	2.4748
SQ41	2.45	0.87	34.92	0.13	0.2548	2.2252	2.7448
SQ42	2.47	0.97	39.23	0.14	0.2744	2.1956	2.7444
SQ43	2.51	0.97	38.56	0.14	0.2744	2.2356	2.7844
SQ44	2.02	0.99	48.87	0.15	0.2940	1.7260	2.3140
SQ45	2.42	1.03	42.66	0.15	0.2940	2.1260	2.7140
SQ46	1.87	1.22	65.21	0.18	0.3528	1.5172	2.2228
SQ47	2.98	0.85	28.54	0.13	0.2548	2.7252	3.2348
SQ48	2.76	0.96	34.74	0.14	0.2744	2.4856	3.0344
SQ49	1.33	0.90	67.84	0.13	0.2548	1.0752	1.5848
SQ50	1.62	0.65	40.06	0.10	0.1960	1.4240	1.8160
SQ51	2.71	0.87	32.06	0.13	0.2548	2.4552	2.9648
SQ52	2.18	0.86	39.51	0.13	0.2548	1.9252	2.4348
SQ53	1.33	0.77	57.65	0.11	0.2156	1.1144	1.5456
SQ54	1.80	0.81	45.26	0.12	0.2352	1.5648	2.0352
SQ55	2.27	0.96	42.48	0.14	0.2744	1.9956	2.5444

VARIABLE	MEAN	STD	CV	ERROR	CI95	LOWER	UPPER
OQ56	2.04	0.67	32.90	0.10	0.1960	1.8440	2.2360
OQ57	2.00	0.80	39.85	0.12	0.2352	1.7648	2.2352
OQ58	2.04	0.82	40.23	0.12	0.2352	1.8048	2.2752
OQ59	1.87	0.73	38.90	0.11	0.2156	1.6544	2.0856
OQ60	1.93	0.69	35.56	0.10	0.1960	1.7340	2.1260

APPENDIX (C)

IMPORTANCE AND RANKING TABLES BY THE THREE PARTIES

TABLE C.1 IMPORTANCE AND RANKING OF THE CAUSES BY THE CONTRACTOR

TABLE C.2 IMPORTANCE AND RANKING OF THE CAUSES BY THE CONSULTANT

TABLE C.1 IMPORTANCE AND RANKING OF THE CAUSES BY THE OWNER

COMPUTER PRINTOUT OF THE FREQUENCY AND SEVERITY OF THE CAUSES

TABLE C.1 IMPORTANCE INDEX AND RANKING OF THE CAUSES BY THE CONTRACTOR

RANK	NO.	CAUSE OF DELAY	IMPORT. INDEX
1	37	Delay in progress payments by the owner	61.86
2	47	Difficulties in obtaining work permits from the authorities concerned	57.04
3	31	Delay in the settlement of contractor' s claims by the owner	53.02
4	51	Effect of subsurface conditions	48.38
5	28	Cash flow problems faced by the contractor	47.28
6	41	Excessive bureaucracy in the owner administration	45.42
7	39	Insufficient coordination by the owner in the early planning & design stages	44.62
8	48	Low performance of the lowest bidder contractor in the Government Tendering System	43.39
9	38	Poor communications by the owner with the construction parties involved, and Government Authorities concerned during construction	43.21
10	34	Delay in making decisions by the owner within a reasonable time	41.84
11	42	Changes in the scope of the project	40.84
12	33	Delay in issuance of change orders by the owner	39.64
13	27	Difficulties in financing the project by the contractor	39.45
14	55	Poor qualification of supervision staff of the consultant engineer	39.28
15	56	Delay in the approval of contractor submittals by the engineer	38.28
16	35	Interference by the owner in the construction operation phases	37.69
17	43	Ambiguities, defaults, and inconsistency of specifications, and drawings	37.48

Continued .....

TABLE C.1 IMPORTANCE INDEX AND RANKING OF THE CAUSES BY THE CONTRACTOR

RANK	NO.	CAUSE OF DELAY	IMPORT. INDEX
18	40	Poor coordination by the owner with the parties involved during construction	36.32
19	57	Poor communication by the consultant engineer	36.28
20	58	Poor coordination by the consultant engineer	35.59
21	52	Traffic control and restrictions at the job site	35.09
22	45	Original contract duration too short	33.14
23	60	Slow response to the contractor inquiries in the job site by the consultant engineer	33.14
24	32	Suspension of work by the owner	32.35
25	59	Delay in performing inspection and testing by the consultant engineer	31.31
26	2	Delay in materials delivery	30.98
27	44	Differing site conditions	30.89
28	30	Delay in furnishing and delivering the site to the contractor by the owner	29.35
29	36	Uncooperative owner with contractor	28.35
30	1	Shortage of materials required	25.99
31	9	Shortage of manpower	25.99
32	17	Delay in mobilization to start the project	24.43
33	14	Poor coordination by the contractor with the parties involved in the project	24.31
34	46	Ineffective delay penalty	24.27
35	13	Poor communication by the contractor with the parties involved in the project	23.91
36	10	Low skills of manpower	23.55
37	54	Interference with other contractor's work	23.24
38	21	Ineffective planning and scheduling of the project by the contractor	23.16
39	6	Failure of equipment	22.87
40	29	Subcontractor problems with the contractor	22.73

Continued .....

TABLE C.1 IMPORTANCE INDEX AND RANKING OF THE CAUSES BY THE CONTRACTOR

RANK	NO.	CAUSE OF DELAY	IMPORT. INDEX
41	4	Changes in materials specifications	22.73
42	3	Changes in materials prices	22.33
43	12	Shortage of technical professionals in the contractor's organization	21.99
44	20	Improper technical study of the project in the bidding stage by the contractor	21.38
45	15	Slow preparation of change orders requests by the contractor	21.27
46	23	Ineffective control of project progress by the contractor	20.46
47	50	Severe weather conditions on the job site	20.35
48	22	Delay in the field survey done by the contractor	20.27
49	5	Shortage of equipment required	20.27
50	7	Shortage of supporting and shoring installations for excavations .	20.2
51	49	Changes in Government regulations and laws	19.57
52	25	Delay in the preparation of contractor submittals	19.23
53	53	Effect of social and cultural conditions	18.59
54	19	Poor qualifications of the contractor's technical staff (engineers, inspectors, etc.)	17.72
55	16	Ineffective contractor head office involvement in construction of the project	17.66
56	11	Shortage of contractor's administrative personnel	17.01
57	24	Inefficient quality control by the contractor	16.95
58	26	Improper construction method implemented by the contractor	16.94
59	8	Inadequate equipment used for the works	14.28
60	18	Loose safety rules and regulations within the contractor's organization	12.48

TABLE C.2 IMPORTANCE INDEX AND RANKING OF THE CAUSES BY THE CONSULTANT

RANK	NO.	CAUSE OF DELAY	IMPORT. INDEX
1	28	Cash flow problems faced by the contractor	60.94
2	27	Difficulties in financing the project by the contractor	54.43
3	25	Delay in the preparation of contractor submittals	51.56
4	20	Improper technical study of the project in the bidding stage by the contractor	51.13
5	17	Delay in mobilization to start the project	50.00
6	48	Low performance of the lowest bidder contractor in the Government Tendering System	50.00
7	21	Ineffective planning and scheduling of the project by the contractor	48.44
8	23	Ineffective control of project progress by the contractor	45.75
9	14	Poor coordination by the contractor with the parties involved in the project	44.41
10	19	Poor qualifications of the contractor's technical staff (engineers, inspectors, etc.)	41.71
11	51	Effect of subsurface conditions	41.54
12	12	Shortage of technical professionals in the contractor's organization	40.10
13	37	Delay in progress payments by the owner	39.06
14	9	Shortage of manpower	39.06
15	47	Difficulties in obtaining work permits from the authorities concerned	39.02
16	5	Shortage of equipment required	36.69
17	24	Inefficient quality control by the contractor	36.46
18	45	Original contract duration too short	36.11
19	10	Low skills of manpower	35.24
20	29	Subcontractor problems with the contractor	35.24

Continued .....

TABLE C.2 IMPORTANCE INDEX AND RANKING OF THE CAUSES BY THE CONSULTANT

RANK	NO.	CAUSE OF DELAY	IMPORT. INDEX
21	42	Changes in the scope of the project	35.24
22	26	Improper construction method implemented by the contractor	32.23
23	2	Delay in materials delivery	31.64
24	13	Poor communication by the contractor with the parties involved in the project	31.60
25	1	Shortage of materials required	30.99
26	43	Ambiguities, defaults, and inconsistency of specifications, and drawings	30.47
27	31	Delay in the settlement of contractor' s claims by the owner	29.30
28	6	Failure of equipment	29.30
29	22	Delay in the field survey done by the contractor	29.17
30	34	Delay in making decisions by the owner within a reasonable time	28.13
31	18	Loose safety rules and regulations within the contractor's organization	27.69
32	7	Shortage of supporting and shoring installations for excavations	27.23
33	41	Excessive bureaucracy in the owner administration	26.04
34	33	Delay in issuance of change orders by the owner	24.96
35	15	Slow preparation of change orders requests by the contractor	24.83
36	16	Ineffective contractor head office involvement in construction of the project	23.87
37	52	Traffic control and restrictions at the job site	23.87
38	54	Interference with other contractor's work	23.87
39	46	Ineffective delay penalty	21.69
40	11	Shortage of contractor's administrative personnel	21.01

Continued .....

TABLE C.2 IMPORTANCE INDEX AND RANKING OF THE CAUSES BY THE CONSULTANT

RANK	NO.	CAUSE OF DELAY	IMPORT. INDEX
41	56	Delay in the approval of contractor submittals by the engineer	20.83
42	30	Delay in furnishing and delivering the site to the contractor by the owner	20.46
43	4	Changes in materials specifications	20.05
44	60	Slow response to the contractor inquiries in the job site by the consultant engineer	19.97
45	32	Suspension of work by the owner	19.35
46	8	Inadequate equipment used for the works	18.23
47	3	Changes in materials prices	17.81
48	55	Poor qualification of supervision staff of the consultant engineer	17.36
49	35	Interference by the owner in the construction operation phases	17.32
50	38	Poor communications by the owner with the parties involved, during construction	17.19
51	44	Differing site conditions	16.90
52	40	Poor coordination by the owner with the construction parties involved, and Government Authorities concerned during construction	16.49
53	50	Severe weather conditions at the job site	16.49
54	39	Insufficient coordination by the owner in the early planning & design stages of the project	16.41
55	58	Poor coordination by the consultant engineer	15.67
56	57	Poor communication by the consultant engineer	14.84
57	59	Delay in performing inspection and testing by the consultant engineer	14.01
58	36	Uncooperative owner with contractor	11.57
59	49	Changes in Government regulations and laws	9.77
60	53	Effect of social and cultural conditions	9.03

TABLE C.3 IMPORTANCE INDEX AND RANKING OF THE CAUSES BY THE OWNER

RANK	NO	CAUSE OF DELAY	IMPORT. INDEX
1	28	Cash flow problems faced by the contractor	61.63
2	47	Difficulties in obtaining work permits from the authorities concerned	58.00
3	27	Difficulties in financing the project by the contractor	55.69
4	21	Ineffective planning and scheduling of the project by the contractor	54.44
5	20	Improper technical study of the project in the bidding stage by the contractor	52.31
6	17	Delay in mobilization to start the project	47.13
7	9	Shortage of manpower	45.5
8	46	Ineffective delay penalty	43.88
9	48	Low performance of the lowest bidder in the Government Tendering System	46.75
10	23	Ineffective control of project progress by the contractor	40.50
11	14	Poor coordination by the contractor with the parties involved in the project	37.50
12	25	Delay in the preparation of contractor submittals	36.75
13	22	Delay in the field survey done by the contractor .	36.74
14	37	Delay in progress payments by the owner	36.25
15	42	Changes in the scope of the project	35.94
16	24	Inefficient quality control by the contractor	35.75
17	41	Excessive bureaucracy in the owner administration	35.75
18	51	Effect of subsurface conditions	35.00
19	12	Shortage of technical professionals in the contractor's organization	34.38
20	43	Ambiguities, defaults, and inconsistency of specifications, and drawings	34.38

Continued .....

TABLE C.3 IMPORTANCE INDEX AND RANKING OF THE CAUSES BY THE OWNER

RANK NO		CAUSE OF DELAY	IMPORT. INDEX
21	5	Shortage of equipment required	34.13
22	16	Ineffective contractor head office involvement in construction of the project	33.00
23	29	Subcontractor problems with the contractor	33.00
24	1	Shortage of materials required	32.81
25	10	Low skills of manpower	31.63
26	6	Failure of equipment	31.63
27	45	Original contract duration too short	30.56
28	13	Poor communication by the contractor with the parties involved in the project	30.25
29	15	Slow preparation of change orders requests by the contractor	30.19
30	19	Poor qualifications of the contractor's technical staff (engineers, inspectors, etc.)	30.19
31	2	Delay in materials delivery	30.19
32	33	Delay in issuance of change orders by the owner	28.88
33	39	Insufficient coordination by the owner in the early planning & design stages of the project	28.88
34	40	Poor coordination by the owner with the parties involved during construction	28.88
35	56	Delay in the approval of contractor submittals by the engineer	28.13
36	52	Traffic control and restrictions at the job site	27.50
37	26	Improper construction method implemented by the contractor	27.00
38	58	Poor coordination by the consultant engineer	26.25
39	57	Poor communication by the consultant engineer	26.13
40	32	Suspension of work by the owner	26.00

Continued .....

TABLE C.3 IMPORTANCE INDEX AND RANKING OF THE CAUSES BY THE OWNER

RANK NO		CAUSE OF DELAY	IMPORT. INDEX
41	38	Poor communications by the owner with the parties involved during construction	25.88
42	31	Delay in the settlement of contractor' s claims by the owner	24.94
43	34	Delay in making decisions by the owner within a reasonable time	24.94
44	11	Shortage of contractor's administrative personnel	23.75
45	55	Poor qualification of supervision staff of the consultant engineer	23.38
46	59	Delay in performing inspection and testing by the consultant engineer	23.38
47	18	Loose safety rules and regulations within the contractor's organization	22.50
48	44	Differing site conditions	22.50
49	54	Interference with other contractor's work	22.50
50	30	Delay in furnishing and delivering the site to the contractor by the owner	22.00
51	60	Slow response to the contractor inquiries in the job site by the consultant engineer	22.00
52	4	Changes in materials specifications	20.19
53	8	Inadequate equipment used for the works	19.00
54	7	Shortage of supporting and shoring installations for excavations	18.06
55	3	Changes in materials prices	18.00
56	35	Interference by the owner in the construction operation phases	16.00
57	36	Uncooperative owner with contractor	15.44
58	50	Severe weather conditions on the job site	12.04
59	53	Effect of social and cultural conditions	11.11
60	49	Changes in Government regulations and laws	10.71

STANDARD IMPORTANCE INDEX

OBS	FACTOR	C_INDEX	S_INDEX	C_INDEX	STDINDEX
1	SQ28	47.2826	60.9375	61.625C	56.6150
2	SC47	57.0416	39.0191	58.0CCC	51.3536
3	SC27	39.4454	54.4271	55.6875	49.8547
4	SC37	61.862C	39.C625	36.250C	45.7248
5	SC48	43.3884	50.CCCO	43.750C	45.7128
6	SC21	23.1569	48.4375	54.4444	42.0129
7	SQ51	48.3814	41.5365	35.CCCC	41.6393
8	SQ20	21.3843	51.1285	52.3125	41.6084
9	SQ17	24.4329	50.0000	47.1250	40.5193
10	SC42	40.835C	35.2431	35.9375	37.3385
11	SQ9	25.9924	39.0625	45.5CCC	36.8516
12	SQ25	19.2344	51.5625	36.75CO	35.8490
13	SC31	53.0246	29.2969	24.9375	35.7530
14	SC41	45.4159	26.0417	35.750C	35.7358
15	SQ23	2C.4545	45.7465	40.500C	35.5670
16	SC14	24.3147	44.4C1C	37.5CCC	35.4053
17	SC43	37.4764	3C.4687	34.375C	34.1067
18	SQ45	33.1404	36.1111	30.5556	33.2690
19	SC12	21.9991	40.1C42	34.375C	32.1594
20	SC34	41.8388	28.1250	24.9375	31.6238
21	SC33	39.6385	24.9566	28.875C	31.1567
22	SC2	3C.9783	31.64CE	30.1875	3C.9355
23	SQ5	20.2741	36.6951	34.125C	3C.3647
24	SC29	22.7273	35.2431	33.CCCO	30.3234
25	SC10	23.5537	35.2431	31.625C	3C.140E
26	SC39	44.6125	16.4063	28.875C	29.9646
27	SQ46	24.267C	21.6942	43.875C	29.9454
28	SQ1	25.9924	30.9517	32.8125	29.9322
29	SC19	17.7248	41.7101	30.1875	29.8741
30	SQ24	16.9542	36.4583	35.75CC	29.7208
31	SC56	38.2798	2C.8333	28.125C	29.0794
32	SC52	35.0898	23.8715	27.5CCC	28.82C4
33	SC38	43.2183	17.1875	25.875C	28.76C3
34	SC22	2C.2741	29.1667	36.7361	28.7256
35	SQ13	23.9130	31.5972	30.25CC	28.5868
36	SC6	22.8733	29.2969	31.625C	27.9317
37	SC40	36.3185	16.4931	28.8750	27.2289
38	SC55	39.2787	17.3611	23.375C	26.6716
39	SQ32	32.3529	19.3452	26.CCOC	25.8994
40	SQ58	35.5888	15.6684	26.2500	25.8357
41	SQ57	36.2732	14.8438	26.125C	25.7473
42	SQ15	21.2665	24.8264	30.1875	25.4268
43	SQ26	16.9421	32.2314	27.00C0	25.3912
44	SQ60	33.1404	19.9653	22.CCCC	25.0352
45	SQ16	17.6653	23.8715	33.0000	24.8456
46	SQ30	29.3478	20.4545	22.CCCC	23.9341
47	SC35	37.6890	17.3177	16.CCOC	23.6689
48	SQ44	30.8884	16.9C34	22.5CCO	23.43C6
49	SQ54	23.2426	23.8715	22.5CCC	23.2047
50	SC59	31.3C91	14.C191	23.375C	22.9011
51	SC7	2C.2032	27.2254	18.0625	21.8304
52	SC4	22.7273	20.0521	20.1875	2C.9890
53	SQ18	12.4764	27.6910	22.5CC0	20.8891
54	SC11	17.0132	21.0069	23.75CC	2C.59C1
55	SC3	22.3299	17.8125	18.CCCO	19.3808
56	SC36	28.3447	11.5702	15.4375	18.45C8

STANDARD IMPORTANCE INDEX

OBS	FACTOR	C_INDEX	S_INDEX	C_INDEX	STDINDEX
57	SQ8	14.2840	18.2292	19.0000	17.1711
58	SQ50	20.3450	16.4531	12.0370	16.2917
59	SQ49	19.5724	9.7656	10.7143	13.3508
60	SQ53	18.5937	9.0278	11.1111	12.9109

IMPORTANCE INDEX OF SUPERVISORS

OBS	FACTOR	CINDEX	SINDEX	IMPINDEX
1	SQ28	3.CCCCC	3.25000	60.9375
2	SQ27	2.75CCC	3.16667	54.4271
3	SQ25	3.CCCCC	2.75CCC	51.5625
4	SQ20	2.58333	3.16667	51.1285
5	SQ17	3.CCCCC	2.66667	50.CCCC
6	SQ48	2.66667	3.CCCCC	50.CCCC
7	SQ21	2.58333	3.CCCCC	48.4375
8	SQ23	2.58333	2.83333	45.7465
9	SQ14	2.75CCC	2.58333	44.401C
10	SQ19	2.58333	2.58333	41.7101
11	SQ51	2.41667	2.75CCC	41.5365
12	SQ12	2.33333	2.75CCC	40.1042
13	SQ37	2.5CCCC	2.5CCCC	39.0625
14	SQ9	2.5CCCC	2.5CCCC	39.0625
15	SQ47	2.41667	2.58333	39.0191
16	SQ5	2.27273	2.58333	36.6951
17	SQ24	2.33333	2.5CCCC	36.4583
18	SQ45	2.16667	2.66667	36.1111
19	SQ10	2.41667	2.33333	35.2431
20	SQ29	2.33333	2.41667	35.2431
21	SQ42	2.41667	2.33333	35.2431
22	SQ26	2.18182	2.36364	32.2314
23	SQ2	2.25CCC	2.25CCC	31.6406
24	SQ13	2.33333	2.16667	31.5972
25	SQ1	2.27273	2.18182	30.9917
26	SQ43	2.16667	2.25CCC	30.4687
27	SQ31	2.25CCC	2.08333	29.2969
28	SQ6	2.25CCC	2.08333	29.2969
29	SQ22	2.33333	2.CCCCC	29.1667
30	SQ34	2.CCCCC	2.25CCC	28.1250
31	SQ18	2.41667	1.83333	27.691C
32	SQ7	2.09091	2.08333	27.2254
33	SQ41	2.08333	2.CCCCC	26.0417
34	SQ33	1.91667	2.08333	24.9566
35	SQ15	2.16667	1.83333	24.8264
36	SQ16	2.08333	1.83333	23.8715
37	SQ52	2.08333	1.83333	23.8715
38	SQ54	2.08333	1.83333	23.8715
39	SQ46	1.90909	1.81818	21.6942
40	SQ11	1.83333	1.83333	21.0069
41	SQ56	1.66667	2.CCCCC	20.8333
42	SQ30	1.63636	2.CCCCC	20.4545
43	SQ4	1.75CCC	1.83333	20.0521
44	SQ60	1.66667	1.91667	19.9653
45	SQ32	1.44444	2.14286	19.3452
46	SQ8	1.66667	1.75CCC	18.2292
47	SQ3	1.58333	1.8CCCC	17.8125
48	SQ55	1.66667	1.66667	17.3611
49	SQ35	1.75CCC	1.58333	17.3177
50	SQ38	1.5CCCC	1.83333	17.1875
51	SQ44	1.54545	1.75CCC	16.9034
52	SQ40	1.58333	1.66667	16.4931
53	SQ50	1.66667	1.58333	16.4931
54	SQ39	1.50000	1.75CCC	16.4063
55	SQ58	1.58333	1.58333	15.6684
56	SQ57	1.50CCC	1.58333	14.8438

IMPORTANCE INDEX OF SUPERVISORS

OBS	FACTOR	CINDEX	SINDEX	IMPINDEX
57	SQ59	1.41667	1.58333	14.0191
58	SQ36	1.27273	1.45455	11.5702
59	SQ49	1.25000	1.25000	9.7656
60	SQ53	1.33333	1.08333	9.0278

IMPORTANCE INDEX OF OWNERS

OBS	FACTOR	CIINDEX	SIINDEX	IMPINDEX
1	SQ28	2.90000	3.40000	61.6250
2	SQ47	2.90000	3.20000	58.0000
3	SQ27	2.70000	3.30000	55.6875
4	SQ21	2.80000	3.11111	54.4444
5	SQ20	2.70000	3.10000	52.3125
6	SQ17	2.90000	2.60000	47.1250
7	SQ9	2.60000	2.80000	45.5000
8	SQ46	2.60000	2.70000	43.8750
9	SQ48	2.50000	2.80000	43.7500
10	SQ23	2.40000	2.70000	40.5000
11	SQ14	2.40000	2.50000	37.5000
12	SQ25	2.10000	2.80000	36.7500
13	SQ22	2.30000	2.55556	36.7361
14	SQ37	2.00000	2.90000	36.2500
15	SQ42	2.30000	2.50000	35.9375
16	SQ24	2.20000	2.60000	35.7500
17	SQ41	2.20000	2.60000	35.7500
18	SQ51	2.33333	2.40000	35.0000
19	SQ12	2.20000	2.50000	34.3750
20	SQ43	2.20000	2.50000	34.3750
21	SQ5	2.10000	2.60000	34.1250
22	SQ16	2.20000	2.40000	33.0000
23	SQ29	2.20000	2.40000	33.0000
24	SQ1	2.10000	2.50000	32.8125
25	SQ10	2.20000	2.30000	31.6250
26	SQ6	2.20000	2.30000	31.6250
27	SQ45	2.00000	2.44444	30.5556
28	SQ13	2.20000	2.20000	30.2500
29	SQ15	2.30000	2.10000	30.1875
30	SQ19	2.10000	2.30000	30.1875
31	SQ2	2.10000	2.30000	30.1875
32	SQ33	2.20000	2.10000	28.3750
33	SQ39	2.10000	2.20000	28.8750
34	SQ40	2.10000	2.20000	28.8750
35	SQ56	1.80000	2.50000	28.1250
36	SQ52	2.00000	2.20000	27.5000
37	SQ26	1.80000	2.40000	27.0000
38	SQ58	2.00000	2.10000	26.2500
39	SQ57	1.90000	2.20000	26.1250
40	SQ32	1.60000	2.60000	26.0000
41	SQ38	1.80000	2.30000	25.8750
42	SQ31	1.90000	2.10000	24.9375
43	SQ34	1.90000	2.10000	24.9375
44	SQ11	2.00000	1.90000	23.7500
45	SQ55	1.70000	2.20000	23.3750
46	SQ59	1.70000	2.20000	23.3750
47	SQ18	2.00000	1.80000	22.5000
48	SQ44	1.80000	2.00000	22.5000
49	SQ54	2.00000	1.80000	22.5000
50	SQ30	1.60000	2.20000	22.0000
51	SQ60	1.60000	2.20000	22.0000
52	SQ4	1.90000	1.70000	20.1875
53	SQ8	1.60000	1.90000	19.0000
54	SQ7	1.70000	1.70000	18.0625
55	SQ3	1.80000	1.60000	18.0000
56	SQ35	1.60000	1.60000	16.0000

IMPORTANCE INDEX OF OWNERS

OBS	FACTOR	CINDEX	SINDEX	IMPINDEX
57	SQ36	1.30000	1.90000	15.4375
58	SQ50	1.33333	1.44444	12.0370
59	SQ53	1.33333	1.33333	11.1111
60	SQ49	1.20000	1.42857	10.7143

APPENDIX (D)

RANK CORRELATION CALCULATIONS

APPENDIX D

CALCULATIONS OF RANK CORRELATION

Rank correlation coefficient is used to express the correlation between the parties; contractor, consultant, and owner in the importance of the causes of delay according to the importance index of these causes. The causes of delay of the same importance index will carry the same rank. The rank assigned will be the average of the tied ranks. For example, if the causes number 12, 25, 46 have the same importance index, with rank 17, 18, and 19, then each will be ranked as 18.

Rank correlation coefficient is denoted by (r) and calculated by the following formula (Kindle & Gibbons 1990):

$$r_{cs} = (N - \Sigma d_i^2 - U_c - U_s) / (N - 2U_c) * (N - 2 U_s) \quad \text{Eq. D.1}$$

Where :

$N = (n^3 - n) / 6$ n = number of pairs of ranks = 60

$N = (60^3 - 60) / 6 = 35990$

d_i = the difference between the ranks assigned to the two variables, which is the difference in ranks for each cause by the parties as shown in Table (D.1).

$U = 1 / 12 \Sigma (u^3 - u)$

TABLE D.1 SPEARMAN RANK CORRELATION CALCULATIONS

NO	RANK BY			DIFFERENCE IN RANKS					
	CONTRACTOR C	CONSULTANT S	owner O	d_{cs}	d^2_{cs}	d_{co}	d^2_{co}	d_{so}	d^2_{so}
1	30.5	25	24	5.5	30.25	6.5	42.25	1	1
2	26	23	30	3	9	3	9	-7	49
3	42	47	55	-5	25	-13	169	-8	64
4	40.5	43	52	-2.5	6.25	-11.5	132.3	-9	81
5	48.5	16	21	32.5	1056.3	27.5	756.3	-5	25
6	39	27.5	25.5	11.5	132.25	13.5	182.3	2	4
7	50	32	54	18	324	-4	16	-22	484
8	59	46	53	13	169	6	36	-7	49
9	30.5	14	7	16.5	272.25	23.5	552.3	7	49
10	36	20	25.5	16	256	10.5	110.3	-5.5	30.3
11	56	40	44	16	256	12	144	-4	16
12	43	12	19.5	31	961	23.5	552.3	-7.5	56.3
13	35	24	28	11	121	7	49	-4	16
14	33	9	11	24	576	22	484	-2	4
15	45	34	30	11	121	15	225	4	16
16	55	37	22.5	18	324	32.5	1056	14.5	210
17	32	5.5	6	26.5	702.25	26	676	-0.5	0.25
18	60	31	48	29	841	12	144	-17	289
19	54	10	30	44	1936	24	576	-20	400
20	44	4	5	40	1600	39	1521	-1	1
21	38	7	4	31	961	34	1156	3	9
22	48.5	29	13	19.5	380.25	35.5	1260	16	256
23	46	8	10	38	1444	36	1296	-2	4
24	57	17	16.5	40	1600	40.5	1640	0.5	0.25
25	52	3	12	49	2401	40	1600	-9	81
26	58	22	37	36	1296	21	441	-15	225
27	13	2	3	11	121	10	100	-1	1
28	5	1	1	4	16	4	16	0	0
29	40.5	20	22.5	20.5	420.25	18	324	-2.5	6.25
30	28	42	50.5	-14	196	-22.5	506.3	-8.5	72.3

Continued .....

TABLE D.1 SPEARMAN RANK CORRELATION CALCULATIONS

NO	RANK BY			DIFFERENCE IN RANKS					
	CONTRACTOR C	CONSULTANT S	owner O	d_{cs}	d^2_{cs}	d_{co}	d^2_{co}	d_{so}	d^2_{so}
31	3	27.5	42.5	-24.5	600.25	-39.5	1560	-15	225
32	24	45	40	-21	441	-16	256	5	25
33	12	34	33	-22	484	-21	441	1	1
34	10	30	42.5	-20	400	-32.5	1056	-13	156
35	16	49	56	-33	1089	-40	1600	-7	49
36	29	58	57	-29	841	-28	784	1	1
37	1	13	14	-12	144	-13	169	-1	1
38	9	50	41	-41	1681	-32	1024	9	81
39	7	54	33	-47	2209	-26	676	21	441
40	18	52.5	33	-34.5	1190.3	-15	225	19.5	380
41	6	33	16.5	-27	729	-10.5	110.3	16.5	272
42	11	20	15	-9	81	-4	16	5	25
43	17	26	19.5	-9	81	-2.5	6.25	6.5	42.3
44	27	51	48	-24	576	-21	441	3	9
45	22.5	18	27	4.5	20.25	-4.5	20.25	-9	81
46	34	39	8	-5	25	26	676	31	961
47	2	15	2	-13	169	0	0	13	169
48	8	5.5	9	2.5	6.25	-1	1	-3.5	12.3
49	51	59	60	-8	64	-9	81	-1	1
50	47	52.5	58	-5.5	30.25	-11	121	-5.5	30.3
51	4	11	18	-7	49	-14	196	-7	49
52	21	37	36	-16	256	-15	225	1	1
53	53	60	59	-7	49	-6	36	1	1
54	37	37	48	0	0	-11	121	-11	121
55	14	48	45.5	-34	1156	-31.5	992.3	2.5	6.25
56	15	41	35	-26	676	-20	400	6	36
57	19	56	39	-37	1369	-20	400	17	289
58	20	55	38	-35	1225	-18	324	17	289
59	25	57	45.5	-32	1024	-20.5	420.3	11.5	132
60	22.5	44	50.5	-21.5	462.25	-28	784	-6.5	42.3
		SUM OF d2			35682		28936		6430

u = number of scores in each tied ranks for each party.

$U_c = 1 / 12 \sum (u_c^3 - u_c)$

$u_c = 2, 2, 3, 2.$

Then $\sum (u_c^3 - u_c) = 3 (2^3 - 2) + (3^3 - 3) = 42$

$U_c = 1/ 12 (42) = 3.5$

$U_s = 1 / 12 \sum (u_s^3 - u_s)$

$u_s = 2, 2, 3, 2, 3.$

Then $\sum (u_s^3 - u_s) = 3(2^3 - 2) + 2(3^3 - 3) = 66$

$U_s = 1/ 12 (66) = 5.5$

$U_o = 1 /12 \sum (u_o^3 - u_o)$

$u_o = 2, 2, 3, 2, 3, 2, 2, 3, 2, 2.$

Then : $\sum (u_o^3 - u_o) = 7 (2^3 - 2) + 3 (3^3 - 3) = 114$

$U_o = 1/ 12 (114) = 9.5$

Table (D.1) shows difference in ranks (d_i), and the calculation of $\sum d_i^2$. By using these values in equation D.1 above, then r is calculated as follow :

$r_{cs} = (N - \sum d_i^2 - U_c - U_s) / (N - 2U_c) * (N - 2 U_s)$ Eq. D.1

$r_{cs} = 35990 - 35682 - 3.5 - 5.5 / (35990 - 2*3.5)*(35990 - 2*5.5)$
$= 0.00831$

$r_{co} = (N - \sum d_i^2 - U_c - U_o) / (N - 2U_c) * (N - 2 U_o)$ Eq. D.2

$r_{co} = 35990 - 28936 - 3.5 - 9.5 /(35990 - 2* 3.5)*(35990 - 2*9.5)$
$= 0.1957$

$$r_{so} = (N - \sum d_i^2 - U_s - U_o) / (N - 2U_s) * (N - 2U_o) \quad \text{Eq. D.3}$$

$$r_{so} = 35990 - 28936 - 5.5 - 9.5 / (35990 - 2*3.5) * (35990 - 2*9.5)$$
$$= 0.8211$$

Where :

r_{cs} = The rank correlation coefficient between the contractor and the consultant engineer, while ignoring the ranking of the owner.

r_{co} = The rank correlation coefficient between the contractor and the owner, while ignoring the ranking of the consultant engineer.

r_{so} = The rank correlation coefficient between consultant engineer and owner, while ignoring the ranking of the contractor.

The following equations are used to calculate the partial correlation (Snedecor & Cochran 1980):

$$r_{cs.o} = (r_{cs} - r_{co} * r_{so}) / (1 - r^2_{co})(1 - r^2_{so})$$
$$= (0.00831 - 0.1957*0.8211) / (1 - (0.1957)^2)(1 - (0.8211)^2)$$
$$= -0.2722$$

$$r_{co.s} = (r_{co} - r_{cs} * r_{so}) / (1 - r^2_{so})(1 - r^2_{cs})$$
$$= (0.1957 - 0.00831*0.8211) / (1-(0.8211)^2)(1-(0.00831)^2)$$
$$= 0.3309$$

$$r_{so.c} = (r_{so} - r_{cs} * r_{co}) / (1 - r^2_{cs})(1 - r^2_{co})$$
$$= (0.8211 - 0.00831*0.1957) / (1-(0.00831)^2)(1-(0.1956)^2)$$
$$= 0.8357$$

Where :

$r_{cs.o}$ = The partial rank correlation representing level of agreement between the contractor and the consultant , while holding the owner.

$r_{co.s}$ = The partial rank correlation representing level of agreement between the contractor and the owner, while holding the consultant.

$r_{so.c}$ = The partial rank correlation representing level of agreement between the consultant and the owner, while holding the contractor.

The following equations are used for the calculation of the multiple rank correlation coefficient:

$$r_{c.so} = r_{cs} + r_{co} - 2(R) / 1 - r_{so}$$

$$R = r_{cs} * r_{co} * r_{so} = 0.00831 * 0.1957 * 0.8211 = 0.00134$$

$r_{c.so} = (0.00831) + (0.1957) - 2\,(0.00134) / 1 - (0.8211) = 0.3310$

$r_{s.co} = r_{cs} + r_{so} - 2\,(R) / 1 - r_{co}$

$= (0.00831) + (0.8211) - 2\,(0.00134) / 1 - (0.1957) = 0.8357$

$r_{o.cs} = r_{co} + r_{so} - 2\,(R) / 1 - r_{cs}$

$= (0.1957) + (0.8211) - 2\,(0.00134) / 1 - (0.00831) = 0.8425$

Where :

$r_{c.so}$ = The agreement between the contractor and other two parties; the consultant and the owner.

$r_{s.co}$ = The agreement between the consultant and other two parties; the contractor and the owner.

$r_{o.cs}$ = The agreement between the owner and other two parties; the contractor and the consultant.

Table D.2 summarizes the rank correlation values.

TABLE D.2 SUMMARY OF CORRELATION VALUES

SPEARMAN	PARTIAL	MULTIPLE
$r_{cs} = 0.00831$	$r_{cs.o} = -0.2722$	$r_{c.so} = 0.3310$
$r_{co} = 0.1957$	$r_{co.s} = 0.3309$	$r_{s.co} = 0.8357$
$r_{so} = 0.8211$	$r_{so.c} = 0.8357$	$r_{o.cs} = 0.8425$

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