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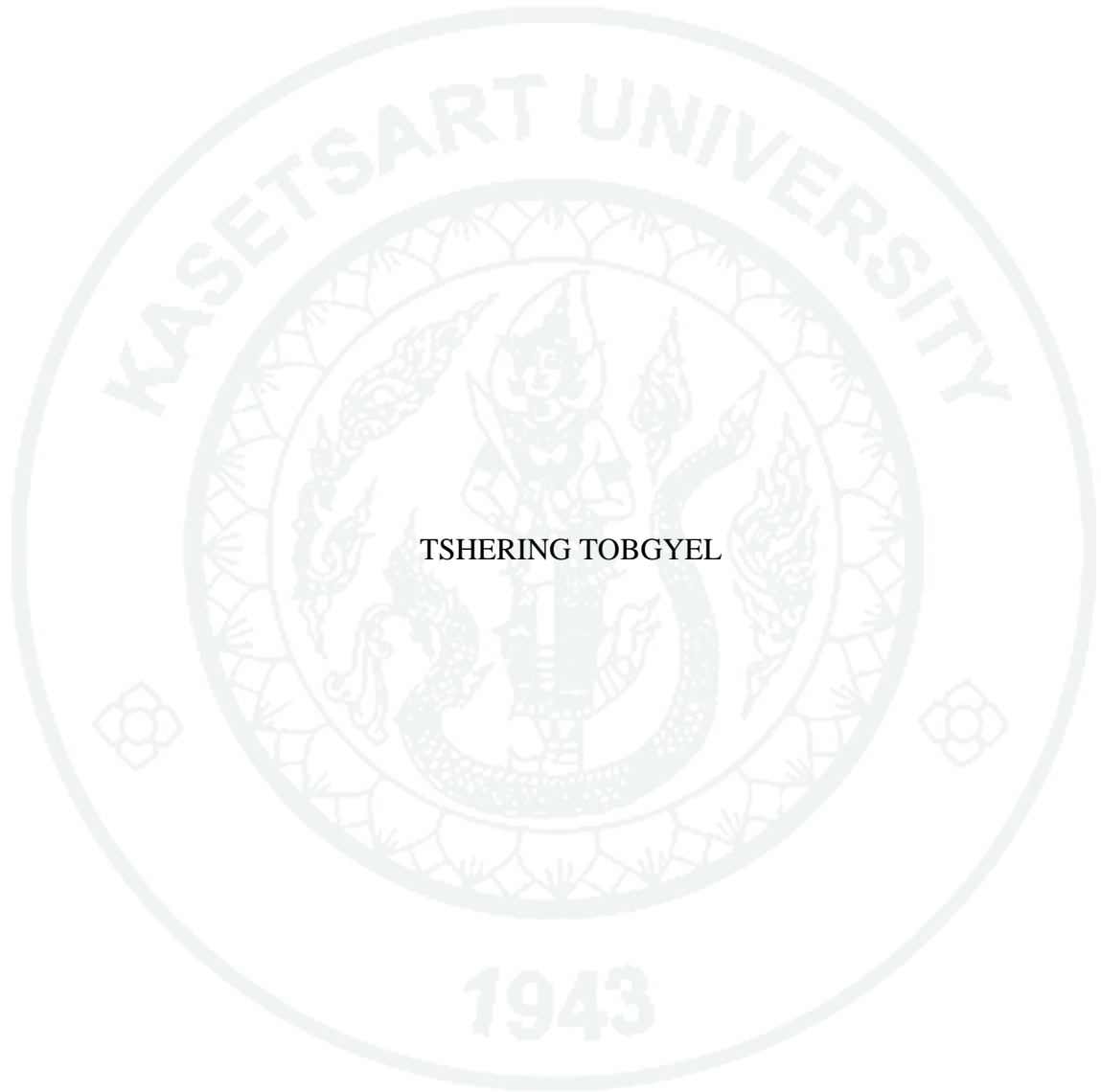
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THESIS

FACTORS AFFECTING CONSTRUCTION QUALITY  
IN BHUTAN



TSHERING TOBGYEL

A Thesis Submitted in Partial Fulfillment of  
the Requirements for the Degree of  
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Identification of the factors affecting construction quality in the districts of Thimphu and Chukha (Bhutan) were done for the first time. The main findings out of hundred seventeen factors affecting quality were quality procedures, improper planning, project budgeting, construction supervision, lack of commitment, period of project, project planning, inefficient site management, skill and experience supervision, project quality plan, implement quality control and assurance system and quality manual. The research study undertook proportional sampling comprising of 30 equal participations from both government and private organizations. Qualitative local quality factors were determined from one round processed questionnaire. Analysis by EFA, CFA, SEM interfering was conducted. Quantitatively SEM model resulted strategic guidelines such as project budgeting, improper planning, quality procedures, construction supervision, project planning, period of the project, lack of commitment, skill and experience supervision staff, inefficient site management and quality manual. Recommendations are made from the comparative findings.

Keywords: Bhutan construction, construction quality, SEM.

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Student's signature

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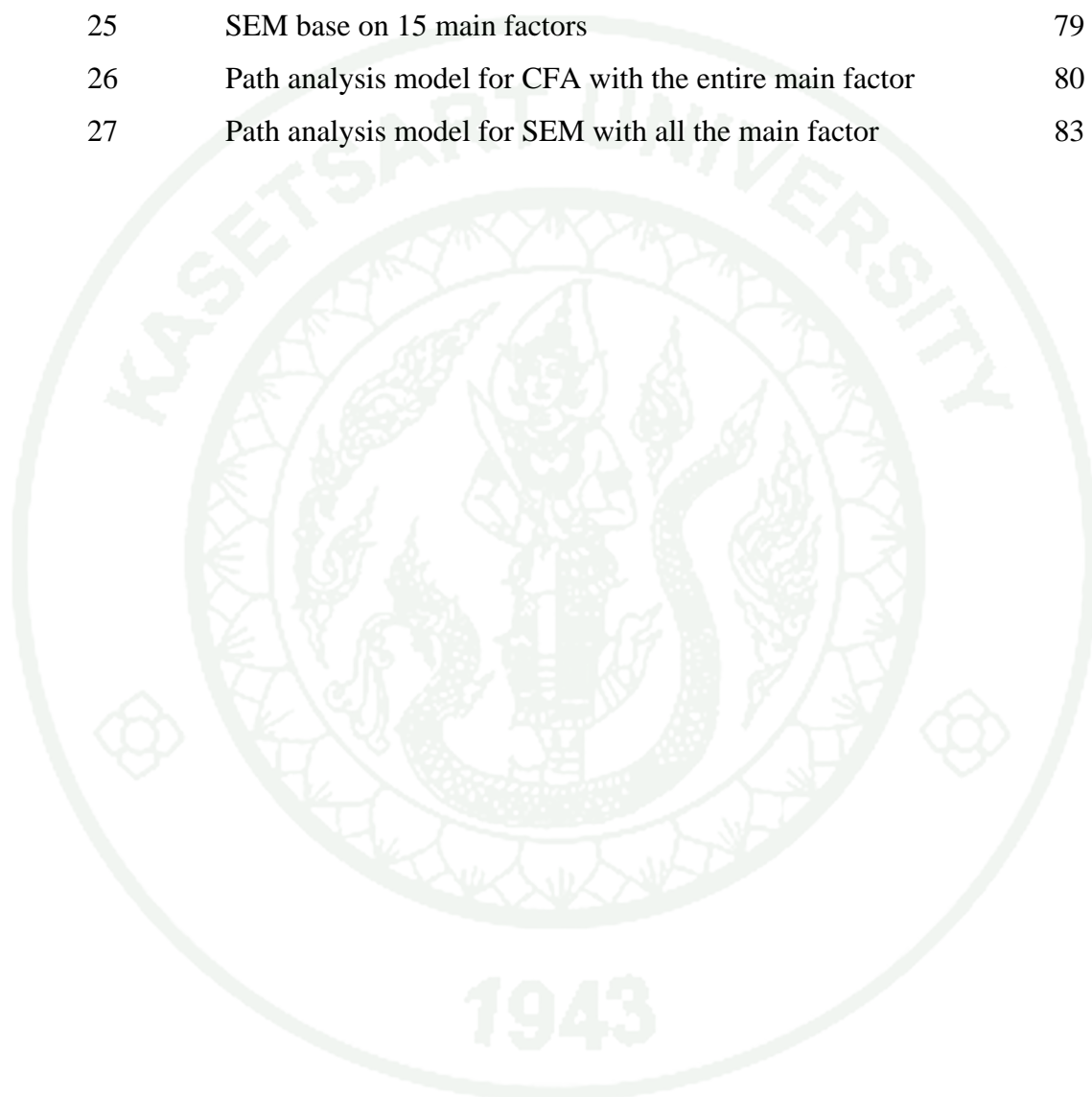
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## LIST OF ABBREVIATIONS

AEC	=	Annual Engineering Conference.
AHP	=	Analytic hierarchy process.
BSB	=	Bhutan Standard Bureau.
SQCA	=	Standard Quality Control Authority.
AB	=	Construction Association of Bhutan.
CDB	=	Construction Development Board.
CDCL	=	Construction Development Corporation Limited.
CFA	=	Confirmatory factor analysis.
COQ	=	Cost of quality.
CST	=	College of Science & Technology.
DZONG	=	Fortress.
EFA	=	Exploratory factor analysis.
ERP	=	Enterprise resource planning.
FYP	=	Five Year Plan.
GDP	=	Gross domestic product.
HRD	=	Human Resource Development.
ISO	=	International Organization for Standardization.
JIT	=	Just-in-Time Philosophy.
JNP	=	Jigme Namgyel Polytechnic.
KBS	=	Knowledge-Based System.
LV	=	Latent variables.
MoLHR	=	Ministry of labor and Human Resources.
MoWHS	=	Ministry of works & Human settlement.
MV	=	Measured variables.
NHDC	=	National Housing Development Corporation.
NSB	=	National Statistical Bureau.
PAF	=	Prevention Appraisal Failure.
PCC	=	Phuntsholing City Corporation.
PM's	=	Project managers.

**LIST OF ABBREVIATIONS (Continued)**

PWD	=	Public Works Department.
QA	=	Quality assurance.
QC	=	Quality Control.
QFD	=	Quality Function deployment.
QMS	=	Quality Management system.
RGOB	=	Royal Government of Bhutan.
RUB	=	Royal University of Bhutan.
ROI	=	Return of Investment.
SEM	=	Structural equation modeling.
SPC	=	Statistical Process Control.
SPSS	=	Statistical Package for the Social Sciences.
SQCA	=	Standard and quality control authority.
TCC	=	Thimphu City Corporation.
TQM	=	Total quality Management.
VET	=	Vocational Education and Training.
CST	=	College of Science and Technology.

# FACTORS AFFECTING CONSTRUCTION QUALITY IN BHUTAN

## INTRODUCTION

Bhutan is an Asian country bordered by China in the north and India on the other three sides. It has Thimphu as the capital city and have twenty districts. The total land area is 38,394 square kilometers with population of 0.73 million as of July 2012. Country has rugged terrain and steep mountain valleys ranging from 150 meters in the sub-tropical valleys in the southern foothills, through temperate zone to heights exceeding 7,000 meters in the alpine regions of the mountains.

Construction industry is the fastest growing of all its industries and contributes to 16.26% of the GDP (2011) in Bhutan. As per 11<sup>th</sup> FYP of Bhutan the average construction capital budget outlay is Ngultrum 22 billion (2013-2018) compared to Ngultrum 10 billion projected from the last 10<sup>th</sup> FYP. The growth rate is 14% annually in the construction sectors to meet the objective of socio economic development. Quality issue problems and their significance are necessary to help professionals to be active (RCSC, bi-annual report of Bhutan, June 2012).

According to Deming quality is defined as predictable degree of uniformity and dependability with a quality standard suited to customer. It is the degree to which performance meets expectations. They should confirm to requirements and satisfy customer. Quality and reliability go hand in hand. It is revealed that the need for achieving quality improvement techniques being popular in manufacturing industry are now also successfully used in the construction industry (Arditi *et al.* 1999). Quality has become very popular subject in recent years due to conceptual changes in the industry reported by Chan *et al.* (2000). One should differentiate between product quality and process quality as written by Nagasaku and Oda (1965). The ultimate quality evaluation process lies with the customer. It is translated into measurable characteristics in a product or service. Also Hozein *et al.* (2011) reveals that the con-

struction costs are becoming far too high and important to look for better method for improvement universally. The current registered contractors under CDB in Bhutan are bound to increase in due course of time. It must adopt quality study factors improvement from its own environment for better performance as stated by Razek (1998). Jurran (1988) writes that quality is met when it is in accordance with design specifications, within cost, finished on time, value for money and to stakeholders' satisfaction. It is the conformance which depends on requirement of clients or project owners. Therefore, this study conducted various countries journal reviews from delays, cost overruns, quality, safety, labor productivity, management, design document etc. and also from specific types of projects. It reveals that common factors affecting construction quality is much more urgent and must reach mutual levels to be successful. Patil *et al*, (2011) says that the system of construction cut corners in time, cost and quality if margin of profit in the competition is low. It is essential to develop the capacity to foresee potential problems that is affecting quality in the current and future constructions. They are very complicated connectivity as well as the construction targets. For this research study identifying and correlating critical quality factors influencing is a good option and awareness in the construction industry.

The aim of this paper is the identification of factors affecting construction quality in the districts of Thimphu and Chukha (Bhutan), which is done for the first time. The main findings affecting quality are the project budgeting, improper planning, quality procedures, construction supervision, project planning, period of the project, lack of commitment, skill and experience supervision staff, inefficient site management and quality manual. The study conducted by proportional sampling comprising of 60 equal participations from government and private organizations took part with 0% non-response rate. Qualitative local quality factors were determined from one round processed questionnaire. Analysis by EFA, CFA, SEM interfering with excel sheet (2007) was conducted. Quantitatively SEM model resulted strategic guidelines. Recommendations are made from the comparative findings. The future study required are site staff, labor, financial issue, material, labor, design, contract,

owner, environment issue, equipment, execution, and sub-contractor for the continuous quality improvement.

### **Statement of problem**

The problem of ensuring construction quality is different in different countries. A country needs to identify factors affecting construction quality from its own environment for better performance as pointed out by (Razek, 1998). Bhutanese private and government sector needs to play a bigger and important role in development. The quality is also the cornerstone of measuring construction success and to attract their participation both within and outside the country. Quality issue in construction has been emphasized in any forum, reports and in various media channels. It has been reported that most of the construction personnel still lack knowledge and experience that limit the success of quality construction works (Penjor, 2007); (Zangmo, 2009).

The World Bank observes that “road building practices in Bhutan use mostly obsolete technology and follow the archaic practices of the mid-20<sup>th</sup> century. All types of construction and maintenance are labor intensive and marked by low productivity and high costs. This result in poor qualities that have high levels of roughness, poor serviceability, and a short life (11<sup>th</sup> FYP, HRD, MoLHR). The impact is known from the depreciation that ultimately contributes to environmental pollution. Construction management including competency of engineering skill training in both government and private are inadequate. There is no quality system in construction professional development, no incentives for firms to invest in the specialized skills of their staff, no expert in mechanization, unavailable skill workers with 80% doubtful skill foreign workers engaged in the construction industry. Proper rules are totally absent or not being fully enforced. As an engine of growth, promotion and participation of the private sector has been very much emphasized by the government. So far quality construction has remained a distant dream in Bhutan and will cause repeated and unnecessary expenditures to small national exchequer if what factors are actually not

known. It is stated in the 11<sup>th</sup> FYP, HRD, MoLHR, p-53, the construction sector is geared towards the following strategic objectives:

- 1) To improve the quality of construction industry and
- 2) To establish pool of experts in construction trades where Bhutan is weakest at present.

The RGOB and international organizations are investing in the construction sector for infrastructure development. The prioritization of factors affecting quality is important and problematic issues. Identification of factors is needed for playing the major role (CAB, 6<sup>th</sup> AEC, 2010). Due to unavailable documented data about factors affecting the quality, construction industries are facing many problems. Therefore, this study is necessitated as per existing problems for better impact and benefits.

There is a need to conduct a study on ensuring quality improvement, from the standpoint of developing human resources, contract document, structure of its construction industry and monitoring by organizations. Further, Bhutan needs to understand the core concept of quality improvement from this current finding. Quality in developed countries is a first strategy towards continuous improvement. This reason makes this study as essential within the purview of above statements. It is specifically seeking to answer the questions in identifying major main and sub-factors affecting construction quality and their relationship in construction quality in Bhutan with some strategic guidelines.

## OBJECTIVES

The objectives of this research study are as given below:

- 1) To identify the main factors and sub-factors affecting construction quality and their relative importance for improving the quality of construction in Bhutan.
- 2) Propose strategic guidelines for the construction quality improvement.

### Scope of the study

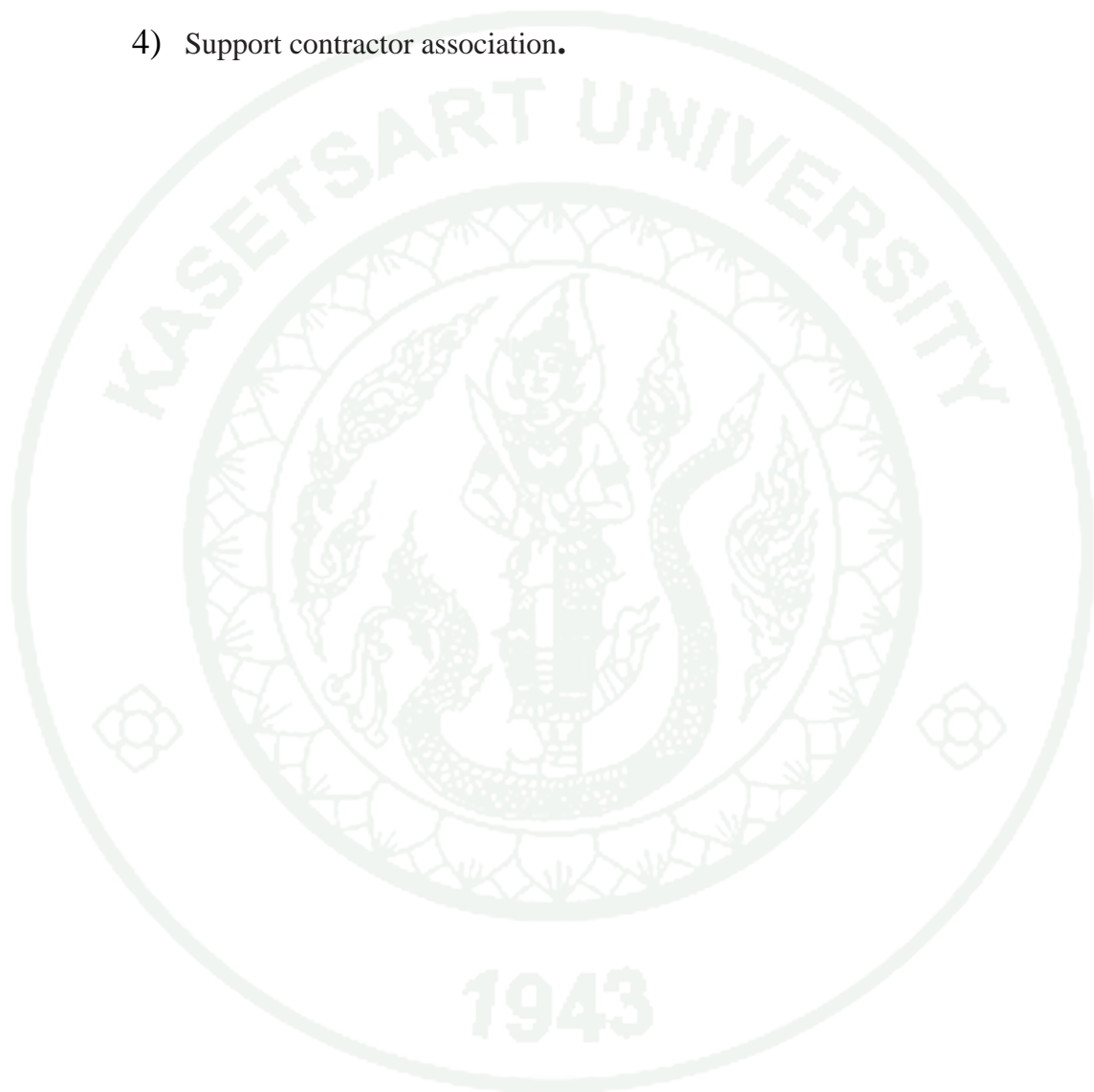
This study was conducted using questionnaire. Thirty questionnaires were distributed equally in both public and private engineering firms which has minimum of 5 years above experience in construction work, in Bhutan. The areas of coverage are Thimphu and Chukka districts only, where the construction industry is highly concentrated. The study considered only the opinions of registered engineers working both in government and private organizations, small, medium and large contractors from private organization and registered architects, registered consultants and senior engineers working in government organizations.

### Expected outcome of this study

The factors identified in this research study will ultimately help to improve construction quality in Bhutan. It will provide useful data for future research in Bhutanese construction industry. Furthermore, following current expected outcomes are expected:

- 1) Supports in identification of roles of royal university of Bhutan and Vocational Institute in Bhutan.

- 2) Support to develop standards/manuals/guidelines for quality construction.  
Strengthening local capacity for rural infrastructure work.
- 3) Support courses in management of construction projects.
- 4) Support contractor association.



## LITERATURE REVIEW

### 1. Introduction

In the following paragraph definitions and concept of quality, various literature reviews on factors attributing to international construction quality problems, construction sector perceived in Bhutan that necessitated essential understanding of its impact and the benefit for this study are presented.

### 2. Bhutanese construction quality history

According to Bhutan times publication dated 1<sup>st</sup> October, 2007, several magnificent quality structures were constructed, known as Dzongs, well before the 12<sup>th</sup> century. It was before the international quality movement traced its root back to medieval Europe by craftsmen unions called guilds in the late 13<sup>th</sup> century. These Dzongs stand even today as a testimony of quality engineering works and designs of the past. History has it that these Dzongs were built by the Bhutanese engineers for defense against invaders as well as for monastic and administrative centers. Amongst the best Dzongs built, thirty Dzongs were constructed between the year 1531-1895 which are still in use as military, government, religious, administrative, social and commercial centers. It was before the industrialized world had tended craftsmen model on product inspection in the mid-1750s growing industrial revolution in the early 1800s. It is during this period some old Dzongs are being reconstructed/ renovated with modern touch keeping the original architectural aspects into the designs. One such architect was Thangtong Gyalpo (1385-1464), a great Buddhist, a yogi, physician, blacksmith, architect, and a pioneering civil engineer who had built many iron chain suspension bridges, structures, etc. around Bhutan and Tibet. Several of which are still in use today (Wood, 2013). Modern Bhutan is behind from several modern studies like in early 20<sup>th</sup> century, manufacturers in outside world had begun quality processes in quality practices aided by the publication of specification standards and training courses in Walter Shewhart's statistical process control techniques. After the United States en-

tered World War II in outside countries total quality revolution input in Japan by Joseph M. Juran and W. Edwards Deming is found to be emphasized.

### **3. Construction sector related ministries and institution in Bhutan**

Ministry of works and human settlement, Bhutan, is established in 2003. The modern construction in Bhutan started only from 1960. In the first five year plan modern infrastructure like buildings, roads, bridges, water supply, irrigation canals etc. were the major capital investment of the government. The first of its engineering organization called Bhutan Engineering was formed in 1961 to look after the construction. It was renamed in 1966 PWD with two departments; departments of roads and the department of urban development and engineering services. Today the ministry have three departments viz. department of roads, department of engineering services and department of human settlement for various categories of infrastructure developments. It also created the CDCL division that was delinked from the department in July 2006 and established as a self-sustaining commercial unit under the MoWHS to meet the global competitive edge. One of its first time ever recently RCC precast bridge spanning 130m at Kheng Panbang across river valley completed in short period of its CDCL establishment in Bhutan in short span of time.

Similarly, to promote and oversee the construction industry developing into an efficient and quality based industry in the country, the CDB was established in 1987. It is an independent organization of the royal government of Bhutan with an institutional mandate to act as both overseer as well as promoter of the construction industry. It is said with over 50 years of history, the Bhutanese firms are themselves a mixed group of with a majority of them inexperienced and engaged in small contracts. The larger ones are few (120) but even these lack the professional competences to undertake the huge government projects. Therefore the design and execution of major projects such as bridges, tunnels and dams continue to be outsourced to foreign firms. More significantly, there is no clear strategy to get the industry to ever grow in capacity to handle such projects. There is demand for quality engineering services to meet the global competitive edge and to promote local builders; CAB was established

in April, 2012 under the civil society organization authority act (CSOA/PBO-21). Today CAB has 83 contracting large firms, 347 contracting medium firms and 1457 contracting small firms representing private construction firm and are fastest growing of all industries and contributes to 16.26% of the GDP (2011). The ministry has currently established the following corporations and authorities working in Bhutan:

- 1) Construction development board (CDB): It operates registration, classification and monitoring of contractors, consultants and engineers/architects. Contractors are classified by financial allowable range  $\leq 4$  million as small, 4-14 million as medium and  $> 15$  million as large scale contractor.
- 2) Standards and quality control authority (SQCA)/Bhutan standard bureau formulate construction standards and monitor quality of construction in the country since then, BSB has prepared several construction standards in the construction sector.
- 3) National housing development corporation (NHDC): mandated with providing quality and affordable homes to the citizen of the country.
- 4) PCC & TCC: Both formulates rules and manages all infrastructure development in the Bhutanese city (availed from <http://www.mowhs.gov.bt>, 5<sup>th</sup> May, 2013).

Ministry of labor and human resources consider the importance of vocational education and training (VET) since from mid 1960s in Bhutan. It has been managing skills development programs in support of construction industries. The future plans and programs related to quality VET is guided by regular monitoring and evaluation by the ministry and extends its policies of various vocational training through department of labor, department of employment, department of human resources and occupational standards. Currently it have ten VET institutes developing future skilled workforce (Published on 5<sup>th</sup> May, 2013. Source: [www.molhr.gov.bt/molhr](http://www.molhr.gov.bt/molhr)).

The Royal University of Bhutan is committed to develop and provide programs of study at tertiary education level, of relevance and good quality in a country for an educated and skilled population. RUB promote and conduct research through creation of knowledge in an international context. It also transfers knowledge of relevance to Bhutan. Under RUB College of Science and Technology and Jigme Namgyel Polytechnic aid major benefits in the construction field of engineering(Published on Friday, 02 December 2011.source:www.rub.edu.bt/).

#### **4. Quality definition and concept**

##### **Quality definitions**

In general a service or product should be suitable for the need and satisfy the customer beyond his expectations. Quality is also defined in many ways as per the literature as follows:

- Fitness for the purpose-Juran.
- Customer satisfaction & beyond- E ward Deming.
- Totality of all the features and characteristics of a product or service that bears on its ability to meet the stated and implied needs - ISO 9000.
- The total composite product and service characteristics of engineering, manufacturing, marketing and maintenance through which the product and service in use meet the expectation of the customers - Feign Baum.

It means, it is perceived by formulating quality through quality assurance systems and quality control system, some definition are resulted from authoritative documentation, while others through expression of experiences, opinions and conjecture. According to Dahlgaard *et al.* (2005); Tayeb *et al.* (2008) there are five common approaches being applied to quality definitions:

- **Transcendent approach** - Its approach is to define quality as highly subjective (Dahlgaard *et al.* 2005) following the principle of Walter Shewhart (1931) from the first definition as "the goodness of a product".
- **Product-based approach**- define as a function of a specific, measurable variable and that differences in quality reflect differences in quantity of some product. As a result, quality is often mistakenly assumed to be related to price, the higher the price, the higher the quality (Evans and Lindsay, 2001).
- **User-based approach**- defined as the extent to which a product or service meets or exceeds customers' expectations. This approach is marketing-based, and emerged primarily out of the services marketing literature. The user-based definition is widely accepted and considered one of the key concepts of TQM (Sebastianelli and Tamimi, 2002).
- **Value-based approach**- The value-based definition equates quality with performance at an acceptable price or alternatively conformance at an acceptable cost. Here, the notion of worth is incorporated into the definition of quality, making this more subjective than objective (Sebastianelli and Tamimi, 2002).
- **Manufacturing-based approach**-Quality is defined as the desirable outcome of engineering and manufacturing practices or conformance to specifications (Evans and Lindsay,2001). This definition allows for the precise and objective measurement of quality, although it has limited applicability for services (Sebastianelli and Tamimi, 2002).

## 5. Dimensions of Quality

Evans and Lindsay (1992); Kennan and Jayabalan (2007) reveals that there is a need for different definitions. Because perspective change at different points in an organization. Reliance on a single definition is frequently a source of problems. One needs to shift perspective of quality as products move from design to market. All

views are necessary and must be embodied in an overall company philosophy in order to result in a quality product or services.

Literature reveals that when a product exceeds the expectation of customer, it is said to be quality. It is somewhat an intangible based on perception. Quality is found quantified as follows.

$$Q = \frac{P}{E}$$

Where, Q= Quality

P= Performance

E= Expectations

The determination of P & E will most likely be based on perception. The organization determines the performance and the customer determines the expectations. However, the diversity of these definitions is found explained by examining nine principal quality dimensions such as performance, reliability, conformance, durability, serviceability, response, aesthetics, reputation/perceived quality (Kannan and Jayabalan, 2007). Conflicts are inevitable because each of the basic definitions above focuses on different quality dimensions. The most applicable definitions are fitness for use (the design perspective) and conformance to specifications (the manufacturing perspective).

## 6. Some quality lessons

Timothy (2003) revealed that most organizations bears about of total costs 33% due to poor quality management (e.g., rework, waste, scrap, etc.). About 80% of all quality efforts have no measurable results. According to Dr. Juran, most failures in quality are due to a poor choice of strategy. In order to choose a quality strategy wisely, organizations need to know how to manage the quality.

## 7. Historical development of quality management

Langford *et al.* (1995); Nee (1996); Dale (2003); Tayeb *et al.* (2008); ISO 9000 reveals that construction must have development of four stages of quality management such as quality inspection, quality control, quality assurance and total quality management as stated below:

- Quality inspection stage is the study of one or more characteristics of a product, examining, measuring or testing and comparing with specified requirements to assess its conformity with specification or performance standards. It is used to appraise the input, output and assemblies in the production process undertaken mainly by staff employed specifically for this purpose. The work which does not conform to specifications may be reworked or causes claim. It is also used to grade the finished products and use inspection-based systems wholly in-house and do not directly involve suppliers or other external party (Dale, 2003); (Tayeb *et al.* 2008).

- Quality control stage is the operational techniques and activities that are used to fulfill requirements for quality. These means product testing and documentation control became the ways to ensure greater process control and reduced non-conformance. Its critical characteristics are performance-data collection, feedback to earlier stages in the process and self-inspection (McCabe, 1998). In construction firstly setting specific standards for construction performance through the plan and specifications is done. Second is the measuring variance from the standards. Third is taking action to correct or minimize adverse variance. Finally planning for improvements in the standards themselves and conformance with the standards is done as revealed by (Barrie and Paulson, 1992); (Tayeb *et al.* 2008).

- Quality assurance is defined as all those planned and systematic actions necessary to provide adequate confidence that a product or service will satisfy the given requirements for quality. The fundamental difference is that quality assurance is prevention-based while quality control is inspection based as revealed by (McCabe, 1998); (Tayeb *et al.* 2008).

- Total quality management stage is the highest level, involving the application of quality management principles to all aspects of the business. TQM requires that the principles of quality management be applied in every branch and at every level in an organization. ISO 8402:1994 defines TQM as a management approach of an organization centered on quality, based on the participation of all its members and aiming at long-term success. This is achieved through customer satisfaction and benefits to all members of the organization and to society (Dale, 1999).

## **8. Quality Planning**

Kannan and Jayabalan (2007) reveal that organization's quality planning is essential activity to decide its success in the market place. It will incorporate the changing customer needs into the product/service. It retains or improves the rank of the product/service between the customers in the market and continuously improves the quality without compromising on cost. To achieve this quality planning must have the following essential steps in any organization.

- Establishing quality goals.
- Identify the goals impacting the customer.
- Discover customer's needs.
- Develop product features.
- Develop process features.
- Establish process controls and transfer to operations.

## **9. Cost of Quality**

The concept of cost of quality is based on the costs due to the lack of quality or costs to ensure the quality. Crosby refers to the COQ cost as the price of conformance, the prevention and appraisal costs and the price of nonconformance, the failure costs. COQ is also known as the sum of the costs incurred by a company in preventing poor quality. It is the costs incurred to ensure and evaluate that the quality requirements are being met. Any other costs incurred as a result of poor quality being

produced. Poor quality is defined as non-value added activities, waste, errors or failure to meet customer needs and requirements. There are three categories of COQ (Kannan and Jayabalan, 2007).

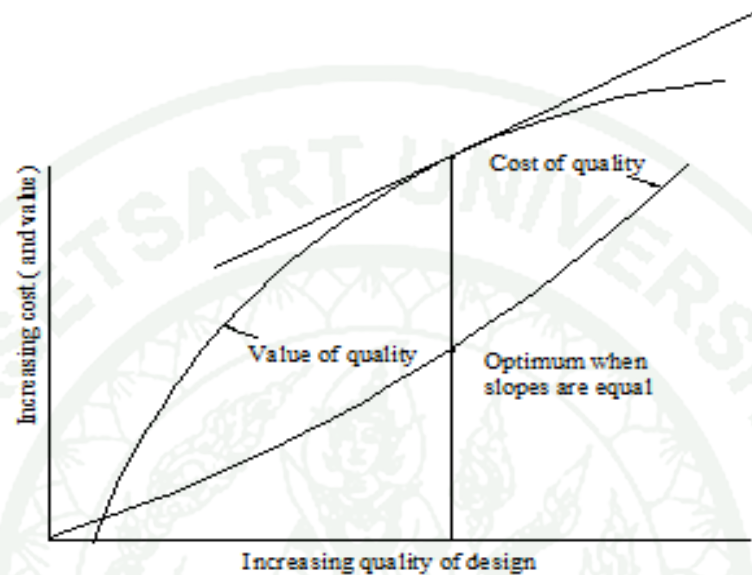
## 10. The Quality Crisis

Timothy (2003) writes, according to Dr. Juran, the cost of poor quality in most companies run at 20 to 40 percent. In other words, about 20 to 40 percent of the company's efforts are spent in redoing things that went wrong because of poor quality (Juran on Planning for Quality, 1988, pg. 1). Crosby's quality management maturity grid states that if an organization doesn't know its cost of quality, it's probably at least 20%. (Crosby, Quality is Free, 1979, pg. 38-39). There will be a crisis in quality. The most obvious outward evidence is the loss of sales to foreign competition in quality and the huge costs of poor quality. It is said in the foreseeable future the crisis will not go away. Our traditional ways will not be adequate to deal with the quality crisis. To deal with the crisis, it requires some major breaks with tradition by improving quality factors.

Economics of quality in design according to Barrie and Paulson (1992) in its simplest form is illustrated in figure 1 showing the relationship between the cost and value of quality in design. The horizontal axis relates to the quality of design as reflected by the quality characteristics chosen for the items concerned. The vertical axis shows that both the cost and value of quality. The value curve is concave downward. As quality increases, the value increases, at a decreasing rate. In other words the value of the additional unit of quality becomes less (Barrie and Paulson, 1992).

On the other hand, the cost curve shows that as quality of design increases, the marginal cost of each additional unit of quality increases more with each step. At the later stages, increment of quality costs for more than the first, until it becomes too costly to specify higher standards. In concept, the optimum level of quality occurs at the level where the marginal cost of one additional unit equals the marginal value. In figure 1, this occurs where the slopes of the two curves are equal. Economics of quali-

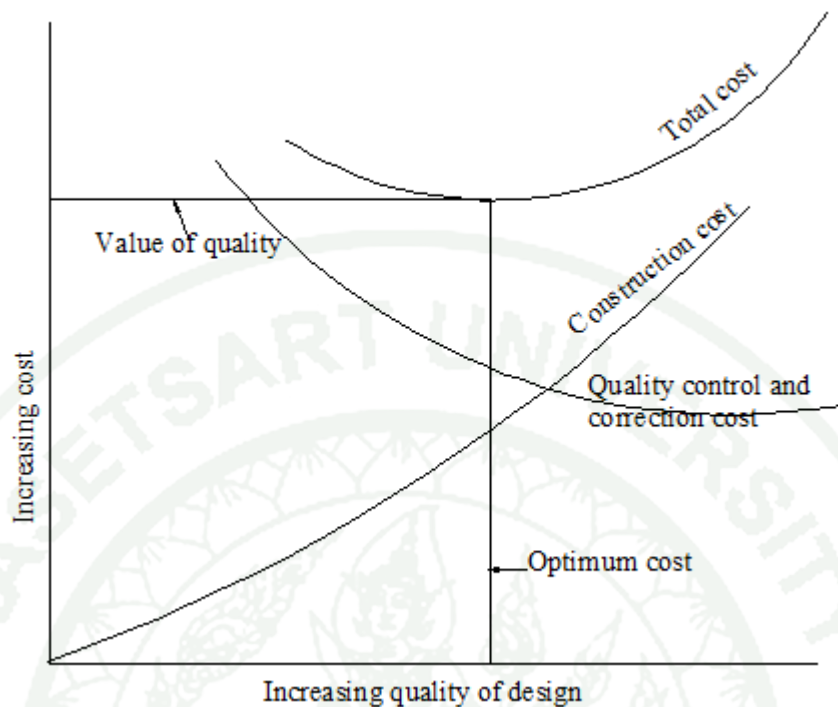
ty of conformance was given by Barrie and Paulson (1992). The cost of quality control is classified in two groups.



**Figure 1** Economics of quality of design.

**Source:** Barrie and Paulson (1992).

The first group includes cost of the skilled labor, equipment, materials, methods and supervision to produce quality output. The second is cost of monitoring and verifying the quality output and correcting or replacing defective work. To achieve increasing quality of conformance directly from the resources and methods, more money should be invested in them, and hence direct cost goes up. On the other hand, as the reliability of the methods and resources improves, less investment is required for monitoring their performance and for correcting and replacing defective work, so the cost of quality control goes down. To optimize conformance costs, the sum of the direct construction costs and the quality control costs should be minimized (Barrie and Paulson, 1992). The figure 2 illustrates the trade-off between these two categories of costs.



**Figure 2** Economics of quality of conformance.

**Source:** Barrie and Paulson (1992).

## 11. Total quality management gurus

Total quality management (TQM) is an enhancement to the traditional way of doing business. It is a proven technique to guarantee survival in the world class competition with guiding principles that represent the foundation of continuously improving organization. It is the application of quantitative methods and human resources to improve all the processes within an organization and exceeds customer needs now and in the future (Gould and Joyce, 2003); (Tayeb *et al.* 2008); (Evans and Lindsay, 1992); (Olomolaiya and Jayawardane, 1998); (Kannan and Jayabalan, 2007). They also reveal basic concepts of TQM as follows:

- A committed and involved management to provide long term top to bottom organization support. Examples are developing clear vision, set long term goals, and direct the program.
- An unwavering focuses on the customer, both internally and externally. Examples are do it right, the first time and every time, to ensure customer satisfaction.
- Effective involvement and utilization of the entire work force. Example empowering people at the lowest level possible level to perform processes in an optimum manner.
- Continuous improvement of the business and production process. Examples are quality function deployment (QFD), SPC, bench marking, ISO 9000, design of experiment for quality improvement.
- Treating suppliers as partners. Example is that raw materials, some sub-assemblies are purchased, processes are outsourced. Supplier quality must be outstanding. A partnering relationship must be developed by focusing on quality and life cycle costs rather than price. If there are few suppliers than a true partnering can occur.
- Establish performance measures for the processes. Examples are up time, percent nonconforming, absenteeism and customer satisfaction determined for each functional area. This measure should be posted for everyone to see. Quantitative data necessary to measure the continuous quality improvement activity.

Olomolaiya and Jayawardane (1998); Tayeb *et al.* (2008) also states some successful TQM program attributes as follows:

- Committed leadership of the highest standard throughout the life time of the organization.

- Training targeted to every level of management and employees.
- Teamwork, which means that everyone participates in the improvement efforts. Upstream prevention management which requires seeking out potential problems and not merely waiting for a failure to happen before effecting improvement.
- Ongoing prevention action requiring the need to attack constantly the real root causes of problems.
- Improved communication to make sure that all required information is supplied at the correct level, at the correct time and to the required degree of detail.
- Clearly identified vision, mission and goals: TQM cannot be steered to continuous improvement without them.
- Focus on employees to include career development plans, profit sharing, enhancing training, employee involvement and recognition, employee satisfaction is indispensable in TQM.

## **12. Quality Management Philosophies.**

W.Edwards Deming; Joseph M. Juran; Philip B. Crosby; Armand V. Feigenbaum; McCabe all as quality gurus in the quality revolution have developed distinct philosophies on how to measure, manage and improve quality as follows.

Deming; McCabe (1998) focuses on the improvement of product and service conformance to specifications by reducing uncertainty and variability in the design and manufacturing process. In Deming's view, variation is the main cause of poor quality. To achieve reduction of variation, he advocates a never-ending cycle of product design, manufacture, test, and sales, followed by market surveys, the redesign, and so forth. Deming claims that higher quality leads to higher productivity, which in turn leads to long term competitive strength (Rustum and Amer, 2002).

Deming; McCabe (1998) identified two sources of improvement in any process. Reducing the “common causes” of variation inherent in the production system and eliminating isolated “special causes” identifiable with a specific individual, machine or batch of materials. Statistical methods provide a means for identifying special causes and understanding common causes (Rustum and Amer, 2002).

Statistical thinking is only a portion of the modern Deming philosophy. Deming emphatically states that managerial practices are in need of a radical overhaul. His 14 points constitutes the core of his program for achieving quality excellence. The Deming philosophy is an all-or-nothing proposition, none of the 14 points can be viewed in isolation and companies cannot be selective in the ones they wish to implement.

Deming constituted quality concept and quality philosophies that apply to both small and large organizations, to the service industry as well as to manufacturing. They also apply to a division within a company.

Juran; McCabe (1998) defines quality as fitness for use. This is broken down into four categories such as quality of design, quality of conformance, availability and field service. Quality of design focuses on market research, the product concept and design specifications. Quality of conformance includes technology, manpower, and management. Availability focuses on reliability, maintainability and logistical support. Field service quality comprises of promptness, competence and integrity. Juran provides ten essential stages explaining his perspective as follows:

- 1) Create awareness of the need and opportunity for quality improvement.
- 2) Set goals for continuous improvement.
- 3) Build on organization to achieve goals by establishing a quality council, identifying problems, selecting a project.
- 4) Give training to everyone.
- 5) Carry out projects to solve problems.
- 6) Report progress.

- 7) Show recognition.
- 8) Communicate results.
- 9) Keep a record of successes.
- 10) Incorporate annual improvements into the company's regular systems and processes, and thereby maintain momentum.

The essence of Crosby's quality philosophy is embodied in what he calls the "Absolutes of Quality Management" and the "Basic Element of Improvement". Rustum and Amer (2002) have studied Crosby's approach summarized in the following points for quality management (McCabe, 1998).

- Quality means conformance to requirements, not elegance.
- There is no such thing as a quality problem. Problems must be identified by those individuals or departments that cause them.
- There is no such thing as the economics of quality. It is always cheaper to do the job right the first time.
- The only performance measurement is the cost of quality.
- The only performance standard is "Zero Defects".

### **13. Construction vs. manufacturing**

One of the most complex and difficult industrial undertakings is the design and construction of a building or civil engineering project, revealed by Willis *et al.* (1996). A construction project usually goes through many phases and spans several years. These individual phases can be carried out by different organizations at different stages. The performance of each phase can affect the quality of the project. Because they typically involve an engineering planning, concept design, bid and proposal, engineering design, procurement, construction, acceptance and test, pilot run, etc. (Tan and Lu, 1995). The construction industry is often small in size and less inclined to formal methods of work study and management. It is different from manufacturing because of its fragmented structure of the construction industry (Jaafari, 1996).

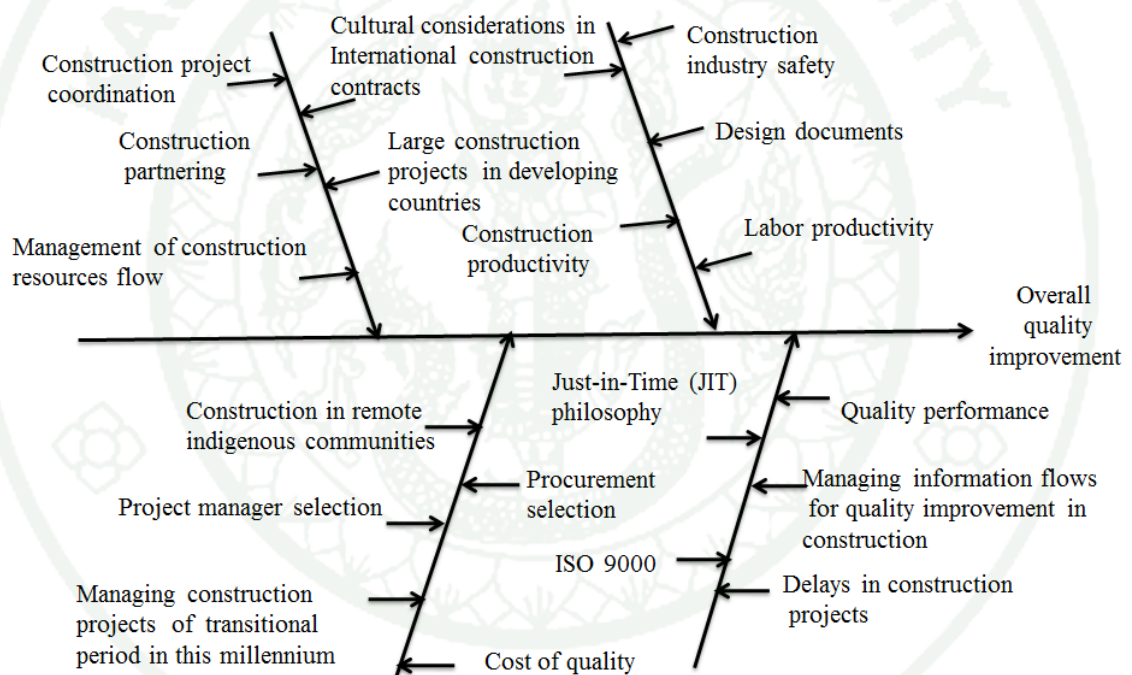
- Diffused responsibility, that is, on normal construction projects typically many individual professionals and firms share the responsibility for the specifications, design and construction of these projects.
- Prototype nature, that is, projects typically resemble ‘prototype’ products in the manufacturing industry, often carrying unique design features, site characteristics and functions.
- Transient and itinerant labor force, who are not trained to operate under the quality assurance mode of construction, that is, the training in the skilled labor has generally been based on learning how to do the work, not necessarily being one’s own inspector to produce zero defect.
- Lack of research and development.
- Subcontracting who need to perform most specialist tasks have been employed as and when required (Langford *et al.* 1995).

#### **14. Quality management in construction**

McCabe (1998); Ashford (1989); Nee (1996); Evans and Lindsay (1992); Rustum and Amer (2002); Kannan and Jayabalan (2007) have studied that, developing a quality system is the first step towards improving quality in construction industry. Reasons are that the skills, loyalty, orientation of professionals and practitioners in the industry have to develop from an environment of specialization, differing traditions and often opposing interests at integration, if any, are currently weak. Thus the construction industry is multifaceted by highly differentiated, fragmented and loosely structured system. A quality system must consist of quality policy, organization for quality having centralized systems and de-centralized system, quality system procedures covering process control, training, quality manuals including control, company policy, company organization, company instruction, project quality assurance.

## 15. Former quality construction journal literature review

Various developing and developed countries journals such as from Thailand, Indonesia, Malaysia, India, China, Japan, North America, Canada, Australia, South America, United Kingdom, New Zealand, Chicago, Egypt, Jordan, Singapore, Saudi Arabia, Texas America, Korea, Hongkong, Uganda, Singapore, Palestian, Turkey, Sri Lanka, Taiwan, Vietnam have made several contributions on factors affecting construction quality. From those overall quality improvement are comprehended and used as shown in figure3 for this research.



**Figure 3** Literature review (former studies).

Razek (1998); Rustum and Amer (2002); Sihaphon (2008) reported that the construction are faced by many faceted thing, conditioned by contextual factors and can be achieved through many mechanisms. It is said that it is not simply a specialist subset of general management. If seen in this partial way, it is inevitable that only partial achievements will be possible. It is also crucially said that the key stakeholder is the client, namely the organization or individual who makes the decision to purchase services from the construction industry.

Abdul and Price (1995); Arditi and Gunayden (1999); Andi and Minato (2003); Alwi (2003); Darwish (2005); Jergeas, (2009); Hamzah *et al.*(2011); Balson *et al.* (2012); Senaratne and Jayarathna (2012); Idoro (2012) reveals that the defective design is the most important risk for the success of a construction industry. It is important to identify designers and contractors different perceptions of the quality of design documents. The finding of defective designs are complex and deep rooted, influence by many factors operating at individual designer, company, construction industry and global or national levels. Design documents quality must discuss these problems and identify possible factors to improve the level of design documents quality.

Alwi (2003) studied that construction experiences poor safety, inferior working conditions and insufficient quality affecting construction's productivity and performance. The need to identify key factors influencing construction productivity and to obtain their causes is necessary. The issues like characteristics of contractors, inadequate management strategy and organization's focus. Knowing this construction productivity will help in providing the constructors with information on which factors they need to focus for the best outcome of quality performance.

Lim and alum (1995); kaming (1997); Kazaz and Ulubeyli (2004); Kadir *et al.* (2005); Alinaitwe *et al.* (2007); Abdel-Razek *et al.* (2007); Shehata and Gohary (2011); Soekiman *et al.* (2011) reveals that poor productivity of construction labor is one of the most daunting human resource problems in developing countries. The craftsmen like bricklayers, carpenters, steel fixers and like more workers in total who participates in production problems are needed. We need to know how much their working productivity is or identify, is it because of lack of materials, rework, absenteeism, lack of equipment and tools and gang interference. They must be compared with those identified from other parts of the world. Construction industry faces challenges of productivity and associated with performance of labor. The performance of labor is affected by many factors and is usually linked to the performance of time, cost, and quality. Factors affecting construction labor productivity need a deeper understanding that may be due to supervision factors, material factors, execution plan

factors and design factors. In addition to these factors, for large companies equipment factors have also high effect. While in small and medium companies, owner/consultant factors also need special attention because it has high effect too. They also mention that health and safety factors has not been a concern of small and medium companies. This is because these factors have some effect. However, in large companies are better, although not as major concern and has average effect. The study of such nature will become worthwhile information in determining the major steps to improve factors affecting labor productivity in construction industry.

Tam *et al.* (2004); Kulchartchai, (2010) conducted study of safety in construction as one of the most hazardous industries due to its unique nature. Construction site safety records should not be poor from risk-prone activities of construction sites. Site safety is of grave concern in construction site. The lack of provision of personal protection equipment, regular safety meetings, and safety training affect performance. Poor safety awareness of top management, lack of training, poor safety awareness of project managers, reluctance to input resources to safety and reckless operations are needed to be improved for quality construction practices.

Rahman *et al.* (2012) studied that the success of any construction is highly depended on how proper and effective the management of construction resources flow. Cost management which result in significant amount of cost overrun are needed to study. There is need of assessment of relationship between these factors. Whether these factors are due to fluctuation of prices of materials, cash flow and financial difficulties faced by contractors, shortages of materials, insufficient numbers of equipment, relationship between management and labor and labor absenteeism are needed to study. Such study will help in controlling resource for achieving project completion within the budget and quality.

Gale and Luo (2004); Soemardi *et al.* (2011); Chen *et al.* (2012) reveals, their study about exploring the success variables (SVs) in construction partnering and the relationships among the success variables. Those were collaborative team culture, long-term quality perspective, consistent objectives, and resource sharing influences

on the success of construction partnering are found identified as necessary. This type of study framework will provide information which will enable the constructor to control individual success variables by considering their relationships with other success variables.

Hai *et al.* (2012) reveals about barriers in construction project coordination. The complexity in construction is one of the most adverse existing businesses. To meet these challenges besides from innovative management and procurement systems introduction such as partnering, joint venture, alliances, supply chain management, enterprise resource planning (ERP), just in time (JIT) and total quality management (TQM) are needed. However, it is said that construction management and procurement systems are meaningless without coordination. The coordination plays crucial functions throughout the construction process especially during the design and construction stages. Study says that the key barriers are due to the nature of construction, traditional contractual arrangement, construction participants, characteristic of organization and construction management. These are needed to be identified. Such investigation will assist the construction players in coordinating their projects towards a better quality implementation of the innovative management and procurement systems.

Patil *et al.* (2011); Tawfek *et al.* (2012); Bari *et al.* (2012) revealed that the cost of quality is an essential element of any construction project. Any attempt to assess the cost of quality should take different cost of quality factors into consideration. The factors may be due to project duration, planned cost of quality for the project, supervision team experience, project size, project location, awareness of quality for the project team, class of contractor, client type and labor skills. These factors are included to assess cost for any project. This will improve the company's performance and its ability to compete with other companies through the improvement of bids accuracy.

Said *et al.* (2009); Jitwasinkul and Hadikusumu (2011) studied about construction organization quality management system (QMS). The implementation of QMS is necessary to mitigate the problems for successful completion within time, cost and quality. QMS ensure successful objectives of a company. In today's globalization

world where economic competition is intensifying, the implementation of QMS will improve the overall construction process. It will also lead to the formulization of successful business strategies to meet international requirements.

Jha and Iyer (2006); Penjor (2007); Zangmo (2009); Hwang *et al.* (2012) have studied the factors adversely affecting quality performance of construction. Those factors were project manager's competence, top management's support, monitoring and feedback by project participants, interaction among project participants, owners' competence, conflict among project participants, hostile socio-economic environment, harsh climatic condition, PM's ignorance and lack of knowledge, faulty project conceptualization and aggressive competition during tendering. We need to analyze out of which one these led to the extent of contribution of various success factors for the current performance of the construction.

Tenah (1986); Hoezen *et al.* (2006); Zeng *et al.* (2007); Arain (2009) have carried out study of managing information flows for quality improvement in construction. The difficulties of sharing information are due to missing an effective channel of information flow for quality management. It is said that there are information asymmetries in quality management from internal and external organizations. Internally, information asymmetry exists between contractor, subcontractors and suppliers. Externally, there is no information sharing mechanism between project departments, information feedback is more difficult than information transferring in a construction firm. The identification of channel of information will reengineer any current management strategy for establishing an effective information network for quality management.

Al-Momani (2000); Chovichien and Suriyanon (2011); Doloi *et al.* (2012) reveals about delays in construction projects such as whether delay relate to designers, user changes, weather, site conditions, late deliveries, economic conditions and increase in quantity. They ultimately affect quality completion in time as contractually specified. These findings will help industry practitioners in minimizing the risk of contract disputes and quality affect.

Pheng and Shang (2011): Alhomadi *et al.* (2011) reported that the Just-in-Time (JIT) philosophy originated from the Toyota Production System (TPS) being used for many decades. In recent years studies in the developed countries have endeavored to introduce JIT in the construction industry to reap similar benefits. This study focus is needed on applying JIT to improve its performance and its competitiveness required to obtain. The potential hindrance to implementing JIT must be crucially studied. The framework for JIT implementation in the areas of design, procurement, construction and inspection. This study is sorted for the government and educational institutions to play a key role in spearheading the application of JIT in the construction industry. It is also reminded to understand that the application of the just-in-time philosophy in the construction industry can lead to low productivity, low profitability and low quality issues if applied wrongly.

Dada (2012) studied that arrangement and organization of participants for construction procurement is critical to project delivery. The study is necessary for projects that are executed or being executed traditionally or by integrated project procurement methods, such study will potentially contribute to the body of knowledge on procurement selection.

ISO 9000 is the series of quality management standards being used by organizations involved in construction industry all over the world. Some developed countries are in the acceptance and implementation of ISO 9000 standards. Different opinions surrounding the issue of ISO 9000 in the construction industry needed to be identified in the form of support or the criticism of its implementation. The effects of ISO 9000 are real improvements in quality against competitiveness and specific requirements at a domestic and international level. This study must attempt to determine its applicability and its effectiveness of ISO 9000 in construction firms. It must determine the effective tool to use in construction firm. Although there may be several obstacles affecting its implementation and acceptance among construction organizations.

Chan and Tse (2003) conducted study on cultural considerations required in international construction contracts. The different political, legal, economic and cul-

tural backgrounds are one of the major issues affecting the management of international construction projects that deserves wide study. The construction industry has to establish a valid groundwork study on the impact of cultural issues on contractual arrangements, conflict causation and selection of dispute resolution mechanisms for international construction projects and ascertain their significance.

Chan *et al.* (1999) have carried out study about managing construction projects of transitional period in this millennium. They pointed out that many foreign organizations experiences in a host country usually from delay and budget overrun and its understanding in this transitional period are necessary.

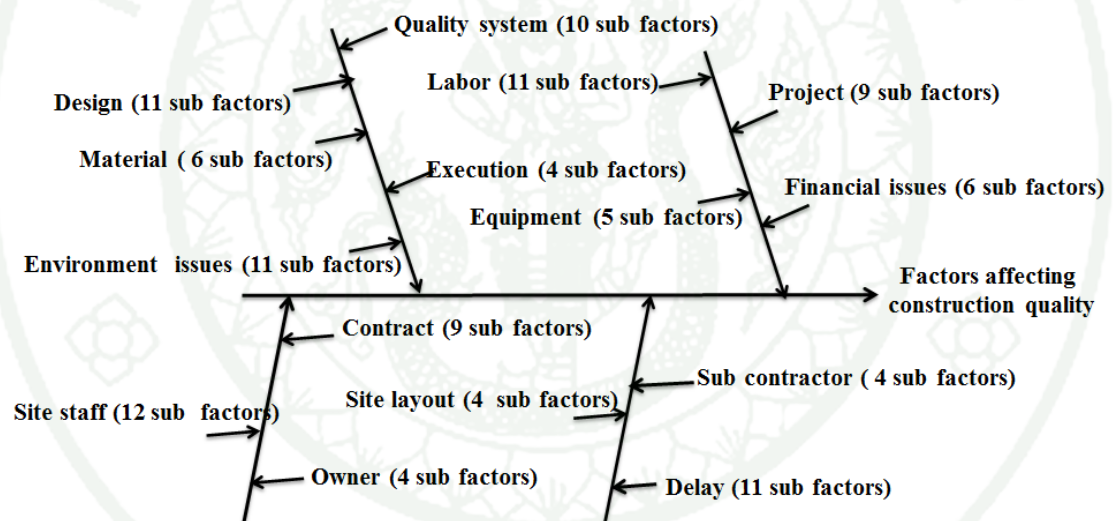
Long *et al.* (2004) have studied in a large construction projects in developing countries about delays, cost overruns, quality, safety, and productivity and other problems in specific types of projects. It is said that even in large construction firm several problems occurs. The problems are incompetent designers/contractors, poor estimation and change management, social and technological issues, site related issues, improper techniques and tools.

Fien and Chaelesworth (2012) revealed that the socio-demographic issues, culture and design, consultation processes, the costs of remoteness, procurement and delivery processes are concern to study for appropriate design and construction of remote indigenous construction. Most significantly these factors cannot be separated from cost. It is reminded that spreading available funds broadly to build the largest number of construction at the best price affects design and construction quality. These are often neglected in the short-term budgeting within this process.

Fatemeh and Rashidi (2011) conducted a study about project manager selected by interviewing applicants and considering their qualifications for the project requirements. It is emphasized as an error of judgment that makes it not dependable. Suitable method such as criteria priorities qualitatively specified and then the applicants ranked using the analytic hierarchy process (AHP), approximate weights of the

criteria and fuzzy technique are said satisfactory for selecting a project manager in construction industry.

In this literature review it is determined that quality problems are not the responsibility of only one person or a few of the different representatives that contribute directly or indirectly to construction quality. All of these problems in greater or lesser are demanding measures, characteristics, practices or ways of improving quality. It showed the direction to prevent from poor quality. How to translate into finished quality are of prime concern. These cause and effect connectivity were aggregated into 15 main factors. Corresponding 117 sub factors were derived as in figure 4 to conduct current research study about local quality factors affecting in Bhutan.



**Figure 4** Cause and effect factors affecting construction quality.

## 16. Modeling Concept

The relevant aspects of the reality or system is represented by a physical or symbol called model. In other words, it portrays the system or reality of concern to the decision-maker. This concept generally imply to a series of connected and identifiable relationships that essentially demonstrate the proposition of action, then the result. Taha (1989) have defined model is an abstraction of the assumed real system. It identifies the pertinent relationships of the system in the form of an objective and a set of constraints. Models can be of several types, but common models in use are found as follows:

- Iconic model: is a pictorial or visual representation of certain aspects of a system. In iconic models the relevant properties of the real thing are represented by the properties themselves, usually with a change of scale.
- Analogue model: use one set of properties to represent another set of properties. They are more abstract than iconic models. Such models are easier to manipulate and can represent situation. Graphs representing time series, flow charts, demand curves, frequency graphs are examples of analogue models.
- Symbolic or Mathematical model: in this model, the components of what is represented and their inter-relationships are given by symbols. These models use letters, numbers and other types of symbols to represent variables and the relationship between them. Such models assume the form of equations or inequalities depicting the relationships amongst the variables of the system (Kothari, 1982). In this study model formulation can be done by following the two steps.
  - Abstraction: it happens to be the first step in modeling and consists of selecting the critical factors or variables from the empirical situation. There are usually an uncountable number of facts in any empirical situation and the decision-maker must intelligently abstract those factors, which he considers to be most relevant to the problem he is facing.

- **Model Building:** the relevant factors or variables selected are put in some logical manner so that they form a model of the given problem. In model building it is generally considered desirable to simplify reality, but only to the point where there is no significant loss of accuracy.

## 17. Structural Equation Modeling

The purposes of structural equation modeling are to understand the patterns of correlation/covariance among a set of variables and to explain as much of their variance as possible with the model specified (Kline, 1998). It is a methodology for representing, estimating, and testing a theoretical network of (mostly) linear relations between variables (Rigdon, 1998). Structural equation modeling is a comprehensive statistical approach to testing hypotheses about relations among observed and latent variables (Hoyle, 1995). It tests hypothesized patterns of directional and nondirectional relationships among a set of observed (measured) and unobserved (latent) variables (MacCallum and Austin, 2000). Therefore it makes us to understand the patterns of correlation/covariance among a set of variables and explain as much of their variance as possible with the model specified (Kline, 1998).

The most common form of structural equation modeling, is to account for variation and covariation of the measured variables (MVs). Path analysis (e.g., regression) tests models and relationships among MVs. Confirmatory factor analysis tests, models of relationships between latent variables (LVs or common factors) and MVs which are indicators of common factors. Latent growth curve models (LGM) estimate initial level (intercept), rate of change (slope), structural slopes, and variance. Special cases of SEM are regression, canonical correlation, confirmatory factor analysis, and repeated measures analysis of variance (Kline, 1998).

SEM is similar to traditional methods like correlation, regression and analysis of variance in many ways. First, both traditional methods and SEM are based on linear statistical models. Second, statistical tests associated with both methods are valid if certain assumptions are met. Traditional methods assume a normal distribution and

SEM assumes multivariate normality. Third, neither approach offers a test of causality (Suhr, 2006).

Statistics: Literature review states that traditional statistical methods normally utilize one statistical test to determine the significance of the analysis. Structural equation modeling, however, relies on several statistical tests to determine the adequacy of model fit to the data. The chi-square test indicates the amount of difference between expected and observed covariance matrices. A Chi-square value close to zero indicates little difference between the expected and observed covariance matrices. In addition, the probability level must be greater than 0.05 when Chi-square is close to zero.

The Comparative Fit Index (CFI) is equal to the discrepancy function adjusted for sample size. CFI ranges from 0 to 1 with a larger value indicating better model fit. Acceptable model fit is indicated by a CFI value of 0.90 or greater (Hu and Bentler, 1999). Root mean square Error of approximation (RMSEA) is related to residual in the model. RMSEA values range from 0 to 1 with a smaller RMSEA value indicating better model fit. Acceptable model fit is indicated by an RMSEA value of 0.06 or less (Hu and Bentler, 1999).

If model fit is acceptable, the parameter estimates are examined. The ratio of each parameter estimate to its standard error is distributed as a z statistic and is significant at the 0.05 level if its value exceeds 1.96 and at the 0.01 level its value exceeds 2.56 (Hoyle, 1995). Unstandardized parameter estimates retain scaling information of variables and can only be interpreted with reference to the scales of the variables. Standardized parameter estimates are transformations of unstandardized estimates that remove scaling and can be used for informal comparisons of parameters throughout the model. Standardized estimates correspond to effect-size estimates.

If unacceptable model fit is found, the model could be revised when the modifications are meaningful. Model modification involves adjusting a specified and estimated model by either freeing parameters that were fixed or fixing parameters that

were free. The lagrange multiplier test provides information about the amount of chi-square change that results if fixed parameters are freed. The wald test provides information about the change in chi-square that results if free parameters are fixed (Hoyle, 1995).

Considerations: Literature review reveals that the use of SEM could be impacted by the following reasons:

- The research hypothesis being testing.
- The requirement of sufficient sample size.
- A desirable goal is to have a 20:1 ratio for the number of subjects to the number of model parameters. However, a 10:1 may be a realistic target. If the ratio is less than 5:1, the estimates may be unstable.
- Measurement instruments.
- Multivariate normality.
- Parameter identification.
- Outliers.
- Missing data.
- Interpretation of model fit indices (Schumacker and Lomax, 1996).

#### SEM Process

SEM adopted in this study process is briefly stated are as follows:

- Review the relevant theory and research literature to support model specification.
- Specify a model (e.g., diagram, equations).
- Determine model identification (e.g., if unique values can be found for parameter estimation; the number of degrees of freedom, df, for model testing is positive)
- Select measures for the variables represented in the model.
- Collect data.

- Conduct preliminary descriptive statistical analysis (e.g scaling, missing data, collinearity issues, outlier detection).
- Estimate parameters in the model.
- Assess model fit.
- Respecify the model if meaningful.
- Interpret and present results.

### Definitions

A measured variable (MV): is a variable that is directly measured whereas a latent variable (LV) is a construct that is not directly or exactly measured.

A latent variable: could be defined as whatever its multiple indicators have in common with each other. Latent variables defined in this way are equivalent to common factors in factor analysis and can be viewed as being free of error of measurement. Relationships between variables are of three types as follows.

- Association, e.g., correlation, covariance.
- Direct effect is a directional relation between two variables, e.g., independent and dependent variables.
- Indirect effect is the effect of an independent variable on a dependent variable through one or more intervening or mediating variables.

Variable Labels are:

- Independent → predictor → exogenous (external) → affect other variables in the model.
- Dependent → criterion → endogenous (internal) → effects of other vari-

ables → can be represented as causes of other endogenous variables.

- Latent variable → factor → construct.
- Observed variable → measured variable → manifest variable → indicator → generally considered endogenous.

A Model: is a statistical statement about the relations among variables.

A path diagram: is a pictorial representation of a model.

Specification: is formulating a statement about a set of parameters and stating a model.

- A critical principle in model specification and evaluation is the fact that all of the models that we would be interested in specifying and evaluating are wrong to some degree.
- We must define as an optimal outcome a finding that a particular model fits our observed data closely and yields a highly interpretable solution.
- Instead of considering all possible models, a finding that a particular model fits observed data well and yields an interpretable solution can be taken to mean only that the model provides one plausible representation of the structure that produced the observed data.

Parameters are specified as fixed or free. Fixed parameters are not estimated from the data and their value is typically fixed to zero or one. The values of fixed parameters are generally defined based on requirements of model specification. A critical requirement is that we establish a scale for each LV in the model, including error terms. To resolve this, we provide each LV with a scale in the model specification process in one of two ways.

- Fix the variance of each LV to 1.0
- Fix the value to 1.0 of one parameter associated with an LV directional influence.

Free parameters are estimated from the data.

Fit indices indicate the degree to which a pattern of fixed and free parameters specified in the model is consistent with the pattern of variances and covariance from a set of observed data. Examples of fit indices are chi-square, CFI, NNFI, RMSEA.

Components of a general structural equation model are the measurement model and the structural model. The measurement model prescribes latent variables, e.g., confirmatory factor analysis. The structural model prescribes relations between latent variables and observed variables that are not indicators of latent variables. Identification involves the study of conditions to obtain a single, unique solution for each and every free parameter specified in the model from the observed data. In order to obtain a solution, the number of free parameters,  $q$ , must be equal to or smaller than the number of nonredundant elements in the sample covariance matrix, denoted as  $p^*$  with  $p^* = p(p + 1)/2$  where  $p$  is the number of measured variables in the covariance matrix ( $q \leq p^*$ )

Evaluation of model fit/goodness of fit: All the test statistics and measures of fit are assessed in addition to fit indices. The Model selection information criteria and modification indices are used for deciding on the best fitted model to improve the model. Enumeration on goodness of fit suggested by Bartholomew *et al.* (2008); Kenny (2014); Surh (2006); Plodwong (2014) are combined together that are adopted as reference in this study are presented in table 1.

**Table 1** Goodness of fit.

Fit indices	Fit Value	Interpretation
Chi-square( $X^2/df$ )	$X^2/df \leq 5$	Accept
p-value	$\geq 0.05$	Reject
GFI and AGFI is	GFI and AGFI $\geq 0.90$	Accept
	RMSEA $\leq 0.05$	very significant
	$0.05 < RMSEA \leq 0.08$	Significant
Root mean square error of approximation (RMSEA)	$0.08 < RMSEA \leq 0.10$	Significant
	RMSEA $> 0.10$	Not significant
	RMSEA $> 1$	poor fit
Standardized root mean square residual (SRMR)	SRMR $< 0.08$	Lesser the value better the fit
	NFI, TLI close to 1	Very good fit/accept it
Tucker-Lewis index(TLI) or non-normal fit index (NNFI).	NFI, TLI $> 1$	Over fitting
	NFI, TLI $< 0.09$	Poor fit
	Factor loading $> 0.50$	Accept
Factor loading	Factor loading $< 0.50$	Accept
	AVE $> 0.50$	Accept
AVE	AVE $< 0.52$	Reject
	CR $> 0.50$	Accept
CR	Standardized residual $\leq 2.5$	Accept
Standardized residual	CFI $\geq 0.90$	Close to 1 very good fit
Comparative fit index(CFI)	$X^2 > 5$	Reject
$X^2$	RMR $> 0.05$	Reject
RMR	0-1	Close to 1 very good fit
Relative fit indices (RFI).	IFI close to 1	Very good fit
	IFI $> 1$	Over fitting
Bollen's incremental fit index (IFI)	IFI $< 0.09$	Poor fit
	Absolute measure of fit $< 0.10$	Small effect
Absolute measure of fit	Absolute measure of fit Around 0.30	Medium effect
	Absolute measure of fit $> 1$	Large effect
PCLOSE	0.05	Worse than close fitting
Akaike Information Criterion (AIC)	Lowest value CFI	Best fitting model

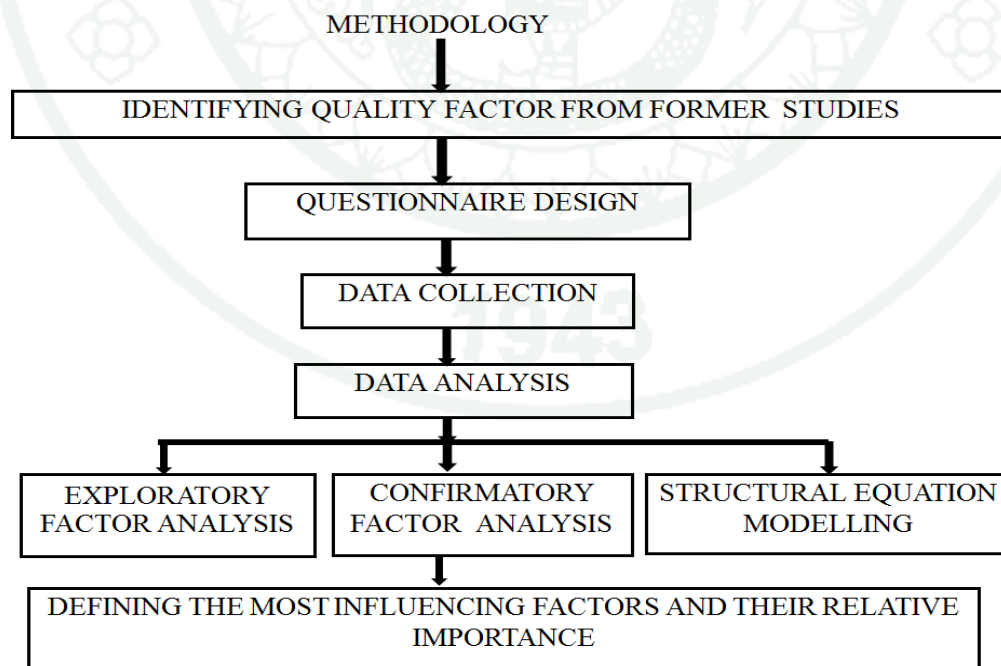
**Source:** Bartholomew *et al.* (2008); Kenny (2014); Surh (2014); Plodwong (2014).

## METHODOLOGY

### 1. Methodology

Methodology means selecting most appropriate method, research strategy and justification. The procedure to be adopted and selecting sample are specified in this chapter. It explains about structured inquiry that utilizes acceptable scientific methods to solve problems and creates new knowledge that is generally applicable (Kumar 2011; p207-212).

The figure5 represents the overall process of this research study. The activities include identifying secondary quality factors based on former studies, (Malhotra, 2006) questionnaire design and scale development concept was referred. The data collection, data analysis by EFA, CFA and SEM model development approach for strategic guideline were to obtain. Finally the most influencing factors and their relative importance is defined.



**Figure 5** Research Methodology.

## **2. Research question**

The research questions for this research are:

- 1) What are main factors and sub-factors affecting construction quality in government and private construction industries in Bhutan?
- 2) How are these factors relatively important for improving the construction quality in Bhutan?

By the conditions such as the:

- Type of question posed.
- Extent of control an investigator has over actual behavior events.
- Degree of focus on contemporary as opposed to historical events.

The case study is identified to be the most appropriate methodology to answer the research questions and the objectives of this study. It will differentiate the various strategies available to the researcher reasons to its ability to deal with a variety of evidence such as documents, observations, artifacts and interviews.

## **3. Identification of local factors based on former studies**

Combining factors from the literature reviews, fifteen main factors and one hundred seventeen sub-factor affecting construction qualities were derived and prepared for a questionnaire. In this study the opinions of experts in many quality arenas were taken for unenviable objective data and subjective judgments. It has been used for two purposes: exploration or confirmation of a concept(s) suitable for exploring complex problems that requires an element of subjective analysis undergoing rapid change in industries.

#### **4. Development of methodology**

The research methodology was developed to facilitate the study from the main factor and subfactors affecting construction quality generated from combining former literature reviews. It facilitates the investigations which are relatively important and how these factors relate to predict quality. The methodology given in figure 5 having 117 independent variables derived was used. The impact and interaction of these independent variables and the 15 dependent variables construction quality is determined statistically by exploratory factor analysis, confirmatory factor analysis and structural equation modeling interfering with excel sheet (2007).

#### **5. Developing the questionnaire**

The questionnaire was developed as the study tool with 5 ordinal scale (given in appendix A). The appendix A questionnaire consist of four sections such as:

- Section one: Organization profile.
- Section two: Seeks to what extend the quality concept is understood in the organization.
- Section three: Respondents ranked main factor affecting quality. This section will make comparison between scores resulted from ranking the main factors presented in it and scores resulted from ranking the sub-factors presented in section four. This comparison will check the priority order of main factors in both ranking.
- Section four: Respondents ranking sub-factors affecting construction quality to obtain corresponding main factor. As this section contains sub-factors affecting construction quality correlated to their main factors, it is used as base for all statistical analysis by EFA, CFA, SEM for defining its relative importance.

## **6. Instrument validity**

The questionnaires demanded review by a group of experts in the field of construction. An expert here means those having, involving in construction, or demonstrating great skill, dexterity, or knowledge as the result of experience or training. They were requested to identify the internal validity and to what extent it was suitable to be used as an instrument to realize the goals and aims of this study. A panel of experts was identified to contribute to the research process. The focus was obtained with the support from General Secretary, construction association of Bhutan (CAB) and the experts agreed that the questionnaire were suitable to achieve the study goals with some amendments. Care in the amendments in the structure and language of the questionnaire to be consistent with the local environment were made.

## **7. The survey strategy**

This study engaged in the processes of:

- Sampling from a population and collecting data through questionnaires.
- Designing instrument for data collection.
- Obtaining high response rate

## **8. Sampling**

The study was conducted carefully. The sampling framing, sample size determination, method of sampling, instrument reliability test, response rate are detailed in the following sections. The lists developed by the construction development board (CDB) and Ministry of Works and human Settlement (MoWH) was taken as the sampling frame (population from which the sample has been drawn, are included in appendix B). A sum total of 71 companies were listed, out of which the sample size was determined.

## 9. Sample size determination

With the resources at hand, nature of population distribution and the variability of characteristics for which the estimates are to be made, a representative sample size of 60 is found statistically adequate to provide reliable estimate of the proposed study. Since there was no such baseline studies conducted before, to be on the more representative side, it was suitable for proportional sample size determination by the formula as illustrated.

$$n = \frac{\left(\frac{Z_{\alpha}}{2}\right)^2 pq}{c^2} = \frac{(1.95)^2 (0.5)^2}{0.05^2} = 384$$

Where

n = proportional sample size.

$\frac{Z_{\alpha}}{2} = 1.96$  @ 95% confidence level.

P = proportion of picking 50-50 right answer one way and other way = 0.5

q = 1 - p = 1 - 0.5 = 0.5

c =  $\pm$  5% confidence interval.

If the population is small then the sample size can be reduced slightly. It is because a given sample size will provide proportionately more information for a small population than for a large population. The sample size (n) can be adjusted using Equation of finite population correction (fpc). The sample size that was necessary is computed.

$$n_1 = \frac{n}{[1+(n-1)/N]} = \frac{384}{[1+(384-1)/71]} = \frac{384}{[1+384/71]} = \frac{384}{6.41} = 60$$

Where  $n_1$  = is the new sample size and N = population of size = 71

The reasons for adjusting for fpc is to determine the sample size to be more than 5% which might carry a wide confidence interval thereby depicting the wrong probability of lying the true values. In other words, if more than 5% of the population is sampled i.e.  $n/N > 0.05$ , the fpc significantly reduces the width of the confidence interval.

## 10. Method of sampling

A multi-stage sampling (stratified and circular systematic sampling) is used in this study. The approach was useful for on-site studies with a list of potential elements in the population is unavailable and do not know in advance who is in the population. The two districts namely Chukha and Phuntsholing were considered as primary strata and the contracting companies (Government and Private) are considered as the secondary strata or primary sampling unit(PSU).

**Table 2** Respondent by sampling.

Organization	Number of companies	Percentage distribution	Number needed from the respective sample size (PPS)
Government	36	51	30
Private contracting company	35	49	30
Total	71	100	60

The secondary sampling units(SSU) are those respondents in both government and private contracting companies that comprises technical Colleges, registered architects, engineers, person working in international organization, registered consultants and registered contractors, which were selected using the probability proportional to size (PPS). The SSU was selected using circular systematic sampling method. Total numbers of respondents from sampling are shown in table 2.

## 11. Instrument reliability test (questionnaire) and one way Anova test.

Reliability measuring the consistency between sub factors toward the main factor is carried out. It was analyzed and the abstract result is illustrated in Table 3 with other subsidiary information presented in appendix (C). The reliability analysis was a carried out to check reliability of the scales (5-points ordinal Scale) and internal consistency is employed. The Cronbach's Alpha value, which is the reliability coefficient, is computed at 0.974. It is highly significant at 95% level of confidence indicating the scales involved in the study are highly reliable. Later One way Anova test for

the various opinion generated by various position of the respondent's filling the questionnaire was cross checked. It resulted that the attitude towards ranking the quality factors does not affect the quality. This meant that that private and government undergo same experiences during the construction process. The P-value was deduced greater than 0.05 in all the factors meaning that there is no significant difference between the means of ranking of positions involved in this study. The null hypothesis is accepted from an overall agreement by all the groups with regard to quality factors. Results are given in appendix F.

**Table 3** Reliability test result (Sub factor correlated to the main factor).

Sl no	Factor	Cronbach's Alpha	Cronbach's Alpha based on standardized items	No of items	Remarks
1	Project	0.873	0.879	10	Cronbach's Alpha shows higher than 0.6 fixed as cut off point Hair et al. (2010). The questionnaire items were reliable.
2	Design	0.792	0.806	12	
3	Contract	0.794	0.787	10	
4	Material	0.78	0.763	7	
5	Labor	0.873	0.873	12	
6	Equipment	0.836	0.828	5	
7	Sub-contractor	0.836	0.828	5	
8	Site layout	0.828	0.838	5	
9	Quality system	0.874	0.879	11	
10	Site staff	0.842	0.852	13	
11	Execution	0.671	0.663	5	
12	Financial issues	0.853	0.845	7	
13	Owner	0.836	0.828	5	
14	Environment issues	0.747	0.737	5	
15	Delay	0.894	0.905	12	

## 12. Data collection

Firstly the quality factors were identified through secondary literature review, and then qualitative local quality factor was identified using an expert's opinion making clarification for the ideas included in the questionnaire. The personnel interview was also made during filling the questionnaire and collecting the data from the respondents.

### **13. Response rate**

There was 0% of non-response rate and the survey enjoyed 100% coverage thereby realizing the precision level as expected by the deduced sample size.

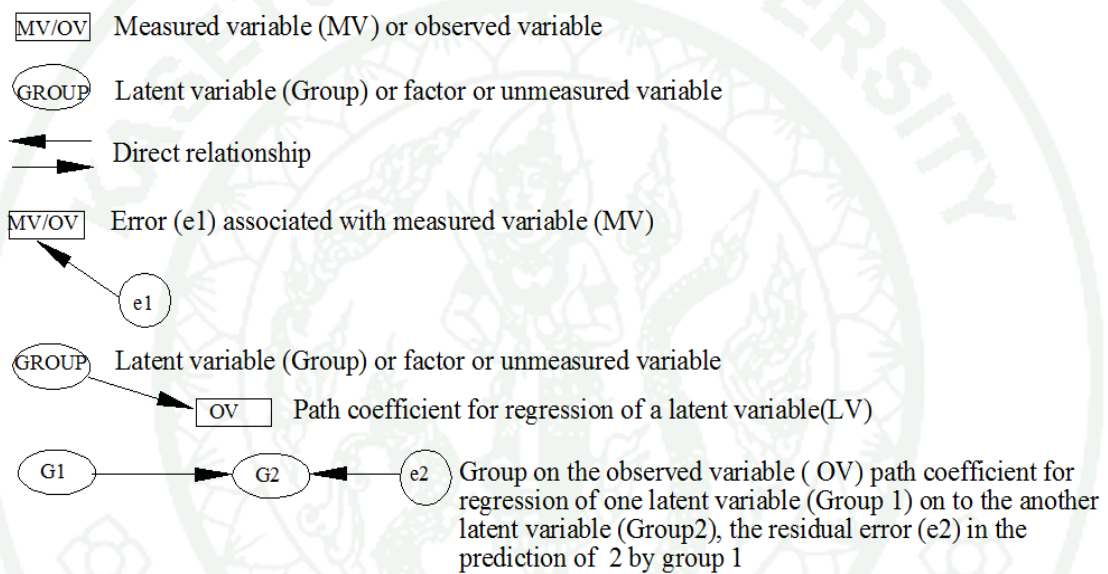
### **14. Method of Data Processing and analysis**

The data was processed using a well-designed data keying interface in CSPro to increase the precision of data quality. Because it has various features that automatically minimize the non-sampling errors. The processed data is then exported for carrying out analysis. The data was further validated in through cross tabulations and running frequencies for each variable. The analysis was done through two statistical analysis methods. The first method is called descriptive statistics method that provides a general overview of the results. It gives an idea of what is happening. The other method which is called statistical method including exploratory factor analysis, confirmatory factor analysis and structural equation modeling applied on different parts of the sample to make comparison of results computed.

### **15. Method of model verification**

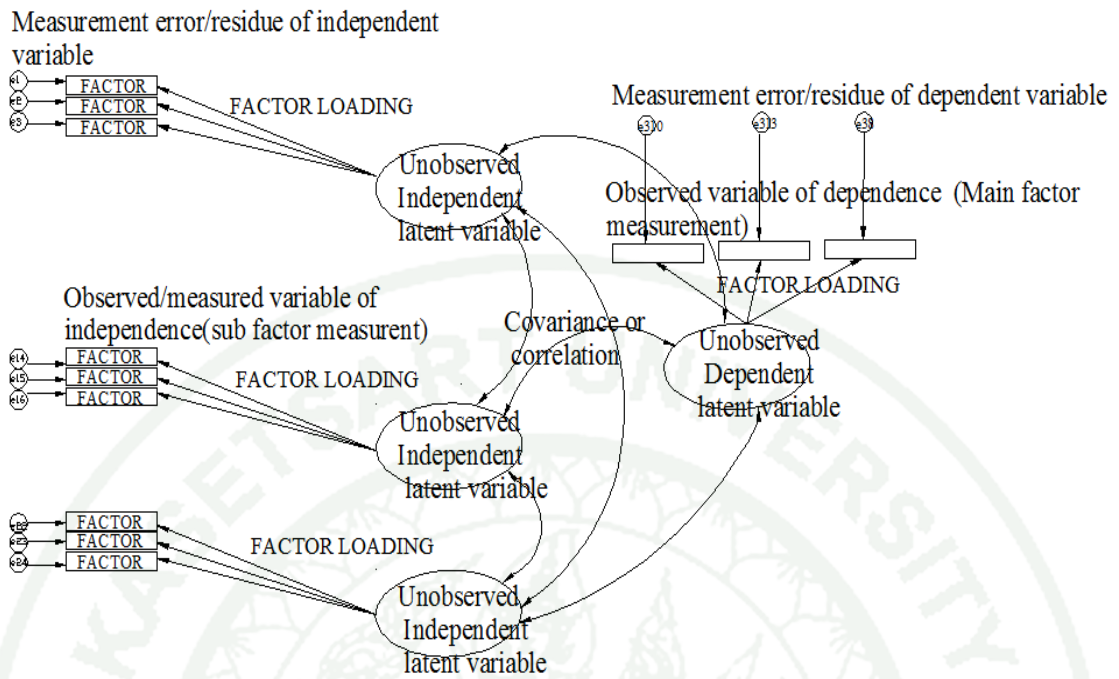
The model verification adopted that are represented by symbol and regression or path analyses are covered. Regression or path analysis model are path coefficient for regression of one variable group 1 on to another latent variable group 2 with other associated symbols. The confirmatory factor analysis and structural equation modeling verification adopted are represented in figure 7 and 8 for the current study adopted. The structural equation model developed will be recommended for strategic guidelines for measuring quality of construction industry. Model development is aim at practicality and applicability in construction industry. So that it can help in identifying the weak points that affect in lowering construction quality. Therefore, it can help project managers to take actions toward improving these weak points area and im-

prove the overall quality. The diagram symbol adopted for developing the regression/path analysis model is briefly illustrated in figure 6 that are developed in for current study. The conceptual path analysis diagram design for the study is illustrated in figure 7 after literature review for the confirmatory factor analysis. In addition the conceptual path analysis diagram illustrated in figure 8 is the diagrams that were designed for the structural equation modeling analysis. Latent constructs are theoretical in nature, they cannot be observed directly and neither measured directly.

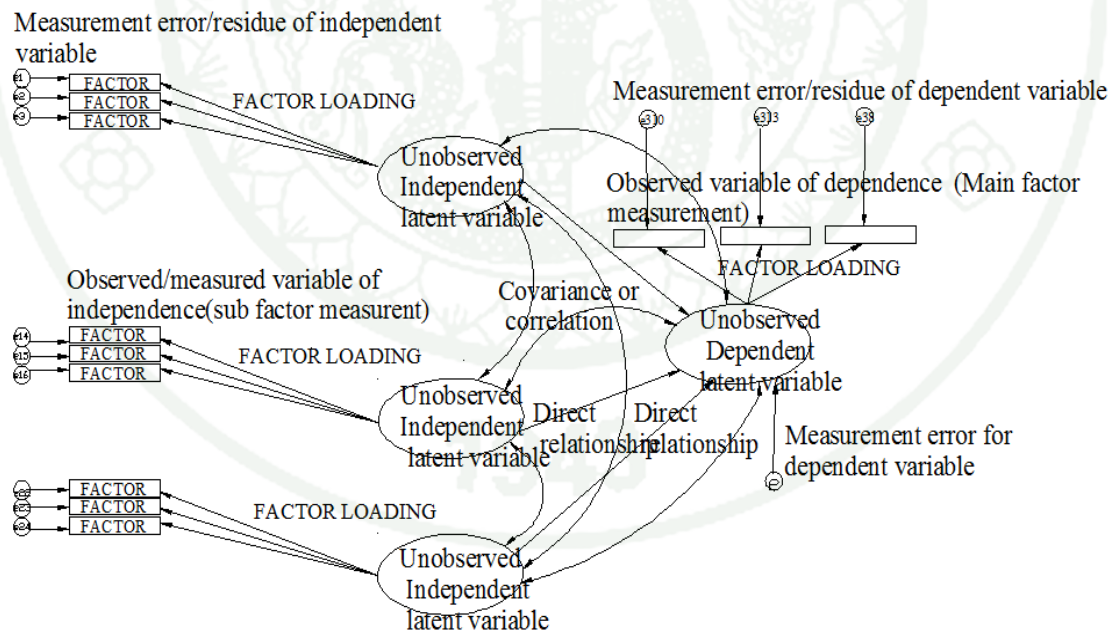


**Figure 6** Path analysis diagram symbol.

The conceptual path analysis diagram design for the study is illustrated in figure 7 after literature review for the confirmatory factor analysis. In addition the conceptual path analysis diagram illustrated in figure 8 is the diagrams that were designed for the structural equation modeling analysis. Latent constructs are theoretical in nature, they cannot be observed directly and neither measured directly. To measure a latent construct, it captures indicators that represent the underlying construct. The indicators are directly observable variables and accurately represents the variable that cannot be observed. The unobserved variable is linked to one that is observable, thereby making its measurement possible.



**Figure 7** Regression/path analysis model for CFA.



**Figure 8** Regression/path analysis model for SEM.

## RESULTS AND DISCUSSIONS

### 1. Results presentation of descriptive and statistical analysis

In the following paragraph all necessary descriptive and statistical analysis by EFA, CFA and SEM attempted are presented. Descriptive analysis is of paramount importance to know what aspects of the research questions are answered through statistical findings. The findings against the raw data collected for descriptive analysis is from section 1 and section 2 and the statistical analysis by EFA, CFA, SEM for the most influencing factor is from section 3 and section 4. That are discussed and presented with figures and tables in the following section.

#### Section 1: Organization profile

- Position of respondents by age: Around 40 percent of the respondents in this research study were those holding managerial positions and followed by 18.3 percent of Executives. Project Engineers topped second in the list of respondents with 23.3 percentages. The lowest comprised of 5 percent who were non-executives are depicted in table 4.

**Table 4** Position of respondents by age range.

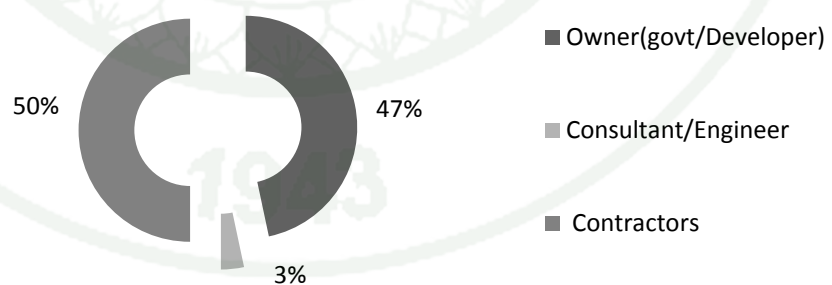
	Age range				Total	Percentage distribution
	20-30	30-40	40-50	> 50		
Managerial	5	6	10	3	24	40
Executive	2	6	2	1	11	18.3
Non-executive	1	2	0	0	3	5
Site engineer	3	3	1	1	8	13.3
Project engineer	3	7	3	1	14	23.3
Total	14	24	16	6	60	100

- Position of respondent by gender: The table 5 illustrates that around 90 percent of the respondents were males. Among them managerial position holders and executives are 21 percent and 10 percent respectively.

**Table 5** Position of respondent by gender.

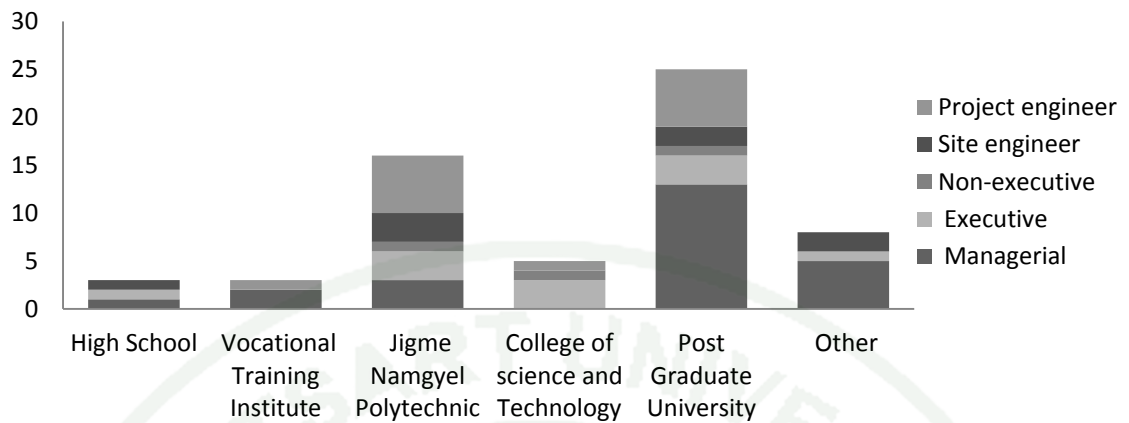
Position	Sex		Total
	Male	Female	
Civil engineer	36	3	39
Electrical engineer	5	1	6
Mechanical engineer	3	0	3
Architect	4	0	4
Others	6	2	8
Total	54	6	60
Percentage distribution	90	10	100

- Type of organization: The figure 9 depicts, 50 percent of the organizations were the contractors followed by owner representing government (47%). The lowest number of respondents covered in this research were those consultants (Engineers), comprising of only 3 percent of the diagram.



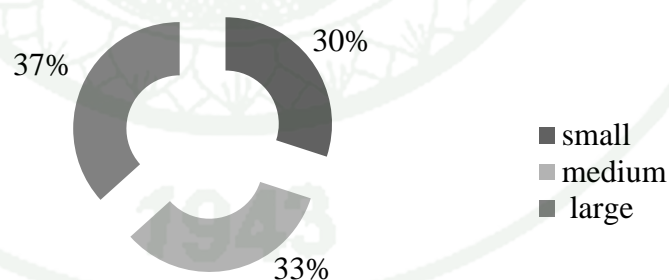
**Figure 9** Type of organization.

- Type of education: The figure 10 illustrates the respondents by level of education. Most of the managerial position holders possess a post graduate university degree.



**Figure 10** Respondents by positions and level of education.

- Classification of contracting companies: According to figure 11 it is depicted that the large category of companies who participated in this study comprises (37%) of large scale, followed by medium (33%) and small (30%) scale companies. Most of the construction works that demand high quality outputs are found executed by large and medium level of contracting companies. The maximum coverage of the same have represented the data well.



**Figure 11** level of contracting companies.

- Number of staff in the organization: In table 6 about 60 % depicts in the range of 6-338 staff, lease the 5 staff by 31.7% and 5% distribution for staff ranging

339-671 and 3.3% for 2668+ above. This indicates that government and private companies are large sized compared to consultant organization.

**Table 6** Type of organization by number of staffs.

No. of staffs	Organization			Total	% distribution
	Owner(govt/pvt)	Consultant	Contractors		
< = 5	7	0	12	19	31.7
6 – 338	21	0	15	36	60
339 - 671	0	0	3	3	5
2668+	0	2	0	2	3.3
Total	28	2	30	60	100

- Number of working experience: The table 7 apparently depicts a good mixture of working experiences for the study conducted. Maximum number of experience greater than 10 years holds 60% distribution.

**Table 7** Year of working experience.

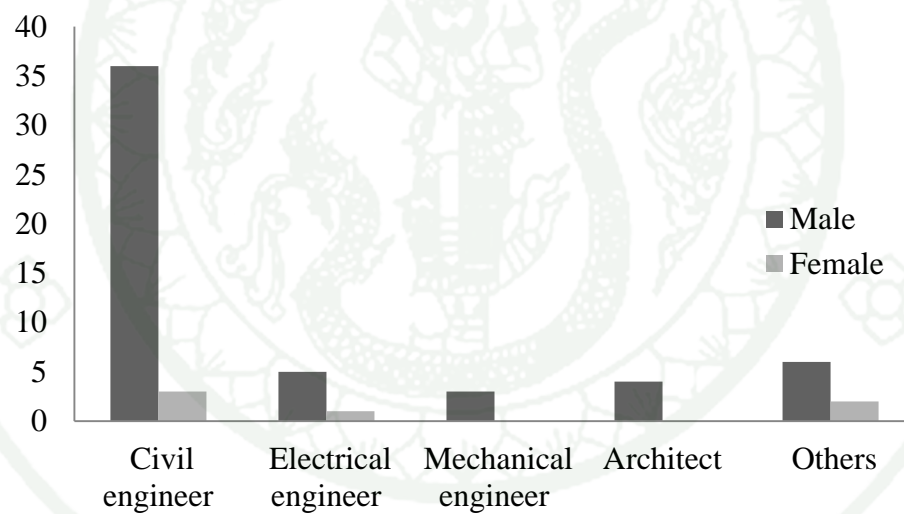
Position	Year of working experience				Total
	< 5 years	22-5 years	6-10 years	> 10 years	
Managerial	0	5	4	15	24
Executive	0	2	2	7	11
Non-executive	0	1	2	0	3
Site engineer	1	1	1	5	8
Project engineer	0	1	4	9	14
Total	1	10	13	36	60
Percentage distribution	1.7	16.7	21.7	60	100

- Number of construction executed: Both the private and government represents equal volume of construction work executed in the last 5 years. This indicates very good experience that enables them to identify the most important factors affecting quality. The table 8 is presented for number of construction executed.

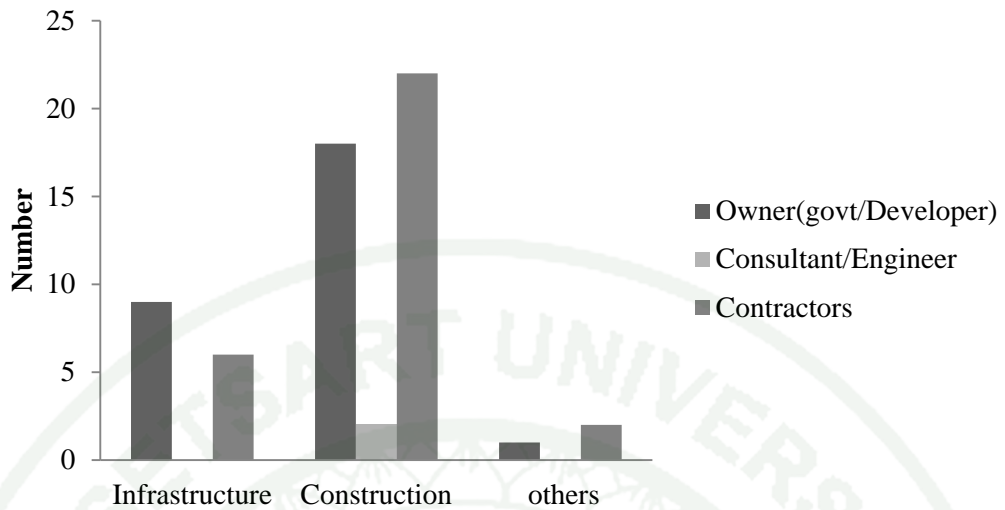
**Table 8** Number of constructions executed by type of organizations.

	No. of construction executed				Total
	<10	11-20	21-30	> 30	
Owner(government/private)	13	5	4	6	28
Consultant/Engineer	2	0	0	0	2
Contractors	7	7	7	9	30
Total	22	12	11	15	60
Percentage distribution	36.7	20	18.3	25	100

- Field of specialization: The figure 12 shows the respondents by field of study and by gender. Civil engineering tops the list and the male category has the highest percentage distribution or in absolute number.

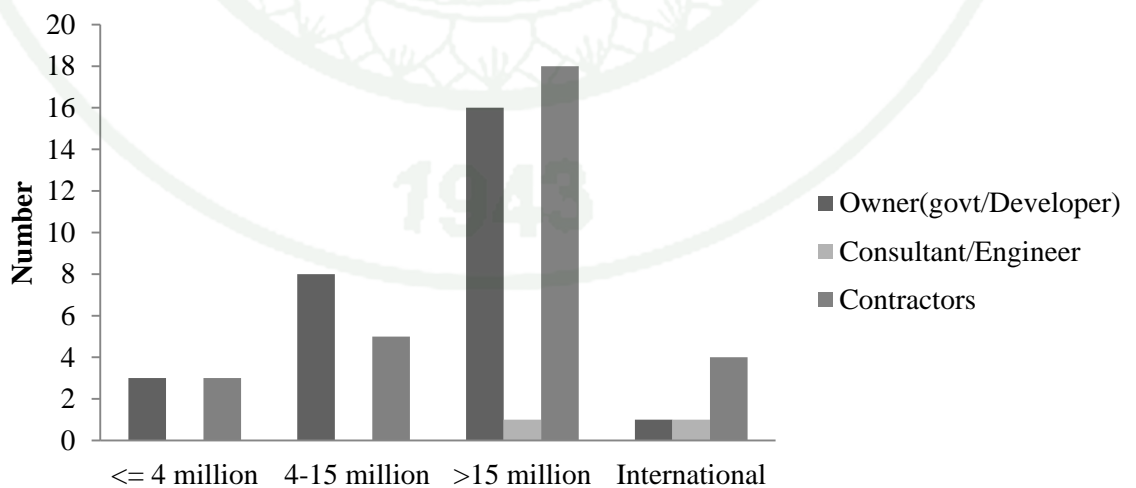
**Figure 12** Respondents by field of specialization by gender.

- Type of construction handled in the last five years: The figure 13 depicts that the general construction tops the lists over the past five years. Owner and contractors have executed the highest number of constructions as in the figure 13.



**Figure 13** Type of construction handled in the past 5 years by type of organizations.

- Largest project involved based on contract amount in the last five years: From figure 14 it is noticed that 18 contractors have executed a volume of work with a value greater than 15 million ngultrum this means that the local construction projects are mainly small to medium compared to international construction works.

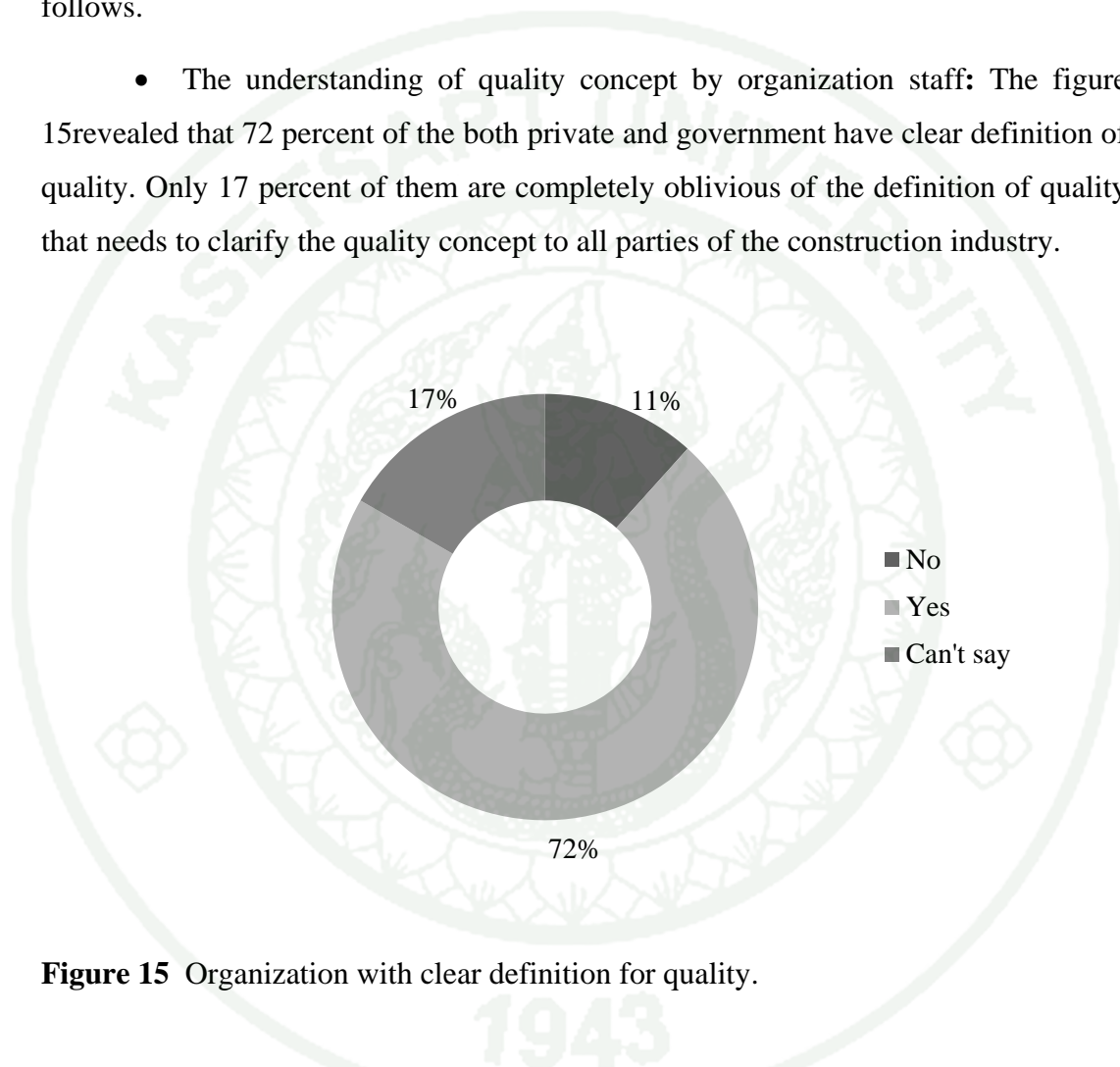


**Figure 14** Largest project involved based on contract amount in the past 5 years by type of organizations.

## Section 2: Quality in the organization

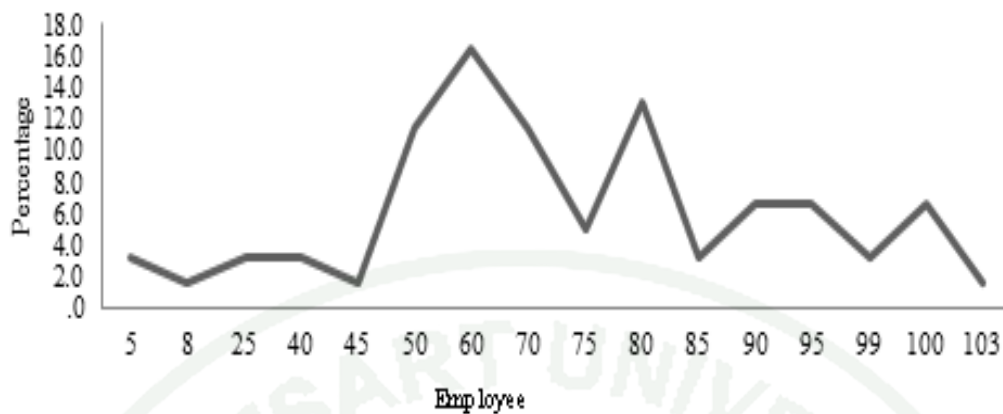
The section 2 of the survey prompted the respondents about their perception and knowledge of quality in the construction industry and the results are revealed as follows.

- The understanding of quality concept by organization staff: The figure 15 revealed that 72 percent of the both private and government have clear definition of quality. Only 17 percent of them are completely oblivious of the definition of quality that needs to clarify the quality concept to all parties of the construction industry.



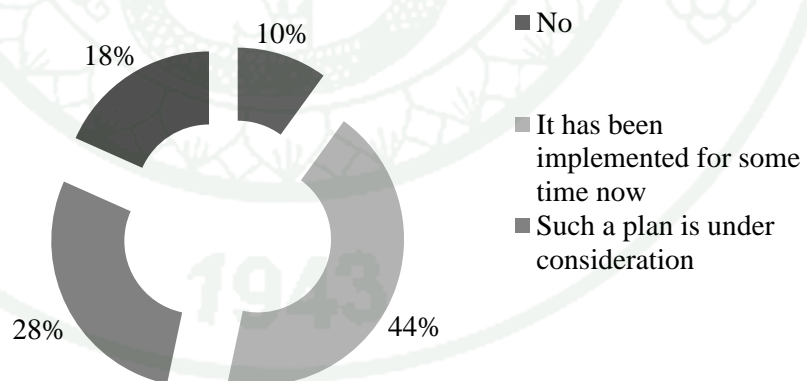
**Figure 15** Organization with clear definition for quality.

- Percentage of employees who are aware of the importance of quality in the organization: The figure 16 illustrates that the percentage of employees who are aware of the importance of quality in the organization. Around 45 respondents show only 2 % awareness of importance of quality. Employees between 45 to 60 are found rising up to 16 % awareness of importance of quality in the organization. The overall perception from the figure 16 indicates that there is a need an emphasis on quality awareness campaign in the organization. Also it indicates low concern for quality in the construction industry.



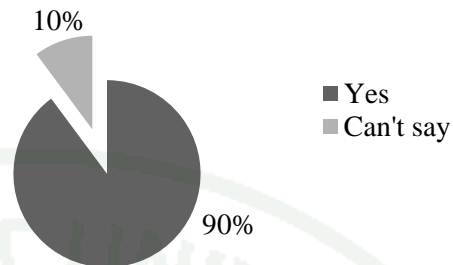
**Figure 16** Percentage of employee with awareness on the importance of quality.

- Organization having a quality improvement plan: The figure 17 illustrates the quality improvement plan implemented in the respective organizations. 10 percent of them have no such plans. About 44 % category shows implementation of the quality improvement for some time. For the under consideration about 28%, 18% that only implemented recently and 10% not implemented at all. However, this indicates that almost 56% having a no quality plan.



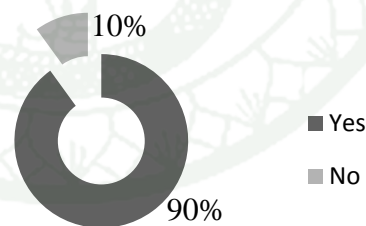
**Figure 17** Quality improvement plan in organizations.

- Top management quality support: The figure 18 depicts as 90% top management's support for quality improvement plan with 10% cannot say.



**Figure 18** Management's support for quality improvement plan.

- Companies having ISO certificate: The figure 19 shows that 90 percent private and government follow Bhutan standard bureau (BSB) and CAB certificate. There is no ISO certification firm as yet. Around 10 percent depicts no such certification interest. These 10 percent could affect the quality negatively. However, further investigation for this particular case is needed if BSB or CAB is to act in line with ISO certificate to reach the competitive edge.



**Figure 19** Proportion of ISO (CAB) certified organization.

### Section 3 and 4 main and sub-factors affecting construction quality

In this section 3 and 4, mean score ranking of private, government and by both are carried out in ranking of main and sub factor. Then the statistical analysis including exploratory factor analysis, confirmatory factor analysis and structural equation modeling (SEM) developed are discussed and presented. Exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) are of two types associated with SEM

modeling. EFA and CFA are employed for understanding variance of measured variables that are attributing to the factor or latent construct. All this analysis was necessary to determine most practical relationship between the influencing factors among 117 sub factors listing (Given in appendix D). Then choosing the right strategy from the model developed followed by comparative study in identifying influential factor ranking are explained based on factor loading.

The table 9 given depicts the prioritized result from ranking the main factors in the order of highest to lowest mean score. The main factors ranking by both private and government were found ranked differently. When combining both ranking by private and government was ranking design, material and quality system as top three factors. Individually the government ranked design, quality system and material as their main factors.

**Table 9** Priority main factor ranking.

Priority	Government ranking	Mean	Private ranking	Mean	Private and Government ranking	Mean
1	Design	4.77	Project	4.77	Design	4.73
2	Quality System	4.7	Design	4.7	Material	4.7
3	Material	4.63	Contract	4.53	Quality System	4.62
4	Execution	4.5	Material	4.5	Execution	4.5
5	Project	4.47	Labor	4.5	Labor	4.35
6	Financial Issues	4.47	Equipment	4.43	Equipment	4.35
7	Site Staff	4.33	Subcontractor	4.27	Project	4.33
8	Contract	4.3	Site layout	4.27	Financial Issues	4.32
9	Equipment	4.27	Quality System	4.2	Site Staff	4.3
10	Owner	4.23	Site Staff	4.17	Contract	4.28
11	Labor	4.2	Execution	3.9	Owner	4.03
12	Site layout	4.03	Financial Issues	3.83	Site layout	3.97
13	Environment issues	3.93	Owner	3.8	Environment issues	3.87
14	Subcontractor	3.63	Environment issues	3.47	Subcontractor	3.55
15	Delay	3.6	Delay	3	Delay	3.3

The private ranked project, design and contract as their factors. The table 9 illustrates all information for comparison conducted of main factor ranking in detail. This result is compared later with the scores resulted from ranking of sub-factors in section 4. In table 10 naming it as 10 a, 10 b, and 10 c in different prioritized ranking by private, government and by both for sub factors ranking resulted from section 4 are presented (Remaining data after top 50 ranking are provided in Appendix D). Calculation of main factor and sub factor are made from the average/mean formula as illustrated below.

$$\bar{X} = \frac{1}{n} \sum_{i=1}^n X_i$$

where

$\bar{X}$  = arithmetic mean

$n$  = sample size

$X_i$  =  $i$ th observation of the random variable  $X$

Example: This is computed by summing up the mean scores of each subfactor and dividing it by the number of sub-factors belonging to the corresponding main factor and sub factor. Average score of main factor “Project” as:

$$= (462 + 445 + 442 + 420 + 495 + 398 + 397 + 388 + 353) / 9 = 422.$$

The result of section 3 is presented in table 9 priority main factor ranking. The purpose was to cross-check the mean scores resulted from the ranking of sub factor in section 4 and it is illustrated in table 10 that comprises a, b and c.

**Table 10a** Priority top 50 sub factor government ranking.

Government ranking	Mean	Rank
Project planning (project)	4.7	1
Completeness & Consistency of design document (design)	4.63	2
Drawing are prepared in full details (Design)	4.6	3
Adherence to specification	4.57	4
Availability of good quality construction materials	4.57	5
Project Scheduling	4.5	6
Owners emphasis on quality	4.5	7
Project budgeting	4.47	8
Implement quality control and assurance system	4.47	9
Skill and experience contractor staff	4.43	10
Using labor with high experience	4.4	11

**Table 10 a** (Continued).

Government ranking	Mean	Rank
Conference to codes and standards	4.4	12
Skill and experience supervision staff	4.37	13
Availability of equipment	4.33	14
Water requirement	4.33	15
Scope of the project	4.3	16
Implement and using time schedule	4.3	17
Quality procedure	4.3	18
Final inspection and hand over	4.3	19
Project quality plans	4.27	20
Using a standard contract	4.23	21
A written contract with clear conditions and fair responsibility distributions	4.23	22
Availability of equipment	4.23	23
Lack of commitment	4.2	24
Poor site coordination	4.2	25
Improper planning	4.2	26
Bill of Quantity	4.2	27
Supply of construction materials economics and market conditions	4.2	28
Quality manual	4.2	29
Period of the project	4.2	30
Construction supervision	4.17	31
Labor management system	4.17	32
Construction Materials	4.17	33
Cooperation between supervision and contractors staff	4.13	34
Site layout is organized well	4.1	35
Price stability of construction materials economic and market conditions	4.1	36
Location of the project	4.1	37
Quality records	4.1	38
Job Site Access	4.07	39
The amount of contractor cash flow	4.07	40
Understanding of contract administration by supervision	4.03	41
Project Tracking	4.03	42
Lack of skills	4.03	43
Lack of clarity in project scope	4	44
Site layout has storage areas for materials	4	45
The knowledge based system is primarily designed for professional to earn from similar past project	4	46
	4	47
The owner not delaying to make decisions	4	48
Inefficient site management	4	49
Site layout is large and suitable for moment of labors and equipment	4	50

**Table 10b** Priority top 50 sub factor private ranking.

Private ranking	Mean	Rank
Inspection and testing (Site staff)	4.7	1

**Table 10 b** (Continued).

Private ranking	Mean	Rank
Availability of good quality construction materials (Material)	4.63	2
Project planning (project)	4.6	3
Skill and experience supervision staff	4.57	4
Skill and experience contractor staff	4.57	5
Adherence to specification	4.5	6
Using labor with high experience	4.5	7
Completeness & Consistency of design document	4.47	8
Drawing are prepared in full details	4.47	9
Construction supervision	4.43	10
Project Scheduling	4.4	11
Conference to codes and standards	4.4	12
Project quality plans	4.37	13
Project budgeting	4.33	14
The amount of contractor cash flow	4.33	15
Implement quality control and assurance system	4.3	16
Implement and using time schedule	4.3	17
Inefficient site management	4.3	18
Availability of equipment	4.3	19
Quality procedure	4.27	20
Labor management system	4.23	21
Cooperation between parties involved in contract	4.23	22
Improper planning	4.23	23
Bill of Quantity	4.2	24
Using a standard contract	4.2	25
Availability of equipment	4.2	26
Period of the project	4.2	27
Owners emphasis on quality	4.2	28
The non-delay interim payments	4.2	29
Using a complete applied materials management system	4.2	30
Quality records	4.17	31
Lack of commitment	4.17	32
Final inspection and hand over	4.17	33
Using a complete execution system	4.13	34
Quality manual	4.1	35
Cooperation between supervision and contractors staff	4.1	36
The knowledge based system is primarily designed for professional to learn from similar past project	4.1	37
Lack of clarity in project scope	4.1	38
Supply of construction materials economics and market conditions	4.07	39
Lack of skills	4.07	40
Preparing and using shop drawings	4.03	41
Poor site coordination	4.03	42
Site layout is organized well	4.03	43
Waiting for client decision and that consultant tend to copy and modify from their previous work	4	44
Good utilization of equipment	4	45
Using cost control system	4	46
Implement a safety program	4	47

**Table 10 b** (Continued).

Private ranking	Mean	Rank
Site document control	4	48
Insufficient overall design time	4	49
Unstable clients requirements	4	50

**Table 10 c** Priority top 50 sub factor private and government ranking.

Private and Government ranking	Mean	Rank
Project planning (project)	4.62	1
Availability of good quality construction materials (site staff)	4.62	2
Completeness & Consistency of design document (Design)	4.55	3
Drawing are prepared in full details	4.53	4
Adherence to specification	4.53	5
Skill and experience contractor staff	4.47	6
Project Scheduling	4.45	7
Using labor with high experience	4.43	8
Skill and experience supervision staff	4.43	9
Project budgeting	4.42	10
Conference to codes and standards	4.4	11
Implement quality control and assurance system	4.4	12
Owners emphasis on quality	4.35	13
Project quality plans	4.32	14
Implement and using time schedule	4.3	15
Construction supervision	4.3	16
Availability of equipment	4.28	17
Quality procedure	4.28	18
Inspection and testing	4.28	19
Cooperation between parties involved in contract	4.27	20
Using a standard contract	4.23	21
Improper planning	4.23	22
Bill of Quantity	4.22	23
Labor management system	4.22	24
Final inspection and hand over	4.22	25
The amount of contractor cash flow	4.22	26
Period of the project	4.2	27
Lack of commitment	4.18	28
Quality manual	4.17	29
Inefficient site management	4.15	30
Quality records	4.13	31
Cooperation between supervision and contractors staff	4.13	32
Supply of construction materials economics and market conditions	4.13	33
Poor site coordination	4.12	34
The non-delay interim payments	4.1	35
A written contract with conditions clear and fair and responsibility distributions is clear	4.08	36
Water requirement	4.08	37
Site layout is organized well	4.07	38

**Table 10c** (Continued).

Private and Government ranking	Mean	Rank
Scope of the project	4.05	39
Lack of skills	4.05	40
The knowledge based system is primarily designed for professional to learn from similar past project	4.05	41
Using a complete execution system	4.03	42
Price stability of construction materials economic and market conditions	4.03	43
Lack of clarity in project scope	4.03	44
Construction Materials	4.02	45
Job Site Access	3.98	46
Site layout is large and suitable for moment of labors and equipment	3.98	47
Using cost control system	3.98	48
Understanding of contract administration by supervision	3.98	49
Project Tracking	3.97	50

The above mentioned result in table 9 and table 10 ranking resulted table 11 priority comparison between section 3 main and section 4 main from sub factor ranking.

**Table 11** Priority between main and main from sub factor ranking.

Priority	Main factor ranking	Mean Score	Main factor from sub factor ranking	Mean Score
1	Design	4.73	Quality System	4.13
2	Material	4.7	Project	4.12
3	Quality System	4.62	Design	4.12
4	Execution	4.5	Site Staff	4.11
5	Labor	4.35	Delay	4.01
6	Equipment	4.35	Owner	3.93
7	Project	4.33	Execution	3.91
8	Financial Issues	4.32	Material	3.89
9	Site Staff	4.3	Financial Issue	3.89
10	Contract	4.28	Labor	3.88
11	Owner	4.03	Equipment	3.88
12	Site layout	3.97	Site Layout	3.86
13	Environment issues	3.87	Contract	3.78
14	Subcontractor	3.55	Environment Issue	3.74
15	Delay	3.33	Sub-contractor	3.59

The varying opinions were depicted from the 60 respondents. The result was not conclusive due to multi variances of ranking in both main and sub factor ranking by respondents (private, government and by both). Moreover the correlation between the variance rankings could not be attempted which is needed for identifying the strategic guidelines. Comparing the results from table 9 and table 11, it was found that the first top three main factors that have ranked the order of priority as design, quality system and material by government and by private were in the priority order of project, design and contract. When both were combined design, material and quality system were ranked.

In addition when comparing main factor from the result of sub factor ranking it is found first three main factors ranked the order of priority as quality system, project and design by both private and government conversely. In the case of sub factor ranking government respondents ranked the order of first top three priorities of sub factor as project planning, completeness and consistency of design, drawings are prepared in full detail. Private respondents ranked the priority order of inspection and testing, availability of good quality construction materials and project planning. When combining by both priorities order is found in project planning, availability of good quality construction materials and completeness & consistency of design document. The reasons were due to requirement differences in management in the private and government organization not the opinion affecting quality. This was the reasons that the priority order was not similar. It showed relationship between all design, quality system, material and project in the case of main factor ranking. In the case of sub factor ranking the government ranking were project planning due to project conceptualization, completeness & consistency of design document due to design problem and drawing are prepared in full details due to design in priority order. Private rankings were inspection and testing due to site staff problem, availability of good quality construction materials due to material, project planning due to project conceptualization problem and when combined both private and government it revealed project planning due to project conceptualization, availability of good quality construction materials due to site staff and completeness & consistency of design document due to design problem. The sub factor ranking comparing with main factor ranking both the

parties reveals somewhat similar problem due to project conceptualization and design inadequacy in factors affecting quality with material, quality system. All these result were considerable for validity of the questionnaire and the consistency in the results, which reflect both the attitudes of the private and government towards the most important factors affecting quality of construction. These influencing factors were further verified for correlation study. The correlation study was conducted by selecting corresponding top 50 sub factors mean ranking. The statistical analysis by EFA, CFA and SEM was carried out to find most influencing factors with relationship among main and sub factors. The further analysis by EFA, CFA and SEM are presented in the following paragraph.

## **2. Exploratory factor analysis**

The aim of EFA is to identify factors based on the data and to maximize the amount of variance explained (Suhr, 2006). Factor analysis is concerned with the patterns of relationships between observed (manifest) variables and unobserved (latent) variables called factors (group). EFA do not determine factor structure prior to running the analysis. It is the development of psychometric measures. In EFA it is not required to have any specific hypotheses about how many factors will emerge, and what items or variables these factors will comprise. If these hypotheses exist, they are not incorporated into and do not affect the results of the statistical analyses. The raw data exploratory factor analysis was run. EFA rotated component matrix that comprises indicators to unobserved latent variables determined with latent variable are named as factor (group 1), factor (group 2) and factor (group 3). It was analyzed from section 4 of the questionnaire. It accounted for three factors dimension reduction and its output resulted are given in appendix C to support its explanation.

The result of Kaiser-Meyer-Olkin measure of sampling adequacy was obtained as 0.60 greater than 0.5 and Bartlett's test of sphericity significance was 0.00 which is highly significant. Therefore this result was fit to construct model for the construction affecting quality. The result of 29 variance of measured variables attributed to new

group /factor/latent variables affecting construction quality having relationship/correlation with three group of latent variable are as given.

Factor 1(group)

- 1 Construction supervision.
- 2 Quality procedures.
- 3 Skill and experience Supervision staff.
- 4 Inspection and testing.
- 5 Project quality plans.
- 6 The amount of contractor's cash flow.
- 7 Skill and experience contractor's staff.
- 8 Implement and using time schedule.
- 9 Quality manual.
- 10 Labor management system.
- 11 Availability of equipment.
- 12 Implement quality control and assurance system.
- 13 Using labor with high experience.

Factor 2(group)

- 1 Improper planning.
- 2 Lack of commitment.
- 3 Inefficient site management.
- 4 Completeness and consistency of design documents support quality control/assurance.
- 5 Final inspection and handover.
- 6 Drawings are prepared in full details to required design quality.
- 7 Bill of quantity is very detailed and accurate as per required design quality.
- 8 Conformance to codes and standards.

Factor 3(group)

- 1 Cooperation between parties involved in contract.

- 2 Project budgeting (to match the project definition and scope). Define the owner's permissible budget and determining direct and indirect costs plus contingencies.
- 3 Using a standard contract.
- 4 Period of the project-under estimated project period may impact quality control.
- 5 Project planning: (the strategy to accomplish the work) by selecting and assigning project staff, identifying the task required to accomplish the work.
- 6 Meeting the budget.
- 7 Project Scheduling (the product of scope, budgeting, and planning). Arrange and schedule activities in a logical activity, link the costs and resources to the schedule activities.
- 8 Owner's emphasis on quality.

### **3. Confirmatory factor analysis (CFA)**

CFA is a validation of psychometric measures. The factor structure prior to running the analysis sets which variables are indicators of which factor. CFA evaluates a priori hypotheses and is largely driven by theory. Priori denotes general knowledge about the data distribution before making an inference. Thus, CFA analyses require test for hypothesis to determine in advance whether or not EFA factors are correlated. The items/measures load on to and reflect which factors in contrast to exploratory factor analysis and all loadings are free to vary. CFA allows for the explicit constraint of certain loadings to be zero. The confirmatory factor analysis was run again to derive all sub factor variable into factor 1(group), factor 2(group) & factors 3 (group) by priori hypothesis analysis as mentioned. In this study CFA reconfirmed the above new three factors of EFA. The results of path analysis diagram are displayed in figure 20, 21 and 22 for the underlying study.

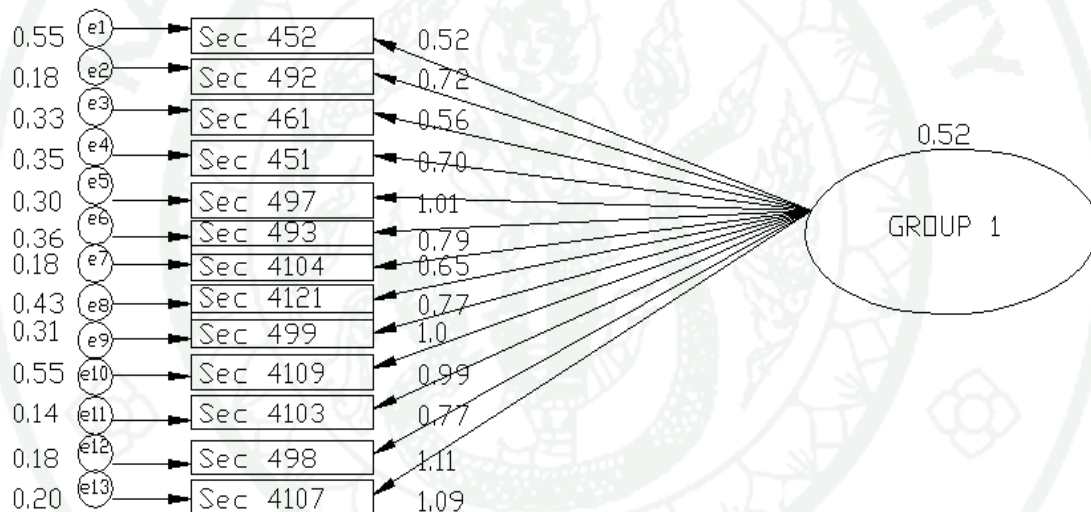
Priori hypothesis testing for CFA was constructed for the study and hypothesis conducted and resulted are as follows.

Hypotheses construct are statement of an explanations or making generalizations about set of facts or principles forming a basis for possible test to confirm viability for the study that are developed are as follows.

H0: Group (Factor) 1, 2 & 3 does not affect construction quality or do no relate to construction quality.

H1: Group (Factor) 1, 2 & 3 affect construction quality or relate to construction quality.

Factor 1(group)



**Figure 20** Path analysis for factor 1(Group 1).

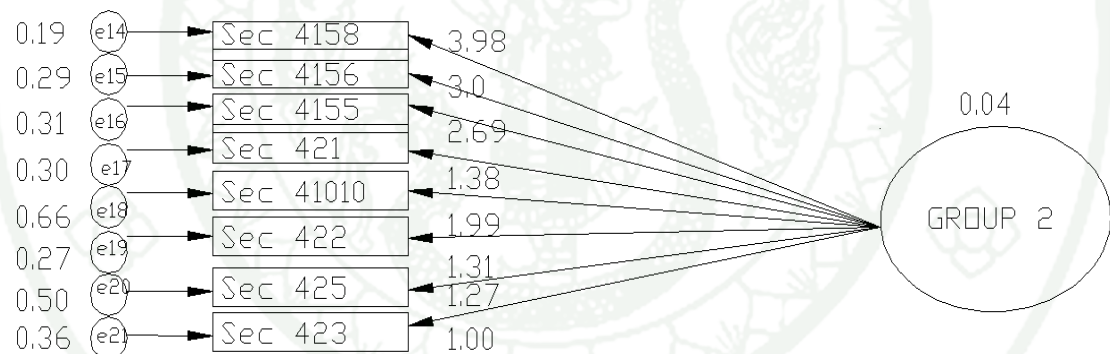
**Table 12** Variance (Group number1).

	Estimate	S.E.	P
Factor1	0.24	0.08	0.002
e13	0.204	0.05	< 0.001
e12	0.175	0.04	< 0.001
e11	0.135	0.03	< 0.001
e10	0.545	0.11	< 0.001
e9	0.311	0.06	< 0.001
e8	0.427	0.08	< 0.001
e7	0.182	0.04	< 0.001

**Table 12** (Continued).

	Estimate	S.E.	P
e6	0.362	0.07	< 0.001
e5	0.296	0.07	< 0.001
e4	0.354	0.07	< 0.001
e3	0.328	0.06	< 0.001
e2	0.184	0.04	< 0.001
e1	0.548	0.1	< 0.001

The result in table 12 displayed p value for factor 1 is 0.002 and the p value for all residual to be less than 0.001. Since the  $P < 0.05$  it indicates statistically significant for factor 1.

**Factor 2(group)****Figure 21** Path analysis for factor 2(Group 2).**Table 13** Goodness of fit (CFA model group 1).

	Absolute fit measures			Incremental fit measures		Parsimony fit measure X
	$\chi^2/df$	GFI	RMSEA	NFI	CFI	AGFI
Obtained	2.537	0.709	0.161	0.582	0.064	0.592

Note:  $\chi^2$  = Chi-square; df= degree of freedom; GFI= Goodness of fit index; RMSEA= Root mean square error of approximation; NFI= Normated fit index; CFI= Comparative fit index; AGFI= Adjusted goodness of fit index

From table 13 based on the result of RMSEA (0.161) it cannot be rejected and Chi-squared  $\chi^2/df$  (2.537) output is less than 5. It is acceptable as goodness of fit index, it was concluded that the factor 1 is fit to the model in relation with the construction affecting quality.

The result in table 14 shows that the p value for factor 2 is 0.236 and the p value for all residual to be less than 0.001 except residual e14 as 0.015 slightly different but still significant for factor 2.

**Table 14** Variance (Group number 2).

	Estimate	S.E.	P
Factor2	0.044	0.037	0.236
e21	0.363	0.068	<0.001
e20	0.499	0.095	<0.001
e19	0.274	0.053	<0.001
e18	0.664	0.128	<0.001
e17	0.298	0.058	<0.001
e16	0.311	0.07	<0.001
e15	0.291	0.068	<0.001
e14	0.188	0.077	0.015

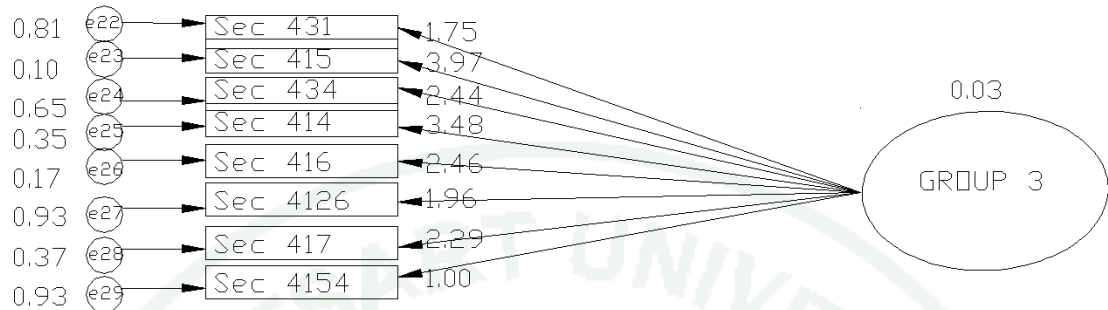
**Table 15** Goodness of fit (CFA model group 2).

	Absolute fit measures			Incremental fit measures		Parsimony fit measure X
	$\chi^2/df$	GFI	RMSEA	NFI	CFI	AGFI
Obtained	3.087	0.779	0.188	0.653	0.722	0.595

Note:  $\chi^2$  = Chi-square; df= degree of freedom; GFI= Goodness of fit index; RMSEA= Root mean square error of approximation; NFI= Normated fit index; CFI= Comparative fit index; AGFI= Adjusted goodness of fit index

According to RMSEA (0.188) and Chi-squared  $\chi^2/df$  (3.087) output is less than 5 result in table 15 is acceptable as goodness of fit index, the proposed model is fit in relation with the construction affecting quality in factor 2.

## Factor 3(group)

**Figure 22** Path analysis for factor 3(Group 3).**Table 16** Variance (Group number 3).

	Estimate	S.E.	P
Factor3	0.028	0.045	0.538
e29	0.933	0.173	<0.001
e28	0.368	0.073	<0.001
e27	0.931	0.175	<0.001
e26	0.167	0.037	<0.001
e25	0.321	0.07	<0.001
e24	0.646	0.125	<0.001
e23	0.102	0.049	0.037
e22	0.81	0.152	<0.001

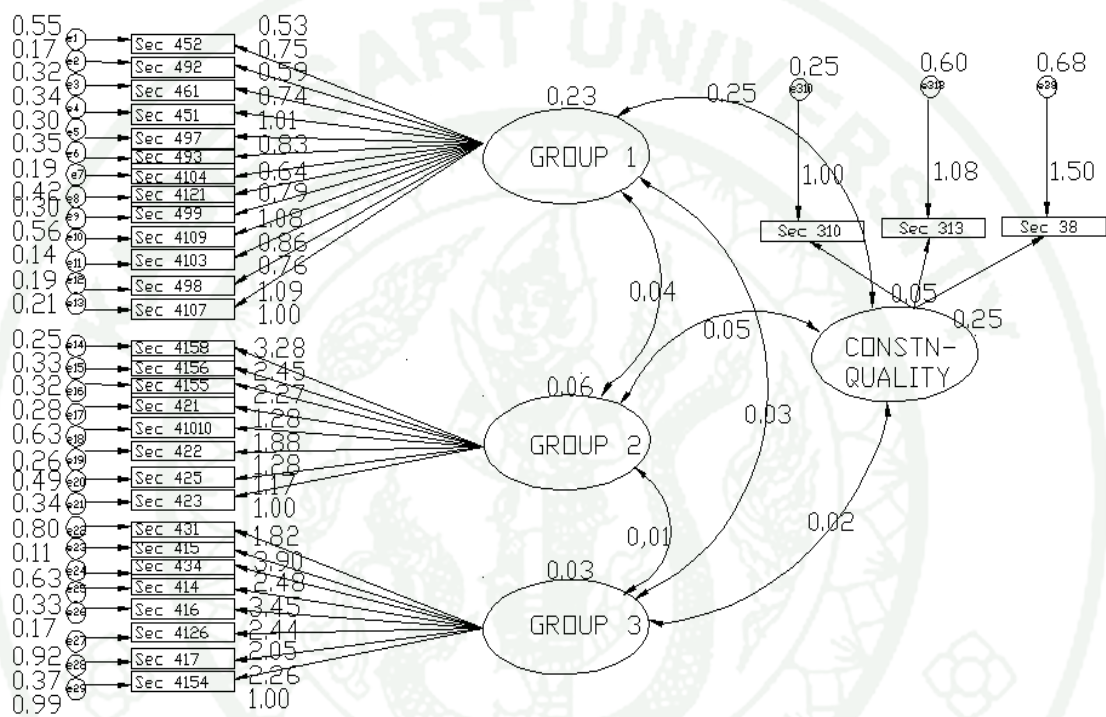
The result in table 16 is depicted showing that the p value for factor 3 is 0.236 and the p value for all residual to be less than 0.001 except residual e23as 0.037 which is still significant for factor 3.

**Table 17** Goodness of fit ( CFA model group 3).

	Absolute fit measures			Incremental fit measures		Parsimony fit measure X
	$\chi^2/df$	GFI	RMSEA	NFI	CFI	AGFI
Obtained	3.087	0.766	0.216	0.583	0.638	0.579

Note:  $\chi^2$  = Chi-square; df= degree of freedom; GFI= Goodness of fit index; RMSEA= Root mean square error of approximation; NFI= Normated fit index; CFI= Comparative fit index; AGFI= Adjusted goodness of fit index

Based on result of RMSEA (0.216) and Chi-squared  $\chi^2/df$  (3.087) output is less than 5 from table 17, it is acceptable as goodness of fit index, it was concluded that the factor 3 is fit to the model in relation with the construction affecting quality. Then afterwards path analysis model for CFA with top three main factor affecting quality were analyzed and the result were determined as in figure 23.



**Figure 23** Path analysis model for CFA with top three main factor.

The result in table 18 shows that the p value for factor 1 is 0.002 and the p value for all residual to be less than 0.001 except residual for Construction quality, e14, e23 were 0.014, 0.002 and 0.021. They were still significant. Since the  $P < 0.05$  indicates a statistically significant difference between groups. Therefore the result for the p value, estimate and SE are significantly acceptable in this model but not significant with the other factor 2 and 3 were 0.154 and 0.533 reconfirming the EFA results. The chi-square computed is 958.073 to measure absolute model fit, degree of freedom is 458 with probability of 0.000 value not greater than 0.05 indication of acceptable model. The reason is Chi-square automatically increases with increasing sample size and p-values reflect increasing power detecting deviations.

**Table 18** Variances for CFA Group 1 (top three).

	Estimate	S.E.	P
factor1	0.235	0.075	0.002
factor2	0.06	0.042	0.154
factor3	0.028	0.046	0.533
Constn_quality	0.229	0.094	0.014
e13	0.209	0.044	<0.001
e12	0.188	0.042	<0.001
e11	0.143	0.03	<0.001
e10	0.561	0.107	<0.001
e9	0.303	0.062	<0.001
e8	0.422	0.081	<0.001
e7	0.185	0.036	<0.001
e6	0.348	0.068	<0.001
e5	0.298	0.06	<0.001
e4	0.342	0.066	<0.001
e3	0.322	0.061	<0.001
e2	0.175	0.035	<0.001
e1	0.546	0.102	<0.001
e21	0.347	0.066	<0.001
e20	0.488	0.092	<0.001
e19	0.259	0.05	<0.001
e18	0.636	0.123	<0.001
e17	0.283	0.055	<0.001
e16	0.319	0.07	<0.001
e15	0.325	0.073	<0.001
e14	0.235	0.078	0.002
e29	0.932	0.172	<0.001
e28	0.368	0.072	<0.001
e27	0.92	0.173	<0.001
e26	0.167	0.037	<0.001
e25	0.321	0.071	<0.001
e24	0.637	0.122	<0.001
e23	0.111	0.048	0.021
e22	0.802	0.15	<0.001
e310	0.247	0.072	<0.001
e313	0.599	0.133	<0.001
e38	0.68	0.18	<0.001

P-values for model chi-squares are pretty useful when sample sizes are less than 200, especially for models that do not include latent variables possessing multi-

ple indicators. In table 19 the Chi-squared( $X^2/df$ ) value 2.115 is  $\leq 5$  that the model is acceptable and GFI and AGFI  $\geq 0.90$  found affected by sample size and the current consensus is not to use these measures (Sharma et al., 2005).

**Table 19** Goodness of fit ( Path analysis CFA model for three main factors).

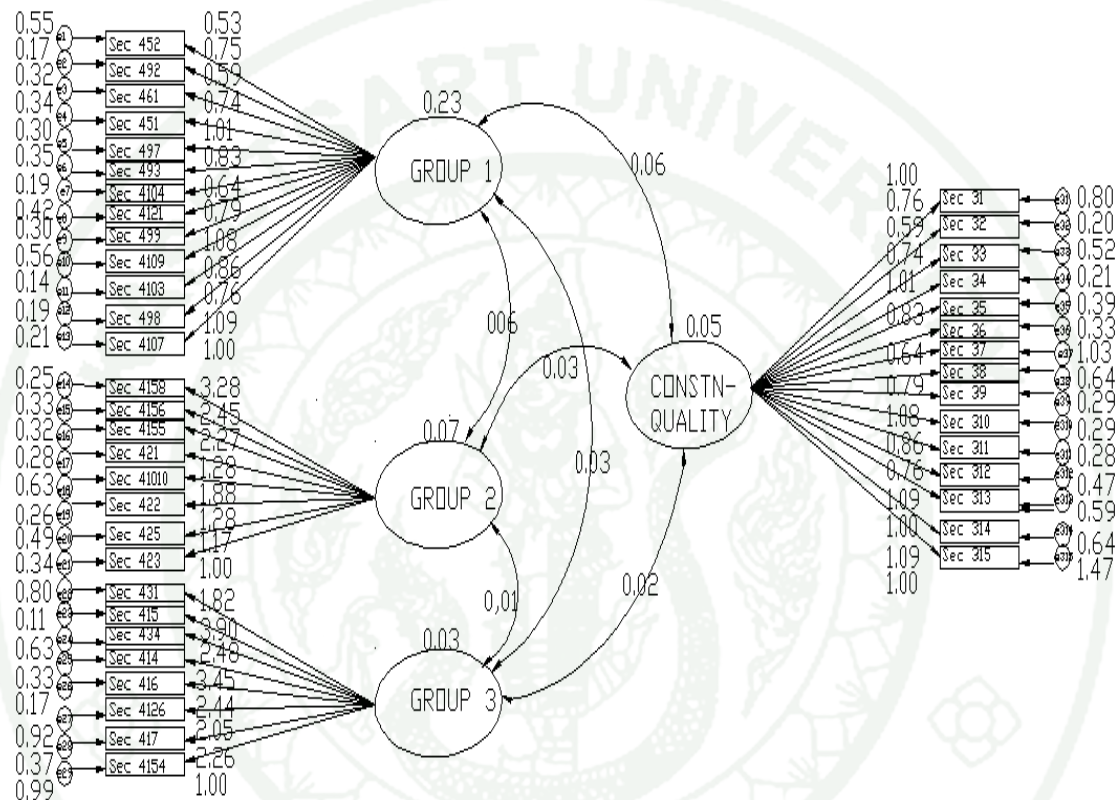
	Absolute fit measures			Incremental fit measures		Parsimony fit measure
	$\chi^2/df$	GFI	RMSEA	NFI	CFI	X AGFI
Obtained	2.115	0.536	0.137	0.335	0.469	0.468

Note:  $\chi^2$  = Chi-square; df= degree of freedom; GFI= Goodness of fit index; RMSEA= Root mean square error of approximation; NFI= Normated fit index; CFI= Comparative fit index; AGFI= Adjusted goodness of fit index

RMSEA is 0.137 showing value in between  $0.08 < RMSEA \leq 0.10$  as significant. RMSEA takes into account the fact that the model might hold approximately rather than exactly in the population. A p-value and a confidence interval can be computed. Indices such as RMSEA are calculated using the chi squared statistics and the degree of freedom of the fitted model, Brown and Cudek, (1993). The NFI is 0.335 which is near to one to be very good fit and acceptable with the model. NFI is relative fit indices. It computes the relative improvement in the overall fit of the fitted model compared to a null model. This is usually the independent model (where the observed variables are assumed to be uncorrelated, Bartholomew et al, (2008). The CFI model is 0.469 although it should be that  $CFI \geq 0.90$  to become very good fit but acceptable from the result. CFI is relative fit indices. It computes the relative improvement in the overall fit of the fitted model compared to a null model. This is usually the independent model (where the observed variables are assumed to be uncorrelated, Bartholomew *et al.* (2008). After CFA analysis by three top main factors further CFA model for all main factors was conducted. Path analysis model for CFA with all main factor affecting quality were analyzed and the result were determined as in figure 24.

The result in table 20 shows that the p value for factor 1, 2, 3 is 0.002, 0.174 and 0.534 respectively. The p value for all residual is less than 0.001 except residual for construction quality, e14, e23 were 0.391, 0.014 and 0.025 respectively. Since the

$P < 0.05$  indicates a statistically significant difference between groups. Therefore the result for the p value, estimate and SE are significantly acceptable in this model but not significant with the other factor 2 and 3 were 0.174 and 0.534 reconfirming the EFA and CFA three main factors analysis results.



**Figure 24** CFA model for all main factors.

**Table 20** Variances CFA (Group number 1).

	Estimate	S.E.	P
Group 1	0.233	0.076	0.002
Group 2	0.069	0.051	0.174
Group 3	0.029	0.046	0.534
Constn_quality	0.051	0.06	0.391
e13	0.211	0.046	<0.001
e14	0.275	0.112	0.014
e29	0.932	0.172	<0.001
e28	0.367	0.073	<0.001

**Table 20** (Continued).

	Estimate	S.E.	P
e27	0.923	0.174	<0.001
e26	0.165	0.037	<0.001
e12	0.184	0.044	<0.001
e11	0.143	0.031	<0.001
e10	0.559	0.107	<0.001
e8	0.425	0.082	<0.001
e7	0.187	0.037	<0.001
e6	0.348	0.069	<0.001
e5	0.295	0.064	<0.001
e4	0.344	0.067	<0.001
e3	0.321	0.061	<0.001
e2	0.175	0.036	<0.001
e1	0.549	0.103	<0.001
e21	0.337	0.069	<0.001
e20	0.478	0.094	<0.001
e19	0.248	0.056	<0.001
e1	0.549	0.103	<0.001
e21	0.337	0.069	<0.001
e20	0.478	0.094	<0.001
e19	0.248	0.056	<0.001
e18	0.628	0.126	<0.001
e17	0.27	0.059	<0.001
e16	0.332	0.084	<0.001
e15	0.344	0.097	<0.001
e25	0.327	0.071	<0.001
e24	0.642	0.124	<0.001
e23	0.107	0.048	0.025
e22	0.803	0.151	<0.001
e310	0.804	0.15	<0.001
e313	0.199	0.038	<0.001
e38	0.52	0.098	<0.001
e315	0.207	0.04	<0.001
e031	0.393	0.077	<0.001
e036	0.326	0.07	<0.001
e037	1.034	0.196	<0.001
e038	0.636	0.143	<0.001
e039	0.29	0.06	<0.001
e0310	0.289	0.064	<0.001

**Table 20** (Continued).

	Estimate	S.E.	P
e0311	0.277	0.054	<0.001
e0312	0.471	0.094	<0.001
e0313	0.587	0.124	<0.001
e0314	0.644	0.137	<0.001
e0315	1.474	0.279	<0.001

**Table 21** Goodness of fit ( Path analysis CFA model for all main factors).

	Absolute fit measures			Incremental fit measures		Parsimony fit measure
	$\chi^2/df$	GFI	RMSEA	NFI	CFI	X AGFI
Obtained	2.183	0.460	0.136	0.242	0.351	0.403

Note:  $\chi^2$  = Chi-square; df= degree of freedom; GFI= Goodness of fit index; RMSEA= Root mean square error of approximation; NFI= Normated fit index; CFI= Comparative fit index; AGFI= Adjusted goodness of fit index

The chi-square computed is 958.073 to measure absolute model fit, degree of freedom is 458 with probability of 0.000 value not greater than 0.05 indicating as acceptable model. The reason is Chi-square automatically increases with increasing sample size and p-values reflect increasing power detecting deviations. P-values for model chi-squares are pretty useful when sample sizes are less than 200, especially for models that do not include latent variables possessing multiple indicators. In table 21 Chi-squared( $X^2/df$ ) value is 2.183 is  $\leq 5$  that the model is acceptable, found GFI and  $AGFI \geq 0.90$  affected by sample size and the current consensus is not to use these measures (Sharma et al., 2005). RMSEA is 0.137 showing value in between  $0.08 < RMSEA \leq 0.10$  as significant. RMSEA takes into account the fact that the model might hold approximately rather than exactly in the population.

The p-value and a confidence interval can be computed. Indices such as RMSEA are calculated using the Chi-squared statistics and the degree of freedom of the fitted model, Brown and Cudek, (1993).The NFI is 0.242 which is near to one to be very good fit and acceptable with the model. NFI is relative fit indices. It computes

the relative improvement in the overall fit of the fitted model compared to a null model. This is usually the independent model (where the observed variables are assumed to be uncorrelated, Bartholomew et al, (2008). The CFI model is 0.351 although it should be that  $CFI \geq 0.90$  to become very good fit but acceptable from the result. CFI is relative fit indices. It computes the relative improvement in the overall fit of the fitted model compared to a null model.

This is usually the independent model (where the observed variables are assumed to be uncorrelated, Bartholomew *et al.* (2008). After CFA analysis by three top main factors further CFA model for all main factors was conducted.

#### 4. Structural equation modeling

Structural equation modeling priori hypothesized based on 15 main factors of section 3 were analyzed. The depicted figure 25 SEM bases on 15 main factors given and table 22 showing the output for the model with 15 main factors are tested for running priori hypothesis test. The detail of indicators for group factors used was same as in figure 23 and 24.

Hypothesis construct

##### 1. Hypothesis A

$H_0$  : The group 1 does not affect to the construction quality.

$H_1$  : The group 1 affect to the construction quality.

The p-value is 0.207 which is greater than significant level 0.05. Thus we cannot reject the  $H_0$ .

##### 2. Hypothesis B

$H_0$  : The group 2 does not affect to the construction quality.

$H_1$  : The group 2 affect to the construction quality.

The p-value is 0.174 which is greater than significant level 0.05. Thus we cannot reject the  $H_0$ .

3. Hypothesis C

H<sub>0</sub> : The group 3 does not affect to the construction quality.

H<sub>1</sub> : The group 3 affect to the construction quality.

The p-value is 0.386 which is greater than significant level 0.05. Thus we cannot reject the H<sub>0</sub>.

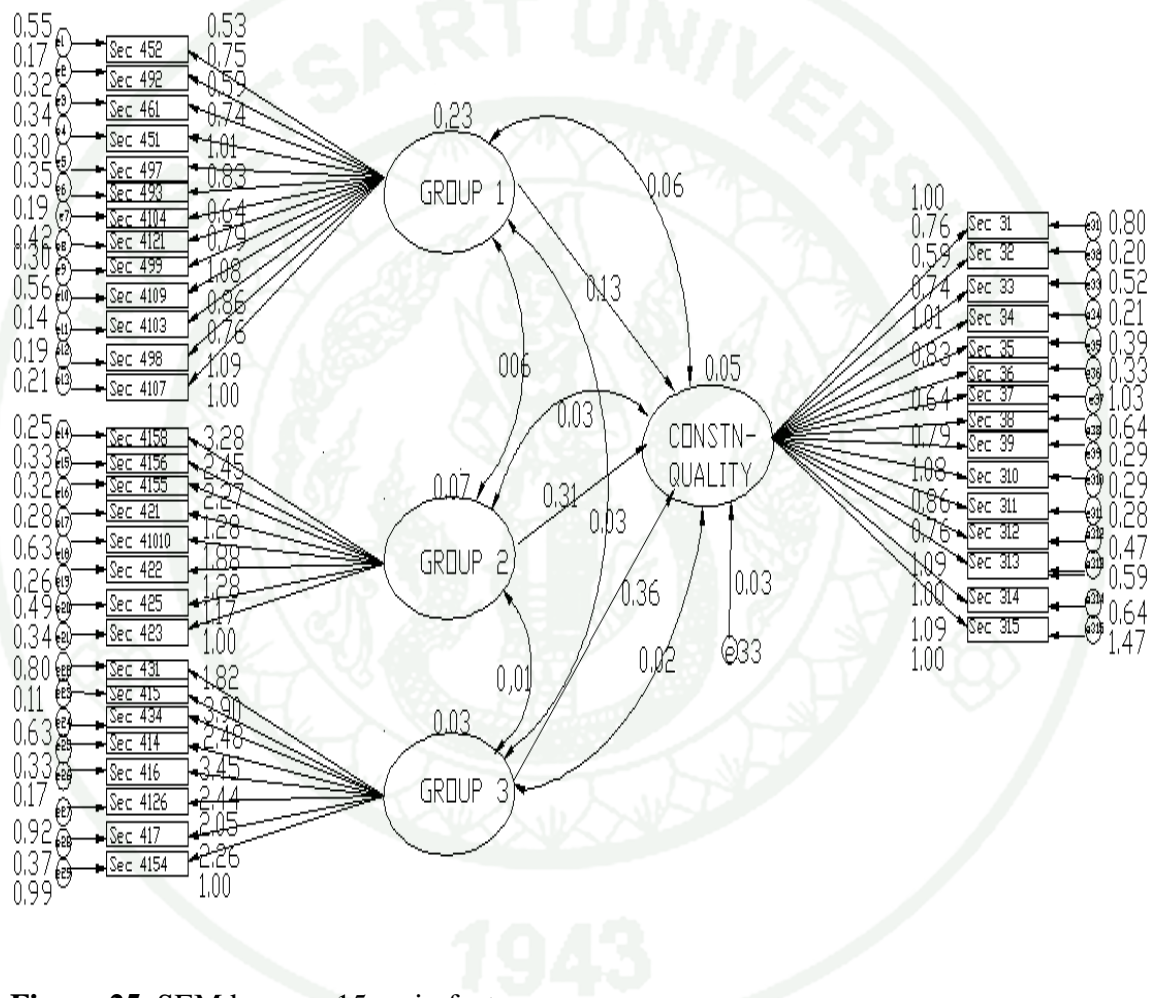
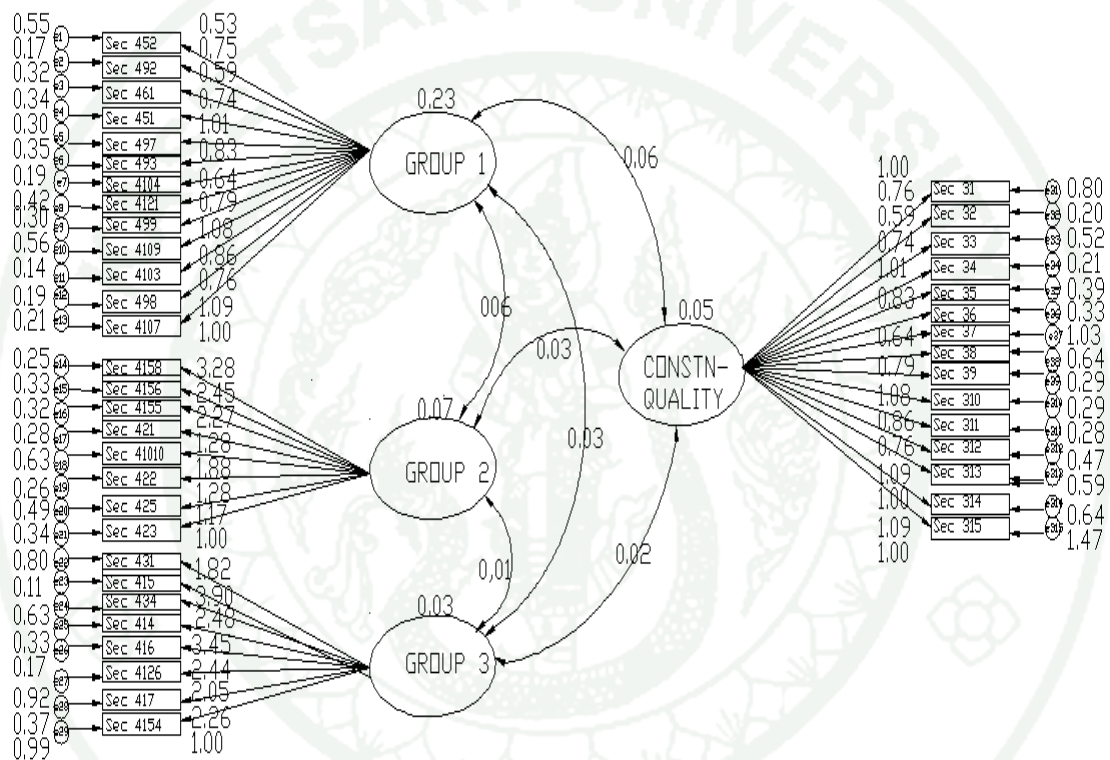


Figure 25 SEM base on 15 main factors.

Table 22 Output Model with 15 main factors.

Variables			Estimate	S.E	P
Construct_quality	<---	Group 1	0.127	0.101	0.207
Construct_quality	<---	Group 2	0.314	0.231	0.174
Construct_quality	<---	Group 3	0.363	0.419	0.386

As per the SEM model it is concluded that hypothesis A, B, C testing group 1, 2 and 3 does not affect to the construction quality. This means factors in group 1, 2 and 3 are affecting quality. Then the path analysis model for CFA with 15 main factor affecting quality was analyzed and the result was determined and presented in figure 26. The path analysis result of figure 26 resulted table 23 for cross verifying the goodness of fit.



**Figure 26** Path analysis model for CFA with the entire main factor.

**Table 23** SEM measurement error for all main factors.

	Estimate	S.E.	P
Group 1	0.233	0.076	0.002
Group 2	0.069	0.051	0.174
Group 3	0.029	0.046	0.534
Constn.qlty	0.051	0.06	0.391
e13	0.211	0.046	<0.001
e12	0.184	0.044	<0.001

**Table 23** (Continued).

	Estimate	S.E.	P
e11	0.143	0.031	<0.001
e10	0.559	0.107	<0.001
e9	0.302	0.062	<0.001
e8	0.425	0.082	<0.001
e7	0.187	0.037	<0.001
e6	0.348	0.069	<0.001
e5	0.295	0.064	<0.001
e4	0.344	0.067	<0.001
e3	0.321	0.061	<0.001
e2	0.175	0.036	<0.001
e1	0.549	0.103	<0.001
e21	0.337	0.069	<0.001
e20	0.478	0.094	<0.001
e19	0.248	0.056	<0.001
e18	0.628	0.126	<0.001
e17	0.27	0.059	<0.001
e16	0.332	0.084	<0.001
e15	0.344	0.097	<0.001
e14	0.275	0.112	0.014
e29	0.932	0.172	<0.001
e28	0.367	0.073	<0.001
e27	0.923	0.174	<0.001
e26	0.165	0.037	<0.001
e25	0.327	0.071	<0.001
e24	0.642	0.124	<0.001
e23	0.107	0.048	0.025
e22	0.803	0.151	<0.001
e310	0.804	0.15	<0.001
e313	0.199	0.038	<0.001
e38	0.52	0.098	<0.001
e315	0.207	0.04	<0.001
e031	0.393	0.077	<0.001
e036	0.326	0.07	<0.001
e037	1.034	0.196	<0.001
e038	0.636	0.143	<0.001
e039	0.29	0.06	<0.001
e0310	0.289	0.064	<0.001
e0311	0.277	0.054	<0.001
e0312	0.471	0.094	<0.001
e0313	0.587	0.124	<0.001

**Table 23** (Continued).

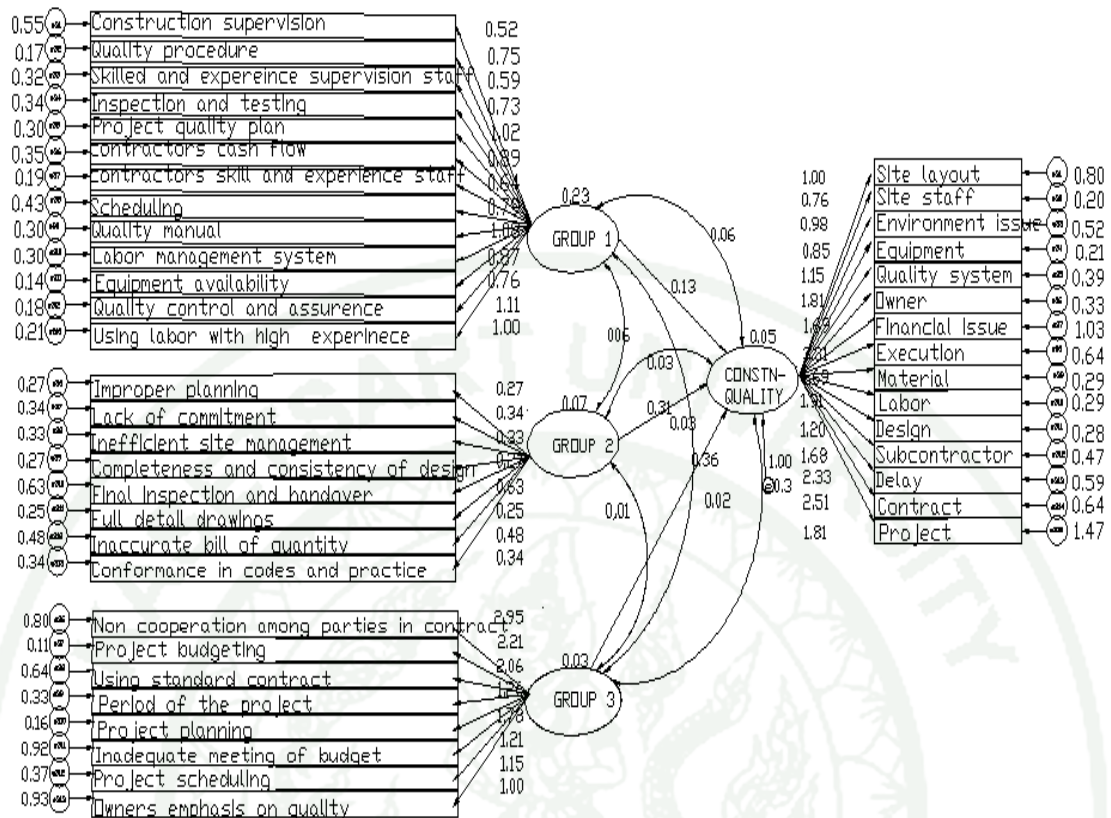
	Estimate	S.E.	P
e0314	0.644	0.137	<0.001
e0315	1.474	0.279	<0.001

The result in table 23 shows similar result as in CFA that the p value for factor 1, 2 and 3 is 0.002, 0.174, and 0.534 respectively. The p value for all residual is less than 0.001 except residual for Construction quality, e14, e23 were 0.391, 0.014 and 0.025. Since the  $P < 0.05$  indicates a statistically significant difference between groups. Therefore, the result for the p value, estimate and SE are significantly acceptable in this model but not significant with the other factor 2 and 3, these factors were 0.174 and 0.534, reconfirming the EFA and CFA three main factors analysis results. The Chi-square computed is 958.073 to measure absolute model fit, degree of freedom is 458 with probability of 0.000 value not greater than 0.05 indication of acceptable model. The reason is, Chi-square automatically increases with increasing sample size and p-values reflect increasing power detecting deviations. P-values for model Chi-squared are pretty useful when sample sizes are less than 200, especially for models that do not include latent variables possessing multiple indicators.

**Table 24** Goodness of fit ( Path analysis SEM model for three main factor).

	Absolute fit measures			Incremental fit measures		Parsimony fit measure X
	$\chi^2/df$	GFI	RMSEA	NFI	CFI	AGFI
Obtained	2.183	0.460	0.142	0.242	0.351	0.403

Note:  $\chi^2$  = Chi-square; df= degree of freedom; GFI= Goodness of fit index; RMSEA= Root mean square error of approximation; NFI= Normated fit index; CFI= Comparative fit index; AGFI= Adjusted goodness of fit index



**Figure 27** Path analysis model for SEM with the entire main factor.

In table 24 the Chi-squared( $X^2/df$ ) value 2.183 is  $\leq 5$  that the model is acceptable, found GFI and AGFI  $\geq 0.90$  affected by sample size and the current consensus is not to use these measures (Sharma, Mukherjee, Kumar, & Dillon, 2005). RMSEA is 0.142 slightly more showing value in between  $0.08 < RMSEA \leq 0.10$  as significant. RMSEA takes into account the fact that the model might hold approximately rather than exactly in the population. A p-value and a confidence interval can be computed. Indices such as RMSEA are calculated using the Chi squared statistics and the degree of freedom of the fitted model, Brown and Cudek, (1993).

The NFI is 0.242 which is between zero to one to be very good fit but found acceptable with the model. NFI is relative fit indices. It computes the relative improvement in the overall fit of the fitted model compared to a null model. This is usually the independent model (where the observed variables are assumed to be uncorrelated, Bartholomew et al, (2008). The CFI model is 0.351 although it should be that

CFI  $\geq 0.90$  to become very good fit but acceptable from the result. CFI is relative fit indices. It computes the relative improvement in the overall fit of the fitted model compared to a null model. This is usually the independent model (where the observed variables are assumed to be uncorrelated, Bartholomew et al, (2008). After CFA analysis by all main factors further SEM model for all main factors was conducted. The SEM with 15 main factor was analyzed through various possible means. The final model for resulting goodness of model fit is depicted in figure 27.

**Table 25** Variances (Group number 1).

	Estimate	S.E.	P
Group 1	0.233	0.076	0.002
Group 2	0.069	0.051	0.174
Group 3	0.029	0.046	0.534
e33	0.028	0.033	0.396
e13	0.211	0.046	<0.001
e12	0.184	0.044	<0.001
e11	0.143	0.031	<0.001
e10	0.559	0.107	<0.001
e9	0.302	0.062	<0.001
e8	0.425	0.082	<0.001
e7	0.187	0.037	<0.001
e6	0.348	0.069	<0.001
e5	0.295	0.064	<0.001
e4	0.344	0.067	<0.001
e3	0.321	0.061	<0.001
e2	0.175	0.036	<0.001
e1	0.549	0.103	<0.001
e21	0.337	0.069	<0.001
e20	0.478	0.094	<0.001
e19	0.248	0.056	<0.001
e18	0.628	0.126	<0.001
e17	0.27	0.059	<0.001
e16	0.332	0.084	<0.001
e15	0.344	0.097	<0.001
e14	0.275	0.112	0.014
e29	0.932	0.172	<0.001
e28	0.367	0.073	<0.001
e27	0.923	0.174	<0.001
e26	0.165	0.037	<0.001
e25	0.327	0.071	<0.001
e24	0.642	0.124	<0.001
e23	0.107	0.048	0.025
e22	0.803	0.151	<0.001
e310	0.804	0.15	<0.001
e313	0.199	0.038	<0.001

**Table 25** (Continued).

	Estimate	S.E.	P
e38	0.52	0.098	<0.001
e315	0.207	0.04	<0.001
e031	0.393	0.077	<0.001
e036	0.326	0.07	<0.001
e037	1.034	0.196	<0.001
e039	0.29	0.06	<0.001
e0310	0.289	0.064	<0.001
e0311	0.277	0.054	<0.001
e0312	0.471	0.094	<0.001
e0313	0.587	0.124	<0.001
e0314	0.644	0.137	<0.001
e0315	1.474	0.279	<0.001

The result in table 25 shows similar result as in CFA that the p value for factor 1, 2 and 3 are 0.002, 0.174, 0.534, respectively. The p value for all residual is less than 0.001 except residual for e14, e23 and e33 were 0.014, 0.025, 0.396 respectively. Since the  $P < 0.05$  indicates a statistically significant difference between groups. Therefore the result for the p value, estimate and SE are significantly acceptable in this model but not significant with the other factor 2 and 3 were 0.174 and 0.534 reconfirming the EFA and CFA all main factors analysis results. The minimum chi-square computed is 1955.583 to measure absolute model fit, degree of freedom is 896 with probability of 0.000 value not greater than 0.05 indicating acceptable model. The reason is Chi-square automatically increases with increasing sample size and p-values reflect increasing power detecting deviations as mentioned before. P-values for model Chi-squared are pretty useful when sample sizes are less than 200, especially for models that do not include latent variables possessing multiple indicators as current sample study is against 200 samples. The final output resulted in table 23 was verified cautiously for treating it as final model.

In table 26 the Chi-squared( $X^2/df$ ) value 2.183 is  $\leq 5$  that the model is acceptable, found GFI(0.460) and AGFI(0.403) is not  $\geq 0.90$  affected by sample size and the current consensus is not to use these measures (Sharma, Mukherjee, Kumar, & Dillon, 2005). RMSEA is 0.142 slightly more from in between  $0.08 < RMSEA \leq$

0.10 as to call it significant. RMSEA takes into account the fact that the model might hold approximately rather than exactly in the population.

**Table 26** Goodness of fit ( Path analysis SEM model including all main factors).

	Absolute fit measures			Incremental fit measures		Parsimony fit measure
	$\chi^2/df$	GFI	RMSEA	NFI	CFI	X AGFI
Obtained	2.183	0.460	0.142	0.242	0.351	0.403

Note:  $\chi^2$  = Chi-square; df= degree of freedom; GFI= Goodness of fit index; RMSEA= Root mean square error of approximation; NFI= Normated fit index; CFI= Comparative fit index; AGFI= Adjusted goodness of fit index

A p-value and a confidence interval can be computed. Indices such as RMSEA are calculated using the Chi-squared statistics and the degree of freedom of the fitted model Brown and Cudek, (1993). The NFI is 0.242 which is not very near to one to be very good fit but found acceptable with the model. NFI is relative fit indices. It is used to compute the relative improvement in the overall fit of the fitted model compared to a null model. This is usually the independent model (where the observed variables are assumed to be uncorrelated Bartholomew *et al.* (2008). The CFI model is 0.351 although it should be that  $CFI \geq 0.90$  to become very good fit but still acceptable from the result. CFI is also relative fit indices. It computes the relative improvement in the overall fit of the fitted model compared to a null model. This is usually the independent model (where the observed variables are assumed to be uncorrelated, Bartholomew *et al.*, (2008). After CFA analysis by all the main factors was followed by SEM model for all the main factors path analysis. In this result RMSEA output obtained is satisfying the goodness of fit index. Finally the model in relation with the construction affecting quality was determined.

CFA and SEM path analysis model fit obtained after attempting by different SEM statistical possible technique test or attempting by increasing number and reduction of factors in the indicators. Similarly in observed main factors variables. Choosing the first best 20 factors loading did not run EFA analysis adequately. Similarly by varying test in increasing and decreasing the indicator of the path diagrams. It did not

run any results better than deciding with the top 50 mean sub-factors out of 117 factors. Therefore, top 50 factors were used for computation. It's correlation between the observed and latent variable from 29 factors affecting quality are measured in this research.

The model agreement was subjected to the following argument regarding the impact of model developed from 60 samples which are against literature revelation as follows:

- The requirement of sufficient sample size was not enough as per the literature requirement and in this research study we have 60 respondents.
- A desirable goal is to have a 20:1 ratio for the number of subjects to the number of model parameters. Thus the estimates were unstable.

There were varying views and it is revealed that the role of sample size in SEM is crucial in all statistical analysis (Lucko and Rojas, 2010). The more sophisticated the statistical analysis the larger the sample needed. Therefore, the sample size requirement is a function of the model or framework development method in consideration. SEM, like other statistical techniques, requires an appropriate sample size in order to produce reliable estimates reveals (Hair *et al.* 2008) but (Gorsuch, 1983) suggests at least 5 participants per construct and not less than 100 individuals per data analysis. According to (Harris and Schaubroeck, 1990) propose a sample size of 200 at least to guarantee robust structural equation modeling and (Kline, 2010) suggested that a very complicated path model needs a sample size of 200 or larger. (Bagozzi and Yi, 2012) proposed that the sample size should be above 100, preferably above 200. In addition (Yuan, *et al.* 2010) after evaluating different models based on various numbers of respondents opined that a sample size of between 300 and 400 should be appropriate for structural equation models using ordinal data. This is found similarly said by (Hair, *et al.* 2008) who recommend sample size of at least 200 but not exceeding 400. It was further pointed out that when the sample size exceeds 400 to 500 participants, the SEM analysis becomes too sensitive and almost any difference is detected, making goodness-of-fit measure poor.

Kenny(2014) after all above discussions reveals that, having a good-fitting model does not prove that the model is correctly specified. Conversely, it is also to be noted, that a model all of whose parameters are statistically significant can be from a poor fitting model. In this research the parameters of SEM model depicted from above figure 27 is a weak model comparing in terms of best goodness of fit. The model is still agreeable and plausible based on the analysis for the main and sub-factor. In addition both the hypothesis test result was not failed in CFA and SEM model. The SEM model cannot be rejected because both hold GFI and AGFI value less than 0.90 which are affected by sample size. The current consensus is not to use these measures (Sharma, *et al.* 2005). It is still a good model according to the above statement revealed by Kenny (2014). In proportionate to small sample size the model was resulted. Also when it is faced by few poor parameters from best parameters result as discussed. These findings of factors correlation can be adopted agreeing with Kenny's (2014) statement.

## 5. Comparative study

The comparative study reflects understanding about factor affecting in respect of time, cost and quality relationship and its most influential factors affecting quality by factor loading. The research question is to find out the main and sub-factors affecting construction quality. The table 27, 28 and 29 were compared in the descending order as determined by the factor loading.

**Table 27** Final group 1 latent variable result of EFA, CFA & SEM.

Group 1				
No	Code	loading	Sub-factor	Main factor
1	sec498	0.779	Quality procedures.	Quality system
2	sec4107	0.725	Construction supervision Skill and experience supervision	Site staff
3	sec4103	0.698	staff	Quality system
4	sec497	0.673	Quality manual	Quality system
5	sec499	0.671	Project quality plans	Quality system

**Table 27** (Continued).

Group 1				
No	Code	loading	Sub-factor	Main factor
6	sec492	0.656	Implement quality control and assurance system	Quality system
7	sec4104	0.582	Skill and experience contractor's staff.	Site staff
8	sec493	0.563	Implement and using time schedule	Quality system
9	sec451	0.516	Labor management system	Labor
10	sec4121	0.504	The amount of contractor's cash flow	Financial issue
11	sec4109	0.491	Inspection and testing.	Site staff
12	sec461	0.45	Availability of equipment	Material
13	sec452	0.322	Using labor with high experience	labor

**Table 28** Final Group 2 latent variable result of EFA, CFA & SEM.

Group 2				
No	Code	loading	Subfactor	Main factor
1	sec4158	0.829	Improper planning	Delay
2	sec4156	0.704	Lack of commitment	Delay
3	sec4155	0.686	Inefficient site management	Delay
4	sec421	0.539	Completeness and consistency of design documents support quality control / assurance	Design
5	sec422	0.538	Drawings are prepared in full details to required design quality.	Design
6	sec41010	0.499	Final inspection and handover	Site staff
7	sec423	0.413	Conformance to codes and standards	Design
8	sec425	0.402	Bill of quantity is very detailed and accurate as per required design quality	Design

**Table 29** Final group 3 latent variable result of EFA, CFA & SEM.

Group 3				
No	Code	loading	Sub-factor	Main factor
1	sec415	0.896	Project budgeting.	Project
2	sec416	0.714	Project planning.	Project
3	sec414	0.71	Period of the project	Project

**Table 29** (Continued).

Group 3				
4	sec417	0.534	Project Scheduling	Project
5	sec434	0.458	Using a standard contract	Contract
6	sec4126	0.334	Meeting the budget.	Financial issue
7	sec431	0.322	Cooperation between parties involved in contract	Contract
8	sec4134	0.172	Owner's emphasis on quality	Owner
4	sec417	0.534	Project Scheduling	Project

**Table 30** Main factor resulted from main factor ranking.

Main factor				
No	Code	Mean	Loading factor	Main Factor
1	s38	3.97	0.685	Site layout
2	s310	4.3	0.627	Site staff
3	s314	3.87	0.587	Environmental issue
4	s36	4.35	0.584	Equipment
5	s39	4.62	0.579	Quality system
6	s313	4.03	0.567	Owner
7	s312	4.32	0.485	Financial issue
8	s311	4.5	0.458	Execution
9	s34	4.7	0.389	Material
10	s35	4.35	0.383	Labor
11	s32	4.73	0.36	Design
12	s37	3.55	0.352	Sub-contractor
13	s315	3.3	0.321	Delay
14	s33	4.28	0.296	Contract
15	s31	4.33	0.245	Project

From table 27 the most influential ranking is quality system (quality procedure). The factor loading determined is 0.779 with the least factor loading of 0.322 for labor (using labor with unskilled). Statistically from the above table 28 delay (improper planning) rank the top main factor loading of 0.829 with the least ranking of design (Bill of quantity is very detailed and accurate as per required design quality) factor loading of 0.402 in group 2(factor). Also statistically from table 29 it ranked pro-

ject (Project budgeting) with factor loading of 0.896 with the least ranking of owner (Owner's emphasis on quality) factor loading of 0.172.

The table 30 depicts statistically site layouts rank the top main factor loading by 0.685. The least ranking was project factor loading of 0.245 contradicting with the main factor determined from the sub-factor ranking as mentioned.

This indicated ranking section 3 questionnaire is found biased with the perception of respondents. Also after site staff all factor loadings were below 0.60 factors loading. Therefore the result Section 4 analyses performed were finalized for determination of strategic guidelines for continuous quality improvement.

## 6. Choosing the right strategy

An organization that wants to be best-in-class in the long term and wants an orderly way to get there must select a quality planning strategy. From the findings for measuring, the strategic guideline for the quality improvement is developed and presented in table 31.

**Table 31** Strategy.

No	Main factor	Sub factor loading	Factor Loading
1	Project	Project budgeting.	0.896
2	Delay	Improper planning	0.829
3	Quality system	Quality procedures.	0.779
4	Site staff	Construction supervision	0.725
5	Project	Project planning.	0.714
6	Project	Period of the project	0.71
7	Delay	Lack of commitment	0.704
8	Site staff	Skill and experience supervision staff	0.698
9	Delay	Inefficient site management	0.686
10	Quality system	Quality manual	0.673

They are the relatively correlated factors as determined. This could benefit in the management of cost planning, control and for constant improvement in the construction sector.

Timothy (2003) reveals in the NDIA conference that most organizations have about 33% in costs of poor quality (e.g., rework, waste, scrap and others). About 80% of all quality efforts have no measurable results. According to Dr. Juran, most failures in quality are due to a poor choice of strategy. In order to choose a quality strategy wisely, organizations need to know how to manage for quality (Timothy, 2003). In managing quality that requires quality planning, control, and improvement strategies. The best-in-class quality organizations they use successful fundamental quality strategies. Choosing a model for implementing the organization's quality goals, objectives and strategy. Quality organizations use many improvement strategies and use many models. The advantage and disadvantage of choosing the right model can be meaningful to decide the right strategy. An organization on a tight budget that needs cost savings and quick return of investment should pick a quality improvement strategy as shown in table 31 for adoption.

## CONCLUSION AND RECOMMENDATION

### 1. Conclusion

The conclusions of this research after understanding definitions and concept of quality. Various literature reviews on factors attributing to international construction quality problems were made. It gave the direction for research study on construction quality problem in Bhutan for essentially understanding its impact and the benefit. The mix mood methodology included identifying secondary quality factors based on former studies, questionnaire design, data collection, and data analysis by EFA, CFA and SEM model development approach for strategic guideline. Lastly defining the most influencing factors and their relative importance. The research study undertook proportional sampling comprising of 30 equal participants from both government and private organizations with 0% non-response rate. Qualitative local quality factors were determined from a processed questionnaire. Analysis by EFA, CFA, SEM interfering with excel sheet (2007) was conducted. Quantitatively SEM model resulted strategic guidelines. Recommendations are made from the comparative findings. It was attempted with structured inquiry that utilized acceptable scientific methods to measure, manage problems and improving in order to benefit time, cost and quality in construction. For creating new findings that is generally applicable from the Bhutanese construction point of view are made.

The findings from section 3 and section 4 questionnaire initially revealed from the mean scores result were project planning due to inadequate project conceptualization, availability of good quality construction materials due to site staff and completeness & consistency of design document due to inconsistent design problem. After the EFA, CFA and SEM analysis the main factors affecting construction quality are found in the area of project, delay and quality system. All of these problems addressed to measure, manage and improve the construction quality through sequential order. The order of factor loading from higher to lower impact are presented. Out of 29 sub-factor findings only 10 sub-factors are recommended that resulted based on influential factor loading above 0.60 value as tabulated in table 31 for practical reasons.

From this findings construction sector in Bhutan is subjected for mitigating it. The conceptual configurations and components to meet the intended use from initial stage. According to the perception of respondents it is indicating problems in scope of project, location of project, site access, period of the project, project budgeting, planning, scheduling, tracking and close out problems. Among these project budgeting, planning, scheduling and period of the project are identified having relationship for mitigation. It is also indicating weak in the area of project investment analysis and estimation in the beginning of project configuration. This may lead to severe failure in the construction sector if viewed from planning, management and implementation point of view. This could be remedied only through its effective correction in terms of short and long term courses in project management in tertiary education level ranging from vocational institute to master level above in organizations, institute, implementing organization, other allied organizations and engineering colleges..

Delay in construction (Bhutan) is found to have most recurring problems like any other countries. The variables are application of just in time philosophy, unstable prices of construction materials economic in the market, supply of construction materials economic in the market, consistent time frame, compensation, cost, claim for the approval of submittals in existing conditions in standard contracts, inefficient site management, lack of commitment, poor site coordination, improper planning, lack of clarity in project scope, late deliveries and user changes. Among the mentioned variables improper planning, lack of commitment and inefficient site management needed to be focus adequately. This is indicating poor scheduling failure from initial to close out phase.

The most daunting issue in this research was quality system problem. Those variables are like computer software and applications, not implementing quality control and assurance system, not implementing time schedule, cost control system, safety program, problem of communication in construction, quality manual, quality procedures, project quality plans and quality records. Among this variables quality pro-

cedures and quality manual needs more attention by implementing agency that needs improvement based on local context.

Site staff is another problem indicated for not having construction supervision, lack of skill and experience supervision that need be adequately improved by the management of construction organization.

The quality of design is used for the constructions to avoid unusual features and well-defined scope. Despite its technological advance, the construction industries have to pay attention to the quality of its design documents. Defective design produced is riskier for the success of a project. To study the quality of design documents in the industry by factors that influence design documents quality and their impact on the construction process is necessary. Factors indicated are completeness and consistency of design documents that need support to quality control /assurance, drawings are not prepared in full details to required design quality, conformance to codes and standards and bill of quantity is not very detailed and accurate as per required design quality.

Therefore, the above findings are required to measure, manage and improve constantly through efficiency and effectiveness both by government and private organization. It is showing current severe economic loss in terms of time, cost and quality. The finding is demanding abounding improvement in the subject area specialization in construction management engineering and project management, information technology for construction operation, management of construction organization, advanced project planning and controlling, project investment analysis, building construction technology and advance computer applications. The above subjects can be introduced at all level of private and government professional implementing institute. It can be linked through subject's improvement in vocational training institute, diploma engineering institute, engineering colleges ranging up to post graduate level and other similar stakeholders. Then only continuous quality improvement in the construction industry can be enhanced to reach competitive edge to meet the objective of the construction sector.

## 2. Recommendation

To measure, manage and improve the quality in construction as per the findings, corrective measures by training, workshops, seminar, short term courses, long term courses and lastly improvement in curriculum in all concern technical institute and implementing organization comprising both private and government can be initiated and ascertain in the following area for continuous quality improvement are as follows.

- 1) The project budgeting problem before start of project must be adequately improved through project investment analysis performance and correct estimation. Project investment analysis can be achieved through making awareness in workshops, seminar and short term courses for concern project officials. The feasibility analysis, time value of money analysis, cash flow, project evaluation, present value of special cash flow corresponding with concept of principle and interest are tools to develop any project budgeting that are required to pay importance.
- 2) Improper planning before start of project must be improved understanding project review, owners orientation, organization structure, work break down structure, forming project team, work package, kick off meeting, follow up and project work planning requirement. All these planning must be improved through enforcing network diagram analysis for early start date, total float, free float, latest start date, critical path method, precedence method and use of software. For private organization use of software is necessary through courses of workshops, training and building in curriculum at all ranges of institute, private and government organization concern. This will avoid delay due to planning.
- 3) Quality procedures are part of quality system requirement to confirm to specific quality requirements including preparation and its effectiveness in documented quality system procedures and instruction. To be more specific for

continuous improvement lessons learned must be used to enhance product and services to retain existing and welcome new procedures. It can be enforced by compulsory project members meeting, weekly/monthly, drawing and equipment index, distribution of documents, empowering authority/responsibility of checklist for work status and tracking, checklist of duty for designing, team management, evaluation of design effectiveness, constructability and post design review are required to improve.

- 4) To improve construction supervision for site staff for undertaking projects to meet quality requirement in implementing. They must be enforced to undertake various administrative procedures at site office with relevant standards after planning, design, bidding and award phase. It is indicated more emphasis are required to be enforced from assumption of construction phase by keeping record of successful project, keeping relation with contractors, contract administration, making awareness of quality among workers, site document control, inspection and testing, corrections for nonconformance, handling and storage, preparing checklist for duties, quality control, dispute resolution, job site safety, management of changes and resource management.
- 5) Project planning must be improved by application of project scheduling by critical path method and precedence method, S-curve for cost in flow and out flow and work progress followed by trend analysis right from the start of any project.
- 6) Period of the project must be improved before start of any project strictly by adequate design of project scope covering study on location of site, job site access, budgeting, planning, scheduling, tracking and close out considerations.
- 7) Lack of commitment can make delay. It must be improved by awareness of concept of management in organization by its way of process, thoughts, ethics, human management, leadership, individuality, motivation, team work, communication and experience sharing are required to enforced. Commitment for importance of drawings, adequate early planning, avoiding slowness of deci-

sion making process, consistent time frame, efficient site management, site coordination, user changes information are necessary for enforcement.

8) Skill and experience supervision for private and government site staff must be from roles and responsibilities of designs and supervision of the construction projects. The construction must demonstrate extensive experience and to meet engineering competency, the knowledge and ability to use various techniques and methods to design and construct physical infrastructures must have pivotal role by applying codes and safety regulations required. It is recommended to improve structured processes to maximize the efficiency and effectiveness of construction projects in the following area.

- Lesson of cooperation between supervision and contractor's staff.
- Making understand contract administration by supervision staff.
- Creating knowledge base system for professionals to learn from similar past projects.
- Giving exposure for quality management system among workers.
- Site document control.
- Inspection and testing.
- Final inspection and hand over.
- Correcting nonconformance of specifications of work.
- Improving handling and storage system.
- Construction supervision.
- Performance of trend analysis for project evaluation.
- Training on applicable building codes and safety regulations to ensure compliance.

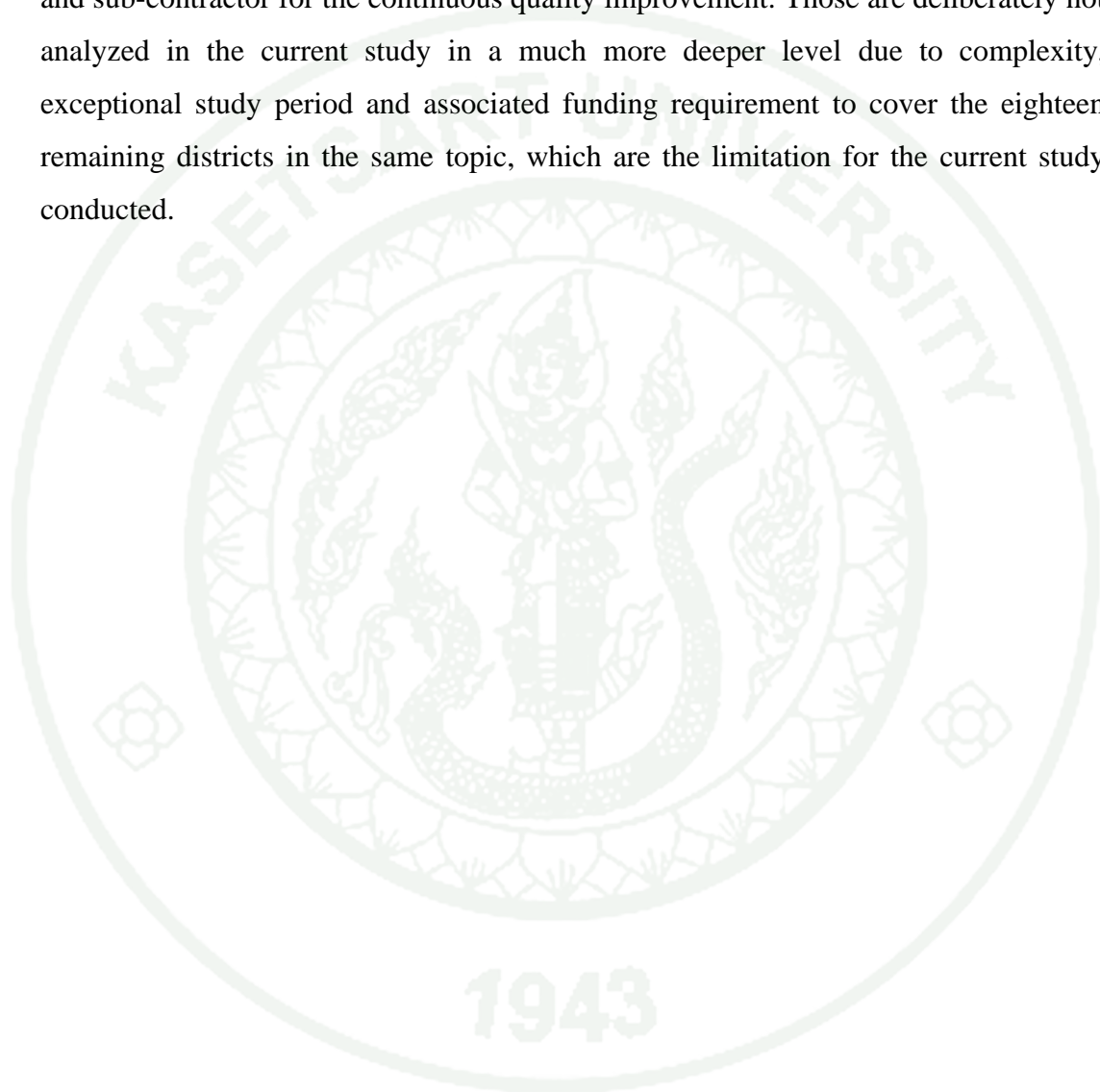
9) Inefficient site management that caused delay must be improved by correct delivery, clarifying project scope, proper planning, informing timely user changes, improving poor site coordination, maintaining consistent time frame, correcting compensation, cost verification, claim for the approval of submittals in existing conditions in standard contracts improvement, improving sup-

ply of construction materials and price stability in the market and careful application of just in time philosophy in the construction are needed to be enforced.

- 10) Quality manuals for maintaining quality system by quality procedures, quality control and assurance, safety programme, scheduling, cost control, communication system and recording system are needed to be enforced by all agencies.
- 11) The owners, managerial, designers, site engineer, project engineer, supervision staff and contractors can use table 31 strategic guidelines to assess the quality level of a construction industry. Assessments of likely quality outcomes can be ascertained during/after construction and any necessary correction actions can be initiated.
- 12) Above all in all engineering institute and concern organization in private and government. The orientation of project management by introducing subject study for uniformity flow of communication in the area of information technology for construction operation, advance computer application in construction, project investment analysis, formwork technology, building construction technology, management of construction organization, advance project planning and controlling, conducting research studies by statistical analysis, equipment study, selecting topic in construction, construction engineering and project management will make an impact in construction sector. This can be improved in accordance with the level of training and courses in academic and vocational training institution, diploma engineering institute, bachelors in engineering and post graduate level of professional courses and all implementing organizations for continuous quality improvement to reach competitive edge by construction sector as being the objective of the government.

### 3. Future research

The future research are required in the areas of site staff, financial issue, material, labor, design, contract, owner, environment issue, equipment, execution and sub-contractor for the continuous quality improvement. Those are deliberately not analyzed in the current study in a much more deeper level due to complexity, exceptional study period and associated funding requirement to cover the eighteen remaining districts in the same topic, which are the limitation for the current study conducted.



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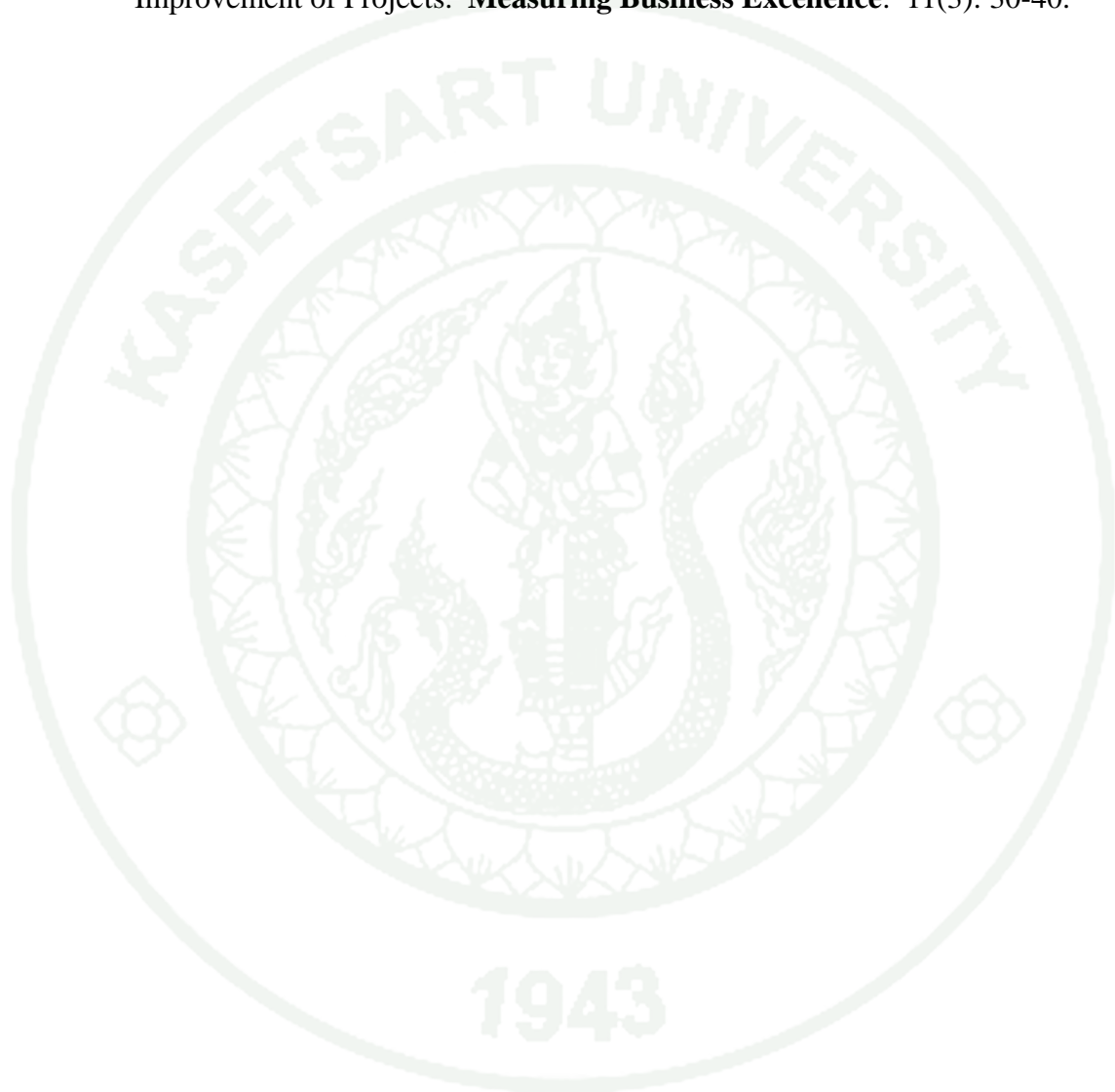
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**APPENDICES**



**Appendix A**  
Questionnaire

**Appendix A Questionnaire.**

## Introduction

Dear

Sir/Madam.....

Improving quality of construction is responsibility of all project stakeholders' such as owners, designers and contractors.

The aim of this survey is to investigate the understanding of main and sub factors affecting construction quality of project owners, contractors and consultants.

This questionnaire is required to be filled with exact relevant facts as much as possible. All the data included in this questionnaire will be used only for academic research and will be strictly confidential.

After all questionnaires are collected and analyzed, interested participants of this study will be given feedback on the overall research results.

**Appendix A** (Continued).

**Instruction:** Please read the following key terms to understand questionnaire.

<b>Project: 1</b>
Project is an attempt that is under taken to produce the results that are expected from the owner. The quality of project must meet the owner's satisfaction and so it is carefully planned and designed to meet the needs of end user or it is conceptual configurations and components to meet the intended use. ( <i>Orbelender2000</i> ):Sub factors are as follows.
1.1 Scope of the project (To meet the project definition)- identification of the quantity, quality, and tasks that must be performed ( <i>Orbelender 2000:Rustom &amp; Amer, 2003: Balson et al. 2012</i> ).
1.2 Location of the project: When an owner is evaluating which method to use in today's complex business environment, geographic or location factors can influence the choice of the best-qualified individual firms. It will further assist in comparing alternative methods influencing the design and specification that will improve cost of quality ( <i>Barrie &amp; Paulson, 1992:Tawfek et al. 2012</i> ).
1.3 Job Site access-It must take into account existing condition at job site. This factor is increasingly important when the designer is located some distance away, since practices differ in various sections of the country. Specification may require particular brand name product that are not readily available or other particular methods may be used called for that will result cost ( <i>Barrie &amp; Paulson,1992:Rustom &amp; Amer,2003</i> )
1.4 Period of the project-under estimated project period may impact quality control ( <i>Rustom &amp; Amer,2003</i> )
1.5 Project budgeting (to match the project definition and scope).Define the owner's permissible budget and determining direct and indirect costs plus contingencies ( <i>Orbelender, 2000</i> ).
1.6 Project planning: (the strategy to accomplish the work) by selecting and assigning project staff, identifying the task required to accomplish the work ( <i>Orbelender, 2000</i> ).
1.7 Project Scheduling (the product of scope, budgeting, and planning)Arrange and schedule activities in a logical activities, link the costs and resources to the schedule activities ( <i>Orbelender, 2000</i> ).
1.8 Project tracking (to ensure the project is progressing as planned) Measure work, time and costs that are expended. Compare actual to planned quality work, time, cost ( <i>Orbelender, 2000</i> ).

**Appendix A** (Continued).

1.9 Project close out (final completion to ensure owner satisfaction) Perform final testing and inspection, archive documents and confirm payments. Turnover the project to the owner ( <i>Orbelender, 2000</i> ).
3.6 Difficulty in the recruitment of supervisors ( <i>Lim &amp; Alum, 1995</i> )
3.7 Difficulty in the recruitment of workers ( <i>Lim &amp; Alum, 1995</i> )
3.8 Waste (non value adding activities): ( <i>Alwi, 2003</i> )
3.9 Lack of Awareness in Benefits of Quality management system ( <i>Said, Razek &amp; Tee, 2009</i> )
<b>Design: 2</b>
Design is a term used for the constructions that have no unusual features and well-defined scope. Despite its technological advance, the construction industries have to pay attention to the quality of its design documents. Defective design produced is riskier for the success of a project. To study the quality of design documents in the industry by factors that influence design documents quality and their impact on the construction process is necessary ( <i>Andi, 2003: Orbelender, 2000</i> ): Sub factors are as follows.
2.1 Completeness and consistency of design documents support quality control /assurance ( <i>Rustom &amp; Amer, 2003: Idoro, 2012</i> ).
2.2 Drawings are prepared in full details to required design quality ( <i>Rustom &amp; Amer, 2003</i> ).
2.3 Conformance to codes and standards. ( <i>Rustom &amp; Amer, 2003</i> ).
2.4 Adherence to specifications to meet design quality. ( <i>Bubshait &amp; Al-Atiq, 1999: Rustom &amp; Amer, 2003</i> ).
2.5 Bill of quantity is very detailed and accurate as per required design quality ( <i>Rustom &amp; Amer, 2003: Hamzah et al. 2011</i> ).
2.6 Several barriers for strategic quality planning affecting design quality assurance ( <i>Senaratne et al. 2012</i> )
2.7 Unstable client's requirements make difficult to meet required time, cost and quality design ( <i>Darwish, 2005</i> )
2.8 The costs of remoteness for large construction at the best price affect design and construction quality, and this are often neglected in the short term budgeting within this process ( <i>Fien &amp; Chaelesworth, 2012</i> )
2.9 Last minute changes by client affect time and design quality.
2.10 Insufficient overall design time will bypass required design quality specification.

**Appendix A** (Continued).

2.11 Waiting for client decision and that Consultants tend to copy and modify from their previous work to minimize time and design cost impact quality assurance.
<b>Contract: 3</b>
The contract documents form the contract for construction. This contract represents the entire and integrated agreement between the parties hereto and supersedes all prior negotiations, representations or agreements, either written or oral. The contract may be amended or modified only by a modification signed by both owner and contractor. Nothing contained in the contract document will create contractual relationship between the parties that will cause quality problem (Jervis & Levin, 1988): Sub factors are as follows.
3.1 Cooperation between parties involved in contract ( <i>Rustom &amp; Amer, 2003: Jha &amp; Iyer, 2006</i> ).
3.2 Previous successful relations between parties ( <i>Rustom &amp; Amer, 2003: Patil et al. 2011</i> ).
3.3 A written contract with conditions clear and fair and responsibilities distribution is clear. ( <i>Rustom &amp; Amer, 2003: Chan &amp; Tse, 2003</i> ).
3.4 Using a standard contract ( <i>Doloi et al. 2012: Chan &amp; Tse, 2003: Rustom &amp; Amer, 2003</i> ).
3.5 Types of awarding system ( <i>Jergeas, 2009: Jitwasinkul &amp; Hadikusumu, 2011: Rustom &amp; Amer, 2003</i> ).
3.6 Difficulty in the recruitment of supervisors ( <i>Lim &amp; Alum, 1995</i> )
3.7 Difficulty in the recruitment of workers ( <i>Lim &amp; Alum, 1995</i> )
3.8 Waste (non value adding activities): ( <i>Alwi, 2003</i> )
3.9 Lack of Awareness in Benefits of Quality management system ( <i>Said et al. 2009</i> )
<b>Material: 4</b>
Materials are one of the most important components of a construction project. The characteristic of it includes quality, availability in the market for construction site. It is procured during all phases of a construction project. Periodically recurring scarcities of both manufactured goods and raw materials, both on a domestic and on outside country gives challenge to experienced industry professionals. Materials quality is an essential part of construction quality and requires the same degree of planning, prevention, appraisal, and corrective action as design engineering and construction. Materials quality control is usually equated with shop inspection. Nonconformance in fabrication must be identified to allow correction in the fabrication shop, where the proper skills and equipment exist to correct nonconformance. Materials quality is more comprehensive than shop inspection.

**Appendix A** (Continued).

It is a continuous process that is part of the total project quality system. ( <i>Barrie &amp; Paulson, 1992: Stukhart, 1989</i> ) :Sub factors are as follows.
4.1 Using a complete applied material management system ( <i>Rustom &amp; Amer, 2003</i> ).
4.2 Cooperation between contractor and material suppliers ( <i>Rustom &amp; Amer, 2003: Kadir et al. 2005</i> ).
4.3 Availability of good quality construction materials ( <i>Rustom &amp; Amer, 2003: Hwang et al. 2012: Chen et al. 2012</i> ).
4.4 Using storage and handling system ( <i>Bubshait &amp; Atiq, 1999: Rustom &amp; Amer, 2003</i> ).
4.5 Construction materials monopoly ( <i>Rustom &amp; Amer, 2003</i> ).
4.6 Fluctuation of prices of materials ( <i>Eshofonie, 2008 : Sihaphon, 2008</i> )
<b>Labor: 5</b>
The labour means people physically doing work, it is opposite of work done by machines and by working animals. The performance of labour is directly or indirectly interrelated having many factors affecting time, cost, and quality ( <i>Soekiman et al. 2011, Wikipedia</i> ).
5.1 Labor management system ( <i>Rustom &amp; Amer, 2003: Jergeas, 2009: Shehata &amp; Gohary et al. 2011,</i> ).
5.2 Using labor with high experience ( <i>Rustom &amp; Amer, 2003: Penjor, 2007</i> ).
5.3 Using quality motivation system ( <i>Rustom &amp; Amer, 2003</i> ).
5.4 Training courses for labor ( <i>Rustom &amp; Amer, 2003: Chan et al. 1999: Tam et al. 2004</i> ).
5.5 Income level and wages of labor ( <i>Rustom &amp; Amer, 2003</i> ).
5.6 Lack of skills.
5.7 Lack of foreign and local workers in the market.
5.8 Difficulty in the recruitment of supervisors ( <i>Lim &amp; Alum, 1995</i> ).
5.9 Difficulty in the recruitment of workers ( <i>Lim &amp; Alum, 1995</i> ).
5.10 High rate of labour turnover <i>i.e</i> The ratio of the number of employees that leave a company through attrition, dismissal, or resignation during a period to the number of employees on payroll during the same period ( <i>Lim &amp; Alum, 1995</i> ).
5.11 A contractor often fail to come out with practical and workable work program at the initial planning stage.

**Appendix A** (Continued).

<b>Equipment: 6</b>
Equipments are mechanical/electrical systems that amplify human energy, improve level of quality control and process information. It transform design into accomplishment of useful required project structure in quality ( <i>Peurifoy et al. 2011</i> ): Sub factors are as follows.
6.1 Availability of equipment ( <i>Rustom &amp; Amer, 2003: Hwang et al.2012</i> ).
6.2 Equipment management system ( <i>Rustom &amp; Amer, 2003: Zangmo,2009</i> ).
6.3 Measurement of equipment productivity ( <i>Tenah ,1986:Rustom &amp; Amer, 2003</i> ).
6.4 Good utilization of equipment ( <i>Rustom &amp; Amer, 2003</i> ).
6.5 Equipment maintenance ( <i>Rustom &amp; Amer, 2003: Long et al.2004</i> ).
<b>Subcontractor: 7</b>
A sub-contractor is a person or entity who has a direct or indirect contract with a main contractor to perform any of the work at the site. The term subcontractor is referred to throughout the contract document as if singular in number and masculine in gender means a subcontractor or his representative. The term subcontractor does not include any separate contractor or his subcontractors. Its experience and capability attribute to quality construction ( <i>Jervis and Levin 1988, p/260</i> ) :Sub factors are as follows.
7.1 Company's methods and procedures of selecting subcontractors ( <i>Rustom &amp; Amer, 2003: Soemardi et al.2011</i> ).
7.2 High cooperation between subcontractors and general contractor ( <i>Rustom &amp; Amer, 2003: Gale &amp; Luo,2004</i> ).
7.3 Using a system to evaluate subcontractors performance ( <i>Rustom &amp; Amer, 2003</i> ).
7.4 Good and fair subcontract conditions ( <i>Rustom &amp; Amer, 2003</i> ).
<b>Site layout: 8</b>
Site layout shows the relationship of the proposed site with its surroundings with respect to communication, approaches and existing facilities. Good site layout planning assists in minimizing the traveling time and movement costs of plant, labor, materials, activity interference during construction work, site accidents, and ensures that work on buildings and other construction positions is not impeded by the thoughtless storage of materials on these locations. Site layout can thus either enhance or adversely affect construction productivity, progress and quality.( <i>Tam et.al,2004</i> ) :Sub factors are as follows.
8.1 Site layout is large and suitable for movement of labors and equipment ( <i>Rustom &amp; Amer, 2003</i> ).

**Appendix A** (Continued).

8.2 Site layout is organized well ( <i>Rustom &amp; Amer, 2003</i> ).
8.3 Site layout has storage areas for materials ( <i>Rustom &amp; Amer, 2003</i> ).
8.4 Site is clean ( <i>Rustom &amp; Amer, 2003; Kulchartchai et al. 2010</i> ).
<b>Quality System: 9</b>
It is a means of ensuring that product confirms to specific quality requirements including preparation and its effectiveness in documented quality system procedures and instruction. To be more specific, it is a continuously improving process where lessons learned are used to enhance future products and services in order to retain existing customers, win back lost customers and welcome new customers. (Paragraph 3.5 in ISO 9000):Sub factors are as follows.
9.1 Using computer software and applications ( <i>Rustom &amp; Amer, 2003</i> ).
9.2 Implement quality control and assurance system ( <i>Rustom &amp; Amer, 2003</i> ).
9.3 Implement and using time schedule ( <i>Rustom &amp; Amer,2003</i> ).
9.4 Using cost control system ( <i>Rustom &amp; Amer, 2003</i> ).
9.5 Implement a safety program ( <i>Rustom &amp; Amer, 2003</i> ).
9.6 Improvement in the problem of communication in construction ( <i>Hoezen et al. 2006</i> )
9.7 Quality manual.
9.8 Quality procedures.
9.9 Project quality plans.
9.10 Quality records.
<b>Site staff: 10</b>
The site staffs are the one who undertake the production of projects and are major part of quality work system implemented. They undertake the various administrative procedures at the site office in relation to the relevant standard requirements after planning, design, bidding and award phases (Barrie and Paulson, 1992,chapter 8 in ISO 9000) :Sub factors are as follows.
10.1 Cooperation between supervision and contractor's staff ( <i>Rustom &amp; Amer, 2003; Hai et al. 2012</i> ).
10.2 Understanding of contract administration by Supervision ( <i>Rustom &amp; Amer, 2003</i> :).
10.3 Skill and experience supervision staff ( <i>Abdel-Razek, 1998;Rustom &amp; Amer, 2003</i> :).
10.4 Skill and experience contractor's staff ( <i>Abdel-Razek, 1998;Rustom &amp; Amer, 2003</i> ).
10.5 The Knowledge base system is primarily designed for professionals to learn from similar past projects ( <i>Arain,2009: Alhomadi et al.2011</i> )

**Appendix A (Continued).**

10.6 Lack of Quality Management system exposure among workers ( <i>Said et al.2009</i> )
10.7 Construction supervision.
10.8 Site document control.
10.9 Inspection and testing.
10.10 Final inspection and handover.
10.11 Non conformances and corrective action.
10.12 Handling and storage.
<b>Execution: 11</b>
The carrying out or putting into effect of a design plan, order, or course of action for the service at a price within the budget and schedule. It has to adapt to operating context to maintain or enhance quality of service level or a construction execution plan to meet project objectives for expected service life. :Sub factors are as follows.
11.1 Using a complete execution system ( <i>Dada, 2012: Rustom &amp; Amer, 2003</i> ).
11.2 Testing for final products only ( <i>Rustom &amp; Amer, 2003</i> ).
11.3 Clear procedure for accepting performed activities ( <i>Rustom &amp; Amer, 2003</i> ).
11.4 Preparing and using shop drawings ( <i>Rustom &amp; Amer, 2003</i> ).
<b>Financial Issues: 12</b>
Scholars in the construction industry have identified sound financing as key to business survival. it is advisable for local contractors to conduct a strategic review for their construction industry and their business environment so as to improve their financial performance in both the near future and longer term. ( <i>Chan et al. 2007</i> ). The financial issues impact to the project objectives of budget, schedule, and quality. Those addressed factors are budget performance, schedule performance, quality performance, and overall project success. Sub factors are as follows.
12.1 The amount of contractor's cash flow. ( <i>Rustom &amp; Amer, 2003: Rahman et al. 2012</i> ).
12.2 The non-delay of interim payments. ( <i>Rustom &amp; Amer, 2003</i> ).
12.3 Methodology of preparing budget.
12.4 Plans to increase income, cut down expenditure.
12.5Corrective action to control project cost.
12.6Meeting the budget.

**Appendix A** (Continued).

<b>Owner: 13</b>
The owner is known by one who knows what to do, He select a process for design and quality construction or does selection of team members, project cost, quality and schedule under his duty. ( <i>Orberlender, 2000</i> ) :Sub factors are as follows.
13.1 Owner organization nature ( Public or Private). ( <i>Rustom &amp; Amer, 2003</i> ).
13.2 The owner not delaying to make decisions. ( <i>Rustom &amp; Amer, 2003</i> ).
13.3 Owner's contribution to design. ( <i>Rustom &amp; Amer, 2003</i> ).
13.4 Owner's emphasis on quality. ( <i>Rustom &amp; Amer, 2003</i> ).
<b>Environment issues: 14</b>
Environment can be considered as all external influences on the construction process. Broadly, these may be grouped as physical, economic, socio-political, and industrial relations, and they act at national or local level, and in different ways in the public and private sectors. There have been dramatic changes in attitudes to the environment over the past 50 years. These changes can create uncertainty, not regarding prices, but also in terms of investment in the work of an organization, which will affect the demand of quality.( <i>Chan and Tam, 2000</i> ). Also environment issues are defined as problems with the planet system (air, water, soil etc) that have developed as a result of human interference or mistreatment on the planet. It can be giving out to the nature or taking from the nature. This is due to negligence in quality control/assurance plan. A growing awareness of the impact of buildings on the environment has created a greater need to take account of environmental factors. To address this effectively, the environmental impact of a construction has to be a primary consideration of the design team. Two approaches are available to the design team to provide clients with assurance that ecological design principles are carried through to construction. These are the comparatively new international environmental management systems standard. Sub factors are as follows.
Giving out to nature such as:
14.1 Construction waste.
14.2 Sewage& surface drainage.
14.3 Soil waste.
14.4 Heat& pollution.
Taking from nature such as:
14.5 Construction materials.
14.6 Energy requirement.

**Appendix A** (Continued).

14.7 Water requirement.
14.8 Native vegetation.
14.9 Socio-economic environment - Causes of socio-economic impacts are for example, new technologies, changes in laws, changes in the physical environment and ecological changes that impact quality design. ( <i>Rustom &amp; Amer, 2003</i> ).
14.10 Closure of border strip. ( <i>Rustom &amp; Amer, 2003</i> ).
14.11 The relation between construction industry and the other industries. ( <i>Rustom &amp; Amer, 2003</i> ).
<b>Delay: 15</b>
Construction delay is considered one of the most recurring problems in the construction industry. Delays have an adverse impact on project success in terms of time, cost, quality and safety. The effects of construction delays are not confined to the construction industry only, but influence the overall economy of a country, where construction plays a major role in its development and contributes to the GDP. Thus, it is essential to define the most significant causes of delay in order to avoid or minimize their impact on construction projects. Approval of drawings, inadequate early planning and slowness of the owners' decision-making process are example that cause of delay in the construction industry. Sub factors are as follows.
15.1 Application of the just-in-time philosophy in the construction industry - The Just-in-Time (JIT) helped to increase the performance with the quality of its products in the areas of design, procurement, construction and inspection ( <i>Pheng &amp; Shang, 2011</i> ).
15.2 Price stability of construction materials economics & market conditions ( <i>Bari et al. 2012</i> ).
15.3 Supply of construction materials economics & market Conditions ( <i>Bari et al. 2012</i> ).
15.4 Consistent time frame, compensation, cost, claim for the approval of submittals in existing conditions in standard contracts ( <i>Chovichien &amp; Suriyanon, 2011</i> ).
15.5 Inefficient site management ( <i>Doloi et al. 2012</i> ).
15.6 Lack of commitment ( <i>Doloi et al. 2012</i> ).
15.7 Poor site coordination ( <i>Doloi et al. 2012</i> ).
15.8 Improper planning ( <i>Doloi et al. 2012</i> ).
15.9 Lack of clarity in project scope ( <i>Doloi et al. 2012</i> ).
15.10 Late deliveries, the act of conveying or delivering. ( <i>Al-Momani, 2000</i> ).
15.11 User changes ( <i>Al-Momani, 2000</i> ).

**Appendix A** (Continued).

## SECTION I: Organization profile

Please tick✓ or fill in the blank the appropriate response.

1. Name:.....
2. Email: .....
3. Mobile No:.....
4. Age: 20-30 30-40 40-50 more than 50
5. Sex: Male Female
6. Education: Junior High School High School VTI  
JNP CST Post Graduate University Other
7. Please classify your Organization:  
Owner(Govt/Developer) Consultant/Engineer Contractors
8. Class of classification(contracting companies)  
Small Medium Large
9. No of staff in your organization:.....
10. Title of position of respondent: Managerial Executive  
Non-Executive Site engineer Project engineer
11. Number of working experience:  
Less than 5 years 2-5 years 6-10 years more than 10 years
12. Number of construction executed:  
Less than 10 11-20 21-30 more than 30
13. Field of specialization:  
Civil engineer Electrical Engineer Mechanical Engineer  
Architect Others
14. Type of construction you have handled in the last 5 years:  
Infrastructure Construction Others(Please specify)
15. Largest project involved based on contract amount in the last 5 years:  
≤ 4million 4 – 15 million  > 15 million International

## SECTION-II Quality in the organization.

Please tick✓ the appropriate response.

1. In your organization do you have a clear definition of quality developed?  
No Yes Can't say

**Appendix A (Continued).**

2. What is the percentage of employees who are aware of the importance of quality in your organization?.....
3. Does your organization have a quality improvement plan?
  - No    It has been implemented for some time now
  - Such a plan is under consideration                      It has been implemented recently
4. Does your quality improvement plan have the full support of top management?
  - No                      Yes                      Can't say
5. Does your company have ISO certificate:
  - No                      Yes

If the answer is Yes, mention the year of having ISO certificate in this blank space:.....

**SECTION-III**

Ranking of main factor affecting construction quality.

Instruction:

Please identify by ticking ✓ only one for each row the degree of importance main factors affecting.

Not relevant=0      Very Important=5                      Important=4      Medium Important=3      Low Important =2      Very Low Important=1

No	Main factor group	Degree of Importance					
		5	4	3	2	1	0
1	Project:						
2	Design:						
3	Contract:						
4	Material:						
5	Labor:						
6	Equipment:						
7	Subcontractor:						
8	Site layout:						
9	Quality System:						
10	Site staff:						
11	Execution:						
12	Financial Issues:						
13	Owner:						
14	Environment issues:						
15	Delay:						

**Appendix A** (Continued).

## SECTION-IV Ranking of sub factor affecting construction quality.

Instruction:

Please identify by ticking✓ only one for each row the degree of importance Sub factors affecting.		Degree of importance					
Not relevant=0 Very Important=5 Important=4 Medium Important=3 Low Important=2 Very Low Important=1		5	4	3	2	1	0
1- Project: sub-factors							
1.1	Scope of the project:						
1.2	Location of the project:						
1.3	Job Site access:						
1.4	Period of the project:						
1.5	Project budgeting:						
1.6	Project planning:						
1.7	Project scheduling:						
1.8	Project tracking						
1.9	Project close out						
2- Design: Sub-factors		5	4	3	2	1	0
2.1	Completeness and consistency of design documents						
2.2	Drawings are prepared in full details.						
2.3	Conformance to codes and standards.						
2.4	Adherence to specifications.						
2.5	Bill of quantity is very detailed and accurate.						
2.6	Several barriers for strategic quality planning.						
2.7	Unstable client's requirements.						
2.8	The costs of remoteness.						
2.9	Last minute changes by client.						
2.1	Insufficient overall design time.						
2.11	Waiting for client decision and that Consultants tend to copy and modify from their previous work.						
3- Contract: sub=factors		5	4	3	2	1	0
3.1	Cooperation between parties involved in contract.						
3.2	Previous successful relations between parties.						
3.3	A written contract with conditions clear and fair and responsibilities distribution is clear.						
3.4	Using a standard contract.						

**Appendix A (Continued).**

3.5	Types of awarding system.						
3.6	Difficulty in the recruitment of supervisors.						
3.7	Difficulty in the recruitment of workers.						
3.8	Waste (non value adding activities)						
3.9	Lack of Awareness in Benefits of Quality management system.						
4- Material: sub-factors		5	4	3	2	1	0
4.1	Using a complete applied material management system.						
4.2	Cooperation between contractor and material suppliers.						
4.3	Availability of good quality construction materials.						
4.4	Using storage and handling system.						
4.5	Construction materials monopoly.						
4.6	Fluctuation of prices of materials.						
5- Labor: sub-factors		5	4	3	2	1	0
5	Labor management system.						
5.2	Using labor with high experience.						
5.3	Using quality motivation system.						
5.4	Training courses for labor.						
5.5	Income level and wages of labor.						
5.6	Lack of skills.						
5.7	Lack of foreign and local workers in the market.						
5.8	Difficulty in the recruitment of supervisors.						
5.9	Difficulty in the recruitment of workers.						
5.1	High rate of labor turnover						
5.11	A contractor often fail to come out with practical and workable work program at the initial planning stage.						
6 -Equipment: sub-factors		5	4	3	2	1	0
6.1	Availability of equipment.						
6.2	Equipment management system.						
6.3	Measurement of equipment productivity.						
6.4	Good utilization of equipment.						
6.5	Equipment maintenance.						
7 -Subcontractor: sub=factors		5	4	3	2	1	0
7.1	Company's methods and procedures of selecting subcontractors.						
7.2	High cooperation between subcontractors and general contractor.						
7.3	Using a system to evaluate subcontractors performance.						

**Appendix A (Continued).**

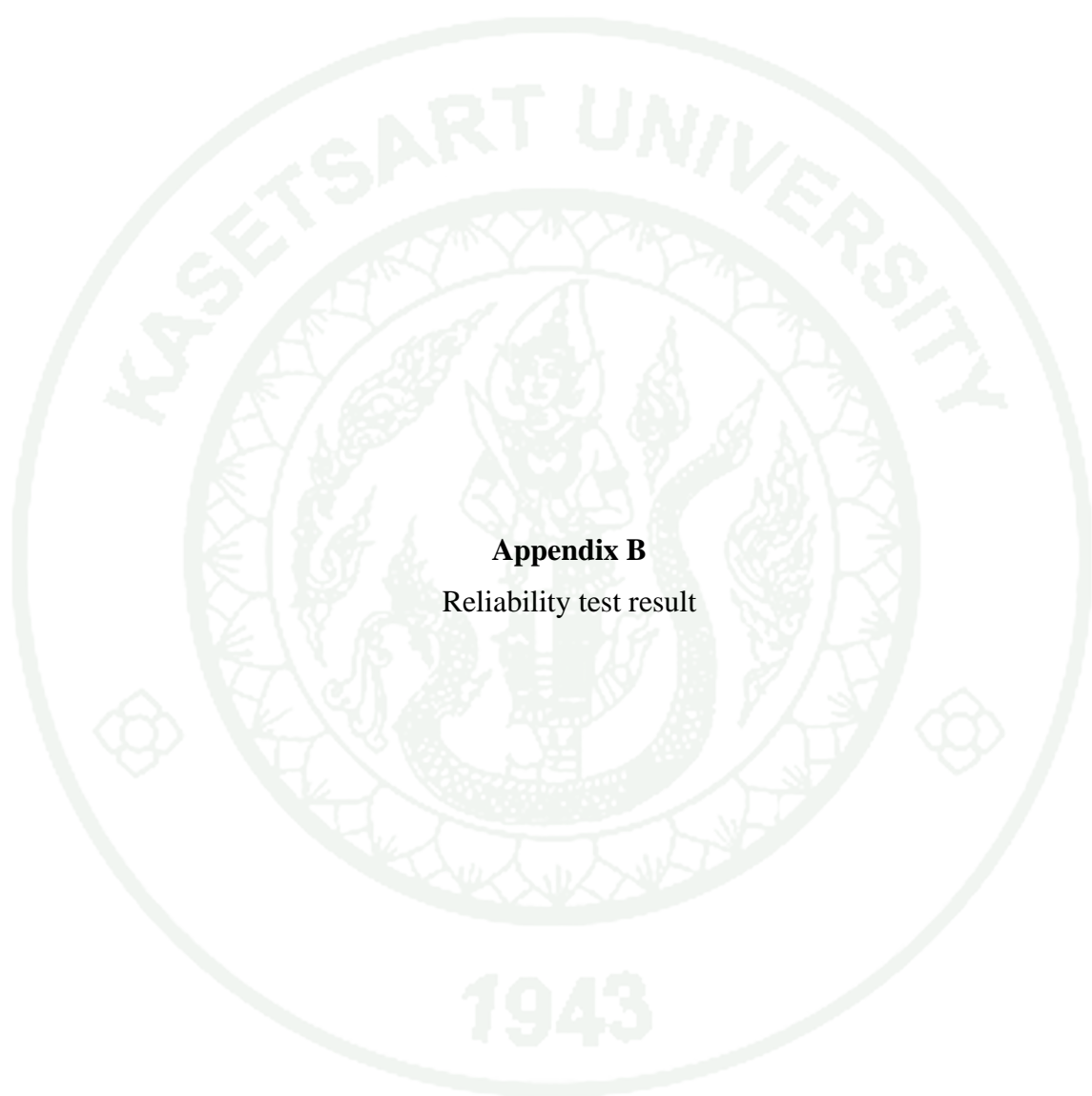
7.4	Good and fair subcontract conditions.						
7.2	High cooperation between subcontractors and general contractor.						
7.3	Using a system to evaluate subcontractors performance.						
7.4	Good and fair subcontract conditions.						
8- Site layout: sub-factors		5	4	3	2	1	0
8.1	Site layout is large and suitable for movement of labors and equipment.						
8.2	Site layout is organized well.						
8.3	Site layout has storage areas for materials.						
8.4	Site is clean.						
9 -Quality System: sub=factors		5	4	3	2	1	0
9.1	Using computer software and applications.						
9.2	Implement quality control and assurance system.						
9.3	Implement and using time schedule.						
9.4	Using cost control system.						
9.5	Implement a safety program.						
9.6	Improvement in the problem of communication in construction.						
9.7	Quality manual.						
9.8	Quality procedures.						
9.9	Project quality plans.						
9.1	Quality records.						
10 -Site staff: sub-factors		5	4	3	2	1	0
10.1	Cooperation between Supervision and Contractor's staff.						
10.2	Understanding of contract administration by Supervision.						
10.3	Skill and experience Supervision staff.						
10.4	Skill and experience contractor's staff.						
10.5	The Knowledge base system is primarily designed for professionals to learn from similar past projects.						
10.6	Lack of Quality Management system exposure among workers.						
10.7	Construction supervision.						
10.8	Site document control.						
10.9	Inspection and testing.						
10.1	Final inspection and handover.						
10.11	Non conformances and corrective action.						

**Appendix A (Continued).**

10.12	Handling and storage.						
11- Execution: sub-factors							
11.1	Using a complete execution system.						
11.2	Testing for final products only.						
11.3	Clear procedure for accepting performed activities.						
11.4	Preparing and using shop drawings.						
12- Financial issues: sub-factors		5	4	3	2	1	0
12.1	The amount of contractor's cash flow.						
12.2	The non-delay of interim payments.						
12.3	Methodology of preparing budget.						
12.4	Plans to increase income, cut down expenditure.						
12.5	Corrective action to control project cost.						
12.6	Meeting the budget.						
13- Owner: sub-factors		5	4	3	2	1	0
13.1	Owner organization nature (Public or Private).						
13.2	The owner not delaying to make decisions.						
13.3	Owner's contribution to design.						
13.4	Owner's emphasis on quality.						
14 -Environment issues: sub factors		5	4	3	2	1	0
	Giving out to nature such as:						
14.1	Construction waste.						
14.2	Sewage & surface drainage.						
14.3	Soil waste.						
14.4	Heat & pollution.						
	Taking from nature such as:						
14.5	Construction materials.						
14.6	Energy requirement.						
14.7	Water requirement.						
14.8	Native vegetation.						
14.9	Socio-economic environment .						
14.10	Closure of Border strip.						
14.11	The relation between construction industry and the other industries.						
15- Delay: sub-factors		5	4	3	2	1	0
15.1	Application of the just-in-Time Philosophy in the Construction Industry.						
15.2	Price stability of construction materials economics & market Conditions.						
15.3	Supply of construction materials economics & market Conditions.						

**Appendix A** (Continued).

15.4	Consistent time frame, compensation, cost, claim for the approval of submittals in existing conditions in standard contracts.							
15.5	Inefficient site management.							
15.6	Lack of commitment.							
15.7	Poor site coordination.							
15.8	Improper planning.							
15.9	Lack of clarity in project scope.							
15.1	Late deliveries.							
15.11	User changes.							
Note: Please feel free to add any other factors which may have been missed out in the above list and blank table provided below.								
1								
2								
3								



**Appendix B**  
Reliability test result

**Appendix B** reliability test result.

## A. Project

**Reliability Statistics**

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No of Items
.873	.879	10

The reliability test (The Cronbach's alpha) for Project factor is .879 which is higher than 0.6 thus the questionnaire items for project is reliable.

## B. Design

**Reliability Statistics**

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No of Items
.792	.806	12

The reliability test (The Cronbach's alpha) for Design factor is .806 which is higher than 0.6 thus the questionnaire items for design is reliable.

## C. Contract

**Reliability Statistics**

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No of Items
.794	.787	10

The reliability test (The Cronbach's alpha) for Contract factor is .787 which is higher 0.6 thus the questionnaire items for Contract is reliable.

**Appendix B** (Continued).

## D. Material

**Reliability Statistics**

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No of Items
.780	.763	7

The reliability test (The Cronbach's alpha) for Material factor is .806 which is higher 0.6 thus the questionnaire items for Material is reliable.

## E. Labour

**Reliability Statistics**

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No of Items
.873	.873	12

F. *Equipment***Reliability Statistics**

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No of Items
.790	.793	6

The reliability test (The Cronbach's alpha) for Equipment factor is .793 which is higher 0.6 thus the questionnaire items for Equipment is reliable.

**Appendix B** (Continued).G. *Subcontractor***Reliability Statistics**

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No of Items
.836	.828	5

The reliability test (The Cronbach's alpha) result for Subcontractor factor is .828 which is higher 0.6 thus the questionnaire items for Subcontractor is reliable.

H. *Site layout***Reliability Statistics**

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No of Items
.828	.838	5

The reliability test (The Cronbach's alpha) result for Site layout factor is .838 which is higher 0.6 thus the questionnaire items for Site layout is reliable.

I. *Quality System***Reliability Statistics**

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No of Items
.874	.879	11

The reliability test (The Cronbach's alpha) result for Quality system factor is .879 which is higher 0.6 thus the questionnaire items for Quality system is reliable.

**Appendix B** (Continued).J. *site staffs***Reliability Statistics**

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No of Items
.842	.852	13

The reliability test (The Cronbach's alpha) result for Site staffs factor is .852 which is higher 0.6 thus the questionnaire items for Site staffs is reliable.

K. *Execution***Reliability Statistics**

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No of Items
.671	.663	5

The reliability test (The Cronbach's alpha) result for Execution factor is .663 which is higher 0.6 thus the questionnaire items for Execution is reliable.

L. *Financial Issues***Reliability Statistics**

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No of Items
.853	.845	7

The reliability test (The Cronbach's alpha) result for Financial issues factor is .845 which is higher 0.6 thus the questionnaire items for Financial issues is reliable.

**Appendix B** (Continued).*M.. Environment issues***Reliability Statistics**

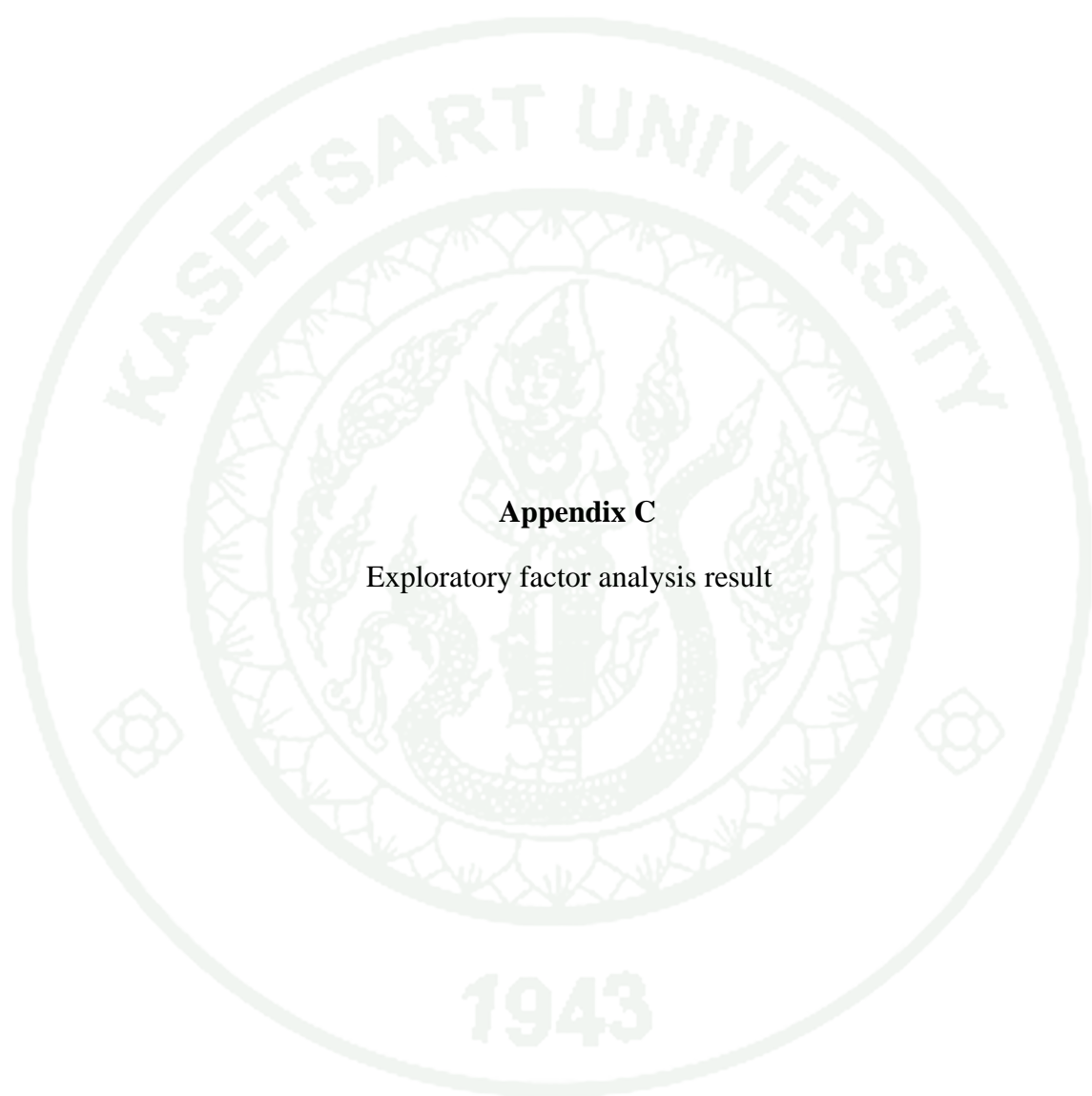
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No of Items
.747	.737	5

The reliability test (The Cronbach's alpha) result for Environmental issues factor is .737 which is higher 0.6 thus the questionnaire items for Environmental issues is reliable.

*N. Delay***Reliability Statistics**

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No of Items
.894	.905	12

The reliability test (The Cronbach's alpha) result for Delay factor is .737 which is higher 0.6 thus the questionnaire items for Delay is reliable.



**Appendix C**

Exploratory factor analysis result

**Appendix C** exploratory factor analysis result.

**Rotated Component Matrix<sup>a</sup>**

	Raw			Rescaled		
	Component			Component		
	1	2	3	1	2	3
sec4107	.529			.789		
sec498	.506			.732		
sec4103	.382			.717		
sec4109	.592			.684		
sec499	.475			.636		
sec4121	.451			.593		
sec4104	.309			.577		
sec493	.393			.546		
sec497	.380		.296	.514		.399
sec451	.338			.489		
sec461	.301	.297		.469	.464	
sec492	.258		.244	.462		.437
sec452	.361			.458		
sec4158		.842		.891		
sec4156		.672		.806		
sec4155		.594		.743		
sec421		.316		.508		
sec41010	.384	.467		.416	.506	
sec422		.268		.450		
sec425		.280		.368		
sec423		.234		.365		
sec431			.652			.683
sec415			.506			.680
sec434		.428	.610	.471		.671
sec414			.481			.587
sec416			.322			.550
sec4126		.449	.508	.437		.494
sec417			.308			.426
sec4134			.401			.406

**Appendix C** (Continued).

<b>KMO and Bartlett's Test<sup>a</sup></b>		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.600
Bartlett's Test of Sphericity	Approx. Chi-Square	1144.007
	df	465
	Sig.	.000
a. Based on correlations		

After selecting 50% the highest average of all 117 sub factors from the raw data exploratory factor analysis model was run. It resulted to a new group of the 30 sub-factor affecting to the construction quality. The exploratory factor analysis was run to derive all sub variable into 3 factors (group). The result of Kaiser-Meyer-Olkin measure of sampling adequacy was obtained as 0.60 greater than 0.5 and Bartlett's test of sphericity significance was 0.00 which is highly significant.

Base on the rotated component factor the three group code factors included are sec4107, sec498, sec4103, sec4109, sec499, sec4121, sec4104, sec493, sec497, sec451, sec461, sec492, sec452 as factor 1; The factor 2 included sec4158, sec4156, sec4155, sec421, sec41010, sec422, sec425, sec423 and lastly factor 3 included is sec431, sec415, sec434, sec414, sec416, sec4126, sec417 and sec4134.



**Appendix D**

Raw data sub factor ranking

**Appendix D** raw data sub factor ranking.

<b>Rank</b>	<b>30 Government ranking</b>	<b>Mean</b>	<b>30 Private ranking</b>	<b>Mean</b>	<b>Private and Government ranking</b>	<b>Mean</b>
1	Project planning	4.70	Inspection and testing	4.70	Project planning	4.62
2	Completeness & Consistency of design document	4.63	Availability of good quality construction materials	4.67	Availability of good quality construction materials	4.62
3	Drawing are prepared in full details	4.60	Project planning	4.53	Completeness & Consistency of design document	4.55
4	Adherence to specification	4.57	Skill and experience supervision staff	4.50	Drawing are prepared in full details	4.53
5	Availability of good quality construction materials	4.57	Skill and experience contractor staff	4.50	Adherence to specification	4.53
6	Project Scheduling	4.50	Adherence to specification	4.50	Skill and experience contractor staff	4.47
7	Owners emphasis on quality	4.50	Using labor with high experience	4.47	Project Scheduling	4.45
8	Project budgeting	4.47	Completeness & Consistency of design document	4.47	Using labor with high experience	4.43
9	Implement quality control and assurance system	4.47	Drawing are prepared in full details	4.47	Skill and experience supervision staff	4.43

**Appendix D** (Continued).

10	Skill and experience contractor staff	4.43	Construction supervision	4.43	Project budgeting	4.42
11	Using labor with high experience	4.40	Project Scheduling	4.40	Conference to codes and standards	4.4
12	Conference to codes and standards	4.40	Conference to codes and standards	4.40	Implement quality control and assurance system	4.4
13	Skill and experience supervision staff	4.37	Project quality plans	4.37	Owners emphasis on quality	4.35
14	Availability of equipment	4.33	Project budgeting	4.37	Project quality plans	4.32
15	Water requirement	4.33	The amount of contractor cash flow	4.37	Implement and using time schedule	4.3
16	Scope of the project	4.30	Implement quality control and assurance system	4.33	Construction supervision	4.3
17	Implement and using time schedule	4.30	Implement and using time schedule	4.30	Availability of equipment	4.28
18	Quality procedure	4.30	Inefficient site management	4.30	Quality procedure	4.28
19	Final inspection and hand over	4.30	Availability of equipment	4.28	Inspection and testing	4.28
20	Project quality plans	4.27	Quality procedure	4.27	Cooperation between parties involved in contract	4.27

## Appendix D (Continued).

21	Using a standard contract	4.23	Labor management system	4.27	Using a standard contract	4.23
22	A written contract with conditions clear and fair and responsibility distributions is clear	4.23	Cooperation between parties involved in contract	4.27	Improper planning	4.23
23	Availability of equipment	4.23	Improper planning	4.27	Bill of Quantity	4.22
24	Lack of commitment	4.20	Bill of Quantity	4.23	Labor management system	4.22
25	Poor site coordination	4.20	Using a standard contract	4.23	Final inspection and hand over	4.22
26	Improper planning	4.20	Availability of equipment	4.23	The amount of contractor cash flow	4.22
27	Bill of Quantity	4.20	Period of the project	4.20	Period of the project	4.2
28	Supply of construction materials economics and market conditions	4.20	Owners emphasis on quality	4.20	Lack of commitment	4.18
29	Quality manual	4.20	The non-delay interim payments	4.20	Quality manual	4.17
30	Period of the project	4.20	Using a complete applied materials management system	4.17	Inefficient site management	4.15
31	Construction supervision	4.17	Quality records	4.17	Quality records	4.13

## Appendix D (Continued).

32	Labor management system	4.17	Lack of commitment	4.17	Cooperation between supervision and contractors staff	4.13
33	Construction Materials	4.17	Final inspection and hand over	4.13	Supply of construction materials economics and market conditions	4.13
34	Cooperation between supervision and contractors staff	4.13	Using a complete execution system	4.13	Poor site coordination	4.12
35	Site layout is organized well	4.10	Quality manual	4.13	The non-delay interim payments	4.1
36	Price stability of construction materials economic and market conditions	4.10	Cooperation between supervision and contractors staff	4.13	A written contract with conditions clear and fair and responsibility distributions is clear	4.08
37	Location of the project	4.10	The knowledge based system is primarily designed for professional to learn from similar past project	4.10	Water requirement	4.08
38	Quality records	4.10	Lack of clarity in project scope	4.07	Site layout is organized well	4.07

## Appendix D (Continued).

39	Job Site Access	4.07	Supply of construction materials economics and market conditions	4.07	Scope of the project	4.05
40	The amount of contractor cash flow	4.07	Lack of skills	4.07	Lack of skills	4.05
41	Understanding of contract administration by supervision	4.03	Preparing and using shop drawings	4.03	The knowledge based system is primarily designed for professional to learn from similar past project	4.05
42	Project Tracking	4.03	Poor site coordination	4.03	Using a complete execution system	4.03
43	Lack of skills	4.03	Site layout is organized well	4.03	Price stability of construction materials economic and market conditions	4.03
44	Lack of clarity in project scope	4.00	Waiting for client decision and that consultant tend to copy and modify from their previous work	4.00	Lack of clarity in project scope	4.03
45	Site layout has storage areas for materials	4.00	Good utilization of equipment's	4.00	Construction Materials	4.02

## Appendix D (Continued).

46	The knowledge based system is primarily designed for professional to learn from similar past project	4.00	Using cost control system	4.00	Job Site Access	3.98
47	The non-delay interim payments	4.00	Implement a safety program	4.00	Site layout is large and suitable for moment of labors and equipment	3.98
48	The owner not delaying to make decisions	4.00	Site document control	4.00	Using cost control system	3.98
49	Inefficient site management	4.00	Insufficient overall design time	4.00	Understanding of contract administration by supervision	3.98
50	Site layout is large and suitable for moment of labors and equipment's	4.00	Unstable clients requirements	3.97	Project Tracking	3.97
51	Lack of quality management system exposure among workers	4.00	Site layout is large and suitable for moment of labors and equipment's	3.97	Using a complete applied materials management system	3.97
52	Lack of foreign and local workers in the market	3.97	Price stability of construction materials economic and market conditions	3.97	Clear procedure for accepting performed activities	3.97

## Appendix D (Continued).

53	Late deliveries	3.97	Methodology of preparing budget	3.97	Good utilization of equipment	3.95
54	Clear procedure for accepting performed activities	3.97	Clear procedure for accepting performed activities	3.97	Implement a safety program	3.95
55	The cost of remoteness	3.97	Using quality motivation system	3.93	Using quality motivation system	3.93
56	A contractor often fail to come out with practical and workable work program at the initial planning stage	3.97	Using computer software and applications	3.93	Consistent time frame, compensation, cost, claim for the approval of submittals in existing conditions in standard contract	3.93
57	Using cost control system	3.97	A written contract with conditions clear and fair and responsibility distributions is clear	3.93	Insufficient overall design time	3.92
58	Consistent time frame, compensation, cost, claim for the approval of submittals in existing conditions in standard contract	3.97	Income level and wages of labor	3.93	Income level and wages of labor	3.92
59	Training courses for labor	3.97	Understanding of contract administration by supervision	3.93	Site document control	3.92

## Appendix D (Continued).

60	Using a complete execution system	3.93	Project Tracking	3.90	Preparing and using shop drawings	3.92
61	Using quality motivation system	3.93	Cooperation between contractor and materials suppliers	3.90	The cost of remoteness	3.9
62	Socio-economic environment	3.93	Equipment management system	3.90	Equipment management system	3.9
63	Equipment management system	3.90	Job Site Access	3.90	Using computer software and applications	3.9
64	Income level and wages of labor	3.90	Types of awarding system	3.90	Location of the project	3.88
65	Non conformances and corrective action	3.90	Consistent time frame, compensation, cost, claim for the approval of submittals in existing conditions in standard contra	3.90	Waiting for client decision and that consultant tend to copy and modify from their previous work	3.88
66	Owner organization nature (public or private)	3.90	Construction Materials	3.87	A contractor often fail to come out with practical and workable work program at the initial planning stage	3.88

## Appendix D (Continued).

67	Good utilization of equipment's	3.90	Last minute changes by client	3.87	Site layout has storage areas for materials	3.88
68	Implement a safety program	3.90	Owner organization nature (public or private)	3.87	Owner organization nature (public or private)	3.88
69	Meeting the budget	3.90	The cost of remoteness	3.83	Late deliveries	3.88
70	Native vegetation	3.90	Improvement in the problem of communication in construction	3.83	Cooperation between contractor and materials suppliers	3.87
71	Using computer software and applications	3.87	Non conformances and corrective action	3.83	Lack of quality management system exposure among workers	3.87
72	Sewage and surface drainage	3.87	User changes	3.83	Non conformances and corrective action	3.87
73	Using storage and handling system	3.87	Water requirement	3.83	Last minute changes by client	3.85
74	Inspection and testing	3.87	Scope of the project	3.80	Unstable clients requirements	3.83
75	Corrective action to control project cost	3.87	Handling and storage	3.80	Using storage and handling system	3.83

## Appendix D (Continued).

76	Energy requirement	3.83	Testing for final products only	3.80	Training courses for labor	3.83
77	Insufficient overall design time	3.83	A contractor often fail to come out with practical and workable work program at the initial planning stage	3.80	Lack of foreign and local workers in the market	3.83
78	Cooperation between contractor and materials suppliers	3.83	Late deliveries	3.80	Improvement in the problem of communication in construction	3.83
79	Last minute changes by client	3.83	Using storage and handling system	3.80	Methodology of preparing budget	3.83
80	Site document control	3.83	Fluctuations of prices of materials	3.77	Meeting the budget	3.83
81	Handling and storage	3.83	High cooperation between sub-contractors and general contractor	3.77	The owner not delaying to make decisions	3.83
82	Construction waste	3.83	Site layout has storage areas for materials	3.77	Socio-economic environment	3.83
83	Improvement in the problem of communication in construction	3.83	Application of the just-in-time philosophy in the construction industry	3.77	Handling and storage	3.82
84	Previous successful relations between parties	3.80	Energy requirement	3.77	Types of awarding system	3.8

**Appendix D** (Continued).

85	Preparing and using shop drawings	3.80	Meeting the budget	3.77	Corrective action to control project cost	3.8
86	Using a complete applied materials management system	3.77	Lack of awareness in benefits of quality management system	3.73	Energy requirement	3.8
87	Lack of awareness in benefits of quality management system	3.77	Socio-economic environment	3.73	Sewage and surface drainage	3.78
88	Measurement of equipment productivity	3.77	Companies method and procedures of selecting sub-contractors	3.73	User changes	3.77
89	Several barriers for strategic quality planning	3.77	Lack of quality management system exposure among workers	3.73	Lack of awareness in benefits of quality management system	3.75
90	Waiting for client decision and that consultant tend to copy and modify from their previous work	3.77	Corrective action to control project cost	3.73	Fluctuations of prices of materials	3.73
91	Owners contribution to design	3.73	Training courses for labor	3.70	Native vegetation	3.73
92	Unstable clients requirements	3.70	Lack of foreign and local workers in the market	3.70	Several barriers for strategic quality planning	3.72

**Appendix D** (Continued).

93	Fluctuations of prices of materials	3.70	Sewage and surface drainage	3.70	High cooperation between sub-contractors and general contractor	3.7
94	Types of awarding system	3.70	Equipment maintenance	3.67	Testing for final products only	3.7
95	Difficulty in the recruitment of supervisors	3.70	Location of the project	3.67	Construction waste	3.7
96	Methodology of preparing budget	3.70	The owner not delaying to make decisions	3.67	Measurement of equipment productivity	3.68
97	User changes	3.70	Difficulty in the recruitment of supervisors	3.63	Application of the just-in-time philosophy in the construction industry	3.68
98	Project close out	3.63	Measurement of equipment productivity	3.60	Owners contribution to design	3.67
99	High cooperation between sub-contractors and general contractor	3.63	Owners contribution to design	3.60	Previous successful relations between parties	3.65
100	Closure of border strip	3.63	The relation between construction industry and the other industries	3.60	Companies method and procedures of selecting sub-contractors	3.62

## Appendix D (Continued).

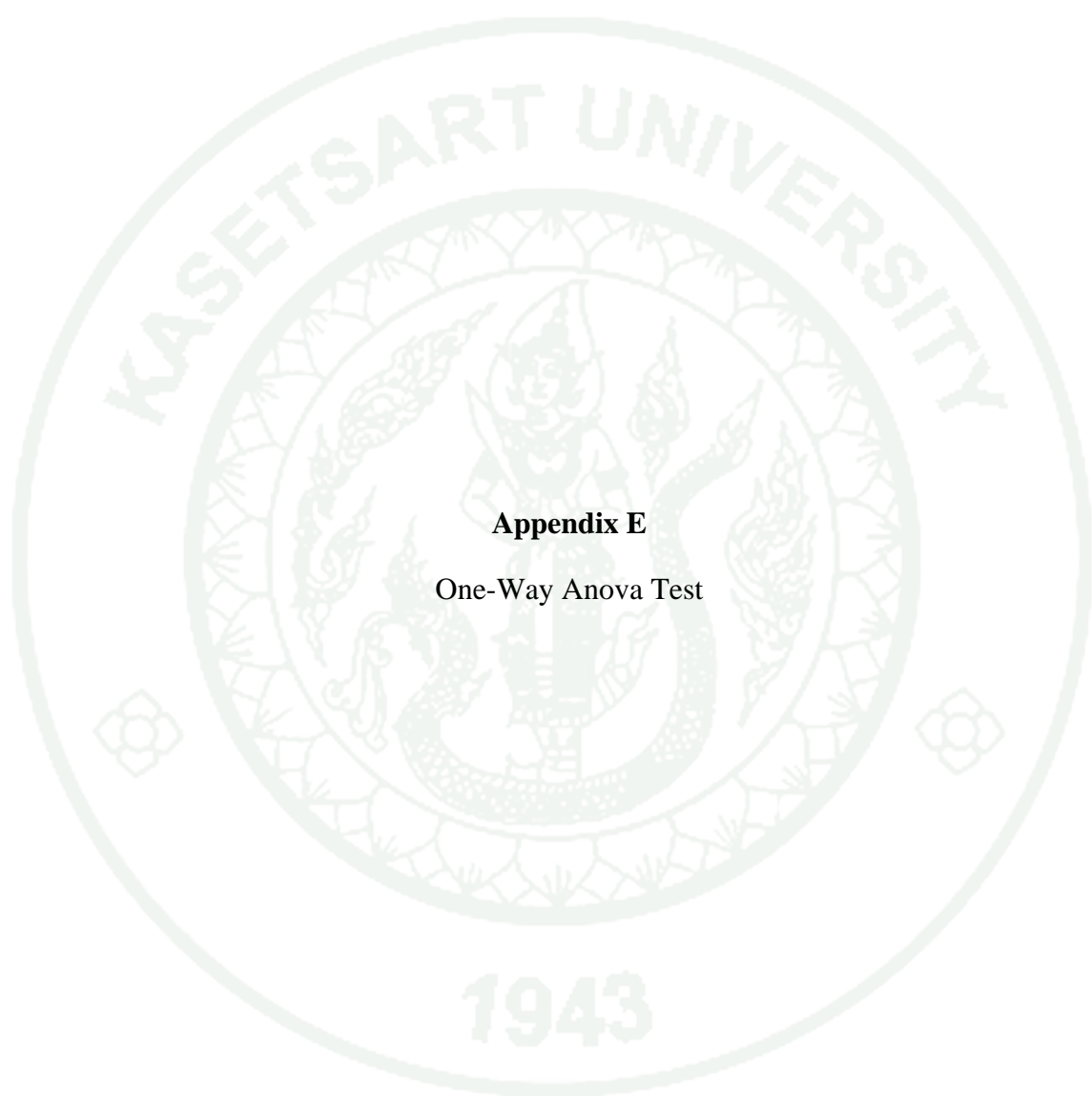
93	Fluctuations of prices of materials	3.70	Sewage and surface drainage	3.70	High cooperation between sub-contractors and general contractor	3.7
94	Types of awarding system	3.70	Equipment maintenance	3.67	Testing for final products only	3.7
95	Difficulty in the recruitment of supervisors	3.70	Location of the project	3.67	Construction waste	3.7
96	Methodology of preparing budget	3.70	The owner not delaying to make decisions	3.67	Measurement of equipment productivity	3.68
97	User changes	3.70	Difficulty in the recruitment of supervisors	3.63	Application of the just-in-time philosophy in the construction industry	3.68
98	Project close out	3.63	Measurement of equipment productivity	3.60	Owners contribution to design	3.67
99	High cooperation between sub-contractors and general contractor	3.63	Owners contribution to design	3.60	Previous successful relations between parties	3.65
100	Closure of border strip	3.63	The relation between construction industry and the other industries	3.60	Companies method and procedures of selecting sub-contractors	3.62

## Appendix D (Continued).

101	High rate of labor turn over	3.60	Difficulty in the recruitment of workers	3.60	Difficulty in the recruitment of supervisors	3.6
102	Soil waste	3.60	Plans to increase income, cut down expenditure	3.60	Equipment maintenance	3.6
103	Testing for final products only	3.60	Soil waste	3.60	Soil waste	3.6
104	Application of the just-in-time philosophy in the construction industry	3.60	Good and fair subcontract conditions	3.57	Plans to increase income, cut down expenditure	3.58
105	Difficulty in the recruitment of workers	3.57	Native vegetation	3.57	Closure of border strip	3.58
106	Site is clean	3.57	Construction waste	3.57	Good and fair subcontract conditions	3.57
107	Plans to increase income, cut down expenditure	3.57	Closure of border strip	3.53	Difficulty in the recruitment of supervisors	3.55
108	Heat and pollution	3.57	Heat and pollution	3.53	Heat and pollution	3.55
109	Good and fair subcontract conditions	3.57	Previous successful relations between parties	3.50	The relation between construction industry and the other industries	3.55
110	Equipment maintenance	3.53	Difficulty in the recruitment of supervisors	3.50	Project close out	3.53

**Appendix D** (Continued).

111	Companies method and procedures of selecting sub-contractors	3.50	Site is clean	3.50	Site is clean	3.53
112	The relation between construction industry and the other industries	3.50	Using a system to evaluate subcontractors performance	3.47	High rate of labor turn over	3.52
113	Difficulty in the recruitment of supervisors	3.47	Project close out	3.43	Difficulty in the recruitment of workers	3.48
114	Using a system to evaluate subcontractors performance	3.47	High rate of labor turn over	3.43	Using a system to evaluate subcontractors performance	3.47
115	Difficulty in the recruitment of workers	3.30	Difficulty in the recruitment of workers	3.40	Difficulty in the recruitment of workers	3.45
116	Constructions materials monopoly	3.27	Constructions materials monopoly	3.37	Constructions materials monopoly	3.32
117	Waste(non value adding activity)	3.20	Waste(non value adding activity)	3.33	Waste(non-value adding activity)	3.27



**Appendix E**  
One-Way Anova Test

### Appendix E One-Way Anova Test.

The respondents of this study comprised of various levels of positions in the construction sector, which might have generated varied opinions while filling the questionnaire. To this effect, a one-way Anova test result is important. There is more than one group belonging to one variable. Respondent's position comprising various level of positions have generated varied opinion in the questionnaire from Executive Officer of both private and government to the site supervisors. The average weighted factors generated from ranking the sub-factors affecting quality (section 4 of the questionnaire) are used for this test.

The research question: Do the position of the respondent affect the ranking of the quality factors?

The null hypothesis ( $H_0$ ): There is no difference amongst the managerial, executive Officer, non-executive, site engineer, project Engineer, etc.

The research hypothesis ( $H_1$ ): There is significant difference amongst the positions.

#### Appendix E One way Anova result.

		Sum of Squares	ddf	Mean Square	F	Sig.
Project	Between Groups	3.097	4	.774	.883	.480
	Within Groups	48.236	55	.877		
	Total	51.333	59			
Design	Between Groups	.777	4	.194	.824	.515
	Within Groups	12.957	55	.236		
	Total	13.733	59			
Contract	Between Groups	2.736	4	.684	1.196	.323
	Within Groups	31.448	55	.572		
	Total	34.183	59			

**Appendix E (Continued).**

Material	Between Groups	.667	4	.167	.658	.624
	Within Groups	13.933	55	.253		
	Total	14.600	59			
Labor	Between Groups	.254	4	.063	.127	.972
	Within Groups	27.396	55	.498		
	Total	27.650	59			
Equipment	Between Groups	.827	4	.207	.395	.812
	Within Groups	28.823	55	.524		
	Total	29.650	59			
Subcontractor	Between Groups	6.891	4	1.723	1.481	.220
	Within Groups	63.959	55	1.163		
	Total	70.850	59			
Site layout	Between Groups	.981	4	.245	.190	.943
	Within Groups	70.952	55	1.290		
	Total	71.933	59			
Quality System	Between Groups	.573	4	.143	.308	.872
	Within Groups	25.610	55	.466		
	Total	26.183	59			
Site Staff	Between Groups	1.391	4	.348	.703	.593
	Within Groups	27.209	55	.495		
	Total	28.600	59			
Execution	Between Groups	2.764	4	.691	2.084	.095
	Within Groups	18.236	55	.332		
	Total	21.000	59			
Financial Issues	Between Groups	.857	4	.214	.326	.859
	Within Groups	36.126	55	.657		
	Total	36.983	59			
Owner	Between Groups	3.533	4	.883	1.004	.414
	Within Groups	48.400	55	.880		
	Total	51.933	59			

**Appendix E** (Continued).

Environment issues	Between Groups	4.990	4	1.247	1.272	.292
	Within Groups	53.944	55	.981		
	Total	58.933	59			
Delay	Between Groups	3.430	4	.857	.495	.739
	Within Groups	95.170	55	1.730		
	Total	98.600	59			

## Statement of hypothesis testing .

One way Anova test reveals that P-value is greater than 0.05 in all the factors meaning that there is no significant difference between the means of ranking of positions involved in this study. Hence, the null hypothesis is accepted depicting that the results display an overall agreement by all the groups with regard to quality factors. In other words, the position of the respondent who filled the questionnaire does not affect the attitude towards ranking the quality factors. This could be deduced as the private and government undergo same experiences during the construction process.

## CURRICULUM VITAE

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