CAUSES OF INCOMPATIBILITY BETWEEN DESIGN AND CONSTRUCTION IN BUILDING CONSTRUCTION

By

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Certified that the contents and form of thesis titled **" CAUSES OF INCOMPATIBILITY BETWEEN DESIGN AND CONSTRUCTION IN BUILDING CONSTRUCTION "** submitted by Mustafa Kamal Khan have been found satisfactory for the requirement of the degree.

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DEDICATED

TO

MY FAMILY, TEACHERS, FRIENDS AND COLLEAGUES

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(Mustafa Kamal Khan)

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ABSTRACT

Building construction projects are started with the ambition to transform the customer requirements into best serving products requiring minimum alterations or additions during the course of construction. However, requirements defined during the design phase change during construction phase (Alarcon et at. 1998). These changes cause incompatibilities between the design and construction phases. The most common changes or incompatibilities are made in the architectural details, structural details, materials and quality. The result of these changes is rework (Undurrage 1996), change orders, construction delays, cost over-runs, etc. Situations like these cause reduction in investment and potential growth of the building construction.

Keeping in view the importance of the building construction and consequences of incompatibilities as explained above, it was decided to carry out a research in this field to study the causes of incompatibilities and their ranking in the building construction industry of Pakistan.

This study included feedback in the form of questionnaire survey from two hundred and eighty one (281) respondents including clients, consultants and contractors connected with building construction constructed using the traditional procurement method. Though most of the respondents are currently working in the twin cities (Rawalpindi/Islamabad), however some of them are working in other parts of the country as well. In addition, many of them have past experience of working in other parts of the country.

From a detailed study of past literature review of international studies, a list of sixty five (65) causes of incompatibilities were outlined which were further grouped in four (04) categories. After obtaining data from the field survey, reliability test of data was conducted in order to confirm the authenticity of the field data. Next the individual ranking of each cause was ascertained using Relative Importance Index for clients, consultants and contractors. Overall ranking for each category was also calculated. Percentage mutual agreement between the three stake holders was also established in order to know the degree of agreement in their views about the causes of incompatibilities.

The present study established Design Phase and Construction Phase as the most important categories which cause incompatibilities between the design and construction in building construction. It was concluded that six most important causes on the basis of overall ranking belong to the Design and Construction Phases. The six most important causes include “Data provided to the designer is incomplete”, “Too little time given to the designer for completion of design documents”, “Approving authorities do not check that structure is designed according to building bye-laws, codes & govt. rules”, “Owner proposes changes due to financial problems”, “Contractor's lack of skilled manpower” and “Approving authorities do not check that structure is constructed according to the approved building plans”.

At the end of this study, some recommendations were made in order to eliminate the major causes of incompatibility in building construction of Pakistan in order to achieve the potential benefits which are planned at the start of a project.

Chapter 1
INTRODUCTION

1.1 INTRODUCTION

1.1.1 Background

Construction industry has become one of the most important industries of any country (Fisk 1997). Performance and success of this sector is very important for a country's economic uplift and financial growth (Ali and Goraya 1998). The management of construction is an enterprise that involves many people with diverse interests, talents and backgrounds. The owner, the design professional and the contractor comprise the primary triad of parties, but others, such as subcontractors, material suppliers, bankers, insurance & bonding companies, attorneys and public agency officials, are vital elements of the project team whose interrelated roles must be coordinated to assure a successful project (Bennett 2003).

The construction industry can be broken down into two very broad categories, i.e. general building construction and engineered construction. With the general building construction, projects such as residential, commercial, institutional and industrial buildings are included. Engineered construction sometimes called engineering construction, is characterized by designs prepared by engineers rather than architects, the provision of facilities usually related to the public infrastructure and thus owned by public-sector entities (Bennett 2003).

Building construction consumes 40% of global energy, generates 5-15% of GDP, and provides 5-10% of employment (EFEI 2011). At the same time, it consumes 40% of the world's raw materials (NIBS 2007). In a developing country like Pakistan, building construction plays a key role in the overall development of the country. It provides employment to a huge bulk of population (Haseeb et al. 2011), brings foreign investment and creates economic activities, provides housing to the nation, contributes in the growth of other industries by using raw materials from them and helps in the circulation of money within the country. In the recent past, this industry brought a lot of foreign investment into the country and it has the potential to bring further investment. It is evident that building industry has an important role in the life of the entire nation. It is also worth mentioning here that the shortage of housing units has increased from 4.3 million in 1998 to an estimated 7.6 million in 2009, with simultaneous increase in the annual depletion of housing stock from 0.3 million in 1998 to 1.28 million in 2009 in Pakistan (World Bank 2010). With the increase in population, the demand for more housing units, educational and health facilities, offices, entertainment centers, etc. is increasing year by year. The cost of construction has also increased many folds during the recent years especially due to inflation. It is therefore imperative that the parties involved in the building construction industry make every possible effort to complete building projects within the planned budget, schedule, cost and quality. Otherwise, the consequences will be rework, cost overrun, schedule overrun, defects, etc.

1.1.2 Incompatibilities between Design and Construction Phases

Various researchers have concluded that variations and changes are common to all types of projects (Thomas et al. 2002). Even if carefully planned, it is likely that there will be changes to the scope of the contract as the work progresses (Harbans 2003). In building projects, customer requirements, constructive aspects and quality standards defined during the design phase change and differ altogether from the ones which finally become part of the constructed facility. Changes normally occur in:

- Architectural details
- Structural details
- Material
- Quality
- Electrical and Plumbing details
- Project time / project schedule
- Project cost
- Construction methods, etc.

These changes cause incompatibilities between the design and construction phases. All of these incompatibilities and changes have far reaching effects on building construction projects. These incompatibilities may result in:

- Rework
- Addition or deletion of tasks in the project program
- Changes in quality of construction, cost overrun or schedule overrun
- Changes in construction methods
- Design and construction defects, etc.

1.1.3 Incompatibilities Pertaining to Architecture, Structure, Material & Quality

Among the incompatibilities mentioned in the previous sub-section, those pertaining to architectural details, structural design details, material, electrical and plumbing details, and quality are more common in building construction projects and these are the focus of the present study as well. These incompatibilities include changes in the:

- Storey heights
- Sizes of rooms
- False ceiling height
- Roof slab levels of adjacent rooms
- Layout of rooms
- Location and thickness of walls
- Location and size of doors and windows
- Alignment of walls and columns
- Elevation of the building
- Location of underground and overhead water tanks
- Plinth level from the ground surface
- Thickness of slabs
- Location of beams and columns
- Depth of beams
- Foundation level from the ground surface
- Foundation types and sizes
- Reinforcement detailing

- ❖ Quality of building materials like concrete, bricks, tiles, paints, wood, etc.
- ❖ Quality of workmanship
- ❖ Insulating materials
- ❖ Size and type of plumbing pipes and accessories
- ❖ Type of electric cables and accessories, etc.

1.1.4 Causes of Incompatibilities

The incompatibilities mentioned in the previous sub-section are caused due to many reasons, yet some of the more common causes include:

- ❖ Lack of proper project planning / analysis of owner requirements at the project start
- ❖ Incorrect or inadequate geotechnical reports
- ❖ Drawings lacking details or showing incorrect references etc.
- ❖ Workability issues like congestion of steel in joints etc. resulting in failure to achieve desired strength or quality
- ❖ The consultant specifies the incorrect material
- ❖ For buildings like hotels, labs, etc., architects / engineer, who are expert in the design of these buildings are not hired
- ❖ Owner chooses material which is not sufficient for the purpose intended
- ❖ Owner recommended changes during construction (when bureaucracy changes, then new bureaucracy proposes changes)
- ❖ Lack of contractor experience and lack of construction supervision
- ❖ Contractor's quality control and workmanship is poor
- ❖ The contractor / subcontractor uses substandard material in an effort to reduce cost
- ❖ Lack of checking by the approving authorities
- ❖ Inflation
- ❖ Shortage of material and labor

It is also interesting to note that sometime construction defects also turn out to be the cause of incompatibilities. For example, if foundation is designed for an assumed bearing capacity of soil and foundation settles during construction, the result will be redesigning of foundation according to the actual bearing capacity of soil. Similarly if low quality plumbing pipes or toilet accessories are used, they may require replacement with different type of items. Construction defects which are likely to be caused by these incompatibilities include settlement of floors, cracks in floor tiles, settlement of foundations, cracks in walls and roofs, lack of ventilation resulting in humidity and smell in the atmosphere, water seepage and leakage, cracks around doors and windows, doors and windows not properly shutting or opening, paint peeling off, faulty drainage, defective plumbing, leaking overhead water tanks, leakage from underground water tank which is located close to column / wall foundation causing floor and foundation settlement, white layer of salts depositing on walls, insect infestation, faulty wiring, improper jointing in brick masonary elements, etc.

1.2 PROBLEM STATEMENT

In most of the building projects in Pakistan, incompatibilities between design and construction phases occur. These incompatibilities include differences in the architectural details, structural details, material, time, cost and quality between the design and construction phases. These incompatibilities create obstructions in achieving the goals that are set at the start of the project. In this regard, research has been done internationally, however in Pakistan, very little research has been carried out and it pertains mostly to time and cost over-runs. There is need for thorough effort to be done in order to identify the causes which result in incompatibilities pertaining to architecture, structural details, material and quality in Pakistan’s building construction environment. Further, these causes must be ranked and the most important causes in building construction projects should be studied in detail to apply counter measures and enhance the efficiency of building construction process.

1.3 RESEARCH OBJECTIVES

The main objectives of the research are:

a. To list down major causes of incompatibilities between design and construction in building construction through review of international and national level literature and then updating the list of those causes with respect to building construction industry of Pakistan.

b. To ascertain ranking of those causes from the perspective of three major stake holders i.e. client, consultant & contractor as well as over-all ranking.

c. Address important causes of incompatibilities for improving efficiency of building construction industry.

1.4 RESEARCH SIGNIFICANCE

The construction industry of Pakistan contributed 2.3 percent of the total GDP of Pakistan in 2009-10. This represented a growth of 15.3% in 2009-10 and a decline of 11.2% in 2008-09 (SBP 2010). About 6.6% of the estimated employed labor force of 52.71 million is employed in the construction industry (FBS 2010). A huge portion of this labor force works in the building construction. With an increase in the urban population and increase in the demand for more buildings, it is important that buildings are completed within the assigned budget and schedule. Unfortunately, the desired project objectives are not achieved due to issues like rework, cost-overrun, time overrun, etc. Most of these problems have their origin in the incompatibilities between design and construction phases. It is therefore need of the time to carry out research in this field, identify the important causes in this regard and find out ways and means to eliminate the effect of those causes. This will consequently eliminate the incompatibilities and ensure completion of building construction projects in Pakistan within the planned budget, schedule and quality standards.

1.5 SCOPE OF THE THESIS

The scope of this research is related to identifying the important causes of incompatibility between design and construction, in building construction of Pakistan. A field survey from 281 clients, consultants and contractors from the building construction industry was conducted. The purpose was to acquire feedback on causes of incompatibility between design and construction of building construction using traditional procurement method. Most of the respondents were taken from Rawalpindi & Islamabad, however professionals currently working in other parts of the country were also included in order to cater for the variations in causes of incompatibility due to geographical factors.

1.6 ORGANIZATION OF THE THESIS

Chapter 1 provides background of construction industry and problem statement that developed the need of this research along with the study objectives, its significance and scope.

Chapter 2 is devoted to literature review. This chapter is divided into two parts. The first part provides brief overview of the traditional procurement method and the role of client, consultant and contractor. The second part throws light on the incompatibilities between design and construction, and their causes. Importance of different causes in the view of various authors is also discussed. Finally a list of causes is made out of literature review peculiar to the environment of Pakistan.

Chapter 3 is concerned with the research methodology employed in the study. The process of survey design, selecting a study sample, development of a questionnaire for data gathering and conducting full scale survey is presented for ranking of causes through statistical tools.

Chapter 4 describes the data analysis and results. The purpose of this analysis was to determine the ranking of various causes targeted in the questionnaire survey.

Chapter 5 is concerned with the conclusions and future recommendations drawn from key research findings. Future directions are also identified.

Survey questionnaire used for survey is available in the appendices. The appendices also contain copies of the reliability tests done using Statistical Package for the Social Sciences (SPSS Ver. 17.0).

1.7 SUMMARY

Brief summary of the research is introduced in this chapter. Starting by reviewing the past literature that developed a need of this research is highlighted. Significance and important aims & objectives are presented. Scope with outline of the thesis chapters is also discussed.

Chapter 2

LITERATURE REVIEW

2.1. INTRODUCTION

This chapter is designed to provide an overview of the survey of the literature. It is divided into two parts. The first part of this chapter provides brief overview of the traditional method of procurement for building construction projects in Pakistan. The relationships and responsibilities of the key stakeholders playing active role in this method i.e. clients, consultants and contractors are elaborated in detail in the sections to follow. The second part of the chapter throws light on the incompatibilities between design and construction in building construction.

2.2. TRADITIONAL METHOD OF PROCUREMENT

2.2.1 Introduction

A construction project is defined as a planned undertaking to construct a facility or group of facilities. The construction of a new project normally starts with the preliminary studies about the possibility and practicality of the proposed project in order to assess the benefits and risks associated with it. All possible options are considered and evaluated in search of the best possible option. The client/owner/principal may be a public sector organization, an autonomous body or any private owner that funds the construction project and will own the completed facility (Eldosouky 2001). After completing the feasibility studies, the next step is to define an organization structure for the construction project. Organization structures for construction projects are a framework of contractual and communication relationships between project players. The organization structures are defined using project procurement systems. Different procurement systems are normally used for the construction projects categorized as traditional and non-traditional procurement systems.

The traditional method of procurement also known as "design-bid-build" is called 'traditional' because it has been the approach of choice for owners of most construction projects during many centuries. The client, consultant and contractor are the three main parties that form the structure of the traditional delivery method as shown in the figure 2.1 (reproduced from Bennett 2003). With this method, the owner contracts with a design organisation to perform preliminary planning, carry out design work and prepare contract documents. Following the completion of this phase, a construction organisation is selected, based upon the owner's criteria, and the owner enters into a contract with the successful contractor for the assembly of the project elements in the field. In this method, the contract for the design work is separate from that for the construction work (Bennett 2003). The contract price paid to the contractor may be in the form of a lump sum, a schedule of prices, or a mixture of both. It may even be, wholly or in part, cost-plus.

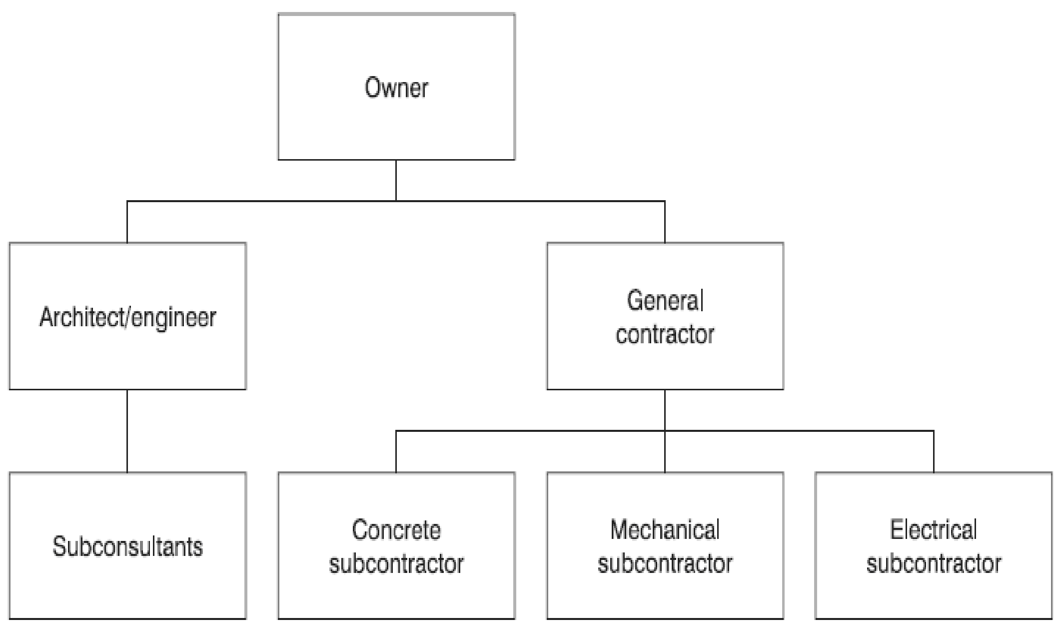

Figure 2.1: Traditional Design-Bid-Build Procurement Method (Bennett 2003)

There are three main sequential phases to the traditional procurement method, 1) Design phase, 2) Bidding (or tender) phase and 3) Construction phase.

2.2.1.1 Design Phase

In this phase the owner hires an architect (or engineer) to act as his consultant to design and produce tender documents on which various general contractors will in turn bid, and ultimately be utilized to construct the project. For building projects, the architect will work with the owner to identify the owner’s needs, develop a written program documenting those needs and then produce a conceptual or schematic design. This early design is then developed, and the architect will usually bring in other professionals including mechanical, electrical, and plumbing engineers (MEP engineers), a fire engineer, structural engineer, sometimes a civil engineer and often a landscape architect to complete documents (drawings and specifications). These documents are then coordinated by the consultant and put out for tender to various general contractors (wikipedia).

2.2.1.2 Bid (or Tender) Phase

In this phase the consultant puts out the tender documents to various general contractors. Bids (tenders) can be "open", in which any qualified bidder may participate, or "select", in which a limited number of pre-selected contractors are invited to bid. The various general contractors bidding on the project obtain copies of the tender documents, and then put them out to multiple subcontractors for bids on sub-components of the project. Sub-components include items such as the concrete work, structural steel frame, electrical systems, and landscaping. Questions may arise during the tender period, for which clarifications or addenda are issued. From these elements, the contractor compiles a complete "tender price" for submission by the closing date and time. Once bids are received, owner’s consultant typically reviews the bids, seeks any clarifications required of the bidders, ensures all documentation is in order (including bonding if required), and advises the owner as to the ranking of the bids. If the bids fall in a range acceptable to the owner, the owner discusses the suitability of various bidders and their proposals. The owner is not obligated to accept the lowest bid, and it is customary for other factors including past performance and quality of other work to influence the selection process. The project is usually awarded to the lowest bid by a qualified general contractor. In the event that all of the bids are in excess of the goals of the owner, the owner may elect to reject all bids. The following options become available, either abandon the project, revise the design making the project smaller or more efficient, or select the lowest qualified bid's general contractor to assist the architectural team / consultant with cost reduction (wikipedia).

2.2.1.3 Construction Phase

After the project has been awarded, the construction documents may be updated to incorporate addenda or changes and they are issued for construction. The necessary approvals (such as the building permit) must be achieved from all jurisdictional authorities for the construction process to begin. In most instances, almost every component of a project is supplied and installed by sub-contractors. The general contractor often provides work with its own forces, but it is not uncommon for a general contractor to limit its role to management of the construction process and daily activity on a construction site.

The consultant acts as the owner's agent to review the progress of the work and to issue site instructions, change orders or other documentation necessary to the construction process (wikipedia). It is important that the consultant must coordinate all parties involved in the project in the most efficient way and exercise the authority and powers in a fair manner in the interest of the project.

2.2.2 Project Participants and Their Contractual Relationships & Responsibilities

The main participants involved on building construction projects are clients, architects & engineers (working as consultants), main contractors and subcontractors. Relationship between the various parties can be seen in figure 2.2 (reproduced from Schexnayder and Mayo 2003).

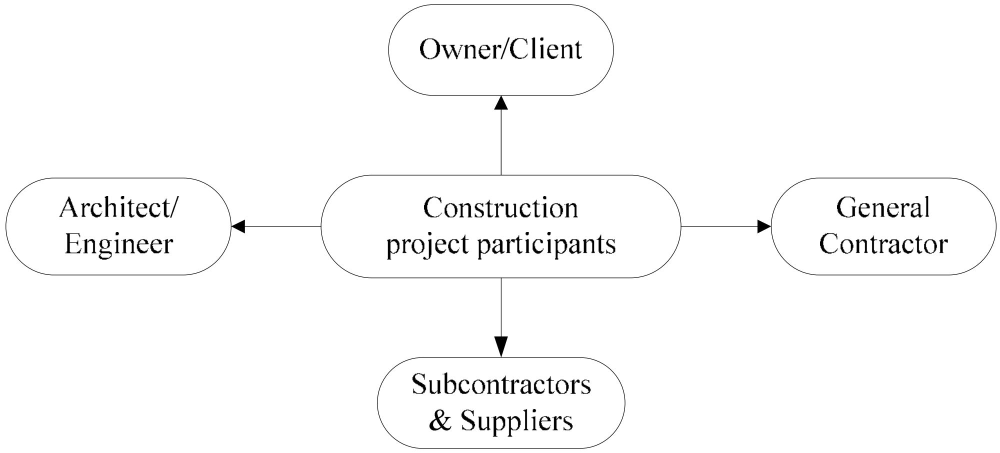

Figure 2.2: Project Members for Construction Undertaking

(Schexnayder and Mayo 2003)

The roles and responsibilities of clients, consultants, main contractors and subcontractors have been explained in the succeeding sections.

2.2.2.1 Client

The client/owner/principal may be a public sector organization, an autonomous body or any private owner that funds the construction project and will own the completed facility (Eldosouky 2001). The client defines the purpose/need and scope of the work and retains the overall control of the construction project. In the traditional delivery method, the client is under contractual obligations with the design consultant and with the contractor. There is no contractual relationship between consultant and contractor, however, a communication link exists between the two key project participants.

2.2.2.2 Consultant

Consultants, generally are designers/architects or engineers (private or public organization). The term 'design professional' is also used to refer to the architect and engineer as they perform their planning, design and construction liaison tasks on a construction project. In addition, it is common to use the words architect-engineer, architectural-engineering firm or A/E, for the party engaged to carry out these tasks (Bennett 2003). The consultants are selected by the owner through competitive selection process based on knowledge and experience. In design-bid-build, the owner generally designates the consultant to oversee the construction work at site. He / she is full incharge of designing and supervising the project on behalf of the client. He / she should be well trained in quality and workmanship requirements and be able to assess quality of construction work. The consultant also verifies the progress payments submitted by the general contractor. The consultant also provides technical advice and solutions to the client and contractor on the potential project problems (Sengupta & Guha 2002, Schexnayder & Mayo 2003). If the consultant hired by the owner has in-house planning and design staff, he would perform all the required planning and design work with his own staff, otherwise he may award the task of planning and designing to design organizations / designer through competitive process and with due knowledge of the owner.

Main responsibilities of the consultant are appended below (Eldosouky 2001):

- Realizing the project defined at sanction
- Overseeing the client's diverse interests
- Selecting a suitable contract strategy
- Preparation of tender documents
- Forecasting project cash flow
- Pre-tender evaluation of contractor
- Evaluation of bids
- Recommendation for selection of contractor
- Approval of contractor's plan
- Coordinating of design and construction
- Review of shop drawings
- Construction quality assurance
- Issuance of variation orders
- Assessment of variations and claims
- Evaluation of completed work
- Certification of contractor's payment requests
- Solving problems with local authorities and inhabitants

- Public relations
- Final inspection of work

2.2.2.3 Contractor

The general contractor is responsible for all works on the project whether constructed by the firm's own forces or by subcontractors. The contractor is responsible for and is involved in all work performed on site, however he is not involved in the design process. He is responsible to control the construction costs, keep the project on schedule and interact with all project members on all matters and issues. The contractor would seek the most efficient use of his resources using construction management techniques (Eldosouky 2001).

Main responsibilities of the contractor are appended below (Eldosouky 2001):

- Success of the contract
- Ensuring maximum cooperation of site staff in all matters affecting the efficiency, economy and smooth running of the construction operation
- Reviewing possibilities of design changes to suit particular methods of working which will result in cost savings
- Reviewing any requirement for additional resources
- Identifying and dealing with problems arising at site level which will result in delays or increase in cost
- Ensuring compliance with contract documents and the Engineer's instructions
- Organization and deployment of the contractor's site staff, plant, labor and all other resources
- Operating and maintaining the site testing laboratory
- Billing
- Providing and updating all the programmes, budgets, expenditures and other records required by the Consultant
- Administering purchases for the supply of materials and services
- Coordination of subcontractors work
- Protection of persons and property on, and adjacent to the construction site

2.2.2.4 Subcontractors and Suppliers

Sub-contractors are also called specialty contractors. The contractors mostly sub-contract a large portion of work to the sub-contractors under a contract. Sub-contractors may be electrical, mechanical, steel fabrication, dry wall, painting and carpeting works specialists. They have no links with other project members. On the building projects, 10 to 15 subcontractors are generally required. On the other hand, suppliers in the construction industry provide construction materials and have a contract with the contractors and subcontractors. They assist the general contractors in preparing the bids, shop drawings and fabrications. Material suppliers may be electrical whole sellers, lumberyards, ready mixed concrete suppliers, plumbing supply stores etc. The project quality is highly dependent on quality of the suppliers used by the contractors.

2.3 INCOMPATIBILITY BETWEEN DESIGN & CONSTRUCTION IN BUILDING CONSTRUCTION

2.3.1 General

Every building construction project is started with the objective of completing it according to the details set in the contract. Every possible effort is made to include the owner's requirements in the design and to produce a final outcome which is up to the expectations of the owner. However, in building projects, customer requirements, constructive aspects and quality standards defined during the design phase may change and differ altogether from the ones which finally become part of the constructed facility. Incompatibilities or changes between design phase and construction phase appear as soon as the construction work starts or even after the award of work.

A construction program, or project plan, consists of a series of inter-related and sometimes inter-dependent activities or processes. Each process requires a set of inputs and produces a set of outputs. Outputs from one process may be inputs to another process. At the start of a project, many input parameters are uncertain and assumptions have to be made. Variations in any of the preexisting conditions, assumptions or requirements during execution will lead to changes from the baseline project plan (Sun and Meng 2009). Normally, these changes occur in architectural details, structural details, material, quality, project time / project schedule, project cost, construction methods, etc. These changes from the baseline project plan are in fact the incompatibilities which occur between design and construction phases.

2.3.2 Incompatibilities between Design and Construction

In this study the main focus is on the causes of those incompatibilities which pertain to architectural details, structural design details, material and quality.

2.3.3 Adverse Effects of Incompatibility in Building Construction

The result of these changes / incompatibilities is addition or deletion of tasks, rework, changes in quantities, delays in start and completion of tasks, cost overruns and occurrence of construction defects.

The resulting consequences of these incompatibilities can be so significant that the project participants may fail in achieving the intended purpose for the completed facility. Overall, these may result in loss of revenue due to delayed handing over of the facility because otherwise the owner would have shifted to the building from a rentable space, or may have used the building for renting purpose or other purpose. In some cases the incompatibility may cause the contractor higher overhead cost because of longer work period, higher material costs due to inflation and labor cost increases.

2.3.4 Causes of Incompatibilities Through Literature Review

A detailed literature review was carried out in order to ascertain the past studies on the topic of causes of incompatibility. This includes international research work on the said topic. Internationally, some research has been carried out in order to ascertain the important causes of incompatibility between design and construction in building construction. Different researchers have carried out research with their own methodologies in order to rank these causes. The purpose of these studies was mostly to enlist various causes and find their ranking.

According to Clough and Sears (1994), these changes or incompatibilities result from various sources, which include the performance of construction parties, resources availability, environmental conditions, involvement of other parties and contractual relations.

Arain and Assaf (2007) studied potential sources of disagreements at the project design and construction interface in large building projects in Saudi Arabia and observed that the contractor's lack of comprehension of drawing details and specifications, involvement of contractor as consultant, time limitation in the design phase, design complexity and participants' honest wrong beliefs were considered as the most important sources of the project design and construction interface problems. On the other hand, project management as professional service, weather conditions, unforeseen problems and involvement of the contractor in design phase were least important sources of problems between professionals at the project design and construction interface.

Study carried out by Arain and Pheng (2005) suggested that change in plans or scope by owner, unforeseen problems, defective workmanship, change in specifications by owner and safety considerations are the most important causes of variation orders for institutional buildings in Singapore. The study recommended the involvement of professionals during the design and construction phases, clear and thorough project brief, frequent communication among professionals, involvement of a project manager from an independent firm to manage the project and involvement of owner during the design phase for controlling the most important causes of variation orders.

In a study carried out by Assaf and Al-Hammad (1988) in Saudi Arabia, it was revealed that most of the design inputs were completed abroad where the designer does not have the statistical data or enough knowledge of the environmental, social and cultural factors which could affect building projects in Saudi Arabia. In addition, contractors in Saudi Arabia were not familiar with resources available and other related issues.

Mendelsohn (1997) observed that probably 75% of the problems encountered on site were generated at the design phase. This is not to say that contractors do not create a slew of problems of their own but that these problems were often compounded by inherent design flaws. If one were to seriously consider ways to reduce problems on site, an obvious place to begin with is to focus on what the project team can do to eliminate these problems at the design phase.

Study carried out by Fredrickson (1998) was for design-build projects, however as noted by him on each project, client and design-construct delivery team has unique design needs. There is no "one size fits all" way of identifying the right design approach to a particular project. However, the guidelines adopted from previous projects can help to assist a project delivery team to determine how the design should be handled that can greatly improve the project's chances of success.

Mendelsohn (1997) further investigated and suggested that a designer has a conceptual mind and a contractor has a concrete mind. One relates to intangibles and the other relates to tangibles.

According to Oyewobi et al. (2011) and Alarcon et al. (1998) design defects are detected during the execution phase of the projects which consequently leads to rework. The problems associated with the designs are mainly incomplete design drawings requiring a great amount of specifications. Specifications are difficult to handle and sometimes are ignored. Very often design documents have inconsistencies, errors and omissions, or simply lack of clarity in the presentation. This implies that those that should carry out the work do not have the necessary information or have the wrong information to do the job which may cause total rework or outright cancellation. Second, there is a lack of standards in the designs, and lack of suitability for the existing technology. In many projects of similar characteristics, or of the same type, the designs used are completely different with the consequent loss of efficiency in the construction phase. Third, an important proportion of the problems detected during construction are due to lack of constructability of the designs. Details not defined in the designs become problems that have to be solved by the contractor on site. Usually the problems are detected just before starting construction of the specific task and sometimes even after the task has been accomplished.

Che et al (2010) postulated that change of plan by owner, substitution of materials by owner and changes of design by consultant were the main causes of change orders in building projects in the states of Selangor Malaysia.

Al-Hammad (2000) observed that owners underestimate the construction costs for a project and demand higher quality and more detailed work.

2.3.5 Selection of Causes for Construction Industry of Pakistan

After going through the detailed study of international as well as national level studies a list of causes was outlined. During this process, it was ensured that maximum causes should form part of the list so that maximum dimension causing incompatibilities in building projects could be explored. These causes were downsized by elimination to the least applicable to suit the building construction industry of Pakistan. Towards the end a total of sixty five (65) causes were selected for the field survey.

2.3.6 Grouping of Causes of Incompatibility

In order to ease the analysis part, grouping of these indicators was carried out. So, in this study sixty five (65) causes were grouped in four (04) categories.

2.4 SUMMARY

In this chapter, first an overview of the traditional method of procurement for construction industry in Pakistan was presented. The role of the key stakeholders playing active role in this method i.e. clients, consultants and contractors was also presented along with their relationships and responsibilities. Next the incompatibilities between design and construction phase in building construction were explained in the light of the work done by many researchers. The next chapter discusses the research methodology developed for this research.

Chapter 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

The purpose of this chapter is to discuss the methodology used for this study in order to achieve research aim and objectives that were introduced in Chapter 1. Based on research questions, survey method is chosen as a research strategy. The whole survey design process is extensively elaborated. The construction of a questionnaire, collection of data through field survey and data analysis strategy is also presented.

3.2 RESEARCH DESIGN

Research strategy defines the layout/design showing how the researchers are going to carry out their study to achieve and answer research questions (Saunders et al. 2003). It comprises of sampling and questionnaire development, data collection sources and considering research constraints. The research strategy is selected on the basis of research aim/objectives. Three different approaches are considered acceptable for the research in construction management. These are: quantitative methods, qualitative methods and combination of both quantitative and qualitative commonly known as 'mixed mode approaches'. Quantitative research methods use deductive approach and are associated with collection of data and statistical analysis. On the other hand, using inductive approach, qualitative methods draw the results from interviews or observations rather than using statistical procedures (Amjad 2004-2005). Association of Researchers for Construction Management (ARCOM) proceeding from period 1991-2001 reveals that qualitative and mixed mode approaches have increased slightly. Root et al. (1997) argued that the choice between quantitative or qualitative methods is highly dependent on the research aim/objectives. Based on the above, the aim of this research was to rank the causes of incompatibility in building construction by evaluating the input from client, consultant and contractor. Quantitative approach was used for this research and survey method is selected for data collection. The research was carried out following the steps shown in figure 3.1.

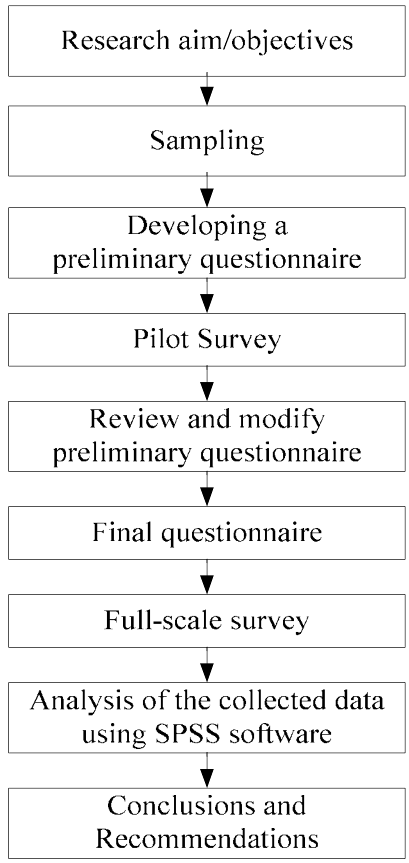

Figure 3.1: Research Methodology Flow Chart

To carry out the study, a questionnaire was developed including the causes of incompatibilities. Pilot study was taken in to consideration and carried out for purpose of the questionnaire validation, refinement and improvement. Having done a feasibility survey, full scale survey was conducted from owners, consultants and contractors working in building industry to get their feedback on (65) causes grouped in (04) categories. Finally, reliability analysis was done on the collected data and relative importance index was calculated for each cause to find their ranking.

3.3 THE SURVEY DESIGN PROCESS

Survey is defined as “data collected from number of cases/projects through systematic measurement and then analyzed to yield the results (Marsh 1982). Trochim (1997) and Bryman (2004) argued that in applied social research, surveys are mostly carried out by questionnaire and interview surveys. Bryman (2004) referred surveys as cross-sectional studies and explained that the data collected from the surveys are generally quantitative in nature and can be used to correlate two or more variables. Trochim (1997) suggests that several issues should be kept in mind when a survey is chosen as a research strategy: a) population, b) sampling and c) question issues. The survey design selected for this research is shown in the Figure 3.2 (adopted from Shuwei 2009).

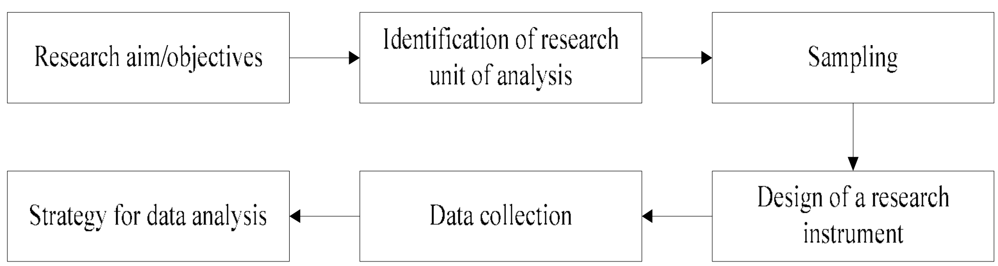

Figure 3.2: Research Survey Design Process (Shuwei 2009)

3.3.1 Identification of Research Unit of Analysis

The identification of unit of analysis is the central part of the survey design process and concerned with the data to be collected (Shuwei 2009). De Vaus (2002) has highlighted the importance of unit of analysis and argued that it is directly associated with the aim/objectives of the research. In this research, each respondent has been taken as one case and opinion of each key stake holder i.e. owner, consultant and contractor is included in the study.

3.3.2 Sampling

In this research, survey was conducted from clients, consultants and contractors. Based on valid individual and company registrations maintained by Pakistan Engineering Council (PEC) up to 2011, there are 485 consultants and around 30500 contractors registered with Pakistan Engineering Council. The number of architects registered with Pakistan Council of Architects and Town Planners (PCATP) is 3100. As for the clients, 540 public organizations are listed with Public Procurement Regulatory Authority (PPRA). The sample size for each of these target populations was calculated using the following equation (Arain & Pheng 2005; Kish 1995):

$n = n' / (1 + n' / N)$ ……………………………………………(3.1)

Where:

n' = Sample size from infinite population = S^2 / V^2

n = Sample size from finite population

N = Total population

V = Standard error of sample population equal to 0.05 for the confidence interval 95%

S^2 = Standard error variance of population elements, $S^2 = P(1 - P)$; maximum at $P = 0.5$

$n' = S^2 / V^2 = (0.5)^2 / (0.05)^2 = 100$ ………………………………(3.2)

1) For clients:

$N = 540$

$n = 100 / (1 + 100 / 540) = 84$

2) For consultants:

$N = 485 + 3100 = 3585$

$n = 100 / (1 + 100 / 3585) = 97$

3) For contractors:

$N = 30500$

$n = 100 / (1 + 100 / 30500) = 100$

Sample sizes calculated for the target populations were 84 clients, 97 consultants and 100 contractors.

3.3.3 Design of a Research Instrument

Based on the research aim/objectives i.e. to rank causes of incompatibilities for building construction industry of Pakistan, a questionnaire was developed for full scale survey based on thorough past review of literature, researcher experience on the building projects and after conducting a pilot survey. Measurement scale selection, attitude measurement and ranges of response category were taken in to consideration for the design of questionnaire. The Arain et al. (2006) questionnaire was adopted which consisted of 45 causes grouped into 3 categories. Based on the discussion with building experts, additional questions were added.

3.3.3.1 Selection of Measurement Scale

Measurement scale is generally divided in to four different levels, namely nominal, ordinal, interval and ratio (Reaves 1992 and Trochim 1997). In this research, client's, consultant's and contractor's perceptions were to be measured, so it was suitable to select the ordinal scale (also called ranking scale) for its measurement.

3.3.3.2 Attitude Measurement

Oppenheim (1992) argued that people's perception about some specific issue goes from low, through neutral to a degree of high level. Attitude measurement is suitable for measuring individuals' perception or feelings, called an attitude scale by Bell (2005). De Vaus (2002) and Saunders et al. (2003) have named attitude scale as numeric rating scale and semantic differential rating scale. There are four commonly used methods of attitude scaling in social research: the Bogardus, Thurstone, Likert and Guttmann (cumulative) scales (Oppenheim 1992; Trochim 1997 and De Vaus 2002). Among them, Likert scale is widely used as it provides better reliability and less laborious (Oppenheim 1992, De Vaus 2002). Therefore, Likert scale was selected to take opinion of the key stake holders i.e. client, consultant and contractor in this research.

3.3.3.3 Ranges of Response Category

Several researchers have recommended 7-point scale (Alwin 1997 and De Vaus 2002); however, the fine distinctions can confuse and requires precision with greater accuracy (Shuwei 2009). Therefore, based on the above, five point scale was adopted for the survey questionnaire to get feedback on each indicator and defined scales as 1 for Not Important (or not sure or never used), 2-Slightly Important, 3-Moderately Important, 4-Very Important and 5-Extremely Important to show their attitude towards each indicator contributing incompatibility in building construction of Pakistan.

3.3.3.4 Pilot Study

The purpose of a pilot survey also known as feasibility survey is to test a questionnaire for its reliability, consistency and validity (Thompson 2010). De Vaus (2002) argued that while conducting a pilot survey, the emphasis should take on checking whether any problem exists with the questionnaire items, how long it will take to fill in and whether respondents are interested in filling the questionnaire. Another important issue is how many pilot surveys be carried out. Shuwei (2009) believed that the number of pilot studies depends on research aim/objectives, size of the research study and available resources (time and money). For this purpose, the questionnaire was presented to 2 clients, 6 consultants and 7 contractors followed by interviews with each participant. Each of the respondents had more than 15 years of experience in building construction. Interviews were conducted face to face, ensuring a 100 per cent response rate. The questionnaire was amended by incorporating feedback of the experts to make it suitable in accordance with the building construction industry of Pakistan. As suggested by Saunders et al. (2003), the questionnaire was also thoroughly discussed with colleagues and friends to pick any error and obtain the face validity of a questionnaire. After that, the questionnaire was refined and ready for carrying out a full scale survey. In the next section, questionnaire layout is presented.

3.3.3.5 Layout of a Questionnaire

Shuwei (2009) suggested that the survey questionnaire should be clear, precise and attractive for the respondents to fill in and return it. In this research, the questionnaire was developed in easy and understandable form keeping in view the context of Pakistani building construction industry environment. A cover letter and survey instructions were prepared to ensure that all participants understood that their responses would be anonymous. The final questionnaire had an introduction of the respondent covering his / her name, qualification, designation, working experience in the building construction industry, organization and the group which they represent (client, consultant and contractor). This was followed by four sections: design phase; tendering phase; construction phase; and overall project phase as given in Table 3.1. In the design phase, 20 major causes were identified, of which 5 were adopted from Arain et al. (2006) and the remainder were incorporated from the input of experts in the pilot survey. The tendering phase was newly added to the questionnaire and was not in the Arain et al. (2006) questionnaire. It included 7 major causes. In the construction phase, 24 major causes were identified, of which 6 were adopted from Arain et al. (2006) and the remainder were incorporated from the input of experts in the pilot survey. In the Overall project phase, 14 major causes were identified, of which 8 were adopted from Arain et al. (2006) and the remainder were incorporated from the input of experts in the pilot survey. Finally, each questionnaire incorporated a five-point Likert-type scale (from 1 = “Not Important” to 5 = “Extremely Important”) facilitating statistical analysis of the information.

Table 3.1: Categories of Causes

Sr. No.	Categories of Causes
1	Design Phase
2	Tendering Phase
3	Construction Phase
4	Overall Project Phase

Respondent from each stake holder group was requested to give input against each cause in the questionnaire.

3.3.4 Data Collection

3.3.4.1 Full Scale Survey

Since most of the respondents were accessible to the researcher, it was decided to deliver questionnaires to the respondents personally. Bell (2005) argued that delivering questionnaires to respondents by hand have distinct advantages. Respondents can get a better understanding of the research purpose, questionnaires can be filled through face to face communication, any difficulty in the questionnaires can be sort out easily and high response rate can be obtained. Therefore, clients, consultants and contractors working in Islamabad and Rawalpindi region were visited personally and questionnaires were delivered to them. In addition, representative samples of owners, consultants and contractors working in other cities were accessed through telephone and delivered questionnaires to them through email or postal mail. In total 300 hard copy questionnaires were distributed, resulting in 283 questionnaires being collected. This included 85 clients, 98 consultants and 100 contractors. Two questionnaires were not complete, which were discarded and considered invalid to prevent a distortion of the results from the data set. The sample size for the data analysis was thus 281. Of the 281 respondents hereinafter called the sample, in terms of building construction experience, 41.64% had experience between 0 to 10 years, 33.81% had experience between 11 to 20 years, 14.95% had experience between 21 to 30 years and the rest 9.61% had more than 30 years experience. 78% of the respondents had an advanced degree, 9% were diploma holder, 8% had simple bachelor's degree and the rest 5% had secondary education.

3.3.5 Strategy for Data Analysis

The survey data collected for this research was an ordinal one and used a Likert scale; Cronbach's Alpha coefficient method was used to check the reliability of the collected data. Further the formula of Relative Importance Index (RII) was used to rank the cause for each stake holder. Overall ranking of categories of causes was also determined. The Rank Agreement Factor (RAF) and Percentage Agreement (PA) were further used to see the percentage of disagreement and agreement between the three stake holders regarding ranking of (04) categories of incompatibilities. The analysis and results are presented in Chapter Four.

Chapter 4

DATA ANALYSIS AND RESULTS

4.1 INTRODUCTION

In this chapter, detailed analysis of the collected data is presented. In this connection, the most comprehensible and popular software for practical statistical analysis SPSS Ver.17.0 (Statistical Package for the Social Sciences) was used. In this research, the client, consultant and contractor gave their perceptions about causes of incompatibility in building construction. Different statistical tests such as Reliability, calculation of Relative Importance Index (RII) for ranking of factors and Percentage Agreement between the three parties was done in order to drive the overall ranking of causes. Six most important causes based on overall ranking are also listed.

4.2 DEFINING VARIABLES

First of all, for conducting reliability analysis on SPSS, causes of incompatibility were encoded in SPSS. The following sections will provide detail about the codes used for each cause.

4.2.1 Causes in each Category

Among each category, there were numerous causes that were attributing towards that particular category. In order to be able to recognize the causes in the software easily, the codes for the causes were abbreviated taking into account the particular category to which they belong. The tables in the following sections show the causes and their relevant codes.

Table 4.1 shows the causes in the Design Phase and the corresponding codes for those causes as given below:

Table 4.1 : Design Phase Related Causes

Sr. No.	Cause	Code
1	Contractor is not involved in the design conceptual phase	DS1
2	Contractor is not involved in the design development phase	DS2
3	Data provided to the designer is incomplete	DS3
4	Data provided to the designer is incorrect	DS4
5	Data provided to the designer is late	DS5
6	Lack of human resources with the designer	DS6
7	Designer busy in too many assignments	DS7
8	Lack of designer's knowledge of building bye-laws, codes & govt. rules	DS8
9	Lack of designer's knowledge of constructability of proposed design	DS9
10	Lack of designer's knowledge of availability of materials for construction	DS10
11	Lack of designer's knowledge of engineering design techniques & softwares	DS11
12	Lack of designer's knowledge of engineering drafting	DS12
13	Lack of designer's knowledge of suitability of materials for construction	DS13
14	Frequent replacement of designer by the owner	DS14
15	Personal and social problems of the designer	DS15
16	Lack of reward, delayed payment or low payment to the designer by the owner	DS16
17	Too little time given to the designer for completion of design documents	DS17
18	Lack of project planning & rigorous analysis of requirements of owner at the project start	DS18
19	Frequent changes in the proposed design due to owner dissatisfaction	DS19
20	Approving authorities do not check that structure is designed according to building bye-laws, codes & govt. rules	DS20

Table 4.2 lists the causes in the Tendering Phase and the corresponding codes for those causes as given below:

Table 4.2 : Tendering Phase Related Causes

Sr. No.	Cause	Code
1	Incomplete or inaccurate design documents un-intentionally provided with bidding documents	TSC1
2	Incomplete or inaccurate design documents intentionally provided with bidding documents	TSC2
3	Contract type	TSC3
4	Contractor did not consider that the design is exotic, complex or difficult to build, and he does not have the required expertise	TSC4
5	Selection of contractor on the basis of lowest bid	TSC5
6	Amount of Performance security / retention money	TSC6
7	Absence of third party validation during defect liability period	TSC7

Table 4.3 lists the causes in the Construction Phase and the corresponding codes for those causes as given below:

Table 4.3 : Construction Phase Related Causes

Sr. No.	Cause	Code
1	Owner proposes changes because he had planned to make changes during construction from the beginning	CN1
2	Owner proposes changes during construction due to sudden changes in his requirements / expectations	CN2
3	Owner proposes changes during construction due to change in ownership	CN3
4	Owner proposes changes to assert his authority and make undue interference in construction	CN4
5	Owner proposes changes due to financial problems	CN5
6	Slowness in decision making process by owner	CN6
7	Changes in building codes, bye-laws & govt. rules	CN7
8	Delayed revision of drawings by designer	CN8
9	Drawings not properly stamped or certified by designer	CN9
10	Custody and supply of drawings at site	CN10
11	Delayed approval of drawings by owner or consultant	CN11
12	Material changes due to shortage of particular material in the market	CN12
13	Material changes due to procurement delays by contractor	CN13
14	Contractor does not follow recommended construction methods and does not use proper construction equipment	CN14
15	Contractor's lack of skilled manpower	CN15
16	Contractor's lack of comprehension of drawing details	CN16
17	Contractor's lack of coordination and management during construction	CN17
18	Contractor’s-staff facing lack of tools, equipment, etc. for measurement, alignment, angular adjustment at corners, etc.	CN18
19	Contractor and his staff focusing on other projects	CN19
20	Designer's lack of awareness / interest about ongoing construction process	CN20
21	Unanticipated weather conditions	CN21
22	Unforeseen problems and differing site conditions	CN22
23	Timing of the proposed changes, i.e. whether at the start or at the end of construction	CN23
24	Approving authorities do not check that structure is constructed according to the approved building plans	CN24

Table 4.4 lists the causes in the Overall Project Phase and the corresponding codes for those causes as given below:

Table 4.4 : Overall Project Phase Related Causes

Sr. No.	Cause	Code
1	Economic situation of the country	PR1
2	Nationality of participants	PR2
3	Organizational structure of owner, consultant and contractor	PR3
4	Lack of communication and coordination between parties	PR4
5	Lack of mutual respect between parties	PR5
6	Conflicts and legal disputes b/w various parties	PR6
7	Participant's honest wrong belief	PR7
8	Corruption / Fraudulent practices	PR8
9	Lack of an experienced consultant or his lack of interest in work	PR9
10	Frequent replacement of consultant during construction	PR10
11	Appointment of contractor as consultant	PR11
12	Appointment of designer as consultant	PR12
13	Design firm or contractor firm goes bankrupt or is black-listed	PR13
14	Withdrawal of licenses and permits	PR14

Before calculating Relative Importance Index (RII) and Percentage Agreement (PA) between the three stake holders, reliability of the collected data was assessed. This is discussed in the next section.

4.3 RELIABILITY ANALYSIS

Repeating any measurement that produces the same result is considered a reliable measurement (Gaur & Gaur 2009). Leech et al. (2005) argued that the reliability test is done to check whether each item in the scale is free from error of measurement. Hinton et al. (2004) have also defined reliability as a questionnaire tested to study any topic at different times and across different populations, if produces same results, the questionnaire is a 'reliable one'.

Different methods are used to assess the reliability. Test-retest method is used to ideally measure the reliability. In this method, the measurement is done on the same object twice and results are compared. If the results are same, the measurement is reliable. However, practically this method is quite difficult to establish the reliability (Hinton et al. 2004).

In SPSS, widely used methods for assessing reliability include Cohen's Kappa Coefficient for categorical data and Cronbach's Alpha for continuous data (Likert-scale type items). Among them, Cronbach's Alpha is most popular method (Hinton et al. 2004 and Leech et al. 2005). Hinton et al. (2004) explained that Cronbach's Alpha value range from 0 (un-reliable) to 1 (reliable) with 0.75 being considered the most sensible value. They have also provided a guide line to assess the reliability of any data as shown in the Table 4.5.

Table 4.5: Guideline for Assessing Reliability Results

a.	0.9 & above	Excellent reliability	**b.**	0.7 to 0.9	High reliability
c.	0.5 to 0.7	Moderate reliability	**d.**	0.5 and below	Low reliability

In reliability analysis, un-dimensionality i.e. correlation of each item with the total scale can be checked as well. De Vaus (2002) and Hinton et al. (2004) argued that if the item-to scale coefficient is below 0.3, the item should be removed. Since the data gathered was based on Likert-scale; therefore Cronbach's Alpha method was used to check the reliability in this research. The summary of the reliability analysis conducted on SPSS is presented here and full results can be seen in the appendices.

4.3.1 Data Reliability of Causes and Categories of Incompatibility

Cronbach's Alpha values for both causes and categories of incompatibilities were found through SPSS. It is observed that all the values were above 0.3, thus all the causes in each category were retained. Cronbach's Alpha values for each cause are given in appendices for client, contractor and consultant. Cronbach's Alpha values for the four categories are given in Table 4.6.

Table 4.6: Cronbach's Alpha Values for Categories of Incompatibility

Sr. No.	Causes of Incompatibility	Client	Consultant	Contractor
1	Design Phase	0.922	0.903	0.933
2	Tendering Phase	0.862	0.756	0.870
3	Construction Phase	0.938	0.929	0.970
4	Overall Project Phase	0.941	0.904	0.957

4.4 DESCRIPTIVE ANALYSIS

Questionnaires were delivered to three hundred (300) professionals, out of which two hundred and eighty one (281) valid responses were collected.

4.4.1 Type of the Projects

Professionals who have worked in the building construction industry were included in the questionnaire survey.

4.4.2 Type of the Respondents

All the three key stake holders i.e. client, consultant and contractors were consulted as part of field survey. This helped to ascertain the perspective of each stake holder regarding causes of incompatibility in Building Construction in Pakistan. The number and percentage of respondents is given in Table 4.7.

Table 4.7: Number and Percentage of Respondents

Respondent Type	Client	Consultant	Contractor
Number of Respondents	84	97	100
Percentage of Total Respondents	29.9%	34.5%	35.6%
Total Respondents	281		

A graphical representation of the number and percentage of respondents is shown in the figure 4.1:

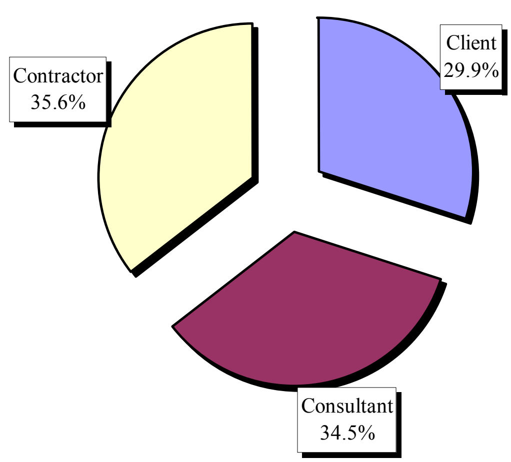

Figure 4.1: Percentage of Respondents

Majority of the respondents had experience in the range 0 - 20 years with about 58% respondents having experience more than 10 years.

Table 4.8 shows the number of respondents and their percentages in different categories of experience:

Table 4.8: Number and Percentage of Respondents in Different Experience Categories

		Client	Consultant	Contractor	Total Number	Percentage
Experience	0 – 10	35	43	39	117	42%
	11 – 20	35	30	30	95	34%
	21 – 30	9	13	20	42	15%
	More than 30	5	11	11	27	10%

A graphical representation of the relationship between respondents and their experience in the building construction industry is shown in figure 4.2:

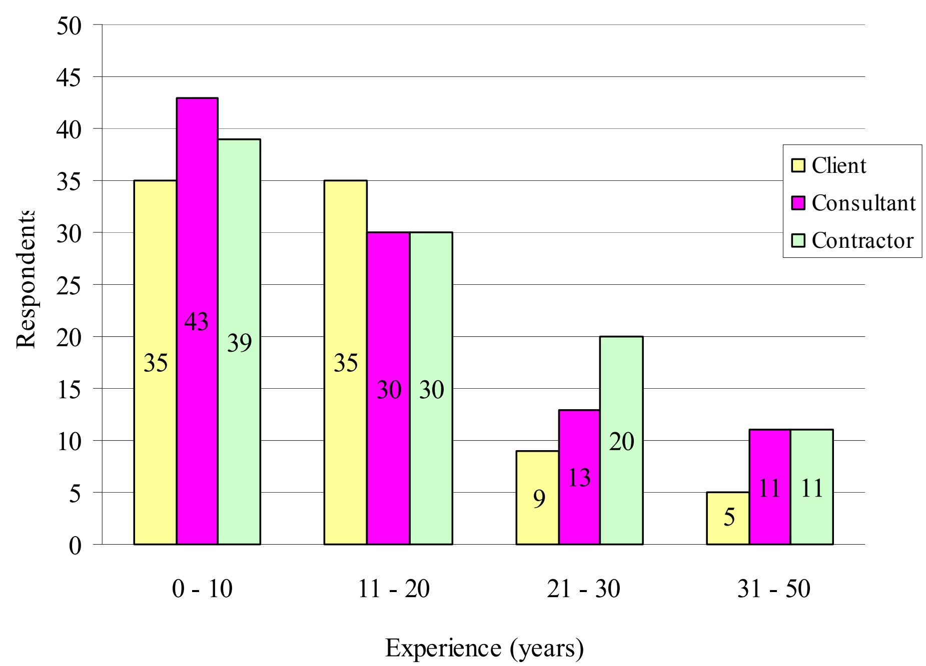

Figure 4.2: Number of Respondents in Different Experience Categories

4.4.3 Ranking of Causes of Incompatibilities

One of the objectives of this study was to rank the causes of incompatibilities. A number of researchers (Chan and Kumaraswamy 1997) have used the Relative Importance Index (RII) method to determine the relative importance of attributes. The same method was used and the respondent's input from the five-point scale in the questionnaire was transformed to relative importance index for each cause of incompatibility to determine the rank of that cause for each stakeholder. The formula for Relative Importance Index (RII) is:

$$RII = \frac{\sum w}{A \times N} \qquad \ldots\ldots(4.1)$$

Where w = weighting as assigned by the each respondent in a range from 1 to 5, where 1 implies Not Important and 5 implies Extremely Important; A = the highest weight (5); N = the total number in the sample.

These rankings made it possible to cross-compare the relative importance of factors as perceived by the three groups of respondents. According to Chan and Kumaraswamy (1997), the mean and standard deviation of each individual factor are not suitable statistics to assess the overall ranking because they do not reflect any relationship between them.

The RII and respective ranking corresponding to client, consultant and contractor for (i) each cause of incompatibility and (ii) each category of causes computed as per the field survey of 84 clients, 97 consultants and 100 contractors are given in the tables in the succeeding sections. The values of overall RII and the respective ranking were also calculated by taking the weighted average of the values of RII for the three stakeholders.

Table 4.9 shows the RII and ranking of causes for the design phase for the three stakeholders alongwith the overall RII and ranking as given below:

Table 4.9: RII and Ranking of Causes for Design Phase

Cause	Client		Consultant		Contractor		Overall	
Design Phase	RII	Rank	RII	Rank	RII	Rank	RII	Rank
Contractor is not involved in the design conceptual phase	0.46	56	0.43	61	0.52	30	0.46	56
Contractor is not involved in the design development phase	0.52	47	0.45	58	0.50	36	0.48	51
Data provided to the designer is incomplete	0.75	**1**	0.74	**1**	0.66	**3**	0.72	**1**
Data provided to the designer is incorrect	0.66	16	0.62	22	0.45	49	0.58	26
Data provided to the designer is late	0.64	25	0.64	17	0.57	17	0.62	17
Lack of human resources with the designer	0.69	10	0.65	14	0.60	6	0.64	12
Designer busy in too many assignments	0.62	29	0.59	28	0.49	43	0.56	29
Lack of designer's knowledge of building bye-laws, codes & govt. rules	0.56	41	0.58	30	0.40	62	0.52	43
Lack of designer's knowledge of constructability of proposed design	0.43	61	0.54	43	0.52	28	0.52	44
Lack of designer's knowledge of availability of materials for construction	0.60	34	0.57	34	0.52	30	0.56	32
Lack of designer's knowledge of engineering design techniques & softwares	0.54	44	0.51	45	0.43	55	0.49	48
Lack of designer's knowledge of engineering drafting	0.49	51	0.51	47	0.47	46	0.49	46
Lack of designer's knowledge of suitability of materials for construction	0.60	34	0.55	41	0.51	34	0.54	39
Frequent replacement of designer by the owner	0.56	41	0.58	30	0.51	34	0.55	34
Personal and social problems of the designer	0.47	55	0.48	51	0.47	46	0.48	51
Lack of reward, delayed payment or low payment to the designer by the owner	0.72	**3**	0.67	13	0.58	14	0.65	10
Too little time given to the designer for completion of design documents	0.71	7	0.73	**2**	0.58	14	0.68	**5**
Lack of project planning & rigorous analysis of requirements of owner at the project start	0.73	**2**	0.67	10	0.60	6	0.66	8
Frequent changes in the proposed design due to owner dissatisfaction	0.72	**3**	0.65	14	0.50	38	0.62	18
Approving authorities do not check that structure is designed according to building bye-laws, codes & govt rules	0.69	10	0.72	**3**	0.69	**1**	0.71	**2**

Table 4.10 shows the Relative Importance Index and ranking of causes for the Tendering phase for the three stakeholders alongwith the overall RII and ranking as given below:

Table 4.10: RII and Ranking of Causes for Tendering Phase

Cause	Client		Consultant		Contractor		Overall	
Tendering Phase	RII	Rank	RII	Rank	RII	Rank	RII	Rank
Incomplete or inaccurate design documents un-intentionally provided with bidding documents	0.59	38	0.46	55	0.45	49	0.47	53
Incomplete or inaccurate design documents intentionally provided with bidding documents	0.61	32	0.56	37	0.50	38	0.55	36
Contract type	0.59	38	0.50	49	0.39	63	0.48	50
Contractor did not consider that the design is exotic, complex or difficult to build, and he does not have the required expertise	0.60	34	0.60	27	0.52	30	0.57	27
Selection of contractor on the basis of lowest bid	0.51	48	0.62	24	0.61	**5**	0.60	23
Amount of Performance security / retention money	0.62	29	0.58	29	0.51	33	0.57	28
Absence of third party validation during defect liability period	0.56	41	0.58	32	0.53	26	0.56	31

Table 4.11 shows the RII and ranking of causes for the Construction phase for the three stakeholders alongwith the overall RII and ranking as given below:

Table 4.11: RII and Ranking of Causes for Construction Phase

Cause	**Client**		**Consultant**		**Contractor**		**Overall**	
Construction Phase	RII	Rank	RII	Rank	RII	Rank	RII	Rank
Owner proposes changes because he had planned to make changes from the beginning	0.44	59	0.57	33	0.60	6	0.56	29
Owner proposes changes during construction due to sudden changes in his req. / expec.	0.45	57	0.56	37	0.48	45	0.52	42
Owner proposes changes during construction due to change in ownership	0.40	62	0.44	60	0.56	20	0.47	54
Owner proposes changes to assert his authority and make undue interference	0.26	65	0.38	64	0.50	36	0.40	64
Owner proposes changes due to financial problems	0.69	10	0.68	9	0.69	**2**	0.69	**3**
Slowness in decision making by owner	0.64	25	0.69	7	0.53	26	0.63	13
Changes in codes, bye-laws & govt. rules	0.48	53	0.47	54	0.41	59	0.45	59
Delayed revision of drawings by designer	0.69	10	0.62	23	0.56	19	0.61	20
Drawings not properly stamped or certified by designer	0.51	48	0.45	56	0.45	49	0.46	56
Custody and supply of drawings at site	0.45	57	0.48	52	0.45	52	0.46	55
Delayed approval of drawings by owner or consultant	0.67	15	0.55	42	0.49	40	0.55	38
Material changes due to shortage of particular material in the market	0.66	16	0.63	21	0.59	12	0.62	16
Material changes due to procurement delays by contractor	0.66	16	0.63	20	0.56	20	0.61	21
Contractor does not follow recommended construction methods	0.65	21	0.69	8	0.49	40	0.62	15
Contractor's lack of skilled manpower	0.68	14	0.72	**4**	0.59	12	0.67	6
Contractor's lack of comprehension of drawing details	0.71	7	0.70	**5**	0.60	10	0.67	7
Contractor's lack of coordination and management during construction	0.66	16	0.56	40	0.40	61	0.53	41
Contractor’s-staff facing lack of tools etc.	0.65	21	0.65	16	0.58	14	0.63	14
Contractor & his staff focusing on other projs	0.64	25	0.57	34	0.47	46	0.55	36
Designer's lack of awareness / interest about ongoing construction process	0.61	32	0.64	18	0.55	22	0.61	22
Unanticipated weather conditions	0.51	48	0.51	45	0.44	54	0.49	49
Unforeseen problems / diff. site conditions	0.63	28	0.61	26	0.54	23	0.59	24
Timing of the proposed changes	0.62	29	0.52	44	0.54	24	0.54	40
Approving authorities do not check that the structure is constructed according to the approved building plans	0.72	**3**	0.69	6	0.65	**4**	0.68	**4**

Table 4.12 shows the RII and ranking of causes for the Overall Project phase for the three stakeholders alongwith the overall RII and ranking as given below:

Table 4.12: RII and Ranking of Causes for Overall Project Phase

Cause	Client		Consultant		Contractor		Overall	
Overall Project Phase	RII	Rank	RII	Rank	RII	Rank	RII	Rank
Economic situation of the country	0.72	**3**	0.67	11	0.60	6	0.66	9
Nationality of participants	0.37	64	0.38	65	0.38	65	0.37	65
Organizational structure of owner, consultant and contractor	0.53	46	0.47	53	0.41	59	0.46	56
Lack of communication and coordination between parties	0.65	21	0.57	34	0.49	40	0.56	32
Lack of mutual respect between parties	0.57	40	0.50	48	0.52	28	0.52	45
Conflicts and legal disputes b/w various parties	0.60	34	0.49	50	0.44	53	0.49	47
Participant's honest wrong belief	0.54	44	0.56	37	0.54	24	0.55	35
Corruption / Fraudulent practices	0.71	7	0.62	24	0.57	18	0.62	18
Lack of an experienced consultant or his lack of interest in work	0.66	16	0.67	11	0.59	11	0.65	11
Frequent replacement of consultant during construction	0.65	21	0.64	18	0.49	43	0.59	24
Appointment of contractor as consultant	0.40	62	0.45	58	0.39	63	0.43	63
Appointment of designer as consultant	0.49	51	0.45	56	0.42	58	0.45	60
Design firm or contractor firm goes bankrupt or is black-listed	0.44	59	0.42	63	0.43	55	0.43	62
Withdrawal of licenses and permits	0.48	53	0.43	62	0.42	57	0.43	61

Relative Importance Index and ranking were also calculated for each category by taking the sum of RII of causes and diving by the number of causes in that category. Table 4.13 shows the Relative Importance Index and ranking of each category of incompatibilities as given below:

Table 4.13: RII and Ranking for each Category

CATEGORY	CLIENT		CONSULTANT		CONRACTOR	
	RII	RANK	RII	RANK	RII	RANK
Design Phase	0.608	1	0.595	1	0.526	2
Tendering Phase	0.582	3	0.556	3	0.499	3
Construction Phase	0.588	2	0.584	2	0.528	1
Overall Project Phase	0.558	4	0.523	4	0.476	4

The values of overall RII and the respective ranking for each category were also calculated by taking the weighted average of RII for the three stakeholders for that category. Table 4.14 shows the overall ranking (weighted) of categories of incompatibilities:

Table 4.14: Overall Ranking of Categories of Incompatibilities

CATEGORY	OVER ALL RII	OVER ALL RANKING
Design Phase	0.576	1
Tendering Phase	0.543	3
Construction Phase	0.567	2
Overall Project Phase	0.514	4

4.4.4 Rank Agreement Factors (RAF) & Percentage Agreement (PA)

Rank Agreement Factors were next computed using formula and methodology described by Okpala and Aniekwu (1988) to quantitatively measure the agreement in ranking between groups of project key stake holders i.e. client, consultant and contractor. This shows the average absolute difference in the rank of factors. The RAF can range from 0, indicating perfect agreement, to a higher value indicating increasing disagreement. The percentage disagreement and Percentage Agreement are also calculated through formulae. Formulae related to these calculations are as under:

Absolute Difference (Di) = | Ri1 - Ri2 |……………………..…………….. (4.2)

Where Ri1 = Ranking of First Group; Ri2 = Ranking of Second Group

Maximum Absolute Difference (Dmax) = | Ri1-Rj2| ……………...…….. (4.3)

Where Ri1 = Ranking ; Rj2 = Ranking with absolute maximum difference

j = N – i + 1

Rank Agreement Factor (RAF) = ∑D/N …………………………………… (4.4)

Where D = Absolute difference; N = Number of Categories

Percentage Disagreement (PD) = RAF / RAFmax or (Di/N) / Dmax/N……(4.5)

Percentage Agreement (PA) = 100% - PD…..………………………............ (4.6)

The above formulae were used to establish the percentage agreement between the three key stake holders i.e. client, consultant and contractor regarding ranking of categories of incompatibility.

Table 4.15 shows the calculations and the results for Percentage Agreement between Client and Consultant:

Table 4.15: Percentage Agreement (PA) between Client and Consultant

FACTOR NO	FACTOR	RII		ABS	FOR MAX ABS DIFF		ABS
		CLIENT (Ri1)	CONSULTANT (Ri2)		Ri1	Rj2	
1	DS	1	1	0	1	4	**3**
2	TSC	3	3	0	3	2	**1**
3	CN	2	2	0	2	3	**1**
4	PR	4	4	0	4	1	**3**
			Di=	**0**	**Dmax=**		**8**

Using equation 4.4, the RAF and RAFmax are calculated as follows:

Rank Agreement Factor (RAF) = 0 / 4 = 0.0

Rank Agreement Factor Maximum (RAFmax) = 8 / 4 = 2.0

Percentage Disagreement = 0.0 / 2.0 = 0.0 %

Percentage Agreement = 100.0 – 0.0 = 100.0 %

Using the above mentioned procedure, the Percentage Disagreement (PD) and Percentage Agreement (PA) between other stakeholders were also calculated.

The Percentage Agreement (PA) and Percentage Disagreement (PD) for the three stakeholders are shown in Table 4.16 given below:

Table 4.16: Percentage Agreement (PA) and Percentage Disagreement (PD) between all Stakeholders

STAKEHOLDER	DISAGREEMENT	AGREEMENT
CLIENT AND CONSULTANT	0.00	100.00
CONSULTANT AND CONTRACTOR	25.00	75.00
CLIENT AND CONTRACTOR	25.00	75.00

The overall results of Percentage Agreement (PA) between the three key stake holders, client, consultant and contractor are plotted in figure 4.3:

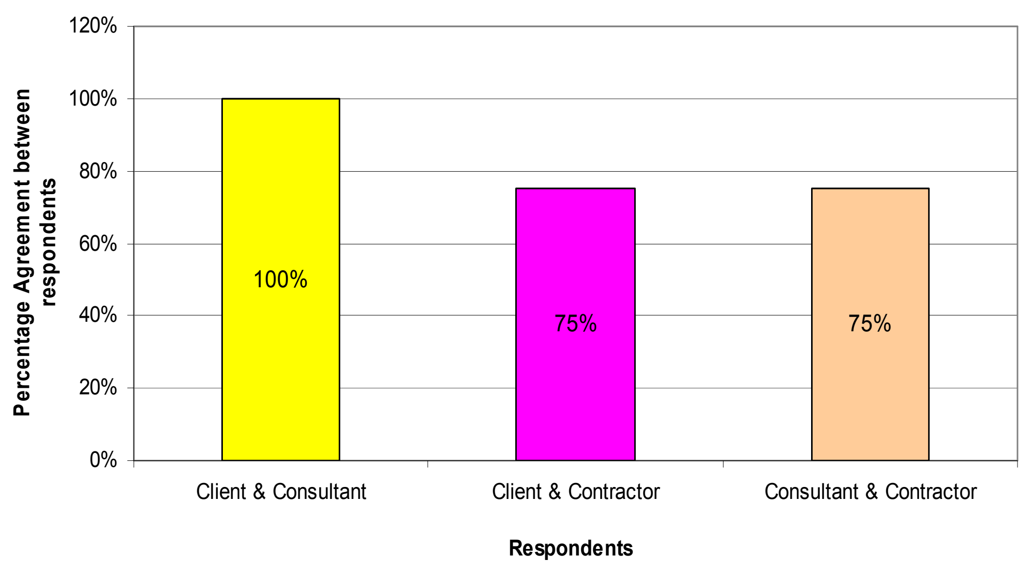

Figure 4.3 : Percentage Agreement (PA) between Key StakeHolders

After obtaining the Percentage Agreement (PA) between the three stake holders about the causes of incompatibilities, it was observed that there was maximum (100%) agreement between consultant & contractor. The Percentage

Agreement (PA) between client & consultant and client & contractor was (75%). This implies that the results obtained from RII for ranking of each category for each stake holder holds good percentages of mutual agreement between each other.

4.5 SUMMARY

In this chapter, detailed statistical analysis has been presented. The data analysis carried out includes: reliability test, relative importance index (RII), rank agreement factor (RAF) and percentage Agreement (PA) thus presenting a final ranking of causes and categories of incompatibility. In the next chapter, the conclusions and recommendations are made based on the basis of results.

Chapter 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS & RECOMMENDATIONS

5.1.1 Conclusions

The results obtained from the analysis of data in chapter four indicate that, on the basis of overall ranking, the categories of incompatibilities were ranked as follows:

1. Design Phase ranked no. 1
2. Construction Phase ranked no. 2
3. Project related ranked no. 3
4. Tendering Phase ranked no. 4

Further, study of top two ranking categories was conducted in order to assess the most important causes in these categories. It was observed that six most important causes, on the basis of overall ranking, belong to the Design and Construction Phases as given in Table 5.1:

Table 5.1: Six Most Important Causes Based on Overall Ranking

CATEGORY	CAUSE	OVERALL RANK
DESIGN PHASE	Data provided to the designer is incomplete	1
	Too little time given to the designer for completion of design documents	5
	Approving authorities do not check that the structure is designed according to building bye-laws, codes & govt. rules	2
CONSTRUCTION PHASE	Owner proposes changes due to financial problems	3
	Contractor's lack of skilled manpower	6
	Approving authorities do not check that the structure is constructed according to the approved building plans	4

5.1.2 Recommendations

Some recommendations are enlisted based on the research findings and conclusions. These will help to reduce incompatibilities in building construction process and will enhance the efficiency of Building Construction Industry of Pakistan. The recommendations for the design phase are as follows:

1. As for the data provided to the designer, it is recommended that all data required by the design team must be provided at the initial stage of the project to the design team in order to enable them to prepare design drawings and specifications which are according to standards, up to the desired satisfaction of the client and consultant and are easily understandable by the site supervisory staff. Data including 1) Layout plan of the site showing location, size and distances of all buildings, 2) Soil investigation report indicating bearing capacity of soil, depth of underground water table, type of soil, recommendation for depth and type of footing, etc., 3) Contour sheet showing the level of ground at different locations, 4) Purpose and type of the proposed building, and all other data required by the designers need to be provided at the early stage.
2. Second, the designers must be paid commensurate with their efforts. If they are not paid well, they may provide design drawings lacking a lot of details.
3. Third, the designers should be given sufficient time to prepare the drawings and specifications.
4. Lastly, the approving authorities should not only check all drawings and specifications used for construction.

The recommendations for the construction phase are as follows:

1. As for the changes proposed by owner due to owner's financial problems, it is recommended that the owners must ensure that they would be able to arrange required financial resources for the project during the entire project execution phases keeping in view all risks like inflation, personal financial problems, overall economy of the country, strikes, etc., so the incompatibilities due to lack of funds could be minimized. It is therefore recommended that timely supply of funds by the

owners must be ensured at the beginning of the project or the scope of the project must be determined keeping in view the available funds and all future risks.

2. Second, prequalification of contractors need to be done taking into account their past performance, projects completed, their financial soundness, qualified engineers employed, utilization of required skilled labor force and equipment fleet.

3. Third, the approving authorities need to check all drawings and specifications used for construction and supervise on-site construction activities. Results showed that vigilant role by the approving authorities will ensure minimizing incompatibilities.

In addition, some recommendations and suggestions which were pointed out by the respondents are also listed below:

1. Thorough site investigation must be conducted as part of the initial stage of project planning exploring all sorts of risks relevant to underground water table, rock, slush, fill material, expansive or collapsing soils, underground streams, possibility of caves, etc. (if any). In addition, the exact location of underground services and utilities should also be confirmed to avoid any problem during construction.

2. The services of a public health engineer must be hired in order to design the plumbing system in a building. Proper plumbing drawings showing location of the entire piping must be produced for construction and should remain available throughout the service life of the building.

3. During the very early stages of project planning, the owner of the building must involve structural engineer, architect, public health engineer, fire safety engineer, geotechnical engineer to thoroughly discuss all the risks involved and bring all his future needs and requirements to the knowledge of all others, so that they could prepare drawings which portray the owner’s desires as far as possible.

5.2 FUTURE DIRECTIONS

The scope of this study was to enlist and rank the causes of incompatibilities for building construction in Pakistan, however during the present work it was felt that if future study is carried out in the following areas, it might help and prove beneficial to the building construction industry:

1. Role of consultant in causing incompatibilities
2. Role of traditional procurement method in creating incompatibilities
3. Ways and means used by the construction professionals to handle the incompatibilities faced by them in the building construction
4. Role of technical training provided by different institutes in reducing the incompatibilities

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APPENDICES

APPENDIX: I LIST OF RESPONDENTS WORKING IN BUILDING CONSTRUCTION

(CLIENTS)

Sr. No.	Client Name	Designation
1	Export Display Centre, Chamber of Comm., G-8, Ibd.	Supervisor
2	Works Directorate, CDA, Islamabad	Project Director
3	Works Directorate, CDA, Islamabad	Assistant Director
4	Works Directorate, CDA, Islamabad	Deputy Director
5	Works Directorate, CDA, Islamabad	Assistant Director
6	ICT, Police Headquarters, Islamabad	Asstt. Executive Engineer
7	NUST, Islamabad	Executive Engineer
8	NUST, Islamabad	Assistant Director
9	Sector Development Directorate, CDA, Islamabad	Project Director
10	Masjid Iman, Rawal Town, Islamabad	Coordinator
11	F-9 Park, PMO, CDA, Islamabad	Project Director
12	Arts and Crafts Village, PMO, CDA, Islamabad	Assitant Director
13	Pak Army, MES, Rawalpindi	Project Officer
14	Sector Development Directorate, CDA, Islamabad	Project Director
15	F-9 Park, PMO, CDA, Islamabad	Project Diretor
16	PARC, Islamabad	Executive Engineer Civil
17	Pak Army, Kharian Cantt.	Project Officer
18	C&W Dept., Government of Punjab	Executive Engineer
19	C&W Dept., Government of Punjab	Executive Engineer
20	C&W Dept., Government of Punjab	Executive Engineer
21	C&W Dept., Government of Punjab	Executive Engineer
22	Pak Army, Rawalpindi	Project Incharge
23	ICT, Police Headquarters, Islamabad	Sub-Divisional Officer
24	ICT, Police Headquarters, Islamabad	Sub-Divisional Officer
25	ICT, Police Headquarters, Islamabad	Sub-Divisional Officer
26	ICT, Police Headquarters, Islamabad	Sub-Divisional Officer
27	Sector Development Directorate, CDA, Islamabad	Assistant Director
28	Pakistan Telecommunication Authority, Islamabad	Deputy Director
29	ICT, Diplomatic Enclave, Islamabad	Coordinator
30	Sector Development Directorate, CDA, Islamabad	Assistant Director
31	C&W Dept., Government of Punjab	Sub-Divisional Officer
32	C&W Dept., Government of Punjab	Sub-Divisional Officer
33	ICT, Diplomatic Enclave, Islamabad	Coordinator
34	PARC, Islamabad	Sub-Divisional Officer
35	F-9 Park, PMO, CDA, Islamabad	Assistant Director
36	S&C Dte., CDA	Assistant Director
37	S&C Dte., CDA	Assistant Director
38	S&C Dte., CDA	Deputy Director Director
39	Pakistan Institute of Medical Sciences, Islamabad	Sub-Divisional Officer

Sr. No.	Client Name	Designation
40	Pakistan Institute of Medical Sciences, Islamabad	Project Manager
41	Capital Hospital, CDA	Assistant Director
42	Capital Hospital, CDA	Administrator
43	Said Pur Village Dte., CDA	Assistant Director
44	Said Pur Village Dte., CDA	Assistant Director
45	Said Pur Village Dte., CDA	Deputy Director
46	Said Pur Village Dte., CDA	Director
47	RDA - Works Division, Rawalpindi	Sub-Engineer
48	RDA - Works Division, Rawalpindi	Sub-Engineer
49	SECP, Islamabad.	Project Engineer
50	Special Projects Directorate, CDA, Islamabad	Project Director
51	Special Projects Directorate, CDA, Islamabad	Assistant Director
52	Special Projects Directorate, CDA, Islamabad	Deputy Director
53	Special Projects Directorate, CDA, Islamabad	Assistant Director
54	Ali Pur Farash, Model Village, CDA	Assistant Director
55	Ali Pur Farash, Model Village, CDA	Assistant Director
56	Ali Pur Farash, Model Village, CDA	Assistant Director
57	Ministry of Housing and Works, Islamabad	Assistant Manager
58	High Court, Islamabad	Coordinator
59	Pakistan Housing Authority, Islamabad	Assistant Manager
60	Comsats, Islamabad	Site Engineer
61	Faisal Masjid, Islamabad	Assistant Director
62	Pakistan Telecommunication Authority, Islamabad	Assistant Director
63	Parliament Lodges, Islamabad	Assistant Director
64	Parliament Lodges, Islamabad	Deputy Director
65	Parliament Lodges, Islamabad	Assistant Director
66	Working Women Hostel, G-6, Islamabad	Coordinator
67	CDA Model School, I-9, Islamabad	Assistant Director
68	CDA Model School, I-9, Islamabad	Coordinator
69	Enquiry Office, Margalla Town, Islamabad	Town Committee
70	Rawal Dam Rest House, Islamabad	Assistant Director
71	Rawal Dam Rest House, Islamabad	Assistant Director
72	Enquiry Office, Margalla Town, Islamabad	Assistant Director
73	S&C Dte., CDA	Deputy Director
74	Judges Colony, F-5, Islamabad	Assistant Director
75	Judges Colony, F-5, Islamabad	Assistant Director
76	PARC, Islamabad	Sub-Divisional Officer
77	NADRA, Islamabad	Assistant Manager
78	Cultural Complex, Near Shakarparian, Islamabad	Assistant Director
79	Islamabad Cultural Club, F-9 Park, Islamabad	Assistant Director
80	Cultural Complex, Near Shakarparian, Islamabad	Deputy Director
81	Islamabad Cultural Club, F-9 Park, Islamabad	Deputy Director
82	Ladies Club, G-10, Islamabad	Sub-Engineer
83	Ladies Club, G-10, Islamabad	Assistant Director
84	Ladies Club, G-10, Islamabad	Deputy Director

(CONSULTANTS)

Sr. No.	Consultant Name	Designation
1	Structures Dte, CDA, Islamabad	Deputy Director
2	Parliament Lodges Dte., CDA, Islamabad	Deputy Director
3	Global Engineering Services	Principal Engineer
4	Structures Dte, CDA, Islamabad	Deputy Director
5	Building Control Dte-II., CDA, Islamabad	Deputy Director
6	National Police Academy Dte., CDA, Islamabad	Deputy Director
7	NESPAK, Islamabad	Consultant
8	Pak. PWD, Islamabad	Assistant Exe. Engineer
9	Maintenance Dte., CDA, Islamabad	Director
10	Moth Macdonald, PHED Dept., Lahore	Junior Engineer
11	Services Dte., CDA, Islamabad	Deputy Director
12	Engineering Project Development Consultant Pvt. Ltd.	Chairman
13	University of South Asia, Lahore	Project Manager
14	Building Control Dte-III, CDA, Islamabad	Deputy Director
15	Works Dte, CDA, Islamabad	Assistant Director
16	Barqaab, Lahore	Consultant
17	Barqaab, Lahore	Architect
18	Parks Dte., CDA, Islamabad	Deputy Director
19	University of South Asia, Lahore	Assistant Engineer
20	Bari Imam Complex Dte, CDA, Islamabad	Deputy Director
21	Bari Imam Complex Dte, CDA, Islamabad	Assitant Director
22	Works Dte, CDA, Islamabad	Deputy Director
23	Tulip Residency, Karachi	Resident Engineer, Supervisor
24	NESPAK, Islamabad	Engineer
25	NESPAK, Islamabad	Engineer
26	Special Projects Dte., CDA, Ibc	Deputy Director
27	University of South Asia, Lahore	Lecturer, Independent Designer
28	Special Projects Dte., CDA, Islamabad	Deputy Director
29	Special Projects Dte., CDA, Islamabad	Deputy Director
30	DESIGNMEN Consulting Engineers Pvt. Ltd.	Director (Technical)
31	Sports and Culture Dte., CDA, Islamabad	Additional Director
32	DESIGNMEN Consulting Engineers Pvt. Ltd.	Director
33	ERRA, Azad Kashmir	Project Engineer
34	ERRA, Azad Kashmir	Project Engineer
35	Aiwan-e-Sadr Dte., CDA, Islamabad	Director
36	Secretariat Block Dte., CDA, Islamabad	Deputy Director
37	NESPAK	Consultant
38	Multinational Engineering Consultants (MEC)	Designer
39	Multinational Engineering Consultants (MEC)	Designer
40	DESIGNMEN Consulting Engineers Pvt. Ltd.	Consultant

Sr. No.	Consultant Name	Designation
41	CDM Smith Inc., Islamabad	Architect
42	CDM Smith Inc., Islamabad	Architect
43	CDM Smith Inc., Islamabad	Architect
44	Structures Dte (Bldgs), CDA, Islamabad	Assistant Director
45	Structures Dte (Bldgs), CDA, Islamabad	Assistant Director
46	CITE, Islamabad	Architect
47	CITE, Islamabad	Architect
48	UET, Taxila	Independent Designer
49	Ghani Associates, Islamabad	Consultant
50	Ghani Associates, Islamabad	Design Engineer
51	Structures Dte (Bldgs), CDA, Islamabad	Deputy Director
52	Architecture Dte., CDA, Islamabad	Director Architecture
53	Architecture Dte., CDA, Islamabad	Architect
54	Architecture Dte., CDA, Islamabad	Architect
55	Modern Consulting Engineers	Design Engineer
56	Modern Consulting Engineers	Design Engineer
57	Arch Vision Plus, Karachi	Project Architect
58	Arch Vision Plus, Karachi	Managing Director
59	Design Tech, Karachi	Chief Structural Engineer
60	Design Tech, Karachi	Structural Engineer
61	Design Tech, Karachi	Structural Engineer
62	TAG International, Lahore	Structural Engineer
63	TAG International, Lahore	Structural Engineer
64	University of South Asia, Lahore	Assistant Professor
65	PCA, Lahore	Senior Engineer
66	University of South Asia, Lahore	Assistant Professor
67	University of South Asia, Lahore	Dean Engineering Dept.
68	Pak. PWD, Islamabad	AEE Civil
69	Pak. PWD, Islamabad	AEE Civil
70	Moeen Mian Associates	Chief Executive
71	Moeen Mian Associates	Design Engineer
72	Moeen Mian Associates	Design Engineer
73	Pak. PWD, Islamabad	SubEngineer
74	Pak. PWD, Islamabad	SubEngineer
75	Pak. PWD, Islamabad	SubEngineer
76	A.N. Associates	Chief Executive
77	A.N. Associates	Design Engineer
78	A.N. Associates	Design Engineer
79	Structures Dte. CDA, Islamabad	D.D.G
80	MKN Engineering Consultant	Designer
81	MKN Engineering Consultant	Designer
82	National Forensic Science Laboratory, Islamabad	Consultant / Proj. Director
83	Tariq & Saad Associates	Design Engineer
84	M.I. Associates	Consultant

Sr. No.	Consultant Name	Designation
85	M.I. Associates	Design Engineer
86	Waseem Associates	Designer
87	Waseem Associates	Designer
88	Loya Associates Consulting Engineers, Karachi	Cooridnator
89	Loya Associates Consulting Engineers, Karachi	Design Engineer
90	Loya Associates Consulting Engineers, Karachi	Design Engineer
91	Structures Dte CDA, Islamabad	Consultant
92	Graffitec, Islamabad	Director
93	Graffitec, Islamabad	Design Engineer
94	Graffitec, Islamabad	Design Engineer
95	Zeeshan Ahmed Engineering Services (Pvt) Ltd.	Designer
96	BCS Dte., CDA, Islamabad	Deputy Director
97	Structures Dte (Bldgs), CDA, Islamabad	Director Structures

(CONTRACTORS)

Sr. No.	Contractor Name	Designation
1	KKP, Margalla Hotel	Site Engineer
2	KKP, Margalla Hotel	Project Engineer
3	Shahid Builders Pvt. Ltd.	Construction Manager
4	Shahid Builders Pvt. Ltd.	Site Engineer
5	Shahid Builders Pvt. Ltd.	Site Supervisor
6	Rapid Construction Pvt. Ltd.	Site Engineer
7	Rapid Construction Pvt. Ltd.	Project Manager
8	Rapid Construction Pvt. Ltd.	Planning Engineer
9	Tameer Associates	Director Projects
10	National Construction Ltd.	General Manager (E)
11	Fast Associates	Executive Manager
12	Fast Associates	Site Engineer
13	Fast Associates	Project Engineer
14	Arif Enterprises	Site Engineer
15	Arif Enterprises	Planning Engineer
16	Arif Enterprises	Project Engineer
17	Guarattee Engineers	Sr. Electrical Engineer
18	Corps of Engineers / CWO / AWT / AGA	Sr. Executive Engineer
19	FWO	Project Manager
20	Self Employed	Manager
21	Descon Engineering Ltd.	Planning Manager
22	Bawaqar	Chief Engineer
23	Bawaqar	Site Engineer
24	Bawaqar	Site Supervisor
25	Rawail Builders	Director
26	Rawail Builders	Contracts Engineer
27	Rawail Builders	Site Engineer
28	Rawail Builders	Site Engineer
29	ECM Pvt. Ltd.	Managing Director
30	ECM Pvt. Ltd.	Site Supervisor
31	ECM Pvt. Ltd.	Site Engineer
32	Greenways Engineers	Chief Engineer
33	Greenways Engineers	Planning Engineer
34	Greenways Engineers	Site Engineer
35	Greenways Engineers	Site Supervisor
36	Bright Business Links	Managing Director
37	Bright Business Links	Director
38	Bright Business Links	Contracts Manager
39	Ali Ahmad Shigri	Director
40	Ali Ahmad Shigri	Site Engineer
41	Ali Ahmad Shigri	Site Supervisor
42	ALDO Enterprises	Director
43	ALDO Enterprises	Site Engineer

Sr. No.	Contractor Name	Designation
44	ALDO Enterprises	Site Engineer
45	Hayat Brothers	Managing Director
46	Hayat Brothers	Site Engineer
47	Hayat Brothers	Site Engineer
48	Neva Enterprises	Director
49	Wahab Traders	Managing Director
50	Wahab Traders	Site Engineer
51	Wahab Traders	Planning Engineer
52	Khattak & Brothers	General Manager
53	Khattak & Brothers	Site Engineer
54	Khattak & Brothers	Planning Engineer
55	Utopia Construction Company	Managing Director
56	Utopia Construction Company	Site Engineer
57	Utopia Construction Company	Site Engineer
58	Rafi Tariq Pvt. Ltd	Director
59	Rafi Tariq Pvt. Ltd	Planning Engineer
60	Rafi Tariq Pvt. Ltd	Site Engineer
61	S & S Associates	Director
62	S & S Associates	Site Engineer
63	S & S Associates	Site Engineer
64	Confidential	Chief Engineer
65	Confidential	Site Engineer
66	Matracon Pakistan Private Limited.	Project Engineer / Manager
67	Matracon Pakistan Private Limited.	Project Engineer
68	Matracon Pakistan Private Limited.	Planning Engineer
69	Shabir and Co.	Site Supervisor
70	Shabir and Co.	Site Supervisor
71	Shabir and Co.	Site Supervisor
72	Spart Private Limited	Site Incharge
73	Spart Private Limited	Site Supervisor
74	Spart Private Limited	Site Engineer
75	Sheikh Muhammad Nazir and Company	Managing Director
76	Sheikh Muhammad Nazir and Company	Site Engineer
77	Sheikh Muhammad Nazir and Company	Site Engineer
78	Sheikh Muhammad Nazir and Company	Site Engineer
79	Rasool Constructors	Director
80	Rasool Constructors	Site Engineer
81	Rasool Constructors	Site Engineer
82	Rasool Constructors	Site Supervisor
83	Zafarullah Butt Traders	Director
84	Zafarullah Butt Traders	Project Engineer
85	Zafarullah Butt Traders	Project Engineer
86	Zafarullah Butt Traders	Contracts Manager
87	AAJ Sons Pvt. Ltd.	Project Engineer

Sr. No.	Contractor Name	Designation
88	AAJ Sons Pvt. Ltd.	Site Supervisor
89	AAJ Sons Pvt. Ltd.	Site Engineer
90	AAJ Sons Pvt. Ltd.	Site Engineer
91	Johnsons Construction Compnay	Site Engineer
92	Johnsons Construction Compnay	Site Engineer
93	Johnsons Construction Compnay	Site Engineer
94	Habib Rafiq Limited (HRL)	Site Engineer
95	Pir Muhammad and Company	Director
96	Pir Muhammad and Company	Site Engineer
97	Khyber Grace Private Limited	Director
98	Khyber Grace Private Limited	Site Engineer
99	CEMCON Pvt. Ltd.	Director
100	CEMCON Pvt. Ltd.	Site Engineer

APPENDIX: II QUESTIONNAIRE COVERING LETTER

SCHOOL OF CIVIL & ENVIRONMENTAL ENGINEERING (SCEE)

Dear Sir,

The undersigned has been assigned to conduct a study of "Causes of Incompatibility between Design and Construction in Building Construction" for partial fulfillment of the requirement for the degree of Master of Engineering in "Construction Engineering and Management" from NUST, H-12, Islamabad. The objectives of the study are:

a) To identify the important causes of incompatibility between design and construction in building construction.

b) Recommend ways and means to eliminate and reduce the effect of these causes.

The questionnaire has been designed for traditional procurement method only – one mostly followed in Pakistan, i.e. where designing & construction are carried out by separate teams of designers and contractors.

Just to recall, the incompatibilities between design and construction are the differences in architectural details, structural design details, project time, project cost material, quality, etc. between the design phase and the construction phase. However, it may please be noted that this study focuses purely on those causes of incompatibilities which pertain to architecture, structural design, electrical and plumbing, material and quality.

The survey form is attached with this letter. You are requested to take few minutes from your precious time and fill the form as per your experience / observation of building construction industry in Pakistan. The information provided by you will be of high value and will be kept confidential.

All information provided in this regard will only be used for academic purposes and will be kept confidential.

Thanks for your support and cooperation in advance.

Yours Sincerely,

Mustafa Kamal Khan
Post Graduate Student- Construction Engineering & Management
Cell. No: 0301-5553333
Email: immkkhan@yahoo.com

Dr. Hamza Farooq Gabriel
BSc Civil Engg (UET, Lahore) | MSc Civil Engg (B'ham, UK) | PhD (CSturt, Australia)
Associate Professor
NUST Institute of Civil Engineering (NICE)
School of Civil & Environmental Engineering (SCEE)
National University of Sciences & Technology (NUST)
NUST Islamabad Campus
Sector H - 12
Islamabad, ICT - 44000

APPENDIX: III QUESTIONNAIRE

GENERAL INFORMATION

MS RESEARCH THESIS QUESTIONNAIRE
Causes of Incompatibility between Design and Construction in Building Construction

GENERAL INFORMATION (NOT TO BE PUBLISHED)	
Name	
Qualification	
Experience in Building Construction Industry (Years)	
Name of Organization / Department / Firm / Company	
Designation	
Type of job (Client / Consultant / Contractor)	

The causes of incompatibility are categorized on a five-point Likert scale as follows:

Degree of Importance	5 = Extremely Important	4 = Very Important	3 = Moderately Important	2 = Slightly Important	1 = Not Important

You are required to tick or check the desired category.

DESIGN PHASE

Sr. No.	Causes of Incompatibility	Degree of Importance				
		5	4	3	2	1
I.	**Design Phase**					
1	Contractor is not involved in the design conceptual phase					
2	Contractor is not involved in the design development phase					
3	Data provided to the designer is incomplete					
4	Data provided to the designer is incorrect					
5	Data provided to the designer is late					
6	Lack of human resources with the designer					
7	Designer busy in too many assignments					
8	Lack of designer's knowledge of building bye-laws, codes & govt. rules					
9	Lack of designer's knowledge of constructability of proposed design					
10	Lack of designer's knowledge of availability of materials for construction					
11	Lack of designer's knowledge of engineering design techniques & softwares					
12	Lack of designer's knowledge of engineering drafting					
13	Lack of designer's knowledge of suitability of materials for construction					
14	Frequent replacement of designer by the owner					
15	Personal and social problems of the designer					
16	Lack of reward, delayed payment or low payment to the designer by the owner					
17	Too little time given to the designer for completion of design documents					
18	Lack of project planning & rigorous analysis of requirements of owner at the project start					
19	Frequent changes in the proposed design due to owner dissatisfaction					
20	Approving authorities do not check that structure is designed according to the building bye-laws, codes & govt. rules					

TENDERING PHASE

Sr. No.	Causes of Incompatibility	Degree of Importance				
		5	4	3	2	1
II.	**Tendering Phase**					
21	Incomplete or inaccurate design documents un-intentionally provided with bidding documents					
22	Incomplete or inaccurate design documents intentionally provided with bidding documents					
23	Contract type					
24	Contractor did not consider that the design is exotic, complex or difficult to build, and he does not have the required expertise					
25	Selection of contractor on the basis of lowest bid					
26	Amount of Performance security / retention money					
27	Absence of third party validation during defect liability period					

CONSTRUCTION PHASE

Sr. No.	Causes of Incompatibility	Degree of Importance				
		5	4	3	2	1
III.	**Construction Phase**					
28	Owner proposes changes because he had planned to make changes during construction from the beginning					
29	Owner proposes changes during construction due to sudden changes in his requirements / expectations					
30	Owner proposes changes during construction due to change in ownership					
31	Owner proposes changes to assert his authority and make undue interference in construction					
32	Owner proposes changes due to financial problems					
33	Slowness in decision making process by owner					
34	Changes in building codes, bye-laws & govt. rules					
35	Delayed revision of drawings by designer					
36	Drawings not properly stamped or certified by designer					
37	Custody and supply of drawings at site					
38	Delayed approval of drawings by owner or consultant					
39	Material changes due to shortage of particular material in the market					
40	Material changes due to procurement delays by contractor					
41	Contractor does not follow recommended construction methods and does not use proper construction equipment					
42	Contractor's lack of skilled manpower					
43	Contractor's lack of comprehension of drawing details					
44	Contractor's lack of coordination and management during construction					
45	Contractor’s-staff facing lack of tools, equipment, etc. for measurement, alignment, angular adjustment at corners, etc.					
46	Contractor and his staff focusing on other projects					
47	Designer's lack of awareness / interest about ongoing construction process					
48	Unanticipated weather conditions					
49	Unforeseen problems and differing site conditions					
50	Timing of the proposed changes, i.e. whether at the start or at the end of construction					
51	Approving authorities do not check that structure is constructed according to the approved building plans					

OVERALL PROJECT PHASE

Sr. No.	Causes of Incompatibility	Degree of Importance				
		5	4	3	2	1
IV.	**Overall Project Phase**					
52	Economic situation of the country					
53	Nationality of participants					
54	Organizational structure of owner, consultant and contractor					
55	Lack of communication and coordination between parties					
56	Lack of mutual respect between parties					
57	Conflicts and legal disputes between various parties					
58	Participant's honest wrong belief					
59	Corruption / Fraudulent practices					
60	Lack of an experienced consultant or his lack of interest in work					
61	Frequent replacement of consultant during construction					
62	Appointment of contractor as consultant					
63	Appointment of designer as consultant					
64	Design firm or contractor firm goes bankrupt or is black-listed					
65	Withdrawal of licenses and permits					

Comments (if any):

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____

APPENDIX: IV RELIABILITY ANALYSIS IN SPSS VER.17.0

FOR CONSULTANT

1. Design Phase related Indicators

Case Processing Summary

		N	%
Cases	Valid	97	100.0
	Excluded(a)	0	.0
	Total	97	100.0

a Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.903	.898	20

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.976	2.149	3.716	1.568	1.730	.206	20
Item Variances	1.558	.902	2.799	1.897	3.104	.226	20

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Ds - contractor is not involved in the design conceptual phase	57.3784	219.964	-.069	.933	.913
Ds - contractor is not involved in the design development phase	57.2703	218.364	-.022	.936	.911
Ds - data provided to the designer is incomplete	55.8108	201.279	.596	.635	.897
Ds - data provided to the designer is incorrect	56.4054	185.614	.761	.858	.891
Ds - data provided to the designer is late	56.3378	184.090	.803	.804	.890
Ds - lack of human resources with the designer	56.2568	203.919	.464	.491	.900
Ds - designer busy in too many assignments	56.5811	198.548	.584	.658	.897
Ds - lack of designer's knowledge of building bye-laws , codes & govt. Rules	56.6216	183.170	.728	.849	.892
Ds - lack of designer's knowledge of constructability of proposed design	56.8108	216.210	.031	.303	.911
Ds - lack of designer's knowledge of availability of materials for construction	56.6757	193.921	.697	.719	.894
Ds - lack of designer's knowledge of engg. Design techniques & softwares	56.9595	186.478	.788	.888	.891
Ds - lack of designer's knowledge of engineering drafting	56.9730	187.753	.817	.857	.890
Ds - lack of designer's knowledge of suitability of materials for construction	56.7703	192.097	.656	.707	.895
Ds - frequent replacement of designer by the owner	56.6216	192.238	.731	.800	.893
Ds - personal and social problems of the designer	57.1216	204.437	.501	.660	.899
Ds - lack of reward, delayed payment	56.1892	201.142	.493	.597	.899

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
or low payment to the designer by the owner					
Ds - too little time given to the designer for completion of design documents	55.8919	201.961	.545	.716	.898
Ds - lack of project planning and rigorous analysis of requirements and need of the owner at the project start	56.1622	196.275	.624	.667	.896
Ds - frequent changes in the proposed design due to owner dissatisfaction	56.2568	196.385	.630	.736	.896
Ds – approving authorities do not check that structure is designed according to building bye-laws, codes & govt. Rules	55.9189	208.185	.282	.526	.904

2. Tendering Phase related Indicators

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.765	.765	7

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.782	2.284	3.095	.811	1.355	.085	7
Item Variances	1.371	.553	2.308	1.755	4.177	.552	7

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Tsc - incomplete or inaccurate design document un-intentionally provided with bidding documents	17.1892	21.690	.388	.213	.758
Tsc - incomplete or inaccurate design document intentionally provided with bidding documents	16.6622	18.117	.689	.567	.685
Tsc - contract type	16.9865	18.315	.557	.338	.722
Tsc - contractor did not consider that the design is exotic, complex or difficult to build and he does not have the required expertise	16.4730	18.143	.635	.516	.699
Tsc - selection of contractor on the basis of lowest bid	16.3784	25.225	.280	.143	.770
Tsc - amount of performance security / retention money	16.5541	23.867	.452	.445	.747
Tsc - absence of third party validation during defect liability period	16.5946	23.587	.448	.429	.746

3. Construction Phase related Indicators

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.929	.929	24

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.918	1.919	3.581	1.662	1.866	.220	24
Item Variances	1.411	.682	1.999	1.317	2.932	.100	24

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Cn - owner proposes changes because he had planned to make changes during construction from the beginning	67.1757	293.051	.426	.601	.929
Cn - owner proposes changes during construction due to sudden changes in his requirements / expectations	67.2297	302.700	.163	.357	.932
Cn - owner proposes changes during construction due to change in ownership	67.8514	292.731	.329	.374	.931
Cn - owner proposes changes to assert his authority and make undue interference in construction	68.1216	297.478	.279	.491	.931
Cn - owner proposes changes due to financial problems	66.6216	281.471	.671	.722	.925
Cn - slowness in decision making process by the owner	66.5946	280.710	.619	.679	.926
Cn - changes in building codes, bye-laws & govt. Rules	67.7027	284.376	.536	.666	.927
Cn - delayed revision of drawings by designer	66.9324	274.283	.832	.859	.922
Cn - drawings not properly stamped or certified by designer	67.7703	280.590	.639	.861	.925
Cn - custody and supply of drawings at site	67.6486	283.382	.684	.831	.925
Cn - delayed approval of drawings by owner or consultant	67.3108	277.614	.693	.741	.924
Cn - material changes due to shortage of material in the market	66.9054	287.950	.616	.876	.926
Cn - material changes due to procurement delays by the contractor	66.8919	284.372	.693	.881	.925
Cn - contractor does not follow recommended construction methods and does not use proper construction equipment	66.6081	278.296	.724	.845	.924
Cn - contractor's lack of skilled manpower	66.4595	275.731	.807	.920	.923
Cn - contractor's lack of comprehension of drawing detail	66.5405	274.060	.754	.878	.923
Cn - contractor's lack of coordination and management during construction	67.2432	276.680	.655	.695	.925
Cn - contractor's-staff facing lack of tools, equipment, etc. For measurement, alignment, angular adjustment at corners, etc.	66.8108	287.964	.493	.744	.928
Cn - contractor and his staff focusing on other projects	67.1892	284.594	.677	.716	.925
Cn - designer's lack of awareness / interest about on-going construction process	66.8649	286.420	.558	.745	.927
Cn - un-anticipated weather conditions	67.4730	285.102	.520	.751	.927
Cn - unforeseen problems and differing site conditions	66.9865	297.767	.387	.668	.929
Cn - timing of the proposed changes i.e. Whether at the start or at the end of construction	67.4324	278.961	.731	.766	.924
Cn – approving authorities do not check that structure is constructed according to approved building plans	66.5676	296.386	.277	.534	.931

4. Project related Indicators

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.904	.903	14

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.616	1.878	3.351	1.473	1.784	.238	14
Item Variances	1.534	1.142	2.111	.969	1.849	.075	14

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Pr - economic situation of the country	33.2703	116.583	.642	.600	.896
Pr - nationality of participants	34.7432	119.070	.546	.625	.899
Pr - organizational structure of owner, consultant and contractor	34.2703	123.926	.301	.576	.909
Pr - lack of communication and coordination between parties	33.7703	110.399	.776	.774	.890
Pr - lack of mutual respect between parties	34.1081	112.372	.665	.762	.895
Pr - conflicts and legal disputes between various parties	34.1486	112.073	.741	.767	.891
Pr - participant's honest wrong belief	33.8108	119.361	.565	.620	.899
Pr - corruption / fraudulent practices	33.5270	126.609	.233	.572	.910
Pr - lack of an experienced consultant or his lack of interest in work	33.2703	115.049	.677	.683	.894
Pr - frequent replacement of consultant during construction	33.4459	116.387	.601	.639	.897
Pr - appointment of contractor as consultant	34.3649	111.934	.639	.694	.896
Pr - appointment of designer as consultant	34.3514	113.026	.710	.766	.893
Pr - design firm or contractor firm goes bankrupt or is black-listed	34.5135	113.541	.655	.603	.895
Pr - withdrawal of licensed and permits	34.4865	115.431	.661	.568	.895

FOR CONTRACTOR

1. Design Phase related Indicators

Case Processing Summary

		N	%
Cases	Valid	100	100.0
	Excluded(a)	0	.0
	Total	100	100.0

a Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.933	.934	20

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.631	1.975	3.450	1.475	1.747	.142	20
Item Variances	1.734	.818	2.705	1.887	3.307	.253	20

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Ds - contractor is not involved in the design conceptual phase	50.0500	297.279	.142	.997	.939
Ds - contractor is not involved in the design development phase	50.1250	300.266	.089	.997	.940
Ds - data provided to the designer is incomplete	49.3250	275.251	.769	.922	.928
Ds - data provided to the designer is incorrect	50.3750	266.804	.683	.948	.929
Ds - data provided to the designer is late	49.7750	262.230	.873	.948	.925
Ds - lack of human resources with the designer	49.6250	287.676	.449	.877	.933
Ds - designer busy in too many assignments	50.2000	282.010	.604	.899	.931
Ds - lack of designer's knowledge of building bye-laws , codes & govt. Rules	50.6500	268.644	.741	.956	.928
Ds - lack of designer's knowledge of constructability of proposed design	50.0250	272.333	.684	.917	.929
Ds - lack of designer's knowledge of availability of materials for construction	50.0500	281.844	.751	.885	.929
Ds - lack of designer's knowledge of engg. Design techniques & softwares	50.4750	265.743	.765	.971	.927
Ds - lack of designer's knowledge of engineering drafting	50.3000	267.497	.812	.953	.926
Ds - lack of designer's knowledge of suitability of materials for construction	50.1000	277.067	.576	.857	.931
Ds - frequent replacement of designer by the owner	50.1000	267.733	.836	.955	.926
Ds - personal and social problems of the designer	50.3000	279.036	.537	.762	.932
Ds - lack of reward, delayed payment or low payment to the designer by the owner	49.7250	288.204	.511	.845	.932
Ds - too little time given to the designer for completion of design documents	49.7250	273.281	.754	.961	.928
Ds - lack of project planning and rigorous analysis of requirements and need of the owner at the project start	49.6250	266.548	.815	.961	.926
Ds - frequent changes in the proposed design due to owner dissatisfaction	50.1500	270.490	.782	.900	.927
Ds – approving authorities do not check that structure is designed according to building bye-laws, codes & govt. Rules	49.1750	296.148	.296	.815	.935

2. Tendering Phase related Indicators

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.870	.877	7

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.493	1.950	3.025	1.075	1.551	.111	7
Item Variances	1.492	.804	2.461	1.656	3.059	.394	7

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Tsc - incomplete or inaccurate design document un-intentionally provided with bidding documents	15.2000	28.472	.651	.699	.854
Tsc - incomplete or inaccurate design document intentionally provided with bidding documents	14.9750	26.846	.727	.692	.843
Tsc - contract type	15.5000	32.051	.578	.501	.861
Tsc - contractor did not consider that the design is exotic, complex or difficult to build and he does not have the required expertise	14.8750	30.215	.721	.550	.842
Tsc - selection of contractor on the basis of lowest bid	14.4250	31.892	.707	.531	.846
Tsc - amount of performance security / retention money	14.9000	31.887	.697	.513	.847
Tsc - absence of third party validation during defect liability period	14.8250	34.712	.531	.444	.867

3. Construction Phase related Indicators

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.970	.969	24

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.639	2.000	3.425	1.425	1.713	.134	24
Item Variances	1.474	.656	2.728	2.072	4.156	.239	24

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Cn - owner proposes changes because he had planned to make changes during construction from the beginning	60.9250	481.610	.581	.	.970
Cn - owner proposes changes during construction due to sudden changes in his requirements / expectations	60.5500	468.254	.612	.	.970
Cn - owner proposes changes during construction due to change in ownership	60.8250	455.071	.846	.	.968
Cn - owner proposes changes to assert his authority and make undue interference in construction	59.9000	457.426	.776	.	.969
Cn - owner proposes changes due to financial problems	60.7000	451.959	.868	.	.968
Cn - slowness in decision making process by the owner	61.2750	465.179	.821	.	.968
Cn - changes in building codes, bye-laws & govt. Rules	60.5250	441.333	.848	.	.968
Cn - delayed revision of drawings by designer	61.0750	455.404	.906	.	.967
Cn - drawings not properly stamped or certified by designer	61.1000	468.246	.705	.	.969
Cn - custody and supply of drawings at site	60.8750	449.651	.833	.	.968
Cn - delayed approval of drawings	60.4000	465.579	.677	.	.969

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
by owner or consultant					
Cn - material changes due to shortage of material in the market	60.5500	452.767	.784	.	.969
Cn - material changes due to procurement delays by the contractor	60.8750	478.215	.604	.	.970
Cn - contractor does not follow recommended construction methods and does not use proper construction equipment	60.4000	454.041	.890	.	.968
Cn - contractor's lack of skilled manpower	60.3500	455.874	.838	.	.968
Cn - contractor's lack of comprehension of drawing detail	61.3250	467.866	.662	.	.969
Cn - contractor's lack of coordination and management during construction	60.4250	480.148	.599	.	.970
Cn - contractor's-staff facing lack of tools, equipment, etc. For measurement, alignment, angular adjustment at corners, etc.	61.0000	462.821	.826	.	.968
Cn - contractor and his staff focusing on other projects	60.5750	451.892	.842	.	.968
Cn - designer's lack of awareness / interest about on-going construction process	61.1500	455.515	.853	.	.968
Cn - un-anticipated weather conditions	60.0750	489.353	.274	.	.972
Cn - unforeseen problems and differing site conditions	60.3250	477.558	.536	.	.970
Cn - timing of the proposed changes i.e. Whether at the start or at the end of construction	60.6250	468.240	.764	.	.969
Cn – approving authorities do not check that structure is constructed according to approved building plans	60.6500	446.131	.925	.	.967

4. Project related Indicators

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.957	.958	14

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.380	1.875	3.000	1.125	1.600	.143	14
Item Variances	1.714	.763	2.400	1.637	3.144	.201	14

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Pr - economic situation of the country	30.3250	186.328	.767	.907	.954
Pr - nationality of participants	31.4500	190.869	.765	.958	.954
Pr - organizational structure of owner, consultant and contractor	31.2750	191.128	.777	.896	.954
Pr - lack of communication and coordination between parties	30.8750	182.317	.847	.944	.952
Pr - lack of mutual respect between parties	30.7250	184.820	.687	.894	.957

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Pr - conflicts and legal disputes between various parties	31.1250	180.625	.880	.978	.951
Pr - participant's honest wrong belief	30.6500	193.362	.727	.876	.955
Pr - corruption / fraudulent practices	30.5000	200.410	.606	.725	.958
Pr - lack of an experienced consultant or his lack of interest in work	30.3750	183.933	.801	.933	.953
Pr - frequent replacement of consultant during construction	30.9000	181.118	.883	.926	.951
Pr - appointment of contractor as consultant	31.3750	186.804	.742	.964	.955
Pr - appointment of designer as consultant	31.2500	184.038	.804	.898	.953
Pr - design firm or contractor firm goes bankrupt or is black-listed	31.1750	192.404	.628	.938	.957
Pr - withdrawal of licensed and permits	31.2250	179.922	.868	.950	.952

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1. Design Phase related Indicators

Case Processing Summary

		N	%
Cases	Valid	84	100.0
	Excluded(a)	0	.0
	Total	84	100.0

a Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.922	.917	20

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	3.039	2.158	3.737	1.579	1.732	.246	20
Item Variances	1.615	.579	3.117	2.538	5.384	.290	20

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Ds - contractor is not involved in the design conceptual phase	58.4737	269.708	-.281	.	.933
Ds - contractor is not involved in the design development phase	58.2105	264.509	-.129	.	.932
Ds - data provided to the designer is incomplete	57.0526	237.830	.620	.	.918
Ds - data provided to the designer is incorrect	57.4737	224.263	.637	.	.918
Ds - data provided to the designer is late	57.5789	230.702	.692	.	.916
Ds - lack of human resources with the designer	57.3158	234.561	.700	.	.916
Ds - designer busy in too many assignments	57.6842	233.450	.660	.	.917
Ds - lack of designer's knowledge of building bye-laws , codes & govt. Rules	58.0000	222.556	.826	.	.913
Ds - lack of designer's knowledge of constructability of proposed design	58.6316	237.912	.635	.	.918
Ds - lack of designer's knowledge	57.7895	224.398	.818	.	.913

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
of availability of materials for construction					
Ds - lack of designer's knowledge of engg. Design techniques & softwares	58.1053	226.544	.763	.	.914
Ds - lack of designer's knowledge of engineering drafting	58.3158	229.228	.822	.	.914
Ds - lack of designer's knowledge of suitability of materials for construction	57.7895	224.953	.804	.	.913
Ds - frequent replacement of designer by the owner	58.0000	238.444	.479	.	.921
Ds - personal and social problems of the designer	58.4211	252.368	.336	.	.923
Ds - lack of reward, delayed payment or low payment to the designer by the owner	57.2105	240.842	.608	.	.919
Ds - too little time given to the designer for completion of design documents	57.2632	230.427	.704	.	.916
Ds - lack of project planning and rigorous analysis of requirements and need of the owner at the project start	57.1579	233.474	.737	.	.916
Ds - frequent changes in the proposed design due to owner dissatisfaction	57.2105	229.398	.758	.	.915
Ds – approving authorities do not check that structure is designed according to building bye-laws, codes & govt. Rules	57.3158	245.895	.395	.	.922

2. Tendering Phase related Indicators

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.862	.837	7

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.910	2.526	3.105	.579	1.229	.039	7
Item Variances	2.020	.708	2.608	1.901	3.686	.447	7

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Tsc - incomplete or inaccurate design document un-intentionally provided with bidding documents	17.4211	36.480	.771	.916	.821
Tsc - incomplete or inaccurate design document intentionally provided with bidding documents	17.3158	35.784	.839	.821	.810
Tsc - contract type	17.4211	39.146	.632	.647	.843
Tsc - contractor did not consider that the design is exotic, complex or difficult to build and he does not have the required expertise	17.3684	39.468	.713	.666	.831
Tsc - selection of contractor on the basis of lowest bid	17.8421	54.140	-.058	.247	.902
Tsc - amount of performance security / retention money	17.2632	38.871	.848	.907	.815
Tsc - absence of third party validation during defect liability period	17.5789	40.924	.585	.485	.849

3.Construction Phase related Indicators

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.938	.929	24

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.941	1.316	3.579	2.263	2.720	.356	24
Item Variances	1.490	.339	2.690	2.351	7.931	.292	24

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Cn - owner proposes changes because he had planned to make changes during construction from the beginning	68.3684	347.357	.096	.	.942
Cn - owner proposes changes during construction due to sudden changes in his requirements / expectations	68.3158	349.673	.070	.	.941
Cn - owner proposes changes during construction due to change in ownership	68.5789	352.813	-.007	.	.941
Cn - owner proposes changes to assert his authority and make undue interference in construction	69.2632	354.649	-.079	.	.941
Cn - owner proposes changes due to financial problems	67.1053	317.433	.685	.	.934
Cn - slowness in decision making process by the owner	67.3684	322.579	.799	.	.933
Cn - changes in building codes, bye-laws & govt. Rules	68.1579	317.140	.741	.	.933
Cn - delayed revision of drawings by designer	67.1053	316.433	.784	.	.933
Cn - drawings not properly stamped or certified by designer	68.0526	317.386	.761	.	.933
Cn - custody and supply of drawings at site	68.3158	320.673	.673	.	.934
Cn - delayed approval of drawings by owner or consultant	67.2105	305.731	.782	.	.932
Cn - material changes due to shortage of material in the market	67.2632	330.760	.528	.	.936
Cn - material changes due to procurement delays by the contractor	67.2632	314.094	.718	.	.933
Cn - contractor does not follow recommended construction methods and does not use proper construction equipment	67.3158	331.117	.553	.	.936
Cn - contractor's lack of skilled manpower	67.1579	308.474	.880	.	.931
Cn - contractor's lack of comprehension of drawing detail	67.0526	313.164	.753	.	.933
Cn - contractor's lack of coordination and management during construction	67.2632	339.649	.365	.	.938
Cn - contractor's-staff facing lack of tools, equipment, etc. For measurement, alignment, angular adjustment at corners, etc.	67.3158	318.784	.744	.	.933
Cn - contractor and his staff focusing on other projects	67.3684	317.023	.764	.	.933
Cn - designer's lack of awareness /	67.5263	319.041	.720	.	.934

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
interest about on-going construction process					
Cn - un-anticipated weather conditions	68.0526	320.608	.745	.	.933
Cn - unforeseen problems and differing site conditions	67.4211	328.480	.687	.	.935
Cn - timing of the proposed changes i.e. Whether at the start or at the end of construction	67.4737	310.374	.756	.	.933
Cn – approving authorities do not check that structure is constructed according to approved building plans	67.0000	334.000	.418	.	.938

4. Overall Project Phase related Indicators

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.941	.941	14

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.789	1.842	3.579	1.737	1.943	.313	14
Item Variances	1.837	.918	2.778	1.860	3.025	.321	14

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Pr - economic situation of the country	35.4737	173.596	.736	.871	.936
Pr - nationality of participants	37.2105	186.287	.648	.960	.939
Pr - organizational structure of owner, consultant and contractor	36.4211	189.813	.450	.891	.943
Pr - lack of communication and coordination between parties	35.7895	167.175	.858	.927	.932
Pr - lack of mutual respect between parties	36.2105	167.287	.846	.900	.933
Pr - conflicts and legal disputes between various parties	36.0526	164.164	.872	.971	.932
Pr - participant's honest wrong belief	36.3684	181.690	.711	.935	.937
Pr - corruption / fraudulent practices	35.5263	180.041	.723	.938	.937
Pr - lack of an experienced consultant or his lack of interest in work	35.7368	178.316	.728	.845	.937
Pr - frequent replacement of consultant during construction	35.7895	172.398	.781	.908	.935
Pr - appointment of contractor as consultant	37.0526	183.608	.562	.850	.941
Pr - appointment of designer as consultant	36.5789	175.257	.650	.940	.939
Pr - design firm or contractor firm goes bankrupt or is black-listed	36.8421	180.140	.609	.846	.940
Pr - withdrawal of licensed and permits	36.6316	175.912	.740	.909	.936