A Model For Measuring Effectiveness Of Building Construction
Organisations: Owner's Perspective

by

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SUMMARY

This research is an effort to devise a model to measure the effectiveness of construction organisations. A major part of the population's income is closely related to construction activities. Not only does this industry touch the lives of virtually everyone on a daily basis, but it also occupies a fundamental position in the national economy. This large and pervasive industry is regarded as one of the major indicators of the state general economy. Periods of prosperity are usually associated with a large volume of construction activities.

Construction organisations live in an ever-changing environment and their survival depends on their ability to adapt to new demands and opportunities. The construction industry often is criticised for failure to apply the common techniques of planning and time studies of the manufacturing industry to their environment. Although these charges are partially true, critics fail to recognise that on-site construction has unique problems and is totally different in many aspects from the manufacturing industry. The construction process is subject to the influence of highly variable and sometimes unpredictable factors. The unwillingness or leisurely approach of the industry towards responding appropriately to customers' demands has created a need to devise a model of measuring effectiveness. This thesis provides a model of measuring effectiveness that can predict the level of effectiveness for the construction organisations. The thesis has utilised the principles of Total Quality Management and the Constituency Model to devise such a model.

The proposed model provides the owners of the construction projects a tool to predict the overall quality of their projects. This research, after analysing an abundance of variables, identifies two variables as the most significant ones. These two independent variables are related to the capability of the prime contractor being on schedule and the ability to comply with the specifications.

The proposed model is validated by using residual. The results have given satisfactory.

Since the proposed model is a customer driven model; the independent variables being the level of satisfaction of the external and internal customers, a periodical assessment of customers' satisfaction is necessary in order to keep the model current. In addition, the accuracy level of the devised model can be improved upon by a regular assessment of the changes in the customer needs.

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To Bernice,
my best friend and my wife,
For all her support.

To my son,
Ryan
For his love.

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CHAPTER I

INTRODUCTION

1.1 Introduction to the Construction Characteristics and Environment

Construction organizations live in an ever-changing environment and their effectiveness depends on their ability to adapt to new demands and opportunities. This industry needs to adjust itself to the changes occurring in its working environment in order to become more effective.

Construction projects are intricate and time-consuming tasks. The total development of a project normally consists of several phases requiring a diverse range of specialized services. In progressing from initial planning to project completion, the typical project passes through successive and distinct stages that demand inputs from such

disparate groups as financial organizations, government agencies, engineers, architects, lawyers, surety companies, contractors, and building trade-persons.

During the construction process itself even a project of modest proportions involves many skills, materials, and literally hundreds of different operations. The assembly process must follow a natural order of events that, in total combination, constitutes a complicated pattern of individual time requirements and restrictive sequential relationships among the many segments of the structure.

To some degree each construction project is unique, and no two projects are ever quite alike. In its specifics, each project is tailored to suit its environment, arranged to perform its own particular function, and designed to reflect personal tastes and preferences. The vagaries of the construction site and possibilities for creative variation of even the most standardized building product, make each construction project a new challenge.

The construction organization sets up its "factory" on the site and, to a large extent, custom builds each project. The construction process is subject to the influence of highly variable and unpredictable factors. The construction team, which includes architects, engineers, building trades-persons, subcontractors, material suppliers, and others, changes from project to project. All the complexities inherent with different construction sites such as subsoil conditions, surface topography, weather, transportation, material supply, utilities and services, local subcontractors, and labor conditions are inseparable parts of construction. As a consequence of these circumstances, construction projects are manifested by their complexity and diversity and by the non-standardized nature of their production. The use of factory-made modular units may reduce this individuality

somewhat, but it is unlikely that field construction will ever be able to adapt itself completely to the standardized methods and product uniformity of assembly-line production.

Construction projects are generally of short duration, and their work stations are of a transient nature. This industry's end product is non-standardized. Each project differs to some extent from the next. The labor force in construction industry is seasonal and highly skillful. Due to the seasonality of the work force and the periodical demands of construction services, this industry faces many difficulties such as inadequate capability for proper training and maintaining high morale among the employees.

Construction firms are typified by small businesses. Construction organizations are highly centralized and functional in nature. This hierarchical characteristic of construction firms has enabled them to adjust rapidly to their environment. This fast adjustment capability plays a significant role in their survival.

Mismanagement of resources has become a prevalent problem in many construction firms. This mismanagement of resources contributes to numerous construction firms' ineffectiveness and frequent failures each year.

1.2. Problem Statement

The level of instability in the environment, when combined with the degree of project complexity, creates an antagonistic operational condition within the construction industry. One of the main factors of survival can be the construction firm's ability to measure and monitor its level of effectiveness on a regular basis. Construction firms are

interacting with their external as well as internal environment on a daily basis. Construction firms, in order to be considered effective organizations, must satisfy the needs of these internal and external components. These groups are constituent parties to construction projects. A constituent party is one who has an interest either in the construction firm's survival or the construction project itself.

The internal constituent components such as employees and management, process the end products of the construction firm. The external constituent components interact with the construction firm from outside of the organization's environment. Such external components are material suppliers, financial institutions, surety companies, end users of products, owners, and architects. Without a doubt, each constituency has a different criterion of satisfaction because they have a different interest in the construction firm's performance. As a consequence, the effectiveness of a construction organization has to be evaluated and monitored by surveying the attitudes of each constituency. On the other hand, managers in construction firms tend to assess the level of their effectiveness on a job by job basis. This is a short term view assessing of effectiveness of the construction firms. Therefore, a comprehensive method of evaluating the performance of the construction firms is desirable.

Hence, construction firms in order to survive for a long time, must:

1. Find a way to measure the level of their effectiveness on a regular basis

2. Identify the changes in their customers demands and tastes

3. Adapt proper change strategies in order to increase their customer satisfaction level and to improve their management process

Naturally, without an objective basis for effectiveness measurement, the construction organization can not control and improve on its effectiveness level. Accordingly, it is clearly becoming meaningful for construction firms to develop satisfactory methods of estimating and predicting their level of effectiveness.

1.3. The Research Objectives

An increase in the effectiveness level of construction organizations, can translate itself into a leaner and more effective industry. Improvement in effectiveness should be viewed as an endless endeavor to help construction firms to better adjust themselves to the changes in their environment. Construction organizations are constantly interacting with their internal and external customers. Keeping these customers satisfied can lead to a more effective organization. The objective of this research is to provide the industry with a model to evaluate the effectiveness level of the construction firms. The application of the research results will ultimately provide:

1. A performance and productivity improvement of construction organizations by receiving improved quality feed back from customers.

2. An increase in top management's awareness regarding sensitive issues facing organizational characteristics that can influence effectiveness of the construction organization.

3. Ultimately, by highlighting the areas that need to be improved upon, can help the construction industry to evaluate better its effectiveness.

1.4. Proposed Model

Total Quality Management (TQM) is a change strategy that emphasizes perfect quality performance, continuous improvement, and being responsive to customers. TQM is a customer driven tool of management for effectiveness improvement. The customers can be either internal or external. Internal customers are referred to those who are working inside the organization, while the external customers are the end users of the manufactured products. TQM management philosophy is principally based on the satisfaction of these two types of customers. In TQM implementation, the top managers emphasize doing things right the first time and always being responsive to the interests of the customers while attempting for a continuous improvement of the management process.

TQM theory in terms of construction is discussed in the course of this thesis and the effectiveness of the construction organization is assessed in terms of TQM processes of input, transformation, and output. These TQM processes are used to categorize the most frequently applied criteria of effectiveness which are internal and external customer satisfaction.

This research also introduces different existing models for measuring organizational effectiveness. The majority of models introduced are based on open and closed system theories. The constituency-model is a model based on open-system theory. The fundamental concept behind the constituency-model is the involvement and satisfaction of all the parties involved in the process of production. In the constituency-model the extent of involvement and satisfaction of the public, owner, designers, government authorities, laborers, and financial entities are assessed.

This research uses these two powerful tools of management, TQM and constituency-model, in order to devise a new model of effectiveness measurement for the construction industry. This proposed model is based on a modified version of the constituency-model synthesized with TQM principles. The proposed model is adopted to the special environment and limitations of the construction industry. The model of effectiveness was tested using 92 construction projects to prove its validity. The following flowchart, Figure-1, shows the above process.

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┌─────────────────────────┐        ┌─────────────────────────┐
│ 1.  Effectiveness Model: │        │ 2.  Change Strategy:    │
│ Constituency Model       │        │ Total Quality Management │
└────────────┬────────────┘        └────────────┬────────────┘
             │                                   │
             ▼                                   ▼
┌──────────────────────────────┐   ┌──────────────────────────────────┐
│ 1.  A modified constituency-  │   │ 1.  Shown that construction is a │
│     model is defined          │◄─►│     process and that TQM is       │
│     for construction          │   │     applicable to construction    │
│ 2.  Constituencies are        │   │ 2.  Demonstrated that customer    │
│     identified                │   │     satisfaction is one of the    │
│ 3.  Criteria of satisfaction  │   │     most important factors in TQM │
│     are defined               │   │                                   │
└───────────────┬──────────────┘   └─────────────────┬────────────────┘
                │                                     │
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        ┌──────────────────────────────────────────────────┐
        │ A New Model of Measuring  Effectiveness Is Proposed │
        └────────────────────────┬─────────────────────────┘
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                    ┌────────────────────────┐
                    │  The Proposed Model is  │
                    │  Validated              │
                    └────────────────────────┘
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Figure-1 Process Flow Chart

1.5. Research Methodology

First- A literature review of the theories and field studies that pertain to management process improvement is performed. The various theoretical viewpoints of organizational effectiveness and different models accompanied with their criteria of measurement are discussed.

Second- The constituents of construction projects are identified as:

1. Architect/Owner

2. Employee

3. Creditor/Supplier

4. Regulatory Body

5. Public

Third- A questionnaire survey is presented and used to collect relevant field data. The collected data was used for analysis, development, testing, and validation of the proposed model. The model is based on linear modeling techniques of multiple regression. To analyze the data, two methods of regression analysis models are used:

1. Linear regression analysis

2. Logistic regression analysis

These two regression analyses can be run by using the Statistical Analysis Software (SAS and SYSTAT), operable on UNIX of University of Waterloo.

- Fourth- The proposed model is validated.

- Fifth- This thesis offers conclusions and recommendations relating to the developed model for use as an efficient tool by the construction firm, and its customers to assess the level of organizational effectiveness.

1.6. Scope of Research

This research has targeted only construction firms in Canada. No limitation is placed on the following construction organization characteristics:

1. Size of contract work

2. Size of firm

3. Volume of business

The following restrictions are imposed on construction organizations to create a homogeneous research environment:

1. This research targets only general contractors responsible for performances of the entire projects.

2. The construction firms in the Institutional, Commercial, and Industrial (ICI) sector of the construction industry are targeted.

3. The construction firms with less than ten years of operational age are the main target.

1.7. Framework Of Research

This thesis is divided into the following chapters:

Chapter-1/Introduction: In this chapter an introduction to the fundamentals governing the construction industry was presented. The research problems, objectives, methodology and a brief introduction to the proposed model were discussed. A discussion regarding TQM and constituency model was also presented.

Chapter-2/Constituency Model: In this chapter an introduction to closed and open system theories was presented. The existing models of effectiveness in the framework of open-system theory were discussed. The advantages and disadvantages of each model were taken into consideration. It further contains descriptions of which model was used to conduct this research and the justification for its use.

Chapter-3/TQM: In this chapter an introduction to Total Quality Management as a change strategy was given. TQM's main objectives, customer satisfaction and process improvement, were discussed. It was also shown that construction was a process and

therefore had the potential to improved upon. It was further presented that the major

obstacle for construction organizations might not be the learning process of the principle

upon which TQM is based, but the implementation process itself of those principles.

Chapter-4/Synthesizing the model: In this chapter the triple-role for construction

was defined. A synthesized model of measuring effectiveness was presented. Data

collection methods and the development of questionnaires were also discussed.

Chapter-5/Model fitting and validation: This chapter provided the regression

analysis results and the methods of validating the proposed model. A set of formula based

on the results of the regression analysis was presented.

Chapter-6/ Conclusions and Recommendations: Appropriate recommendations and

further improvements were suggested.

The following flow-chart represents the steps which were taken to develop, test and

validate the proposed model.

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                    ┌─────────────────────┐
                    │      Chapter-1      │
                    │    Introduction     │
                    └─────────────────────┘
                               │
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                    ┌─────────────────────┐
                    │      Chapter-2      │
                    │    Manufacturing    │
                    │  Constituency Model │
                    └─────────────────────┘
                               │
                               ▼
                    ┌─────────────────────┐
                    │      Chapter-3      │
                    │    Total Quality    │
                    │     Management      │
                    └─────────────────────┘
                    
    ┌───────────────────────────┐         ┌───────────────────────────┐
    │ Chapter-4/Part I          │         │ Chapter-4/Part II         │
    │ Modified Constituency Model│         │ Triple-Role & Customer    │
    │ is defined for construction│         │ Satisfaction based on TQM for│
    │                           │         │ constructions are defined │
    └───────────────────────────┘         └───────────────────────────┘
                    
            ┌─────────────────────────────────────────┐
            │              Chapter-5                   │
            │     Validation of the proposed model     │
            └─────────────────────────────────────────┘
                               │
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            ┌─────────────────────────────────────────┐
            │              Chapter-6                   │
            │      Results and recommendations         │
            └─────────────────────────────────────────┘
                               │
                               ▼
                    ┌─────────────────────┐
                    │     Appendices      │
                    │         &           │
                    │     References      │
                    └─────────────────────┘
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Figure-2 Framework of Research

CHAPTER II

PART 1

EXISTING MODELS FOR MEASURING ORGANIZATIONAL

EFFECTIVENESS

2.1 Introduction

To understand an organization it must be viewed as a system. A system is a set of interrelated elements that acquires inputs from the environment, transforms them into some form of useful output, and discharges the output to the external environment. Viewing an organization as a system of structured activities is specially useful when diagnosing organizational problems or analyzing the competitive advantages of a firm. This chapter provides a discussion on the following topics:

1. A literature review of various organizational effectiveness viewpoints

2. Various relevant existing organizational effectiveness models and their criteria of effectiveness

3. A model is selected for the construction industry

2.2 Various Organizational Effectiveness Theories:

Basically all the existing models of effectiveness fall into two major theories:

- Closed-System

- Open-System

2.2.1 Closed-System Theory

Many studies (e.g. Weber, 1947; Hall, 1963; Price, 1968) of organizational behaviour have examined the internal functioning of organizations as if they were isolated from their environments. A closed-system does not depend on its environment; it is autonomous and is isolated from the outside world. It has all the energy it needs and can function without consuming external resources. Closed-system theory is based on the assumption that the organization does not need to interact with its external environment to be effective. Closed-system theory characterizes the organization by bureaucratic authority and highly hierarchical structure. Such a theory relates the organizational effectiveness to the level of control, equal treatment of work force, and a promotional system which is solely based on skills and expertise. Centralization of decision making and formalization of procedures are among other characteristics of this system.

Closed-system uses efficiency as the appropriate measure of organizational effectiveness. An organization which has a high level of products specialization and

centralization of decision making is considered highly effective. The main disadvantage of this system is that it seals itself off from the external environment and does not adjust itself to the changes in its environment. Closed-system theory has often been criticized by many authors (e.g. Barnard, 1938; McGregor, 1960) for focusing exclusively on internal efficiency in its attempt to improve productivity, without recognizing the influence of the external environment. The closed-system logic assumes that the organization has a ready and constant supply of incoming resources and that the products are automatically consumed by a receptive public. Unfortunately, this closed-system logic is seriously flawed since there are no closed social systems. Even organizations that try to minimize contact with society, such as prisons and some religious communities, still exist within an external environment that influences the availability of resources and the acceptability of output. As a result, in late 1950's other models of organizations start challenging the viability of closed-systems.

2.2.2 Open-System Theory

Nedler et al (1992) talk about open-systems and the way an open-system interacts with its environment. He proposes that the open-system approach stresses the view that the organization is a structured set of interconnected parts that interact with the external environment to accomplish its goals.

Ashby (1956) proposes that an open-system must interact with the environment to survive. It must obtain resources from the environment and export products back to the environment. It cannot isolate itself from the environment; nor can it ignore changes

within the environment. An organization must continue to obtain the necessary inputs and produce acceptable products in spite of an uncertain environment and fluctuations in the availability of resources or demand for the product, Figure-3.
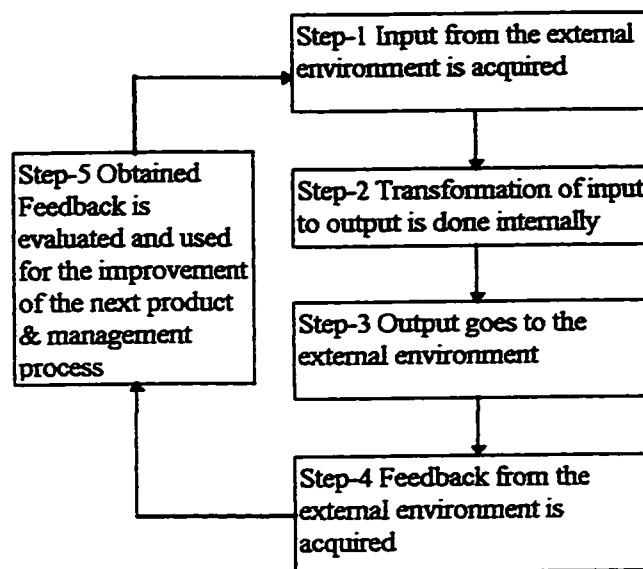
Figure-3 Open-System Flow Of Input To Output

Katz and Kahn (1987) define an organization as an *open social system* that consists of the *patterned activities* of a group that tend to be *goal directed*.

The above definition provides this research with three essential elements in an organization:

1. That organizations are open-systems

2. That organizations have patterned activities, and

3. That organizations are goal oriented

Organizations exist for a purpose and are therefore considered goal-oriented social entities. It is appropriate to say that an organization and its members are trying to achieve a particular goal. Participants may have goals which are different from the organization's, and the organization may have several goals, but organizations exist for one or more purposes without which they would cease to exist.

The models of effectiveness based on open-system theory basically fall into five different model categories. These models are as follows:

1. *Resource Allocation Model*

2. *Transformation Model*

3. *Output Model*

4. *Recycling Model*

5. *Constituency (Stakeholder) Model*

2.2.2.1 Resource Allocation Model

One approach to measuring the organizational effectiveness is to measure the organization's ability to exploit its environment by acquiring scarce and valued resources. According to this criterion, the most effective organizations are the ones that are the most successful in acquiring valued resources, (Yuchtman and Seashore, 1967). This approach is used primarily by organizations in the early stages of development. New businesses often measure their success by their ability to acquire venture capital. Some government agencies measure their effectiveness by the size of their budget or the amount of office space

allocated to them. Along with their ability to attract new faculty or students, universities frequently use allocations from the governing legislature as a measure of effectiveness.

The value of the *resource allocation approach* is threefold:

1. It takes the entire organization as a frame of reference

2. It considers the relationship of the organization to the external environment, and

3. It compares organizations that have different goals.

However, the resource allocation approach also has its limitations. An organization that fails to use its resources effectively should not be considered effective. Many newly founded construction firms consider themselves as being effective by securing a business loan, by renting a spacious place or by purchasing the best computer system and the software. These achievements do not provide enough incentives for this research to consider them as being effective, unless the utilization of the resources is done efficiently.

2.2.2.2 Transformation Model

Several measures of organizational effectiveness focus on internal organizational health and efficiency-whether the employees are happy and satisfied, whether departmental activities are coordinated to ensure high productivity, and whether the inputs are effectively translated into outputs (Georgopoulos, 1957). The *Transformational Approach* incorporates both human resource measures and economic efficiency measures. A wide variety of questionnaires have been developed to measure the attitudes of employees concerning internal organizational health. These questionnaires measure the amount of confidence, trust, and communication between workers and management; they measure

how effectively decisions are made; they determine whether the reward system is fair and adequate; and they determine whether the organization is organized efficiently and coordinated properly. This evaluation of internal health and functioning is often subjective, and they fail to consider adequately the interaction between the organization and its environment. This research not only is interested in the internal health of the construction organizations but also is curious to discover how these construction firms interact with their external environment. The transformational approach only provides half of the answer, the other half is hidden in the assessment of the external customers' satisfaction from the services or products they receive.

2.2.2.3 Output Model

Price (1982) defines effectiveness as the degree of achievements of goals and recognizable outcomes. The *Output Approach* is generally viewed as the most relevant criterion of organizational effectiveness (Campbell, 1977 and Simon, 1964), since it appears to measure goal accomplishment. This approach seems logical because organizations try to maximize their profits by being more efficient. However, this measure of output assesses only one component of the open-system theory, and it is an incomplete model of organizational effectiveness. A construction company, for example, may be very successful in producing large units of housing, but unless the output is consumed by the public, the construction organization may not survive. This type of construction firm is *efficient* but not necessarily *effective*.

This research has referred to terms *efficiency* and *effectiveness* as follows:

- *Efficiency* refers to how well the organization converts inputs into output. Therefore, *efficiency* measures the quality of the transformation process.

- On the other hand, *effectiveness* concerns both the efficiency of the transformation process plus how well the product is exported into environment and recycled back into usable inputs for the organization.

The term *organizational effectiveness* refers to the concept of organizational success, or organizational performance. Basically, it is an indication of how well the organization is doing. Productive companies that provide pleasant jobs are considered highly effective. These short-run measures of productivity and satisfaction, however, are both theoretically and empirically different from long-term effectiveness measures. In the long run the survival of the construction organization is the ultimate measure of its effectiveness.

Organizational efficiency is typically assessed using cost-benefit ratios that compare the number of inputs required per level of output. The process of measuring organizational effectiveness, however, is much more difficult. Organizational efficiency usually contributes to organizational effectiveness but not always. As mentioned, it is possible for a construction firm to be extremely efficient in transforming inputs into outputs, and yet this organization could be ineffective because its products are not accepted by the environment. The example can be found in the mass production of the pre-fabricated homes in 1970's. There were many construction companies which had been very successful in transforming the expertise, technology and the raw construction material into an undesirable product.

The customers did not accept the products. The demand was less than the supply. The customers in this case were looking for *quality work*, which the pre-fabricated housing could not provide at the time. These construction firms were very efficient in transforming the raw material, technology, management and other resources into the final product, but they had not been effective. Simply put, the final product was not saleable. Here, the needs of the customer were ignored.

Pfeffer (1974) proposes that organizations may use a variety of efficiency measures, such as labor costs, productivity per employee per hour, costs per unit, etc. These numbers are interpreted by examining historical trends or by making industry comparisons. Managers use this information to improve their organizational efficiency.

In using the output approach to measure effectiveness, it is important to remember that organizations have multiple goals and outcomes. High achievement on any one goal may mean low achievement on another. Therefore, effectiveness should not be assessed in only one dimension because this would oversimplify the objectives of the organization and produces a misleading conclusion for this research. Just observing a construction organization from its efficiency point of view does not provide a universal assessment of its effectiveness. A construction organization that is efficient, customer oriented, and is in attempt of finding a role in the market should not be confused with the one that is solely efficient. *Given the above definitions and comparisons between the EFFECTIVENESS and EFFICIENCY of organizations in general, it becomes clear that this research is mostly concerned with the effectiveness measurement of the construction organizations and with less or no interest in their efficiency measurement.*

2.2.2.4 Recycling Model

Minner (1988) defines organizational effectiveness as the ability of the organization to receive inputs, transform them into outputs, export them into the environment, constantly monitoring changes in the environment and finally recycling the output into useful products.

The recycling approach concerns the organization's ability to take resources from the environment, transform them into products, and export them to the environment in a way that creates new inputs, this process involves a long term assessment. Accordingly, the final test of organizational effectiveness is whether it is able to sustain itself in the environment. Therefore, survival of the organization is the ultimate measure of organizational effectiveness. Organizations that fail to properly respond to a changing environment or that lose their ability to produce products and transform them into new inputs do not survive and, by definition, they are not effective. Therefore, the only measure of organizational effectiveness in the long run is simply survival. However, this criterion is not very useful for construction managers who want more immediate feedback on the level of effectiveness of their firms.

2.2.2.5 Constituency (Stakeholder) Model

The constituency model approach has been the main topic of many recent effectiveness studies (e.g. Charrington, 1994; Wagner and Schneider, 1987; Tsui, 1990; Cameron, 1978; Zammuto, 1984)

A contemporary method of assessing organizational effectiveness that uses a combination of other approaches; resource allocation, transformation, recycling and output approaches is the *Constituency or Stakeholder Approach.*

Connally et al, (1980) propose that a constituency is a group either inside or outside the organization that has a stake in the organization's performance. These groups are called stakeholders. Employees, customers, and stockholders are all constituencies whose assessment of the organization can serve as a measure of the organization's performance.

Each constituency has a different criterion of success because it has a different interest in the organization. The effectiveness of the organization can be evaluated by surveying the attitudes of each constituency. The strength of the constituency approach is that it uses a broad view of effectiveness and examines factors in the environment as well as within the organization. The concepts of social responsibility and community involvement, absent in the other approaches, are also included here. The constituency approach also tends to integrate several criteria regarding inputs, transformations, and outputs that overcome a serious flaw of many other measures.

Pfeffer and Salanick (1978), advocate that the constituency approach recognizes that there is no single measure of effectiveness and that the achievement of one criterion may be just as important as another. For instance; achieving the well being of employees may be as important as achieving the goals of the owners.

The constituency-model provides the followings:

1. The constituent parties

2. The criteria of satisfaction for the constituent parties

The relationship between the constituent party and the satisfaction criteria is summarized in Table-1. The constituency approach also calls attention to the fact that effectiveness criteria reflect the values of different stakeholders.

Table-1 Manufacturing Based Constituency/Effectiveness Criterion

Constituency	*Effectiveness Criterion*
Employee	Satisfaction with pay, supervision, and the work itself
Owners	Financial Return On Investment
Customers	Quality of goods and services
Suppliers & Creditors	Satisfactory transactions and credit worthiness
Community	Social responsibility
Government	Compliance with laws and regulations

The constituency-model covers the satisfaction of a wide range of customers. These participants in the construction industry can be recognized as the constituent elements of construction projects. These are the participants who have an interest in the outcome of the project. Thus, it is appropriate to assess the satisfaction of these constituent elements when the intention is to determine the level of effectiveness of construction firms. By evaluating the satisfaction of the constituent parties we can obtain the effectiveness of the construction organizations which are responsible for the performance of construction projects.

2.3 Part-1 Summary

Part-1 of this chapter has shown that the effectiveness of organizations is defined as the organization's success in bringing inputs into usable outputs, and recycling them within the environment. Types of models used to assess the organizational effectiveness were discussed. These models either fit themselves into a closed or open system philosophy. The open-system theory provides five different models of effectiveness such as; transformational, output, recycling, resource allocation and constituency models.

While the resource allocation model is a method of measuring organizational effectiveness that focuses on how successfully the organization can acquire valued resources from the environment, the transformational approach focuses on how well inputs are transformed into usable output. At the time, the output approach measures the effectiveness by measuring the output or products of the firm, the recycling model measures organizational effectiveness by focusing on how well the outputs are transformed into usable inputs for the organization.

On the other hand, the constituency-model measures the effectiveness of organizations by surveying the attitudes of constituencies such as owners, customers, suppliers, financial institutions, regulatory bodies and employees. It becomes clear that the model to be used for assessing the effectiveness of construction organization is a model that can cover the interests of all the constituent parties. The constituency model provides a comprehensive tool of measuring the effectiveness of construction firms on a reasonable basis. *Not only must the constituent parties be clearly defined for this model but their criteria of effectiveness must also be given.*

Part-2

TQM: THEORY OF CHANGE

2.4 Introduction

Organizational effectiveness depends in part upon the degree of predictability and stability in the organization. However, organizations can expect to improve their effectiveness by creating a highly structured organization with clearly defined rules and procedures. If the environment remains constant, a stable structure contributes to effectiveness. However, conditions do not remain the same, so organizations are constantly caught in the dilemma, between being highly structured (closed-system structure) and being adaptable (open-system structure). Highly structured organizations that are rigid and inflexible are doomed to inefficiency. Therefore, organizations are constantly trying to balance between being sufficiently organized to operate efficiently, while at the same time being sufficiently adaptable to respond to new forces demanding change (Heather A. Haveman, 1992).

Organizations cannot control the environment; nevertheless, astute managers must identify the external forces for change and respond appropriately to them. The external forces for change can represent themselves in many ways such as; changes in competition, consumer demand, resource availability, social and political changes and; etc. Although change is inevitable, people tend to resist it. This resistance to change can manifest itself either in an individual or at an organizational level. Lind Ackerman (1986), argues that individuals are resisting change because they are afraid of unknowns or new learning makes

them feel uncomfortable. Learning a new task or procedure requires a conscious effort and is not as comfortable as doing it the "same old way."

The organizational structure itself also resists change. Necessary changes may be resisted even when the survival of the organization depends on changing. One of the causes to resist change can be attributed to the threats to the power structure. Most changes have the capacity to disrupt the organization's power structure. Participative changes may be particularly threatening to managers because group decisions tend to restrict the manager's influence.

The inertia of organizational structure also can have influence on resistance to change. Organizational structures are designed to maintain a stable pattern of interactions among people. Therefore, job assignments, the selection of new personnel, training of new employees, performance and reward systems, and many other aspects of the organizational structure are designed to maintain stable interactions, thereby resisting change.

Bert A. Spector, (1989) believes that unless there is no real pain there is no change. A principle that seems rather well accepted among change agents is that significant change only occurs when people are feeling pain. Unless their present conditions create enough discomfort, there is no motive for change.

Many authors in recent years have tried to identify the types of changes at the organizational level (e.g. Linda Ackerman, 1986; Dexter C. Dunphy and Doug A. Stace, 1988). Organizations are constantly involved in change, but not all changes are the same. Although some organizations make minor adjustments to take advantage of new opportunities, other organizations are devoured in corporate takeovers that move them into

entirely different industries. Therefore, some changes have a larger impact on people and are more difficult to implement than others.

Change can display itself in the form of developmental process of methods and skills. *Developmental change* is a gradual improvement in skills, methods, or processes to help an organization function more effectively. Ackerman, (1986) believes that the developmental change might be considered as fine-tuning, because it is usually a small adjustment that helps to raise individual productivity, reduce conflict, improve communication, eliminate wasted motions, or otherwise contribute to organizational effectiveness.

Change can also be transitional in nature, (Dunphy and Stace, 1988). In *transitional change* an organization evolves slowly from old state to a new state. The change occurs gradually over time, but it involves more than improving what is already there, as in developmental change. Transitional change involves new processes, new activities, new products, and sometimes a new organizational structure.

Ackerman (1986) proposes that the most dramatic kind of change is transformational change, which is characterized by a radical reconceptualization of the organization's mission, culture, products, leadership, or structure. This kind of change occurs in companies that have become stagnant and started to disintegrate. A typical scenario is a mature company whose sales plateaued several years earlier and has recently experienced chaos because of declining sales and a loss of market share due to foreign competition.

Many authors have presented various theories of change to cope with different changes in the organizational environment (e.g. Juran, 1988; Kurt Lewin, 1951; Chin and Benne, 1976). One of the earliest theories of change was the field analysis proposed by Kurt Lewin, (Lewin, 1951). Although this model was derived from the physical sciences, it continues to provide a valuable framework for thinking about change and diagnosing problems. Kurt Lewin's theory of change was derived from the laws of physics, which state that the position of an object and its direction are determined by the forces operating on it. Change occurs when the forces pushing in one direction are greater than the forces pushing in the opposite direction. A state of balance exists when the restraining forces acting to prevent change are equal to the driving forces attempting to produce change. The equilibrium point is determined by the resultant forces operating in different directions. According to Kurt Lewin, planned change occurs in three stages: unfreezing, change, and refreezing as shown in figure-4.

Driving Forces   **Equilibrium**   **Restraining Forces**

0%   20%   40%   60%   80%   100%   120%   140%   160%
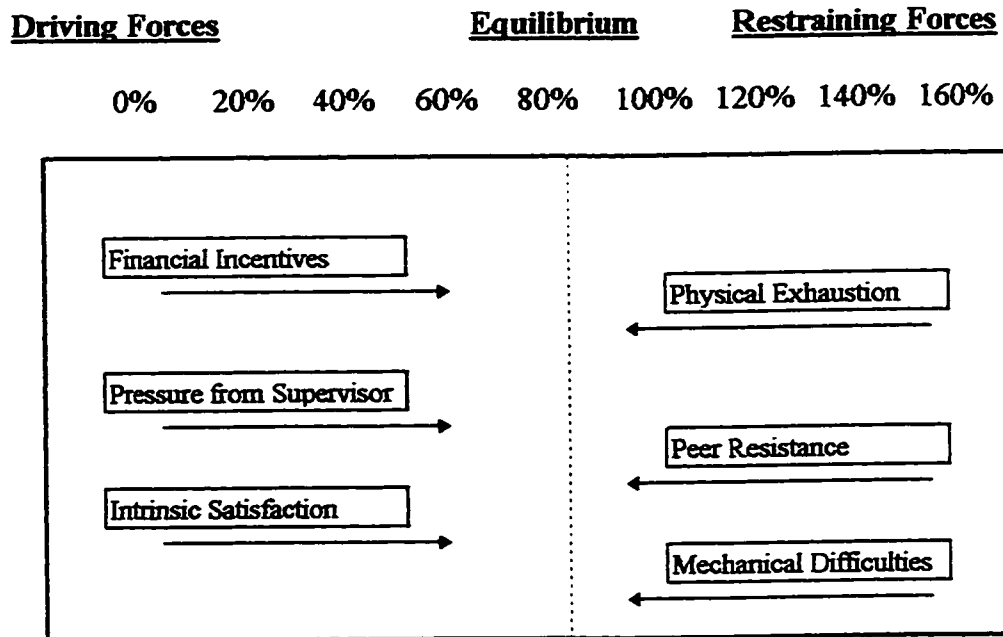
Figure-4 An Illustration Of Kurt Lewin's Force Field Analysis

Unfreezing occurs when people see a need for change. The status quo is disturbed by unsettling forces that challenge current values, attitudes, and behaviour. *Change* is the action-oriented stage, in which the situation is diagnosed, improved patterns of behaviour are selected, and a new equilibrium is created. As a result of change, people develop new values, attitudes, and/or behaviours. The *refreezing* refers to stabilization of the situation. Refreezing stabilizes the change and solidifies the new patterns of behaviour. Refreezing requires continued management of the change process beyond the immediate implementation. Refreezing also requires that people experience positive consequences to strengthen their continuing commitment to the new change. Kurt Lewin (1951) says that the new state then becomes the status quo for future behaviour.

W. Edward Demings in 1951, presented a change strategy to the Japanese industries which is known as Total Quality Management or TQM. After the WWII, Japanese industry needed a dramatic change to cope with the new world; U.S.A. and Europe. During the reconstruction of Japan, Edward Deming was invited to share his ideas about continuous quality improvement. He designed a four-day seminar for Japanese executives in 1950 and subsequently became a national hero to Japanese industry. To honor his contributions, Japanese industry created the Deming Prize in 1951. This annual prize, highly esteemed in Japan, recognizes the company that attains the highest of quality that year.

Deming's ideas attracted little attention in America until a NBC documentary in 1980 featured the work of Deming, J. M. Juran[1], and other colleagues in Japan. Illustrations of dramatic quality improvements in Japanese manufacturing attracted considerable interest and drew attention to the problems of poor quality in the United States. Many in U.S. manufacturing, such as Ford, Motorola, Federal Express, and Xerox, began to use Deming's ideas and consulting services.

- Different titles are used to describe TQM. Total Quality Management is one of the most frequently used titles.

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[1] Juran is one of the prominent figures in management science. Born on Dec. 24, 1904, Brailia, Romania. He is the Chairman of Juran Institute Inc. In 1924 he graduated from the University of Minnesota with a B.S. degree in Electrical Engineering. He is the recipient, Order of Sacred Treasure, 2nd Class (Japan), 1981. The triple role of Juran discusses the role of the supplier, processor and customer.
Edward Deming is also one of the classic figures in Total Quality Management. Born on Oct. 14, 1900, Sioux City, Iowa. Ph.D. (Mathematical Physics) from Yale, 1928. Japan's Deming prize named in his honor. He was also a recipient of Order of Sacred Treasure, 2nd Class (Japan), 1960. Deming presented a relation between incremental improvements, maintenance and innovation. Dr. Deming died in 1994.

Krone (1990) says that Total Quality Management is characterized by three primary principles:

1. Doing things right the first time

2. Striving for continuous improvement

3. Being responsive to the interests of customers

TQM implementation involves making quality a major responsibility of all employees. Continuous improvement usually includes working with suppliers to improve the quality of incoming parts and ensuring that manufacturing processes are capable of consistently high quality. Statistical Process Control (SPC) is a popular TQM technique that is used to improve quality. SPC involves carefully measuring the production process and uses the data to identify problems and monitor quality improvement

Henkoff (1989) describes the steps that might be used in a TQM implementation as:

1. Defining the major functions and services that might be performed

2. Determining the customers and suppliers of these services

3. Identifying the customer's requirements, and developing quantitative measures to assess customer satisfaction regarding these requirements

4. Identifying the requirements and measurement criteria that the suppliers to the process must meet

5. Mapping, or flow-charting the processes that occur within each department and between departments

6. Continuous improving the process with respect to effectiveness, quality, cycle time, and

cost.

TQM is a company-wide effort that involves everyone in the organization to

improve performance. Dr. Edward Deming introduced 14 points to manufacturing as the

fundamentals of TQM. His points are: [2]

1. Create consistency of purpose for improvement of products and services.

2. Adopt the new philosophy.

3. Cease dependence on inspection to achieve quality.

4. End the practice of awarding business on the basis of price tag alone. Instead,

minimize total cost by working with a single supplier.

5. Improve constantly and for ever process for planning, production and service.

6. Institute training on the job.

7. Adopt and institute leadership.

8. Drive out fear.

9. Break down barriers between staff areas.

10. Eliminate slogans, exhortation and targets for the work force.

11. Eliminate numerical quotas for the work force and numerical goals for management.

12. Remove barriers that rob people of pride of workmanship. Eliminate the annual

rating or merit system.

13. Institute a vigorous program of education and self-improvement for everyone.

---

14. Put everybody in the company to work to accomplish the transformation.

In 1991 the Construction Industry Institute (CII) sponsored a research program to investigate the implementation possibility of TQM to the construction industry to address some of the problems facing the industry such as its unwillingness to change. The following are the findings of the research team :(Matthews et al, 1989)

Total Quality Management permeates every aspect of a company and makes quality a strategic objective. TQM is achieved through an integrated effort among personnel at all levels to increase customer satisfaction by continuously improving performance. TQM focuses on the process improvement, customer and supplier involvement, team work, training and education, in an attempt to achieve customer satisfaction, cost effectiveness and defect-free work. TQM provides a culture and climate essential for innovation and for technology advancement. TQM is an effective, comprehensive management technique that has proven successful both overseas and here in North America. Japanese construction companies, benefiting from the experience of manufacturers, began implementing TQM during the 1970's. Although construction is a creative, one time process, the Japanese construction industry embraced TQM ideas that some argued could only apply to mass production. Since the mid-1970's, three Japanese contractors

have been awarded the coveted Dr. Deming's Prize for quality improvement.

Recent research shows that TQM is being effectively applied by both owners and

contractors in the private construction arena.

The CII team in the course of their research found that <u>customer satisfaction</u>

accompanied by <u>continuous improvement</u> are the most crucial principles in TQM. All

efforts undertaken in TQM are directed to satisfy the customer by continuously improving

the methods and procedures that govern the work.

2.5 Customer Satisfaction

The CII team further explains that the function of the construction industry is to

provide customers with facilities that meet their needs, for a company to remain in business

this service must be provided at a competitive price. TQM is a management philosophy

that effectively determines the needs of the customers and provides the framework,

environment and culture for meeting those needs at the lowest possible cost. By ensuring

quality at each stage in the construction process and by minimizing costly re-working of the

original work, the quality of the product should satisfy the final customer.

A strong customer orientation is made possible by using the "market-in" concept,

which recognizes that each work process consists of stages. There is a product, market and

customer for each stage. <u>During each process stage, customer comment is obtained to find</u>

<u>out what changes should be made to better meet the customer's needs.</u>

Customers may be either internal or external. External customers are not part of the

company producing the product or service. For example, for engineering firms the

products are plans and specifications and the customers are the owner and the construction organization responsible for the construction. For construction, the product is the completed facility and the customer is the final user of the facility.

There are also customers within the construction organization. These internal customers receive products and information from other groups or individuals within their organization. Satisfying the needs of these internal customers is an essential part of the process of supplying the final external customer with a quality product.

Juran (1988) suggests that every party in a process has three roles: Supplier, Processor and Customer. Juran originally defined the "triple-role" concept for the manufacturing industry.

The main question that should be answered before one can demonstrate that TQM principles are applicable to the construction industry, is whether construction is a process or not? To find an answer, in 1995 the University of Waterloo, Department of Construction Management introduced the results of a research in investigating the applicability of TQM to the construction industry by questioning the results of seventeen framing projects in residential and commercial projects (H. Kiani, 1995).

One of the efforts of that research focused on the applicability of TQM to the construction industry in general and to the framing industry in particular. The principles of TQM (customer satisfaction and continuous improvement) are applicable to the framing industry if one can demonstrate that the triple-role identified by Juran is applicable not only to the framing industry but also to each individual in the organizational hierarchy. The participant in a construction project such as the owner, the architect, the general

contractor, and the subcontractor have a triple-role among themselves such as presented in Figure-5.

In this figure the role of each participant in the process of constructing an ICI project is explained. The role of the architect as a *customer* of the owner and the role of the general contractor as a *customer* of the supplier is demonstrated. It is further demonstrated that the owner can be the *processor* of the public needs and requirements. In this sense the owner can also be considered as a *customer* of the public. The architect's role can also be viewed as the *processor* of the plans and the specifications. This idea of the triple-role can be followed down the line until it covers all of the parties involved.

Owner   **_Architect_**   **_General Contractor_**

Supplier: Of needs to the architect	**Customer:** Of the owner	**Supplier:** Of the management & technique skills
Processor: Of the public needs & requirements	**Processor:** Of the plans & specifications	**Processor:** Of the overall performance of the project
Customer: Of the public	**Supplier:** Of the plans & specifications	**Customer:** Of the architect

Surveying Contractor   **_Excavation Contractor_**   **_Foundation Contractor_**

Customer: Of the general contractor	**Supplier:** Of the demolished & excavated site	**Customer:** Of the excavation contractor
Processor: Of the surveying task	**Processor:** Of the excavation & Demolishing	**Processor:** Of the concrete and masonry part of project
Supplier: Of the surveying products	**Customer:** Of the surveyor	**Supplier:** Of the foundation & masonry

Cont'd. on next page

Figure- 5 Triple-Role In The Construction Industry

HVAC Contractor

Customer: Is a customer of the framer
Processor: Is a processor of HVAC
Supplier: Of the HVAC products

Framing Contractor

From

previous

Page

Customer: Is a customer of the foundation contractor
Processor: Is a processor of the rough framing
Supplier: Of the final framing product

Plumbing Contractor

Customer: Is a customer of the framing contractor
Processor: Is a processor of the plumbing task
Supplier: Of the rough plumbing

Electrical contractor

Customer: Is a customer of the framer
Processor: Of the rough electrical job
Supplier: Of the rough electrical

Figure-5 Cont'd. From The Previous Page

This idea of the *Triple-role* can also be applied to all other participants in the construction industry. To accomplish that one has to follow common sense by asking the possible role of each participant either it be a **Processor, Customer or Supplier**. These three roles are carried out at every level of the construction process-corporate, division, department and individual. The role of the three parties have not traditionally been viewed this way, but this clearly illustrates that construction is a process and that TQM principles that have been applied to other industries are applicable to the construction industry as well. At each level, each participant has to satisfy the needs of two other participants.

2.6 PDCA Cycle (Plan-Do-Check-Act Cycle)

Petters, T.J., (1987) believes that:

"Excellent firms don't believe in excellence- only in constant improvement and constant change."

Imai (1986) is also a firm believer in the process control and innovation. He says that under TQM, management has two main functions:

1. To maintain and incrementally improve current methods and procedures through process control; and

2. To direct efforts to achieve, through innovation, major technological advances in processes.

He further says that:

The increment improvement and maintenance functions are achieved through process improvement and control. In every organization there are processes by

which all work is accomplished. Similarly, there are innumerable parts to the process. Within each stage, input changes to output and the methods and procedures directing the change of state i.e., the construction procedures can be constantly improved to better satisfy the customer at the next stage. During each stage the employees communicate closely with their supplier and customer to optimize the work process for that stage. This requires each employee to recognize his/her place in the process and their respective supplier and customer.

Deming's Plan-Do-Check-Act (PDCA) cycle, shown in Figure-6, symbolizes the problem analysis steps for narrowing the gap between customer needs and present performance. It is a systematic procedure for incremental improvement methods and procedures by focusing on correcting and preventing defects. This is accomplished by removing the root causes of problems and continually establishing and revising new standards. Improving the process and avoiding defects is usually less costly than the typical approach of attempting afterwards to "inspect out" the defects.

Customer satisfaction is the first primary function of management whereas the second fundamental function of management under TQM is to support the advancement of technology and management techniques. Through innovation major shifts in the present levels of performance can be achieved. An example of a major shift in technology might be to use concrete pumps rather than a crane and bucket or to use a laser-controlled screed. Once established, these new levels of performance must be maintained by the PDCA cycle to prevent deterioration. Without any effort to stabilize and upgrade the newly established

system, its decline is inevitable. This research has mainly focused on the CHECK section of PDCA cycle.

Take corrective action on the opportunity, standardize, and feed forward to the next plan.

Plan improvements for present practices.

ACT

PLAN

CHECK

DO

Verify the results of the plan.

Implement the plan on a small scale.
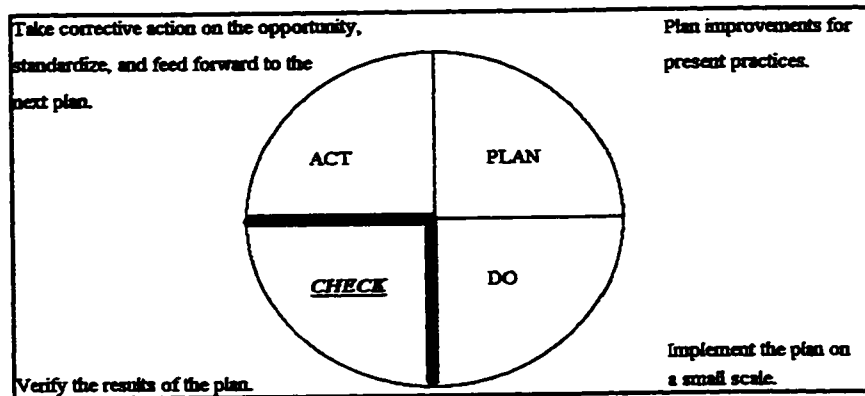
Figure-6 PDCA Cycle

TQM is a process that requires universal involvement to be successful. This includes customer involvement. As more companies become involved in the TQM process and demands for improved quality increase, this concept will become increasingly important. This has proven to be true for the manufacturing and service industries and an increasing number of firms in the construction industry are adopting TQM approaches.

McKim and Kiani (1995), investigated the impact of implementation of a TQM management style to the operations of a framing contractor in the residential construction industry. The results, in terms of productivity and profitability were positive when the framing organization implemented some of the TQM management principles. The outcome

of a series of framing projects were evaluated. The customer satisfaction, productivity, profitability, scheduling, delivery and handling of materials with and without the application of TQM were studied. The results showed that the profitability of the targeted framing company could be increased by almost 25% when TQM was used as a management tool. Furthermore, the result showed that customer satisfaction also increased substantially. The projects which were performed using TQM management had a better schedule, less rework and less waste. The following chart depicts the finding in regard to the reduction in number of defects for two groups of projects A and B. Group-A projects consisted of eight residential framing projects performed without the application of TQM and Group-B projects consisted of seven framing residential projects performed with partial application of TQM.

Chart-1 Defect Reduction By Using TQM
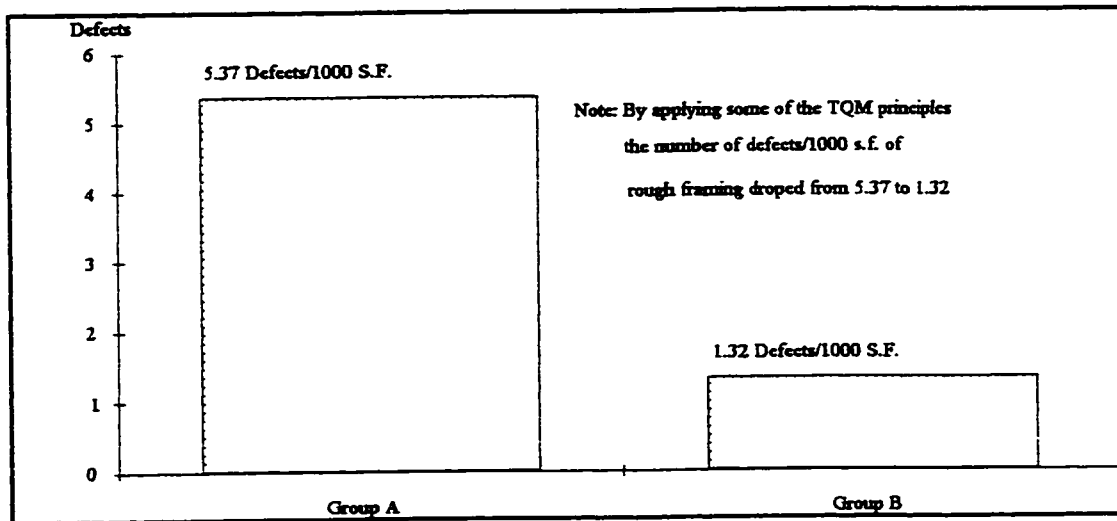
The results showed that the number of defects per 1000 square foot of the rough framing can be reduced from 5.37 defects to as low as 1.32 defects. The above were the direct results of the type of management the framing company was applying to the process of its operation. It is obvious that different contractors get different results, depending on how they have tailored the principles of the TQM management process to their needs and how effective the application has been. The important issue here is not the magic of the numbers obtained (1.32 versus 5.37) but the philosophy behind the processing management that caused the achievement of such a better result: By *application of TQM principles the number of defects can be reduced and better construction projects can be delivered.*

The other important finding of that research was related to the study between labour cost and the style of management. One of the critical issues that the contractors face today is the risk and uncertainty that exist in today's market regarding the labor cost. The expected profit does not always coincide with the actual profit. The possibility of the rise in labor cost is one of the issues that has to be addressed with great sensitivity. Chart-2 and Chart-3 are the results obtained from analyzing the actual profit versus expected profit for the same two groups of the projects; groups A and B. It is clear, from these two charts, that the disparity between the expected and actual profit for the group-A project was larger than that of the group-B projects.

The profitability of the framing company was also measured in two different ways:

1- The percentage of the profit versus management process was investigated for the group-A projects.

2- The percentage of profit versus management process was also investigated for the group-B projects.

The result showed that for group-A projects the framing contractor's profit was 14% of the gross sales. The result of the research for group-B projects was 35% of the annual gross sale. The reason for achieving better results in profitability was attributed to the followings:

1- Cost of pick-up work (re-work) was reduced to a minimum level; the pieceworker teams were to correct their mistakes free of charge.

2- The time required to measure and cut on site was saved by cutting off-site. The lumber was delivered pre-cut in pre-assorted packages as needed and when needed (just-in-time).

3- Uncertainty about future labor cost was removed by using the lump-sum, pre-agreed prices with the pieceworkers.

4- Cost of purchasing equipment and maintenance was reduced to a minimum level by using the self-organized teams of pieceworkers; the pieceworker teams were already equipped with the latest invented tools for framing.

In addition, the satisfaction of the owners, general contractors (external customers) was achieved by providing a defect-free, fast operation and with the least amount of waste.

The point here is that the construction industry is capable of utilizing the new methods of manufacturing management. Construction organizations have to tailor the principles of the TQM to their needs and environments. To effectively utilize these tools of management the top construction management teams have to be educated in proper implementation of such tools.
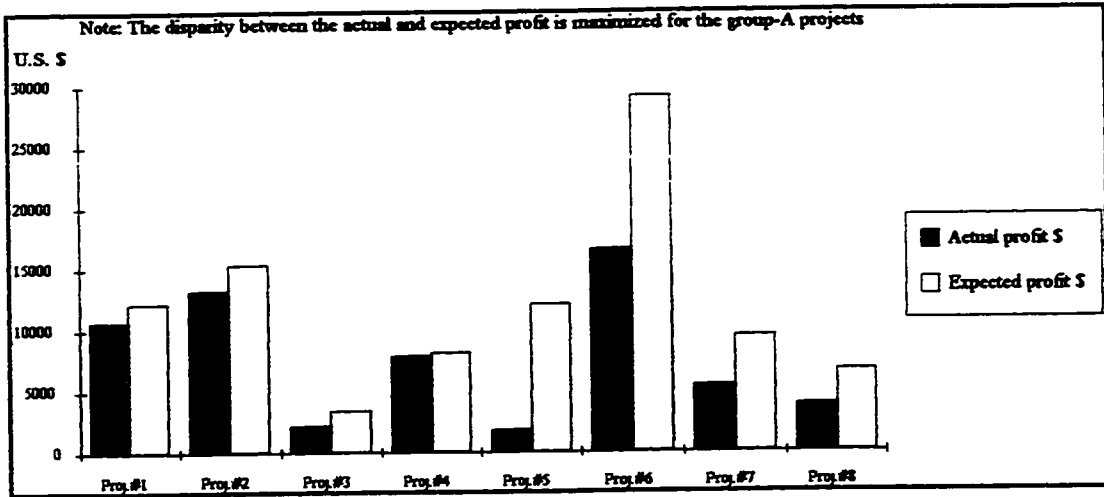
Chart-2 The Disparity In Actual & Expected Profit For Group-A Projects
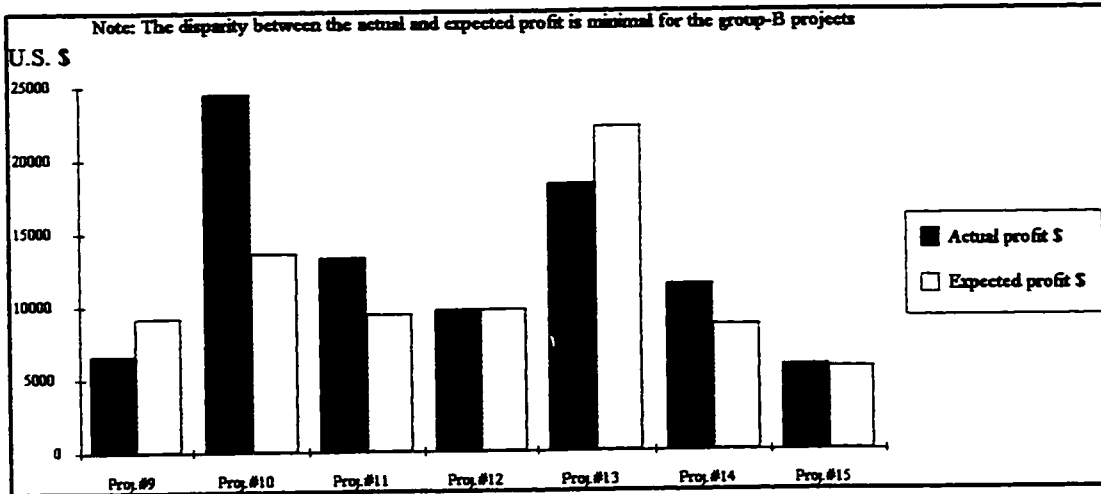
Chart-3 The Disparity In Actual & Expected Profit For Group-B Projects

2.7 Part-2 Summary

The literature review presented, was a summary of two prominent change strategies; Kurt Lewin's Force Field Analysis and Deming's TQM theories of change. This research could not identify an implementation of Kurt Lewin's change theory to the construction industry. However, many studies indicate that Deming's change theory is applicable to the construction industry such as confined by the findings of the Construction Industry Institute (CII) and the results of McKim and Kiani.

Total Quality Management (TQM) is a customer driven tool of management for effectiveness improvement. The customers can be either internal or external. Internal customers are referred to those who are working inside the organization, while the external customers are the end users of the manufactured products. TQM philosophy is principally based on the satisfaction of these two types of customers. In TQM implementation, the top managers should emphasize doing things right the first time and always being responsive to the interests of the customers while striving for a continuous improvement of the management process.

It becomes clear that this research is equipped with two sets of tools: TQM and constituency-model. This researcher has observed a great potential for using the above two management tools; TQM and constituency-model, in order to devise a new model of effectiveness measurement for the construction industry. The proposed model is adjusted to fit to the environment and limitations of the construction industry.

By utilizing the constituency-model this research is able to define:

1. The *constituent parties* for construction organizations, and

2. Pinpointing their *criteria of satisfaction.*

   On the other hand, by employing the TQM theory of change this research:

1. Establishes the fact that a *customer-supplier-processor* role exists among all the constituent parties in the construction industry. As a result, construction becomes a process and every process apparently can be improved upon.

2. Demonstrates that *customer satisfaction* is an outstanding issue which has to be considered when attempting to devise a model for measuring the effectiveness of construction organizations.

   The above processes are fully explained in chapter-4.

CHAPTER III

PART 1

THE NEEDS

3.1 The Need For An Effectiveness Measurement

Study Of The Construction Organizations

Clough and Sears (1991) state that in terms of the dollar value of product produced, the construction industry is the largest single production activity of the American economy. The annual expenditure for total construction accounts for approximately 10 percent of the gross national products (GNP). Thus, about one of every 10 dollars spent for goods and services is a construction dollar. The construction industry is directly responsible for approximately 6 percent of the private employment (or 5 percent of the total jobs) in the United States. The same proportions hold true for the Canadian construction industry as well.

Many effectiveness studies[5] have found deficiencies in almost all aspects of the

construction process, ranging from planning and design through to the construction process

itself. Among them are those outlined in Report A-6 of Construction Industry Cost

Effectiveness (CICE) Task Force, entitled "Modern Management System" (November

1982), which states that:

> *The construction industry has been criticized, to a large extent justifiably, for its*
>
> *slow acceptance and use of modern management methods to plan and execute*
>
> *projects. Many people both inside and outside the industry view this as a primary*
>
> *cause of serious delays in schedules and large cost overruns that have plagued*
>
> *the industry in recent years. Yet there is no lack of modern cost-effective*
>
> *management systems that can provide project managers with all the control they*
>
> *need.*

How construction companies use their resources effectively is very important in

their success or failure. Construction organizations live in an ever-changing environment

---

[5] One of the valuable studies that has been conducted in this area is a research sponsored by the Construction Business Roundtable, in U.S.A. The Business Roundtable (BRT), an association of the chief executives of 200 major corporations in America, was founded in 1972. As part of its work, BRT has published a series of investigative reports focusing on some of the problem areas faced by the construction industry. In 1972, the construction industry was the largest business segment in the U.S. economy, representing about 10 percent of the GNP. However, construction's percentage of GNP has since eroded by half, to about 5 percent of GNP.(Ritz, 1994)

The BRT reports indicated a continuing decline in construction industry cost effectiveness, so it formed a special committee called the Construction Industry Cost Effectiveness (CICE) Task Force. The CICE task force included several hundred experts from all branches of the construction industry including owners, contractors, labor unions, trade associations, academia, government, and the like. After five years of studying the problems underlying the decline in construction industry performance, CICE, in 1983, issued a series of reports that tried to come to grips with the problems. The resulting series of reports is available free from the Business Roundtable, and is an excellent source of construction information useful to a construction manager. Those reports are listed in Appendix12-BRT of this research.

and their effectiveness depends on their ability to adapt to new demands and opportunities. The construction industry must find ways to adapt to changes and add to its effectiveness. A model of measuring effectiveness must be designed to monitor the effectiveness of a construction organization on a regular basis. The customers of construction organizations need to have a model of measuring effectiveness to screen the effective construction contractors from the ineffective ones. The top management of these organizations, on the other hand, also need to know the level of their effectiveness on a regular basis to adapt proper decisions to master the new demands and changes. The constituents of the construction projects can help the industry in this process by providing their feed-backs. The contractors in order to be more effective have to be more customer oriented and have to be able to improve their process management and techniques. There are probably very few construction organizations that can effectively implement the principles of TQM to their work environment in order to become more effective. Some construction organizations may give up in the middle of the process and yet some may claim the process improvement is nothing but a delusion. These types of thinking are generated because the managers and the top executive officers are not properly trained in the utilization of the management tools available, such as TQM. The wisdom comes from the right application of the knowledge. The knowledge exists, but unfortunately there might be a lack of wisdom to apply it properly.

McKim and Kiani (1995), also believe that the construction industry is behind manufacturing in terms of innovation and customer satisfaction:

The construction industry, in general, faced a setback in the recent years when compared with the auto industry in terms of innovation and process control.

In the late 1980s, members of the Business Roundtable decided that something should be done about all aspects of construction performance.(Oglesby & Parker, 1989)

The construction industry builds for industry, business, individual and government agencies. All about us are plants, buildings, roads, houses, system to supply water and dispose of waste that are required to keep our modern society viable. A major overhaul is needed for this industry.

Residential buildings alone in the United States according to the study performed by the Construction Cost Effectiveness Project took 48.1% share of the total 389 billion dollar's work done by the construction industry in 1986.

Government studies (Statistics Canada, 1994) also show that a massive amount of employment exists due to the construction industry in Canada. The total number employed in the construction industry in Canada for the month of March 1993, was estimated at 450,000 employees . For February of the same year the number was 435,800 and for March of 1992 the number employed was 477,300.

As can be seen a major part of the population's income is closely related to the construction organization prosperity. The construction industry has a very important position in the national economy of U.S.A and Canada.

Clough and Sears (1991) compare the gross national products of many small countries with the annual budgets of large construction firms. They say that:

Some very large contracting firms put more than 10 billion dollars worth of

construction into place each year. The annual budgets of the largest construction

firms rival the gross national products of many small countries. However, in

terms of number of contracting companies, the construction industry is typified by

small businesses.

Given the above facts, a way must be found to evaluate the effectiveness of the

construction organizations. This research clearly understands that the effectiveness

measurement of the construction organizations is a hard task to perform. The reason may

be attributed to the industry's fragmentation, lack of a comprehensive monitoring and of a

general recording system, shortage of enthusiasm among the constituent parties such as

financial institutions, owners, architects, regulatory bodies, internal and external customers

to exchange information regarding the performance of contractors. However, this research

is after evaluating the effectiveness of the construction organization as objectively as

possible.

The majority of the population is unaware of the complexity of the construction

organizations that provide the basic goods and services to society. How well these

construction firms function has a significant influence on the quality of the public's lives.

Inefficient construction firms can waste an enormous amount of society's resources.

Construction organizations in general are open-systems. In other words, these

organizations have to interact with their external environment to stay competitive. The key

to their survival is probably the right utilization of external and internal resources. The

construction industry, in order to become more effective, must be tuned to the latest

innovations and be sensitive to the needs of the internal and external customers. The top

managers have to be well informed of the changes that surround the construction

environment. If construction organizations are not constantly improving and adapting

themselves to their environment they can not survive. The key to survival is the proper

adaptation and the proper usage of the resources.

3.2 Differences Between The Construction
And Manufacturing Industries

Since the constituency model was originally designed to measure the effectiveness

of the manufacturing industry, some minor modifications are needed to fit the model to

the construction environment. Construction organizations are open-systems and they are in

constant interaction with their environment. These open-systems cannot isolate themselves

from their surrounding environment.

This thesis investigates the level of satisfaction of internal and external customers of

the construction organizations in order to develop a new model of measuring effectiveness.

The intention is to develop a model that can predict the outcome of any construction

project based on a historical satisfaction data received from the external and internal

customers. In order to devise the model this research has to modify the existing

manufacturing constituency model to fit it to construction environment and limitations.

The construction industry is different in many aspects from manufacturing. Thus,

this research can not directly apply a manufacturing model of effectiveness to the

construction industry without adequate modifications.

Oglesby and Parker (1989) categorize these differences as follows:

3. 2.1 *Duration.*

The duration of construction projects or their individual work phases are of relatively short duration. One consequence is that the management teams and possibly the work forces must be assembled quickly and cannot be shaken out or restructured before the project or work phase is completed. Also, planning and tooling up for an operation can be done only once.

3.2.2 *Transient Nature Of On-Site Work Stations*

On-site work stations are not permanent. In a manufacturing plant, for example, a given operation is assigned to and carried out in one place. In contrast, specialized construction crews progress from location to location. Often this must be done in sequence; for example, crews doing excavation, concrete forms, reinforcing steel, and concrete placing must finish before structures can be set in place. Often, the additions made by succeeding crews modify or further restrict the available working space.

3.2.3 *Non-Repetitiveness Of The Products*

The final product is usually of unique design and differs from work station to work station so that no fixed arrangement of equipment or aids such as jigs and fixtures is possible. Even so, given that many operations are highly repetitive-for example, a weld is a

weld-standardization of procedures and special means for making the work go faster and more easily should not be overlooked.

3.2.4 *Safety Provision Enforcement*

Because construction is a preliminary step leading to a completed facility, the layout and arrangements may make access for construction difficult and permanent provisions for safety impossible.

3.2.5 *Specialized Nature of Work*

Because construction often needs highly skilled crafts-persons rather than unskilled workers, individual crews, whether union or nonunion, usually do specialized operations. This means that tasks which must be carried out in sequence have crew following crew. Unless schedules are done carefully and are accompanied by commitments to see that they are met, delays and cost overruns are almost inevitable.

3.2.6 *Outdoor Operations*

Operations are commonly conducted out of doors and are subject to all the interruptions and variation in conditions and the other difficulties that rain, snow, heat, and cold can introduce.

3.2.7 *Difficulties In Assembly*

Construction often involves large-scale, cumbersome, and heavy assemblies of components that are difficult to handle and fasten in place.

3.2.8 *Owner Involvement*

The owner is deeply involved in the construction process while the purchaser of manufactured goods is not. Buyers of the usual manufactured products seldom have access to the plant where they are made, nor do they deal directly with factory managers. For example, most electric appliances are stock items which reach the buyer through wholesalers and retailers. Purchasers merely select a particular make and model. Even with semi-custom built items such as automobiles, buyers have almost no input into basic design details such as engine bore and stroke, the physical and chemical properties of steels, plastics, or paints. Rather, purchases are made from a limited number of machines on a take it or leave it basis. Rarely do buyers deal personally with anyone at any level in the manufacturer's management hierarchy or labor force.

Even when the contractor bids a lump sum on a supposedly complete set of plans and specifications, owner's representatives, for example the architects or supervisors, are involved since they stipulate how to adapt the design to the site or other conditions. Also, they monitor the quality, dimensioning, and placement of materials. Before acceptance, there is a final review, which often brings a sizable "punch list" of supposed or actual deficiencies to be corrected. On fast-track or other projects where the overall project

concept may not have been finalized or at least construction begins before design is completed, even more of the owner, designer, or other interventions are to be expected.

The point being made here is that in manufacturing, the buyer does not enter the scene; in construction, the buyer is in it from beginning to end. Thus, construction managers have an added set of players with which to contend. Usually, these individuals or groups have different purposes, concerns, and reward systems. As a result, communication often becomes difficult, and clashes become commonplace. Adversarial relationships can easily develop, with each party attempting to frustrate the other or cover up its own mistakes.

3.2.9 Seasonal Work Force

The labor force in manufacturing is not seasonal while the construction industry is faced with a seasonal work force. The training process consequently is more difficult, time consuming and probably more costly than in manufacturing. The above differences are summarized in table below.

Table-2 Differences Between Manufacturing & Construction Industry

Nature	Construction Industry	Manufacturing Industry
Duration	Short	Long
Work station	Transient	Stable
Standardization	Non-standardized	Standardized
Safety provision	Less enforced	Highly enforced
Labor force	Highly skillful/Seasonal	Less skillful/Non seasonal
Environment	Productivity influenced by the change in environment	Productivity less influenced by the change in environment
Assembly	Difficult	Easy
Owner involvement	Highly involved	Less involved

The differences between manufacturing and construction industry may not end here. Probably there are other differences that need more research. The point here to make is that the construction industries' hostile environment evidently has an adverse results on the effectiveness of the construction organizations. As a result of an antagonistic environment naturally construction becomes a risky venture. To reduce the risk, and increase the effectiveness, construction organizations have to be able to adjust themselves to this unfriendly environment. There are some proven risk control strategies in manufacturing industry that the top managers in the construction industry can adapt to control their environmental uncertainties. Most of these efforts focus on gaining greater

control over environmental resources and responding properly to customers demands. One of the effective methods that can provide greater control on the environment is to be able to monitor the level of their effectiveness on a regular basis and using effective change strategies such as TQM.

Given the above facts, the end result of any attempt to devise a model of effectiveness for construction industry can not be one hundred percent accurate. The reason is that the construction industry operates in an unstable and complex environment. In addition, the tools of manufacturing management are designed according to that environment, when an attempt is undertaken to implement them to the construction industry, naturally the results are different. Simply stated one can not and should not take a model of effectiveness out of the manufacturing bookshelf and apply it directly to the construction industry. For the above reasoning this research has modified the existing constituency-model of effectiveness from manufacturing to fit it for the construction industry.

3.3 The Recent Work Of Others: Effectiveness Study For Construction Industry

In the recent years efforts have been made to identify and rank the project characteristics that affect the outcome of construction projects. The need to identify and rank such characteristics is generally self evident and has been called for by many experts and organizations such as: Spaulding (1998), the Federal Highway Administration (1995), Mcmanamy (1994), Rosenbaum (1995) and Yates (1995). One of the most recent publication in this field relates to the work of Anthony Songer and Keith Molenaar (1977).

Their main motivation for conducting such a research is derived due to an increase in the use of design-build projects in the public sector. Songer and Molenaar claim that:

Rapid growth, combined with a lack of long-term experience among many public agencies, necessitates continued investigation of the underlying principles of deign-build. Understanding which project characteristics are critical for success is fundamental for improved public agency implementation.

They have conducted a comprehensive research on recognizing the most important criteria for success in public sector construction projects. The results of their work suggests there are certain characteristics that affect project success more than others.

To achieve that end, they have conducted unstructured interviews to define and filter the project characteristics. They have also performed a survey to validate and priority rank all data. Finally, as a result of comprehensive structured interviews, they could provide additional insight concerning project characteristics. The result of their work is that in design-build public projects the following rankings holds true among the success criteria:

1. Being on budget
2. Conforming to the user's expectations
3. Being on schedule
4. Meeting the expectations
5. Meeting high quality of workmanship
6. Minimizing the construction aggravation

The following table provides definitions for the above criteria:

Table-3 Criteria Definition

Success criteria	Definitions
On budget	The project is completed at or under the contracted cost
On schedule	The project is completed on or before the contracted finish date
Meets specifications	The completed project meets or exceeds all technical performance specifications provided by owner
Conforms to user's expectations	The completed project meets or exceeds the user's envisioned functional goals (fitness for purpose)
High quality of workmanship	The completed project meets or exceeds the accepted standards of workmanship in all areas
Minimizes construction aggravation	The construction process does not unduly burden the owner's project management staff

The second study that this author could reference regarding the overall success of a construction project was the research conducted by Jeffrey S. Russell, Edward J. Jaselskis and Samuel P. Lawrence (1997)

The main motivation behind their research work was that they recognized that the managers for owners, designers, and contractors need real-time information to assist them in managing construction projects. As a result they have produced a process where owner, engineer, and construction contractor organizations can use continuous on time-dependent variables (e.g., owner expenditures, construction hours expended) to predict project outcome from start of detailed design through to construction completion. The hypothesis of their research relates to the ability of using continuous or time-dependent variables to

predict project cost and schedule performance. These authors define a continuous variable

as a time-dependent quantity whose value can be collected at several points during the

course of a project (e.g., contractor expenditure, invoices paid by the contractor, owner

project commitments, and designer cost).

In order to achieve such a real-time assessment of the construction project's

success, they collected 76 continuous variable data on 54 construction projects. The 54

construction projects fall into the following categories:

- 65%, of the projects were predominantly process projects (e.g., petrochemical,

  chemical, food, and paper projects).

- 35% of the projects were in manufacturing and general buildings

They could identify 76 continuous project variables with the assistance of the Construction

Industry Institute Predictive Tools Task Force. Based upon the collective experience of task

force members, variables were identified for owners, designers, and contractors and

selected because of their suitability for predicting a project's outcome as well as data

availability. The research identified that how many variables out of 76 original variables can

predict the out come of construction projects. They had to limit the number of independent

variables affecting the construction outcome to just a few variables. The reason was that it

was difficult to conceive that first-aid cases; facilities; days lost due to weather; days lost

due to strikes; overtime work; cost and quantity of remaining change orders; schedule

impact of variance/trends; among others, would independently predict the cost and

schedule outcomes of a project. Appendix-14 provides the above 76 variables.

Best fit models were developed for two project outcome categories:

1. "Successful"; meeting or exceeding budget and schedule expectation

2. "Less-than-successful"; not meeting budget and/or schedule expectations of the owner

Subsequently, statistical analysis was performed to identify those variables showing a significant difference between the "Successful" and "Less-than-successful" projects which can be used as predictors of project outcome. The results shows that different variables are predictors of success at different points of time during the project life cycle. As a result of their research, a unique approach has been developed for real-time project control that can assist project managers in better predicting the success of a project prior to its completion. Results showed that it was possible to predict outcome based on continuous variables and that the predictive ability of a variable changed depending on the type and phase of the project.

3.4 Defining The Role of Constituent Parties For The Construction

Industry & Their Satisfaction Criteria

3.4.1 Architects[6]

The architect can occupy a variety of positions with respect to the owner for whom the design is done. Many public agencies and large corporate owners maintain their own in-house design capability. In such instances the architect is the design arm of the owner. The traditional and most common arrangement is where the architect is a private and independent design firm that accomplishes the design under contract with the owner. Where the design-construct mode of construction is used, the owner contracts with a single party for both design and construction. In such a case, the architect is a branch of or is affiliated in some way with the construction contractor. The role of the designers can be of great importance in construction projects. The architects in construction projects, specially in Industrial, Commercial and Institutional have a critical role to play. These architectural firms are there for a sound and economical design of the project. They have a comprehensive knowledge of the construction from the inception of the design to the completion of the projects. They probably know the extent of the satisfaction of the owner/s, supplier/s, financial institution/s, customer/s and regulatory bodies where the performance of the general contractor is concerned. Obtaining the above information has

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[6] The architects, in residential buildings usually hire the design engineer to perform the necessary calculations. The architect-engineer, also known as the design professional, is the party or firm that design the project.

shown a critical significance for this research in its attempt to devise a new model based

on TQM principles and the Constituency Model. Naturally, the architect's satisfaction is

achieved when the projects meet all the aesthetic and engineering specifications.

3.4.2 General Contractor/Sub-Contractor

This research is assessing the satisfaction of the architect, owner, public, regulatory

bodies, external and internal customers from the performance of the prime contractor[7].

The prime contractor is also called a general contractor. A prime contractor is selected by

the owner on the basis of competitive bidding, negotiation, or some combination of the

two. A major portion of the construction in North America is done by contractors who

obtain their work in bidding competition with other contractors. The competitive bidding of

public projects is normally required by law and is standard procedure for public agencies.

Essentially all public construction work is done by this method. When bidding a project,

the contractor estimates how much the structure will cost using the architect's drawings and

---

[7] A prime contractor, also known as general contractor, is the firm that is in contract with the owner for the construction of a project, either in its entirety or for some specialized portion thereof. In this regard, the owner may choose to use a single prime contractor or several prime contractors.

Under the single-contract system, the owner awards construction of the entire project to one prime contractor. In this situation, the contractor brings together all the diverse elements and inputs of the construction process into a single, coordinated effort and assumes full, centralized responsibility for the delivery of the finished job constructed in accordance with the contract documents. The general contractor is fully responsible to the owner for the performance of the subcontractors and other third parties to the construction contract.

When separate contracts are used, the project is not constructed under the centralized control of a single prime contractor. Rather, several independent contractors work on the project simultaneously, each of the contractors is in contract with the owner and each functions independently of the others. Hence each of these contractors is a prime contractor. Coordination of these contractors may be made the responsibility of the owner, the architect, a construction manager, or one of the prime contractors who is paid to perform certain overall job-management duties.

specifications as a basis for the calculations. To this cost it adds what seems to be a reasonable profit and guarantees to do the entire job for the stated price.

Price amounts quoted by the bidding contractors most often constitute the principal basis for selection of the successful contractor, the low bidder usually receiving the contract award. Most bidding documents stipulate that the work shall be awarded to the "lowest responsible bidder." This gives the owner the right to reject the proposal of a bidding contractor if the contractor is judged to be unqualified for some reason. If its bid is selected, the contractor must complete the work in exchange for the contract amount.

Clough and Sears (1991) propose that competitive bidding can also be used where the successful contractor is determined on a basis other than the estimated cost of the construction. Such as when the contract will involve the payment of a prescribed fee to the constructor. The amount of the fee is sometimes used as a basis of competition among contractors. To illustrate, construction management services are sometimes obtained by an owner using the fees proposed by the different bidders as the basis for contract award.

There are times when it can be advantageous for an owner to negotiate a contract for its project with a pre-selected contractor or small group of contractors. It is common practice for an owner to waive the competitive bidding process and to hand-pick a contractor on the basis of its reputation and overall qualifications to do the job. A contract is negotiated between the owner and the chosen contractor. Such contracts can obviously

include any terms and provisions that are mutually agreeable to the parties. The general

contractor may sub-contract some or entire project to subcontractors.[8]

The point here is that the construction industry's method of selecting contractors,

suppliers and subcontractors is still the same old fashion way; rewarding the contract to the

lowest bidder. The Total Quality Management philosophy and the point number #4 of

Demings, mentioned in chapter-2, completely reject this type of awarding of the contracts

to contractors and suppliers. Point #4 of Deming's stresses the importance of rejecting the

old way of rewarding contracts to the contractors, subcontractors and suppliers by using

price tag alone:

End the practice of awarding business on the basis of price tag alone. Instead,

minimize total cost by working with a single supplier.

This researcher is aware that the above point while it works well for manufacturing,

may not work as well in the construction industry. The reason may be attributed to the

fragmentation, small type of business, lack of a universal coordination and probably the

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[8] The extent to which a general contractor will subcontract work depends greatly on the nature of the project and the contractor's own organization. There are instances where the job is entirely subcontracted, the general contractor providing only supervision, job coordination, and perhaps general site services. At the other end of the spectrum, there are those projects where the general contractor does no subcontracting, choosing to do the entire work with its own forces. In the usual case, however, the prime contractor will perform the basic project operations and will subcontract the remainder to various specialty contractors. Work of a type with which it is not experienced or for which it is not properly equipped is usually subcontracted. Qualified subcontractors are usually able to perform their construction specialty more quickly and at lesser cost than can the general contractor. In addition, many construction specialties have specific licensing, bonding, and insurance requirements.

When the prime contractor engages a specialty firm to accomplish a particular portion of the project, the two parties enter into a contract called a subcontract. No contractual relationship is thereby established between the owner and the subcontractor. When a general contractor sublets a portion of its work to a subcontractor, the prime contractor remains responsible under its contract with the owner for any negligent or faulty performance by the subcontractor. The prime contractor assumes complete responsibility

scattering of construction suppliers, subcontractors and contractors all over the map. The

manufacturing industry is a monopoly type of business. This exclusive possession provides

an environment that makes the manufacturing industry capable of doing business with

single supplier or contractor. Establishment of any manufacturing venture is far more

complex than construction. Single supplier idea of Deming's makes sense in

manufacturing, but may not make as much sense in the construction industry. On the other

hand, the contractual agreements between contractors, suppliers and the owners also must

be drawn in a manner to eliminate the existing adversarial relationships in the construction

industry. McKim and Kiani, 1995 believe that:

> *Applying TQM often requires a new perspective of existing practices. Normal*
>
> *contractual relationships between owners, contractors, subcontractors, and*
>
> *suppliers, regardless of the industry, often create an adversarial atmosphere in*
>
> *the work environment. Traditional work relationships promote attitudes such as*
>
> *"I will only do exactly what the contract says" and "I will get away with whatever*
>
> *I can" between working partners. These problems interfere with overall*
>
> *productivity and efficiency.*

It becomes clear that the differences between the manufacturing and construction

industries should be given a serious thought when attempting to devise a model of

effectiveness for the construction industry by using the manufacturing tools of

management.

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to the owner for the direction and accomplishment of the total work. An important part of this responsibility

3.4.3 Owner/s

The owner is referred to as the proprietor of the project. The owner gets the project financed, designed and built. The owner is either a private entrepreneur (in capital improvement projects) or a government entity (public owner).

Clough and Sears (1991) divide the owners into two groups; private and public owners. Public owners are public bodies of some form ranging from the federal government through provinces, country, and municipal entities to a multiplicity of local boards, commissions, and authorities. Public projects are paid for by appropriations, bonds, or other forms of financing and are built to perform a defined public function. Public owners must proceed in accordance with applicable statutes and administrative directives pertaining to advertising for bids, bidding procedures, construction contracts, contract administration, and other matters relating to the design and construction process.

Private owners may be individuals, partnerships, corporations, or various combinations thereof. Most private owners have the structure built for their own use: business, habitation, or otherwise. However, many private owners do not intend to become the end users. The completed structure is to be sold, leased, or rented to others. These parties may or may not be known to the owners at the time of construction.

This research assesses the satisfaction of the owner/s from the performance of the general contractor. In the existing manufacturing's constituency model the criterion that satisfies the owner the most is the Financial Return On Investment, table-1, chapter-2.

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is the coordination and supervision of the subcontractor. (Clough and Sears, 1991)

3.4.4- Customers

3.4.4.1 External Customers:

The third constituent party is the external customer. The external customers are the end users of the construction projects. Therefore, their satisfactions have to be evaluated accordingly. According the manufacturing's Constituency-Model the external customers are satisfied when they receive quality of goods and services, table-1, chapter-2. This research considers the communities as the external customers. This party is the end user of the construction projects.

3.4.4.2 Internal Customers or Employees

The fourth party is known as the internal customers such as employees. The satisfaction of this party is also investigated. The satisfaction of the internal customers according the constituency-model is based on the manner he/she receives the pay and also on the work itself, table-1, chapter-2.

3.4.5 Suppliers/ Creditors

The fifth party in the constituency model is the supplier/creditor. The model tells us that the most important criterion of satisfaction is a *Satisfactory Transaction and Credit Worthiness* of the general contractor table 1, chapter-2. The creditors/suppliers are curious to know if:

- The contractor is worth the risk of extending the necessary credit to?

- The contractor is able to pay his/her obligations to the suppliers, laborers, etc.?

3.4.6 Government Bodies

The sixth party in the proposed model is the government bodies. This party is the regulator of the codes and specifications that governs the performance of the construction projects. The satisfaction of this party is also considered. The constituency-model suggests that this group's interest is in the ability of the contractor to cope with the governing rules and regulations.

3.5 Defining Construction As A Process

The construction organization's effectiveness can be achieved if the management process can be improved upon. How do we know that construction is a process? In chapter-2, literature review of TQM, it was presented that any process encompasses three members, *customer, supplier and processor*. Juran (1988) introduced the concept of the triple-role to the manufacturing industry. McKim and Kiani (1995) also advocate that construction is a process and the triple-role of *supplier, customer and processor* holding true for this industry as well.

In TQM, business relationships are a series of transactions between customers and suppliers. A customer takes a product from a supplier, performs some value-added function to the product, then provides the transformed product to another

customer, thereby becoming a supplier. All organizations are thus both suppliers and customers.

They also believe that providing a strong customer feedback is a key element of TQM. The reason is that each stage of the process provides some sort of feedback on performance to the supplier about the quality and timeliness of the service given by the supplier. Naturally, there will be a continual flow of information about the process circulating among all participants. The key point here is the *continuous improvement of the process*. TQM's philosophy is a strong defender of the process improvement. The triple-role for construction is presented in Figure-7.
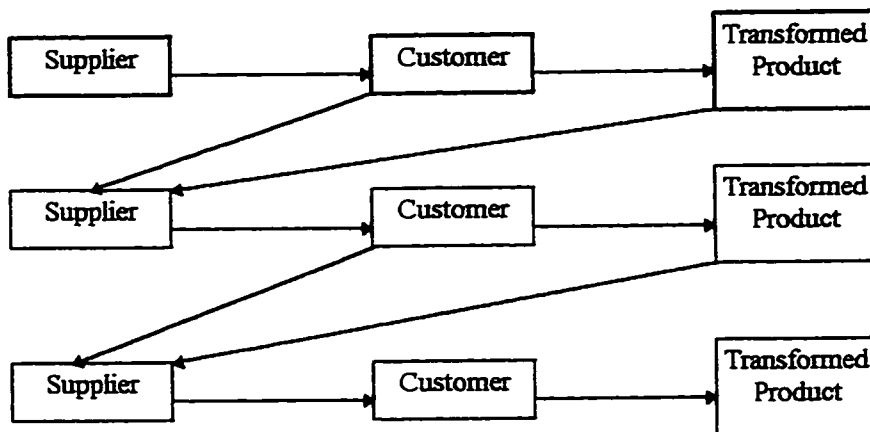
Figure-7 Customer/Supplier Relationship

The concept of the triple-role has been used in this research extensively. The role of each of the parties in the constituency-model is discussed according to the triple-role concept. The triple-role process in terms of Total Quality Management is schematically presented in Figure-8.

Input #2

Material flows in
as much as
&
when needed
(JIT System of delivery)

Output

A finished product
is produced as an
output/the customer
feedback is obtained
and improvement for the
next project is undertaken
according to the analysis of
the feedback information

Input #1

Plans & specs
are provided by the
architect as an input
according to the
needs of the public
and the owner and
after a careful review
on ROI

The construction techniques
&
proper management process
are applied

Input #3

Skillful personnel are provided
to exercise the TQM management process
&
to use proper tools and to apply the necessary techniques
in a team work environment

Figure-8 Construction Process Based On TQM Theory

In table-4 the role of each member in the construction industry is shown in relation

to the other parties. For instance; the internal customers or employees of the construction

organization is capable to supply services to the contractor or the owner. In this sense this

employee is a supplier of services. His/her role as a processor comes into picture when the

employee utilizes acquired expertise to transform the raw material into a product. This

employee has a role as a customer when his/her relation is related to the material supplier,

architect or the owner- in this case the employee is the customer of these parties. The same

concept can be applied to all the other members of the constituency such as material suppliers, contractors, architects, creditors, public, and the owner. Thus, Juran's manufacturing triple-role concept is applicable to the construction industry as well. Since the triple-role concept can be applied to the construction industry, therefore, the construction industry can be classified as a process and any process can be improved upon.

Table-4 Triple-Role of Constituency Model's Elements For Construction Organizations

Constituency Role	Is a supplier of:	Has supplied to:	Is a processor of:	Is a customer of:
1- Employee	Services & Expertise	Contractor & Owner	Material & Information	Material Supplier, Architect & the Owner
2- Material Supplier & Creditors	Construction Material & Credit	Owner, Contractor, Architect	Delivery of Material & Finance	Contractor, Architect & Employees
3- Contractor	Management & Technology	Owner & Public	Management & Technique	Owner & Public
4- Architect	Plans & Specifications	Owner and Contractor	Plans and Specs	Owner and the Contractor
5-Public	Constructed Facilities	Community	Constructed Facility Utilization	Members of Communities
6- Owner	Constructed Facilities	Public	Constructed Facilities, Finances	Creditors, Public & Government

3.6 Summary:

In this chapter, the needs of construction organizations and their customers for having a model to measure the effectiveness is presented. It is shown that the impact of construction activities on the national economy of U.S.A. and Canada is enormous. Construction activities are regarded as a valid indicator of the health of the economy. The differences between two industries; construction and manufacturing also presented.

It is shown that construction is a process and the triple-role of Juran can be applied to the construction process. The role of each constituency in construction process as a customer, supplier and processor is discussed. As a result of being a process, construction management can be improved upon.

It is further shown that the main reasons of utilizing TQM when devising a model of measuring effectiveness is two-fold:

- First: Showing that construction is a *process* and therefore it can be improved

- Second: Presenting the fact that the *customer satisfaction* is one of the most important aspect of TQM. Thus, for designing an effectiveness measurement model this research *must* assess the satisfaction of the external as well as internal customers.

Any attempt to propose a model of measuring effectiveness without assessing the customer's satisfaction can not be categorized as a fair study. Simply stated: One *can not ignore the needs of the customers when attempting to design a model of measuring effectiveness for the construction industry*. Nonetheless, this research is about to propose a *customer driven* model of effectiveness based on TQM when synthesized with the Constituency Model.

CHAPTER IV

SYNTHESIZING THE MODEL

4.1 Introduction

As mentioned in the previous chapters, this research proposes a model of measuring effectiveness for construction organizations. To accomplish this the principles of TQM and the constituency-model are synthesized. The principles governing the constituency-model have great similarities with those of TQM. In TQM we are attempting to be effective by satisfying the needs of all the parties involved. Similarly, the concept behind the constituency-model is based on the satisfaction of all the stakeholders. Therefore, this research combines these two related concepts, TQM and constituency-model, to devise a new model for measuring the effectiveness of the construction organization. This devised model has to be fitted to the environment that the construction industry operates in.

TQM management philosophy provides this research with the following:

1. **Customer-Supplier-Processor (Triple-Role) principle**: Verifies that construction is a process, therefore can be improved on and become more effective

2. **Customer satisfaction principle**: To achieve a valid effectiveness model this research *must* assess the *satisfaction of the internal and external customers*

On the other hand, the constituency-model furnishes this research with the following:

1. **Identification of the constituent parties in construction**: these are external and internal customers

2. **Providing the satisfaction criteria for each constituent party/customer**

TQM theory shows that any construction project is a *process* and the *customer satisfaction* is one of the main forces behind any *effective* construction organization. On the other side, the constituency model provides the identification of the *constituent parties (customers)* and their *criteria of satisfaction*. Therefore, by synthesizing these two management tools, TQM and the constituency-model, the research creates a model of effectiveness that can identify the constituent parties and their criteria of satisfaction. Figure-9 presents such a synthesizing of the TQM and Constituency.

From TQM:
1. Triple-Role is defined and it is proven that construction is a process
2. Further it is proven that the Customer Satisfaction is *the* most important factor when an attempt is made to create a model of measuring effectiveness

From Constituency Model:
1. The Constituent parties for the construction industry are identified
2. The satisfaction criteria of the constituent parties are defined

The synthesized model can predict the effectiveness of construction organization/s based on the satisfaction of the following constituent parties:
1. Architect/Owner representative or Owner
2. Public/End users of the products
3. Employee/s
4. Regulatory body/s
5. Suppliers/Creditors
where the satisfaction of each constituent party is investigated by using the appropriate criteria of satisfaction provided by the existing Constituency Model.

Figure-9 Synthesized TQM And Constituency Model

For developing the model the research has to determine the variables that control the model. In the remainder of this chapter the following procedures will be discussed which finally leads to the development of the proposed model.

1. Data Collection

2. Development of Questionnaires, and

3. Development of the Proposed Model

4.2 Data Collection Methodology

When evidence of a problem exists and the magnitude of the problem is serious enough to merit attention, the first step of resolving the problem is to gather information. Data may be collected about the causes of the problem and its seriousness from a variety of sources including interviews, observations, questionnaire surveys, and archival data. All data collection methods need to satisfy two requirements:

1. The data must be reliable

2. The data must be valid

The term *reliability* refers to the consistency of the measure. A research instrument is said to be reliable if it produces consistent and repeatable measures each time it is used. Counting the number of bricks a mason has laid should be a very reliable measure of productivity, because the results should be the same time they are counted. Questionnaires are usually reliable if the questions are clear; if they are ambiguous, the responses will be random and the instrument will be unreliable.

The term *validity* refers to whether the research instrument actually measures what it is supposed to be measuring. The number of bricks a mason has laid is a very valid measure of productivity because laying bricks is what a mason is supposed to do. The

validity of a questionnaire, however, is more difficult to assess. For example, does a questionnaire measuring company commitment really measure what it is supposed to measure? Are people with high scores more loyal to the company? Do the people who leave have lower scores? Are the scores related to the willingness of employees to defend the company against public criticism?

Each method of data collection contains advantages and disadvantages. This research uses the questionnaires method of data gathering in its methodology. Questionnaires can be used to gather large volumes of information from many people in a short time. Everyone can be involved in the diagnosis stage, and the information can be summarized in a short time. Various sampling techniques allow researchers to survey only a small number of people and make remarkably accurate judgments about the attitudes of others, as is done with the political surveys. The major disadvantage of questionnaires is that the information obtained from them is largely limited to confirming or not-confirming the expectations of those who designed the questionnaire. If the relevant issues are not covered in a questionnaire, the information will be inadequate or misleading. The best solution to this dilemma is either to interview a sample of targeted individuals to identify the relevant issues and use this information to construct the questionnaire or to ask for open-ended comments at the end of the questionnaire.

Furthermore, questionnaire data can be conveniently analyzed using a variety of statistical procedures. *Most well developed questionnaires have also been found to be reliable and valid measures of specific variables* (Cherrington, 1994).

4.3 Data Administration:

The Statistics Department of the University of Waterloo was consulted for the development of the questionnaire and the final analysis of results. Approximately 900 architects in the Province of Ontario were contacted to receive their assessments as far as the quality of the projects and the performance of the general contractors (who performed those projects) are concerned. As an outcome, the research is supplied with the results of 92 projects.

The architectural firms were informed about the primary objective of the research; *Devising and testing a model for monitoring the effectiveness of the construction companies.*

Each architectural firm chose two general contractors with whose work they were most familiar. One firm is a general contractor that is highly effective (the best contractor), and the other is a general contractor that is ineffective (the worst contractor). The architectural firm was asked to answer pages A-1, A-2, B-1 and B-2 of the questionnaires. A copy of these pages is provided in appendices 1, 2, 3 and 4. The architect indicated the satisfaction of the various constituent parties in the construction project. The reason behind approaching architectural firms for their assessment is based on their impartial reputations and also due to the facts that architects are generally involved in the construction projects process from inception to the completion and perhaps to the occupancy and the maintenance phases of the constructed projects.

4.3.1 Questionnaire A-1

The main purpose for provision of questionnaire A-1 is to furnish the researcher with the performance information of the best general contractor that the architectural firm has had experience with. In this way the researcher can assess the satisfaction of the parties involved from the best general contractor's performance. Appendix-1 presents the A-1 questionnaire.

Here, the architectural firm was asked to provide the research with the satisfaction of the constituency parties from the best general contractor's performance. The intention here was to find out what characteristics of the contractor had the most effect on making him/her a good contractor. These characteristics manifest themselves in the scheduling, budgeting, compliance with rules and regulations, management, knowledge of construction, and the financial solvency of the prime contractor .

As it is apparent from appendix-1, the architect is supposed to rate the satisfaction on a scale of 0-100 basis, where

Very satisfied = 100

Adequately satisfied = 50

Completely dissatisfied = 0

4.3.1.1 Definition of the characteristics associated with contractor:

The study and analysis of the associated characteristics without providing a sound description for them is meaningless. What do we mean when we refer to a contractor who

can complete projects on-budget, on-time and according to specifications? The following section provides a description of "on-budget projects", "on-schedule projects", "on-specification projects"; in addition a description of the management and the solvency issues of the contractor is provided.

- **On-Budget Projects:**

  We define an ICI project **on-budget** when the project is completed at or under the original contracted cost.

- **On-Schedule Construction Projects:**

  This research has defined **on-schedule** construction project as follows:

The completed project is said to be **on-schedule** if it is completed on or before the original contracted finish date (disregarding the time extension associated with the extras. The main reason we disregard the extras at this time is the lack of data). For example; if the prime contract between the owner of an ICI project and the contractor called for completing the project within 365 working days, and the contractor was able to complete the project in less than or equal to 360 working days, then the project is said to be completed on-schedule. Here again the research is not concerned with the time extension due to the extras. Holidays, rainy days and the non-working days related to unforeseen acts of God; such as earthquakes, floods, wind are not considered as working days. On the other hand, the days that the contractor has been delayed due to the negligence of the owner or his refusal in following his contractual obligations are not considered working days either.

Therefore, a contractor that historically could produce on-time projects, possess good time scheduling characteristics.

- **On-specs Projects/Compliance With Rules & Regulations:**

A project upon completion is defined as "on-specs project" when the completed project has met or has exceeded all of the technical performance specifications provided by the owner, architect and the regulatory bodies. In this case the completed project meets or exceeds the accepted standards of workmanship in all areas. This type of project; on-specs projects, meets or exceeds the user's envisioned functional goals and is fit for the owner's purposes. In this case the completed project has met all the specifications, the contractor has complied with all the rules and regulations imposed on him by the architect and the regulatory bodies.

The owners usually request the contractor to provide them with some form of insurance that the final product is completed according the specification and the contracted documentation. Performance bonds provide the owner with insurance that the contractor will perform according the contract documentation, and specifications and that the completed project will exceed or equals the required workmanship, specs, and local codes. Simply, the performance bond is a safeguard protecting the property owner from financial loss resulting from failure or default of a general contractor to perform the job according to terms and conditions of the contract. Hence, good compliance characteristics of a

contractor can be referred to his/her capability of providing the owners with projects that are according the specification and document contract on a regular basis.

- **Solvency of the General Contractor:**

The solvency issue refers to the financial capability of the contractor in fulfilling his monetary obligations towards his sub-contractors, material suppliers, employees, etc. As a normal practice the owners of the projects usually request that the contractor to provide them with payment bond insurance.

In case that the contractor defaults in his monetary obligations towards his sub-contractors, material suppliers or employees, the payment bond insurance will safely cover the owner from any possible future law suits such as mechanic's lien against the property, etc. If the contractor defaults on his monetary obligation towards his sub-contractors/supplier, they can file a mechanic lien against the property.

The cost of obtaining the payment bond varies depending on the credit history of the contractor, which insurance company the bond is obtained from, the size of the project, etc. The cost of securing this type of bond is a mutual consent between the contractor and the insurance company determined by some percentage of the total contract cost.

Hence, the questionnaire A-1 consists of 35 questions (Number of Constituents 5, times number of variables 7). Questionnaire A-1 has 35 variables X_1 through X_{35} . These dependent variables are defined in appendix-12

4.3.2 Questionnaire A-2

Questionnaire A-2 is designed to complement questionnaire A-1. While questionnaire A-1 is asking about the characteristics of the prime contractor, the questionnaire A-2 provides this research with the construction project data as it was built by the best prime contractor.

Appendix-2 contains the questionnaire A-2. Questionnaire A-2 is designed to receive a binary responses to questions 1 to 3, YES or NO, and an ordinal response (on a basis of 0-100) for question # 4, which shows the overall quality of the project. This research has only used the response #4, the overall quality of the project, in its data analysis.

Question 1 through 4 are explained as follow:

1. **Question 1 = Y_1**: Asks if the project is completed within the ORIGINAL TIME SCHEDULE? (Note: The best contractor has performed this project).

2. **Question 2 = Y_2** : Asks if the project is completed within the ORIGINAL COST ESTIMATE?

3. **Question 3 = Y_3** : Asks if the project has fulfilled the SPECIFICATIONS?

4. **Question 4 = Y_4** : Asks the assessment of the architect in respect to the OVERALL QUALITY of the project

Hence, the questionnaire A-2 provides this research with the construction project data which is performed by the best prime contractor. Simply put, the outcome of A-2 questionnaire provides the research with the specifications of the projects which are

performed by the best prime contractors. The questionnaire asks if the projects which were performed by the best contractors were on schedule, on cost and according the specifications. The question 4, provides this research with the overall quality of the projects which are performed by the best prime contractors.

4.3.3 Questionnaire B-1

The main purpose for designing the B-1 questionnaire is to provide this research with the characteristics information of the worst prime contractor. In this way, the satisfaction of the parties can be assessed as far as <u>the worst general contractor's performance</u> is concerned.

The architectural firms provide this research with the satisfaction of the constituency parties from the worst general contractor as far as scheduling, budgeting, compliance, management, knowledge of construction and financial solvency are influenced.

The architect is supposed to rate the factors on an ordinal scale of 0-100 basis, where:

Very satisfied = 100

Adequately satisfied = 50

Completely dissatisfied = 0

The definitions for the SCHEDULING, COST, COMPLIANCE, MANAGEMENT, KNOWLEDGE OF CONSTRUCTION, and FINANCIAL SOLVENCY in B-1 are the same as the ones in A-1.

The outcome of this questionnaire, similar to questionnaire A-1, is 35 variables; X_1 through X_{35}. The definition of these variables is provided in Appendix-13

4.3.4 Questionnaire B-2

Questionnaire B-2 is a reproduction of the questionnaire A-2 with the exception that it refers to the construction project data that is performed by the worst prime contractor. Questions 1 through 3 can be answered on a binary basis, YES or No, and question # 4 which evaluates the *overall quality of the project* is answered on an ordinal basis, scaled from 0 to 100. Again, this researcher has only used the answers to question #4 for analyzing the data.

Table-5 provides a summary for questionnaires A-1, A-2, B-1 and B-2

Table-5 Summary Of The Questionnaires A-1, A-2, B-1, And B-2

Questionnaire A-1	*Provides the research with: The characteristic information about the best general contractor*	*Measures the satisfaction of the constituency parties of the following items:* 1. *Scheduling management skills* 2. *Budgeting management skills* 3. *Compliance with the rules and regulations* 4. *General Management skills* 5. *Knowledge of construction* 6. *Financial solvency*
Questionnaire A-2	Provides the research with: The construction project data which is performed by the best general contractor	Measures the architect's assessment of the following project data on a binary type response: 1. Was the project completed within the scheduled TIME? 2. Was the project completed within scheduled COST? 3. Did the project fulfill the specifications? 4. How would you assess the overall quality of the project? Note: Question #4 is answered by the architect on an ordinal scale.
Questionnaire B-1	Provides the research with: The characteristic information about the worst General contractor	Measures the satisfaction of the constituency parties of the following items: 1. *Scheduling management skills* 2. *Budgeting management skills* 3. *Compliance with the rules and regulations* 4. *General Management skills* 5. *Knowledge of construction* 6. *Financial solvency*
Questionnaire B-2	Provides the research with: The construction project data which is performed by the worst general contractor	Measures the architect's assessment of the following project data on a binary type response: 1. Was the project completed within the scheduled TIME? 2. Was the project completed within scheduled COST? 3. Did the project fulfill the specifications? 4. How would you assess the overall quality of the project? Note: Question #4 is answered by the architect on an ordinal scale.

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The triple-role concept; depicted in Figure-10, justifies this high rate of response in regards to the satisfaction of the owner and regulatory bodies from the construction firm.

Regulatory Body is a:
Supplier of the codes and regulations to both architect and the general contractor

Owner is a:
Customer of the public and a supplier of the ideas to the architect

Architect is a:
Processor of the idea received from the owner and the supplier of the plans and specifications to the general contractor

General Contractor is a:
Processor of the architect's plans and specifications

Figure-10 Relationship Of Triple-Role Among The Architect- Owner - General Contractor And Architect - Regulatory Body And The General Contractor

As seen from Figure-10, the architect due to a direct involvement with the processing of the plans and specifications (as per requirements of the owner and the regulatory bodies) not only has a good knowledge with respect to the general contractor's performance, also has a good knowledge of the owner's and the regulatory body's satisfaction from the general contractor's performances. Table-6 also tells us that the

architect is aware of the owner's satisfaction from seven different perspectives (through X_1,

X_2, X_3, X_4, X_5, X_6 and X_7). The architect can assess the regulatory bodies' satisfaction

from one single aspect (X_{10}) alone.

These eight independent variables and their descriptions are listed in Table-7.

Table-7 Eight independent variables and their descriptions

Independent Variable	Description
X_1	Architect's/owner's satisfaction of the general contractor's scheduling characteristics
X_2	Architect's/Owner's satisfaction of the general contractor's project cost control characteristics
X_3	Architect's/Owner's satisfaction of the general contractor's compliance with the rules and regulations characteristics
X_4	Architect's/Owner's satisfaction of the general contractor's management characteristics
X_5	Architect's/Owner's satisfaction of the general contractor's knowledge of construction characteristics
X_6	Architect's/Owner's satisfaction of the general contractor's financial solvency characteristics
X_7	Overall rating of the General Contractor by the architect
X_{10}	Regulatory bodies' satisfaction of the general contractor's compliance with the rules & regulations characteristics

X_7 by definition is the overall rating of the general contractor by the architect.

Therefore, X_7 can be regarded as a function of X_1 through X_6 and X_{10} :

$X_7 = f(X_1.$ through X_6 & $X_{10})$

4.4 Summary:

This chapter started with an introduction to the questionnaires and their development. It was shown that this research had developed questionnaires to assess the satisfaction of the constituency parties from the general contractors responsible for performing the construction projects. It was further demonstrated that different types of questionnaires were designed to assess the overall quality of the projects performed by the general contractors.

The 35 independent variables (from questionnaires A-1 and A-2), through the frequency analysis, were narrowed down to a set of 8 independent variables: X_1, X_2, X_3, X_4, X_5, X_6, X_7, and X_{10}.

CHAPTER V

MODEL FITTING & VALIDATION

5.1 Introduction:

This research uses *linear regression analysis model* to investigate the joint relationships among the variables. The independent variables are classified as ordinal response variables, measured on an interval scale from 0 to 100

The ordinal response variables (e.g., none, mild, severe, or in this case a response based on an interval scale) arise in many fields of study. The simplest model for ordinal response data involves parallel lines regression on some appropriately chosen scale. Regression analysis is the analysis of the relationship between one variable and another set of variables. The relationship is expressed as an equation that predicts a response variable (also called a dependent variable) from a function of the regressor variables (also called independent or explanatory variables) and parameters. The parameters are adjusted so that a measure of fit is optimized. For example, the equation for the ith observation might be:

$$Y_i = \beta_0 + \beta_1 X_i + \varepsilon$$

Where Y_i is the response variable, X_i is a regressor variable, β_0 and β_1 are unknown parameters to be estimated, and ε is an error item. (SAS/STAT User's Guide, 1990)

The formula simply represents a framework within which this research is able to study the relationships which are of interest, e.g., the overall quality of the project (Y_4) and the characteristics of the general contractor (X_1 to X6 and X_{10} independent variables

$$Y_4 = f(X_1 \text{ through } X_6 \text{ and } X_{10})$$

The devised regression formula should be regarded simply as an attempt to provide an empirical result of the observed data. It should be noted that no model can be routinely used without checking that it does indeed provide a resound description of the variable data.

5.2 Definition of variables X_1 through X_7 and X_{10}

In the context of this research X_1 is defined as the owner's satisfaction of the general contractor's characteristics of providing _on schedule_ projects. The owner expresses his rate of satisfaction on a scale from 0 to 100 basis through X_1 from the scheduling characteristics related to the contractor.

X_2 is defined on an ordinal basis from 0 to 100. It is the owner's expression of his satisfaction from the general contractor's characteristics in providing _on budget_ project. In

other words, the owner shows his satisfaction of budgeting characteristics of the contractor though X_2.

X_3 is a measure of the satisfaction of the owner from the general contractor's characteristic of providing projects according the specification; *on specs*.

X_4 is the satisfaction rating of the owner from the contractor's management characteristic capability. This variable measures the rate of satisfaction on an ordinal basis from 0 to 100. The result shows how capable the contractor had been in managing the related material and human resources

X_5 is a measurement of the owner's satisfaction from the general contractor's knowledge of construction. This figure; on an ordinal basis from 0 to 100 basis, provides us the level of the contractor's construction knowledge. X_5 demonstrates how prominent the contractor's knowledge of construction had been.

X_6 is a demonstration of the owner's satisfaction from the general contractor's solvency characteristic. It shows if the contractor's financial situation is as such to pay his monetary obligations to his suppliers, employees and his sub-contractors. This figure is also measured on an successive basis from 0 to 100 basis.

X_7 is the satisfaction of the owner from the overall performance or effectiveness of the general contractor. X_7 demonstrates the overall performance capability of the general contractor on a continuous basis from 0 to 100 basis.

X_{10} is the satisfaction of the regulatory bodies from the general contractor's capability of codes and specifications.

5.3 Significance Level

For better understanding the end results of this research, it is appropriate to explain one factor which is of importance when analyzing the data:

The significance level represents a statistical yardstick that is used to assess the degree of consistency between a particular hypothesis regarding a parameter value, such as a regression coefficient, b, and the evidence contained in the data concerning the value of that parameter, based on a fitted model. The standard statistical theory predicts that the sampling distribution follows a distribution that is approximately normal with mean equal to the true value of the regression coefficient, and a variance that is roughly the square of the estimated standard error of the regression coefficient estimate. Thus, if there is no relationship between a response variable, Y, and the explanatory variable, X, corresponding to the estimate, $\propto$ of the regression coefficient, b, then the statistic

$(\propto - 0)/\text{est se} \propto$

should behave like an observation from a normal distribution with mean 0 and standard deviation 1. If the observed value of this statistic, i.e.,

$\propto/\text{est se} \propto$

lies in the interval (-2, +2), the result is interpreted as indicating that there is no evidence in the data to contradict the hypothesis that the true value of b in the regression model for Y is 0, i.e., that there is no relationship between the response variable, Y, and the explanatory variable X. On the other hand, if the observed value of this statistic lies outside the interval (-2,+2), the result is interpreted as indicating that the data provides at least some evidence to contradict the hypothesis that the true value of b in the regression model for Y is 0, i.e.,

that there is apparently a systematic relationship between the response variable, Y, and the

explanatory variable X. The significance level (or p-value) is two times the probability in

the smaller tail determined by the observed value of

$\alpha/est\ se\ \alpha$

for a normal distribution with means 0 and standard deviation 1.

5.4 Results Of Data Analysis:

To better understand the nature of the data obtained for this thesis, it is necessary to

explain the environment from which the data is received. The construction industry in

general is divided into two major sectors; ICI and the Heavy Construction. The ICI sector

concerns the construction of the Institutional, Commercial and Industrial projects.

Construction of single family homes, condominiums, apartment buildings, shopping centers

and office buildings is part of the activities in the CI sector of the construction industry.

On the other hand, the heavy construction sector relates to the construction of Dams,

Roads, Bridges, Earth Moving projects, Irrigation channel system and etc.

The data which are gathered for this research relates to the ICI section of the

construction industry. This research has not imposed any restriction on the size of the

targeted projects. As a result, the respondent can choose any size of the construction

projects which he has experience with in the past. Another viewpoint is that while the

targeted architectural firms are mainly located in the province of Ontario, they can provide

their insights regarding any project's data constructed anywhere in North America.

However, the collected data showed that the projects varied in size from $500,000 to approximately $10,000,000 with an average size of $6,789,000

The project duration, from the beginning of the detailed design to the completion of construction, ranged from eight to 36 months with an average duration of 22 months. While the results of this research hold true for the ICI sector of the construction industry, the author can not speculate that the results will be applicable for the heavy construction industry. The reason is due to the nature of the designed questionnaires and subsequently, lack of a related data for the heavy construction industry to substantiate the claim. Considering the fact that the architectural firms in the ICI sector have been the main respondent for this research, if the future researchers are interested to check the results of this research for the heavy construction, they should target the civil/structural engineering or the consultant firms responsible for the design-supervision of the heavy construction projects. Contrary, In the ICI sector, the architect normally provides the owner with the design of the project and the construction documents, based on the owner's needs. He is often engaged in providing construction administration for the project, acting as the owner's agent. The architect also provides an interpretation of the contract documents.

- As a results of a correlation analysis performed on the variables X_1 through X_7 and X_{10} the following matrix is produced:

Table- 8 Correlation Analysis among X_1, X_2, X_3, X_4, X_5, X_6, X_7, and X_{10}

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_{10}
X_1	100	72	80	90	72	64	94	86
X_2		100	76	77	76	57	75	62
X_3			100	86	79	65	80	92
X_4				100	80	67	82	62
X_5					100	78	71	56
X_6						100	60	51
X_7							100	95
X_{10}								100

The above matrix shows that X_7; the overall contractor's performance, is highly correlated with X_1 and X_{10}. The correlation between X_7 and X_1 is 94% and of X_7 to X_{10} is 95%. Further the table shows that X_1 (time characteristics) and X_4 (Management characteristics) are highly correlated, 90%. Hence, the time scheduling characteristics can be regarded as a function of the management characteristics of the contractor. In other words, instead of measuring the management characteristics of the contractor, which is a difficult task to perform, it would be easier to consider his time scheduling capability. X_3 (specification characteristics from the owner's point of view) and X_{10} (specifications characteristics of the contractor from the regulatory body's point of view) are also highly correlated; 92%. This research, instead of choosing two points of views for measuring the

same characteristics (in this case choosing X_3 and X_{10} for measuring the specifications characteristics), has chosen only X_{10}. The reasoning is related to the fact that the regulatory bodies; such as the inspectors, municipalities and the City authorities responsible for regulating and implementing the rules and the regulations have a better knowledge of the contractors specification characteristics performance. In additions, since the high correlation between X_3 and X_{10}, one can be regarded as the function of the other. For the above reasoning this researcher has chosen the X_{10}, as the viable candidate when the freedom of choice exists between X_3 and X_{10}.

A subsequent correlation analysis between X_7; the overall performance, and Y_4; the overall project quality, shows an 85% correlation factor. Simply, this high correlation shows that the overall outcome of any ICI project can depend on certain characteristics of the contractor responsible for performing the project.

From the above correlation analysis and the thought process this researcher has concluded that:

The overall quality of any ICI project depends on the following two characteristics of the contractor:

1. The contractor's time scheduling characteristics
2. The contractor's capability of proper following specifications and codes

The question which will remain to be answered is that of determining what relation exists among the time scheduling characteristics (X_1), Specification (X_{10}), and overall quality projects (Y_4) ?

To achieve this end a regression fitting model of overall quality against characteristics of the contractor shows that the overall quality of any ICI construction project has the following relations with specifications and time scheduling characteristics of the contractor.

Overall quality of the project = -15.6 + .49X₁ (Time scheduling characteristics) + .69X₁₀ (Capability of following the codes & Specification characteristics)

The above model tells us that the characteristics related to time scheduling and capability of following codes and specifications are the most important characteristics of the contractor responsible for the performance of any ICI project.

The model further tells us that in the order of significance the specification stands at the top of the list followed by time scheduling. Thus, according to the results, each one-unit rise in the explanatory variable X_1 is associated with an estimated increase of 0.49 in the mean value of the overall quality of a construction project, provided the value of the other explanatory variable, X_{10}, is held constant. With respect to X_{10}, each one-unit rise in this variable is associated with an estimated increase of 0.69 in the mean value of the overall quality of a construction project, provided the value of X_1 is simultaneously held constant.

The customer satisfaction for a construction firm is achieved when and if the construction organization can provide its customer with on specs (quality work) and on time projects. In other words, the effectiveness of a construction organization depends on how it has followed the specifications and time scheduling.

Therefore, good construction companies are those that can possess the following characteristics:

1. Can follow the specifications vigorously (producing defect-free product, according the specifications), and

2. Have good time scheduling capability (eliminating the rework as much as possible, and efficiently managing the time scheduling)

In the recent years, efforts have been directed towards measuring the effectiveness of construction organizations by many authors and researchers. Some has dedicated enormous efforts in assessing the effectiveness of the construction organizations by considering several variables. Most of the efforts of theses researchers has finally narrowed down to evaluating the effectiveness of construction organization to just a few variables; either because of a lack of sufficient data, frustration or interrelationship among several variables. For example, in the previous chapters this author mentioned the work of Jeffery Russell, et all (1997). The above researchers has originally investigated 76 variables when assessing the effectiveness issue; refer to appendix 14, in the final stages of their research they had narrowed down the results to just a few variables to show if the projects are on time and on cost. This researchers has also boiled down the effectiveness measurement study of a construction organization by measuring only two variables. This author firmly

believes that other variables are a function of these two important variables, **quality and time variables,** when assessing the effectiveness of any construction organization. For instance; the variables relating to cost; the number of claims, the number of accidents, solvency , severity rate, construction hours earned, first-aid cases, recordable incident rate, management, etc. will manifest their presence in the capability of the contractor in providing on-time projects and according to the codes and specifications. Simply put, the end user is not assessing the effectiveness of the construction organization from a detailed view rather they would evaluate the effectiveness of a construction organization from a broader view which relates to its capability in providing quality and on-time products. This researcher has investigated the issue of effectiveness from a broad picture rather than tormenting with details.

In addition, capability of proper following the specifications and being right on time scheduling are mentioned as the main results of correct application of TQM principles to the work environment by many authors. For example; Matthews et al, (1986) believes that:

TQM focuses on the process improvement, customer and supplier involvement, team work, training and education, in an attempt to achieve customer satisfaction, cost effective, on schedule and defect-free work.

The research work of McKim and Kiani (1995) also has shown that the construction companies that follow TQM principles correctly can produce defect-free and on time projects.[10]

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[10] For further information, the reader can refer to chapter II of this research.

Therefore, the construction companies that have the capability of proper implementation of TQM principles to their work environment can produce projects that are on time scheduled and defect-free (according to the specifications).

Having said that, however, this researcher does not claim that the other factors have no effect on the outcome of any ICI project. Contrary, the believe is that those factors have some effect on the outcome of the projects but their effect is included in the time scheduling and proper following specifications. For example, tardiness issue might effect the time scheduling and the claims issue may be a side-effect of the capability of the contractor in his following the proper specifications. The management characteristics has a direct effect on time scheduling and quality work.

It should also be noted that the original mission of this research was not to investigate the detailed influence of various variable on the effectiveness study but looking at the effectiveness from a broader view. Furthermore, this research is using constituency model and the TQM management theories, to identify the most important characteristics of the contractors that can have an effect on the outcome of any ICI project. The aforementioned proven theories have provided and meanwhile restricted this researcher with the following most important characteristics:

Time scheduling; Cost scheduling, Solvency , Management, knowledge and compliance. Therefore, according to the TQM and Constituency theories, this researcher should have restricted its finding within the above framework.

The other reasoning behind limiting the effectiveness study to just two characteristics can be attributed to the nature of the data received. The data analysis,

regression model fitting, has depicted two very important factors among all of the other variables. The concentration/congestion of data related to the time scheduling and specification has forced the regression model to depend on only two most provided data: Time scheduling characteristics and characteristics related to the proper following codes/specifications. This can be related to the nature of triple-role of the architect-general contractor-the owner and/or the triple role among the architect-regulatory bodies-general contractor. The targeted architects could provide this research with those characteristics; time scheduling and compliance characteristics, of the contractor that could have the most effect on the satisfaction of the owners and consequently the effectiveness study of the contractors.

5.5 Validation

Graphical diagnostic checks, using the estimated residuals from the set of data were prepared to ensure that the data did not contradict the underlying assumptions on which the statistical analysis leading to the preceding models was based.

Neter, et al (1990) do not believe that direct diagnostic plots for the dependent variable, in this case $\hat{Y}_4$, are very useful in regression analysis. The reason given is that the values of the observations on the dependent variable are a function of the level of the independent variable. Instead, diagnostics for the dependent variable are usually carried out indirectly through an examination of the residuals. The residual e_b is the difference between the observed value and the fitted value:

$$e_i = Y_i - \hat{Y}_I$$

As such the residual may be regarded as the observed error, in distinction to the unknown

true error $\varepsilon_I = Y_i - E\{Y_i\}$

Neter, et al (1990) further point to the fact that if a model is appropriate for the

data at hand, the observed residuals e_i should then reflect the properties assumed for the e_i.

This is the basic idea underlying the residual analysis, a highly useful means of examining

the validation of a model.

To validate the model which deals with the overall quality of the project and the

characteristics of the general contractor, ten test cases; setting aside when devising the

regression model, are also used. The regression fitted formula which governs the model is:

$$\hat{Y}_4 = -15.60 + 0.49X_1 + 0.69X_{10}$$

The following Table-9 shows the results of the testing the model. Two out of ten

test cases were eliminated because of the lack of supporting data.

Table-9 Validation table

Y4 Observed	90	90	50	98	90	25	50	55
$\hat{Y}_4$ Predicted	90.6	96.15	50	95.5	97.5	18.9	53.4	48.4

As it is clear the observed and the predicted values are very close. P-value is $0.000<0.005$

which is a good indication in regard to normalcy of the data governing the model.

CHAPTER VI

CONCLUSIONS, RECOMMENDATIONS

AND CONTRIBUTIONS

6.1 Conclusions:

This thesis has devised the following model for measuring the effectiveness of construction firms responsible for ICI projects.

$$Y_4 \text{ (overall quality of the project)} = -15.60 + 0.49X_1 \text{ (Time)} + 0.69X_{10} \text{ (Specification)}$$

The model shows that the characteristics of a contractor which can have the most impact on overall quality of any ICI project are:

1. X_{10}; The capability of the contractor in **Compliance With The Governing Rules And Regulations** and,

2. X_1; **Time Scheduling Capability**

It becomes clear that the regulatory bodies as well as the owners (represented by the architect) of the ICI construction projects are very sensitive towards the contractor's compliance with the rules and regulations and its ability in regard with time scheduling. Simply stated, **the ability of construction firms to comply with the rules and regulations and time scheduling plays an important factor when assessing their effectiveness.**

It is also shown that while the architects are capable of assessing the satisfaction of the owners and the regulatory bodies (concerning the performance of the general contractor) these architects can not assess the satisfaction of the other constituent parties. This phenomenon is the direct result of the architect's role in the triple-role; the architect has a triple-role in the **owner - architect - general contractor** and also in the **regulatory bodies - architect - general contractor.** These architects due to their lack of triple-role with the remaining constituent parties can not assess their satisfaction.

6.2 Recommendations

The constituents of the construction industry can use the devised model to predict the overall quality of the future construction projects. The usage of the model is recommended to ICI capital improvement projects as well as the ICI public projects. The internal and external customers of the construction firms can use the model to monitor the level of effectiveness of the firms. The model can also be used as a contractor pre-qualification tool.

- **Usage of Model for Pre-qualification Purposes:**

This author suggests that the following procedure might be followed if an attempt is made

to pre-qualify future contractors:

1. The contractors bidding on the project, should provide the owner with minimum of

   three references. The referees would provide the owner of the project with their

   comments regarding to the following characteristics of the contractor on an ordinal

   basis of zero to 100

   - Following specifications/codes capability

   - Following time scheduling capability

2. The owner of the ICI project would subsequently use the above data to calculate the

   averages for the specifications and the time scheduling capabilities of the contractor

3. The owner would then use the following formula to obtain the possible overall quality

   of the future projects for each contractor :

   Y_4 (overall quality of the project) = -15.60 + 0.49X_1 (Time)+ 0.69X_{10}

   (Specification)

4. As a result, the owner would negotiate the contract with the most qualified bidder.

A simulation will demonstrate the method:

Let's assume that five contractors are bidding on a capital improvement project.

Furthermore, let's assume that the owner's original cost estimate for this particular project

is $5,345,800.00 This estimate is obtained after a comprehensive study of the cost

associated with the material and labour, no provision for the contractor's overhead and

profit is considered at this stage. Simply, the above figure represents the project bare costs.

The owner also holds the discretion of rejecting any contractor's bid, on the other words, the only criteria for being selected as the winner of the contract is not based on the lowest bid. Naturally, the owner would consider further investigation on contractor's qualifications before awarding the contract.

The first stage of awarding contract is considering the bid amounts. Table-10 represents the hypothetical bid results which are received from the participants on this particular project:

Table-10; Hypothetical Estimates

Contractors	#1	#2	#3	#4	#5
Estimate	$5,880,380	$6,147,670	$8,018,700	$2,672,900	5,613,090

The bids of contractors #3 and #4 are not in line with the rest of the contractor's bid and also these bids are considerably off from owner's original estimate by plus/minus 50%. Therefore, the owner may eliminate the bidders #3 and #4 from further considerations due to their bids being off line. Further, it should be noted that it is assumed that contractor #4 is not providing any justification for his lowest bid, for example, no value engineering or re-engineering process is proposed by this contractor.

According to the owner's original cost estimate the contractor # 1 has a 10% provision for the overhead and profit. The contractor #2 and #5 have 15% and 5% provisions for their overhead and profits, respectively.

The second stage of contractor's qualification is for the owner to obtain the historical data from these three contractors. Let's assume that the following data is obtained regarding the capability of contractors in following the specifications and the scheduling. The owner has also calculated the averages for the scheduling and the specifications accordingly.

Table #11: **Contractor #1**

Referee/Characteristics	Time Scheduling	Specifications
Referee #1	80	90
Referee #2	100	95
Referee #3	90	85
Averages	(270)/3 = 90	(270)/3 = 90

For contractor #4, the following table is produced

Table #12: **Contractor #4**

Referee/Characteristics	Time Scheduling	Specifications
Referee #1	60	60
Referee #2	100	75
Referee #3	80	75
Averages	(240)/3 = 80	(210)/3 = 70

As a results of the data received from the referees of contractor #5, the owner has

produced the following table.

Table #13: Contractor #5

Referee/Characteristics	Time Scheduling	Specifications
Referee #1	80	80
Referee #2	80	55
Referee #3	90	75
Averages	(250)/3 = 84	(210)/3 = 70

The next step in qualification process is to calculate the overall project quality by utilizing

the following formula.

Y_4 (overall quality of the project) = -15.60 + 0.49X_1 (Time)+ 0.69X_{10}

(Specification)

the following table shows the results of the calculations:

Table # 14: Overall Project Quality

Contractors	Overall future project quality
#1	90.60
#2	71.9
#5	73.86

The last stage of pre-qualifications of contractors is the most puzzling one. At this stage of qualification the trade off between the construction quality and the associated cost may be taken into consideration; finding a happy medium between quality versus cost. At the first glance, contractor #2 can be eliminated from further considerations due to its lower score in providing quality work and its highest bid when compared to the bids received from contractors #1 and #5

The final qualification process is the process of choosing either contractor #1 or contractor #5.

The contractor #1's bid is 5% higher than the bid from contractor #5, on the other hand contractor #1 can provide project with a higher quality.

- **Usage of the introduced model by the CEO/Top Managers of the construction organization**

The second usage of the model is recommended to the CEO's and the top managers of the construction organizations responsible for the ICI construction projects. This research

recommends that the following procedure to be considered by the CEO's when an attempt is made to measure the level of the effectiveness of their construction organization. The idea is to monitor the capability of the construction organizations in providing quality work. As long as the construction organizations are capable of providing quality projects, the top managers can be assured that their organization is an effective one.

1. The construction organizations should keep records of the historical satisfaction of the owners regarding the following two items:

• The capability of their organization in following proper codes/specifications

• The capability of their organization in being on time scheduling

   The above satisfaction rating should be obtained on an ordinal basis, from zero to 100

   These data are provided to the construction organizations by their customers of the ICI projects.

2. Each pair of data; specification and time scheduling, can provide the construction organization with a figure for the *Overall Project Quality*. The Overall Project Quality is calculated by using the following formula:

   Y_4 (overall quality of the project) = -15.60 + 0.49X_1 (Time)+ 0.69X_{10}

   (Specification)

3. Find a three-points-data moving average of the results obtained in step 2.

4. As a result of comparing the three-points- moving average with the results of the recent accomplished project, two conceivable scenarios might occur for the construction organization:

If the Overall Quality of the recent accomplished project is lower than the three-points-moving average, the organization should take appropriate steps in finding the roots of the problem and taking the right actions to rectify the problem.

If the Overall Quality of the recent accomplished project is higher than the three-points-moving average, the organization is on the right track. Simply, this organization is currently producing construction projects that have better results than the average of the previous ones.

Note that the above procedure is a tool for the CEO's/Managers to monitor the level of their organization's effectiveness on a periodical basis. *In TQM theory the effort is also directed to the Plan-Do-Check-Act; PDCA cycle, in order to provide quality projects or products.* The results of this research can be used to achieve the above goal. The process is simple and rather practical as well.

An example can clear the above process. Let's assume that on an ordinal basis the customers of "XYZ Construction Corporation" have measured the following two characteristics of the construction organization for ten ICI projects:

- Capability of following specifications

- Capability of being on time scheduling

The top managers of this construction organization in turn have calculated the overall quality and the three-points moving averages of the data.

Table - 15 Results of Moving Averages

	Time	Specs.	$Y_4 =$ $-15.60 + 0.49(Time) +$ 0.69 (Specifications)	Moving Average
The oldest project Project #1	80	70	71.9	
Project #2	55	90	73.45	
Project #3	90	90	90.6 > 79 O.K.	79
Project #4	100	90	95.5 > 87 O.K.	87
Project #5	60	90	75.9 < 87 Needs improvement	87
Project #6	90	100	97.5 > 90 O.K.	90
Project #7	50	60	50.3 < 75 Needs improvement	75
Project #8	70	90	80.8 > 76 O.K.	76
Project #9	80	80	78.8 > 70 O.K.	70
The current project Project #10	100	80	88.6 > 83 O.K.	83

The performance of projects #5 and #7 has produced projects with lower results than the three-point moving average. Hence, the top managers of this organization, should take appropriate actions to rectify the problem as soon as possible. The rest of the projects have results which are higher than the three-point moving average, therefore, the above construction organization for the rest of projects; except #5and 7, is on the right track.

The construction organization can also graphically present the relationship between the moving average and the data.

It should be noted that while this researcher has chosen three-points moving average for the purposes of comparison, the construction organizations might choose higher or even lower moving averages. The choice between a higher or a lower degree of the moving averages

is based on the degree of the sensitivity of the construction organization towards its performance.

If the construction organization intends to monitor its level of effectiveness on a short time basis, it might use low degrees of moving averages, possibly three-points moving averages would be good enough.

On the other hand, if the construction organization's intention is to monitor its level of effectiveness on a longer time basis, it may use high degree of moving averages.

6.3 Further recommendations:

It should be noted that construction projects are faced with so many unknown factors that devising an exact model for predicting the precise relationships of dependent variables to independent variables is almost impossible. To devise a more comprehensive model, the future researcher needs:

- To improve the existing questionnaires: The scaling system for the satisfaction assessment can be more accurate than what is presented in this thesis. This thesis uses increments of 10 units on the satisfaction scaling. This interval can be reduced to 5 or even lower to increase the sensitivity of the model.

- The accuracy of the results can be improved upon by increasing the number of targeted architects. This research mailed 860 questionnaires and received the results of 92 projects. Increasing the number of targeted architects produces a greater number in responses.

- Building codes of the various provinces can have a great influence on the outcome and quality of the work. Thus, if further research in this area is of interest, the researcher should extend the target population beyond the Province of Ontario most likely to a national level.

- The devised model is fitted using software packages known as SAS and SYSTAT available on Watstar system of the University of Waterloo. There is the possibility of using Neural Network to check the accuracy of the results of this research. The researchers can use both software to check the results of one against the other.

- To devise a model of effectiveness that can assess the satisfaction of all the constituent parties combined, different questionnaires should be designed to target each constituent party. The best way is to assess the opinion of each constituent party concerning the satisfaction of the other two parties in the triple-role. For recognizing which constituent party to target, the future researcher can refer to Chapter-3 Table-4 of this research.

Finally, for details concerning the underlying calculations involved in the multiple linear regression modeling, the researchers can refer to chapter 7 of Neter, J., Wasserman, W. and Kutner, M.H. (1985), *Applied Linear Statistical Models. Regression Analysis of Variance and Experimental Design*, 2nd edition, Homewood, IL: Richard D. Irwin, Inc. And, for details concerning the maximum likelihood estimation of unknown parameters in the binary logistic regression models, the researcher can refer to chapter 6 of Cox, D.R. (1970). *The Analysis of Binary Data*. London: Chapman and Hall.

6.4 A Word Of Caution:

This research , like many others on effectiveness studies, may have left the reader with the impression that the effectiveness study of a construction firm can be reduced to a series of arithmetic calculations. Although, the science of evaluation of effectiveness is an important part of the process, theoretical models are only a tool to help the evaluator to make a more intelligent decision. This brings us to a final point: the person who tries to evaluate the effectiveness of a construction firm must know that there is no substitute for common sense. The person who fully understand what the devised model can do and can not do, will benefit the most of this devised model. A model is a scaled down (in case of physical models such as airplane or construction models) or more easily managed representation of the real world (in case of mathematical model). It is unwise, and sometimes dangerous to assume that the mathematical model and the real world which it represents are identical in any way. They may be very similar, but the model is unlikely to exactly duplicate every feature of the real world specially when an attempt is made to devise a predictive model for an industry which operates in a hostile and un-predictive environment such as construction industry. All mathematical models, if they are to be effective, require making a certain assumptions about the real world. Mathematical models require input of numbers which quantify these assumptions. If we feed incorrect data into the model, we can expect an incorrect representation of the real world.

6.5 Contribution Of The Author:

In the course of this Ph.D. dissertation, the author has clearly linked the construction industry's effectiveness to the capability of the construction managers in the proper application of Total Quality Management. It is proven that those construction organizations that can fulfill the needs of their customers in terms of being on-time scheduling and providing quality works according to the specifications, are considered to be effective organizations. Formerly, according to the general expectation, the effectiveness of a construction organization was based on how it could produce on-time and on-budget products. This research has presented that being on-budget is not one of the main factors when determining the effectiveness of the construction organizations. It was further demonstrated that the capability of construction organizations in providing quality work was one of the most important factors in determining the effectiveness. This author believes that the logic behind this shift of opinion (shifting from being on-time/on-budget to being on-time/on-specs when evaluating the effectiveness of a construction organization) is that:

- In the period that mass production of construction products is the main requirement by the public, the effectiveness of the construction organizations can relate mainly on providing products which are affordable (on-budget), and on-time.

- Contrary, in the period of time during which the quality production is needed by the customers, such as the late 20th century and possibly beyond, the effectiveness is related

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- In the period that mass production of construction products is the main requirement by the public, the effectiveness of the construction organizations can relate mainly on providing products which are affordable (on-budget), and on-time.

- Contrary, in the period of time during which the quality production is needed by the customers, such as the late 20th century and possibly beyond, the effectiveness is related

mainly on providing products which are considered to be quality work according to the specifications and on-time.

The above statements have proven to be valid for the auto industry of the United States. For example, FORD Company, used to produce mass auto productions from the early years of its business formation till the late 1970's. In that period of time, the effectiveness of the FORD Company was measured on its capability of producing affordable and on-time products. In that era, the customers were not mainly concerned with the quality of the products they would receive. Their main concern was if they could afford the products and how fast they could get their hands on the wheels of any Ford manufactured auto.

The international competition, the globalization concept of marketing, and shifting in the needs and tastes of the customers have entirely changed the philosophy behind the mass production. The new customers of the auto industry are more interested in quality plus availability rather than affordability coupled with availability. The customers of the construction products are also following the same path. These new customers of the construction industry are presently more interested in how quickly (on-time), and with what quality they can reach the final products.

The outcome of this research has entirely changed the old way of thinking regarding the effectiveness measurement of the construction organizations. This author believes that the era of MASS PRODUCTION in the construction industry for the NORTH AMERICAN Market is near to be over (not entirely yet). If the construction

organizations are interested in surviving in this competitive world, they must respond rapidly to the needs of their customers by providing the end products which are:

1. On-Time products, and

2. According to the specifications and codes.

The new customers of construction products are no longer interested in leaky condos, they are interested in quality condos according to the specifications. They are not interested to live in pre-fabricated condos or apartments in which the joints are not properly sealed and can not respond to their daily routine needs.

The competition among the construction organizations is so extensive, that the customers now can have the freedom of choice. This author believes as long as the free-market concept and the freedom of choice are encouraged, the customers of the construction products would demand better quality workmanship as well as availability for the end products. The customers of the construction products are becoming wiser in their assessment of the construction organization's effectiveness. They mainly base their effectiveness assessment of the construction organizations on the capability of the organization in providing on-time and quality work projects. They do not believe in the old way of assessing the effectiveness of construction organizations any longer; being on-time/on-budget. Contrary, they demand that the construction organizations provide them with quality and on-time projects. While the capability of providing affordable end products is a necessary function of the construction organizations, it is not a main factor in determining their effectiveness. This author further is convinced that:

If the construction organization can provide quality (on-specs) and on-time end products, the concepts behind the free marketing and the competition would enforce these organizations to provide on-budget products as well. Simply, on-budget project is a side effect of providing on-time plus on-specs projects.

The above statement clearly deviates us from the old fashioned way of evaluating the effectiveness of construction organizations rooted on-budget and on-time concept. We would no longer evaluate the effectiveness of the construction organizations solely established on their capability of providing us on-time and on-budget end products. We would rather evaluate their effectiveness on their capability of providing us the end products which are on-time and according the specifications. It seems that the old fashioned way of measuring effectiveness is more geared towards measuring efficiency rather than effectiveness! For decades we were measuring the efficiency of the construction organizations instead of measuring their effectiveness. In the new way of measuring effectiveness we are indeed measuring effectiveness not the efficiency.

Given the above facts; this researcher has clearly changed the old way of evaluating the existing assumptions pertaining to the construction industry's effectiveness and the method of studying of effectiveness as well.

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Questionnaire A-1
Contractor's Performance Data
For The Best General Contractor

Please provide us with your opinion regarding the satisfaction of the following parties.
Rate the factors on a scale of 0-100 basis, where *Very satisfied*=100, *Adequately satisfied*=50 and
Completely dissatisfied=0.

Party Satisfaction	1- Scheduling [1]	2- Cost [2]	3- Compliance [3]	4- Management [4]	5- Knowledge of Construction [5]	6- Financial Solvency [6]	7- Overall Performance
1- Architect's Satisfaction [7]							
2- Regulatory Bodies' Satisfaction	N/A.	N/A.		N/A.		N/A.	
3- Public's Satisfaction[8]						N/A.	
4- Creditor's Satisfaction							
5- Employee's Satisfaction[9]		N/A.				N/A.	

[1]— "Scheduling" means the original time schedule that was specified for the completion of the contractor's portion of the project (do not consider the extras).

[2]— "Cost" means the original cost estimate of the contractor's portion of the project (do not consider the cost of the extras).

[3]— "Compliance" means following the rules and regulations per contract documentation

[4]— " Management" means the way that the contractor managed the construction operation (personnel management, material management, time management , financial management and etc.).

[5]—"Knowledge of Construction" means general knowledge of construction application and methods.

[6]— "Financial Solvency" deals with the financial situation of the contractor, either the contractor was solvent to carry the project or was not able to do so.

[7]— "Owner" refers both to the public as well as private owners. In the ICI section of construction industry, the architect is considered to be owner's representative.

[8]— " Public" refers to the final user of the project outcome.

[9]— "Employee" refers to the people who were working for the general contractor during the project.

Further comments & Suggestions:

Questionnaire B-1
Contractor's Performance Data
For The Worst General Contractor

Please provide us with your opinion regarding the satisfaction of the following parties.
Rate the factors on a scale of 0-100 basis, where _Very satisfied_=100, _Adequately satisfied_=50 and _Completely dissatisfied_=0.

Party Satisfaction	1- Scheduling [1]	2- Cost [2]	3- Compliance [3]	4- Management [4]	5- Knowledge of Construction [5]	6- Financial Solvency [6]	7- Overall Performance
1- Architect's Satisfaction [7]							
2- Regulatory Bodies' Satisfaction	N/A	N/A		N/A		N/A	
3- Public's Satisfaction[8]						N/A	
4- Creditor's Satisfaction							
5- Employee's Satisfaction[9]		N/A				N/A	

[1]-- "Scheduling" means the original time schedule that was specified for the completion of the contractor's portion of the project (do not consider the extras).

[2]-- "Cost" means the original cost estimate of the contractor's portion of the project (do not consider the cost of the extras).

[3]-- "Compliance" means following the rules and regulations per contract documentation

[4]-- " Management" means the way that the contractor managed the construction operation (personnel management, material management, time management, financial management and etc.).

[5]--"Knowledge of Construction" means general knowledge of construction application and methods.

[6]-- "Financial Solvency" deals with the financial situation of the contractor, either the contractor was solvent to carry the project or was not able to do so.

[7]-- "Owner" refers both to the public as well as private owners. In the ICI section of construction industry, the architect is considered to be owner's representative.

[8]-- " Public" refers to the final user of the project outcome.

[9]-- "Employee" refers to the people who were working for the general contractor during the project.

Further comments & Suggestions:

<u>*Questionnaire A-2*</u>
<u>CONSTRUCTION PROJECT DATA</u>
<u>For The Best General Contractor</u>

1- Was the project completed within the scheduled **TIME**? Yes........ No..........Do not know...............
Original time estimate............................**Actual completion time**..................................

2- Was the project completed within the scheduled **COST**? Yes........No..........Do not know..................
Original cost estimate............................**Actual cost** ....

3- Did the project fulfill the **SPECIFICATION**? Yes..............No..................Do not know............If the answer is NO, please briefly explain why:

....
....
....

4- How would you assess the **OVERALL QUALITY** of the project? Please circle one or mark the scale.

Excellent=100
Average=50
Poor=0

Poor=0————————Average=50————————Excellent=100

<u>*Questionnaire B-2*</u>
<u>CONSTRUCTION PROJECT DATA</u>
<u>For The Worst General Contractor</u>

1- Was the project completed within the scheduled **TIME**? Yes........ No..........Do not know.................
Original time estimate.............................**Actual completion time**................................

2- Was the project completed within the scheduled **COST**? Yes.........No.........Do not know..................
Original cost estimate..............................**Actual cost** ....

3- Did the project fulfill the **SPECIFICATION**? Yes..............No................Do not know...........If the answer is NO, please briefly explain why:
....
....
....

4- How would you assess the **OVERALL QUALITY** of the project? Please circle one or mark the scale.

Excellent=100
Average=50
Poor=0

        Poor=0————————Average=50————————Excellent=100

Appendix-S

Architect's/Owner's Representative or the Owner's Satisfaction Criteria Table

Variables	Description
X_1	Satisfaction of the general contractor's scheduling
X_2	Satisfaction of the general contractor's project cost
X_3	Satisfaction of the general contractor's compliance with the rules & regulations
X_4	Satisfaction of the general contractor's management
X_5	Satisfaction of the general contractor's knowledge of construction
X_6	Satisfaction of the general contractor's financial solvency
X_7	Overall rating of the general contractor's performances

Appendix-6

Regulatory Bodies' Satisfaction Criteria Table

Variables	Description
X_8	N/A.
X_9	N/A.
X_{10}	Regulatory bodies' satisfaction of the general contractor's compliance with the rules & regulations
X_{11}	N/A.
X_{12}	Regulatory bodies' satisfaction of the general contractor's knowledge of construction
X_{13}	N/A.
X_{14}	Regulatory body's overall rating of the general contractor's performances

Appendix-7

Public's Satisfaction Criteria Table

Variables	Description
X_{15}	Public's satisfaction of the general contractor's scheduling accuracy
X_{16}	Public's satisfaction of the general contractor's project cost
X_{17}	Public's satisfaction of the general contractor's compliance with the rules & regulations
X_{18}	Public's satisfaction of the general contractor's management
X_{19}	Public's satisfaction of the general contractor's knowledge of construction
X_{20}	N/A.
X_{21}	Public's overall rating of the general contractor's performances

Appendix-8
Creditor's Satisfaction Criteria Table

Variables	Description
X_{22}	Creditor's satisfaction of the general contractor's scheduling accuracy
X_{23}	Creditor's satisfaction of the general contractor's project cost
X_{24}	Creditor's satisfaction of the general contractor's compliance with the rules & regulations
X_{25}	Creditor's satisfaction of the general contractor's management
X_{26}	Creditor's satisfaction of the general contractor's knowledge of construction
X_{27}	Creditor's satisfaction of the general contractor's financial solvency
X_{28}	Creditor's overall rating of the general contractor's performances

NOTE TO USERS

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Appendix-10
Variables Y_1 To Y_4 & Their Description Table

Variables	Description
Y_1	Is a binary YES or NO answer to the question #1 in the A-2 and B-2 questionnaires: Was the project completed within the scheduled TIME?
Y_2	Is a binary YES or NO answer to the question #2 in the A-2 and B-2 questionnaires: Was the project completed within scheduled COST?
Y_3	Is a binary response in the form of YES or NO to question #4 in the questionnaires A-2 and B-2: Did the project fulfill the specifications?
Y_4	Is an ordinal response on a scale of 0 = poor to 100 = excellent with the average being 50 to the question #8 in the A-2 and B-2 questionnaires: How would you assess the overall quality of the project?

Business Roundtable Report List[1]

Project Management-Study Area A

A-1   Measuring Productivity in Construction
A-2   Construction Labor Motivation
A-3   Improving Construction Safety Performance
A-4   First and Second Level Supervisory Training
A-5   Management Education and Academic Relations
A-6   Modern Management Systems
A-7   Contractual Arrangements

Construction Technology-Study Area B

B-1   Integrating Construction Resource and Technology into Engineering
B-2   Technological Progress in the Construction Industry
B-3   Construction Technology Needs and Priorities

Labor Effectiveness-Study Area C

C-1   Exclusive Jurisdiction in Construction
C-2   Scheduled Overtime Effect on Construction Projects
C-3   Contractor Supervision in Unionized Construction
C-4   Constraints Imposed on Collective Bargaining Agreements
C-5   Local Labor Practices
C-6   Absenteeism and Turnover
C-7   The Impact of Local Union Politics

Labor Supply and Training-Study Area D

D-1   Sub-journeymen in Union Construction
D-2   Government Limitations on Training Innovations
D-3   Construction Training Through Vocational Education
D-4   Training Problems in Open Shop Construction
D-5   Labor Supply Information

Regulation And Codes-Study Area E

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[1] Copies may be obtained at no cost by writing to:
The Business Roundtable, Attn.: CICE
200 Park Avenue, New York, NY 10166

E-1   administration and Enforcement of Building Codes and Regulations

Summary
More Construction for the Money
CICE: The Next Five Years and Beyond
CISE
Model Safety Programs
Model for an Owner safety Process-Air Products and Chemicals, Inc.
Model for an Owner safety Process-Monsanto Chemical Company
Model for a Construction Safety Process-Gulf States Inc.
Model for a Construction Safety Process-Shell oil Company

Independent variables X_1 through X_{35} for the Best General Contractor

1. X_1 = Architect's/Owner's satisfaction of The Best General Contractor's Scheduling Capability
2. X_2 = Architect's/Owner's satisfaction of The Best General Contractor's Cost Control Capability
3. X_3 = Architect's/Owner's satisfaction of The Best General Contractor's Compliance With the Governing Rules and Regulations Capability
4. X_4 = Architect's/Owner's satisfaction of The Best General Management Capability
5. X_5 = Architect's/Owner's satisfaction of The Best General Contractor's Knowledge Of Construction
6. X_6 = Architect's/Owner's satisfaction of The Best General Contractor's Solvency
7. X_7 = Architect's/Owner's satisfaction of The Best General Contractor's General Performance On A Scale Of 0-100 basis
8. X_8 = Regulatory Bodies' satisfaction of The Best General Contractor's Scheduling Capability/Not Applicable
9. X_9 = Regulatory Bodies' satisfaction of The Best General Contractor's Cost Control Capability/Not Applicable
10. X_{10} = Regulatory Bodies' satisfaction of The Best General Contractor's Compliance with the Governing Rules and Regulations
11. X_{11} = Regulatory Bodies' satisfaction of The Best General Contractor's Management Capability/Not Applicable
12. X_{12} = Regulatory Bodies' satisfaction of The Best General Contractor's Knowledge Of Construction
13. X_{13} = Regulatory Bodies' satisfaction of The Best General Contractor's Solvency
14. X_{14} = Regulatory Bodies' satisfaction of The Best General Contractor's General Performance on a scale of 0-100 basis
15. X_{15} = Public's satisfaction of The Best General Contractor's Scheduling Capability
16. X_{16} = Public's satisfaction of The Best General Contractor's Cost Control Capability
17. X_{17} = Public's satisfaction of The Best General Contractor's Compliance Capability
18. X_{18} = Public's satisfaction of The Best General Contractor's Management Capability
19. X_{19} = Public's satisfaction of The Best General Contractor's Knowledge Of Construction
20. X_{20} = Public's satisfaction of The Best General Contractor's Financial Solvency/Not Applicable
21. X_{21} = Public's satisfaction of The Best General Contractor's Performance in General on a scale of 0-100 basis
22. X_{22} = Creditor's satisfaction of The Best General Contractor's Scheduling Capability
23. X_{23} = Creditor's satisfaction of The Best General Contractor's Cost Control Capability
24. X_{24} = Creditor's satisfaction of The Best General Contractor's Compliance Capability
25. X_{25} = Creditor's satisfaction of The Best General Contractor's Management Capability
26. X_{26} = Creditor's satisfaction of The Best General Contractor's Knowledge Of Construction
27. X_{27} = Creditor's satisfaction of The Best General Contractor's Financial Solvency
28. X_{28} = Creditor's satisfaction of The Best General Contractor's Performance in General on a 0-100 basis
29. X_{29} = Employee's satisfaction of The Best General Contractor's Scheduling Capability
30. X_{30} = Employee's satisfaction of The Best General Contractor's Cost Control Capability/Not Applicable
31. X_{31} = Employee's satisfaction of The Best General Contractor's Compliance with Governing Rules and Regulations Capability
32. X_{32} = Employee's satisfaction of The Best General Contractor's Management Capability
33. X_{33} = Employee's satisfaction of The Best General Contractor's Knowledge of Construction
34. X_{34} = Employee's satisfaction of The Best General Contractor's Solvency/Not Applicable
35. X_{35} = Employee's satisfaction of The Best General Contractor's Management Capability

Independent variables X_1 through X_{35} for the Worst General Contractor

1. X_1 = Architect's/Owner's satisfaction of The Worst General Contractor's Scheduling Capability
2. X_2 = Architect's/Owner's satisfaction of The Worst General Contractor's Cost Control Capability
3. X_3 = Architect's/Owner's satisfaction of The Worst General Contractor's Compliance With the Governing Rules and Regulations Capability
4. X_4 = Architect's/Owner's satisfaction of The Worst General Management Capability
5. X_5 = Architect's/Owner's satisfaction of The Worst General Contractor's Knowledge Of Construction
6. X_6 = Architect's/Owner's satisfaction of The Worst General Contractor's Solvency
7. X_7 = Architect's/Owner's satisfaction of The Worst General Contractor's General Performance On A Scale Of 0-100 basis
8. X_8 = Regulatory Bodies' satisfaction of The Worst General Contractor's Scheduling Capability/Not Applicable
9. X_9 = Regulatory Bodies' satisfaction of The Worst General Contractor's Cost Control Capability/Not Applicable
10. X_{10} = Regulatory Bodies' satisfaction of The Worst General Contractor's Compliance with the Governing Rules and Regulations
11. X_{11} = Regulatory Bodies' satisfaction of The Worst General Contractor's Management Capability/Not Applicable
12. X_{12} = Regulatory Bodies' satisfaction of The Worst General Contractor's Knowledge Of Construction
13. X_{13} = Regulatory Bodies' satisfaction of The Worst General Contractor's Solvency
14. X_{14} = Regulatory Bodies' satisfaction of The Worst General Contractor's General Performance on a scale of 0-100 basis
15. X_{15} = Public's satisfaction of The Worst General Contractor's Scheduling Capability
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28. X_{28} = Creditor's satisfaction of The Worst General Contractor's Performance in General on a 0-100 basis
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31. X_{31} = Employee's satisfaction of The Worst General Contractor's Compliance with Governing Rules and Regulations Capability
32. X_{32} = Employee's satisfaction of The Worst General Contractor's Management Capability
33. X_{33} = Employee's satisfaction of The Worst General Contractor's Knowledge of Construction
34. X_{34} = Employee's satisfaction of The Worst General Contractor's Solvency/Not Applicable
35. X_{35} = Employee's satisfaction of The Worst General Contractor's Management Capability

List of continuous variables:

1. Designer Cost

2. Designer effort hours

3. Cost of change orders

4. Construction percent complete

5. Quantity of change

6. Design percent complete

7. Number of contractor team personnel

8. Number of actual construction effort hours

9. Owner expenditures

10. Invoiced construction costs

11. Project cost percent complete

12. Designer planned effort hours

13. Planned construction percent complete

14. Cost of contingency expended

15. Cost of contractor project commitments

16. Total commitments for material and equipment

17. Invoices for material and equipment

18. First-aid cases

19. Planned design percent complete

20. Invoices paid by contractor

21. Planned designer cost

22. Paid construction costs

23. Contractor expenditures

24. Planned project cost percent complete

25. Contractor's commitments

26. Number of planned construction effort hours

27. Recordable incident rate

28. Cost of owner project commitments

29. Planned owner expenditures

30. Planned contractor expenditures

31. Cost of variance/trends

32. Procurement percent complete

33. Construction drawings

34. Owner effort hours

35. Injuries resulting is lost work days

36. Contractor's commitments for engineering equipment and long lead items

37. Severity rate

38. Recordable incident rate

39. Overtime work

40. Total commitment for engineering equipment and long lead items

41. Planned invoices for material and equipment

42. Construction hours earned

43. Owner personnel actual quantity

44. Cost of change orders

45. Quantity of change orders

46. Cost of rework due to designer

47. Planned construction drawings

48. Less retention held

49. Planned procurement percent complete

50. Cost of rework due to owner

51. Number of personnel turnover

52. Injuries resulting in restricted work days

53. Severity rate

54. Cost of remaining change orders

55. Quantity of remaining change orders

56. Shop drawings

57. Schedule impact - owner approved

58. Quantity of request for proposal

59. Owner's direct commitments

60. Cost of rework due to vendors

61. Days lost to weather

62. Cumulative days lost to weather

63. Owner personnel planned quantity

64. Schedule impact of variance/trends

65. Cost of rework due to contractor

66. Owner's commitments for engineering equipment and long lead items

67. Cost of requests

68. Planned owner effort hours

69. Schedule impact - contractor perceived

70. Impact of pending change orders

71. Cost of rework due to field conditions
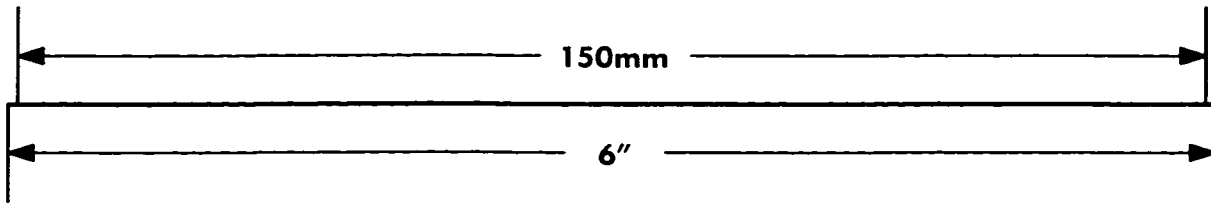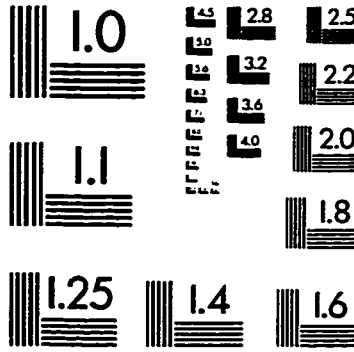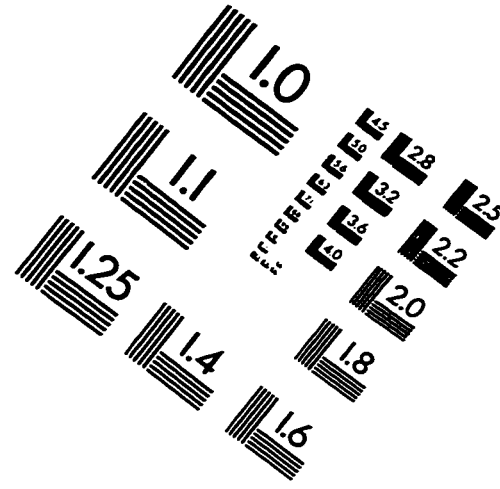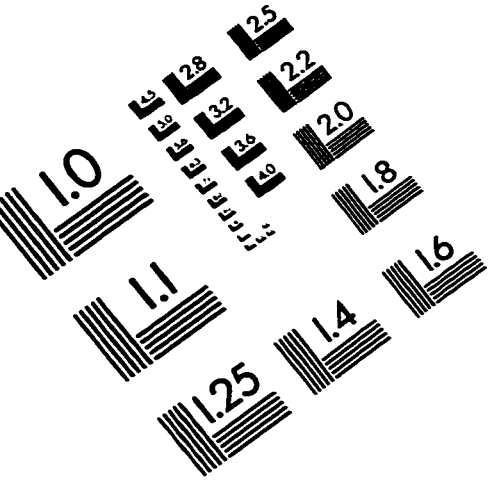
72. Number of days remaining

73. Fatalities

74. Days lost due to strike

75. Planned overtime work

76. Planned shop drawings

IMAGE EVALUATION
TEST TARGET (QA–3)

150mm

6"