DESIGN-CONSTRUCTION INTERFACE PROBLEMS IN LARGE BUILDING CONSTRUCTION PROJECTS

BY

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IN THE NAME OF ALLAH, THE MOST BENEFICENT, THE MOST MERCIFUL

Dedicated

To

My Beloved Parents

May Allah Prolongs their life

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All praise is due only to ALLAH subhanaho wa ta'ala for his guidance and protection throughout the period of my study. I wish to thank my parents for their love and encouragement. I also acknowledge the authority of King Fahd University of Petroleum and Minerals (KFUPM) for giving me the chance and logistic support to pursue MS Program in Construction Engineering and Management (CEM).

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ABSTRACT

Full Name : Khaled Zakariya Ibrahim Sha'ar
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This research was conducted to identify the causes of design-construction interface problems in large building construction projects in Palestine. To achieve the research objectives, a questionnaire survey was carried out to collect information on these causes. Responses from 34 consultants and 30 contractors were analyzed.

The results revealed that the top ten extreme significant causes are "Unstable client's requirements", "Lack of proper coordination between various disciplines of design team", "Awarding contract to the lowest price regardless of the quality of services", "Lack of skilled and experienced human resources in the design firms", "Lack of skilled human resources at the construction site", "Delaying of dues payments", "Lack of specialized quality control team", "Lack of professional construction management", "Delaying the approval of completed tasks", and "Vague and deficient drawings and specifications".

On the other hand, "Not involving the contractor in the design phase", "Bad weather", "Differing site conditions", "Lack of awareness about governmental regulations, municipality requirements, statutes, and their modifications", and "Inappropriate choice of project delivery system (design-build, design-bid-build, etc.)" were the least significant causes of design-construction interface problems.

Spearman's rho coefficient calculation was carried out and found to be almost 0.64 which indicates that the overall level of correlation between Palestinian consultants and contractors in the context of this research can be identified as moderate.

ABSTRACT (ملخص)

الاسم الكامل: خالد زكريا ابراهيم شعار

عنوان الرسالة: المشاكل الناشئة في واجهة التصميم-التشييد لمشاريع البناء الإنشائية الكبيرة

التخصص: ادارة البناء والتشييد

تاريخ الدرجة العلمية: نيسان، 2015

تم إجراء هذا البحث بهدف تحديد أسباب المشاكل الناشئة في واجهة التصميم-التشييد لمشاريع البناء الإنشائية الكبيرة في فلسطين. لتحقيق أهداف البحث، تم عمل استبيان لجمع بيانات عن هذه المسببات. بعد ذلك، تم تحليل البيانات المجمعة من 34 استشاري و 30 مقاول.

وكشفت النتائج أن أهم عشرة مسببات هي "عدم ثبات متطلبات المالك"، "عدم التنسيق السليم بين مختلف التخصصات في فريق التصميم"، "ترسية العقد لأدنى سعر بغض النظر عن نوعية الخدمات"، "عدم توفر الموارد البشرية الماهرة وذوات الخبرة في شركات التصميم"، "نقص الموارد البشرية الماهرة وذوات الخبرة في موقع البناء"،"تأخير الدفعات المستحقة"،"عدم وجود فريق متخصص لضبط الجودة"،"عدم وجود إدارة مهنية لعملية الإنشاء"، "تأخير الموافقة على المهام المكتملة"، و"غموض ونقص في الرسومات والمواصفات".

من ناحية أخرى، "عدم اشراك المقاول في مرحلة التصميم"، "سوء الاحوال الجوية"، "ظروف الموقع المختلفة"، "نقص الوعي حول اللوائح الحكومية ومتطلبات البلدية والقوانين وتعديلاتها"، و "اختيار غير لائق من نظام تسليم المشروع (التصميم والإنشاء بعطاء واحد، التصميم والإنشاء بعطاءين منفصلين، أو غير ذلك)" كانت أقل المسببات أهمية في واجهة التصميم والبناء.

وقد تم إجراء حساب معامل سبيرمان (رو) ووجدت لتكون تقريبا 0.64 مما يدل على أن المستوى العام للتوافق في الرأي بين الاستشاريين والمقاولين الفلسطينيين يعد متوسطا في سياق هذا البحث.

CHAPTER 1

INTRODUCTION

The construction industry has been distinguished by many characteristics which make it different from other economic sectors. Its fragmentation and sensitivity for many changing variables, such as political and environmental factors, increase the rate of business failure. In any construction project, time, cost, and quality are the triple constraints of project management triangle which are used to be an indicator for measuring project success based on the degree to which the project's team could be able to manage these constraints and produce the expected result within the allocated time and budget. Unluckily, it rarely happens that a project completes exactly as it is planned in the beginning and it often incurs time overrun, cost overrun, or quality deviation. There are many reasons stand behind this issue, but an axial factor which can be attributed to this calamity is the interface problems among design and construction phases.

Thus, this research introduces the connotation of design-construction interface, reviews the common causes of problems leading to discrepancies, assessing them from the perspective of profession practitioners, and also recommending possible methods for reducing or even preventing them as much as it is possible.

1.1 Overview on the Palestinian Construction Industry

The construction sector has been always considered of special importance in all countries since it has wide and intense linkage with other economic sectors. This catalyzes the economic development in the whole country by generating huge number of jobs and significantly contributing in the Gross Domestic Product (GDP) *(El-Namrouty, 2012)*. In Palestine, as one of the developing countries, the construction sector plays a strategic role through accounting for 14% of the added value to GDP and employing more than 15.6% of Palestinian workforce *(PCBS, 2013).*

1.1.1 Historical Background

The Palestinian Construction sector witnessed different phases throughout the history. *Abedmousa (2008)* indicated that previous researches in the early 1990s showed that most of construction projects in West Bank (WB) and Gaza Strip (GS) consisted of housing. These researches can be concluded as follows:

Between the years 1950s – 1960s, housing construction prospered since a lot of Palestinians working in Gulf countries were sending money to their families in the Palestinian territories for investment. However, during the years 1948 to 1967, most of private houses were constructed by private sectors, whereas public buildings like schools, hospital, etc. were constructed by central authorities or their representative agencies. In the same period and especially in the 1960s, some infrastructure and public works such as roads, water and electricity distribution networks were executed in the country.

During that period, the construction sector's contribution in the GDP was 16% in WB and 6% in GS. Furthermore, this sector was suffering inefficient planning and management practices. Concerning the construction material like sand and stones, it used to be available in the local market or imported from other countries such as Jordan and Egypt.

After the Israeli occupation to the Palestinian territories in 1967 and up to 1972, a severe decline hit the construction sector due to the political instability and the countless restrictive policies imposed by the Israeli occupation. However, a significant growth in the Palestinian construction sector was recorded during the 1972 to 1987 as it had doubled its contribution in GDP in 1987 to 17% in WB and 21% in GS after it was 9% and 6% in 1972 in WB and GS respectively.

In 1987, the first "Intifada" was ignited and new physical and financial restrictions were emerged, the thing that negatively affected the housing development in the Palestinian territories. From the year 1987 until the beginning of 1990s, the construction sector witnessed a sharp decline due to closing large areas of land and preventing the expansion of municipal boundaries as well as villages, this what we called physical restrictions. The other type of restrictions is the financial one which could be represented by the limited control imposed by the occupation on transforming money or funds from the external donors as well as the Palestinian investors outside the country. As an expected result for of these restrictions between the year 1987 and 1994, scarce facilities and severe overcrowding went to be the main characteristics of Palestinian housing conditions.

In the year 1994, the first "Intifada" ended and peace agreement was signed. At that time, housing was a real problem that needs an urgent solution from the new rulers. This problem was solved through international and Arab communities which contributed with millions of US dollars to the Palestinian government during the period 1994 - 1996. An emergency plan was established to utilize this money through improving the infrastructure in the country and building as much as possible in a short time.

After this period, the construction sector became the growth motive in Palestine as its contribution of GDP raised by 15.2% and 23% from the year 1989 to 1995. Here things remain unchanged until the second Intifada was ignited in 2000. Since then, the Palestinian construction industry has suffered a lot of problems due to instability of political situation and other problems, but it is still a vital activity in the Palestinian economy.

1.1.2 Statistical Background

The latest estimates issued by Palestinian Central Bureau of Statistics (*PCBS, 2013*), denoted that Palestine has a population of nearly about 4,485,459 people distributed between WB which has 2,754,722 and GS which has 1,730,737. This population undergoes a growth at a rate of 2.94% annually in Palestine as a whole. However, different rates of growth were recorded; WB which has a rate of 2.62% while a rate of 3.44% was recorded for GS. Concerning the density of population, Palestine has a relatively reasonable density of 745 capita per km^2 but it is unequally distributed between WB that has a rational density of 487 capita per km^2 and GS that has the largest density of population in the world with 4,742 capita per km^2. Therefore, it can be concluded that the need for more buildings and infrastructure will be highly demanded. That is why the Palestinian construction sector witnessed an escalation amounting 112% from the year 2011 to 2013 in its participation rate to the GDP as well as the employment of workforce.

During the years 1970 to 2012, the investment in the construction sector in Palestine rose from 17 million US dollars to 750 million US dollars (44.1 times); 47 million of them were due to the increment of population by 3.1 million of people, while the rest of the invested money, 690 million, resulted from increasing of construction per capita by 162.7 US dollars to reach 177.9 US dollars (11.7 times). These numbers reported that the average annual growth of the Palestinian construction is 102.7%, whereas for construction per capita the average annual growth is 25.5% *(Kushnir, 2012).*

Indeed, what has mentioned above gives an impression on the scale of the Palestinian construction industry. Hence, and due to the costly nature of the construction industry, any peccadillo will result in wasting extra time and effort in addition to large sums of money if it is compared to other economic sectors. An important cause that can negatively affect this business and create a bad reputation on a certain firm is the feeble management of the design-construction project interface. Such problem will result in wasting most of the design time in frequent design changes and rework, in addition to the extra time and cost associated to the execution of the project during the construction phase. Thus, more investigation should be conducted on this issue for effective design-construction interface management to improve the construction industry in the country.

1.2 Statement of Research Problem

Generally speaking, any project whether it was a building, a heavy civil, or an industrial project starts with a group of ideas which can be transformed into reality to achieve the anticipated goals of the project. This transformation process requires input data from various and wide range members of the project team which is used to be composed of diversified organizations and sub-organizations. Each organization has many administrative units working with its own system, organizational culture, and technical approach to achieve the individual project objectives *(Sugumaran and Lavanya, 2013).*

Moving towards the building projects, traditionally each project used to have a set of teams which are coordinate, communicate, and cooperate throughout project's life cycle to end up with a successful and completed project measured by time and cost consumed as well as quality of the final product. These teams involve: the owner, the designers (architects), and the construction contractor and sub-contractors (builders), as well as the maintenance contractors *(Wang, 2000).*

Usually, the two major professionals and key players involved in the construction process are the designer and the constructor. The effective collaboration and interaction between these two parties in addition to the owner could be considered as the key factor for the successful completion of construction projects *(Arain et al, 2006).* Thus, a kind of harmony as well as compatibility should be existed between individuals in the same organization in the one hand and also between different organizations on the other hand, otherwise many barriers and obstacles would be created in both design and construction phase.

During the past few years, many of the construction projects that executed in the Palestinian territories, especially in WB, incurred losses due to time and cost overrun, which mean they failed *(Dmaidi et al, 2013).* Many reasons might be standing behind this failure as the construction process in its nature is affected by many variables and unpredictable factors resulted from different sources. Such sources might be the performance of participants, the availability of resources, the environmental conditions, the involvement of other parties, as well as some contractual related issues *(Assaf and Al-Hejji,* *2006).* As a sequence of these sources, the completion time of the construction project, the allocated budget, and sometimes the quality of the final products might be affected.

In construction projects, multiple interfaces would appear among various construction parties, such as the interfaces between contractors, engineering teams and owners, as well as contractors and manufacturers, and also contractors and subcontractors *(Mortaheb and Rahimi, 2010).* All of these are kinds of interface issues which resulted from unconscious communication, coordination, and responsibility management across the design team itself in a side and the construction team itself in the other side, in addition to the lack of interaction between design and construction team.

Interface issues have been discussed for many years as their problems lead to delays, cost overruns, quality deviation, low productivity, sub-optimal solutions, great number of changing orders, and other troubles which affect the overall project performance negatively and thus hinder the industrialization of the construction process *(Sugumaran and Lavanya, 2013).*

There are many studies in the literature which deal with many types of construction projects in different countries and outline the causes of interface problems between two parties or more. However, in Palestine, there is a lack of such studies although the United Nation Relief Works Agency (UNRWA) in the year 2006 reported the frequent causes of poor performance of many local construction projects where most of them were causes of interface problems. These reported causes were: excessive amendments of design and drawings, unavailability of materials, ineffective monitoring and feedback, poor coordination among participants, and lack of project leadership skills *(Mahamid, 2011).*

Therefore, this research investigates the design-construction interface and its associated problems as a prevalent phenomenon in the Palestinian construction industry from the perspective of the local consultants and contractors. It is a good exposure to have such research in Palestine to be utilized by construction participants by realizing the major sources of interface issues to overcome them and increase the probability of project success. By comparing the current situation with other Arab countries in the surrounding environment, where the construction sector is supposed to be more profitable and governed, a reasonable and logical feedback could be provided to help in improving the ongoing interface management in the country such that it could be utilized for future practices.

1.3 Objectives of Research

The main objectives of this research are outlined as below:

(1) Identifying design-construction interface problems in large building construction projects.

(2) Gauging the appraisal of Palestinian consultants and contractors in terms of the significance of each problem to identify the most significant design-construction interface problems.

(3) Analyzing the degree of agreement between Palestinian consultants and contractors in determining the most significant problems and developing the consensus list of them.

By the end of this research, it is hoped that a kind of control on the design-construction interface will be achieved through eliminating the root causes of this problem even before their inception. As a subsequent result of this elimination, the problems related to time, cost, and quality outlined in the beginning will be depleted. An important issue to put in mind is that denying such causes will directly affect the entire project negatively.

1.4 Significance of Research

After establishing the Palestinian National Authority (PNA) as well as imposing its control and leadership on the Palestinian territories in 1994, a remarkable expansion and development in the construction sector has been testified. As an expected result of this change, the profession was refreshed, the thing that led to encourage the investment in the local construction sector especially by Palestinian's expatriates, and also creating new job opportunities for thousands of Palestinians. This is why the Palestinian Contractors Union (PCU) claims that the first rank among the Palestinian economic sectors has been occupied by the construction sector *(Enshassi et al, 2012)*. However, the construction process itself is becoming progressively more complex due to the technical and managerial complexity of the industry as well as the large number of contributed parties such as clients, consultants, contractors, shareholders, regulators, vendors, suppliers, and many others *(Ronie, 2005)*. In this regard, the primary difficulty lies in channeling the right information, in the right format, to the right person, at the right time. Even though if there is a high level of concurrency, but managing the inflow and outflow information still the main challenge that must be confronted *(McCarthy et al, 2000)*.

Considering the recent increasing in scale and complexity of construction projects, Interface Management (IM) has been emanating as a significant aspect of management practices. Simply it relates to managing the communication, coordination, and responsibility across a common boundary between two organizations, phases, or physical entities which are independent. In other words, it aims at managing the problems that often occur among people, departments, and disciplines rather than within the project team itself *(Sugumaran and Lavanya, 2013).* As much as it was effective, alignment level among participants will be improved and conflicts will be reduced; that is because it increases the clarity on roles, responsibilities, as well as deliverables, especially in large projects *(Shokri et al, 2014).* This significance could be succinctly captured in this quotation: “Interfaces, joints and connections between different elements or sections cause more problems than most of the rest of the building” (Pavitt and Gibb, 2003, P.8).

It is obviously noticeable in the traditional approach of building construction that there is a lack of interaction between project participants, especially designer and constructor, which may create adversarial relations between them, increase the chance of going wrong, and affect project performance. This can be considered a major obstacle which precludes a stronger design-construction interface. Thus, it is extremely important to eliminate the inconsistency on interfaces in the same party and between various parties that might be raised during the project to ensure the successful completion of the project. If not, the project might be delayed, cost might be increased, or quality might be scarified. Considering these issues (i.e. time, cost, and quality) which definitely shape up any construction project, there is an urgent need to have extensive solutions of many problems such that a better control on time, cost and quality could be emerged and a better management on the interface could be reached as well *(Sugumaran and Lavanya, 2013)*.

Here comes this research work to assess the professional interface between design and construction phases of project life cycle for large building construction projects in Palestine. In this regard, this study will:

(1) Provide the Palestinian industry practitioners with the most significant design-construction interface problems that affect their building construction projects.

(2) Help owners, consultants, and contractors in overcoming the weakness points in terms of the design-construction interface management to ensure a successful completion of the project.

(3) Increase the probability of the project accomplishment with minimum time and cost, through reducing the amount of rework, and also with desired quality.

(4) Compare the current situation with other Arab countries in the surrounding environment and give a reasonable and logical feedback that could be utilized for future practices.

1.5 Research Scope and Limitations

Listed below are the limitations of this research:

(1) Large building construction projects will be surveyed.

(2) Design-Bid-Build project delivery system will be considered.

(3) Study constrained to the West Bank region of Palestine.

(4) Research deals with both design and construction phases.

(5) Views will be taken from consultants and contractors.

CHAPTER 2

LITERATURE REVIEW

A significant number of papers address the issues relating to design and construction processes interface in a way or another. Out of the found issues, design-construction interface and its associated problems were considered as a key issue in this regard which requires a fair attention. A reason for this is that better managing this interface and knowledge transformation process across it will reduce project delivery time and cost and also save the quality of the final product. Moreover, both design and construction phases are just starting points at the beginning of the line of projects lifecycle. The status of the construction phase totally depends on the design phase, and the statuses of the other phases depend on the successful relationship between them both. Thus, the lack of conscious concerning the problems that may arise on the interface between design and construction and the different ways in solving them might have a bad effect on the status of the whole project.

2.1 Interface Management

Little exposure to the concept of Interface Management (IM) could be obviously noticed in management literature in general, and particularly in construction researches, through the limited number of publications and the time gaps between them *(McCarney and Gibb, 2012)*. The concept of IM was developed by *Wren (1967)* to review the relationships between organizations, two or more, and thus indicating the issues which people or processes may arise.

2.1.1 Definition of Interfaces

Defining interfaces before analyzing the factors influencing them is a very important step for successful management. Although there is no consensus among previous researchers on a certain or standard definition of the interfaces, most of them agreed that it is the common boundaries or connections among two organizations or firms that may affect each other *(Wren, 1967).*

Verma (1995) defined interfaces as the formal and informal boundaries and relationships among people, departments, organizations, or functions. From this definition he defined the interfacing process as the process of establishing a satisfactory working boundary between two adjacent parts. Thus, interface management is the place where there is a lot of overlap and opinion diverges.

Many definitions of IM have been reported by many researchers. *Weshah, et al (2013)* could gather some of them as appears in the following table:

Table 00.1 Different definitions of Interface Management

Definitions	References
It is "the systematic control of communication supporting a process operation".	Healy (1997)
It has two meanings within construction projects: (1) It is "the management of communication, coordination, and responsibility across a common boundary between two organizations, phases, or physical entities which are interdependent". (2) It is "Managing the problems that often occur among people, departments, and disciplines rather than within the project team itself".	Wideman (2002)
It is "the management of ordinary limits among people, tools, equipment, and thoughts".	Nooteboom (2004)
It has been shown to "address project complexity and allows for a dynamic and well-coordinated construction project system".	Chen, et al (2008)
It is "the interfaces that are present within different components and elements of the projects, equipment, systems, processes, and occasions".	Huang, et al (2008)

It could be briefly concluded that the above mentioned definitions discuss the interfaces as the boundaries and connections among various project phases, systems, tools, people, organization, physical elements, and others. However, this research adapts IM's definition given by *Wideman (2002)* which was quoted from *Verma (1995).* This definition may refine IM's goal in the built environment.

2.1.2 Categorization of Interfaces

Many researchers have provided different ways to classify the interface problems affecting projects. For instance:

Gibb (1999) categorized project interfaces into three distinct forms:

(1) Physical Interfaces: which refer to the hard interfaces where there is an actual physical connection or actual linkage between two or more elements or components.

(2) Contractual Interfaces: which refer to the contractual basis which identify how the work packages have been formed. It can influence the number of people and process interfaces.

(3) Organizational Interfaces: which refer to the soft interfaces that affect project successful management. It can relate to individual and/or group relationships.

Tian (2013) put project interfaces into four main categories:

(1) Time Interfaces: which refer to the ones between various project stages, between various project processes, and also the interfaces generating from factors connecting multiple buildings. An example of these interfaces is the information and material exchange generated between different project stages and in various construction entities.

(2) Relational Interfaces: which refer to the ones between different project participants, and it can be divided into contractual and non-contractual relational interfaces. The contractual is coordinated by contracts' relationship, while numerous number of non-contractual relational interfaces would appear between design, supervision, construction, as well as equipment and raw material suppliers.

(3) Informational Interfaces: which refer to the interfaces generated between different departments and personnel resulted from exchanging project information.

Managing such interfaces should be strengthen as the smooth exchanges of information is the key to successful project operations.

(4) Environmental Interfaces: which refer to ones developed between the project and the environment as a result of exchanging information and energy between them. Managers should consider these interfaces since many factors will affect them such as the resources inputs, profits, legal policy, and natural climate.

Weshah, et al (2013) could generally summarize some of the other classification made by different researchers as appears in the following table:

Table 0.2 Different categorizations of Interfaces

Categories	References
Personal, Organizational, and Systematic Interfaces	Stuckenbruck (1983)
Static and Dynamic Interfaces	Morris (1983)
Time, Geographic, Technical, and Social Interfaces	Wren (1967) Stuckenbruck (1983) Healy (1997)
Static and Dynamic Interfaces	Sanchez (1999)
Functional, Physical, and Organizational Interfaces	Laan, et al (2000)
Internal and External Interfaces	Awakul and Ogunlana (2002)
Product and Project Interfaces	Archibald (2003)
Actual, Functional, Extended, Temporal, and Future Interfaces	Korman, et al (2003)
Physical, Contractual, and Organizational Interfaces	Pavitt and Gibb (2003)
Physical, Functional, Contractual/Organizational, and Recourse Interfaces	Chen, et al (2010)

It is worth to mention that all the above classifications have been done from the researchers' subjective point of view. However, by adopting *Verma (1995)* categorization of interfaces, this study will focus on interfaces issues with the following emphasis:

(1) Interpersonal: it is also known as People Interfaces and it deals amongst team members, i.e. with superiors, with line or staff individuals on the team, with subordinates, with team members generally, with clients and product users, or with contractors or subcontractors representatives.

(2) Organizational: it deals amongst resource suppliers when viewing the total project organization as a system, i.e. with the performing organization's functional departments, with suppliers of the technology, or with suppliers of services, equipment or hardware.

(3) Technical: it deals with reporting relationships amongst the technical experts or design professionals, especially during the design stage of the project, i.e. between architects, engineers, programmers, or with authorities having technical jurisdiction.

2.2 Relevant Previous Studies

This section explores the various findings of previous studies related to design-construction interface:

Sugumaran and Lavanya (2013) studied the causes of discrepancies at design-construction interface for large building projects in India. First, a review of literature talking about design-construction interface issues was conducted where the resulted information regarding the potential discrepancies between design and construction were utilized to develop an initial questionnaire that would be used in the next step. Then, a pilot study was carried out on three large building projects to validate the initial questionnaire and develop a final one for the survey purpose. Two samples of 31 consultants and 30 contractors were statistically analyzed and the results indicate that the most important origins of design-construction interface discrepancies were "Lack of coordination", "Insufficient working drawing details", "Involvement of designer as consultant", "involvement of contractor as consultant", and "participant's honest wrong beliefs". Against the most important origins there are the least important origins which were "Project management as individual professional service", "nationality of professional firms", "involvement of contractor in design conceptual phase", and "involvement of contractor in design development phase". Cause and effect analysis were used to improve the design-construction interface.

Tian (2013) studied the factors influencing project interface management to catch the key impact factors. Four different types of interface management were categorized: time interface, relational interface, information interface, and environmental interface. Based on this categorization, index system for the anticipated factors was established and DEMATEL model was constructed to analyze these indexes, and then draw the conclusion. An example was chosen to analyze the interface management's most important influencing factors using the developed model. After analysis, its results were in accordance with the actual results which gives a proof of its applicability.

Weshah, et al (2013) studied the factor analysis of the interface management problems in Alberta construction projects. These problems were investigated, identified, and classified through a series of stages. First, a comprehensive review of literature and a face-to-face interviews and pilot studies with construction industry practitioners were conducted. Six important interface management problems' categories were identified: management problems, information, bidding, and contracting problems, by-law and regulation problems, technical engineering and site issues problems, and other interface problems category. Then, a web-page questionnaire was developed based on the data collected from the previous phase and distributed to various construction parties in the country. Based on the results of this survey, a factor analysis and Pearson's correlation matrix were applied. Finally, the correlation between the problems of interface management and the different data of construction was tested. As a result, a comprehensive view of the main factors causing conflicts in interface management in Alberta construction industry was provided.

Enshassi, et al (2012) studied the major problems between contractors and subcontractors in Gaza Strip's construction industry. 53 causes of problems were identified from literature and put in a form of questionnaire. A pilot study was considered to develop this questionnaire for final distribution. The purpose of the questionnaire was to extract both contractors' and subcontractors' viewpoints regarding the significance of the major causes of problems which have a negative effect on the relationship between them. 150 questionnaire were distributed to respondents of extensive experience in the field with an average working experience of 20 years. After analyzing the questionnaire, the most important causes of problems raised by respondents were "Assigning part of the works to new subcontractor without informing the original subcontractor", "Contractor's financial problems", "Delay in contract progress payments", "Non-adherence to the conditions of the contract", "Non-adherence of the subcontractor to the time schedule", and "Lack of construction quality work". On the opposite side came "Involvement in several projects with the contractor at the same time", "Weather conditions", and "Geological problems on site" which were the causes of the least importance. At the end, recommendations were given to each party to minimize or eliminate those causes to improve contractor-subcontractor interface.

McCarney and Gibb (2012) studied the relationship between offsite construction and organizational interface management to determine the various factors of process and people which affect its efficiency. The focus in this study was on design management as the process factor and communication as the people factor. Literature review was conducted to end up with having 16 factors, in addition to performing a pilot study using interviews with six academics and professionals in UK to gauge the validity of the questions and the relevance of the collected factors. The analysis of the results of the pilot study from this small sample indicated clearly the importance of early involvement of the contractor in the design phase. It also indicated the essentialness of having an open communication between all project stakeholders to resolve organizational interface issues. Furthermore, a confirmation on the importance of interface management was pointed out as of equal, if not more, importance when incorporating offsite forms of wet construction into the construction process.

Mitchell, et al (2011) studied the interface between design and construction processes to investigate a conceptual framework of this interface such that a foundation for improving its understanding could be provided for a better management. A theoretical understanding of the relationship between both design and construction processes was considered to produce a framework that reflects what actually occurs at this interface theoretically and empirically. To achieve this goal, literature and different theoretical backgrounds for the processes of both design and construction phases, as well as the significance of developing such framework were reviewed. As a result of this review, a significant difference between the theoretical understandings of these two processes was identified to mark a starting point for developing a conceptual framework for the interface between design and construction. This difference is that while design process can be described as iterative and circular, construction process is sequential and linear in nature, and there is a kind of uncertainty in design much more than it is in construction. This significant theoretical dichotomy between these two processes will affect the information's flow through their interface and as a result the interface management will be affected as well. The developed framework is considered to have a considerable effect in improving project management techniques on this interface and optimizing the process of subcontractors' selection, input, and appointment. Furthermore, it opened the door for further researches in the future through providing a good understanding of the characteristics of the interface.

Chang, et al (2010) studied the design and construction coordination problems that any new user might encounter in execution of design-build projects in Taiwan. The case study approach was selected to analyze these problems such that coordination problems and their possible solutions were investigated through studying 5 ongoing design-build projects and interviewing 9 major contract parties. The analysis of the collected information revealed that inadequate planning and execution are the main causes of coordination problems in design-build projects. Inadequate planning comprises completion of conceptual design at a high level, while inadequate execution comprises dissonant design-construction, long review process, and little feedback between designer and constructor. It was concluded that the problems of major influence on design-build projects were the dissonant design-construction and the little feedback between designer and constructor. Furthermore, the results indicated that inadequate coordination between design and construction will affect project time and cost and will lead to many design changes and conflicts. At the end, the researcher advises for good planning and execution guidelines in addition to good management practices to avoid, minimize, and solve such problems.

Chen, et al (2008) studied the importance of interface management in the construction industry and developed a multi-perspective approach, from six different but interrelated perspectives, which explores comprehensive factors that cause various interface issues. These perspectives were people/participants, methods/processes, resources, documentation, project management, and environment. Under each perspective, hierarchical cause factors were identified and structurally displayed. An object data model and a systematic model-based interface management strategy for all interface issues were developed from the identified factors using a series of interface management and control elements. This is why the developed approach performs better than other approaches which used to analyze interface issues in a loose and isolated way. So, the contribution here was a comprehensive view of interface issues' causes through the delivery process of the entire project and the operation and maintenance of a built facility. This will help in avoiding, minimizing, and resolving many interface issues.

Huang, et al (2008) studied the resulted problems from different interfaces among Taiwanese construction parties that lead to extra losses. Problems resulting from complicated mechanical, electrical, civil, and track interfaces in the mass rapid transit system (MRTS) were the main target of the study. A quantitative method was used to categorize these problems and identify the individual impacts associated with them. After conducting a literature review and face-to-face interviews, a questionnaire was developed and sent to respondents of high experience in the field including owners, designers, contractors, and subcontractors. Factor Analysis as well as multiple regression analysis were the two quantitative methods used in questionnaire results' analysis. Six dimensions in the interface problems could be identified where the experience and coordination dimensions considered as crucial regarding progress rate and quality. At the end of the study, suggestions were provided for all practitioners dealing with such interface problems to enhance the efficiency and effectiveness similar projects in future.

Arain and Assaf (2007) studied the sources of problems at design and construction interface in large building projects in Saudi Arabia from the consultants' point of view. They distributed a questionnaire on consultant firms to collect the required information about the potential sources of design-construction interface dissonances. Responses from 24 consultant firms were analyzed and the conclusion was that "Contractors' lack of comprehension of drawing details and specifications", "Involvement of contractor as consultant", "Time limitation in the design phase", "Design complexity", and "Honest wrong beliefs of participants" were the sources of problems with the highest significance on design-construction interface. On the opposite side comes the sources of problems with the lowest significance which were “Project management as professional services”, “Weather conditions”, “Unforeseen conditions”, “Involvement of contractor in the design conceptual phase”, and “Involvement of contractor in the design development phase”. At the end, various ways of reducing the gap between the consultants and contractors were suggested to improve the design-construction interface.

Arain, et al (2006) studied the causes of inconsistencies between design and construction of large building projects in Saudi Arabia from the contractors’ point of view. They distributed a questionnaire on contractor firms to collect the required information about the potential causes of inconsistencies at design-construction interface. 27 responses were collected from contractor firms and then analyzed to conclude the most important causes which were “Involvement of designer as consultant”, “Communication gap between designer and constructor”, “Insufficient working details”, “Lack of coordination between parties”, and “Lack of human resources in design firm”. Moreover, the least important causes on the other side could be concluded as well. They were considered by respondents to be “Project management as a professional service”, “Weather conditions”, “Nationalities of participants”, “Involvement of contractor in the design conceptual phase”, and “Unforeseen conditions”. At the end of the research, many recommendations were suggested to overcome the most important causes of inconsistencies such that the design-construction interface will improve.

Al-Hammad (2000) studied common interface problems among various construction parties in Saudi Arabia. He identified and assessed these problems through conducting two phases of research: the first phase was conducting a literature review and interviews with various construction professionals from various parties to identify the potential interface problems among them and then he classify them into categories to be presented in a logical sequence by grouping the problems that have a common purpose, while the second one comprised developing a questionnaire containing the problems previously identified from the first phase to be distributed on respondents. A sample of 102 construction professions including owners, designers, general contractors, subcontractors, and maintenance contractors was selected for the survey to assess the severity of 19 potential interface problems which were classified in 4 general categories from a subjective perspective: financial, contract and specifications, environmental, and other common interface problems. A severity index was used to determine the relative severity of each category and its related problems such that a ranking order could be built for them. Analyzing the survey's results revealed that the highest severity ranking of the presented interface problems was given to "Violating conditions of the contract", "Owners low budget for construction relative to requirement", "Insufficient working drawing details", "Poor quality of work", and "Poorly written contract". On the opposite side of the highest ranking comes the lowest ranking where "Weather", "Delay in finish of project", "Prices change of materials and laborers during construction", "Geological problems at site", and "Unavailability of professional construction management" were ranked as the lowest severity interface problems. Additional interface problems which were added by respondents to be part of the survey's final results.

McCarthy, et al (2000) studied the evolution of information exchange and sharing interfaces between designer and constructor during a project in UK and identified the critical success factor of knowledge management in this regard. This work was part of a project entitled Knowledge Learning In CONstruction (KLICON) which aims at improving the quality and value solution of project environment. This project examined knowledge transformation mechanism from the early design of the project to the detailed design and then going on to the construction phase. The researcher part examined the mechanism of knowledge transformation in the tendering phase as it is the initial interface between the designer and some potential constructors and it set the foundation for exchanging information efficiently throughout the project. He also examined the flow of geotechnical and site investigation information through the project activities.

Wang (2000) studied the pros and cons of the foreign design that might affect the construction market and the local community in China. A questionnaire survey was conducted to evaluate the positive and negative effects. Despite the advantages of introducing foreign design companies into the local construction market in the country, the survey revealed a problem in the coordination issue between foreign designers and local project participants as one of the most prominent negative effects in this regard. Furthermore, different backgrounds of the Western construction industries and the Chinese one were analyzed in addition to the other factors that might lead to coordination problems. An evaluation of some measures that try to solve this coordination problem was conducted proposing other measures to help in the same issue. Finally, possible coordination methods were suggested to grasp the advantages of utilizing foreign designers such as careful selection of architects, better organization, appropriate selection of communication tool, and adopting other professional agencies.

Alarcon and Mardones (1998) studied design-construction interface performance in an attempt to improve the quality of design to fit with the construction. Interviews with experts, data collection from different designs and related project sites in Chile, and implementation of improvement techniques, all were went through to achieve this goal. Four building project sites were intended for data collection purpose concerning the problems that have an effect on the design-construction interface. The collected information regarding the most frequent design defects, which were discovered during construction, gave a chance to design many tools that might help in preventing such defects again. The most effective tool among these tools was identified by Quality Function Development (QFD) which helped in setting priorities for their implementation. A methodology to improve the quality of design was suggested as well. The "House of Quality" technique was applied in the study to evaluate the technical responses by determining which would be the most effective to avoid the design defects found by the preliminary study for the project site. The main changes resulted from the study were implemented in a construction company which were participating in it. A considerable impacts on performance were grasped due to applying new design and review procedures, communication standards, and also an obvious determination of customer requirements and design attributes. These changes had a great effect in reducing design defects and their related impacts in this company.

Al-Hammad and Al-Hammad, (1996) studied the relationship between building owners and designers in Saudi Arabia. The aim of this study was to identify and assess the potential interface problems affecting this relationship. The process went through two main phases: the first phase comprises conducting a literature review as well as interviews with different professionals from building owners and designers to identify the common interface problems between them, while the second phase comprises developing a questionnaire that could be answered by professionals from both parties to evaluate the severity of the problems identified in the previous phase. 20 potential interface problems could be identified from the first phase which were grouped subjectively in three main categories: financial, inadequate contract and specifications, and lack of proper communication problems. Two samples of 30 building owners and 30 designers was chosen to undertake the questionnaire where both respondents were asked to evaluate the severity of the 20 problems. Based on the relative severity of these problems, they could be ranked according to a severity index for both samples. The questionnaire results were analyzed and it revealed that building owners gave the highest rank to “Lack of accuracy in specifications and working drawings”, “Poorly written contract agreement document between owner and designer”, “Lack of cost indexes for material, labor, and equipment to be used by designer for cost estimation”, “Designer's lack of experience”, and “Owner’s desire to modify the use of space after design process”, while “Owner’s low budget for design services relative to requirements”, “Owner's lack of awareness of municipality requirements”, “High cost of design fees”, “Delay in completion of design services”, and “Owner’s unawareness of environmental factors that must be considered by designer when designing project” were given the lowest rank. On the other hand comes the designers who gave the highest rank to “Designers’ lack of experience”, “Owner’s desire to modify the use of space after design process”, “Change orders”, “Owner’s low budget for design services relative to requirements”, and “Poorly written contract agreement document between owner and designer”, while the least rank was given to “Inappropriate size selection of construction materials”, “Delay in completion of design services”, “Owner's lack of awareness of municipality requirements”, “High cost of design fees”, and “Owner’s unawareness of environmental factors that must be considered by designer when designing project". The results also indicates a kind of agreements between building owners and designers on the severity of their interface problems.

Al-Hammad (1995) studied the relationship between owners and maintenance contractors in Saudi Arabia to identify and assess the potential interface problems between the two parties. He first developed a questionnaire containing 30 problems which were gathered from literature and a pilot study and subjectively compiled in 4 general categories: financial, inadequate contract and specifications, lack of proper supervision, and laborers' problems. The questionnaire then distributed and the respondents from both parties were asked to rank the importance of the identified problems based on their own experience. This survey revealed that "Lack of directed supervision by the contractor", "Lack of accuracy in specifications and standards", "Owners' low budget", "Contractors unawareness of owner complaints about his laborers abilities", and "Unspecified labor skills in contract" grasped the highest ranking among other interface problems. While "Laborers' illiteracy", "Adaptation of old technology and systems by old personnel", "Inflexibility of contractors/owners in arranging labor assignment from one site to another", "Contractors' lack of knowledge of local climatic and environmental factors", and "Sudden decision by laborers to leave or strike" grasped the lowest ranking. Some discussion was conducted on the results at the end of the research to interpret and utilize them in improving the interface between both parties.

Hinze and Tracey (1994) studied the relationship between general contractor and subcontractors from the perspective of subcontractors in the Puget Sound Area on the coast of the state of Washington. He focused on the actual process of subcontractors' initiation, making award arrangements, and managing subcontractors. A sample of 28 subcontracting firms representing eight areas of specialty were interviewed personally. These areas were drywall-plaster (3), painting (5), mechanical (5), electrical (5), masonry (2), utility (2), flooring (3), and elevator (3) and they were specifically chosen since they have various needs for coordination in the project. Information was mainly obtained on bidding practices, subcontracting arrangements, administrative practices, payment procedures, and project closeout. The results of these interviews were detailed information on the methods used by general contractors to put subcontractors at risk. Subcontractors are often forced to assume any contractual unexpected risks. They are also required to assume the contractually stipulated obligations between the owner and the general contractor without examining it. Also, bid shopping as well as payment problems was pointed out as a continuing practice in the construction industry. Many suggestions to improve the relationship between the general contractor and subcontractors were offered at the end of the research.

Vanegas and Opdenbosch (1994) studied the design-construction interface and developed a new methodology for simulating construction operations in a way that strengthening this interface. This methodology runs a simulation of interactive and real-time construction operations in a virtual environment such that a user will be closer to the real world than he was before. Within this environment, problems during the planning or design phases of any project could be identified virtually and solved before starting facility construction. This helps in improving the quality of facility construction many times as the quality of generated information improved, especially in the degree of construction input and its enhancement for the design process.

Al-Mansouri, (1988) studied the relationship between the consultant and contractor in Saudi construction industry. He concluded that it was poor due to applying the traditional procurement method which is totally dissociate the design phase from the construction phase. He also analyzed the effects of applying this procurement method on the efficiency of the industry and on the people involved in it. To do so, he first determined the factors that affect the efficiency which could be gathered from literature and classify them in three separate categories: factors affecting design efficiency, factors affecting construction efficiency, and factors affecting the efficiency of both design and construction phases. Then he distributed two questionnaires: one for a sample of consultants to determine the extent to which these factors affect the design efficiency and the design-construction interface, and the other distributed to a sample of contractor regarding the factors that affect the construction efficiency and the design-construction interface. Statistical analysis was performed on this survey to analyze design efficiency, construction efficiency, and the relationship between both. He found that "fast track" and "work packaging" were agreed upon to be of low importance, while "early involvement of contractor" and the other related factors had a contradiction between consultants and contractors, the thing that reflects the low efficiency and poor relationship. After that he distributed a third questionnaire to consultants only to test their experience in using alternative procurement approaches and to determine if these approaches could give them the anticipated contractor's response or not. This questionnaire was to find out the requirements that allow consultants and contractors acting hand by hand. After analysis he could conclude that the Professional Construction Management (PCM) contract type could solve the poor efficiency of design-construction interface as well as the relationship between consultant and contractor in the country.

2.3 Construction Project Life Cycle

Any project in the life includes certain number of phases of development. These phases should be clearly understood for more efficient project control as they represent the path which takes the project from the starting point to the end point and are generally referred to as “the project lifecycle”. However, there is no standard project life cycle as it may differs in both the number of phases and the detailed within each phase.

Shokri, et al (2014) indicated that the Construction Industry Institute (CII) described the traditional project life cycle for most construction projects that it is relatively linear in its process where each phase should have completely finished before starting the subsequent phase. The main phases that consist this process are:

(1) Feasibility.

(2) Concept.

(3) Detailed Scope.

(4) Design and Procurement.

(5) Construction.

(6) Commissioning and Start-up.

(7) Operation.

Arain (2002) indicated that the Royal Institute of British Architects (RIBA) segmented the construction project life cycle is into the following phases:

(1) Appraisal.

(2) Strategic Brief.

(3) Outline Proposals.

(4) Detailed Proposals.

(5) Final Proposals.

(6) Production Information.

(7) Tender Documentation.

(8) Tender Action.

(9) Mobilization.

(10) Construction to Practical Completion.

(11) After Practical Completion.

According to *Kartam (1996)*, four common phases form a construction project life cycle which are conceptual planning and feasibility studies, design and engineering, construction, and operation and maintenance.

Besides that, *Alsubbak, et al (2009)* classified project life cycle of a construction project into five sequential phases which are feasibility phase, design phase, construction phase, exploitation phase, and dismantling phase. The first phase is the feasibility phase where the issues of economical, safety of workers, technical aspects, and basic information for the all phase in construction are shaped. Then comes the design phase which is not only concentrated on the design itself, but also includes the details of project, proposing initial tests, the calculation of each element of the structure, drawings and specifications, and also the estimated costs. In the construction phase, there are two sub-phases of the execution and inspection. The execution phase includes all activities of the construction works until the project is completed, while the inspection phase involves a continuous inspection on work to ensure that the construction works are carried out in the right way, and also assuring of safety and environmental quality. The next phase is the exploitation phase in which activities of use and maintenance will be activated after completion of evaluation stage. Least but not last, dismantling phase is the end-point of a project life cycle where activities of demolishing start and removing the facilities from the service depends on their use and life expectancy.

In another study conducted by *Saad (2011)*, construction project life cycle was divided into five phases to include conceptual planning and feasibility study phase, engineering and functional design phase, phase (III), construction and completion phase, and operation and utilization phase. The first phase comprises of conceptual planning and feasibility study on a project using a few number of components such as analyzing the concept, studying technical and economic issues, and reporting the expected impact on the environment. The engineering and functional design phase was divided into two main stages or sub-phases which are preliminary engineering and design, and detailed engineering and design. However, both of these stages have more emphasis on the architectural concepts and structure analysis to guarantee that there is no contradiction between any structural element and its actual specification. For the phase (III), all contract documents should be prepared by the designer and submitted to the contractor. The accomplishment of this phase goes through an order of the following steps: preparing drawings and specifications, tendering and awarding, and procurement process. Next, in construction and completion phase, project execution starts, where the on-paper designs are to be converted into a physical component, and goes on until completion within the previously allocated time, cost and quality. Finally, operating and utilizing the project begins and it is usually determined since the concept development during the beginning of project.

Moreover, *Ismail, et al (2013)* in his research focused on four main phases of project life cycle which were planning phase, design phase, construction phase, and finishing phase. The planning phase was considered to emphasis on few things like the scope, purpose, objectives, resources, time, cost, and deliverables of the construction project to guarantee a desired completion. In the design phase, detailed plans and drawings are prepared according to the owner requirements. After finishing the design, the construction phase starts which comprises of project plans execution, communication between various parties, project progress reporting, and time, cost, and quality control. Finally comes the finishing phase to conclude the construction work where exterior and interior finishes are conducted for the constructed facility, such as plastering, flooring, painting, glazing, and others.

However, this study will focus only on two main phases of project life cycle in addition to the relationships between them. These phases are:

(1) Design Phase: in which the owner's strategic need has been recognized by the designer, the preliminary goals of the project are established along with exploring the availability of means to achieve them, and a set of formal drawings and other related documents that reflect these goals has been developed properly for execution.

(2) Construction Phase: in which the actual work of the project is performed, materials and resources are procured, performance capabilities are verified, and, at the end of this phase, the project will transferred to the intended users for utilization.

It is worth to mention that the design phase itself usually splits into several temporary sequences and delivered to various specialists to be executed. The construction phase as well involves many participants such as sub-contractors, vendors, suppliers, and others who have to communicate and coordinate with each other. Little interaction among design and construction, including their specialists, would lead to suboptimal solutions and great number of changing orders (rework of design and construction).

2.4 Common Project Delivery Methods

The successful completion of a building project requires a clear vision on client's requirements, the nature of the service to be provided, and the responsibilities of all concerned authorities. A variety of prime authorities and different responsibilities could be found in any construction project based on the selected delivery method for this project.

Mahdi and Alreshaid (2005) described three common method for project delivery, and below is a brief explanation of this description:

2.4.1 Design-Bid-Build (DDB)

It is often referred as the "traditional" or "conventional" delivery system. This system has three main players: owner, designer (architect), and constructor (general contractor). Here, design is followed by construction and they are assigned to two separate entities, where the design contract is assigned on a quality-based selection, while the construction contract is assigned to a bid-based competitive.

The owner is responsible for defining project requirements, providing finance, and providing whatever standards and contractual terms that are going to be followed. Under the authority of the owner comes the designer who is responsible for designing the project as well as representing the owner in construction contract's administration, while the constructor is responsible for the proper construction of the design in addition to the selection of the appropriate methods and procedures to complete this construction.

It is obviously seen that both designer and constructor are the responsibility of the owner and no one is responsible for the other, the thing that creates an independent relationship between them. This separation in turn creates a system of checks or balances as both entities are in a position to discover the errors committed by the other and sometimes they are required to report it to the owner such that an error effects can be minimized or eliminated and the quality of the construction project will be improved.

However, this method is often criticized due to the time extension in both design and construction as well as the adversarial nature of relationship between designer and constructor. That is why many variations of this project delivery system have been developed.

2.4.2 Design-Build (DB)

This method has been seen by some as the perfect solution in addressing the other methods' limitations. As an owner, the great benefit lies under the simplicity of having one party which is responsible for the development of the project. Many of the disputes raised among various project participants, when using the other delivery methods, turned to be internal team issues in this system which do not affect the owner since he will not be a referee any more.

Moreover, this system typically requires owner's completion of only 5-30% of the project's preliminary design before transforming it to the design-build team for completion. On the other hand, this system gives the design-build team an opportunity to merge alternative technical concepts at both design and construction phase in a way that improves the project's delivery process.

2.4.3 Construction Management at Risk (CMR)

Here, the architect or engineer is selected first to design the project and then a construction manager is hired at risk in order to serve as a general contractor during construction while guaranteeing the facility construction at a certain price. At the same time, he is responsible for providing consultation to the design phase in terms of evaluating schedule, costs, as well as alternative designs, systems, and materials during and after the design of the facility. It is somehow similar to DBB, but the advantage here is that the construction manager holds the risk of subletting construction works to trade subcontractors and providing a guaranteed maximum price for project completion, either a fixed or negotiated price.

While no project delivery option is totally perfect, one may be better suited than the other based on the requirements of a particular project. In this study, DBB is going to be the main area of interest as it is the primary one adopted in Palestine and most Arab countries in terms of the execution of construction projects.

2.5 Conventional Architectural/Engineering and Construction Practices (AEC)

A successful project should be carried out in an atmosphere of mutual trust, goodwill, and synergism between the diversified involved parties which perform certain services to achieve certain goals. *Arain (2002)* described the designer and constructor's conventional services for a building construction project to include these jobs:

2.5.1 Architectural/Engineering Practices

A. Preliminary Services

(1) Inception:

This includes discussion of owner's requirements, the allocated time and cost, and the desired level of quality, to assess all of these constraints and advise the owner. For this purpose, many project information should be encircled and a primary analysis of project concept including a conceptual design proposal should be initiated to help the owner in site selection (if required).

(2) Feasibility:

Through the project feasibility study, owner secure his investment return where the designer consider all the available data on the project and owner requirements, review alternative designs and the associated construction methods a cost implications, advise on to obtain planning permissions or approvals under building acts or even regulations (if there is a need).

B. Basic Services

(1) Sketched Design Proposal:

This requires a collaboration with other consultants (if appointed) and a comprehensive analysis of owner's requirements in order to prepare an outline proposals associated with as approximation of construction cost to be preliminary approved by the owner.

(2) Final Design Proposal:

This is going to be developed based on the approved sketch considering owner's amendments. A modified cost estimate will be prepared in addition to providing an indication of possible schedule for the contract (if applicable). This proposal will illustrate, in details, project size and character in a way enabling the owner to agree on the building final image including the spatial arrangement, materials, and appearance. It also includes advising the owner concerning any implication of subsequent changes on project cost or outcomes.

(3) Detailed Design:

It comprises the development of the final proposal agreed by the owner to result in completed design documents which are drawings, specifications, and calculations. The main services of this job include:

- Preparation of production information such as drawings and others,
- Obtaining the owner's approval of construction type, materials quality, and workmanship standards,
- Obtaining quotations and other information concerning specialists' work,
- Coordinating other contractors, manufacturers, and suppliers,

- Checking construction cost,
- Advise the owner of the subsequent of any changes on the cost and schedule, and
- Negotiate to obtain the required approvals on building acts, regulations, and other statutory requirements.

(4) Quantity Take-off and Tenders:

To finalize the design, all the related information concerning, construction schedule, specification of materials and workmanships bill of quantities, expected cost should be available in sufficient details to help the owner during tendering as it is going to be his reference, and also to enable the constructor prepare his tender properly.

2.5.2 Construction Practices

Construction services refer to all services required to transform the design into an operating facility. These services are mainly include:

(1) Provision of Human Resources:

It is the constructor responsibility to provide the required human resources for the project in addition to any specialist as indicated by the contract.

(2) Machines and Equipment:

All machines and equipment stipulated by the construction contract should be provided on time at the construction site by the constructor.

(3) Building Materials:

Construction materials provided by the constructor should be as specified in the documents and as required by the owner. Also, they should be approved for quality and materials and so on before installation.

2.6 The Influence of Design and Communication on Interface Management

Traditionally, the design phase and the construction phase used to be seen as separate operations where each one is able to function separately. However, *Alarcon and Mardones (1998)* in his research concluded that 40-50% of design time is consumed by rework and design changes, while the significant amount of this time was wasted during the flow of design information. This reflects the importance of the design construction interface and how it affects the project. He also highlighted the lack of communication and coordination between the design team itself as they directly affects the design interface and attributed this to the scanty knowledge of designers in the area of build-ability/constructability practices as well as the insufficient inputs by various specialists involved in the project. This emphasizes the necessity of a qualified design manager to coordinate the whole process, and also encourages the contractor involvement in the design phase which in turn highly depends on the procurement method.

For the same purpose of better managing the design process, *Chua, et al (2003)* developed a model to encourage the transparency in communication and collaboration during the design phase. The design interface was included as a part of the model which motivates the design specialists to share essential design information with others to create a more transparent environment. The other parts of the developed model were the design engine, which promotes the collaboration between various parties, and the design dictionary, which acts as a vehicle of accumulation of information passing between specialists and all of them can access it to grasp the anticipated appreciation of other design functions. The added value of this model is highlighting the importance of sharing information, the thing that can have a great effect on the design interface especially in the process of design review.

In addition to these studies, *Wang (2000)* oriented his research towards measuring the pros and cons of the foreign design that might affect the construction market and the local community in China. He concluded that introducing the Western designers to the Chinese construction market has many advantages, but to avoid its negative effects, certain measures should be considered. A problem in the coordination issue between foreign designers and local project participants was identified as one of the most prominent problems in this regard. An evaluation of some measures that try to solve this coordination problem was conducted proposing other measures to help in the same issue, and also, possible coordination methods were suggested to grasp the advantages of utilizing foreign designers such as careful selection of architects, better organization, appropriate selection of communication tool, and adopting other professional agencies.

CHAPTER 3

RESEARCH METHODOLOGY

Research methodology or strategy can be described as the way in which the research objectives can be questioned, and this way depends on the type and availability of required information *(Naoum, 2007)*. In order to improve the design-construction interface, researchers used different tools based on the case they have such as work breakdown structure concept, regression analysis, factor analysis techniques *(Sugumaran and Lavanya, 2013)*.

This research is directed towards large building construction projects in Palestine, specifically in the West Bank, and a set of goals for improving the design-construction interface has been developed to be achieved. For this purpose, the researcher intends to acquire the latent knowledge in the literature through an extensive review and analysis of literature to identify the potential causes of discrepancies between parties in both design and construction phases of project life cycle and afterwards they will be put in a form of a questionnaire. Then, a pilot study will be carried out to analyze the initial form of the questionnaire through a deep discussion with selected local consultants and contractors. After that, the questionnaire will be revised based on the results of the pilot study to be distributed on different respondents of the selected samples for data collection. Finally, the collected data will be analyzed to come up with the main objectives of the research.

3.1 Research Systematic Phases

The research will basically include the following eight phases:

3.1.1 Literature Review and Analysis

Searching the information in the literature is an essential part of planning any research which helps the researcher in developing his own line of thought. In this research, the researcher will review and analyze various research studies conducted in the past which relate, in one way or another, to the selected topic. The purpose here is to obtain a comprehensive knowledge about the actual scenario of engineering and construction practices and its associated problems that relates to this study. This will help in determining the main causes of design-construction interface problems which were referenced by previous researchers. For this purpose, the review will include previous research papers and dissertations which deal with interface management issues, the relationship between parties, causes of delays, cost overrun, and quality deviation as these are the expected consequences of interface problems.

3.1.2 Developing the Research's Primary Foundation

By the end of the previous phase, a comprehensive catalog developed from the literature should be ready to serve as the primary foundation of this research to fulfill its main objectives. This catalog should indicate the main causes of design-construction interface problems that could be collected from the literature, and how they affect this interface and lead to problems. By doing this, the first objective of the research will be accomplished.

3.1.3 Designing the Initial Questionnaire

The initial questionnaire will be designed based on the catalog developed in the previous phase considering the main objectives of this research (Refer to Appendix B). This questionnaire basically will be categorized in three major segments.

The first one includes general information about the respondent and the company which he or she represents as well as some characteristics of its work within the scope of this study. For this segment, the respondents will provided with multiple-choice questions to mark the most suitable answer.

Whereas the second segment, which can be considered the core of the questionnaire, contains the main causes of design-construction interface problems. This segment itself is split into five categories according to the source of the problem from the researcher's subjective classification of what has been collected from the literature. These categories are owner-related causes, consultant-related causes, contractor-related causes, project-related causes, and finally the external causes of these problems. This classification will help in presenting the identified problems in a logical sequence by grouping the problems that have a common purpose. Under each category there is a list for the main causes belonging to it such that the respondents will be provided with a Likert Scale ranges from 1 "Not Significant At All" to 4 "Extremely Significant" to mark the significance level of each cause based on their professional experience.

Finally, the last segment of the questionnaire will be left open ended for the respondents to fill in if he or she could come up with other causes that are, according to their perception, should be included in this research. In this segment, the floor will be opened to the respondent to give any additional suggestions or recommendations to improve this particular study.

3.1.4 Conducting a Pilot Study

Naoum (2007) indicates that the main purpose of the pilot study is to provide a trial run for the initial questionnaire, through which the words could be tested, ambiguous questions could be identified, data collection technique could be examined, etc. Since it is advised to complete a pilot study to validate the questionnaire before collecting the final data, the researcher will distribute the initial questionnaire to some professional experts and arbitrators who are qualified with sufficient experience to amend and correct the questionnaire. The selected arbitrators will be local consultants and contractors to give their assessment on the clarity and accuracy of the questionnaire content and language and also to give their feedback concerning the core part of the questionnaire by modifying, adding, or even removing some of the collected causes of the research problem in the line with local work environment. In addition to these professional experts, the research supervisor will audit the questionnaire statistically and make sure that it has a statistical significance since he has a strong experience in this field.

For the purpose of fitting the research into conditions in the Palestinian construction industry, four experts were involved in this pilot study; two consultants and two contractors from two different large building construction projects that are being built recently in Ramallah-West Bank. All respondents were experienced industry professionals, with an average working experience in the construction industry of 20 years and thus it is expected that the data collected from them are reliable. The designation of respondents were managing director and senior project manager from the consultant firms, in addition to construction manager and site engineer from the contractor firms. These respondents were asked to critically review the questionnaire design as well as the compatibility of the raised interface problems collected from the literature with the characteristics of the local construction industry. Their valuable comments, suggestions, and modifications were accommodated based on the findings of this pilot study and considered in developing the final questionnaire.

Two large building construction projects were selected through which the previously mentioned respondents were individually met and interviewed. Appendix A shows the main characteristics of these buildings. The following items summarize the main results of the pilot study:

(1) It is better for the questionnaire to start with a cover page expressing general information about the researcher and the main objectives of his research.

(2) The questionnaire was translated into Arabic as it is easier for respondents to deal with, therefore, more concern was given for the translated words and phrases to give the same expression and to guarantee the full understanding from the respondents' side.

(3) Some choices were modified in the first part of the questionnaire in order to achieve more accurate and suitable choices for respondents.

(4) Some sentences was modified and represented with more details so as to give more clear meaning and understanding.

(5) Some of the gathered problems were repeated more than once with the same meaning, and so, repeated problems were eliminated.

(6) Some local problems were added as recommended by local experts that they expect to be important causes of design-construction interface problems in the country.

(7) There are some problems which are not realistic with respect to the actual situation in the country, and so, they were removed or modified.

(8) Likert scale of 4-points instead of 5-points was recommended to use such that respondents may be confused in evaluating the high severe problems.

3.1.5 Developing the Final Questionnaire

After the pilot study, the questionnaire should be refined to be ready for final distribution. Thus, any logical comment or suggestion received from the arbitrators should be utilized for the benefit of this research. Special care will be given for the selection of simple phrases to guarantee a convenient comprehension by respondents. By the end of this phase, the final form of the questionnaire with the gist of the reviewed causes of design-construction interface problems is supposed to be well-done in an unambiguous and easy-understand format (Refer to Appendix C).

3.1.6 Data Collection

In this phase, the questionnaire will be sent to the local consultants and contractors to be answered. Different techniques might be used to send the questionnaire, due to expected responses deficiency, such that a sufficient number of respondents could be acquired. These techniques are:

(1) Telephone calls asking for an appointment to send the questionnaire personally to be filled by hand.

(2) Making an electronic questionnaire through a special website. Then, the questionnaire is given a link which could be sent by email for any respondent who in turn replies at any time. By clicking a button, this replication will be saved in the responses database directly to be viewed by the researcher at any time without noticing any information related to respondent.

*The questionnaire link is *https://docs.google.com/forms/d/1izm4myiWNfzNUxdTh5r4lRt2cQEhZ4bYN0MzbIYXUM8/viewform*

3.1.7 Data Analysis and Validation Procedures

A detailed analysis of the collected data using an appropriate statistical analysis software, such as SPSS and MS Excel, will be conducted based on the significance index to come up with two separate lists representing the appraisal of both consultants and contractors regarding the most significant design-construction interface problems. This will achieve the second objective of the research.

To measure the significance of each problems in terms of the severity of the effect it makes on the design-construction interface, respondents were given four options as follow:

Table 0.1 Significance levels, meanings, and their indexes

Significance Level	Meaning	Index
1	Not Significant At All	0 < I ≤ 25 %
2	Slightly Significant	25 < I ≤ 50 %
3	Significant	50 < I ≤ 75 %
4	Extremely Significant	75 < I ≤ 100 %

The significance index of each problem can be calculated based on the following formula *(Al-Hazmi, 1987)*:

Significance Index (SI) = $\frac{\sum_i^n a_i\, x_i}{n \sum x_i}$ x 100% …………………… (Equation 3.1)

where:

(i) is the response category.

(a_i) is a constant expressing the weight given to (i^{th}) response.

(x_i) is a variable expressing the frequency of (i).

In this case:

A 4-ponits Likert Scale was chosen and n = 3.

i = 0, 1,2, 3 and a_i = 0, 1, 2, 3 for the weights 1, 2, 3, 4 respectively.

x_0 is the number of respondents answering "*Not Significant At All*",

and corresponding to a_0=0.

x_1 is the number of respondents answering "*Slightly Significant*",

and corresponding to a_1=1.

x_2 is the number of respondents answering "*Significant*",

and corresponding to a_2 =2.

x_3 is the number of respondents answering "*Extremely Significant*",

and corresponding to a_3 =3.

Moving to the third objective of this research, Spearman rho will be computed to measure the degree of agreement in ranking between consultants and contractors using the following formula *(Pffaffenberger and Patterson, 1977)*:

rho (p) = $1 - \frac{6\sum D^2}{N(N^2-1)}$ …………………… (Equation 3.2)

where:

D is the difference between consultants' and contractors' ranking for each problem.

N is the total number of ranked variables.

At the end of this, a consensus list of the most significance problems will be developed.

3.1.8 Conclusions and Recommendations

The findings of this research will be concluded. Furthermore, recommendations for improving the current situation of design-construction interface for large building construction projects in Palestine will be suggested as the baseline for future research.

3.2 Population and Sample Size Determination

Four restrictions will be imposed on respondents' selection:

(1) Restricted to only one Region of the Palestinian territories which is West Bank, while Gaza Strip and Occupied Palestine will be excluded.

(2) Restricted to local consultants classified by the Engineers Association (EA), and also local contractors classified by the Palestinian Contractors Union (PCU).

(3) Restricted to large projects:

The word "large" has different appreciation between one country and another. Having a look on how local consultants and contractors have been classified will help in determining the specific indication of the word "large".

Table 0.2 Engineers Association classification for local consultants, 2014

Consultants Classification	No.	Maximum Allowable Area (m^2) for Architectural Design and Supervision of a Single Project	Maximum Allowable Area (m^2) for Architectural Design and Supervision of Projects Executed Yearly
Consultant	129	8000 + 500n (n: years of experience)	45,000
Grade 1	71	6000	25,000
Grade 2	108	4000	18,000
Grade 3	30	2000	12,000
Total	*338*		

Table 00.3 Palestinian Contractors Union classification for local contractors, 2014

Contractors Classification	No.	Maximum Allowable Cost (*JD*) of a Single Project	Maximum Allowable Cost (*JD*) of Projects Executed Yearly
Grade 1A	27	6,000,000	15,000,000
Grade 1B	69	3,000,000	6,000,000
Grade 2	93	1,000,000	2,000,000
Grade 3	58	500,000	1,000,000
Grade 4	29	250,000	500,000
Grade 5	57	100,000	200,000
Total	*333*		

Let's roughly say that large building construction projects in the country have been generally executed by consultants of grade "consultant" and contractors of grade "1", and thus, both will be the target group that should answer the questionnaire. However, this information was examined after conducting the pilot study.

(4) Restricted to building projects only, whereas civil engineering and industrial projects will be excluded.

(5) Restricted to projects with Design-Bid-Build delivery system, so other types of project delivery system will not be considered.

Considering these restrictions, the research will be targeted towards two main populations which are the Palestinian consultants and contractors working in large building construction projects in West Bank. The portal of Engineers Association *(EA-Jerusalem, 2014)* indicates that West Bank has 129 consultants of the target population working on building projects. On the other hand, the portal of Palestinian Contractors Union *(PCU, 2014)* indicates that there are 96 contractors of the target population working on building projects as well.

To insure that the statistical sample fully represents the population, some statistical calculations have to be done. The following formula will be used to determine the representative sample size for both populations *(Kish, 1995)*:

$$n_0 = \frac{p\,q}{SEM^2} \quad \text{(Equation 3.3)}$$

$$n = \frac{n_0}{1+\frac{n_0}{N}} \quad \text{(Equation 3.4)}$$

where:

(n_0) is the first estimate of the sample size.

(p) is the proportion of the characteristics being measured in the target population, usually expressed as decimal equals to 0.5 which reflects the proportion of 50% for getting the maximum sample size.

(q) is equal to ($1- p$) which is 0.5.

(*SEM*) is the maximum percentage of the standard error allowed for the sample mean, where in this study it was chosen as 0.1 which reflects an allowed standard error of ±10% because responses will be selected on a qualitative manner rather than a quantitative manner, the thing that will lead to a certain lower accuracy.

(n) is the final estimate of the sample size.

(N) is the target population size.

So, applying the first equation will give n_0 equals to *25* responses from each population. The substitution of this number in the second equation will give the final estimate of the sample size for each population as follows:

(1) For consultants, the target population is 129 and the representative sample size is 20.94 responses, which means (n=21).

(2) For contractors, the target population is 96 and the representative sample size is 19.84 responses, which means (n=20).

3.3 Thesis Layout

This research will be apportioned into five distinct chapters carrying the whole essence as follows:

3.3.1 Chapter One: Introduction

This chapter outlines what the research intends to do. It gives a historical and statistical overview on the construction industry in the concerned country and highlights the relevance of the issue being tackled to the construction industry in this country. Then, it gives a brief description of research objectives within the determined scope and limitations. It also provides the benefits that could be gained by construction practitioners after performing this research which increase the success probability of their projects.

3.3.2 Chapter Two: Literature Review

An integral part of any research is conducting a literature review for a number of relevant researches. Here, this chapter concludes what was found in the literature starting with enumerating and illustrating different definitions and categorizations of interfaces indicated by previous researchers. It also discusses prior studies on the issue and tracking their routes and findings. Then, it expounds the construction project's life cycle from various perspectives of previous researchers since there is no standard one and it may differs in both the number of phases and the detailed within each phase. More emphasis is given to both design and construction phase as they are the main areas of interest in this research. In addition to that, the common methods of project delivery are explained including their pros and cons in terms of how project delivery will be affected in both design and construction phases. Furthermore, the Architectural Engineering and Construction (AEC) conventional practices is illustrated in details and the main design and construction components are summarized. At the end this, some evidences from literature will be given on how the design and communication affect the interface management.

3.3.3 Chapter Three: Research Methodology

In this chapter, a detailed breakdown of the methodology employed to conclude the thesis was illustrated including research systematic phases as well as population and sample size determination. Here, questionnaire development process was described from the creation of the primary questionnaire to conducting the pilot study and moving towards finalizing the questionnaire. After that, data collection, analysis and validation procedures were described in details.

3.3.4 Chapter Four: Design-Construction Interface Problems

This chapter takes the reader to the heart of the topic. It explores potential causes of problems between professionals on project interfaces classified into five main segments based on the responsibility of managing each problem. It also describes briefly these problems according to the conventional professional practices in construction industry.

3.3.5 Chapter Five: Data Analysis and Results

This chapter reveals the results and findings through all the segments in the questionnaire. The potential causes of problems are subdivided into three parameters: responses from consultants, contractors, and the combination of both. Mean, standard error, standard deviation, as well as minimum and maximum ranges are tabulated for each problem according to the previous parameters. Considering the ranking of each problem, the highest five and the lowest five ranked problems are filtered and displayed in separate segment and they are briefly described.

3.3.6 Chapter Six: Conclusions and Recommendations

This chapter concludes the research and provides recommendations for future studies based on the analysis. The conclusion is presented considering the highest five and the lowest five ranked problems to be interpreted briefly. Based on this conclusion, recommendations are suggested from the researcher subjective perception to provide guidelines for future studies in this particular field.

CHAPTER 4

DESIGN-CONSTRUCTION INTERFACE PROBLEMS

Based on a review of the literature, 70 main interface problems have been identified representing the various relationships between parties in both design and construction phase. Not only researches on interface issues were reviewed, but also many researches on causes of time and cost overrun as well as causes of quality deviation were reviewed as some of these causes are found as kind of interface issues. These problems were then classified into five categories according to the sources of the problem from a subjective point of view. These categories are owner-related causes, consultant-related causes, contractor-related causes, project-related causes, and finally the external causes of these problems. In addition to that, and after conducting the pilot study, some other causes of interface issues raised by construction participants were added, some were deleted, and others were modified to end up with 60 problems which form the final questionnaire.

4.1 Owner-related Causes

4.1.1 Unstable client's requirements

Design phase may include reworks and time extension due to frequent changes of clients' requirements. These requirements limit the designer choices to investigate innovative approaches to better meet the specific project requirements *(Drawish, 2005).* There are various reasons for such changes during the course of a project and whenever they occur, design solutions need to be modified accordingly *(Sun and Meng, 2009).* Frequent client's mind changes can lead to inconsistencies between him and the designer. Moreover, if such changes took place after starting the construction process, it can lead to different problems at the interface with the constructor and the other construction parties.

4.1.2 Unrealistic client's expectations regarding project time, cost, and quality

Often clients underestimate the time and cost of the project. They also used to think of high quality of design standards and, on the other hand, they are unaware of the actual construction costs. Consequently, when the designer is done with the final design based on what the client required, the client starts cutting the cost of the final design. Also, if the client face the unexpected high cost during construction, they would like the designer to modify the design in order to meet the allocated budget *(Al-Hammad and Al-Hammad, 1996).* Such variations in client's expectations can be represented by updating requirements, reducing budget, demanding for accelerated completion, or other actions

(Sun and Meng, 2009). This can easily affect the design-construction interface and lead to many problems.

4.1.3 Outsourcing of design services

Foreign designers usually have inadequate experience about the culture, nature, and environment of the country in which the project is going to be executed. Thus they might need more time to produce a compatible design with the client's needs and with local environmental requirements *(Drawish, 2005).* In addition to that, it was widely admitted that hiring foreign design firms can cause many coordination problems which may not be existed if local firms had been used *(Wang, 2000).* In Palestine, most clients prefer making a design contract with a foreign firm instead of the local one due to lack of confidence of local design capabilities to compete the foreign one. Various problems might be encountered in this regard, such as the incompatibility of foreign design's standards and specifications with the local market *(Pilot study, 2014).* This may lead to many changes in the design and negatively affect the construction process as well as the relationship between the designer and constructor.

4.1.4 Not involving the contractor in the design phase

The contribution of contractor with his professional experience, creative, and practical ideas at the design phase may assist in developing better design as he is supposed to have recent knowledge about construction techniques and materials in the markets. Many researchers suggested that getting the contractor involved in the design can reduce the interface problems between him and the designer *(Arain, et al, 2006).* However, in

Palestine, the conventional practice in the construction industry, which is the one commonly used, does not imply such contribution and clients try to avoid it as it increase the design cost *(Pilot study, 2014).* Project progress in the construction phase will be affected by not accommodating the contractor's practical ideas during the design phase, and this impact will be of more severity than in the design phase *(Arain et al, 2006).* Thus, not involving the contractor in the design phase may cause inconsistences between design and construction.

4.1.5 Awarding contract to the lowest price regardless of the quality of services

Clients tend to "shop around" more for design services and frequently search for cheaper designers regardless of their experience and efficiency *(Drawish, 2005).* Not only with the design services, but also they do the same with the construction services. Such practices affect the overall project performance during construction and lead to many interface problem between the designer and the constructor.

4.1.6 Unclear definition for scope of work

Client should be able to provide comprehensive and consistent project briefs before awarding the contract. If he is unsure of his requirements, this should be clearly stated in the tender documents to let the tenderers know the actual situation *(Drawish, 2005).* If the scope of work is ill-defined whether in design or construction, then work boundaries cannot be well-adjusted and thus many inconsistencies may be occur between design and construction.

4.1.7 Inappropriate work packaging and subcontracting

Work packaging is important to the design efficiency and affect the construction efficiency as well through a thoughtful subcontracting. It allows better controlling the efficiency of the whole construction process *(Al-Mansouri, 1988).* In Palestine, work packaging has been commonly used in large projects and nevertheless many problems encountered during construction due to the lack of detailed reviews *(Pilot study, 2014).* However, it is preferable to divide the work into packages but this process should be done in a very clear manner and every contractor should know exactly the scope of his job. Failure of doing so will lead to many problems at the design-construction interface.

4.1.8 Poorly written contract with insufficient details

A contract is a voluntary agreement written between two or more parties to prevent any unlawful act and it refers to all records in connection with the work at any time. The contract usually covers the responsibilities of client, designer, contractor, and subcontractor. It also contains the time and cost agreed on to complete the specified work *(Al-Hammad and Al-Hammad, 1996).* If this contract is vaguely written, rights will be lost and this results in many inconsistences between design and construction parties.

4.1.9 Delaying the approval of completed tasks

The speed of execution of project design and construction depends on two main factors: the performance of designer or constructor in terms of time and quality, as well as work approval or acceptance by the client *(Al-Hammad, 1995).* However, if the client hesitates in approving various portions of work whenever it is needed, then work on subsequent activities will be delayed and affect the project completion. Moreover, if the client approval needs to be done on a design change while a certain part of project construction is waiting for this approval, then the design-construction interface of the project will be affected negatively.

4.1.10 Delaying of dues payments

Any construction party whether it is a designer or a constructor usually bases his specific financial plan on an expected cash flow payment from the client. Any delay occurs in the payment for any reason such as improper work or financial problems will affect the financial plan for a specific construction party which in turn affects the performance of the party and it may not be able to complete the job *(Al-Hammad, 1995).* Such kind of problems will affect the overall project performance as it leads to raise many issues at the design-construction interface.

4.1.11 Inappropriate choice of project contract type (unit price, lump sum, etc)

There are different types of construction contracts whose selection is basically distinguished by the method of determining the final price. No matter what contract type to choose, but the main goal is completing the project within the expected time and quality as well as meeting the all the required specifications for the lowest possible price while, at the same time, maintaining a reasonable profit for the contractor. However, the chosen contract type may depends on many factors including the identity and relationship between the client and the other party, design completeness and complexity, type of work being done, in addition to the desire of competitive pricing *(Fisk, 1997).* In this regards, inappropriate choice of contract type may lead to various interface problems especially if the contracting party doesn't know well the detailed conditions of the selected contract type.

4.1.12 Inappropriate choice of project delivery system (design-build, design-bid-build, etc)

Contractually, there are many systems of project delivery whose selection is based on the objectives of the owner *(Adrian, 1983).* Each system has its pros and cons in addition to specific rules implemented during the project completion and handing over. Generally in Palestine, tendered projects used to be delivered according to design-bid-build system which is characterized by its relative abundance problems comparing to the other systems *(Pilot study, 2014).* This can lead to many inconsistences between designer and constructor as it basically isolates both design and construction processes from each other.

4.1.13 Involvement of designer as construction supervisor

Mostly, in Palestine, the designer used to be involved as construction supervisor *(Pilot study, 2014).* However, this practice may lead to problems as the construction supervisor in this situation tries to put the blame for design errors on the constructor and evade the responsibilities for design issues *(Arain et al, 2006).* Such behavior increases the level of rivalry between the two parties and initiate problems at the project interface.

4.2 Consultant-related Causes

4.2.1 Lack of project stipulated data

The designer should spend enough time with the client to establish a comprehensive idea of his project requirements such that a proper and accurate understanding could be reached before starting the design process *(Darwish, 2005).* A clear project brief should be developed in the beginning, otherwise client's requirements may be wrongly understood as result in wrong assumptions on key project aspects *(Sun and Meng, 2009).* Such a bad start affects the design at latter stages, and if the client did not review the design carefully, the construction process will be affected as well. Due to this, many design-construction interface problems are going to be encountered and affect the project performance.

4.2.2 Lack of experienced and skilled human resources in the design firms

The existence of proficient and adequate manpower support is very important to meet the anticipated work quality and time schedule *(Al-Mansouri, 1988).* A lack of experienced and skilled human resources may delay the design process or result in a poor design quality which in turn can affect all the following jobs in the supply chain *(Arain et al, 2006).* When executing such design, many problems may be raise in the construction stages and result in different kinds of conflicts between the designer and the constructor.

4.2.3 Lack of proper coordination between various disciplines of design team

In most projects, the multi-participant working environment requires a kind of coordination. With a careful coordination, many errors that may occur can be resolved in their early stages *(Arain et al, 2006).* However, the absence of such coordination between the various disciplines of design team may affect the design time and quality. Carrying out this design at the construction phase would reveal many problems at the design-construction interface and affect the project negatively.

4.2.4 Lack of awareness about construction knowledge and ongoing site operations

The designer should be aware about the construction knowledge to develop a practical design. He also should be aware about what is going on at the construction site such that any default in the construction process can be controlled to save the later stages of project execution. The issue behind that is if construction errors occur, it should be reported to the designer promptly to take the correct action in this regard *(Arain et al, 2006).* This will reduce the dissonances between the designer and the constructor in addition to serving in timely completion of the project construction.

4.2.5 Lack of awareness about the availability of construction materials and equipment in the local market

Developing a comprehensive design requires adequate knowledge of available materials and equipment *(Assaf et al, 1996)*. Palestine is an occupied country and some specified materials or equipment require a specific time to be ordered and imported while the others are not allowed to cross the country borders *(Pilot study, 2014)*. Thus, the lack of such knowledge will affect the project negatively as the design might be changed to accommodate the replacement of a specific material or equipment. Such practice increase the conflict at the design and construction interface and lead to problems.

4.2.6 Lack of awareness about governmental regulations, municipality requirements, statutes, and their modifications

Naturally, local authorities may have specific regulations that should be accommodated in the design. These regulations are revised periodically for compliance by designer *(Assaf and Al-Hammad, 1988)*. Lack of awareness about such regulations will create problems between the client and the designer as it delay the design approval by the concerned authority. Moreover, the client may require designing an element which is in conflict with the imposed regulations and lead to problems between both parties *(Al-Hammad and Al-Hammad, 1996)*. Thus, successfully execution of the project and elimination of such problems require the designer to be familiar with such regulations. This will reduce the design time as well as improve the overall design performance.

4.2.7 Inaccurate estimation of project elements costs and quantities

If the designer commits any mistake in estimating project costs, this will eventually affect the client ability to finance the project during its execution. Consequently, the client may require some modifications in the design to meet his actual budget *(Al-Hammad and Al-Hammad, 1996).* Furthermore, the lack of designer's cost indexes for certain project elements will lead to inaccurate cost estimation. Here, the client will complain as the actual construction cost does not meet the estimated one *(Al-Hammad, 1995).* In both cases, the designer cost estimation mistakes will raise many conflicts at the interface with the client and lead to problems in the subsequent phases if it could not be noticed and corrected.

4.2.8 Insufficient geotechnical investigation

A Comprehensive site investigation is a must to be done at the design phase. Insufficient investigation may lead to different variations during the construction phase *(Akinsiku et al, 2014).* Such late changes may result in design modification, suspending the work at the construction site, delaying the project completion, and many other problems that will result in discrepancies between design and construction.

4.2.9 Vague and deficient drawings and specifications

Construction drawings and specifications should be clear, complete, and accurate to better understand the developed design, otherwise, major variations might occur and affect the project completion *(Assaf et al, 1996).* Such changes in drawings and specifications during the construction phase will eventually call for changes in planning, costing, and procurement activities *(Arain et al, 2006).* This will create interpretation problems and inconsistences at the design and construction interface.

4.2.10 Mistakes and discrepancies in design documents

Design documents should be free from errors whose occurrence may affect the project negatively based on the time of their occurrence *(Assaf et al, 1996).* However, it was argued that creating a perfectly error-free design is impossible *(Chappell and Willis, 1996).* The problem is that if these errors are not rectified in the design phase, they will eventually come to light in the construction phase where the severity of their impact can be more than if they were discovered earlier. This fact would lead to many interface problems between design and construction.

4.2.11 Lack of design quality assurance practices

Designers should exert additional effort to meet quality assurance requirements. However, they tend to condone these requirements to reduce overhead cost *(Darwish, 2005).* Such poor practices may affect the design documents' quality and, in addition to that, it will eventually affect the construction phase. Quality assurance practices should be highly considered in the design firms as it directly affects the project interface.

4.2.12 Inflexibility or rigidity in supervising construction works

Functionally, construction supervisor can be considered as the operational link between craft workers and management team, whether on a construction project or within a construction company *(Rounds and Segner, 2011).* There is a minimum limit which can be accepted by the construction supervisor concerning the quality of the executed work and making sure that it follows the drawings and specifications. This limit varies based on the inspected element or the case. However, some supervisors expect that they are going to inspect a perfect work without any peccadillo, especially if they have less field experience, and it is very difficult to happen. Such practice may delay the constructor's performance and lead to many inconsistencies with the construction supervisor.

4.3 Contractor-related Causes

4.3.1 Insufficient comprehension of design documents

The only mean for the constructor to comprehend the job requirements is the design drawings, details, and specifications *(Chappell and Willis, 1996).* Thus, information from these sources should be clear enough for the constructor before starting the construction, otherwise, misunderstanding of design documents may can initiate different problems in executing the job *(Arain et al, 2006).* It was observed that as much as the design is clear, it tends to be comprehend more readily, the thing that help in creating a better work environment with less conflict *(O'Brien, 1998).* However, insufficient comprehension of design documents increase the conflicts between the designer and the constructor and negatively affect the design-construction interface.

4.3.2 Lack of experienced and skilled human resources at the construction site

The non-availability of skilled manpower had obliged construction supervisor to modify the method of construction *(Al-Mansouri, 1988).* As much as the project is technologically complex, there is a high need for specialized manpower *(Arain et al, 2006).* If such manpower could not be available, many problems may arise during project construction which can affect the construction efficiency. Moreover in this case, design entirety may not be applicable due to the deficiency of construction staff. All of these issues can affect the project design-construction interface and lead to problems.

4.3.3 Inadequate pre-construction study and review of design documents

Constructability can be described as the integration of construction expertise into the design phase. Naturally, construction resources have the maximum opportunity to deliver a project complying with stakeholders' objectives regarding time, cost, quality, and safety *(Gambatese and McManus, 1999).* Unfamiliarity of the designer with construction process of his design will result in designs that are either difficult to execute or even not practical to be implemented *(Arain et al, 2006).* In Palestine, such constructability practices are not applicable in the country, at all *(Pilot study, 2014).* Nevertheless, the constructor should carefully study the design and review in details all the related documents before starting construction. This can help in detecting design errors and rectifying them in early stages before their actual occurrence at the construction site. Failure to do so will affect the designer-constructor relationship and lead to problems.

4.3.4 Lack of experience about new construction technology

Contemporary knowledge about new construction technology, materials and equipment, is very important in any construction project *(O'Brien, 1998).* The constructor should be aware of this, otherwise, it would be difficult to perform the project's tasks and thus project completion date may not be met *(Arain et al, 2006).* New construction technologies supposed to facilitate the construction process and at the same time meeting the designer requirements. Lack of such knowledge will lead to inconsistencies and negatively affect the project performance.

4.3.5 Inaccurate estimation of construction cost

Lack of cost indexes (materials, labor, and equipment) to be used by the constructor for the pricing purposes will result in an inaccurate bid estimation. Furthermore, the unexpected escalation of resource prices can be another reason for such wrong estimation *(Al-Hammad, 1995).* This may force the constructor to "cut corners" to compensate his loss, the thing that may affect the quality of the constructed facility. Such practice can lead to many inconsistencies and negatively affect the overall project performance.

4.3.6 Construction errors and defective works at the construction site

During the construction process, different errors can occur frequently such as human errors, errors caused by inclement weather, and others *(Fisk, 1997).* The effect of these errors is commensurate with their context and size *(Arain et al, 2006).* Such faulty works give an impression about the bad quality of the constructor's work that makes it below the expected level. This will affect the project completion time due to rework or affect the quality of the constructed facility. Due to this result, many problems can initiate conflicts at the project's design-construction interface.

4.3.7 Lack of specialized quality control team

Contractor quality control has its own effect on project performance in terms of time, cost, and quality. Its main job is to perform a self-supervision and field inspection on construction work to immediately report any deviation from drawings, specifications, and standards. This mission can help in avoiding any defects whose repair requires extra time and effort and end up with delaying the work progress *(Al-Ghafly, 1995).* In Palestine there is no such specialized team and thus different problems occur due to issues related to quality deviations *(Pilot study, 2014).* The unavailability of this team can affect the overall project performance and lead to many conflicts.

4.3.8 Failure of construction equipment

If a piece of equipment was not available or failed to do the job, this may force the constructor to change his plan. As an example, the design may require a crane capacity which is not available in the country. This will force the constructor to think in other lifting methods *(Al-Dubaisi, 2000).* Failure of the constructor to take the correct action in a timely manner will affect the overall project performance and lead to problems at the design-construction interface.

4.3.9 Difficulties in financing project requirements

There are many new contractors in Palestine working in the construction industry. Due to their recent involvement in this business, it is expected for them to face financial difficulties in executing large projects which will affect their ability to execute or deliver *(Pilot Study, 2014).* Such financial problems will affect the project performance and delay the project schedule. This can lead to different interface problems.

4.3.10 Involvement of sub-contractor in several projects at the same time

Usually, the contractor needs to assign part of his works to a subcontractor who performs certain work items, such as mechanical and electrical work *(Al-Ghafly, 1995).* However, it is frequently happening that the subcontractor used to be busy with a lot of works here and there, the thing that affects the schedule of his performance and, as a result, affect the whole contractor schedule. Such practice creates many conflicts and affect the project performance.

4.3.11 Frequent changes of sub-contractors

The inefficiency of sub-contractor may result in his elimination from the construction site *(Assaf and Al-Hejji, 2006).* Sometimes, the sub-contractor himself decide to leave the job due to some problems with the main contractor or the supervision staff *(Pilot study, 2014).* Such issue can breakdown the work at the construction site until the job assigned to a new sub-contractor. This will lead to delaying the project and arising many conflicts between construction participants and, as a result, the design-construction interface will be negatively affected.

4.4 Project-related Causes

4.4.1 Poor project organizational structure

Actually, there is no single organization chart that can approximate the project organizational structure of the field forces including the owner, designer, and contractor on all projects *(Fisk, 1997)*. However, for successful implementation of construction contract, the contractual relationship between the various parties should be built carefully. Moreover, the authorities and responsibilities should be clear to every entity as well. Otherwise, various interface problems may be encountered that affect the overall project performance.

4.4.2 Lack of professional construction management

Managerial skills are very important for all construction parties. Project management professionals and other participants should spend enough time in the comprehension of project scope before they plan the management strategies for project completion *(Halpin and Woodhead, 1980)*. The absence of the adversarial relationship between the designer and the constructor can be considered as one of the most important advantages of a successful professional construction management. This practice can help in discussing the discrepancies internally and straightened out before finalizing the construction contract *(Mezher and Tawil, 1998)*. This managerial technique can protect the project design-construction interface from various problems that might be raised and affect the project performance negatively.

4.4.3 Uncooperative managers and slow decision making

To achieve a successful project, the flow of information between all members of project team must be done timely and in a well-organized manner. In addition to that, the person who is responsible for making the decisions should be clearly identified and known for all members *(Chan and Kumaraswamy, 1997).* Failure to do so can lead to conflicts among various project teams and negatively affect the project interfaces.

4.4.4 Information problems leading to rework and variation orders

Many reasons may be standing behind changing orders during the construction process *(O'Brien, 1998).* The occurrence of change orders indicates addition, deletion, or modification of original drawings and specifications which may affect the relationship between project participants and delay the project completion *(Al-Hammad, 2000).* Thus, any issued information should be documented correctly, carefully, in a timely manner. Otherwise, information problems can lead to many inconsistences between professionals.

4.4.5 Lack of communication and coordination between various project teams

In a multi-participant working environment such as most construction process, communication and coordination are very important factors for the successful completion of the project *(Al-Hazmi, 1987).* However, communication and coordination can help in resolving the occurred errors in their early stages before their aggravation *(Arain et al,* *2006).* Their absence between parties may lead to many conflicts and affect negatively the project interfaces.

4.4.6 Adversarial relationship between consultant and contractor

The work efficiency in construction projects is highly affected by the relationship between the consultant and the contractor *(Al-Mansouri, 1988).* It is commonly prevalent in Palestine that the work relationship between consultant and contractor is lean, and this is mainly due to the job characteristics for both parties *(Pilot study, 2014).* If this relationship maintains lack of respects between them both, project design-construction interface will be affected and work efficiency will be also below the expected level. Due to this, many conflicts can occur which affect the whole project performance.

4.4.7 Low designs' fee structure

Due to severe competition through consultancy firms, designers over and over accept work from clients for insufficient fees. However, they have to make sure that the necessary time and effort required to complete the design and documentation process are adequately accounted for within the fee structure *(Darwish, 2005).* Failure of doing so may lead the designer to start "cutting corners", the thing that affect the design quality and arise many problems during the construction process, and so, the project design-construction interface will be negatively affected.

4.4.8 Design complexity

Skilled professionals should be involved in the complex designs *(Fisk, 1997).* This complexity affects the flow of construction activities in comparison to simple and linear construction works where activities are relatively easy to handle. Moreover, complex designs lead to productivity loss *(Al-Mansouri, 1988).* Hence, design complexity itself lead to complexity in construction whose level differentiates based on the degree to which the constructor understands the project and what he has to do. In this way, and with the absence of skilled project staff, design complexity can lead to interface problems between the designer and the constructor.

4.4.9 Lack of experience-related project nature

Strange designs require more efforts and detailed interpretations from designers to make them understandable for all participants *(Al-Mansouri, 1988).* If the project is experienced for the first time, more coordination and cooperation are required between construction parties to reduce inconsistencies *(Arain et al, 2006).* In this way, the strange design itself with the lack of experts can be an important cause of design-construction interface problems.

4.4.10 Shop drawings' submission and approval

Shop drawings preparation procedures are one of the integral parts of managing the construction process. These procedure consume time and they may affect the project schedule *(Arain et al, 2006).* Thus, if they were prepared insensibly, not submitted and approved on time, many conflicts may arise and project completion will be negatively affected.

4.4.11 Work overload and lack of incentives

Labor incentives affect workers' productivity and morale especially when they suffer work overload. Sometimes, the contractor has to use such incentives, otherwise, work schedule may be delayed. However, the client force the contractor to work overtime to meet the project finish date, and thus additional costs are required from the contractor side *(Al-Hammad and Al-Hammad, 1996).* In this way, many conflicts may arise and affect the relationship between the construction professionals.

4.4.12 Time pressure due to unreasonable contract duration

Using unachievable work time-schedule, especially in the design phase as it is the basis on which the subsequent phases are built, can lead to many problems. This may allocate more work pressure on staff as they have to finish on time, and also result in generating different errors and conflicts between various engineering disciplines contributing in the design *(Darwish, 2005).* Design deficiency will lead to different problems during construction and may consume time due to frequent rework practices, especially with the fact that construction contract has a time limit as well. Such problems can leads to conflicts between the designer and the constructor and affects the overall project performance.

4.4.13 Lack of unified design code

The designer should be familiar with the used building codes and their modifications, otherwise, the project would be rendered difficult to execute *(Al-Dubaisi, 2000).* In Palestine, the problem is that there is no unified building code and every designer uses the code that he get used to it *(Pilot study, 2014).* So it could be said that there is no common language between designers, the thing that may make difficulties in coordination among construction professionals and lead to different problems.

4.4.14 Violating conditions of project contract

Construction parties may neglect implementing some conditions of the agreed contract between them and the client resulting in arising disputes if the client becomes aware of this *(Al-Hammad and Al-Hammad, 1996).* Such disputes that took place at the design or construction phases are a kind of interface problems that lead to conflicts among the contracting parties.

4.4.15 Long period between time of bidding and awarding

Delaying the project procurement process has negative effects on the other following processes in the project life cycle *(Fisk, 1997).* It sometimes happens during this period a kind of prices differentiation or building regulations changes that will make a confusion to the contractor if he won the bid later on. Such problem can be considered as an interface problem which affect the relationship between the contracting parties from the beginning and lead to conflicts.

4.5 External Causes

4.5.1 Differing site conditions

The contractor or his subcontractor may discover that the geological characteristics of the project site are different than it was expected. For instance, the site is rockier than it was thought or at elevations which are different than what was reported. Sometimes, such cases require changes in design, equipment used, foundation, or excavations *(Al-Hammad and Al-Hammad, 1996).* If these conditions are not solved, then project schedule delays and conflicts may initiate among construction professionals which in turn affect the design-construction interface and lead to problems.

4.5.2 Poor economic conditions

Economic condition is an influential factor that affects construction projects *(Assaf and Al-Hammad, 1988).* Generally, Palestine suffers a poor economic condition due to the Israeli occupation and other political situation issues which directly affect the Palestinian economic *(Pilot study, 2014).* Such poor economic condition has its negative effect on the overall project performance, the thing that lead to many problems at the project interface.

4.5.3 Labor shortage

This is a vital problem resulted from the polarization of Palestinian laborers by the Israeli market because of the high wages; 4 or 5 times the wages in the Palestinian market. However, in the case of border closure, the Palestinian market turned to be crowded with such labors *(Pilot study, 2014).* If the work was not carried out by qualified labors, many problems may be encountered and this increases the interface problems between design and construction.

4.5.4 Unsettlement of the local currency in relation to dollar value

The common currency in Palestine is New Israeli Shekel (NIS). However, the majority of construction projects are financed in US Dollar. If any fluctuation happens in the exchange rate between dollars and shekels will result in changing the construction cost. Moreover, it could be noted that most of project indirect costs such as materials purchasing, renting of equipment, employees' salaries, and others, all are in NIS. This may result in escalating the construction cost and lead to conflicts between the owner and the contractor *(Enshassi et al, 2009).*

4.5.5 Bad weather

The outside activities in construction are affected by bad weather and adverse environmental conditions *(O'Brien, 1998).* However, the general weather in Palestine is acceptable but it happens to see a rainy or snowy day during the winter which make it difficult to perform some construction activities such as concreting. Consequently, work quality or construction schedule may be affected *(Pilot study, 2014).* When weather conditions vary, the contractor has to make an adjustment to the construction schedule accordingly such that the project is completed in the anticipated dates to remove the possibility of any conflict with the client. Otherwise, many problems would appear at the project interface and affect the relationship between participants.

4.5.6 Country border closure

It is well-known that Palestine has an unstable political situation. It sometimes happens that country borders are closed by Israeli army, the thing that leads to shortage in construction materials and prices escalation. If the contractor was not prepared in advanced for such occasions, the project will be delayed and design may be modified to deal with the current situation *(Pilot study, 2014).* Such uncontrolled issue can lead to many discrepancies at the project interface and lead to problems.

4.5.7 External or internal military actions

The poor Palestinian political situation due to Israeli occupation and its frequent military actions in the Palestinian territories may suspend the ongoing work on construction projects. This unexpected suspension may last for months and affect the whole project performance *(Pilot study, 2014).* As a result, this will delay the project completion and thus cause inconsistences at the project interface.

4.5.8 Unexpected changes in materials availability and prices

After assigning the construction contract, any changes in materials availability or prices will lead to different problems *(Al-Hammad, 1990)*. This will affect the construction schedule and cost and may require some design rework. Such practice may make conflicts between construction parties.

4.5.9 Unexpected delays in construction materials' arrival

Due to different reasons, it sometimes happens that materials don't arrive the construction site on the expected time. There are many constraints imposed on importing various construction materials due to Israeli occupation, and if the materials are allowed to enter the country, they will not arrive on time and the contractor should consider this when ordering them *(Pilot study, 2014).* If the materials' arrival consumes too much time, this may force to change or replace the originally specified materials or equipment which means a need for some rework in project activities. Such situation may lead to arise interface problems and affect the relationship between parties.

CHAPTER 5

DATA ANALYSIS AND RESULTS

The data obtained from the received questionnaires was analyzed according to the three distinguished segments of the questionnaire form.

The first segment will discuss the results on the general information of respondents and the prevailing industry characteristics. These include respondents' field of work, job title, major discipline, years of experience, and type of executed projects. In addition to that, their perception in prioritizing the triple management constraints (time, cost, quality) and how they describe the relationship between consultant and contractor were also measured. These features are thought to have an indicator on respondents' profile and the current situation of the construction industry in the context of this research. This will help to better understand the settings of this study.

In the second section, data on causes of design-construction interface problems will be analyzed. Frequency, mean, standard deviation, significance index, and ranking order are going to be reported for both consultants and contractors individually as well as for the combination of both. In addition to that, spearman's rho will be used to test if consultants and contractors agree on the causes of design-construction interface problems or not. At the end, t-test will be used to test for the significance of difference in means between consultants and contractors for each individual problem.

Finally, the third section lists the problems added by some respondents which can be considered as other causes of design-construction interface problems in the country and should be mentioned as part of this study.

5.1 Part One: General Information

Large building construction projects are mainly managed by two parties which are the consultant and the contractor. They are the experts who can give the answer of the questions raised regarding design-construction interface problems. The consultant can be considered as the playmaker of the design phase, and the same for the contractor who can be considered as the playmaker of the construction phase. Of course, the owner role should not be eliminated, but in both design and construction phases, consultant and contractor still play the major roles. This is why this research conducted a questionnaire survey among them. In this regards, 34 consultants and 30 contractors were selected among too many questionnaires distributed using the different methods identified in the research methodology. The following sections briefly discuss the general information of these respondents and the prevailing industry characteristics from their point of view.

5.1.1 Type of respondents' field of work

The following table shows the frequency and percent of each type of the target groups:

Table 0.1 Frequency and percent of each type of the target groups

Respondents' field of work	Frequency	Percent
Consultant	34	53.12%
Contractor	30	46.88%
Total	64	100.00%

All accepted consultant respondents were from organizations of grade "Consultant" based on the classification of the Jordanian Engineers Association. Also, all accepted contractor respondents were from organizations of "Grade 1" which includes "1A and 1B" based on the classification of the Palestinian Contractors Union. Some of the received questionnaires were from respondents working in organizations of other classification and they were excluded from the analysis to maintain the target sample. Concerning the size of each sample that could have been collected, it is clearly noticed that it is larger than the minimum sample size calculated previously based on Kish formula, the thing that gives a good indication on results of this study.

5.1.2 Job title of respondents

The following table shows the frequency and percent of respondents' job title according to each type of the target groups:

Table 0.2 Frequency and percent of respondents' job title

Job title of respondents	Consultants		Contractors		Combination	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Managing director	8	23.53%	3	10.00%	11	17.19%
Project manager	9	26.47%	14	46.67%	23	35.93%
Office/site engineer	17	50.00%	13	43.33%	30	46.88%
Total	34	100.00%	30	100.00%	64	100.00%

From the above table, it could be seen that the majority of respondents from both groups were office/site engineers, then comes project managers and managing directors respectively. That is due to the nature of the construction industry itself, where it is not easy to get contact with the top management team in a company as they often claim that they don't have enough time to be interviewed or fill in a questionnaire. However, the questions of this research can be answered by any personnel involved in this business especially if he has a sufficient experience in his field.

5.1.3 Major discipline of respondents

The following table shows the frequency and percent of respondents' major discipline according to each type of the target groups:

Table 0.3 Frequency and percent of respondents' major discipline

Major discipline of respondents	Consultants		Contractors		Combination	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Architect	13	38.24%	2	6.67%	15	23.44%
Civil engineer	16	47.06%	20	66.67%	36	56.24%
Electrical engineer	3	8.82%	3	10.00%	6	9.38%
Mechanical engineer	2	5.88%	5	16.66%	7	10.94%
Total	34	100.00%	30	100.00%	64	100.00%

To develop a comprehensive idea about the background and the major disciplines of respondents, a question was asked to identify the major discipline of each respondent. The results in this regard reveal that the majority of respondents were architects and civil engineers, while there were some respondents of electrical and mechanical engineering background. However, architects and civil engineers play significant roles in this field and are usually assigned more duties than electro-mechanical engineers, and thus, they are susceptible to face more problems. Consequently, their opinions will be of high importance than the others.

5.1.4 Years of experience of respondents

The following table shows the frequency and percent of respondents' years of experience according to each type of the target groups:

Table 0.4 Frequency and percent of respondents' years of experience

Years of experience of respondents	Consultants		Contractors		Combination	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Less than 5 years	6	17.65%	3	10.00%	9	14.06%
5 – 10 years	6	17.65%	8	26.67%	14	21.88%
10 – 15 years	9	26.47%	9	30.00%	18	28.12%
More than 15 years	13	38.23%	10	33.33%	23	35.94%
Total	34	100.00%	30	100.00%	64	100.00%

Respondents' years of experience is a very important indicator that gives an impression on the reliability of the results. Respondents of high experience are more reliable than the ones of low experience, and thus, they should have a dominant percentage against the others, and that is what has been achieved in this study. From the above table, it could be clearly seen that more than half of respondents were of more than 10 years of experience. However, every participant has his own experience, and that is why some respondents of low experience were included.

5.1.5 Type of projects in which respondents are involved

This research investigates design-construction interface problems in large building construction projects. Thus, all respondents should have experience in this type of projects to release a confident information. To achieve this goal, all received questionnaires which were filled by respondents working in building construction projects were accepted for the analysis and any received questionnaire from respondent working in civil engineering construction projects were excluded. However, and due to the nature of the Palestinian construction industry, there is a lack of specialization in a certain type of work, thus some respondents mentioned that they worked in both building and civil engineering projects, and so, their response were included in the analysis as they were asked to fill in the questionnaire in terms of their experience in large building construction projects.

5.1.6 Priorities in managing large building construction projects

The following table shows the frequency and percent of how respondents from each type of the target groups prioritize management constraints:

Table 0.5 Frequency and percent of how respondents prioritize management constraints

Management constraints	Consultants		Contractors		Combination	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Time	8	23.53%	9	30.00%	17	26.56%
Cost	15	44.12%	17	56.67%	32	50.00%
Quality	11	32.35%	4	13.33%	15	23.44%
Total	34	100.00%	30	100.00%	64	100.00%

From this table, it could be concluded that the majority of respondents indicates that the main driving factor in this business is the cost. “Cost” here is the main concern in the job of both consultants and contractors, then comes “quality” followed by “time” in the consultants’ case, while in the contractors’ case “time” comes next and followed by “quality”. In this context, it is a natural result for the “cost” to be in the top of the triangle of project management constraints as money is the sinew and most important component in any business, and this was agreed upon from both groups in consensus. However, for “time” and “quality” there are two opinions. Consultant firms’ main interest in the case of design is to maintain the “quality” over “time” as it highly affect the reputation of the firm as well as the construction process. In addition to that, in the case of supervision, their main responsibility is to maintain the “quality” of the constructed work, and that why they give it the priority over “time”. For contracting firms, the opposite happens where the main concern of the contractor is the “time” and meeting the project completion to save himself from liquidated damages regardless of what the “quality” of work is. Generally, the contractor loss due to not meeting the project completion time is much higher than the consultant one, and that is because the consultant pays his staff as long as they work in the firm even after finishing the project whereas the contractor pays his workers per every single day they work in a project.

5.1.7 The relationship between consultant and contractor

The following table shows the frequency and percent of how respondents from each type of the target groups evaluate the relationship with the other group:

Table 5.6 Frequency and percent of how respondents evaluate consultant-contractor relationship

Relationship type	Consultants		Contractors		Combination	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Excellent	3	8.82%	4	13.33%	7	10.94%
Good	24	70.59%	17	56.67%	41	64.06%
Poor	7	20.59%	9	30.00%	16	25.00%
Total	34	100.00%	30	100.00%	64	100.00%

This table shows how each group designates the relationship with the other group. The results above give a reasonable indication on the consultant-contractor relationship in the country since 64.06% of respondents classify it as good and 10.94% of respondents describe it as excellent. However, the nature of the construction industry itself creates an adversarial relationship between the consultant and the contractor, and that is why it is expected to find some respondents (25%) who consider it as poor depending on their personal experience in this business.

5.2 Part Two: Design-Construction Interface Problems

The responses on the potential causes of design-construction interface problems will be looked at and analyzed from three different perspectives. The first one contains responses from consultants only which going to be analyzed to come up with a conclusion based on this analysis. Frequency, mean, standard deviation, significance index, and ranking order will all be determined for every single problem using MS Excel and SPSS. Then, the same analysis will be done on the contractors group as well as for the combination of both groups' respondents. Since there were 5 categories and 60 problems fall under these categories, both of them were discussed in distinctly. Finally, in the combined evaluation of respondents, the top ten problems in addition to the least five problems will be filtered based on the calculated significance index for further elaboration and detailed description.

5.2.1 The Frequency

Table 1 in Appendix D shows the frequency of how respondents from each type of the target groups evaluate the significance of each problem. The numbers in this table were utilized to calculate the significance index using Equation 2.1 noted previously.

5.2.2 The Mean and Standard Deviation

Table 2 in Appendix D shows some descriptive statistics, which include the mean and standard deviation, calculated using SPSS for each individual problem. They are classified based on the group which the respondent is belonging to, consultant or contractor, in addition to a classification containing all respondents from both groups.

It is worth noting that the data collected from respondents is widely spread and reflects differing opinions about the significance of each problem. This wide dispersion is clearly reflected by the high standard deviation values which in some cases exceeds 1 as appears in the previous table. However, as mentioned earlier, each respondent has his own experience and evaluate the problems from his subjective point of view, and due to the diversity of respondents in terms of their years of experience, positions, and disciplines, it is expected to find such dispersion.

5.2.3 The Significance Index (SI) and Ranking Order

Table 3 in Appendix D shows the significance index (SI) and ranking order for each problem which were identified using MS Excel. This table was developed on three steps which include the calculation of significance index and determining the ranking order for each problem among other problems for consultants, contractors, and the combination of both groups separately.

From the table, it could be observed that the significance index given for many causes is more than 50% indicating a frequency of "significant" or "extremely significant". This might be due to the difficulty in assigning a number to a qualitative response. Trends here are more important than the numerical value.

5.2.4 Responses of Consultants

Table 4 in Appendix D shows the Palestinian consultants' ranking for the design-construction interface problems. Among the 60 identified problems, they ranked 17 problems as extremely significant, 39 problems as significant, and 4 problems as slightly significant. From this table, it could be concluded that the five most common causes of design-construction interface problems from the consultants' point of view are:

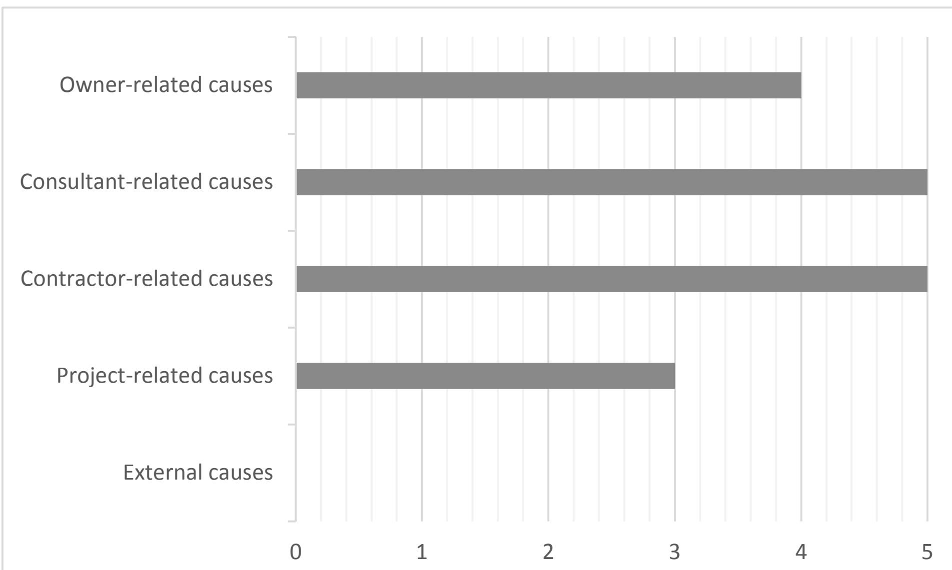
Table 0.7 Top five common problems based on consultants' evaluation

Design-Construction Interface Problems	Category	SI	Rank
Unstable client's requirements	Owner-related	83.33	1
Lack of proper coordination between various disciplines of design team	Consultant-related	81.37	2
Lack of specialized quality control team	Contractor-related	81.37	3
Lack of skilled human resources at the construction site	Contractor-related	80.39	4
Lack of professional construction management	Project-related	80.39	5

It could be noted that "Lack of proper coordination between various disciplines of design team" is originated by consultants, which means that the consultants themselves admit with some dereliction and misbehavior regarding some issues which they consider main causes of design-construction interface problems. However, respondents generally evaluate the general situation of the business in the country rather than evaluating the situation in their specific firms, and so their responses represent the general status of the construction industry in the country. Furthermore, the number one cause which is "Unstable client's requirements" is originated by owners, while two of the top ranked causes which are "Lack of specialized quality control team" and "Lack of skilled human resources at the construction site" are originated by contractors, and this was expected from the consultants' side since any working party tries to blame the others for originating the problems in the construction business. The last top rank cause is "Lack of professional construction management" is belonging to project related category as it is rare to include such delivery system is the construction business in the country.

When presenting the "Extremely Significant" ranked factors in a bar chart, an impression about the most dominant causative in originating dissonances among the design-construction interface might be grasped.

Figure 0.1 Number of "Extremely Significant" ranked factors in each category based on consultants' evaluation



The above graph reveals that among the "Extremely Significant" causes of design-construction interface problems, 5 causes were from the consultant category, another 5 from the contractor category, followed by 4 from the owner category, and 3 from the project category. No external causes were ranked by consultants as of extreme significance. So consultants here believe that they, along with contractors, are the main originators of design-construction interface problems even though they ranked the number one cause as "Unstable client's requirements".

In addition to that, the table reveals that the five least common causes of design-construction interface problems from the consultants' point of view are:

Table 0.8 Least five common problems based on consultants' evaluation

Design-Construction Interface Problems	Category	SI	Rank
Outsourcing of design services	Owner-related	52.94	56
Lack of awareness about governmental regulations, municipality requirements, statutes, and their modifications	Consultant-related	50.00	57
Differing site conditions	External	49.02	58
Bad weather	External	42.16	59
Not involving the contractor in the design phase	Owner-related	32.35	60

It could be noticed that "Not involving the contractor in the design phase", "Bad weather", "Differing site conditions", and "Outsourcing of design services" converge on that it mainly affect the contractor's performance at the construction site, that is why these problems are of least significance based on consultants ranking. For "Lack of awareness about governmental regulations, municipality requirements, statutes, and their modifications", it seems that it rarely happens that consultants make design mistakes under this item.

It is also possible here to compare the strength or the importance of each category by finding the mean value of the causes that compose this category from the consultants' point of view. The results of this calculation are tabulated below:

Table 0.9 Significance index (SI) mean value of the causes belonging to each category and their ranking order based on consultants' evaluation

Category	SI	Rank
Owner-related causes	64.55	4
Consultant-related causes	70.43	2
Contractor-related causes	73.17	1
Project-related causes	68.17	3
External causes	61.88	5

The above table reveals how the consultant primarily blame the contractor as the number one attributer to design-construction interface problems. Then comes the consultants themselves in the second rank, followed by some project-related causes as the third contributors. After that comes the owners in rank number four, followed by some external causes.

Going closer to what is going on inside each one of these categories, table 5 in Appendix D was developed based on the calculated significance index to rank order each individual problem within its related category. From this table, it is clearly seen that the consultants gave "Unstable client's requirements" as the number one cause of design-construction interface problems among "Owner-related causes" category. Among "Consultant-related causes", the highest rank was given to "Lack of proper coordination between various disciplines of design team". Among "Contractor-related causes", "Lack of specialized quality control team" was the top ranked cause. In "Project-related causes" category, the most significant cause was "Lack of professional construction management", while "Poor economic conditions" was the most significant one among "External causes" category.

5.2.5 Responses of Contractors

Table 6 in Appendix D shows the Palestinian contractors' ranking for the design-construction interface problems. Among the 60 identified problems, they ranked 14 problems as extremely significant, 45 problems as significant, and 1 problem as slightly significant. From this table, it could be concluded that the five most common causes of design-construction interface problems from the contractors' point of view are:

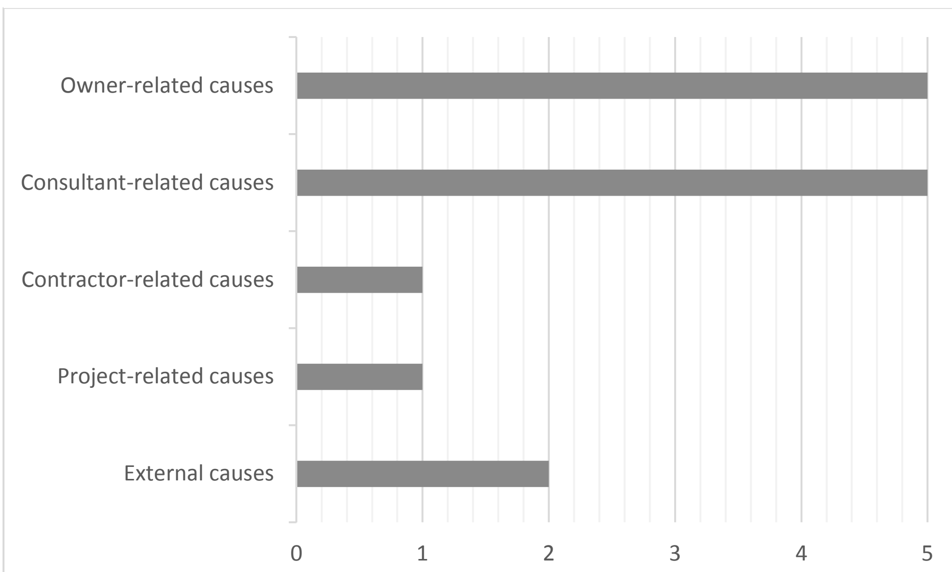
Table 0.10 Top five common problems based on contractors' evaluation

Design-Construction Interface Problems	Category	SI	Rank
Unstable client's requirements	Owner-related	88.89	1
Awarding contract to the lowest price regardless of the quality of services	Owner-related	83.33	2
Lack of proper coordination between various disciplines of design team	Consultant-related	81.11	3
Unexpected delay in construction materials' arrival	External	80.00	4
Lack of skilled and experienced human resources in the design firms	Consultant-related	78.89	5

It could be noticed that the first two top rank causes which are "Unstable client's requirements" and "Awarding contract to the lowest price regardless of the quality of services" respectively are originated by owners. For number one rank, it is agreed upon with both consultants and contractors in the same ranking order, while for number two rank, contractors claim that owners when they assign a contract to a specific party, they give the priority to the price over the quality. Another two top ranked causes are "Lack of proper coordination between various disciplines of design team" in rank number three and "Lack of skilled and experienced human resources in the design firms" in rank number five, and both are originated by consultants. Concerning rank number three, this also was agreed upon with both consultants and contractors but with a little bit difference in the ranking order, while in rank number five, contractors respond to consultants allegations concerning the lack of skilled human resources at the construction site with the lack of skilled human resources in design firms. The last top ranked cause is “Unexpected delay in construction materials’ arrival” and it was ranked as number four. This is an external cause that contractors should consider when ordering the materials.

When presenting the “Extremely Significant” ranked factors in a bar chart, an impression about the most dominant causative in originating dissonances among the design-construction interface might be grasped.

Figure 0.2 Number of “Extremely Significant” ranked factors in each category based on contractors’ evaluation



The above graph reveals that among the “Extremely Significant” causes of design-construction interface problems, 5 causes were from the owner category, another 5 from the consultant category, 2 from the external category, 1 from the contractor category, and another 1 from project category. So contractors here believe that they are the least contributor in initiating design-construction interface problems.

In addition to that, the table reveals that the five least common causes of design-construction interface problems from the contractors' point of view are the listed below:

Table 0.11 Least five common problems based on contractors' evaluation

Design-Construction Interface Problems	Category	SI	Rank
Not involving the contractor in the design phase	Owner-related	54.44	55
Low design's fee structure	Project-related	54.44	56
Lack of unified design code	Project-related	54.44	57
Inappropriate choice of project delivery system (design-build, design-bid-build, etc.)	Owner-related	53.33	58
Bad weather	External	53.33	59
Differing site conditions	External	50.00	60

It could be noticed here that there is a kind of agreement between consultants and contractors on "Differing site conditions", "Bad weather", and "Not involving the contractor in the design phase" as problems of least significance. Although these problems are mainly affect the contractor's performance at the construction site, but it seems that they can be controlled. Moreover, although contractor's involvement in the design phase is not used as a practice in construction business in the country, neither consultants nor contractors consider it of high importance to reduce conflicts between designer and constructor. The other problems which were ranked of least significance by contractors are "Lack of unified design code", "Inappropriate choice of project delivery system (design-build, design-bid-build, etc.)", and "Low design's fee structure". Concerning the availability of unified design code, it seems that contractors through their works became familiar with the different codes used in the country. The choice of project delivery system has limited effect based on contractors evaluation as the most commonly system used in the country is the design-bid-build one especially for building projects and it is very rare to find companies that have design and construction team at the same time. About the design fees, it was expected from the contractor's side to give it such ranking although consultants consider it as a significant problem.

It is also possible here to compare the strength or the importance of each category by finding the mean value of the causes that compose this category from the contractors' point of view. The results of this calculation are tabulated below:

Table 00.12 Significance index (SI) mean value of the causes belonging to each category and their ranking order based on contractors' evaluation

Category	SI	Rank
Owner-related causes	68.80	2
Consultant-related causes	70.65	1
Contractor-related causes	66.77	3
Project-related causes	66.59	4
External causes	63.95	5

The above table reveals how the contractor primarily blame the consultant as the number one attributer to design-construction interface problems. Then comes the owners in the second rank, followed by the contractors themselves as the third contributors. After that comes the project-related causes in rank number four, followed by some external causes.

Going closer to what is going on inside each one of these categories, table 7 in Appendix D was developed based on the calculated significance index to rank order each individual problem within its related category. From this table, it is clearly seen that the contractors gave "Unstable client's requirements" as the number one cause of design-construction interface problems among "Owner-related causes" category. Among

“Consultant-related causes”, the highest rank was given to “Lack of proper coordination between various disciplines of design team”. Among “Contractor-related causes”, “Difficulties in financing project requirements” was the top ranked cause. In “Project-related causes” category, the most significant cause was “Time pressure due to unreasonable contract duration”, while “Unexpected delay in construction materials’ arrival” was the most significant one among “External causes” category.

5.2.6 Combined Responses of Both Groups

Table 8 in Appendix D shows the combined ranking of both Palestinian consultants and contractors for the design-construction interface problems. Among the 60 identified problems, they ranked 10 problems as extremely significant, 47 problems as significant, and 3 problems as slightly significant. From this table, it could be concluded that the ten most common causes of design-construction interface problems based on the combined evaluation of both consultants and contractors are:

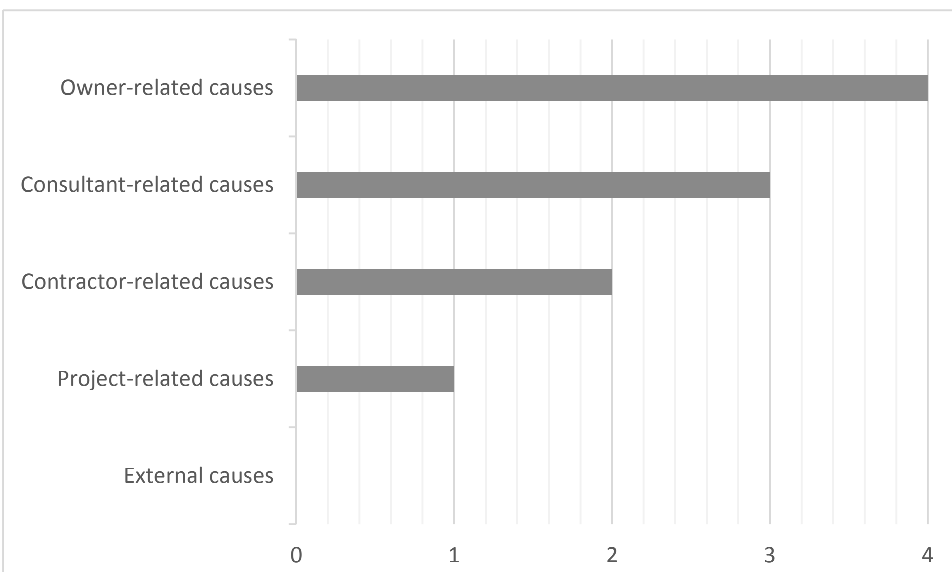
Table 0.13 Top ten common problems based on the combined evaluation

Design-Construction Interface Problems	Category	SI	Rank
Unstable client's requirements	Owner-related	85.94	1
Lack of proper coordination between various disciplines of design team	Consultant-related	81.25	2
Awarding contract to the lowest price regardless of the quality of services	Owner-related	79.69	3
Lack of skilled and experienced human resources in the design firms	Consultant-related	78.65	4
Lack of skilled human resources at the construction site	Contractor-related	77.08	5
Delaying of dues payments	Owner-related	76.56	6
Lack of specialized quality control team	Contractor-related	76.04	7
Lack of professional construction management	Project-related	76.04	8
Delaying the approval of completed tasks	Owner-related	75.52	9
Vague and deficient drawings and specifications	Consultant-related	75.52	10

It could be noticed from this section that both consultants and contractors believe that the owner is a major contributor to design-construction interface problems in large building construction projects as four out of ten top ranked problems are originated by the owner which are “Unstable client’s requirements”, “Awarding contract to the lowest price regardless of the quality of services”, “Delaying of dues payments”, and “Delaying the approval of completed tasks”. Similar to the owner, the consultant has his own contribution through “Lack of proper coordination between various disciplines of design team”, “Lack of skilled and experienced human resources in the design firms”, and “Vague and deficient drawings and specifications”, and the contractor also has his own contribution through “Lack of skilled human resources at the construction site” and “Lack of specialized quality control team”. Finally the last top rank problem is “Lack of professional construction management” which can be attributed the paucity of utilizing such project delivery system is the construction business in the country.

When presenting the “Extremely Significant” ranked factors in a bar chart, an impression about the most dominant causative in originating dissonances among the design-construction interface might be grasped.

Figure 05.3 Number of “Extremely Significant” ranked factors in each category based on the combined evaluation



The above graph reveals that among the “Extremely Significant” causes of design-construction interface problems, 4 causes were from the owner category, followed by 3 from the contractor category, 2 from the contractor category, and 1 from the project category. No external causes were ranked as of extreme significance.

In addition to that, the table reveals that the five least common causes of design-construction interface problems based on the combined evaluation are the listed below:

Table 0.14 Least five common problems based on the combined evaluation

Design-Construction Interface Problems	Category	SI	Rank
Inappropriate choice of project delivery system (design-build, design-bid-build, etc.)	Owner-related	55.73	56
Lack of awareness about governmental regulations, municipality requirements, statutes, and their modifications	Consultant-related	53.13	57
Differing site conditions	External	49.48	58
Bad weather	External	48.96	59
Not involving the contractor in the design phase	Owner-related	42.71	60

It could be noticed that “Not involving the contractor in the design phase”, “Bad weather”, and “Differing site conditions” were raised and agreed upon by both consultants and contractors as problems of least significance as mentioned before. Concerning “Lack of awareness about governmental regulations, municipality requirements, statutes, and their modifications”, it was raised by consultants, while “Inappropriate choice of project delivery system (design-build, design-bid-build, etc.)” was raised by contractors. Each of them consider the problems which are in direct touch with his performance.

To evaluate the perception of each target group in addition to the combined evaluation of them both for the purpose of identifying how each group attributes the origins of design-construction interface problems, the following table was developed to conclude this point:

Table 0.15 Significance index (SI) mean value of the causes belonging to each category and their ranking order – comparative table

Category	Consultants		Contractors		Combination	
	SI	Rank	SI	Rank	SI	Rank
Owner-related causes	64.55	4	68.80	2	66.55	4
Consultant-related causes	70.43	2	70.65	1	70.53	1
Contractor-related causes	73.17	1	66.77	3	70.17	2
Project-related causes	68.17	3	66.59	4	67.43	3
External causes	61.88	5	63.95	5	55.10	5

It could be concluded that there is no consensus among Palestinian consultants and contractors on the major source of design-construction interface problems in large building construction projects. The above table reveals that consultants believe that contractors are the major source of these problems, while the opposite is true for the contractors who believe that consultants are the major source of these problems. This was expected as each party tries to blame the other party when they are discussing an issue which is directly in touch with them both. However, the combined evaluation indicates that consultants are the number one contributor in initiating these problems, followed by the contractors which ranked as number two. Regarding this, it is worth to mention that there is not that much difference in the significance index between consultants and contractors in the combined evaluation, but this difference put the consultants in rank number one over the contractors.

It is also possible here to compare the strength or the importance of each category by finding the mean value of the causes that compose this category based on the combined evaluation of both consultants and contractors. The results of this calculation are tabulated below:

Table 0.16 Significance index (SI) mean value of the causes belonging to each category and their ranking order based on the combined evaluation

Category	SI	Rank
Owner-related causes	66.55	4
Consultant-related causes	70.53	1
Contractor-related causes	70.17	2
Project-related causes	67.43	3
External causes	55.10	5

The above table reveals that the combined evaluation indicates that consultants are the number one attributer to design-construction interface problems, and then comes the contractors. This is a logical result as the role of consultant firms starts from day one in the design stage and proceed to the supervision on the construction stage. Thus, any error initiated in the design stage will definitely affect the construction stage where the contractor's role becomes the dominant, the thing that leads to many problems at the design-construction interface and negatively affect the relationship between consultant and contractor. Although the owner category has the largest portion among the top ten causes, but the degree of their significance does not match for those of consultants or contractors. After that comes project-related causes in the third rank, followed by owner-related causes as the fourth contributors, and finally comes the external causes ranked as number five.

Going closer to what is going on inside each one of these categories, table 9 in Appendix D was developed based on the calculated significance index to rank order each individual problem within its related category. From this table, it is clearly seen that the combined evaluation of all respondents gave “Unstable client’s requirements” as the number one cause of design-construction interface problems among “Owner-related causes” category. Among “Consultant-related causes”, the highest rank was given to “Lack of proper coordination between various disciplines of design team”. Among “Contractor-related causes”, “Difficulties in financing project requirements” was the top ranked cause. In “Project-related causes” category, the most significant cause was “Lack of professional construction management”, while “Poor economic conditions” was the most significant one among “External causes” category.

From the previous three sections, it could be obviously noticed that there is a kind of agreement among Palestinian consultants and contractors on the top ranked causes of design-construction interface problems. However, this should be emphasized statistically as appears later on.

5.2.7 Correlation of Ranking and Hypothesis Testing

Spearman's rank correlation between Palestinian consultants and contractors has been done to establish the relationship between the two parties. Besides that, hypothesis test has been conducted for justifying whether significance difference exists among them. In this case, t-test was found best suited since only two groups of respondents is going to be analyzed. The results of both analyses are discussed below.

Spearman's rank correlation is the type of correlation which assess the relationship between two variables. It works for ordinal data set where order of the variable is important. However, since this study used ordinal data and presented as numeric value in the form of a questionnaire, and then by the analyses of the collected data, ranks of the problems have been found, and thus Spearman's correlation is one of the perfect uses to express the level of relationship between both consultants and contractors.

The rank coefficient ranges from -1 to +1, where -1 indicates strong negative relation, while +1 indicates strong positive relation. All 60 problems were taken to calculate the Spearman's rank coefficient between consultants and contractors. In the table below, it could be noticed that there are so much differences between their judgments on some problems, while there is no such much difference in judging the others.

$$\text{rho (p)} = 1 - \frac{6\sum D^2}{N(N^2-1)}$$

$$= 1 - \frac{6(13126)}{60(60^2-1)}$$

$$= 1 - \frac{78756}{215940}$$

$$= 0.6353$$

Here, Spearman's rho coefficient calculation was carried out and found to be almost 0.64 which indicates that there is a kind of understanding between the two parties (Refer to table 10 in Appendix D). Some similarities as well as dissimilarities are found between their knowledge regarding causes of design-construction interface problems in Palestine, but the overall level of correlation can be identified as moderate.

One of reasons standing behind this would be that each party votes for the problems which directly affect its performance and are frequently encountered by this party. For example, both consultants and contractors agree that "Unstable client's requirements" is the number one cause of design-construction interface problems since it will directly affect the performance of the consultant during design or the contractor during construction. Another example in this regards is "Unsettlement of local currency in relation to dollar value" which was ranked 37 by consultants and 9 by contractors. This huge gap in ranking this problem can be attributed to that the fluctuation of dollar value is directly affect the performance of contractor since he has many duties which are closely linked with the dollar value such as purchasing of materials and it may affect his capability to complete the job, while this issue does not have a similar severe effect on the consultant performance.

5.2.8 t-Test for Equality of Means

A t-test is a statistical hypothesis test which can be used to determine if two sets of independent data are significantly different from each other. Detailed analysis for all the 60 problems have been done by this method using SPSS and the results are tabulated in Table 11 in Appendix D. Here, the sample size is all the 64 respondents, and thus, the degree of freedom is 62. Mean differences and standard error of differences for each problem are illustrated in the table clearly to make it easy for the reader to understand the expert's opinion at a glance. The value of (t) here shows the corresponding level of significance (α) and the confidence level as well. The α value also is the indication of the acceptance or rejection of the null hypothesis (H_0) which includes there is no significance difference between the respondents groups. Alternatively, significant relaxation exists among them and the difference in results was obtained by chance, and this is the indication of the alternative hypothesis (H_1). H_0 can be rejected if the absolute value of (t) is greater than the absolute value of the critical value (sig.) at the chosen significance level. Since this study has been done based on the sample of the data but decisions have to take on the population of those data, the level of significance should be 0.05 for very good data set and it means the confidence level is 95%.

Now, the null hypothesis and the alternative hypothesis can be formulated as follows:

H_0: There is no significance difference between the means of populations from which the two samples were taken, and the two data sets are random samples from a common population, i.e. consultants and contractors have the same point of view and came from the same population.

H_1: There is a significance difference between the means of populations from which the two samples were taken, and the two data sets are random samples from different populations, i.e. consultants and contractors have different points of view and came from the different populations.

Table 11 in Appendix D shows the results of testing H_0 for each individual problem. It could be noticed that it has been rejected in some problems and accepted in the others. However, considering the top ten ranked problems as of extreme significance, which are:

(1) Unstable client's requirements.

(2) Lack of proper coordination between various disciplines of design team.

(3) Awarding contract to the lowest price regardless of the quality of services.

(4) Lack of skilled and experienced human resources in the design firms.

(5) Lack of skilled human resources at the construction site.

(6) Delaying of dues payments.

(7) Lack of specialized quality control team.

(8) Lack of professional construction management.

(9) Delaying the approval of completed tasks.

(10) Vague and deficient drawings and specifications.

t-test reveals that different statuses of H_0 were found. In "Unstable client's requirements", "Awarding contract to the lowest price regardless of the quality of services", "Lack of skilled human resources at the construction site", "Lack of specialized quality control team", and "Lack of professional construction management", H_0 was rejected which means that there is a significance difference between the means of populations from which the two samples were taken, and the two data sets are random samples from different populations. Besides that, in "Lack of proper coordination between various disciplines of design team", "Lack of skilled and experienced human resources in the design firms", "Delaying of dues payments", "Delaying the approval of completed tasks", and "Vague and deficient drawings and specifications", H_0 was accepted which means that there is no significance difference between the means of populations from which the two samples were taken, and the two data sets are random samples from a common population.

In general, the table reveals that in 31 problems out of 60, H_0 was rejected, which gives an indication that there is a significance difference found among Palestinian consultants and contractors on their perception as in almost half of the problems the null hypothesis was rejected at 95% confidence level.

5.3 Part Three: Other Problems

The followings were added by consultants and contractors on the third part of the questionnaire form and documented here for reference. This might give a further understanding of the nature and problems of the construction in large building projects in Palestine. The comments are documented here as written on the forms with slight corrections when necessary.

(1) Not considering the safety construction aspects by the designer.

(2) The absence of effective client participation in reviewing the design before tendering it for construction.

(3) Lack of Palestinian contractors' knowledge about lump sum contracts and their conditions.

(4) Lack of detailed review of work packaging when it is used.

(5) Lack of integrated master schedule which is approved from the beginning of the project.

(6) Lack of clients' trust in local designs.

(7) The designer often does not make a site visit for the project before starting his job.

(8) Assigning the contract to an unqualified contractor due to vested interests.

(9) The actual required staff might not be available as it is envisaged in the contract, especially the part-timers who are not required to be available all the times.

(10) Unavailability of local standards which are associated with the international standards.

(11) The Specified building techniques may not be compatible with the local skills.

(12) Lack of professional ethics.

(13) Lack of qualified laboratories that can make the required test as specified in the design.

(14) Shortage of design experts.

(15) Poor logistic capabilities for contractors.

(16) Lack of interaction with the external market weaken the Palestinian construction sector.

(17) Lack of suitable profits affect the quality of the work.

(18) Untrusted subcontractors regarding the work schedules and quality.

5.4 Discussion

This research was conducted to find out the main causes of design-construction interface problems in Palestinian large building construction projects from consultants' and contractors' point of view. After analyzing the data, the results are documented where it could be obviously noticed that different stakeholders have distinct view and responded according to their self-judgments. In addition to that, the results obtained some similarities as well as dissimilarities with important causes of design-construction interface problems in different countries identified by the literature review. Below is a brief description of the most prominent design-construction interface problems based on Palestinian consultants' and contractors' perception.

As agreed before, both consultants and contractors believe that the owner is a major contributor to design-construction interface problems in large building construction projects as four of the top ten ranked problems fall under the responsibility of the owner.

In this context, a consensus was found that "Unstable client's requirements" is the most extreme significant cause of design-construction interface problems. However, gathering client's requirements is not a waste of time. It is a crucial strategy to a project's success for engineers and project managers to obtain accurate user requirements as well as increase the level of client and user involvement on a project. In fact, it is understandable that sometimes requirements change, but the problem is how often the changes occur and how it is easy for them to be managed since sometimes new requirements or fundamental changes are imposed. Clients should consider that both designer and constructors are working on tight deadlines and have impression that instead of going forward with their work, they are running in circles. A related study done by *Al-Hammad and Al-Hammad (1996)* in Saudi Arabia and concluded that owner modification after design is one of the top problems that affect the relationship between owners and designers.

Another significant problem initiated by the owner is "Awarding contract to the lowest price regardless of the quality of services". It seems that in Palestinian construction business, clients don't matter to select the highest qualified bidder if his price was not the lowest. Often, clients request the bidder to submit two proposals, technical and financial, where a certain weight is given to each one of them and during the evaluation process a mark is put out of the given weight. Here, tradeoffs among non-cost factors such as technical approach, management plan, past performance, etc. and cost is conducted to compare between bidders based on the total score given for each bid to end up with assigning the contract to the highest score. However, it seems that clients attempt to ignore such approach and tend to "shop around" for the cheapest price regardless of the quality of services.

The last two top ranked problems that can be controlled by the owner are "Delaying of dues payments", and "Delaying the approval of completed tasks". In this regards, owner usually puts himself in a position of supreme authority were no one can blame him if he makes a mistake. However, it seems that delaying works is common practice between owners. As money is the artery of any business, delaying payments will affect the performance of both designer and constructor and initiate many problems which when discovered affect the relationship between them both. An issue that might be raised in this regard is that some governmental projects used to be financed through external donors, and the procedures for releasing payments from these donors usually take time and sometimes it happened that the donor himself cut his fund on the projects and lead to confusion among various construction parties. A related study done by *Enshassi, et al (2012)* in Gaza strip and concluded that delaying the progress payments is one of the top problems that affect the relationship between contractors and subcontractors. Concerning work approval, it seems that client hesitates in approving various portions of work whenever it is needed, the thing that will eventually affect the work on subsequent activities. For example, if the client approval needs to be done on a design change while a certain part of project construction is waiting for this approval, then the relationship between designer and constructor will be affected because of the owner.

Similar to the owner, consultant and contractors have their own contribution in affecting the design-construction interface. For consultants "Lack of proper coordination between various disciplines of design team", "Lack of skilled and experienced human resources in the design firms", and "Vague and deficient drawings and specifications" are the problems of the highest significance among the top ten ranked problems, while for contractors “Lack of skilled human resources at the construction site” and “Lack of specialized quality control team” are the problems of the highest significance in the same range.

It could be noticed here that there is a common problem among design and construction firms in terms of the leakage of experienced and skilled human resources. One reason might be standing behind this is that these firms try to make more profit through employing human resources of low experience in order to pay them small salaries and thus increase the acquired profit. Another reason is that most of experienced and skilled human resources are working outside the country due to the poor economic conditions as they did not find the opportunities they deserve in their country.

In addition to that, lack of proper coordination between designers is another problem of extreme significance. As project designs become more challenging and complex, there is an increased need for specialized design services. Whether driven by the unique design needs of the project or by the requirements of the permitting agencies, there should be an increased reliance on specialized design services in the common delivery system for complex projects in the country. Along with this increase in specialized services come new duties and new requirements for the integration and coordination of design responsibilities. However, getting the coordination function wrong is an open invitation for claims.

Furthermore, as technology advances and workloads and project complexity increases, the risk of error and adverse outcomes such as rework, accidents and building failure is augmented. Problems here are related and interdependent. As a result of the poor coordination and other reasons, design quality will be affected and many mistakes and discrepancies will be generated in design documents and, of course, if they were not discovered early, they will come to light in the construction phase and generate many errors which can affect the constructor performance. A related study done by *Al-Hammad and Al-Hammad (1996)* in Saudi Arabia and concluded that lack of accuracy in drawings and specifications is one of the top problems that affect the relationship between owners and designers.

Another issue is the quality control during construction. It is during these preliminary stages that component configurations, material specifications and functional performance are decided. Hence, quality control during construction consists largely of insuring conformance to these original design and planning decisions. In addition, quality requirements should be clear and verifiable, so that all parties in the project can understand the requirements for conformance. The problem in Palestine is that it is very rare to have a quality control team who is specialized in the development and implementation of quality assurance programs suitable for construction and safety. A related study done by *Enshassi, et al (2012)* in Gaza strip and concluded that lack of construction quality is one of the top problems that affect the relationship between contractors and subcontractors.

Finally, the last top rank problem is "Lack of professional construction management" which can be attributed the paucity of utilizing such project delivery system is the construction business in the country. Assigning a professional construction manager can help in discussing the discrepancies between design and construction internally and straightened out through a neutral party before finalizing the construction contract, this is why it was agreed upon by both parties. However, as mentioned before, such practice is very rare and not commonly used in the country.

5.5 Comparison with Previous Studies

A similar study have been done by *Arain (2002)* in Saudi Arabia. Two samples from consultants and contractors were statistically analyzed. The following table shows a comparison between the top ten significant causes of design-construction interface problems between Palestine and Saudi Arabia:

Table 0.17 Comparison between Palestine and Saudi Arabia in terms of the top ten significant problems

Recent Study in Palestine	SI	Rank	Previous Study in Saudi Arabia	SI	Rank
Unstable client's requirements	85.94	1	Lack of coordination	86.73	1
Lack of proper coordination between various disciplines of design team	81.25	2	Insufficient working drawing details	86.22	2
Awarding contract to the lowest price regardless of the quality of services	79.69	3	Involvement of designer as consultant	85.21	3
Lack of skilled and experienced human resources in the design firms	78.65	4	involvement of contractor as consultant	84.70	4
Lack of skilled human resources at the construction site	77.08	5	Contractor's lack of comprehension of drawings, details and specifications	83.16	5
Delaying of dues payments	76.56	6	Participant's honest wrong beliefs	83.16	6
Lack of specialized quality control team	76.04	7	Lack of human resources in design firms	82.65	7
Lack of professional construction management	76.04	8	Lack of designer knowledge of available material and equipment	82.65	8
Delaying the approval of completed tasks	75.52	9	Insufficient communication	82.65	9
Vague and deficient drawings and specifications	75.52	10	Incomplete & inadequate plans and specifications	82.14	10

It could be concluded that there are some differences between both study respondents' opinions about the significance of design-construction interface problems. Those differences may represent the actual difference between the construction industry issues in both study regions. However, there are some agreement about the significance of certain problems like “Lack of coordination”, “Lack of human resources in design firms”, and “Incomplete and inadequate plans and specifications”.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

The data obtained from the received questionnaires was analyzed according to the three distinguished segments of the questionnaire form.

6.1 Summary of the Study

The objectives of this research were straight forward to find existing causes of design-construction interface problems in Palestinian large building construction projects, specifying their significance, and checking the variance among consultants' and contractors' respondents. At the end, recommendations to improve the design-construction interface will be concluded.

To achieve these objectives, relevant literatures were reviewed to identify the causes of design-construction interface problems encountered in different countries worldwide and the relevant methods of research in this arena. The collected information of these problems then summarized on questionnaire form. 70 problems were identified and grouped under 5 major categories, and distributed to some experts in Palestinian construction for pilot study. Some of the problems were modified or merged with others, some were added and others were deleted, and as a result, 60 problems were listed in the final questionnaire to ask the respondents. Respondents were consultants and contractors who have working experience in large building construction projects. Total 64 questionnaire were accepted for the analysis, and they include 34 consultants and 30 contractors. All data were then analyzed to find the significance index of each single problem, and based on these indices the problems were ranked and classified into different categories to reach in conclusion. Moreover, the correlation between both parties were checked by Spearman's rank coefficient, and variance analysis among the two parties was also done using t-test for each single problem. Based on the findings of the study, conclusions and recommendations are written below.

6.2 Conclusions

The study result has been divided into three major parts such as the significance of the causes, correlation, and variance among the parties. Thus, this research has been concluded on the following heading:

6.2.1 Causes of design-construction interface problems

After completing the study about the causes of design-construction interface problems, 60 problems are identified. Among these, there are different categories of problems found. The study reveals that the top ten and extremely significance problems are:

(1) Unstable client's requirements.

(2) Lack of proper coordination between various disciplines of design team.

(3) Awarding contract to the lowest price regardless of the quality of services.

(4) Lack of skilled and experienced human resources in the design firms.

(5) Lack of skilled human resources at the construction site.

(6) Delaying of dues payments.

(7) Lack of specialized quality control team.

(8) Lack of professional construction management.

(9) Delaying the approval of completed tasks.

(10) Vague and deficient drawings and specifications.

As categories, consultant-related causes come in rank number one as the most significant category in this regard, followed by contractor-related causes in rank number two. The next rank is the portion of project-related causes, then owner-related causes, and finally the external causes.

In addition to that, the five least common causes of design-construction interface problems are the listed below:

(1) Not involving the contractor in the design phase.

(2) Bad weather.

(3) Differing site conditions.

(4) Lack of awareness about governmental regulations, municipality requirements, statutes, and their modifications.

(5) Inappropriate choice of project delivery system (design-build, design-bid-build, etc.).

6.2.2 Correlation among the group of respondents

Spearman's rho coefficient calculation was carried out and found to be almost 0.64 which indicates that there is a kind of understanding between the two parties. Some similarities as well as dissimilarities are found between their knowledge regarding causes of design-construction interface problems in Palestinian construction projects, but the overall level of correlation can be identified as moderate.

6.2.3 Variance among the group of respondents

From the significance point of view, there is a significance difference found among Palestinian consultants and contractors on their perception because in almost half of the problems the null hypothesis was rejected at 95% confidence level.

6.3 Recommendations

Based on the findings previously discussed, the followings are recommended to improve the design-construction interface in large building construction projects in Palestine:

(1) The interface between Palestinian consultants and contractors needs to be improved. The key to effective interfacing throughout the project lifecycle is the good communication – frequent, timely, succinct, high-grade, and reliable.

(2) Since there is a consensus that frequent changes in client's requirements are the major contributor to design-construction interface problems, this is a clear message for client's to set their complete requirements in advance before starting the design process. However, if changes are inevitable, they should be handled through a properly coordinated and controlled process and retained throughout the project life cycle. Thus understanding, documenting, and managing requirement changes effectively would facilitate not only proper design change management, but any other requirements related changes within and during a project life cycle.

(3) Clients should put in mind that engineering services, in design or construction, are not like services from suppliers. Quality of services here should have a considerable portion of tender's evaluation process. In this context, clients may go through a selective tendering process as a substitute for an open one. By this approach, clients guarantee the expected quality of the services and reduce the possibility of rework or errors occurrence, and thus, reduce conflicts. If the case was to go through an open tendering process, technical evaluation of the tenderer should be done carefully and decision should be made before evaluating the price.

(4) Clients should pay attention to do their work and perform their responsibilities on time to close the door of rising claims from their side. Delaying payments and delaying approvals on completed tasks have its bad effect on other parties' performance and will definitely lead to conflicts. Thus, clients is a party as any other parties involved in the project, and it is preferable to prepare a check list for his tasks including a deadline to complete these tasks.

(5) Design firms should improve the coordination process among the design team to reduce the possibility of design errors' generation and reduce conflicts. In many cases an architect may be the best professional to lead a job, especially as project designs become more challenging and complex, new duties and new requirements for the integration and coordination of design responsibilities came to light.

(6) To improve the quality of drawings and specifications, design firms may assign a team whose responsibilities are to create quality control checklists for projects and implementing quality control measurements in a way that reduces errors and saves the firm a lot of time and money and also increase the level of confidence with the design. Moreover, it is possible to utilize Building Information Modeling (BIM) as an advocated panacea for reducing design errors and rework in construction and engineering projects.

(7) In order to cope up with lack skilled and experienced human resources, whether in design firms or construction sites, firms need to provide training programs. Such training programs supply the employees as well as the company with multiple benefits if they are carefully planned and properly implemented. Besides that, good

salaries, good incentives, and competitive rates can help in attracting skilled workforce to meet the company requirements.

(8) It is advisable to find inspectors and quality assurance personnel involved in a project and belonging to a specialized organizations. However, quality control should be a primary objective for all the members of a project team and managers should take responsibility for maintaining and improving quality control. Construction team also may introduce new ideas to maintain the quality of the constructed facility. Moreover, quality improvement can improve productivity through the suggestion of new work methods, avoiding rework, and avoiding long term problems. By this, good quality control can pay for itself and clients should promote it and seek out contractors who maintain standards.

(9) It is recommended to utilize Professional Construction Management (PCM) as a project delivery system, in addition to the concept of the need for construction expertise during construction. This will help in improving the communication and coordination between designer and constructor through a third party and thus reduce conflicts. In this way, the client will acquire and realize its benefits and will not feel that he will be at risk.

6.4 Recommendations for Future Studies

Recommendations for further researches, which can be explored in the referring light of information revealed in this study, are mentioned as follow:

(1) Since both consultants and contractors agreed that the most significance cause of design-construction interface problems is attributed to the owner, it is worthy to take the owner's opinion in order to respond to their allegations in the context of this study.

(2) This study mainly directed towards building construction projects in the Palestinian environment. Here, it is interesting to expand this research to include civil engineering projects, such that a comparison can be done between the results of them both.

(3) In this research, opinions were grasped from the top grade of classified consultants and contractors as they are mainly involved in large projects. It is recommended also to take the opinions of other classified consultants and contractors who are less that the top grade in order to compare the results with what has been obtained in this research.

(4) Since this research was conducted within the area of West Bank, it deserves also to be conducted in Gaza Strip in order to evaluate the differences in perceptions among construction practitioners in the both bisects of the country.

(5) Investigate why clients frequently change their requirements and amend design documents.

(6) Investigate why both consultants and contractors prefer not to interface each other in the design stage.

(7) Evaluate the implementation of BIM in design firms and identify the barriers of its utilization.

(8) Evaluate the concept of involving a specialized contracting organization to perform quality control practices during construction.

(9) Measure the degree of acceptance for clients to utilize PCM as a project delivery system.

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APPENDIX A

PILOT STUDY PROJECTS

AMAAR Commercial Tower

The tower is a prominent commercial landmark which is being built in Ramallah - West Bank as a part of Al-Irsal Commercial Center, one of the huge real-estate investment commercial projects in Palestine. The tower consists of 17 floors with a total area of 29,826 m^2 on a land of 4,200 m^2 area. The building is purely based on modern architectural design.

Following are the basic vital information regarding the project participants:

(1) Project Owner : AMAAR Real-Estate Group - Palestine

(2) Project Designer : Consolidated Consultant (CC) - Jordan

(3) Project Consultant : Universal Group for Engineering and Consulting (UG) - Palestine

(4) Project Contractor : Al-Mukawilon Contracting Company – Palestine

CCC Commercial Tower

The tower is a prominent commercial landmark which is being built in Ramallah - West Bank as a part of Al-Irsal Commercial Center, one of the huge real-estate investment commercial projects in Palestine. The tower consists of 13 floors with a total area of 18,221 m^2 on a land of more than 3,000 m^2 area. The building is purely based on modern architectural design.

Following are the basic vital information regarding the project participants:

(1) Project Owner : Consolidated Contractors Company (CCC) - Palestine

(2) Project Designer : Consolidated Consultant (CC) - Jordan

(3) Project Consultant : Madar Consulting Engineers - Palestine

(4) Project Contractor : Consolidated Contractors Company (CCC) – Palestine

APPENDIX B

INITIAL QUESTIONNAIRE

Design-Construction Interface Problems in Large Building Projects in Palestine

<< QUESTIONNAIRE >>

PART (A) : ~~RESPONDENT INFORMATION~~ (GENERAL INFORMATION)

1. Type of services rendered by your company :

a) Consultancy	b) Contracting
~~c) Both~~	d) Other, specify:

2. If you ~~provide a consultancy services~~ (are a Consultant), what is the classification of your company based on the Jordanian Engineers Association :

a) Consultant	b) Grade 1
c) Grade 2	d) Grade 3

3. If you ~~provide a contracting services~~ (are a Contractor), what is the classification of your company based on the ~~Ministry of Public Works and Housing~~ (Palestinian Contractors Union) :

a) Grade 1	b) Grade 2
c) Grade 3	d) Grade 4 or below, specify:

4. Your position in the company is :

a) Managing Director	b) ~~Vice Director~~ (deleted)
c) Project Manager	d) Site/Office Engineer
e) Other, specify:	

5. Your major discipline is :

a) Architect	b) ~~Structural~~ Engineer (Civil)
c) ~~Civil Engineer~~ (Electrical)	d) ~~MEP Engineer~~ (Mechanical)
e) Other, specify:	

6. Your professional experience in the line of work is :

a) Less than 5 years	b) 5-10 years
c) 10-15 years	d) More than 15 years, specify:

7. Types of projects ~~your company is typically involved in are~~ (you are typically involved in):

a) Building projects	b) Civil engineering projects
~~c) Electro-Mechanical projects~~	d) Other, specify:

8. The primary driving factor in large building projects is:

a) Time	b) Cost
c) Quality	d) Other, specify:

9. The working relationship between the designer and the contractor is normally:

a) Excellent	b) Good
~~c) Fair~~	d) Poor

PART (B) : CAUSES OF DESIGN-CONSTRUCTION INTERFACE PROBLEMS

The list below includes the potential causes of problems which have an interface between design and construction for large building projects. Considering your professional experience in the context of this area, you are kindly requested to express your opinion as a consultant or contractor for each of these causes and designate the appropriate intensity of the following list :

No.	Potential Causes of Design-Construction Interface Problems	Not at all Significant	Slightly Significant	Moderately Significant	~~Very Significant~~	Extremely significant
		1	2	3	4	5
	Owner-related causes					
1	Unstable client's requirements					
2	Unrealistic client's expectations regarding project time, cost, and quality					
3	Outsourcing of design services					
4	Not involving the contractor in the design phase					
5	Awarding contract to the lowest price regardless of the quality of services			added		
6	Unclear definition for scope of work					
7	Inappropriate work packaging and subcontracting					
8	Poorly written contract with insufficient details					
9	Delaying the approval of completed tasks			added		
10	Delaying of dues payments					
11	Design changing after starting the construction			deleted		
12	Inappropriate choice of project contract type (unit price, lump sum, etc.)					
13	Inappropriate choice of project delivery system (design-build, design-bid-build, etc.)					
14	Involvement of designer as construction supervisor					
15	Involvement of constructor as construction supervisor			deleted		
	Consultant-related causes					
16	Lack of project stipulated data					
17	Lack of experienced and skilled human resources in the design firms					
18	Lack of proper coordination between various disciplines of design team					
19	Lack use of design standards			deleted		
20	Lack of awareness about construction knowledge and ongoing site operations					
21	Lack of awareness about the availability of construction materials and equipment in the local market			added		
22	Lack of awareness about governmental regulations, municipality requirements, statutes, and their modifications					
23	Inaccurate estimation of project elements costs and quantities					
24	Insufficient geotechnical investigation					
25	Vague and deficient drawings and specifications					
26	Mistakes and discrepancies in design documents					
27	Lack of design quality assurance practices			added		
28	Inflexibility or rigidity in supervising construction works					
	Contractor-related causes					
29	Insufficient comprehension of design documents					
30	Lack of experienced and skilled human resources at the construction site					
31	Inadequate pre-construction study and review of design documents					
32	Lack of experience about new construction technology					
33	Inaccurate estimation of construction costs					

No.	Potential Causes of Design-Construction Interface Problems	Not at all Significant	Slightly Significant	Moderately Significant	~~Very Significant~~	Extremely significant
		1	2	3	4	5
34	Construction errors and defective works at the construction site					
35	Inappropriate choice of construction method	deleted				
36	Lack of specialized quality control team	added				
37	Failure of construction equipment					
38	Difficulties in financing project's requirements	added				
39	Bad quality of materials used	deleted				
40	Involvement of sub-contractor in several projects at the same time					
41	Frequent changes of sub-contractors					
	Project-related causes					
42	Poor project organizational structure					
43	Lack of professional construction management					
44	Uncooperative managers and slow decision making					
45	Information problems leading to rework and variation orders					
46	Lack of communication and coordination between various project teams					
47	Lack of trust among various project teams	deleted				
48	Adversarial relationship between designer and contractor					
49	Personal conflicts between personnel	deleted				
50	Low designs' fee structure					
51	Design complexity					
52	Lack of experience-related project type	added				
53	Shop drawings' submission and approval					
54	Insufficient wages, work overload, and lack of incentives	added				
55	Time pressure due to unreasonable contract duration					
56	Lack of unified design code	added				
57	Violating conditions of project contract					
58	Poor documentation system	deleted				
59	Long period between time of bidding and awarding					
	External causes					
60	Differing site conditions					
61	Difficulties in obtaining work permits	deleted				
62	Poor economic conditions					
63	Labor shortage	added				
64	Unsettlement of the local currency in relation to dollar value	added				
65	Bad weather					
66	Country border closure	added				
67	External or internal military actions					
68	Sudden strikes	deleted				
69	Unexpected changes in materials' availability and prices					
70	Unexpected delay in construction materials' arrival					

Please specify any additional potential problems and their rate:

No.	Potential Causes of Design-Construction Interface Problems	Not at all Significant	Slightly Significant	Moderately Significant	Very Significant	Extremely significant
		1	2	3	4	5
71						
72						
73						
74						
75						

Please add any additional comments or suggestions on Design-Construction Interface Problems:

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Do you want to get a summary of the results of this survey?

a) Yes	b) No

Thanks a lot for your cooperation

Best Regards

APPENDIX C

FINAL QUESTIONNAIRE

DESIGN-CONSTRUCTION INTERFACE PROBLEMS FOR LARGE BUILDING CONSTRUCTION PROJECTS

QUESTIONNAIRE

Dear Professionals;

I am a graduate student at King Fahd University of Petroleum & Minerals in Saudi Arabia, and I am now preparing a master thesis in the Construction Engineering and Management Program. The aim of this thesis is to visualize and assess the main causes of problems which have an interface between design and construction for large building construction projects in the West Bank. For this purpose, your participation is highly appreciated to fill in this questionnaire with the needed information from your own perspective expressing your constructive suggestions, if any. The questionnaire will take less than 10 minutes of your valuable time. If you would like to have any clarification about any ambiguity in the questionnaire, please do contact me at the indicated mobile number or e-mail address.

The questionnaire consists of three sections. The first one seeks information about the respondent and his/her firm, while the second and the third seek information related to the causes of the previously described problems.

Your immediate action will be highly appreciated and thank you in anticipation for your cooperation.

Thesis Advisor:

Prof. Sa'di Assaf

The Researcher:

Arch. Khaled Z. I. Sha'ar

khaled.shaar39@hotmail.com

Mob. 00970 59 9 397 375

General Information

1. The field you are working in is:

a) Consultancy	b) Contracting
c) Other, specify:	

2. If you are a Consultant, your classification based on the Engineers Association is:

a) Consultant	b) Grade 1
c) Grade 2	d) Grade 3

3. If you are a Contractor, your classification based on the Palestinian Contractors Union is:

a) Grade 1	b) Grade 2
c) Grade 3	d) Grade 4 or below, specify:

4. Your Job Title is:

a) Managing Director	b) Project Manager
c) Site/Office Engineer	d) Other, specify:

5. Your major discipline is:

a) Architect	b) Civil Engineer
c) Electrical Engineer	d) Mechanical Engineer
e) Other, specify:	

6. Your professional experience in the line of work is:

a) Less than 5 years	b) 5-10 years
c) 10-15 years	d) More than 15 years, specify:

7. Type of projects you are typically involved in is:

a) Building projects	b) Civil engineering projects
c) Other, specify:	

8. The common working relationship between the designer and the contractor in the country can be described as:

a) Excellent	b) Good
c) Poor	

9. The primary driving factor in completing large building construction projects in the country is:

a) Time	b) Cost
c) Quality	

Design-Construction Interface Problems

The list below includes the potential causes of problems which have an interface between design and construction for large building construction projects. Considering your local professional experience in the context of this area, you are kindly requested to express your opinion as a consultant or contractor for each of them through designating the significance of each one on the construction project:

No.	**Potential Causes of Design-Construction Interface Problems**	**Not Significant at all**	**Slightly Significant**	**Significant**	**Extremely Significant**
		1	**2**	**3**	**4**
	Owner-related Group				
1	Unstable client's requirements				
2	Unrealistic client's expectations regarding project time, cost, and quality				
3	Outsourcing of design services				
4	Not involving the contractor in the design phase				
5	Awarding contract to the lowest price regardless of the quality of services				
6	Unclear definition for scope of work				
7	Inappropriate work packaging and subcontracting				
8	Poorly written contract with insufficient details				
9	Delaying the approval of completed tasks				
10	Delaying of dues payments				
11	Inappropriate choice of project contract type (unit price, lump sum, etc.)				
12	Inappropriate choice of project delivery system (design-build, design-bid-build, etc.)				
13	Involvement of designer as construction supervisor				

No.	Potential Causes of Design-Construction Interface Problems	Not Significant at all	Slightly Significant	Significant	Extremely Significant
		1	**2**	**3**	**4**
	Consultant-related Group				
14	Lack of project stipulated data				
15	Lack of experienced and skilled human resources in the design firms				
16	Lack of proper coordination between various disciplines of design team				
17	Lack of awareness about construction knowledge and ongoing site operations				
18	Lack of awareness about the availability of construction materials and equipment in the local market				
19	Lack of awareness about governmental regulations, municipality requirements, statutes, and their modifications				
20	Inaccurate estimation of project elements costs and quantities				
21	Insufficient geotechnical investigation				
22	Vague and deficient drawings and specifications				
23	Mistakes and discrepancies in design documents				
24	Lack of design quality assurance practices				
25	Inflexibility or rigidity in supervising construction works				

No.	Potential Causes of Design-Construction Interface Problems	Not Significant at all	Slightly Significant	Significant	Extremely Significant
		1	2	3	4
	Contractor-related Group				
26	Insufficient comprehension of design documents				
27	Lack of experienced and skilled human resources at the construction site				
28	Inadequate pre-construction study and review of design documents				
29	Lack of experience about new construction technology				
30	Inaccurate estimation of construction costs				
31	Construction errors and defective works at the construction site				
32	Lack of specialized quality control team				
33	Failure of construction equipment				
34	Difficulties in financing project’s requirements				
35	Involvement of sub-contractor in several projects at the same time				
36	Frequent changes of sub-contractors				

No.	Potential Causes of Design-Construction Interface Problems	Not Significant at all	Slightly Significant	Significant	Extremely Significant
		1	2	3	4
	Project-related Group				
37	Poor project organizational structure				
38	Lack of professional construction management				
39	Uncooperative managers and slow decision making				
40	Information problems leading to rework and variation orders				
41	Lack of communication and coordination between various project teams				
42	Adversarial relationship between designer and contractor				
43	Low designs' fee structure				
44	Design complexity				
45	Lack of experience-related project type				
46	Shop drawings' submission and approval				
47	Work overload and lack of incentives				
48	Time pressure due to unreasonable contract duration				
49	Lack of unified design code				
50	Violating conditions of project contract				
51	Long period between time of bidding and awarding				

No.	Potential Causes of Design-Construction Interface Problems	Not Significant at all	Slightly Significant	Significant	Extremely Significant
		1	2	3	4
	External Causes Group				
52	Differing site conditions				
53	Poor economic conditions				
54	Labor shortage				
55	Unsettlement of the local currency in relation to dollar value				
56	Bad weather				
57	Country border closure				
58	External or internal military actions				
59	Unexpected changes in materials availability and prices				
60	Unexpected delay in construction materials’ arrival				

Please specify additional potential problems and their rate, if you have any:

No.	**Potential Causes of Design-Construction Interface Problems**	**Not Significant at all**	**Slightly Significant**	**Significant**	**Extremely Significant**
		1	**2**	**3**	**4**
61					
62					
63					
64					
65					
66					

Please add additional comments or suggestions, if you have any:

____

____

____

____

____

Do you want to get a summary of the results of this research?

a) Yes	Contact (E-mail, Fax, …) ……………………..…………..……………….
b) No	

Thanks a lot for your cooperation

Best Regards

APPENDIX D

TABLES

Table 1 - Frequency of evaluating the significance of each problem

Design-Construction Interface Problems	Consultants				Contractors				Combination			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Owner-related causes												
Unstable client's requirements	-	2	13	19	-	1	8	21	-	3	21	40
Unrealistic client's expectations regarding project time, cost, or quality	-	4	19	11	-	5	15	10	-	9	34	21
Outsourcing of design services	4	10	16	4	2	10	9	9	6	20	25	13
Not involving the contractor in the design phase	14	8	11	1	7	7	6	10	21	15	17	11
Awarding contract to the lowest price regardless of the quality of services	-	5	14	15	1	2	8	19	1	7	22	34
Unclear definition for scope of work	1	5	15	13	0	4	14	12	1	9	29	25
Inappropriate work packaging and subcontracting	3	8	16	7	6	7	6	11	9	15	22	18
Poorly written contract with insufficient details	2	11	11	10	-	6	13	11	2	17	24	21
Delaying the approval of completed tasks	-	3	19	12	-	5	12	13	-	8	31	25
Delaying of dues payments	-	5	14	15	3	3	6	18	3	8	20	33
Inappropriate choice of project contract type (unit price, lump sum, etc.)	4	8	15	7	3	8	12	7	7	16	27	14
Inappropriate choice of project delivery system (design-build, design-bid-build, etc.)	6	5	15	8	3	10	13	4	9	15	28	12
Involvement of designer as construction supervisor	4	8	14	8	4	5	10	11	8	13	24	19
Consultant-related causes												
Lack of project stipulated data	-	6	14	14	-	5	13	12	-	11	27	26
Lack of skilled and experienced human resources in the design firms	1	5	9	19	-	4	11	15	1	9	20	34
Lack of proper coordination between various disciplines of design team	1	3	10	20	1	3	8	18	2	6	18	38
Lack of awareness about the construction knowledge and ongoing site operations	2	4	16	12	-	4	13	13	2	8	29	25
Lack of awareness about the availability of construction materials and equipment in the local market	2	8	15	9	3	7	11	9	5	15	26	18

Lack of awareness about governmental regulations, municipality requirements, statutes, and their modifications	3	16	10	5	4	8	11	7	7	24	21	12
Inaccurate estimation of project elements costs and quantities	-	8	20	6	1	5	7	17	1	13	27	23
Insufficient geotechnical investigation	3	6	14	11	3	9	13	5	6	15	27	16
Vague and deficient drawings and specifications	1	4	14	15	-	5	12	13	1	9	26	28
Mistakes and discrepancies in design documents	2	3	12	17	-	6	13	11	2	9	25	28
Lack of design quality assurance practices	2	5	8	19	1	3	15	11	3	8	23	30
Inflexibility or rigidity in supervising construction works	1	6	18	9	1	10	10	9	2	16	28	18
Contractor-related causes												
Insufficient comprehension of design documents	2	4	16	12	1	7	13	9	3	11	29	21
Lack of skilled human resources at the construction site	2	1	12	19	1	5	11	13	3	6	23	32
Inadequate pre-construction study and review of design documents	2	2	15	15	2	7	9	12	4	9	24	27
Lack of experience about new construction technologies	1	10	16	7	1	11	10	8	2	21	26	15
Inaccurate estimation of construction costs	-	6	14	14	1	7	12	10	1	13	26	24
Construction errors and defective works at the construction site	-	2	21	11	-	8	16	6	-	10	37	17
Lack of specialized quality control team	1	2	12	19	2	5	11	12	3	7	23	31
Failure of construction equipment	-	9	21	4	2	9	14	5	2	18	35	9
Difficulties in financing project requirements	2	7	9	16	1	6	7	16	3	13	16	32
Involvement of subcontractor in several projects at the same time	1	2	15	16	-	9	18	3	1	11	33	19
Frequent changes of subcontractors	2	4	13	15	1	7	10	12	3	11	23	27
Project-related causes												
Poor project organizational structure	2	3	13	16	1	6	9	14	3	9	22	30
Lack of professional construction management	-	3	14	17	-	5	16	9	-	8	30	26
Uncooperative managers and slow decision making	2	3	17	12	-	8	10	12	2	11	27	24
Information problems leading to rework and variation orders	1	4	14	15	2	3	13	12	3	7	27	27
Lack of communication and coordination between various project teams	1	2	20	11	1	5	11	13	2	7	31	24
Adversarial relationship between consultant and contractor	-	8	17	9	3	6	13	8	3	14	30	17

Low design's fee structure	3	3	15	13	1	14	10	5	4	17	25	18
Design complexity	5	11	9	9	1	7	12	10	6	18	21	19
Lack of experience-related project nature	1	5	19	9	-	4	20	6	1	9	39	15
Shop drawings' submission and approval	2	6	15	11	1	7	14	8	3	13	29	19
Work overload and lack of incentives	1	8	16	9	1	5	14	10	2	13	30	19
Time pressure due to unreasonable contract duration	1	6	15	12	-	5	12	13	1	11	27	25
Lack of unified design code	-	12	15	7	2	12	11	5	2	24	26	12
Violation of project contract's conditions	1	10	15	8	2	9	11	8	3	19	26	16
Long period between time of bidding and awarding	2	13	13	6	3	9	11	7	5	22	24	13
External causes												
Differing site conditions	5	13	11	5	2	16	7	5	7	29	18	10
Poor economic conditions	2	4	16	12	1	4	13	12	3	8	29	24
Labor shortage	2	6	12	14	2	3	14	11	4	9	26	25
Unsettlement of local currency in relation to dollar value	2	4	20	8	1	6	6	17	3	10	26	25
Bad weather	5	18	8	3	1	15	9	5	6	36	17	8
Country border closure	1	11	13	9	4	5	7	14	5	16	20	23
External or internal military actions	1	9	12	12	2	6	9	13	3	15	21	25
Unexpected changes in materials' availability and prices	3	3	20	8	2	3	12	1	5	6	32	21
Unexpected delay in construction materials' arrival	3	6	18	7	-	6	6	18	3	12	24	25

Table 2 - Descriptive statistics which include the mean and standard deviation

Design-Construction Interface Problems	Consultants		Contractors		Combination	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Owner-related causes						
Unstable client's requirements	3.50	0.62	3.67	0.55	3.58	0.59
Unrealistic client's expectations regarding project time, cost, or quality	3.21	0.64	3.17	0.70	3.19	0.66
Outsourcing of design services	2.59	0.86	2.83	0.95	2.70	0.90
Not involving the contractor in the design phase	1.97	0.94	2.63	1.19	2.28	1.11
Awarding contract to the lowest price regardless of the quality of services	3.29	0.72	3.50	0.78	3.39	0.75
Unclear definition for scope of work	3.18	0.80	3.27	0.69	3.22	0.74
Inappropriate work packaging and subcontracting	2.79	0.88	2.73	1.17	2.77	1.02
Poorly written contract with insufficient details	2.85	0.93	3.17	0.75	3.00	0.85
Delaying the approval of completed tasks	3.26	0.62	3.27	0.74	3.27	0.67
Delaying of dues payments	3.29	0.72	3.30	1.02	3.30	0.87
Inappropriate choice of project contract type (unit price, lump sum, etc.)	2.74	0.93	2.77	0.94	2.75	0.93
Inappropriate choice of project delivery system (design-build, design-bid-build, etc.)	2.74	1.02	2.60	0.86	2.67	0.94
Involvement of designer as construction supervisor	2.76	0.96	2.93	1.05	2.84	1.00
Consultant-related causes						
Lack of project stipulated data	3.24	0.74	3.23	0.73	3.23	0.73
Lack of skilled and experienced human resources in the design firms	3.35	0.85	3.37	0.72	3.36	0.78
Lack of proper coordination between various disciplines of design team	3.44	0.79	3.43	0.82	3.44	0.79
Lack of awareness about the construction knowledge and ongoing site operations	3.12	0.84	3.30	0.70	3.20	0.78
Lack of awareness about the availability of construction materials and equipment in the local market	2.91	0.87	2.87	0.97	2.89	0.91

Lack of awareness about governmental regulations, municipality requirements, statutes, and their modifications	2.50	0.86	2.70	0.99	2.59	0.92
Inaccurate estimation of project elements costs and quantities	2.94	0.65	3.33	0.88	3.13	0.79
Insufficient geotechnical investigation	2.97	0.94	2.67	0.88	2.83	0.92
Vague and deficient drawings and specifications	3.26	0.79	3.27	0.74	3.27	0.76
Mistakes and discrepancies in design documents	3.29	0.87	3.17	0.75	3.23	0.81
Lack of design quality assurance practices	3.29	0.94	3.20	0.76	3.25	0.85
Inflexibility or rigidity in supervising construction works	3.03	0.76	2.90	0.88	2.97	0.82
Contractor-related causes						
Insufficient comprehension of design documents	3.12	0.84	3.00	0.83	3.06	0.83
Lack of skilled human resources at the construction site	3.41	0.82	3.20	0.85	3.31	0.83
Inadequate pre-construction study and review of design documents	3.26	0.83	3.03	0.96	3.16	0.89
Lack of experience about new construction technologies	2.85	0.78	2.83	0.87	2.84	0.82
Inaccurate estimation of construction costs	3.24	0.74	3.03	0.85	3.14	0.79
Construction errors and defective works at the construction site	3.26	0.57	2.93	0.69	3.11	0.65
Lack of specialized quality control team	3.44	0.75	3.10	0.92	3.28	0.84
Failure of construction equipment	2.85	0.61	2.73	0.83	2.80	0.72
Difficulties in financing project requirements	3.15	0.96	3.27	0.91	3.20	0.93
Involvement of subcontractor in several projects at the same time	3.35	0.73	2.80	0.61	3.09	0.73
Frequent changes of subcontractors	3.21	0.88	3.10	0.88	3.16	0.88
Project-related causes						
Poor project organizational structure	3.26	0.86	3.20	0.89	3.23	0.87
Lack of professional construction management	3.41	0.66	3.13	0.68	3.28	0.68
Uncooperative managers and slow decision making	3.15	0.82	3.13	0.82	3.14	0.81
Information problems leading to rework and variation orders	3.26	0.79	3.17	0.87	3.22	0.83

Lack of communication and coordination between various project teams	3.21	0.69	3.20	0.85	3.20	0.76
Adversarial relationship between consultant and contractor	3.03	0.72	2.87	0.94	2.95	0.82
Low design's fee structure	3.12	0.91	2.63	0.81	2.89	0.89
Design complexity	2.65	1.04	3.03	0.85	2.83	0.97
Lack of experience-related project nature	3.06	0.74	3.07	0.58	3.06	0.66
Shop drawings' submission and approval	3.03	0.87	2.97	0.81	3.00	0.84
Work overload and lack of incentives	2.97	0.80	3.10	0.80	3.03	0.80
Time pressure due to unreasonable contract duration	3.12	0.81	3.27	0.74	3.19	0.77
Lack of unified design code	2.85	0.74	2.63	0.85	2.75	0.80
Violation of project contract's conditions	2.88	0.81	2.83	0.91	2.86	0.85
Long period between time of bidding and awarding	2.68	0.84	2.73	0.94	2.70	0.89
External causes						
Differing site conditions	2.47	0.93	2.50	0.86	2.48	0.89
Poor economic conditions	3.12	0.84	3.20	0.80	3.16	0.82
Labor shortage	3.12	0.91	3.13	0.86	3.13	0.88
Unsettlement of local currency in relation to dollar value	3.00	0.78	3.30	0.92	3.14	0.85
Bad weather	2.26	0.83	2.60	0.81	2.42	0.83
Country border closure	2.88	0.84	3.03	1.10	2.95	0.97
External or internal military actions	3.03	0.87	3.10	0.96	3.06	0.91
Unexpected changes in materials' availability and prices	2.97	0.83	3.20	0.89	3.08	0.86
Unexpected delay in construction materials' arrival	2.85	0.86	3.40	0.81	3.11	0.88

Table 3 - Significance index (SI) and ranking order

Design-Construction Interface Problems	Consultants		Contractors		Combination	
	SI	Rank	SI	Rank	SI	Rank
Owner-related causes						
Unstable client's requirements	83.33	1	88.89	1	85.94	1
Unrealistic client's expectations regarding project time, cost, or quality	73.53	20	72.22	22	72.92	20
Outsourcing of design services	52.94	56	61.11	45	56.77	54
Not involving the contractor in the design phase	32.35	60	54.44	55	42.71	60
Awarding contract to the lowest price regardless of the quality of services	76.47	8	83.33	2	79.69	3
Unclear definition for scope of work	72.55	23	75.56	10	73.96	15
Inappropriate work packaging and subcontracting	59.80	50	57.78	50	58.85	51
Poorly written contract with insufficient details	61.76	45	72.22	23	66.67	38
Delaying the approval of completed tasks	75.49	12	75.56	11	75.52	9
Delaying of dues payments	76.47	9	76.67	7	76.56	6
Inappropriate choice of project contract type (unit price, lump sum, etc.)	57.84	52	58.89	49	58.33	52
Inappropriate choice of project delivery system (design-build, design-bid-build, etc.)	57.84	53	53.33	58	55.73	56
Involvement of designer as construction supervisor	58.82	51	64.44	40	61.46	46
Consultant-related causes						
Lack of project stipulated data	74.51	18	74.44	15	74.48	12
Lack of skilled and experienced human resources in the design firms	78.43	6	78.89	5	78.65	4
Lack of proper coordination between various disciplines of design team	81.37	2	81.11	3	81.25	2
Lack of awareness about the construction knowledge and ongoing site operations	70.59	26	76.67	8	73.44	17
Lack of awareness about the availability of construction materials and equipment in the local market	63.73	42	62.22	43	63.02	43

Lack of awareness about governmental regulations, municipality requirements, statutes, and their modifications	50.00	57	56.67	53	53.13	57
Inaccurate estimation of project elements costs and quantities	64.71	41	77.78	6	70.83	28
Insufficient geotechnical investigation	65.69	38	55.56	54	60.94	48
Vague and deficient drawings and specifications	75.49	13	75.56	12	75.52	10
Mistakes and discrepancies in design documents	76.47	10	72.22	24	74.48	13
Lack of design quality assurance practices	76.47	11	73.33	16	75.00	11
Inflexibility or rigidity in supervising construction works	67.65	33	63.33	42	65.63	40
Contractor-related causes						
Insufficient comprehension of design documents	70.59	27	66.67	38	68.75	34
Lack of skilled human resources at the construction site	80.39	4	73.33	17	77.08	5
Inadequate pre-construction study and review of design documents	75.49	14	67.78	34	71.88	22
Lack of experience about new construction technologies	61.76	46	61.11	46	61.46	47
Inaccurate estimation of construction costs	74.51	19	67.78	35	71.35	25
Construction errors and defective works at the construction site	75.49	15	64.44	41	70.31	30
Lack of specialized quality control team	81.37	3	70.00	29	76.04	7
Failure of construction equipment	61.76	47	57.78	51	59.90	50
Difficulties in financing project requirements	71.57	24	75.56	13	73.44	18
Involvement of subcontractor in several projects at the same time	78.43	7	60.00	48	69.79	32
Frequent changes of subcontractors	73.53	21	70.00	30	71.88	23
Project-related causes						
Poor project organizational structure	75.49	16	73.33	18	74.48	14
Lack of professional construction management	80.39	5	71.11	26	76.04	8
Uncooperative managers and slow decision making	71.57	25	71.11	27	71.35	26
Information problems leading to rework and variation orders	75.49	17	72.22	25	73.96	16
Lack of communication and coordination between various project teams	73.53	22	73.33	19	73.44	19
Adversarial relationship between consultant and contractor	67.65	34	62.22	44	65.10	41

Low design's fee structure	70.59	28	54.44	56	63.02	44
Design complexity	54.90	55	67.78	36	60.94	49
Lack of experience-related project nature	68.63	32	68.89	33	68.75	35
Shop drawings' submission and approval	67.65	35	65.56	39	66.67	39
Work overload and lack of incentives	65.69	39	70.00	31	67.71	37
Time pressure due to unreasonable contract duration	70.59	29	75.56	14	72.92	21
Lack of unified design code	61.76	48	54.44	57	58.33	53
Violation of project contract's conditions	62.75	43	61.11	47	61.98	45
Long period between time of bidding and awarding	55.88	54	57.78	52	56.77	55
External causes						
Differing site conditions	49.02	58	50.00	60	49.48	58
Poor economic conditions	70.59	30	73.33	20	71.88	24
Labor shortage	70.59	31	71.11	28	70.83	29
Unsettlement of local currency in relation to dollar value	66.67	37	76.67	9	71.35	27
Bad weather	42.16	59	53.33	59	48.96	59
Country border closure	62.75	44	67.78	37	65.10	42
External or internal military actions	67.65	36	70.00	32	68.75	36
Unexpected changes in materials' availability and prices	65.69	40	33.33	21	69.27	33
Unexpected delay in construction materials' arrival	61.76	49	80.00	4	70.31	31

Table 4 - Significance index (SI) and ranking order based on consultants' evaluation

Design-Construction Interface Problems	Category	SI	Rank
75 < I ≤ 100 % ‖ Extremely Significant			
Unstable client's requirements	Owner-related	83.33	1
Lack of proper coordination between various disciplines of design team	Consultant-related	81.37	2
Lack of specialized quality control team	Contractor-related	81.37	3
Lack of skilled human resources at the construction site	Contractor-related	80.39	4
Lack of professional construction management	Project-related	80.39	5
Lack of skilled and experienced human resources in the design firms	Consultant-related	78.43	6
Involvement of subcontractor in several projects at the same time	Contractor-related	78.43	7
Awarding contract to the lowest price regardless of the quality of services	Owner-related	76.47	8
Delaying of dues payments	Owner-related	76.47	9
Mistakes and discrepancies in design documents	Consultant-related	76.47	10
Lack of design quality assurance practices	Consultant-related	76.47	11
Delaying the approval of completed tasks	Owner-related	75.49	12
Vague and deficient drawings and specifications	Consultant-related	75.49	13
Inadequate pre-construction study and review of design documents	Contractor-related	75.49	14
Construction errors and defective works at the construction site	Contractor-related	75.49	15
Poor project organizational structure	Project-related	75.49	16
Information problems leading to rework and variation orders	Project-related	75.49	17
50 < I ≤ 75 % ‖ Significant			
Lack of project stipulated data	Consultant-related	74.51	18
Inaccurate estimation of construction costs	Contractor-related	74.51	19
Unrealistic client's expectations regarding project time, cost, or quality	Owner-related	73.53	20
Frequent changes of subcontractors	Contractor-related	73.53	21
Lack of communication and coordination between various project teams	Project-related	73.53	22
Unclear definition for scope of work	Owner-related	72.55	23

Difficulties in financing project requirements	Contractor-related	71.57	24
Uncooperative managers and slow decision making	Project-related	71.57	25
Lack of awareness about the construction knowledge and ongoing site operations	Consultant-related	70.59	26
Insufficient comprehension of design documents	Contractor-related	70.59	27
Low design's fee structure	Project-related	70.59	28
Time pressure due to unreasonable contract duration	Project-related	70.59	29
Poor economic conditions	External	70.59	30
Labor shortage	External	70.59	31
Lack of experience-related project nature	Project-related	68.63	32
Inflexibility or rigidity in supervising construction works	Consultant-related	67.65	33
Adversarial relationship between consultant and contractor	Project-related	67.65	34
Shop drawings' submission and approval	Project-related	67.65	35
External or internal military actions	External	67.65	36
Unsettlement of local currency in relation to dollar value	External	66.67	37
Insufficient geotechnical investigation	Consultant-related	65.69	38
Work overload and lack of incentives	Project-related	65.69	39
Unexpected changes in materials' availability and prices	External	65.69	40
Inaccurate estimation of project elements costs and quantities	Consultant-related	64.71	41
Lack of awareness about the availability of construction materials and equipment in the local market	Consultant-related	63.73	42
Violation of project contract's conditions	Project-related	62.75	43
Country border closure	External	62.75	44
Poorly written contract with insufficient details	Owner-related	61.76	45
Lack of experience about new construction technologies	Contractor-related	61.76	46
Failure of construction equipment	Contractor-related	61.76	47
Lack of unified design code	Project-related	61.76	48
Unexpected delay in construction materials' arrival	External	61.76	49
Inappropriate work packaging and subcontracting	Owner-related	59.80	50

Involvement of designer as construction supervisor	Owner-related	58.82	51
Inappropriate choice of project contract type (unit price, lump sum, etc.)	Owner-related	57.84	52
Inappropriate choice of project delivery system (design-build, design-bid-build, etc.)	Owner-related	57.84	53
Long period between time of bidding and awarding	Owner-related	55.88	54
Design complexity	Project-related	54.90	55
Outsourcing of design services	Owner-related	52.94	56
25 < I ≤ 50 % ‖ Slightly Significant			
Lack of awareness about governmental regulations, municipality requirements, statutes, and their modifications	Consultant-related	50.00	57
Differing site conditions	External	49.02	58
Bad weather	External	42.16	59
Not involving the contractor in the design phase	Owner-related	32.35	60

Table 5 – Severity index (SI) and ranking order of problems within the belonging category based on consultants' evaluation

Design-Construction Interface Problems	SI	Rank
Owner-related causes		
Unstable client's requirements	83.33	1
Awarding contract to the lowest price regardless of the quality of services	76.47	2
Delaying of dues payments	76.47	3
Delaying the approval of completed tasks	75.49	4
Unrealistic client's expectations regarding project time, cost, or quality	73.53	5
Unclear definition for scope of work	72.55	6
Poorly written contract with insufficient details	61.76	7
Inappropriate work packaging and subcontracting	59.80	8
Involvement of designer as construction supervisor	58.82	9
Inappropriate choice of project contract type (unit price, lump sum, etc.)	57.84	10
Inappropriate choice of project delivery system (design-build, design-bid-build, etc.)	57.84	11
Outsourcing of design services	52.94	12
Not involving the contractor in the design phase	32.35	13
Consultant-related causes		
Lack of proper coordination between various disciplines of design team	81.37	1
Lack of skilled and experienced human resources in the design firms	78.43	2
Mistakes and discrepancies in design documents	76.47	3
Lack of design quality assurance practices	76.47	4
Vague and deficient drawings and specifications	75.49	5
Lack of project stipulated data	74.51	6
Lack of awareness about the construction knowledge and ongoing site operations	70.59	7
Inflexibility or rigidity in supervising construction works	67.65	8
Insufficient geotechnical investigation	65.69	9
Inaccurate estimation of project elements costs and quantities	64.71	10

Lack of awareness about the availability of construction materials and equipment in the local market	63.73	11
Lack of awareness about governmental regulations, municipality requirements, statutes, and their modifications	50.00	12
Contractor-related causes		
Lack of specialized quality control team	81.37	1
Lack of skilled human resources at the construction site	80.39	2
Involvement of subcontractor in several projects at the same time	78.43	3
Inadequate pre-construction study and review of design documents	75.49	4
Construction errors and defective works at the construction site	75.49	5
Inaccurate estimation of construction costs	74.51	6
Frequent changes of subcontractors	73.53	7
Difficulties in financing project requirements	71.57	8
Insufficient comprehension of design documents	70.59	9
Lack of experience about new construction technologies	61.76	10
Failure of construction equipment	61.76	11
Project-related causes		
Lack of professional construction management	80.39	1
Poor project organizational structure	75.49	2
Information problems leading to rework and variation orders	75.49	3
Lack of communication and coordination between various project teams	73.53	4
Uncooperative managers and slow decision making	71.57	5
Low design's fee structure	70.59	6
Time pressure due to unreasonable contract duration	70.59	7
Lack of experience-related project nature	68.63	8
Adversarial relationship between consultant and contractor	67.65	9
Shop drawings' submission and approval	67.65	10
Work overload and lack of incentives	65.69	11
Violation of project contract's conditions	62.75	12
Lack of unified design code	61.76	13

Long period between time of bidding and awarding	55.88	14
Design complexity	54.90	15
External causes		
Poor economic conditions	70.59	1
Labor shortage	70.59	2
External or internal military actions	67.65	3
Unsettlement of local currency in relation to dollar value	66.67	4
Unexpected changes in materials' availability and prices	65.69	5
Country border closure	62.75	6
Unexpected delay in construction materials' arrival	61.76	7
Differing site conditions	49.02	8
Bad weather	42.16	9

Table 6 – Significance index (SI) and ranking order based on contractors' evaluation

Design-Construction Interface Problems	Category	SI	Rank
75 < I ≤ 100 % ‖ Extremely Significant			
Unstable client's requirements	Owner-related	88.89	1
Awarding contract to the lowest price regardless of the quality of services	Owner-related	83.33	2
Lack of proper coordination between various disciplines of design team	Consultant-related	81.11	3
Unexpected delay in construction materials' arrival	External	80.00	4
Lack of skilled and experienced human resources in the design firms	Consultant-related	78.89	5
Inaccurate estimation of project elements costs and quantities	Consultant-related	77.78	6
Delaying of dues payments	Owner-related	76.67	7
Lack of awareness about the construction knowledge and ongoing site operations	Consultant-related	76.67	8
Unsettlement of local currency in relation to dollar value	External	76.67	9
Unclear definition for scope of work	Owner-related	75.56	10
Delaying the approval of completed tasks	Owner-related	75.56	11
Vague and deficient drawings and specifications	Consultant-related	75.56	12
Difficulties in financing project requirements	Contractor-related	75.56	13
Time pressure due to unreasonable contract duration	Project-related	75.56	14
50 < I ≤ 75 % ‖ Significant			
Lack of project stipulated data	Consultant-related	74.44	15
Lack of design quality assurance practices	Consultant-related	73.33	16
Lack of skilled human resources at the construction site	Contractor-related	73.33	17
Poor project organizational structure	Project-related	73.33	18
Lack of communication and coordination between various project teams	Project-related	73.33	19
Poor economic conditions	External	73.33	20
Unexpected changes in materials' availability and prices	External	33.33	21
Unrealistic client's expectations regarding project time, cost, or quality	Owner-related	72.22	22
Poorly written contract with insufficient details	Owner-related	72.22	23

Mistakes and discrepancies in design documents	Consultant-related	72.22	24
Information problems leading to rework and variation orders	Project-related	72.22	25
Lack of professional construction management	Project-related	71.11	26
Uncooperative managers and slow decision making	Project-related	71.11	27
Labor shortage	External	71.11	28
Lack of specialized quality control team	Contractor-related	70.00	29
Frequent changes of subcontractors	Contractor-related	70.00	30
Work overload and lack of incentives	Project-related	70.00	31
External or internal military actions	External	70.00	32
Lack of experience-related project nature	Project-related	68.89	33
Inadequate pre-construction study and review of design documents	Contractor-related	67.78	34
Inaccurate estimation of construction costs	Contractor-related	67.78	35
Design complexity	Project-related	67.78	36
Country border closure	External	67.78	37
Insufficient comprehension of design documents	Contractor-related	66.67	38
Shop drawings' submission and approval	Project-related	65.56	39
Involvement of designer as construction supervisor	Owner-related	64.44	40
Construction errors and defective works at the construction site	Contractor-related	64.44	41
Inflexibility or rigidity in supervising construction works	Consultant-related	63.33	42
Lack of awareness about the availability of construction materials and equipment in the local market	Consultant-related	62.22	43
Adversarial relationship between consultant and contractor	Project-related	62.22	44
Outsourcing of design services	Owner-related	61.11	45
Lack of experience about new construction technologies	Contractor-related	61.11	46
Violation of project contract's conditions	Project-related	61.11	47
Involvement of subcontractor in several projects at the same time	Contractor-related	60.00	48
Inappropriate choice of project contract type (unit price, lump sum, etc.)	Owner-related	58.89	49
Inappropriate work packaging and subcontracting	Owner-related	57.78	50

Failure of construction equipment	Contractor-related	57.78	51
Long period between time of bidding and awarding	Project-related	57.78	52
Lack of awareness about governmental regulations, municipality requirements, statutes, and their modifications	Consultant-related	56.67	53
Insufficient geotechnical investigation	Consultant-related	55.56	54
Not involving the contractor in the design phase	Owner-related	54.44	55
Low design's fee structure	Project-related	54.44	56
Lack of unified design code	Project-related	54.44	57
Inappropriate choice of project delivery system (design-build, design-bid-build, etc.)	Owner-related	53.33	58
Bad weather	External	53.33	59
25 < I ≤ 50 % ǁ Slightly Significant			
Differing site conditions	External	50.00	60

Table 7 - Severity index (SI) and ranking order of problems within the belonging category based on contractors' evaluation

Design-Construction Interface Problems	SI	Rank
Owner-related causes		
Unstable client's requirements	88.89	1
Awarding contract to the lowest price regardless of the quality of services	83.33	2
Delaying of dues payments	76.67	3
Unclear definition for scope of work	75.56	4
Delaying the approval of completed tasks	75.56	5
Unrealistic client's expectations regarding project time, cost, or quality	72.22	6
Poorly written contract with insufficient details	72.22	7
Involvement of designer as construction supervisor	64.44	8
Outsourcing of design services	61.11	9
Inappropriate choice of project contract type (unit price, lump sum, etc.)	58.89	10
Inappropriate work packaging and subcontracting	57.78	11
Not involving the contractor in the design phase	54.44	12
Inappropriate choice of project delivery system (design-build, design-bid-build, etc.)	53.33	13
Consultant-related causes		
Lack of proper coordination between various disciplines of design team	81.11	1
Lack of skilled and experienced human resources in the design firms	78.89	2
Inaccurate estimation of project elements costs and quantities	77.78	3
Lack of awareness about the construction knowledge and ongoing site operations	76.67	4
Vague and deficient drawings and specifications	75.56	5
Lack of project stipulated data	74.44	6
Lack of design quality assurance practices	73.33	7
Mistakes and discrepancies in design documents	72.22	8
Inflexibility or rigidity in supervising construction works	63.33	9
Lack of awareness about the availability of construction materials and equipment in the local market	62.22	10

Lack of awareness about governmental regulations, municipality requirements, statutes, and their modifications	56.67	11
Insufficient geotechnical investigation	55.56	12
Contractor-related causes		
Difficulties in financing project requirements	75.56	1
Lack of skilled human resources at the construction site	73.33	2
Lack of specialized quality control team	70.00	3
Frequent changes of subcontractors	70.00	4
Inadequate pre-construction study and review of design documents	67.78	5
Inaccurate estimation of construction costs	67.78	6
Insufficient comprehension of design documents	66.67	7
Construction errors and defective works at the construction site	64.44	8
Lack of experience about new construction technologies	61.11	9
Involvement of subcontractor in several projects at the same time	60.00	10
Failure of construction equipment	57.78	11
Project-related causes		
Time pressure due to unreasonable contract duration	75.56	1
Poor project organizational structure	73.33	2
Lack of communication and coordination between various project teams	73.33	3
Information problems leading to rework and variation orders	72.22	4
Lack of professional construction management	71.11	5
Uncooperative managers and slow decision making	71.11	6
Work overload and lack of incentives	70.00	7
Lack of experience-related project nature	68.89	8
Design complexity	67.78	9
Shop drawings' submission and approval	65.56	10
Adversarial relationship between consultant and contractor	62.22	11
Violation of project contract's conditions	61.11	12
Long period between time of bidding and awarding	57.78	13

Low design's fee structure	54.44	14
Lack of unified design code	54.44	15
External causes		
Unexpected delay in construction materials' arrival	80.00	1
Unsettlement of local currency in relation to dollar value	76.67	2
Poor economic conditions	73.33	3
Labor shortage	71.11	4
External or internal military actions	70.00	5
Country border closure	67.78	6
Bad weather	53.33	7
Differing site conditions	50.00	8
Unexpected changes in materials' availability and prices	33.33	9

Table 8 - Significance index (SI) and ranking order base on the combined evaluation

Design-Construction Interface Problems	Category	SI	Rank
75 < I ≤ 100 % ‖ Extremely Significant			
Unstable client's requirements	Owner-related	85.94	1
Lack of proper coordination between various disciplines of design team	Consultant-related	81.25	2
Awarding contract to the lowest price regardless of the quality of services	Owner-related	79.69	3
Lack of skilled and experienced human resources in the design firms	Consultant-related	78.65	4
Lack of skilled human resources at the construction site	Contractor-related	77.08	5
Delaying of dues payments	Owner-related	76.56	6
Lack of specialized quality control team	Contractor-related	76.04	7
Lack of professional construction management	Project-related	76.04	8
Delaying the approval of completed tasks	Owner-related	75.52	9
Vague and deficient drawings and specifications	Consultant-related	75.52	10
50 < I ≤ 75 % ‖ Significant			
Lack of design quality assurance practices	Consultant-related	75.00	11
Lack of project stipulated data	Consultant-related	74.48	12
Mistakes and discrepancies in design documents	Consultant-related	74.48	13
Poor project organizational structure	Project-related	74.48	14
Unclear definition for scope of work	Owner-related	73.96	15
Information problems leading to rework and variation orders	Project-related	73.96	16
Lack of awareness about the construction knowledge and ongoing site operations	Consultant-related	73.44	17
Difficulties in financing project requirements	Contractor-related	73.44	18
Lack of communication and coordination between various project teams	Project-related	73.44	19
Unrealistic client's expectations regarding project time, cost, or quality	Owner-related	72.92	20
Time pressure due to unreasonable contract duration	Project-related	72.92	21
Inadequate pre-construction study and review of design documents	Contractor-related	71.88	22
Frequent changes of subcontractors	Contractor-related	71.88	23

Poor economic conditions	External	71.88	24
Inaccurate estimation of construction costs	Contractor-related	71.35	25
Uncooperative managers and slow decision making	Project-related	71.35	26
Unsettlement of local currency in relation to dollar value	External	71.35	27
Inaccurate estimation of project elements costs and quantities	Consultant-related	70.83	28
Labor shortage	External	70.83	29
Construction errors and defective works at the construction site	Contractor-related	70.31	30
Unexpected delay in construction materials' arrival	External	70.31	31
Involvement of subcontractor in several projects at the same time	Contractor-related	69.79	32
Unexpected changes in materials' availability and prices	Owner-related	69.27	33
Insufficient comprehension of design documents	Contractor-related	68.75	34
Lack of experience-related project nature	Project-related	68.75	35
External or internal military actions	External	68.75	36
Work overload and lack of incentives	Project-related	67.71	37
Poorly written contract with insufficient details	Owner-related	66.67	38
Shop drawings' submission and approval	Project-related	66.67	39
Inflexibility or rigidity in supervising construction works	Consultant-related	65.63	40
Adversarial relationship between consultant and contractor	Project-related	65.10	41
Country border closure	External	65.10	42
Lack of awareness about the availability of construction materials and equipment in the local market	Consultant-related	63.02	43
Low design's fee structure	Project-related	63.02	44
Violation of project contract's conditions	Project-related	61.98	45
Involvement of designer as construction supervisor	Owner-related	61.46	46
Lack of experience about new construction technologies	Contractor-related	61.46	47
Insufficient geotechnical investigation	Consultant-related	60.94	48
Design complexity	Project-related	60.94	49
Failure of construction equipment	Contractor-related	59.90	50

Inappropriate work packaging and subcontracting	Owner-related	58.85	51
Inappropriate choice of project contract type (unit price, lump sum, etc.)	Owner-related	58.33	52
Lack of unified design code	Project-related	58.33	53
Outsourcing of design services	Owner-related	56.77	54
Long period between time of bidding and awarding	Project-related	56.77	55
Inappropriate choice of project delivery system (design-build, design-bid-build, etc.)	Owner-related	55.73	56
Lack of awareness about governmental regulations, municipality requirements, statutes, and their modifications	Consultant-related	53.13	57
25 < I ≤ 50 % ‖ Slightly Significant			
Differing site conditions	External	49.48	58
Bad weather	External	48.96	59
Not involving the contractor in the design phase	Owner-related	42.71	60

Table 9 - Severity index (SI) and ranking order of problems within the belonging category based on the combined evaluation

Design-Construction Interface Problems	SI	Rank
Owner-related causes		
Unstable client's requirements	85.94	1
Awarding contract to the lowest price regardless of the quality of services	79.69	2
Delaying of dues payments	76.56	3
Delaying the approval of completed tasks	75.52	4
Unclear definition for scope of work	73.96	5
Unrealistic client's expectations regarding project time, cost, or quality	72.92	6
Poorly written contract with insufficient details	66.67	7
Involvement of designer as construction supervisor	61.46	8
Inappropriate work packaging and subcontracting	58.85	9
Inappropriate choice of project contract type (unit price, lump sum, etc.)	58.33	10
Outsourcing of design services	56.77	11
Inappropriate choice of project delivery system (design-build, design-bid-build, etc.)	55.73	12
Not involving the contractor in the design phase	42.71	13
Consultant-related causes		
Lack of proper coordination between various disciplines of design team	81.25	1
Lack of skilled and experienced human resources in the design firms	78.65	2
Vague and deficient drawings and specifications	75.52	3
Lack of design quality assurance practices	75.00	4
Lack of project stipulated data	74.48	5
Mistakes and discrepancies in design documents	74.48	6
Lack of awareness about the construction knowledge and ongoing site operations	73.44	7
Inaccurate estimation of project elements costs and quantities	70.83	8
Inflexibility or rigidity in supervising construction works	65.63	9
Lack of awareness about the availability of construction materials and equipment in the local market	63.02	10

Insufficient geotechnical investigation	60.94	11
Lack of awareness about governmental regulations, municipality requirements, statutes, and their modifications	53.13	12
Contractor-related causes		
Difficulties in financing project requirements	75.56	1
Lack of skilled human resources at the construction site	73.33	2
Lack of specialized quality control team	70.00	3
Frequent changes of subcontractors	70.00	4
Inadequate pre-construction study and review of design documents	67.78	5
Inaccurate estimation of construction costs	67.78	6
Insufficient comprehension of design documents	66.67	7
Construction errors and defective works at the construction site	64.44	8
Lack of experience about new construction technologies	61.11	9
Involvement of subcontractor in several projects at the same time	60.00	10
Failure of construction equipment	57.78	11
Project-related causes		
Lack of professional construction management	76.04	1
Poor project organizational structure	74.48	2
Information problems leading to rework and variation orders	73.96	3
Lack of communication and coordination between various project teams	73.44	4
Time pressure due to unreasonable contract duration	72.92	5
Uncooperative managers and slow decision making	71.35	6
Lack of experience-related project nature	68.75	7
Work overload and lack of incentives	67.71	8
Shop drawings' submission and approval	66.67	9
Adversarial relationship between consultant and contractor	65.10	10
Low design's fee structure	63.02	11
Violation of project contract's conditions	61.98	12
Design complexity	60.94	13

Lack of unified design code	58.33	14
Long period between time of bidding and awarding	56.77	15
External causes		
Poor economic conditions	71.88	1
Unsettlement of local currency in relation to dollar value	71.35	2
Labor shortage	70.83	3
Unexpected delay in construction materials' arrival	70.31	4
Unexpected changes in materials' availability and prices	69.27	5
External or internal military actions	68.75	6
Country border closure	65.10	7
Differing site conditions	49.48	8
Bad weather	48.96	9

Table 10 – Difference in ranking between consultants and contractors

Design-Construction Interface Problems	Consultants Ranking	Contractors Ranking	Difference Between Rankings (D)	D^2
Owner-related causes				
Unstable client's requirements	1	1	0	0
Unrealistic client's expectations regarding project time, cost, or quality	20	22	2	4
Outsourcing of design services	56	45	11	121
Not involving the contractor in the design phase	60	55	5	25
Awarding contract to the lowest price regardless of the quality of services	8	2	6	36
Unclear definition for scope of work	23	10	13	169
Inappropriate work packaging and subcontracting	50	50	0	0
Poorly written contract with insufficient details	45	23	22	484
Delaying the approval of completed tasks	12	11	1	1
Delaying of dues payments	9	7	2	4
Inappropriate choice of project contract type (unit price, lump sum, etc.)	52	49	3	9
Inappropriate choice of project delivery system (design-build, design-bid-build, etc.)	53	58	5	25
Involvement of designer as construction supervisor	51	40	11	121
Consultant-related causes				
Lack of project stipulated data	18	15	3	9
Lack of skilled and experienced human resources in the design firms	6	5	1	1
Lack of proper coordination between various disciplines of design team	2	3	1	1
Lack of awareness about the construction knowledge and ongoing site operations	26	8	18	324
Lack of awareness about the availability of construction materials and equipment in the local market	42	43	1	1
Lack of awareness about governmental regulations, municipality requirements, statutes, and their modifications	57	53	4	16

Inaccurate estimation of project elements costs and quantities	41	6	35	1225
Insufficient geotechnical investigation	38	54	16	256
Vague and deficient drawings and specifications	13	12	1	1
Mistakes and discrepancies in design documents	10	24	14	196
Lack of design quality assurance practices	11	16	5	25
Inflexibility or rigidity in supervising construction works	33	42	9	81
Contractor-related causes				
Insufficient comprehension of design documents	27	38	11	121
Lack of skilled human resources at the construction site	4	17	21	441
Inadequate pre-construction study and review of design documents	14	34	20	400
Lack of experience about new construction technologies	46	46	0	0
Inaccurate estimation of construction costs	19	35	16	256
Construction errors and defective works at the construction site	15	41	26	676
Lack of specialized quality control team	3	29	26	676
Failure of construction equipment	47	51	4	16
Difficulties in financing project requirements	24	13	11	121
Involvement of subcontractor in several projects at the same time	7	48	41	1681
Frequent changes of subcontractors	21	30	9	81
Project-related causes				
Poor project organizational structure	16	18	2	4
Lack of professional construction management	5	26	21	441
Uncooperative managers and slow decision making	25	27	2	4
Information problems leading to rework and variation orders	17	25	8	64
Lack of communication and coordination between various project teams	22	19	3	9
Adversarial relationship between consultant and contractor	34	44	10	100
Low design's fee structure	28	56	28	784
Design complexity	55	36	19	361

Lack of experience-related project nature	32	33	1	1
Shop drawings' submission and approval	35	39	4	16
Work overload and lack of incentives	39	31	8	64
Time pressure due to unreasonable contract duration	29	14	15	225
Lack of unified design code	48	57	9	81
Violation of project contract's conditions	43	47	4	16
Long period between time of bidding and awarding	54	52	2	4
External causes				
Differing site conditions	58	60	2	4
Poor economic conditions	30	20	10	100
Labor shortage	31	28	3	9
Unsettlement of local currency in relation to dollar value	37	9	28	784
Bad weather	59	59	0	0
Country border closure	44	37	7	49
External or internal military actions	36	32	4	16
Unexpected changes in materials' availability and prices	40	21	19	361
Unexpected delay in construction materials' arrival	49	4	45	2025

Table 11 - t-Test results for equality of means for each individual problem

Design-Construction Interface Problems	t	df	Sig. (2.tailed)	Mean Difference	Std. Error Difference	Reject H_0 If $\lvert t \rvert > \lvert sig. \rvert$
Owner-related causes						
Unstable client's requirements	-1.139	62	0.259	-0.17	0.15	Rejected
Unrealistic client's expectations regarding project time, cost, or quality	0.234	62	0.816	0.04	0.17	Accepted
Outsourcing of design services	-1.085	62	0.282	-0.25	0.23	Rejected
Not involving the contractor in the design phase	-2.491	62	0.015	-0.66	0.27	Rejected
Awarding contract to the lowest price regardless of the quality of services	-1.101	62	0.275	-0.21	0.19	Rejected
Unclear definition for scope of work	-0.481	62	0.633	-0.09	0.19	Accepted
Inappropriate work packaging and subcontracting	0.236	62	0.814	0.06	0.26	Accepted
Poorly written contract with insufficient details	-1.479	62	0.144	-0.31	0.21	Rejected
Delaying the approval of completed tasks	-0.012	62	0.991	0.00	0.17	Accepted
Delaying of dues payments	-0.027	62	0.979	-0.01	0.22	Accepted
Inappropriate choice of project contract type (unit price, lump sum, etc.)	-0.134	62	0.894	-0.03	0.23	Accepted
Inappropriate choice of project delivery system (design-build, design-bid-build, etc.)	0.569	62	0.571	0.14	0.24	Accepted
Involvement of designer as construction supervisor	-0.673	62	0.503	-0.17	0.25	Rejected
Consultant-related causes						
Lack of project stipulated data	0.011	62	0.992	0.00	0.18	Accepted
Lack of skilled and experienced human resources in the design firms	-0.069	62	0.945	-0.01	0.20	Accepted

Lack of proper coordination between various disciplines of design team	0.039	62	0.969	0.01	0.20	Accepted
Lack of awareness about the construction knowledge and ongoing site operations	-0.932	62	0.355	-0.18	0.20	Rejected
Lack of awareness about the availability of construction materials and equipment in the local market	0.196	62	0.845	0.05	0.23	Accepted
Lack of awareness about governmental regulations, municipality requirements, statutes, and their modifications	-0.865	62	0.390	-0.20	0.23	Rejected
Inaccurate estimation of project elements costs and quantities	-2.039	62	0.046	-0.39	0.19	Rejected
Insufficient geotechnical investigation	1.329	62	0.189	0.30	0.23	Rejected
Vague and deficient drawings and specifications	-0.010	62	0.992	0.00	0.19	Accepted
Mistakes and discrepancies in design documents	0.624	62	0.535	0.13	0.20	Rejected
Lack of design quality assurance practices	0.437	62	0.664	0.09	0.22	Accepted
Inflexibility or rigidity in supervising construction works	0.630	62	0.531	0.13	0.21	Rejected
Contractor-related causes						
Insufficient comprehension of design documents	0.561	62	0.577	0.12	0.21	Accepted
Lack of skilled human resources at the construction site	1.015	62	0.314	0.21	0.21	Rejected
Inadequate pre-construction study and review of design documents	1.033	62	0.306	0.23	0.22	Rejected
Lack of experience about new construction technologies	0.095	62	0.925	0.02	0.21	Accepted
Inaccurate estimation of construction costs	1.015	62	0.314	0.20	0.20	Rejected
Construction errors and defective works at the construction site	2.105	62	0.039	0.33	0.16	Rejected

Lack of specialized quality control team	1.634	62	0.107	0.34	0.21	Rejected
Failure of construction equipment	0.663	62	0.510	0.12	0.18	Rejected
Difficulties in financing project requirements	-0.511	62	0.611	-0.12	0.23	Accepted
Involvement of subcontractor in several projects at the same time	3.252	62	0.002	0.55	0.17	Rejected
Frequent changes of subcontractors	0.479	62	0.634	0.11	0.22	Accepted
Project-related causes						
Poor project organizational structure	0.295	62	0.769	0.06	0.22	Accepted
Lack of professional construction management	1.663	62	0.101	0.28	0.17	Rejected
Uncooperative managers and slow decision making	0.067	62	0.947	0.01	0.21	Accepted
Information problems leading to rework and variation orders	0.471	62	0.639	0.10	0.21	Accepted
Lack of communication and coordination between various project teams	0.031	62	0.976	0.01	0.19	Accepted
Adversarial relationship between consultant and contractor	0.785	62	0.435	0.16	0.21	Rejected
Low design's fee structure	2.233	62	0.029	0.48	0.22	Rejected
Design complexity	-1.612	62	0.112	-0.39	0.24	Rejected
Lack of experience-related project nature	-0.047	62	0.963	-0.01	0.17	Accepted
Shop drawings' submission and approval	0.298	62	0.767	0.06	0.21	Accepted
Work overload and lack of incentives	-0.646	62	0.521	-0.13	0.20	Rejected
Time pressure due to unreasonable contract duration	-0.766	62	0.447	-0.15	0.19	Rejected
Lack of unified design code	1.102	62	0.275	0.22	0.20	Rejected
Violation of project contract's conditions	0.228	62	0.820	0.05	0.22	Accepted
Long period between time of bidding and awarding	-0.255	62	0.800	-0.06	0.22	Accepted
External causes						
Differing site conditions	-0.131	62	0.896	-0.03	0.22	Accepted

Poor economic conditions	-0.398	62	0.692	-0.08	0.21	Accepted
Labor shortage	-0.070	62	0.944	-0.02	0.22	Accepted
Unsettlement of local currency in relation to dollar value	-1.417	62	0.162	-0.30	0.21	Rejected
Bad weather	-1.630	62	0.108	-0.34	0.21	Rejected
Country border closure	-0.621	62	0.537	-0.15	0.24	Rejected
External or internal military actions	-0.309	62	0.759	-0.07	0.23	Accepted
Unexpected changes in materials' availability and prices	-1.066	62	0.291	-0.23	0.22	Rejected
Unexpected delay in construction materials' arrival	-2.608	62	0.011	-0.55	0.21	Rejected

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