THE CONSULTANCY FEE FOR STRUCTURAL DESIGN CHANGES OF REINFORCED CONCRETE BUILDINGS IN OMAN

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ABSTRACT

Design changes in reinforced concrete buildings have for long time been a topic of prolonged arguments and frequent disputes due to their common phenomena of incidents in the construction industry. Although design changes in many cases are essential, clients, consulting engineers and contractors all have become increasingly worried about the negative parts that are associated with them. Design changes do not only affect the reliability of design but also increase the possibility of contractual disputes due to unpredictable delay and cost overrun on the original scope of work. While the cost of modifying the construction scopes is well defined in normal contract documents, but the fee of engineering changes is yet to receive more attention. Therefore this research has been developed with the aim to investigate such issues and to develop an alternative approach in evaluating the fee of altering the original scope of design work. Extensive study was performed at the initial stage of this research work in term of interviews, case studies and questionnaire survey in order to identify the sources, causes and impacts of design changes on reinforced concrete buildings as well as to establish corrective actions and preventive measures to minimise the avoidable ones. Frequency analysis and non-parametric statistical technique employed in this research to analyse the qualitative and quantitative data. It was found that engineering design changes are common in the industry and, in many cases, lead to excessive claims and disputes due to lack of appropriate and practical methods to assess their associated fee. Although there are various methods being used for assessing the fee of design changes, this study identified their limitations for practical use. Consequently, an alternative method for assessing the fee of the structural design changes has been developed in this research based on designing various type and complexity of low rise RC buildings. The developed method has been verified by a panel of experts by means of questionnaire survey and found to be practical, suitable and effective. Set of guidelines for improving consultancy design documents with respect to design changes and another set of guidelines for managing their claims have been also developed. These guidelines have been validated by panel of experts using Delphi technique. The result of the validation process provides encouragement to recommend the guidelines for practical implementation.

ABSTRAK

Perubahan terhadap rekabentuk asal bagi pembinaan bangunan konkrit bertetulang (RC) sering berlaku dan isu ini telah sekian lama diperbahaskan. Ia juga sering menjadi punca perbalahan dalam industri pembinaan. Walaupun perubahan dalam rekabentuk dalam keadaan tertentu adalah perlu dilakukan tetapi kesan negatif akibat daripada perubahan yang dibuat juga turut mebimbangkan pihak yang terlibat seperti klien, jurutera perunding dan kontraktor. Perubahan terhadap rekabentuk bukan sahaja meninggalkan kesan terhadap kredebilitinya rekabentuk itu sendiri malah boleh mendorong kepada berlakunya perbalahan kontrak disebabkan oleh kelewatan kerja dan perubahan kos akibat daripada perubahan daripada skop asal kerja. Lazimnya kaedah penilain terhadap perubahan kos bagi kerja pembinaan akibat daripada perubahan skop kerja agak jelas mengikut peruntukan yang sedia ada didalam kontrak pembinaan. Walaubagaimana pun kaedah penialaian kos terhadap perubahan bagi kerja merebentuk tidak begitu mendapat perhatian para penyelidik. Oleh itu kajian ini telah dijalankan untuk mengenalpasti masaalah ini dengan lebih mendalam serta mengemukakan suatu kaedah alternatif bagi menilai kos perubahan bagi mengubahsuai rekabentuk asal yang dilaksanakan oleh pihak perunding. Pada peringkat awal kajian ini tela mengenalpasti punca, kesan dan kaedah penialain kos dalam proses membuat perubahan terhadap rekabentuk bagi sesabuah bangunan konkrit. Juga dikaji adalah kaedah yang boleh digunakan untuk mengurangkan keperluan membuat prubahan rekabentuk oleh pihak klien. Kaedah penyelidikan yang digunakan termasuklah sesi temubual, kajian kes dan menghantar borang soal selidik kepada responden. Kaedah analisa frekuensi dan kaedas Statistik Tak Berparametar telah digunakan untuk membuat analisa data kualitatif dan kuantitatif yang digunakan dalam penyelidikan ini. Hasil dari kajian mendapati bahawa perubahan terhadap rekabentuk adalah sesuatu yang lazim berlaku dan dalam banyak kes menyebabkan berlakunya tuntutan tambahan yang berlebihan yang dibuat oleh perunding akibat daripada tidak ada kaedah yang sesuai untuk membuat penialaian kos yang praktikal dan wajar digunakan. Lanjutan dari itu hasil dari penyelidikan ini telah membangunkan satu kaedah yang sesuai digunakan untuk sebagai kaedah alternatif untuk membuat penialaian apabila berlakunya perubahan atau pengubahsuaian terhadap rekabentuk asal terhadap struktur bangunan konkrit bertetulang sederhana tinggi. Kaedah ini telah dipersetujui sebagai sesuai digunakan oleh panel para professional yang mempunyai pengalaman yang luas dalam industri pembinaan di Oman. Selain dari itu penyelidikan ini turut membangunkan satu garispanduan yang sesuai diterapkan dalam kontrak untuk mengemaskini lagi proses membuat perubahan rekabentuk dan menguruskan tuntutan yang dibuat berkaitan dengan perubahan yang dibuat tersebut. Garispanduan ini telah dibuat pengesahan dengan panel yang berpengalaman dalam industri pembinaan di Oman dengan menggunakan kaedah Delphi.

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di	-	The different between the rank given by one group and the rank given by another group
f	-	frequency of responses to each score for each factor
fn	-	Total number of factors ranked by any two groups for any given category
OCC	-	Original Contract Fee
MS	-	Mean Score
N	-	Number of responses
Nf	-	total number of responses
NMM	-	Number of the Modified structural Members
TNM	-	Total Number of the structural Members
S	-	Score given to each factor as ranked by the respondents

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CHAPTER 1

INTRODUCTION

1.1 Background and Rationale

Engineering design changes and their consultancy design fee assessment for reinforced concrete buildings' design have, for long time, been a topic of prolonged discussions and frequent disputes between clients and their appointed consulting engineers. Design changes in their simple term are defined as any addition, omission or modification to the original scope of work in which a contract was signed (Akinsola *et al.*, 1997) or an adjustment to the completed design that may leads to change the original contract design fee (Baxendale and Schofield, 1996). These design changes might have great effect especially on cost and time and are likely to be a cause of claims and disruptions. In general, consulting engineers provide the necessary effort to develop the concept of the design to fulfil the intended use of the projects under design to their client's requirements. An approval to preliminary design principle sets the basis for subsequent detailed design and for production of technical specification and construction documents.

It is common in the construction industry for almost all projects to go through various degrees of modifications at the design stage and more commonly during the construction. These changes are mostly caused by clients, in favour of getting new ideas or cost reduction on projects (Federal Construction Council, 1983; Kelvin, 1996). Design members have been also the main contributors of the design changes in the construction industry. They originate the changes to rectify their mistakes and

to improve or optimize their design (Hibberd, 1982; Choy and Sidwell, 1991). Contractors may also introduce changes to adopt alternative construction methods that are of more familiarity (McDermott and Dodd, 1984; Yogeswaran, 1998) and suppliers, in order to meet the manufacturer's recommendation to use a specific material (Emmitt, 2001).

The most common reasons that necessitate design changes are financial (Ssegawa, *et al.* 2003), clients' new requirements (Wilson, 1982), coordination problems (Bubshait *et al.*, 1998), unclear scope of work (Austin *et al.*, 2002), design errors (Leonard, *et al.*, 1988), unexpected site conditions (Essex, 1996) and insufficient design information at the design stage (Ogunlana, *et al.*, 1996). The possible changes could be minor related to design development which have no or relatively low cost effect on overall agreed design fees and could be major related to new ideas or changing the principle of the original design which, in turn, required re-planning and re-designing that leads to a major cost effect.

There are numerous impact caused by design changes that influence the outcome of a project. Any inferior assessment, determination, misunderstanding or unavailability of relevant information or knowledge during the design stage leads inevitably to less than an optimum design that can be unnecessarily expensive and difficult to correct/alter at later stages of a project life cycle (Hashimoto, 1993). A successful project means that the project has met the required quality level, completed on time and within the allocated budget (Chan and Kumaraswamy, 1994; Frimpong *et al.* 2003). Design changes usually divert these fundamental aims in the construction industry. These changes lead to great disruption on design and construction activities which, in turn, increase the chances for errors, increase cost, delay and decrease productivity.

Although design changes in many cases are essential for, as example, design development; clients, consulting engineers and contractors all have become increasingly worried about their magnitude and their impact that are associated with them. Design changes do not only affect the reliability of the design but also increase the possibility of contractual disputes due to the unpredictable delay and cost overrun on the original scope of work. The three case studies that have been

carried out from the construction industry in the Sultanate of Oman and were part of this research investigation have shown that the engineering consultancy fee can be as high as 189.8 percent of the original fee and the engineering consultancy time can increase by 195 percent.

While the cost of modifying the construction scopes is well defined in normal contract documents, the fee of engineering changes is yet to receive more attention. Clients are not always willing to accept the variation charges set by consulting engineers mainly because they feel they are unjustifiable and consultants, on the other hand, feel that clients unreasonably reject or reduce the claimed amount. This can be predicted to some extend since the design changes are not easily quantified.

They are various methods in which consulting engineers have been using to assess the consultancy design fee associated with design changes These methods have been identified from the result of the interviews with the professionals working in the construction industry, from the case studies and from the questionnaire that all were carried out at the initial stage for this research work. These methods are the Man-Hours method, Percentage of Construction Cost method, Area Unit Rate method and the Lump-Sun method. However the result of the interviews with the professionals working in the construction industry; the case studies; and the questionnaire survey that have been conducted as part of this research revealed that each one of these methods has various degrees of difficulties and limitations for implementation to the point where it becomes unpractical to adopt anyone of them. To avoid the possible disputes arising from the lack of an affective way to evaluate the engineering consultancy fee of design changes, there is a need to develop a practical method for fee assessment of the structural design changes when they arise. The primary aim of this research work is to develop an alternative method for assessing the consultancy design fee as a result of modifying the original structural design; to highlight suggestions for minimizing the avoidable design changes; and to provide guidelines for improving the consultancy design documents with respect of managing design changes

1.2 Problem Statement

Many articles have been written on the general subject of design changes. Much of that research have focused on their nature and extend such as causes, sources and impacts, where others have concentrated on their legal aspects such as claims and disputes. Although design changes in many cases are essential for, as examples, design developments, design improvements, rectification of mistakes and resolution of problems related to unexpected circumstances, nevertheless, clients, consulting engineers and contractors all have become increasingly worried about the negative parts that are associated with design changes, and the poor recovery of the actual fee associated with their settlements (Jergeas and Hartman, 1994). Nevertheless, design changes are still an ongoing problem that continues to raise the concerns in the construction industry. Such concerns stimulated this research and others to produce a series of reports, for example Latham report (1994) where variations have been identified as one of the main problems challenging the construction industry.

Almost all projects go through different level of modifications not only at the design stage but also during the construction. Previous studies such as the one by Anderson and Tucker (1994) reveals that about one third of architectural/engineering projects missed cost and schedule targets as a result of design changes. Burati *et al.* (1992) have shown that design changes increased the construction cost by an average amount of 12.4 percent of the total cost of the projects in the United Kingdom. Chang (2002) reported that an engineering consultancy fee increased on an average of 24.8 percent based on four sampled projects in Taiwan as a result of design changes.

Delays have been identified as a key factor that increase the construction cost of the projects worldwide (Kartam, 1999). Design changes are one of the main causes that lead to such construction delays. Arditi *et al.* (1985) found that 3.54 percent of the delays in public projects in Turkey were caused by design changes. In the UK, 49 percent of the delays are caused by factors related to design changes (Sullivan and Harris, 1986). In Nigeria, this percentage is reported to be as high as 71 percent (Okpala and Aniekwu, 1988).

Consulting engineers are familiar with the methods of pricing their consultancy design services at the tender stage. These methods are well developed and well documented as it will be seen in the next chapter. When changes are introduced, there is a lack of an affective method to assess their fee. Normally consulting engineers either estimate their extra design fee for modifying the original design in a lump-sum basis or alternatively predict the most likely man-hours that are needed to carry out the change; or keep record of the man-hours they spend to execute the changes. The consulting engineers then submit the man-hours to their clients for payments. Clients, on the other hand, do not always accept the submitted man-hours because they feel the man-hours are overestimated due to lack of trust. At the same time, there is no well accepted alternative methods that might be used to quantify the design changes and hence to assess their fee. Such situations may increase the possibility of contractual disputes, affect the relationships and lead to dissatisfaction and disappointment to both the clients and the consulting engineers. Recognizing these facts, there is an obvious need for in depth study to address these issues and to find a practical solution that might be used to assess the fee of modifying the original design changes. This research is a step toward satisfying this need.

1.3 Aim and Objectives

It is a well known fact that many design changes are most likely inevitable during the life cycle of the projects. These changes might be minor so that no major claims on fee or time extension takes place or might be major in which it results in main claims. While the original consultancy design fee is normally stated in the contract documents based on the tender submission and negotiation, there is no practical and acceptable method yet to assess the fee of modifying the original design. The primary aim of this research work is to formulate practical procedures for the assessment of the structural design changes so that an enhancement can be made to the existing practice. The result of this study will put forward practical means of avoiding and resolving the disputes caused by the lack of appropriate method of assessing the fee of design changes.

The review and investigation of this research work are to be carried out with the following objectives:

(1) To identify the sources, the causes, and the impacts of the design changes on reinforced concrete buildings;

(2) To establish corrective actions and preventive measures to minimise the avoidable design changes;

(3) To identify and evaluate the various methods for assessing the fee of the structural design changes and to identify their limitations;

(4) To develop an alternative method to assess the fee of the structural design changes for low rise RCC buildings;

(5) To develop guidelines to improve the consultancy design documents; and

(6) To develop guidelines to manage the design changes when they occur

1.4 Scope and Limitations of the Research

In this study, the proposed method for assessing the fee of the structural design changes is based on designing 12 number small scale low rise reinforced concrete buildings consisting of one floor to four floors. These buildings have already been constructed in the Sultanate of Oman prior to this study. The buildings under this research work have been designed using both manual calculations and STAAD Pro 2003 software and have been drafted by AutoCAD 2000 software. The investigation and the scopes of this study were carried out in the Sultanate of Oman and hence limited to the typical standard details and normal practice in the country. The finding can only be applied to these types of projects.

1.5 Brief Research Methodology

Research methodology provides a general plan and necessary steps to execute the research in a scientific manner. It is a logical model for collecting the information, analysing the data and interpreting the findings of the research. It is also the necessary methods that lead to achieve the aim and the objectives of the research. To this end, Figure 1.1 outlines a flow chart for the methodology of this research. A more detailed research methodology is discussed in Chapter 5.

1.6 Justification of the Research

The idea of this work came from the past experience and knowledge on the extent of the problems and the size of the claims associated with the structural design changes. In many cases, design changes lead to disputes due to lack of proper guidelines to manage them and lack of appropriate methods on their fee variation assessment. The topic went through progressive refinement taken into consideration the interest in the area of the study, findings of previous works as well as the professional opinion from the industry in order to explore areas of dissatisfaction. As a result of this initial investigation, the topic of this research is advanced to the state that it is delineated sufficiently for the aim and objectives of the research and importantly to make significant contribution to the subject.

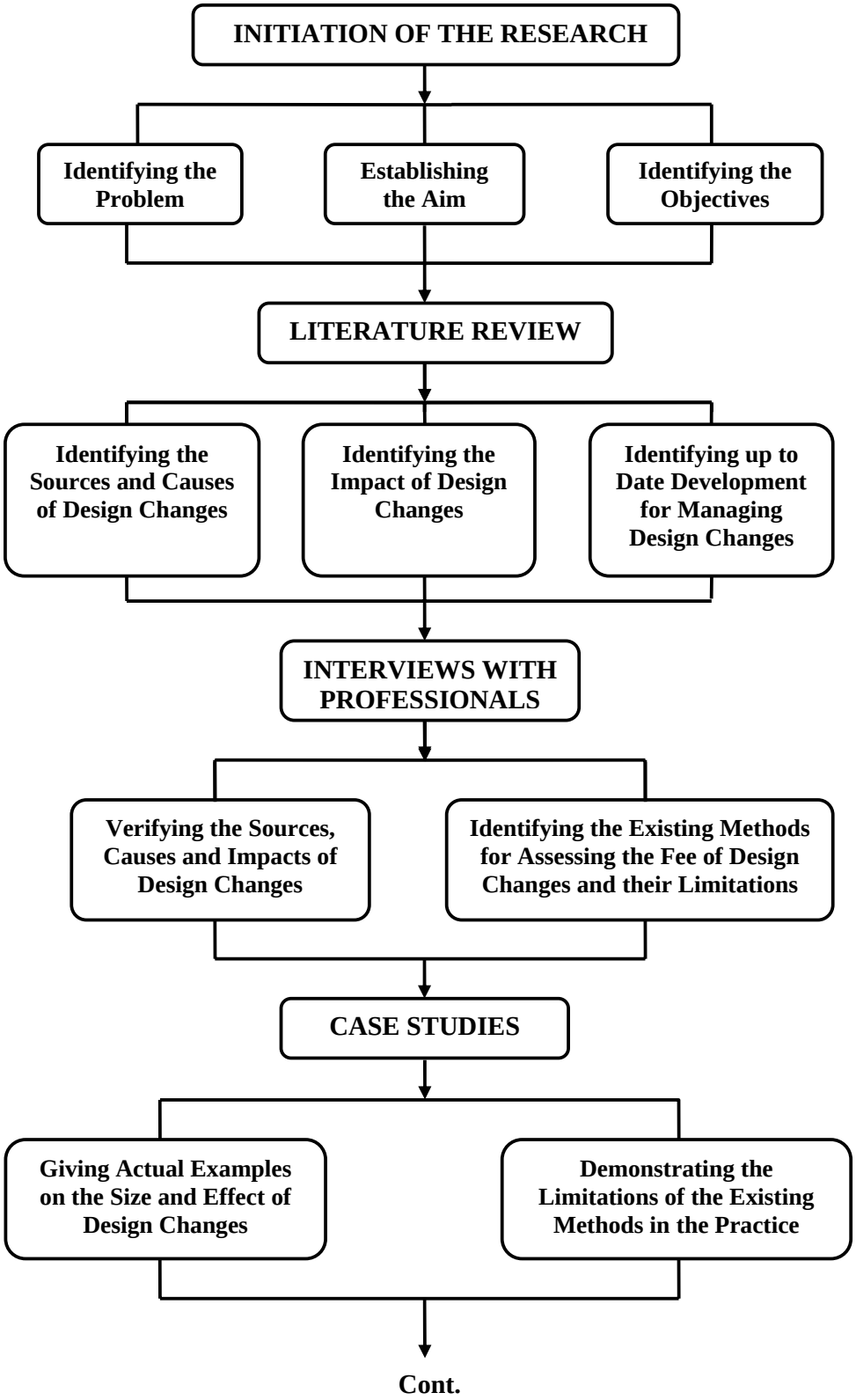

Figure 1.1 : Research Methodology Flow Chart

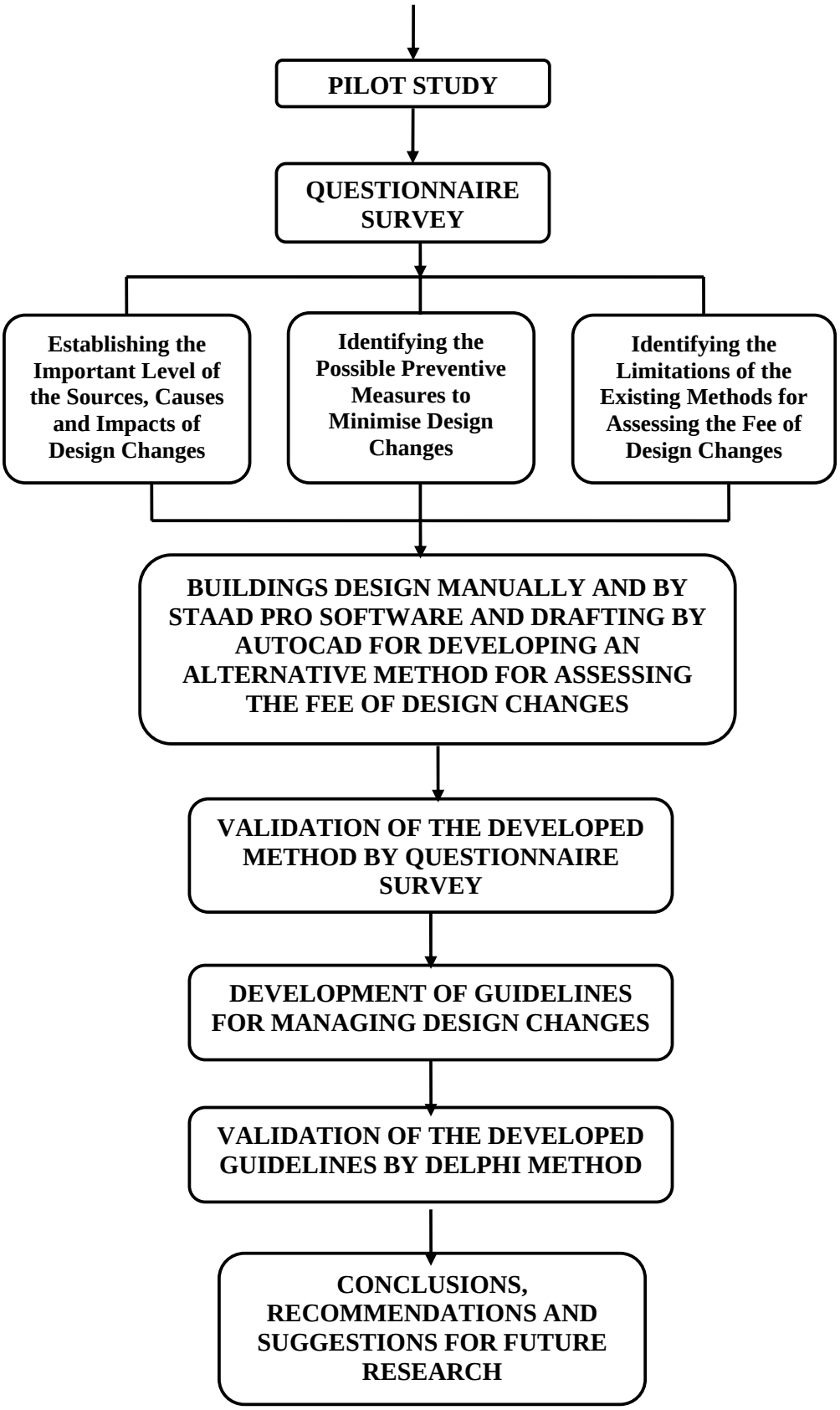

Figure 1.1 : Research Methodology Flow Chart (Continue)

1.7 Significance of the Study

The study is unique in the sense that no previous attempts have been made on the subject in spite of wide spread dissatisfaction associated with design changes, their impact and their fee assessment on reinforced concrete buildings. Surely it will improve the industry's understanding on the negative aspects that are related to design changes and help to reduce the possible disputes in this regard. The study will improve the efficiency, effectiveness and satisfaction in the construction practice and it will make a contribution to the construction industry in general and especially to the consulting engineering firms by developing a practical method of charging for design changes. The study will help define the related issues and directions that need to be addressed in the future.

1.8 Research Contributions

The main contribution of this study to the body of knowledge falls on the following aspects: Firstly, the study gives emphasis on identifying the sources, causes and impacts of design changes on reinforced concrete buildings as well as on establishing corrective actions and/or preventive measures to minimise the avoidable ones. This study has developed practical and reliable method for fee variation assessment that might be implemented by professionals to assess the fee of changing or modifying the original design of reinforced concrete buildings. In addition, it is anticipated that the study will provide set of guidelines to improve the current design contract documents with respect to design changes and another set of guidelines to manage their claims

1.9 Organization of the Thesis

This thesis comprises four major components which can be summarized as follows:

- Providing background, identifying the problems of design changes and reviewing their associated issues through literature searching;

- Investigating and validating the main topics related to this research work through interviews with the professionals working in the construction industry, case studies and a questionnaire survey;

- Making a contribution to the body of knowledge by developing an alternative method to assess the fee of the structural design change when they occur; and

- Providing practical guidelines to manage design changes.

The four main components of the research are presented in nine chapters and are briefly described as follow:

Chapter 1 introduces the background of the research, its aim and objectives**.** It also discusses the brief research methodology used; the research justification; the significant of the study; the contributions; the scope of the research and a brief summary on the structure of the thesis.

Chapter 2 presents the findings from the literature review. It focuses on the issues of design changes which include the following:

- definitions and classifications of the design changes;
- sources, causes and impacts of the design changes; and
- new developments for managing design changes

Chapter 3 focuses on the discussion related to the principle of consulting engineering practice. The emphasis is given to these issues:

- the definitions of the clients and the consulting engineers
- the reasons for consulting engineering services
- the services provided by the consulting engineers

- the method of charging for consulting engineering services

Chapter 4 presents an overview of the construction industry in the Sultanate of Oman from which the majority of the data for this study has been carried out. It gives basic information about Oman as a country; brief highlights on Omani economy; the construction sector in Oman and the consulting engineering services in the country.

Chapter 5 discusses the methodology adopted for this research. It starts by discussing the method used to justify the need for this research through the interviews with the professionals, case studies and questionnaire survey. Then it discusses the method used for data collection. An explanation was given to each method in term of their relation to the study, selection criteria and the anticipated result of each method.

Chapter 6 presents the data collection for the initial investigation to establish the extent of the problems associated with design changes and to justify the need for this research as perceived by the professionals in the industry. Interviews with professionals, three case studies and two stages questionnaire survey have been conducted and their results were presented in this chapter. In the interviews and in the case studies, the main problems of design changes have been identified as well as their causes, sources and impacts on the projects. From the results of the questionnaire survey, the significant level of the causes, sources and impacts of design change were identified along with the possible corrective measures to minimise them. The limitations of the existing methods are presented in this chapter as well.

Chapter 7 presents the development of the proposed method to assess the fee of the structural design changes in RCC buildings. It starts by highlighting the general approach that has been adopted for generating the data. The results have been shown in tables and illustrated graphically for comparisons. From the obtained data, a method for assessing the fee of the structural design changes has been developed. Practical examples to illustrate the use of the proposed method are provided. The

chapter also provides the result of the questionnaire survey that has been conducted for validating the developed method.

Chapter 8 discusses the development of guidelines to manage design changes. It also provides in details the findings from the Delphi study that has been used as a method to validate the developed guidelines.

Chapter 9 concludes the results of the research. Discussions are made on the achievement of the objectives of the study, on the contribution of the research to the existing knowledge and recommendations are made for future research on the subject.

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