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The constraints of using design and build for the procurement of construction projects in South Africa

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1 Chapter one: Introduction

1.1 Background

The nature of construction project delivery has changed greatly in the recent past with a lot more project owners requesting shorter delivery time and an early indication of the final project cost at the start of the project (Doren and Briders, 2005). This has exposed many inadequacies in the traditional methods which had dominated the industry until recently, and led to the increase in the use of more integrated construction methods. Most of the problems associated with the traditional construction methods stem from the fact that different parties are responsible for the different functions of designing and building, meaning construction may only begin after design is complete. With the design and build system, both activities could be performed at the same time as one company is responsible for both functions.

Chan, Lam and Scott (2002) find that time, cost and quality are some of the performance measures used to gauge the performance of construction projects. In all these measures, several researchers (ling and Kerh (2004); Tulacz (2003); Songer and Molenaar (1996) have found that design and build leads to better performance when compared to other construction methods. Similar results were found in South Africa by Grobler and Pretorius (2002). While design and build is being used widely in other parts of the world, they find that the traditional construction methods remain dominant in South Africa.

While design and build has several advantages, it is also known to have some constraints. A lot more has been said of the benefits that users of design and build reap but not much emphasis has been placed on the drawbacks. The original definition of design and build meant that one firm was contracted by the project owner to do all the design, construction and complete delivery of a construction project. This has evolved with time to involve several hybrids in an effort to widen the scope of projects that can be procured using design and build, and also to reduce the problems faced during implementation. Despite this, design and build still has so many

constraints and might be the reason for its slow growth in South Africa (Grobler and Pretorius, 2002).

Ndeugri and Turner (1994) conducted a study which investigated some of the constraints associated with design and build. It found that major areas of concern with design and build include the very costly tender process, and that the standoff between design and build firms and other professionals in the industry hampers its growth. These, coupled with the fact that the method is relatively new in many countries including South Africa, means that it is absolutely important to look at both the benefits and drawbacks of the method before deciding to make use of it. This is so because, choosing the right procurement system is very crucial for the success of any project.

This research takes a look at the constraints that have hampered the growth of design and build in South Africa, and the reasons why design and build has not made the kind of inroads in the construction industry in South Africa that it has made in other regions of the world. It also recommends some solutions in the implementation of design and build, in an attempt to increase its use in SA.

Quantitative methods are used to find the most serious problems that are associated with using design and build in the delivery of construction projects. A survey is adopted whereby respondents from all the major professions in the construction industry are asked to respond to questions designed to investigate the major problems with design and build. Sample t-tests are used to find out how serious problems are. Also, solutions to these problems will be proposed.

Tulacz (2003) finds that the use of design and build can satisfy the owner's thirst for quicker delivery of projects, making it the norm with owners around the globe. This study investigates why South Africa is not taking advantage of this. It also evaluates the type of environment and structures that need to be put in place in order to increase its usage.

1.2 Problem statement

Despite numerous advantages of design and build, including benefits in time, cost and sometimes quality, its use as the construction procurement method of choice in South Africa has not been extensive, in terms of the percentage of projects which have been completed using it. This could be due to the fact that the constraints associated with the method are multiple and serious, although more attention has been given to the benefits. Grobler and Pretorius (2002) find that only about 29% of construction and civil projects in South Africa have been delivered using design and build, a figure which is considerably lower than those from studies conducted in other regions. In the UK, about 42% of projects are being delivered using design and build (Kassim and Shamsaddin, 2004) while the US department of commerce finds that up to 50% of all projects in the US will be procured using design and build by the year 2010.

Clearly, South Africa is not reaping the benefits of the method despite the fact that the Federation International de Football Association (FIFA) World cup has considerably increased the number of construction projects running concurrently, all with similar timelines. This slow growth in the use of design and build could be due to the constraints associated with the method. In light of the foregoing, this project seeks to identify the constraints associated with design and build and how serious these constraints are perceived. More emphasis has thus far been given to the benefits of design and build with very few researchers dwelling on the shortcomings of the method. Use of the method could improve tremendously if the drawbacks are identified and solutions proposed.

Ling and Poh (2007) find that the deployment of a project manager in Singapore either as an in-house employee of the design and build company or independent consultant, greatly allays most of the fears that owners have and this generally increases the satisfaction of the client when the final product is delivered. Also, some clients feel like they need to have a certain degree of influence in the running of their projects. Gordon (1994) finds that it is very important to include the owner in the early stages of the project**.** Studies have not been done in South Africa on how the construction environment could be changed in order to improve the use of design and build. This study will investigate the following issues:

Statement of research problems

- Design and build is not as widely used in the construction industry in SA as in other regions of the world, which could be due to the problems faced during implementation.
- Allowing a project owner to add a project manager to the construction team will ease the problems faced during project implementation and thus allay some of the fears of owners.

From the problem statement, the following research questions arise:

Question one

What are the constraints of design and build as a construction procurement method in SA?

Question two

How can the design and build environment be improved in order to increase its use?

1.3 Objectives

The following objectives have been identified for this study;

- Firstly, to investigate the constraints which are associated with design and build as a construction procurement method in South Africa.
- Secondly, to investigate the environment that leads to constraints faced when design and build is used in South Africa.

1.4 Hypotheses

Based on the above-mentioned research questions, the following hypotheses were proposed;

- Firstly, design and build has management problems in the tender, design and construction phases when used as a construction procurement method.
- Secondly, there are serious challenges in the management of projects due to the non-deployment of project managers in the projects.

1.5 Significance of the study

Design and build has several advantages as discussed above, one of the main ones being the fact that it shortens project completion time. With the recent trend worldwide of owners increasingly demanding that projects be delivered faster, and more emergency projects being procured (Doren and Bridgers, 2005), one would expect the use of design and build to be more rampant.

There is also a recent boom in construction projects in South Africa due to various activities related to the FIFA World cup in 2010. Tulacz (2003) finds that design and build satisfies this urge for quicker project delivery. This study is important because by identifying the constraints associated with design and build, and engaging with professionals to find solutions or changes that can enhance its use, it could increase the speed with which construction projects are completed in South Africa.

1.6 Delimitations

A major handicap of this study is the fact that only the main definition of design and build is considered, where the contractor takes full charge of both design and construction. Design and

build has many variants but only the one where the design and build firm undertakes complete design and construction will be investigated for problems and solutions. In other words, the constraints of every design and build type will not be separately studied and also, a separate study will not be done to investigate the environment that will foster the growth of each type.

1.7 Scope of the study

This study covers the construction industry in South Africa. Respondents were chosen randomly from all parts of the country from all the professions included. The professions chosen are the major ones in the construction industry including engineers, quantity surveyors, project managers, project owners, architects and contractors. Only those who have worked with design and build projects were considered.

1.8 Assumptions

The following assumption will be taken into account;

- That the different variants of design and build have similar problems which hinder their growth.

1.9 Structure of the research report

The rest of this project will be structured as follows;

The literature review will be presented in the next section. Chapter two gives an introduction to procurement systems, by explaining how design and build is related to other procurement methods. Chapter three introduces the design and build system while chapter four discusses the functioning of design and build and management issues. Chapter five discusses the methodology

used, while chapter six presents the results, analysis and recommendations. Chapter seven presents the conclusions of the study.

2 Chapter Two: Procurement Systems

This chapter gives an in-depth introduction to procurement in general and in the construction context. It will give a better picture of design and build as a construction procurement method, its place among other procurement methods and how it relates to them. By using the correct procurement method to deliver any particular project, the constraints experienced are greatly reduced.

2.1 Introduction to Procurement systems

Procurement is a term which is as broadly used as the number of definitions that exist for it. It is used in almost every field or sector including manufacturing, chemical, medical, transportation and construction sectors. Akintoye, 1994 states that as long as there is an arrangement in place that leads to a final deliverable, instruments have to be set in motion in order to arrive at that final output. All the processes that are involved in trying to deliver the final output comprise procurement.

2.2 Definition of procurement in the construction context

Procurement involves all the processes involved in trying to bring a construction owner's idea or concept into reality (Davidson and Mohsini (1987). It can be regarded in two distinct ways; firstly, the owner and in some instances his team, have to select the contractual nature or type of system that will be used to achieve his goal. Secondly, the selection of the construction team is known as the bidding process.

The above definition may make the whole process sound easy but in reality, there are so many small processes and activities that all require procurement. Davidson and Mohsini (1987) describe procurement as all the contracts and processes involved in bridging the gap between an owner's concept and the actual realization of the project. There are several types with each one better suited to certain types of construction projects.

2.3 Major trends in procurement systems

Choosing the right procurement system is crucial for the success of any procurement project and almost as important as choosing the right procurement team. Smith et al (2004) describe it as the 'single most important decision that the client makes other than the decision to build.' This is so because the type of procurement system chosen should be adequate enough to address the particular needs of the client. Moreover, the benefits of any particular method will not be gained if it is wrongly applied and the constraints will be magnified if used to procure the wrong type of project. There are so many procurement systems available for clients to choose from, according to their specific needs, and there are several major groups under which these are classified. However the most notable involve classifications that either separate the functions of design and build or integrate them.

Masterman (1996) identifies three major categories under which procurement systems can be classified. These include; the separated and co-operative systems, the integrated procurement systems and the management-oriented procurement systems.

2.3.1 Separated and co-operative procurement systems

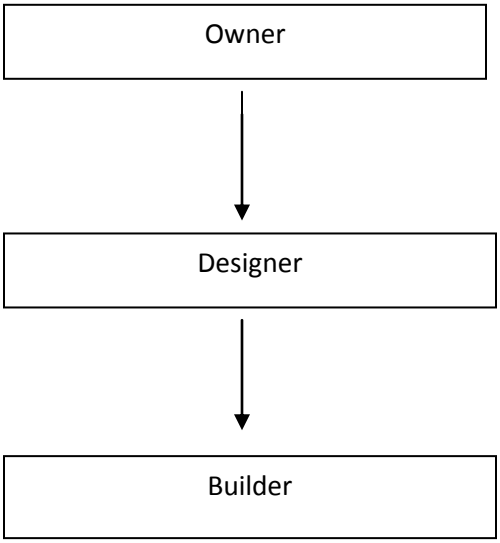


Figure 1: Separated procurement systems (Wadani, 2004)

The main feature of this category is that the functions of design and construction are separate and handled by different firms. Here, the owner engages an architect to do the full design of the project before the tender process begins. Call for tenders are only sent out after the completion of the design phase, meaning the contractor who is eventually selected has to construct according to the specified drawings and details handed to him. In most instances, the architect then acts as an agent of the client, supervising all aspects of the project, including construction and making sure that the interests of the client are protected.

This might seem straight forward but like the other major categories, it has several types and hence different conditions. In some of these cases, the contractor comes on board before the design is completed in order to make contributions using his expertise and thus enhance constructability. However, the main idea here is that actual construction only begins after design has been completed and furthermore, it is usually handled by a different firm to the one that does

the design. Another name for this is the traditional procurement method. The following variances of the traditional method were also identified by Masterman (1986):

- Two-stage selective tendering
- Negotiation
- Continuity contracts
- Serial contracts
- Cost reimbursable contracts.

2.3.2 Integrated procurement system

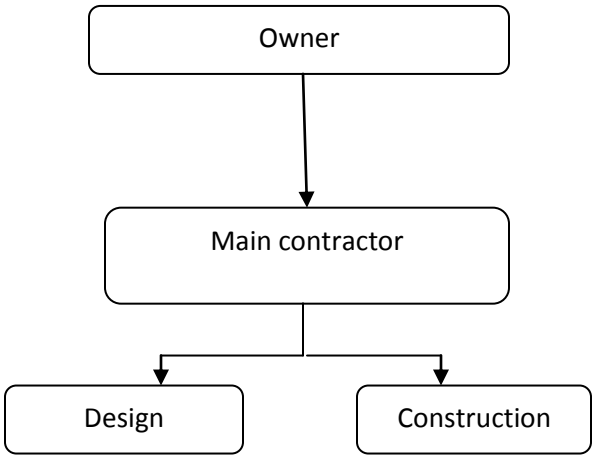


Figure 2: Integrated procurement methods (Mohamed, 2005)

The main feature of integrated systems is that one organization is usually responsible for both design and construction. This means that there is usually one main contract between the client and the main contractor and hence one point of reference. This seems to be the recent trend in construction as clients seek faster project completion, higher quality, early knowledge of costs, and ease of information acquisition because they know exactly where to turn to whenever they need to know about any aspect of the project. Because the contractor is in charge of every aspect of the project, it is easier to give the owner an indication of what the full project cost will be.

Integrated procurement systems are otherwise known as design and build and have the following variants;

- Package deals
- Turnkey
- Develop and construct

2.3.3 Management-Oriented Procurement System

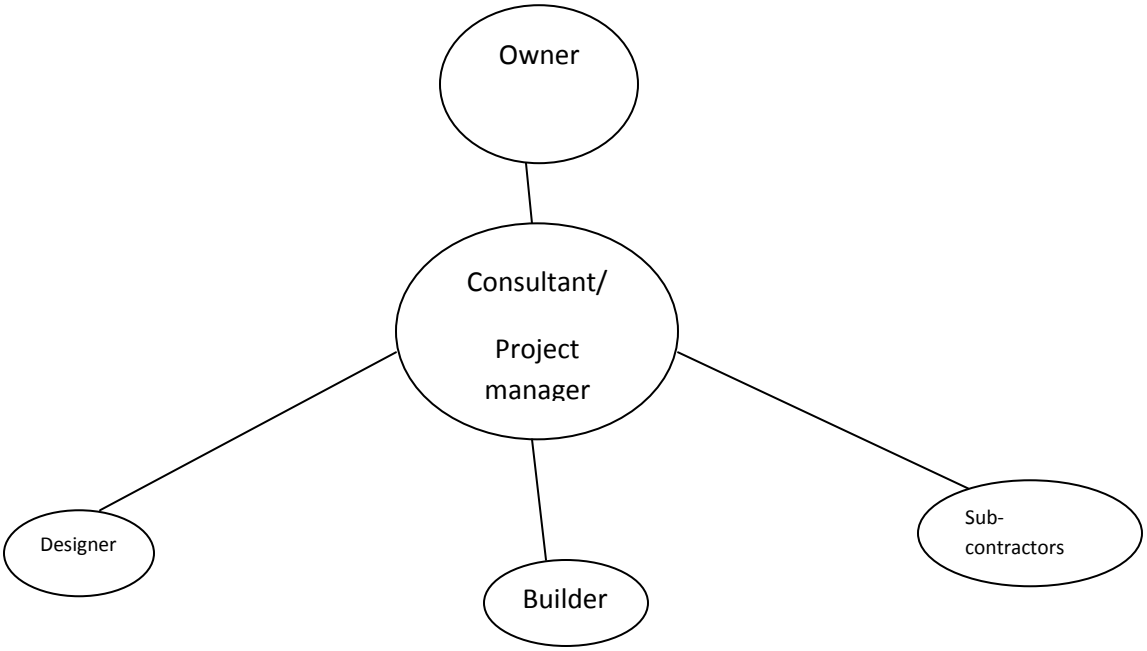


Figure 3: Management procurement systems (Mosley, 1990)

With this system, the whole management process is contracted to a consultant whose objective is to manage the entire process, with specific attention to the construction aspects. In some instances, the owner simply engages a construction manager who then hires the subcontractors or the owner directly hires the subcontractors himself and the construction manager simply manages the team of subcontractors. Usually, the functions performed by the other consultants are directly under the supervision of the client, however, sometimes a super manager is hired to

oversee not only the construction process, but also the other functions in the entire building process. Mastermans (1985) also identifies the following sub-categories under this major group;

- Management contracting
- Construction management
- Design and manage

2.4 Factors to consider when selecting a procurement method

As already alluded to above, choosing the right procurement system is crucial for the success of construction projects. Almost every project is unique in the field of construction and that means each one has features that are unique to it. Thus the main features around a project should determine which procurement system is appropriate for the particular project. Ashworth (2004) states some of the points that owners should take into consideration when deciding on which procurement system to use. Project owners should use processes that will encounter the least constraints during the building process. Some of these factors are discussed below.

2.4.1 The time line facing the owner

This is a very important point as some projects require quick completion and hence have very short time lines. Such project owners should consider using integrated systems as design and building take place simultaneously and hence construction begins before design is complete, thus reducing the construction period (Songer and Molenaar, 1996). This is the situation currently facing South Africa as it races to complete all the FIFA World Cup projects on time.

2.4.2 Financing issues

The type of financing and entity financing the project are important for any project. If the financiers require knowledge of the project cost at the beginning of the project, it becomes ideal to use a system that could help the owner ascertain the total project cost at the beginning (Mohamed, 2005). In such instances, it would be ideal to use to an organization that can integrate both design and build since they will be responsible for the execution of the entire project.

2.4.3 Size and complexity of the project

The size and complexity of a project should determine the type of procurement system to use as certain systems might not be best suited for certain projects. McCaffer (2001) finds that small projects will be better suited to traditional procurement methods while complex projects should be procured using management systems since they source consultants with vast knowledge.

2.4.4 Owner's knowledge of the construction industry

This is very important as some procurement systems like design and build require the owner to have a certain degree of knowledge of the industry in order to realize the benefits of using it. As Ling and Poh (2007) find, a detailed Request for Proposal, which should contain a well-defined scope of work must be prepared before the design and build organization is contracted. This can only be done if the owner is sure of what his needs are and what he wants the project to achieve.

2.4.5 Legal issues

In some countries, not all systems can be used to procure all types of projects, especially public ones. It is only recently that some countries like China passed laws allowing construction projects to be procured by one entity from start to finish.

2.5 *Conclusion*

Construction is a disintegrated industry with every product unique and with various functions independent by nature. Every contract is designed to suit a particular project, meaning there are no standard contracts or products. This makes it very important for project owners to choose both the right procurement system and also the right team in order to get desired outcomes. Choosing the wrong system increases the problems that will be encountered during the project as well as a lack of realization of the benefits of the system chosen.

This chapter gave a brief introduction to procurement in general in order to be able to gauge how design and build relates to the other methods. It becomes easier to do an in-depth study of design and build with background knowledge of the role of procurement in projects, substitutes to design and build and how it compares in terms of importance to the other procurement methods. The next chapter gives a concise introduction to design and build as a procurement method in construction projects.

3 Chapter Three: Design and Build Procurement

This section gives an in-depth introduction to design and build as a construction procurement system, in order to get a better understanding of the constraints that are associated with the method when they are presented later in the next chapter.

3.1 Definition

Design and build is one of the oldest construction delivery methods as it has its roots in the medieval period where the Master Builder was knowledgeable and in charge of all aspects of the construction process. Songer and Molenaar (1996) describe it as the oldest procurement method, which temporarily disappeared during the Renaissance period due to specialization of various functions in the industry, but resurfaced again strongly in the 1970s because of the rising inflation and the increasing need for projects to be finished quicker than previously.

Design and build is a construction delivery method that offers the owner a single point of reference, meaning one company is responsible for both design and construction as opposed to the traditional methods in which the owner engages different companies to perform different tasks. Beard et al (2001) define it as a delivery method in which the design and build team is responsible for the design, construction and ultimately every other aspect involved in bringing the project to completion.

Songer et al (1997) define design and build as a project procurement method whereby one entity or consortium is contractually responsible for both design and construction. This means that most of the risks of the project are on the design and build company and the owner knows exactly where to go to when he needs to know about any aspect of the project. Also, because only one firm is in charge of delivering the entire project, it is expected that teamwork, communication and general coordination should be easier.

Although the main definition of design and build requires that one company completes the entire project from planning to construction, using in-house expertise, many hybrids of the method have emerged. The misunderstandings between various experts in the field and also the argument on who should lead the design and build process led to different variants of the method, in a bid to accommodate all the professionals and also expand the net of project types that are suited for design and build. The main difference between design and build and the other construction methods is the fact that in design and build, the owner's team carries out a very small amount of the design while in the other methods, the owner's team is fully in charge of design. This means not all projects are suited to design and build and only those that are easy to incorporate both functions of design and build should be procured using design and build.

3.2 Project types suited to design and build systems

This section discusses the type of projects that are most suited to design and build in order for the benefits of the method to be realised. It is important to know the types of projects that would be best procured using design and build so as to understand how constraints encountered relate to different project types. Just like it is very important to select the right project team, it is also important to establish the right project contract in order to avoid multiple problems during the project.

Ling and Lau (2002) find that design and build is not suited to disconnected projects. This is so because design and build by nature is integrated and might not be good for projects with multiple phases and sub-projects. The reason for this is that the project might need to be broken down into several sub-projects for easier management. This defeats the core objective of design and build as a project delivery method, which is to integrate the project in order to reap most of its benefits. It is for this reason that some have concluded that design and build is better suited for smaller projects, although they might be very complex in nature.

In design and build projects, the contractor handles both the design and construction functions. This means he has the advantage of doing a design that is more constructible than a contractor

who simply inherits a complete design and has to build it. This means design and build contractors can be more innovative when doing their designs as it is the same organization that does the construction. Moreover, such innovations in design will only be incorporated if they can be built.

3.3 Sectors that make use of design and build

It is extremely vital to know if a project from a particular sector would be best procured using design and build. This would expose some of the constraints that will be encountered even before they do occur and provision can be made in advance to deal with them.

Design and build has traditionally been used in private sector projects, although it is starting to gain ground in the public sector. A lot of the benefits reaped from using the method in the private sector could be transferred to some similar public sector projects. This will include projects that face time and cost issues. Akintoye (1994) finds that in 1991 in the US, while 21% of projects were procured using design and build in the private sector, only 12% of public sector projects used the method.

However, Law (2004) reports that the use of design and build for the procurement of public projects in the US has increased as several states pass new laws allowing design and build to be used on public projects. A study done by Xu and Greenwood (2006) finds that there was a huge interest in the use of design and build, especially in the public sector, to procure construction projects after a law was passed allowing projects (including public projects), to be completed using design and build.

Hanscomb (2004) conducted a study which investigated how various countries using design and build used it in the public and private sectors and also among the other sectors within the economy. In all the countries looked at, all but Greece used design and build more in the private sector than in the public sector. Use in the private sector was usually more than double its usage in the public sector. The study revealed that sectors using design and build to procure projects

included retail, education, medical, and road and rail construction. Surprisingly however, globally the sectors that made the most use of design and build were manufacturing, distribution and warehousing.

3.4 Use of design and build in South Africa

Not a lot of work has been done to find out which sectors or project types are more suited for design and build projects. However, in the study by Grobler and Pretorius (2002) it was found that more professionals from the construction industry thought the traditional methods were more suited to public sector projects, while design and build was better suited to the private sector.

There was however a dispute among various professionals over which type of projects suited design and build. Contractors claimed that large and complex projects would be better procured using design and build; while designers said the traditional methods would be better. From the list of prominent projects presented in the study that have been procured using design and build, it seems office buildings and highway projects are the projects that have been most procured using design and build in South Africa. Grobler and Pretorius (2002) listed some of the major projects that have been procured using design as follows:

- Saldanha Steel Plant valued at R800 million – private sector
- The Techno Centre for Vodacom in Bellville valued at R116 million – private sector
- The Prison at Louis Trichard valued at R300 million – public sector
- The Nelson Mandela Bridge in Johannesburg valued at R81 million – public sector
- Samlam office spaces in Sandton valued at R40 million – private sector

This range of projects shows that in South Africa, design and build has been used to procure in various sectors and the project sizes have also varied from huge projects to very small ones. It also shows that design and build has been used more to procure private sector projects. It will also be interesting to see how use of design and build in SA compares with usage in other regions across the world.

3.5 Comparison of use of the design and build in South Africa and other regions

The issue of skills shortage in South Africa is well documented, especially in the construction and other engineering industries. The coming of the soccer World Cup to South Africa in 2010 has led to an increase in the demand for professionals in almost every sector of the construction industry. All projects related to the world cup have similar timelines. This adds more pressure to the already strained resources, especially the required skills needed to complete these projects. There is the issue of projects falling behind schedule. Design and build reduces project delivery time as will be discussed later. This means innovative procurement methods like design and build could be used to curb some of the problems that the construction industry in South Africa currently faces.

Despite the numerous advantages that design and build possesses as a construction procurement method, growth in its usage in South Africa to deliver construction projects has not been as fast as it has been in other regions around the globe. Grobler and Pretorius (2002) find that only 29% of construction and civil projects in South Africa are delivered through design and build, although they also find that there seems to be a bright future for design and build. This is a far cry from the 62% of projects that are still procured using the traditional methods.

In Asia, the use of design and build has also been slow. A study by the Building and Construction Authority (2006) in Singapore finds that between 1997 and 2006, only about 20% of construction projects were procured using design and build. The study reveals that the reasons for this include the fact that project owners feel they need to bear more risk and participate more

in their projects, concerns about the quality of projects procured using design and build and issues surrounding maintenance, which they say are not adequate.

Chan, Chan and Lam (2004) also find that design and build is still used very sparingly in Hong Kong and other Asian countries. Their study reveals that the slow growth of design and build in Asia is also attributed to the strict government control of construction activities in the region. However, the significant change in the economic landscape in the region, has seen a recent reduction in government control over design institutes (China Statistics Press, 2002) and hence the entire construction industry.

Growth in the use of design and build has however been faster in some regions around the world, especially Europe and America, with more satisfactory results. Konchar and Sanvido (1998) find in a study that design and build has been experiencing extraordinary growths in the US, compared to figures of the early eighties and nineties and also when compared to other methods used in the delivery of construction projects. Rosenbaum (1995) quotes a study by the US Department of Commerce which predicted that usage of design and build as procurement method for nonresidential construction will be up to 50% of all projects by the year 2010. In the UK, about 42% of projects in terms of value are being delivered using design and build (Kassim and Shamsaddin, 2004). This section concludes that design and build is not as widely used in SA as in other regions especially Europe and North America. This may be due to the fact that some of the defining features of the method are not better suited to the South African construction industry.

3.6 Characteristics of the design and build system

It is very important to know the characteristics of design and build as a procurement system as it helps owners to analyse if it is the right method for their project or not. For example, by knowing that a well defined scope is essential for design and build contracts, an owner who does not have the expertise or right staff to prepare this for him, may avoid from the method and thus evade many of the problems he might encounter during the project.

Design and build has certain characteristics that are peculiar to it and make it stand out as a construction procurement method. Besides the fact that there is a single organization responsible for delivery of the project, the following features set design and build apart from the other procurement methods:

3.6.1 Early knowledge of contract sum and project time

In a design and build project, the contractor is involved from the beginning and that makes it easier for the owner to know what the total cost of the project will be. The contractor is responsible for both functions of design and construction, meaning the price can be set before the project even commences, or early on during the design phase. This is in stark contrast to the traditional building methods where the tender process is only carried out after the design has been completed by another party. This means in such instances, the contract price is usually known much later after the project has started.

3.6.2 More accurate estimation of cost and time

This is a key feature of design and build projects due to the fact that an experienced contractor would know how long and how much it would cost to construct a design they have undertaken. This is so provided the owner does not make many changes to the scope. However, even in the event of changes, Mohamed (2005) finds that there is usually adequate arrangement made for evaluating changes in design and build projects, therefore impacting less on project cost and time issues.

3.6.3 Well defined scope/brief

In design and build projects, the owner usually has much less influence after the project has been commissioned as the design and build team is responsible for all aspects of the project. This means the owner must make his needs very clear from the beginning. The scope or client brief which is usually part of the Request for Proposal should be clear and should clearly define what the client expects to get as his final output. Songer and Molenaar (1997) find that a well defined scope is critical for the success of design and build projects. Knowledge of the construction industry helps owners to better define their goals and it is for this reason that Ndekugri and Church (1996) claim that owners without any construction knowledge should stay away from design and build.

3.6.4 Contractors must have both design and build capabilities

In traditional building systems, the contractor is only responsible for building a design that has been given to him, which is very different in design and build where the contractor has many roles. Stillman (2002) finds that the contractor in design and build projects has many roles including design, construction and their integration. Even in instances where the contractor outsources the design phase of the project, it is still important that he or his team has design knowledge in order to enhance the constructability of the project. Kassim and Shamsaddin (2004) find that one of the main problems with design and build projects is the fact that many contractors lack the capabilities to manage the design processes.

While it is true that some of the characteristic features of design and build, like the fact that contractors have to have both design and construction knowledge will make it less suitable to SA, the fact that there are many variants of the method make it less difficult to implement.

3.7 Hybrids of design and build

It is very important to have knowledge of the different forms of design and build contracts in order to be able to choose the form that best suits project owners. Design and build has evolved over time, its definition is now broader and many more projects can be procured using the method. By selecting the best contract form that suits owners, a lot of problems are avoided during project implementation.

Also, because this study only considers one definition of design and build where one firm is contracted to procure the whole project, it becomes important to examine how all hybrids are related to general definition of design and build and how constraints of the main form could be related to the constraints of each sub category. It is important to choose hybrids suited to each project to limit the constraints faced during construction.

Two things are very important when doing the planning of any project and these are; the contract type and the organizational structure of the team that the owner decides to choose. One of the

major advantages of the design and build system is that it allows the owner to have a single contract with the main contractor and there is therefore only one point of reference.

It is however not as straight forward as it may sound, as the various hybrids have different features that can sometimes be swayed from the main definition. Several forms of design and build have been discussed in the literature with Rowlinson (1987) identifying three major types thus;

- pure design and build
- integrated design and build
- fragmented design and build.

Akintoye (1994) identifies the following six forms of design and build;

- traditional design and build
- package deal (including turnkey)
- design and manage
- design, manage and construct
- novation design and build
- develop and construct.

The forms of design and build discussed in this study will be a combination of the two earlier categorizations mentioned. While Rowlinson (1987) uses a very broad categorization, Akintoye breaks design and build down in a less broad manner. A closer look at both categorizations reveals that Akintoye's the six categories of the latter's method can fit into Rowlinson's broad categories identified with the exception of novation design and build.

3.7.1 Pure design and build

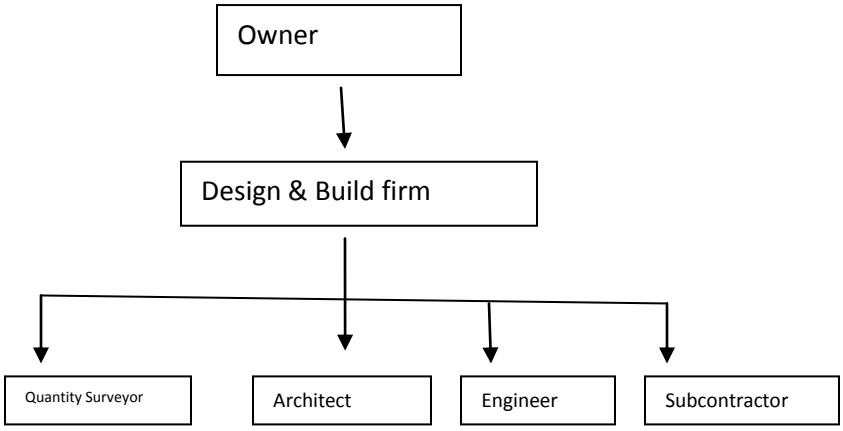


Figure 4: Pure design and build systems (Mosley, 1990)

Traditional design and build

This form represents the original idea that design and build represents and it is the form considered in this study. A contractor is engaged to perform all functions including design and construction while producing an output that reflects the client's need. Here, the contractor usually has most of the required specialists within the company and only subcontracts out very specialised or hi-tech functions. In this set up, there is usually a one stage tender where one contractor is appointed by the owner, although Janssens (1999) distinguishes two types which include the single stage tender and two-stage tender.

3.7.2 Integrated design and build

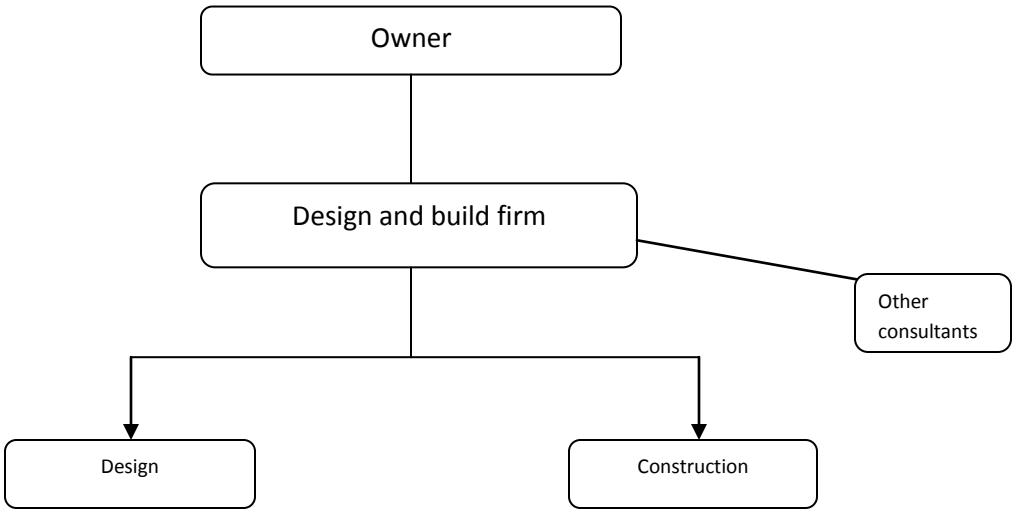


Figure 5: Integrated design and build system (Mohamed, 2005)

With integrated design and build, the main contractor does not have all the major functions within his organization but has subcontractors with such capacities that he can always rely on. There is an ongoing relationship between the main contractor and these specialists which makes it easier for the main contractor to manage the process. The following forms of design and build have been identified with the integrated design and build method;

Design and manage

With this form, the main contractor assumes more of a management role, although design is also a core responsibility for him. The contractor does the design and then manages all other aspects of the project, including the subcontractors hired to do the other functions.

Develop and construct

With this form, the main contractor inherits a partly designed structure to which he has to complete in accordance with the constructability of the project. He will normally do this with his

own in-house design team or outsource it to a subcontractor. He is however responsible for design as he makes the decision on whom to complete the design and has some allowance to do it in such a way that complements the whole project.

3.7.3 Fragmented design and build

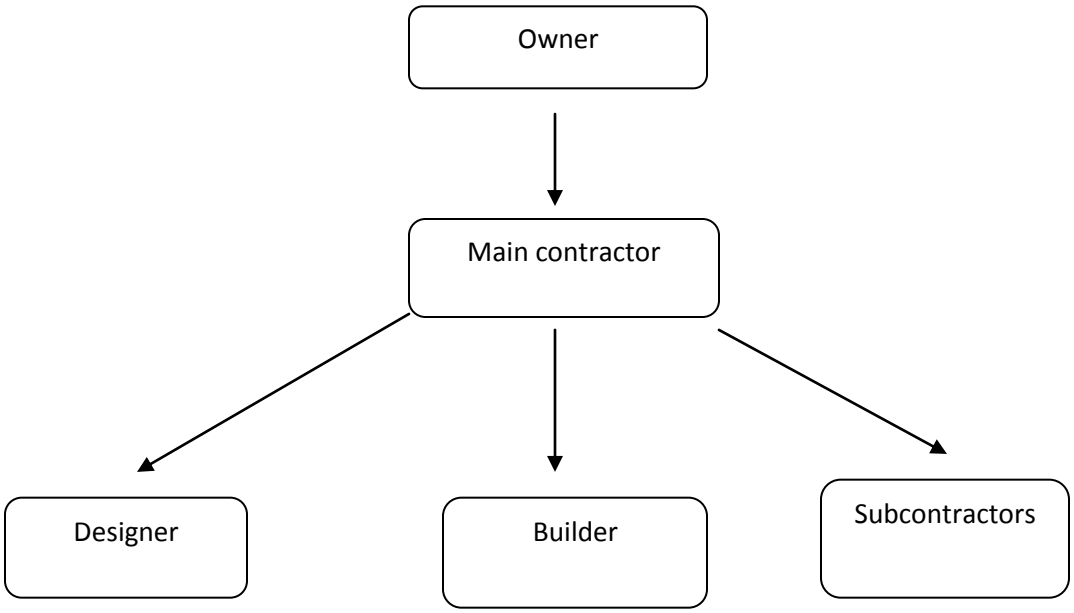


Figure 6: Fragmented design and build systems (Mohamed, 2005)

In this form, the main contractor's role is mostly in terms of co-ordination and management. The main contractor accepts the responsibility for the entire project but has no in-house specialists and so he has to subcontract almost every function and then co-ordinate to make sure that they all work together properly in order to achieve the desired end product. The following forms of fragmented design and build methods were identified:

Package deal

This form includes some turnkey contracts and is usually huge projects, where the main contractor gets into partnership with several partners to do standard projects for a client. The

partners can sometimes be varied and diversified and usually the main contractor does not have a relationship with the other partners. This is why it is considered here under the main category, fragmented design and build.

Design, manage and construct

This form is very close to the pure design and build but for the fact that the main contractor only has responsibility for part or some of the construction and not the whole process. He essentially co-ordinates all the functions even those that are not his responsibility. He would normally not have many ties with these subcontractors as they are sometimes appointed by the owner.

3.7.4 Novation design and build

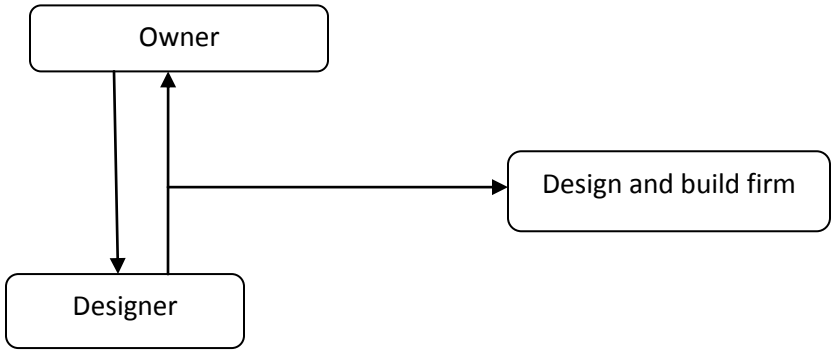


Figure 7: Novation design and build system (Wadani, 2004)

The client hires an architect or design team to complete part of the design, to the extent that the client's needs have been fully identified. The partly designed structure is then sent out for tender, after which a contractor is identified and the architect or design team then transferred to the main contractor, to work as part of the team under him. It should be noted that the architect starts as an employee of the client but ends up as an employee of the main contractor and is paid by the contractor after he joins the contractor's team. So the contract which the client gets into with the contractor stipulates that the architect will be transferred to his team when he takes over. This

means the liability for the contractor for design should be much less than in other design and build hybrids.

The hybrids of design and build make it less problematic for design and build to be used in construction projects as it makes it more suitable to particular types of projects and thus reduces the room for complexities.

3.8 Benefits of using design and build in construction projects

Although this study looks at the constraints of using design and build in South Africa, it is important to note that the method has numerous advantages. It is important to know that if solutions to the constraints can be identified, it could become a very beneficial procurement system.

The advantages of design and build as a procurement method in construction are numerous and have been well documented by several authors. These include faster project delivery thus shorter project time, cost savings, single point of reference, and the much debated increase in the quality of projects procured through design and build compared to those procured using traditional and other methods. The advantages of design and build are discussed below.

3.8.1 Single point of reference

This is probably the most important advantage of design and build as a project delivery method and is derived from the meaning of the method itself. The same company is employed to handle both design and build giving it a distinct advantage in terms of coordination and integration of all aspects of the project. This is very important as it means that the project owner will know exactly where to go to in case he has any concerns. One company bares most of the risks, which makes it easier for the owner in case of any problems, especially if he decides to proceed with a law suit. Sometimes, there may be numerous consultants and other sub-contractors involved but it still does not change much as the main contractor will still be the point of reference as the other consultants and sub-contractors will be contracted by the main contractor.

The steering committee for construction in Singapore (1999) finds that the main advantage gained from the single point of reference is that project integration leads to fewer cases of re-works and other errors, which eventually leads to savings in cost and time. Using design and build does not simply mean the advantages from the method will be derived. The atmosphere has to be made right and the biggest factor here will be that of coordination and team work. If these are lacking, then the benefits of using the method will not be attained. Kumaraswamy et al (2005) find that team work in design and build projects is crucial for it to benefit from these advantages.

3.8.2 Shorter project time

Research findings on design and build have almost always shown that projects using design and build result in shorter delivery times. Tulacz, 2003 and Songer and Molenaar (1996) find that using design and build shortens the delivery time of construction projects. In South Africa, the same result was found by Grobler and Pretorius (2002). Ling and Kerh (2004) find design and build projects to be 12% faster than projects that use traditional methods. The time used to deliver projects is becoming more and more important nowadays as the numbers of projects that are needed urgently continue to increase.

In South Africa today, the issue of skills shortage is fundamental in the construction industry and thus makes it more important for projects to be completed as quickly as possible. The same type of projects are all competing for the same kinds of skills and what makes it worse is the fact that most of the projects have almost the same time line. The coming of the world cup to South Africa in 2010 has meant an even worse situation as concerns increase due to the competition for skilled people. Some projects are already behind schedule, meaning innovative ways have to be employed in order to get the products in on time.

3.8.3 Savings in cost

When one company carries out both functions of design and build, it ensures constructability, meaning it creates a design and project that can be completed. Issues like over-design are avoided as the company in charge of both design and construction will only come up with a design they know can be built.

Linked to costs is the fact that project owners have an idea of the cost early enough, helping them plan better. Hanscomb (2004) finds that one of the reasons for the growth in the use of design and build is that more and more owners are striving to have an idea of total project cost at the beginning of the project. An indication of project costs and delivery time is given at the beginning of the project which is important in helping project owners plan. Grobler and Pretorius (2002) and Songer et al (1996) find that one of the main parameters that project owners use to gauge success is the amount of budget variation during the life of the project. In design and build projects, budget variations are avoided as the contractor is required to give a total cost in the tender documents.

3.8.4 Possible increases in the quality of projects

The issue of whether design and build leads to better quality projects is one of much debate. While some studies show that it offers slightly better quality than the traditional method, several others believe there is no significant change in quality when either method is used. Konchar and Sanvido (1998) find that design and build on average offer the best performance, although quality was the only aspect they felt was almost the same for both methods. However, Akintoye (1994) finds that there was no significant change in quality when either method was used, Gidado and Arshi (2004) contradict it with results that showed 54% of their respondents accepted that there was an improvement in the quality of projects when design and build was used compared to the traditional procurement method.

3.8.5 Room for innovation and improvement

This is possible because the design and build firm takes charge of both design and construction, meaning it (the design firm) can be industrious and inventive during the project (Cecil, 1983). This is possible as the contractor is able to only make such changes when constructability is enhanced.

3.9 Summary

This chapter gave an introduction to design and build and compared its use in the rest of the world with that in SA. A discussion on the various categories of the method were carried out and

also the types of projects that are suited to the method. Characteristics and advantages of using the method were also explored. The next section takes it a step further to look into the management issues that could arise when design and build is used as the procurement method in construction projects. Issues are investigated at all levels of project implementation including tender management, design, and construction right to project closure.

4 Chapter Four: Constraints and Management Issues Associated with the use of Design and Build in Construction

A general description of the functioning of design and build contracts is presented, before potential problems are discussed.

4.1 The general mechanism of design and build systems

Design and build procurement systems start with the owner's concept which is developed in the form of a Request for Proposal. This is the document which is sent out to potential contractors to prepare tenders and bid for the project. The key difference with the traditional methods is that while full design is complete before tendering for the traditional methods, only the specific needs of the owners are communicated to the contractors with only schematic design (or varying levels of designs depending on which variant of design and build is being used) done before the tender process in design and build projects. Ling and Poh (2007) find that one of the problems with tender preparation and evaluation is the fact that both contractors and owners have to make decisions on the price for the entire project from half complete designs.

After the detailed Request for Proposals have been fully established by the owner, they are then sent out to potential contractors, depending on the tender process adopted by the owner and his team. Potential bidders will, based on their understanding of the Request for Proposal, submit their tenders to the client. The client then goes through the selection processes before finally choosing the contractor for the project. This is a problem area as tenders for the full project will have to be submitted using very limited information. This is different compared to traditional methods where full designs are used to prepare the tender.

Depending on the organizational structure of the contractor, the full design could be done in-house, or subcontracted to a design company. However, the main point here is that there is only one major contract between the owner and the main contractor. Subsequent sub-contracts could

exist between the main contractor and other consultants but the owner has only one place to go to if he needs to know about any aspect of the project; to the main contractor. Weatherall (2000) gives the example of the Novation design and build system where the owner initially gets into a contract with a designer to do a part of the design (up to 30% in some cases) and the subsequent creation of a new contract with the chosen contractor and the eventual transfer of the part design, designer and other experts to the design-build team. This reiterates the fact that at each point, the owner only has one existing contract.

One of the major advantages of design and build is the fact that it leads to shorter project times, which is possible because the builder takes charge of both functions of design and build, meaning he can decide to start preparations for construction, or actual construction even before design is complete. While this is a benefit to the process, it could also become a big problem area if not properly managed. Also, the fact that design and build firms make only designs that they can build, enhances constructability and reduces the number of reworks (Akintoye, 1994).

The main contractor should appoint a project or construction manager who is knowledgeable in both design and construction issues in order for the full benefits of using the system to be realized. Stillman (2002) finds that in order for the two processes to run smoothly, the project manager appointed by the contractor must have knowledge in both design and construction. However, Horwitz (2001) highlights the fact that there are very few professionals in the construction industry with knowledge in both fields. This has also become one of the major disadvantages of design and build as a procurement method in construction.

While supervision of the entire project, especially construction, is the responsibility of the project manager appointed by the main contractor, Mckew (2001) states that there is a new trend in design and build, with owners appointing their own project managers to approve packages of work delivered and defend their interest. Ling and Poh (2007) find that the inclusion of a project manager by the owner, especially those owners not knowledgeable in construction, increases owner's confidence in the method and hence its use to procure construction projects.

Design and build begins from tender process through contract management, design, construction and project closure. There are management issues in all these stages of implementation of design and build.

4.2 Tender preparation and evaluation issues in Design and Build

The fact that owners have considerably less influence in design and build procurement systems compared with other construction procurement systems makes it imperative for the owner to select the right design and build team. Kumaraswamy et al (2005) find that it is more important for owners using design and build methods to get the right contractor than those using other construction systems. This is so because once the project has been handed over to the contractor, the owner cannot be able to make much contribution. It therefore becomes crucial for the owner to select a team that can bring his concept to reality.

It is for this reason that design and build owners have tended to use the most stringent methods for contractor selection. Abi-Karam (2001) states that, 'the selection method for the successful design-build team is one of the most intensive, challenging, and risky propositions for all parties.' Ling and Poh (2007) support this in their study where they find that it is considerably more difficult to evaluate design and build tenders than tenders in other construction methods due to the fact that design is only half complete at the bidding stage.

4.2.1 Tender preparation constraints

In design and build systems, potential bidders prepare their bids according to the information found in the Request for Proposal. This means the quality of both the design done by the contractor and hence the tender sum will depend on the information they receive. It is therefore very important that the owner conveys in no uncertain terms, his needs in the request for proposal. This is usually difficult for owners with no knowledge of the construction industry.

The scope statement supplied should be very detailed, including performance and quality criteria. Because the final contractor will be chosen from the bids submitted, it is very important that the

potential contractors submit the right bids and also that the right process is used. Thus, owners who do not quite understand the technical aspects of the process should seek advice from appropriate consultants.

There are several types of tendering practices used by design and build owners and each project should adopt the process that best suits its needs. The size of the project, owner type, complexity of the project, cost and time are some of the issues owners should take into account when choosing the right tender preparation method.

4.2.2 Tender evaluation constraints

As already alluded to, selecting the right contractor or team is very important for design and build projects. Chan et al, (2001) in an extensive study on the success factors most important for design and build projects, find that along with effective teamwork and proper coordination of the project, the ability and competence of the contractor are crucial for success. This means evaluating tenders should be a very important process to all owners using design and build systems. The processes used should be in such a way that all details are considered, including the character of potential contractors. This makes the evaluation process more detailed and rigorous for design and build contractors than for other procurement systems.

The process can also be very different for private and public projects. Al-Rashaid and Kartam (2004) state that while design and build has been embraced by the private sector, there is still some skepticism in the public sector, thus making the selection process of contractors a more complex process in public projects. This can also be due to the fact that owners of private projects tend to be more hands on while public project owners are usually more distant. For this, Wardani (2004) recommends that owners in design and build projects should spend a lot of time on the procurement process for the right project team. More time, money and effort should be dedicated to select the right contractor by project owners who choose to use design and build.

4.3 Contract management issues in design and build systems

A major advantage of design and build is that only one major contract exists between the owner and the main contractor. However, depending on the formal contract between the owner and the contractor, and also the organizational structure of the main contractor's firm, several other sub contracts could arise. This is the case with novation design and build where the owner first establishes a contract with a designer to do part of the design, and then cancels the contract afterwards and subsequently signs another contract with the main contractor, who then completes the design and does the construction. This is a major problem area in design and build projects as the main contractor may not always be willing to work with the designer appointed by the owner.

Although standard forms of contract exist for various regions developed by various institutions, Chan and Yu (2005) find that the fragmented nature of the construction industry makes it very crucial for each project to carefully consider its contract specifications with other parties. The problem of establishing ideal contracts in construction is exacerbated by the fact that design and build is new is many regions, meaning standard contracts do not yet exist for design and build projects.

4.3.1 Contract between the owner and the main contractor

Because the main contractor is responsible for both design and construction, this is obviously the main contract and should technically be the only contract in any design and build project. This is however never the case as the different hybrids of the method allow the owner to get into different contracts with other professionals like designers. The level of design allowed to the owner usually indicates the amount of influence he will have on the project (Frederickson, 1998). Jansens (1991) claims that the reason for different variants of design and build is due to the amount of design influence that owners like to have. It is however not always easy to transfer half complete designs together with the design manager to the main contractor as issues of separation of responsibility become apparent.

Ling and Lau (2002) present the following contract types, depending on the amount of design input made by the owner and his team;

The scheme design system

Here, the owner first gets into a contract with an architect to provide a full schematic design for the project. This forms part of the Request for Proposal that is then sent out to potential bidders. From this, it is clear that they establish two contracts, first with the architect and then with the main contractor when the tender process is over. Only owners with in-house consultants will avoid getting into a separate contract for the schematic design to be completed. This means the issue of having two contracts will affect owners who do not have in-house teams that can produce these design schemes for them.

Outline design

With outline design, only an outline of the project is prepared by the owner or his representatives and sent out to potential bidders. This is conducive for one-stage design and build tenders where potential bidders are asked to provide their documents including their designs for evaluation and a choice is made directly. In this situation, it is most likely that there will only be one contract, between the owner and the main contractor. However, there are issues as potential bidders will have to provide tenders using very limited sketchy information and may hence miss the concept.

Sketch a plan

Sketchy plans are done by the owner and his team and sent out together with the Request for Proposal. Potential contractors are then asked to submit their design proposals for evaluation, after which a number of contractors are short-listed and asked to submit full designs including prices. The contractor for the project is then chosen. There is also the danger of the bidders misunderstanding the concept as the information supplied is usually very limited.

Turnkey

The last contract type is the turnkey where no designs at all are submitted with the Request for Proposal. Contractors are tasked with complete design and full control of the project from start to finish and hence the owner has only one contract with the main contractor. Although this arrangement has many benefits, there is the danger usually most associated with design and build

projects, which is that the contractor ends up constructing the project more to his taste than to that of the owner.

4.3.2 Design and build Contract Liability

As contracts in construction are typically drafted to suit the particular project in question, the liability for each project or part of the project is also dependent on the outlook of the contract. The party responsible for the project is also responsible for any shortcomings that might be experienced. The liability to the main contractor depends on the amount of input that the owner or his representatives make. The more input contributed by the owner, the more liability he will expose himself to and the less liability the main contractor will bear.

In design and build projects, especially in hybrids of design and build where the owner's representative undertakes part of the design, it becomes difficult to place the liability of design and also the entire project on any individual. This could lead to several complications, as the level at which contractors in design and build setups should perform is not clear. It is specified in the contract but the level at which it is judged (that the contractor has performed at an optimum) remains a challenge in design and build projects. Chan and Yu (2005) propose two generally accepted types of liabilities in design and build projects;

Fitness for purpose

This refers to liability that applies to the industry in the UK where the main contractor is expected to use 'due care and skill' in the execution of their task. It is generally accepted that the final output delivered by the contactor should be fully representative of the brief supplied by the owner and also be useful for the purpose for which it was intended.

Reasonable skill and care

In Hong Kong, the reasonable skill and care option to evaluate projects was established. It is a scaled down evaluation method from the fitness for purpose, which considers the situation or conditions under which the contractor had to work, before making a decision on whether the contractor did everything within his power to deliver the best project possible.

4.4 Management issues at project implementation (design and construction phases) level in design and build

One of the pillar stones of design and build is the fact that the functions of design and build are integrated in order to reap the benefits of shorter delivery time, reduced cost and early knowledge of what the final cost will be. The fact that construction actually begins before design is complete means that communication, teamwork, planning and information dissemination should be at their best. It could be very disastrous if a situation arises where the construction team starts constructing using a half complete design, only to later realize that aspects of it have been changed. This is in stark contrast to the traditional building methods where design is completed and approved before any construction can begin. This means communication between team members in design and build projects should be much enhanced.

Here are some of the management issues that arise during design and build projects;

4.4.1 Planning and scheduling issues

It has already been established that in design and build projects, the owner must have a well defined scope included in the Request for Proposal. This is because the contractor is responsible for both the design and construction aspects of the project and can hence proceed with construction even before design is complete. This makes Planning and scheduling much more complicated as the team has both functions of design and build to integrate and make sure they work properly in order to benefit from using the method

Planning and scheduling should base on the following important components;

<u>Sequence and duration of activities identified</u>

As time is a crucial factor in design and build projects, it is very crucial to get the sequence of activities and their durations right. This issue is compounded by the fact that construction can begin before design is complete. Activities with long leads should be identified and started early so that they do not hinder the progress of subsequent activities and hence slow down the speed of the project. This makes it much more complicated to create a correct sequence for all the

activities for both design and construction functions. It is also very important that each member of the team keeps to schedule in order to have the desired output. If there are subcontractors hired by the owner or main contractor to do any special works, they must be advised to communicate their own schedule to the project manager so that it can be incorporated into the overall project plan

Regular project meetings

Although the main contractor is charged with the overall responsibility of delivering the entire project, some hybrids of design and build allow for the owner to approve of work packages as the project progresses. This will mean that regular meetings will have to be held between the main contractor and the owner's representatives. Regular meetings should also be held between the various teams, like the design and construction teams or the main contractor and subcontractors. This is usually easier in design and build organizations that incorporate the various teams inside the organization as opposed to contractors that outsource some aspects to external subcontractors. Although the burden of meetings to coordinate design and construction which could run concurrently is higher, it is very necessary in order to keep everyone on the same page.

Permit issues

Securing permit in time is serious in design and build projects as they usually have shorter durations. Sometimes it takes weeks or even months for construction and other permits needed in construction projects to be approved. It is very important to make sure that approval for the required permits are obtained in time or that the applications are made at such times that they would be approved by the time they are needed. Failure to do this will lead to a situation where certain activities cannot go on because of a delay in the approval of such permits. The whole project could end up being delayed if these activities happen to be in the critical path. Such permits include planning and zoning approvals, plan approvals from the local council and building permits.

4.4.2 Communication and information dissemination constraints

Gould (2003) finds that one of the main advantages of design and build projects is the fact that there is more effective communication between various project teams, especially between the design and build teams. This is so because both responsibilities are handled by the same organization. However, this is not always the case as the nature of design and build could also lead to some information dissemination constraints and the sidelining of certain parties. Some owners have complained of being kept in the dark about the progress of their projects.

Various relationships exist in design and build projects and all those parties need various information for the different tasks they have to accomplish. How this information is managed will have an impact on the final project output. An information manager should be appointed to make sure that information is properly collected, collated and properly disseminated to all parties involved (Ling and Lau, 2001). Also, one member should be appointed to deal with information for each team so that there is no ambiguity and confusion.

Communication in design and build projects could be between the owner and the contractor, or various team members as explained below:

The owner and contractor

One of the main disadvantages of design and build projects is that owners usually feel left out after handing over the project to the contractor and hence want to bear more liability for their project by having more influence (Ling and Poh, 2007). Even in design and build contracts that do not allow the owner to interfere in the construction process, it is still important to let the owner know how the project is progressing.

Various team members

It is very important that communication amongst team members be as effective as possible. In design and build, construction begins even before design is completed, meaning it is very important that both teams have a good communication link. If proper information is not made available on issues like changes to design and scope, it could be disastrous as the construction team could build the wrong structure due to a breakdown in communication.

4.4.3 Coordination issues among various teams

Effective teamwork is very important for design and build contracts to have the desired outcome. The design and construction teams in design and build projects are usually integrated to form one big team as opposed to the traditional procurement systems where each team is managed separately. It therefore becomes imperative that the teams are properly managed and coordinated in order to avoid problems (Schwager and Sullivan, 1991). It is also more difficult to manage teams in design and build projects as they are usually bigger and include different expertise. Team members in design and build projects should trust each other and work together for a common purpose as changes in scope would warrant a well coordinated team for timely responses and amendments.

4.5 Summary of constraints associated with design and build systems

4.5.1 The tender process in design and build contracts

In design and build projects, the main contractor is responsible for both design and construction. This makes it even more important for the owner to not only choose the right procurement method to employ, but more importantly, the right contractor for the job. The owner has much less influence in design and build than in the traditional construction methods. Songer and Molenaar (1997) state that the Request for Proposal in design and build, which should include the owner's needs in exact terms, should contain a well defined scope of work that makes everything to be achieved as clearly as possible.

The nature of design and build as a procurement method makes it more challenging for owners than the traditional methods. This is because they are required to have some technical abilities or background in the field of construction, or better still proper understanding of the required product. This point is further reiterated by Church and Ndekugri (1996) who go as far as saying the method may actually not be advisable for project owners who have no knowledge in construction.

4.5.2 The design phase

With the traditional construction methods, the contractor only focuses on the construction phase of the project with a designer contracted to complete the design. This is however not the case with integrated construction methods like design and build where the contractor has to carry out both functions. This is a recent development especially in South Africa and other regions like Asia hence most contractors have not yet acquired design capabilities. Schwager and Sullivan (1991) find that one major problem with design and build is that projects are likely to be managed by people not knowledgeable enough in design.

Also, while innovation is possible in design and build systems, there is the danger that it might lead to a situation where the design and build contractor effects changes that are to his taste rather to that of the owner. This has led to many owners wanting to have more input especially during the design phase of their projects (Ling and Poh, 2007).

4.5.3 Construction phase

Most owners would like to know on a continuous basis how their projects are progressing and whether they are meeting their required standards. Unfortunately, for most project owners, design and build does not seem to offer this option. Because they are not involved in the day to day progress of the project, it is easy for them to feel that the contractor could easily take advantage of them. Cecil (1983) states that project owners feel that they have no influence over their projects. This means the design and build company could take advantage of the owners if and when the opportunity arises. This is a very important point and goes to emphasise the point that project owners who are not very knowledgeable in the field of construction, should be able to deploy knowledgeable people like project managers in order to protect their interests throughout the process.

4.6 Changes to the design and build environment that could increase its use in South Africa*.*

This section looks at some changes that could be made in order to increase use of design and build as the procurement method of choice in South Africa.

4.6.1 Including knowledgeable owners in the design and build process

In design and build projects, owners are required to hand over all aspects of the project to the design and build contractor. This means even in the early stages of the project, owners seem to have little or no say about their projects. Many project owners are wary of the fact that they have no part to play in design and build projects. Linowes (2000) finds that owners' fears are exacerbated by the fact that some contractors usually have privacy clauses in their contracts with consultants, meaning project owners would have no way of having access to information, leaving them worrying that this might lead to poor project quality. Also, projects without any input from owners could end up being more in the liking of the contractor than the owner.

Ling and Poh (2007) alluded to the fact that in order to increase the use of design and build by project owners, it is vital to include owners in certain important project discussions. Even if they have no active role in the execution of the project, there are certain basic inputs that if they are allowed to make, could make a huge difference in the way the owner perceives the final product. In traditional procurement methods, project owners appoint the designer and readily contribute towards what will be the final outlook of the product. Even during the construction process, the designer looks after the interest of the owner right up to the end of the project. This is seemingly why most project owners tend to be at ease with the traditional procurement method. Also, it is more likely that in traditional methods, the interest of the owner will be well looked after since the designer is independent of the contractor, unlike in design and build systems where the same company carries out both design and construction.

Songer and Molenaar (1996) find that for design and build to be successful, the owner must know his product very well. Much as it is important for the owner to at least know exactly what product he wants, or better still have some technical insight about the process, his continuous input could be crucial especially with complex products. This so because construction projects are becoming more complex in nature (Songer and Molenaar (1996) and very complex construction projects could change a lot from the time the brief is made, to the time that the final product is handed over to the owner. Thus, it would be important to incorporate continuous input from the owner in order to make sure he is happy with some of the changes that could arise.

4.6.2 Including the owner's project manager in the design and build process

Project managers play a very crucial role in design and build projects. This will especially be the case when the project owner is clueless about the project, as is usually the case with complex projects requiring many changes. The project manager could be deployed to the offices of the contractor in order to play a similar role that an architect plays in traditional procurement systems. This involves following the daily construction processes and making sure that the owner's interests are protected. It is crucial to include a project manager in the following instances;

When the project owner has no previous construction knowledge

Project owners who have no experience in construction are bound to have problems especially in crucial decision making issues. Sometimes they might know what they want but not know how to convey it to the contractor. Ling and Poh (2007) find that project owners face problems in all four stages of the construction process which include tender preparation, tender evaluation, and the design and construction stages. They go on to say that most owners do not even know which contractor will give them the best value for their money. The project owner must therefore have someone very knowledgeable and experienced in the construction industry throughout the process, to continuously advice them and make crucial input when necessary. Moreover, they should protect the owner's interest to make sure they get the best value for their money.

Complex projects requiring multiple changes

Complex projects are usually huge and the final product always considerably different from the concept briefing. This means a lot of important decisions will have to be made during the course of these projects. Instead of the contractor discussing such changes with an owner who has little or no clue about the technicalities of the project, it will be preferable for the owner to appoint someone to represent him during such discussions. Ling and Poh (2007) find that project managers have the most difficulty when making decisions that have to do with the technical aspects of their projects. These include issues like approving designs for the project. They recommend that project owners should appoint their best project managers to work with contractors during this crucial phase.

4.7 Summary of findings from Literature

The literature reviewed has revealed several key issues associated with design and build in general and in SA in particular. A summary of the findings is prevented below:

- Design and build is still very sparingly used in SA for the procurement of construction projects.
- Several disadvantages exist when design and build is used and some are more peculiar to SA because of the skills problems already being experienced.
- Problems are experienced at all phases of project implementation including tender management, contract management, planning, design and construction.

These problems experienced could be the reasons for the limited use of design and build in SA. The following chapters will investigate some of the problems experienced in SA when design and build is used and solutions proposed. Hypothesis 1 will investigate the problems experienced while Hypothesis 2 will try to propose solutions to the problems.

5 Chapter Five: Methodology

5.1 Introduction

This chapter presents the methods that are used to investigate the research questions of this project. It discusses the procedures used, including the literature review, the strategies for collection of data for the survey that was conducted, the procedures for the analyses of information gathered and presentation of results.

5.2 Objectives

The following objectives of the methodology have been identified:

- To investigate the major problems faced in the various stages of construction project implementation using design and build. This will be investigated by exploring Hypothesis 1 of the study.
- To investigate how design and build could be improved in order to increase its use. These objectives are attained by conducting a survey of various professionals in the construction industry, which will be analysed through Hypothesis 2.

5.3 Research Approach

Several approaches and methods exist for conducting research but the two broad categories most easily recognized are the qualitative and quantitative methods. Most methods fall under these two broad categories. Quantitative research uses models and hypotheses to investigate relationships between various variables or relationships (Yin, 1994). The central issue with

quantitative research is the measurement and establishment of hierarchy among variables. Typical research questions for quantitative research include ‘what’, ‘how many’ and ‘how much’, ‘why’ and ‘how’ questions.

Qualitative research on the other hand attempts to understand human behavior and why people do make certain decisions (Yin, 1994). Typical research questions for qualitative research include ‘how’ and ‘why’ as these explain the process people use to make decisions and also the reasoning behind their conclusions. Findings are usually based on an assessment of work already done by other researcher or the author’s own insights of the situation. It is more intuition based than quantitative methods.

Other research techniques that fall under these two broad categories include case studies and historical facts for qualitative, and analysis of static or archival data for the quantitative method. A study that uses either quantitative or qualitative data to draw its conclusions, should design its methodology in such a way that it can acquire, collate, analyse data in order to arrive at its conclusions.

Yin (1994) finds that exploratory studies including ‘what’ and ‘how’ questions are best explored using quantitative methods of which surveys are the most prominent. He goes on to explain that when a study is being carried out where a specific variable is to be tested or verified, it is advisable to use quantitative methods. The two research questions in this research report are thus suited to the survey approach as they are both ‘what’ and ‘how’ questions and also because the questions seek to find out if certain variables are valid or no. This study therefore adopts the quantitative methods through a survey because the study does not only identify problems, but also seeks to find out how serious they are.

This research methodology follows the following four steps;

- data gathering
- data analysis

- results, conclusions and recommendations

5.4 Information collection models

Several methods exist for data collection for any project and can be broadly classified into primary and secondary data. These include;

- telephonic interviews
- one-on-one interviews
- project documents
- questionnaire(s)
- literature review

In-depth literature review was used to gather secondary data, and a questionnaire to generate its primary data. Telephonic interviews and one-on-one interviews were done in order to clarify some of the proposed questions and also for the pilot study. Telephonic follow-ups on any outstanding issues were also done.

5.4.1 Secondary data source: Literature Review

The literature review presented in chapters 2, 3 and 4 gave an insight into design and build as a procurement method in construction, for better understanding of the issues. Although only the traditional design and build method, where one contract is entered into between the owner and contractor was considered for this study, other hybrids were discussed in order to understand how their existence limits constraints of the method.

The literature was carried out through several resources including journal articles, books, websites, conference papers, some standard design and build contracts and magazines. All information that was of importance to the research, including all the phases of design and build projects were gathered and analysed.

While a major role of the literature review is to give a better understanding of design and build especially the key issues of design and build constraints and potential ways to improve it, it is also useful in that it provides guidelines for the interview questions for key informants, and other professionals.

5.4.2 Primary data collection

Questionnaires were sent out to a variable range of professionals in the construction industry including project owners, project and construction managers, architects, quantity surveyors, contractors and engineers in order to get a balanced viewpoint. This was important because it would have been unfair to collect data from just one profession within the industry, thus rendering the results biased. Most of the professional associations provide information on their website, which includes the contact details of members.

A list of project and construction project managers was obtained from the website of the South African Council for Project and Construction Project Managers (SACPCPM). A data base for Quantity surveyors was obtained from the website of the Association of South African Quantity Surveyors (ASAQS), while that for Architecture firms was obtained from the website of the South African Institute of Architects. The email addresses of construction contractors were found on the yellow pages, while those for project owners and investors from the list of delegates who attended the SOPOA 2008 conference. This list was deemed representative of property investors and owners as it is usually well attended and most major stakeholders in the industry usually attend.

The responses from all these major stakeholders in the construction industry formed the basis of the primary data. The first part of the questionnaire was demographic, and asked respondents which profession they identified themselves with. This formed the basis for the answers to all three research questions.

5.4.3 Questionnaire design

Table 1: Issues faced in various stages of design and build projects

1.Tender preparation and evaluation	
1.1	**Level of Knowledge for scope preparation**
1.2	**Manpower for scope preparation**
1.3	**Level of information required in Request for proposal**
1.4	**Lack of knowledge to evaluate tender**
1.5	**Cost to prepare and evaluate tender**
1.6	**Time to prepare and evaluate tender**
Design phase	
2.1	**Lack of design knowledge**
2.2	**Contractors lack adequate insurance for both design and construction**
2.3	**Poor communication**
2.4	**Design not to taste of owner**
Construction phase	
3.1	**Owners don't get information on the progress of projects**
3.2	**High level of price uncertainty**
3.3	**Delays in construction commencement due to disagreements**
3.4	**Larger team difficult to coordinate**

Performance indicators	
4.1	**Time**
4.2	**Budget management**
4.3	**Quality**
4.4	**Functionality**
4.5	**Safety**

In order to better prepare the questionnaire, a wide range of reading was done especially in the preparation of the literature review. This, coupled with an interview with two experienced project managers, served as a pilot for the study as they helped to establish whether the questions were adequate enough to attain the study's objectives. The problems investigated were divided according to the various phases of the construction process, including tender preparation and evaluation, design and construction. Also, the key performance indicators of design and build projects were investigated to find out if they performed well in South Africa.

Mostly, closed-ended questions were sent out to the survey participants in order to make it easier and hence increase the number of responses. Questionnaires were sent out via email, with the addresses obtained as explained above. Reminders were sent after two weeks in an attempt to increase the response rate.

The questionnaire is divided into three sections in order to adequately deal with the three research questions. The first section seeks general information from the respondents. It is used to split respondents according to their various professions and sectors. In essence, it is demographic in nature.

The second section includes questions that seek to answer the first research question, which strives to identity the most serious constraints associated with design and build in South Africa.

Here, participants were asked to rate questions that have been identified in the literature for all stages of design and build. This includes tender preparation and evaluation, the design and construction stages. Respondents were also asked to indicate what they thought of the outcome of key performance indicators using design and build.

The third section includes a series of open-ended questions that seek to find out changes that could be used to improve design and build in order to increase its use in South Africa. Respondents are asked to state if including project managers or other professionals chosen by the owner would lead to more owners choosing it as the method of choice.

5.4.4 Likert's Scale

Quantitative methods were used where respondents were asked to rate the way they felt about different problems with design and build. For each question, each respondent had to rate it according to how strong they feel about it, as follows; 1 = strongly agree, 2 = agree, 3 = neither agree nor disagree, 4 = disagree and 5= strongly disagree. The mean was set at 3 meaning anything below 3 means the respondent agrees that the particular issue is a problem while anything above three means they do not agree it is a problem.

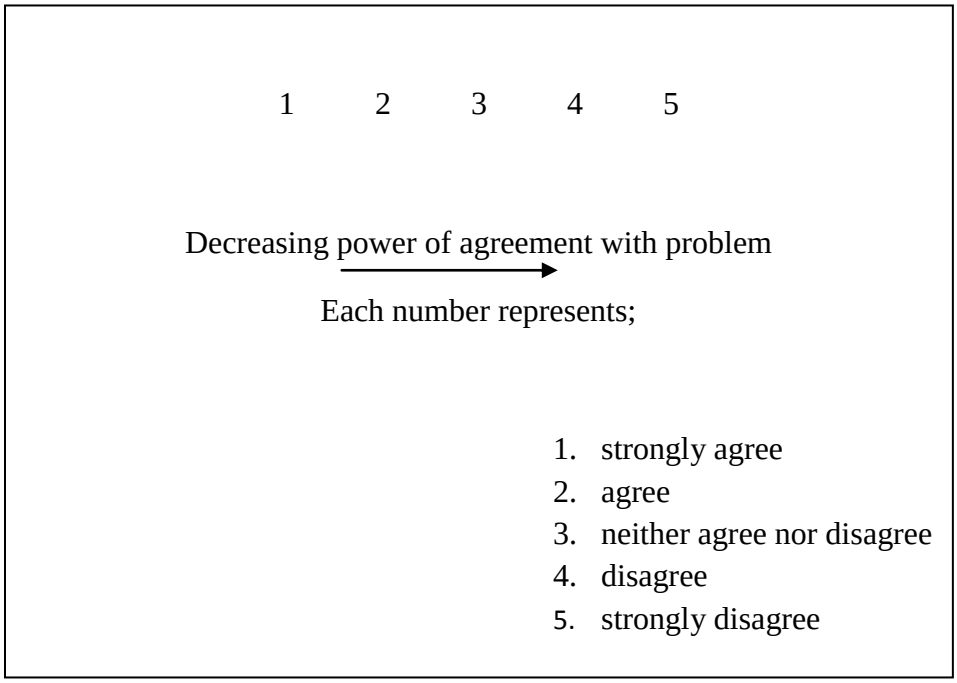


Figure 8: Likert's scale adopted for the project

5.5 Test for data reliability: Cronbach's Alpha Test

Reliability tests the consistency of a data or method that is used to arrive at the data collected for research purposes. This means the researcher tries to verify if the data or measuring instrument being used can be repeated with the same or very similar outcomes. Various types of reliability tests exist including the inter-rater reliability test which is the difference in results when different people are used with same method, the inter-method reliability which examines the difference in results due to change in methods on same person, the internal consistency which looks at the consistency of variables across different items in a test and the test-retest which looks at the variation in results when the same person responses differently in different instances under similar conditions. This study could not adopt the test re-test method because the questionnaire could not be administered twice to the respondents. It instead adopts the internal consistency as it is important to see if a particular respondent is consistent in the way he answers his questions.

In order to test for internal consistency, a number of tests can be used. These include the Spearman-Brown prophecy formula, the Kudar-Richardson formula and the Cronbach's Alpha test, with the latter two more accurate (Brown, 1997). However, the Kudar-Richardson formular is only one dimensional, meaning it can only measure variables that have yes or no answers while Cronbach's Alpha is multidimensional, meaning it can support variables with several responses. For this reason, Cronbach's Alpha was chosen as respondents had up to five choices to pick from.

Cronbach's alpha measures how well or poorly a set of variables measure a particular construct. It shows whether a particular set of data collected was consistent in the way that respondents attempted the questions. This is important as it shows that differences were really due to difference in ideology of each person and not just random.

Del Siegel established a very simple way using excel of computing Cronbach's Alpha in which a single set of data is split into two sections and tested for consistency in the way respondents rated the problems. It is expected that respondents should respond to items (questions) regarding a

particular issue in a certain way. We are testing the similarity of responses to questions that test a particular issue. The variance between the answers for all the responses, give an indication of how consistent they were in their responses. Alpha coefficients will vary between 0 and 1, with an alpha of 0.6 or more judged to mean the data is a good fit.

5.6 Data analysis

The statistical tool SAS was used to collate data and also for the statistical tests. Sample t-tests were conducted in order to answer the two research questions. Because the Likert's Scale ranges from strongly agree, agree, neutral, disagree to strongly disagree, it means the parameters will be set as follows;

- population mean $\mu_o = 3$ which is the neutral option
- any number below 3 will mean problem is serious
- any number above 3 will mean problem not considered serious
- Null hypothesis will be set at Ho: $\mu \geq \mu_o$, meaning problems assumed not to be serious
- Significance level set at 0.05
- Meaning H_o accepted when $p \geq 0.05$, meaning problem not serious
- Alternate hypothesis will be H_1: $u < \mu_o$.
- Meaning we accept H_1 when $p < 0.05$

5.7 Hypotheses testing

Hypothesis 1: design and build has problems in the tender, design and construction phases when used as a construction procurement method.

The first aim of this study is to investigate the seriousness of problems faced in the implementation of design and build at various stages of the construction process. The stages chosen for this study are tender preparation and evaluation, design and construction phases. T-Tests were carried out to test how respondents rated various problems that were presented in the questionnaire. From the hypothesis presented in the data analysis section, the null hypothesis states that the mean will be greater than or equal to three, meaning that particular problem is not rated serious by respondents. A score of less than three will mean that the respondent rates the problem as serious. Because a confidence interval of 95% was chosen, it means that we will reject the null hypothesis if $p < 0.05$, meaning the problem is deemed serious during design and build implementation.

Hypothesis 2: there are serious challenges in the management of projects due to the non-deployment of project managers in construction projects.

The second aim was to investigate the structures in place that lead to design and build management problems. Here, respondents were asked to indicate whether they believed including a project manager by the owner in the construction process would improve on some of the problems encountered. It is investigated whether by the owner not appointing a project manager, it creates an environment for design and build to experience numerous problems. The result is presented in the last row of table 2. There is a strong indication by respondents that letting owners to appoint a project manager will be a positive step for design and build. Respondents were also asked open-ended questions on how they thought various problems could be improved. The outcomes are presented later when the recommendations are discussed.

The next section presents a finding of the tests conduction and a discussion based on the hypothesis designed. Conclusions are drawn based on whether the hypotheses tests designed are found to be consistent with results found in other regions of the world.

6 Chapter Six: Results and analyses

6.1 Characteristics of the sample obtained

Fifty questionnaires were sent out to each of the professions chosen which included project owners, contractors, project and construction managers, architects, quantity surveyors and engineers. Thirty two responses were obtained from the three hundred questionnaires sent out, making it a 10.7% response rate. Two responses were discarded for being incomplete. The poor response rate stems from the fact that many of the addresses got were for companies and not for the various professionals. This means that the email then had to be forwarded internally to the right person to respond. This reduced the chance of the questionnaire getting to the right person. Also, some of the addresses were either outdated or wrong.

Responses were received from all professions, although it was not equally spread as respondents from some professions were more eager than others. The highest number of responses was from quantity surveyors with nine of the thirty. Project and construction managers had seven, architects followed with five, while the other categories of contractors, owners, and engineers each had three responses. It would have been ideal but not obligatory to get an equal number of responses from each profession. This was so because the idea was to get a view from each group.

In terms of spread across sectors, 20 of the responses were from the private sector while 10 were from the public sector. While this is skewed, it is consistent and representative of the situation in the industry. Akintoye (1994) finds that about twice more projects are being procured using design and build in the private sector than in the public sector. Grobler and Pretorius (2002) also find that more projects in the private sector are procured using design and build than the public sector in South Africa.

6.2 Reliability of the data: Cronbach's Alpha test

The test carried out using the Siegel formula on Excel gave a Cronbach's alpha of 0.841697341, a value which is much higher than the 0.6 required for data to be considered a good fit for any particular construct. Values between 0.8 and 0.9 are usually considered 'good fits'. It can therefore be concluded that the data used for this study has a good construct.

6.3 Results obtained

Table 2: Results of tests obtained for various potential problems in design and build

No		mean	Std Dev	minimum	maximum	t-test	Sign(1 tail)
	Tender preparation and evaluation						
1.1	**Lack of knowledge for scope preparation**	1.8667	0.7303	1	3	-8.50	<.0001
1.2	**Lack of man power for scope preparation**	2.2	0.7144	1	4	-6.13	<.0001
1.3	**Level of information for brief uncertain**	2.1	0.803	1	4	-6.14	<.0001
1.4	**Lack of knowledge for tender evaluation**	2.5	1.0422	1	5	-2.63	0.0136
1.5	**High cost for preparation and evaluation of tenders**	2.8333	1.2058	1	5	-0.76	0.4551

1.6	**Time to prepare and evaluate tenders**	3.3	1.0554	1	5	1.56	0.1303
	Design phase						
2.1	**Lack of design knowledge**	2.4333	1.1651	1	5	-2.66	0.0125
2.2	**Lack of adequate insurance to cover both design and construction**	2.8	1.1861	1	5	-0.92	0.3633
2.3	**Poor communication**	2.6333	0.9643	1	5	-2.08	0.0462
2.4	**Design not to taste of owner**	3.1	0.9229	2	5	0.59	0.5575
	Construction phase						
3.1	**Owners don't get enough information on progress of project**	3.0667	0.9072	2	5	0.40	0.6903
3.2	**Price very uncertain**	3.2	1.2149	1	5	0.90	0.3746
3.3	**Delays in construction commencement**	3.1333	1.1366	1	5	0.64	0.5256
3.4	**Larger team difficult to coordinate**	3.5	0.9738	2	5	2.81	0.1087
	Performance indicators						
4.1	**Time management**	2.5	0.9377	1	5	-2.92	0.0067

4.2	**Budget management**	2.7	1.0222	1	5	-1.61	0.1188
4.3	**Quality**	2.3333	1.0613	1	5	-3.44	0.0018
4.4	**Functionality**	2.9333	0.9444	2	5	-0.39	0.7019
4.5	**Safety**	3.0333	1.0662	2	5	0.17	0.8652
	Effect of including a project manager by the owner						
	Will including project manager in design and build processes increase use of design and build?	1.7333	0.6915	1	3	-10.03	<.0001

The first objective of this study is to investigate the seriousness of problems faced in the implementation of design and build at various stages of the construction process. The stages chosen for this study are tender preparation and evaluation, design and construction phases. T-Tests were carried out to test how respondents rated various problems that were presented in the questionnaire. From the hypothesis presented in the data analysis section, the null hypothesis states that the mean will be greater than or equal to three, meaning that particular problem is not rated serious by respondents. A score of less than three will mean that the respondent rates the problem as serious. Because a confidence interval of 95% was chosen, it means that we will reject the null hypothesis if $p < 0.05$, meaning the problem is deemed serious during design and build implementation.

The results of the t-test for all the problems have been presented in table 2. It is clear that there are many problems faced in all phases of design and build implementation, as indicated by all the p-values for the t-tests that are lower than 0.05, presented in column 8 of table 2. Also, in order

to be doubly sure of the results, we check the means (presented in column 3 of table 2) of each of the problems to make sure they are less than 3.

The second objective was to investigate the structure in place that lead to design and build management problems. Here, respondents were asked to indicate whether they believed including a project manager by the owner in the construction process would improve on some of the problems encountered. It is investigated whether by the owner not appointing a project manager, it creates an environment for design and build to experience numerous problems. The result is presented in the last row of table 2. There is a strong indication by respondents that letting owners to appoint a project manager will be a positive step for design and build. Respondents were also asked open-ended questions on how they thought various problems could be improved. The outcomes are presented later when the recommendations are discussed.

6.4 Analyses

6.4.1 Tender preparation and evaluation

Table 3: Tender preparation and evaluation

No		mean	Std Dev	minimum	maximum	t-test	Sign(1 tail)
	Tender preparation and evaluation						
1.1	**Lack of knowledge for scope preparation**	1.8667	0.7303	1	3	-8.50	<.0001
1.2	**Lack of man power for scope preparation**	2.2	0.7144	1	4	-6.13	<.0001
1.3	**Level of information for brief uncertain**	2.1	0.803	1	4	-6.14	<.0001

1.4	**Lack of knowledge for tender evaluation**	2.5	1.0422	1	5	-2.63	0.0136
1.5	**High cost for preparation and evaluation of tenders**	2.8333	1.2058	1	5	-0.76	0.4551
1.6	**Time to prepare and evaluate tenders**	3.3	1.0554	1	5	1.56	0.1303

The results presented in table 3, column 8 show that there are considerably many problems (1.1, 1.2, 1.3 and 1.4 all having $p < 0.05$ and means below 3) encountered during design and build implementation at the initial stages. This is consistent with work done by Chan et al, (2001), who find that there are considerable problems associated with design and build at the tender stages. Also, in design and build, the contractor handles all aspects of the project, making it absolutely crucial for owners to select the right building team. Wardani (2004) recommends that project owners spend considerable amounts of time on this stage of the project and make sure the right team is chosen.

The respondents seem to agree that most problems encountered during this stage have to do with the lack of resources. The first problem is that of 'lack of knowledge by owners to prepare the Request for Proposal', which has a p-value of 0.001 and a mean of 1.87, which is way below the general mean of 3. Ndekugri and Church (1996) find that owners without the required knowledge to prepare detailed briefs should either get help, or consider using other methods, as they will experience several problems in the latter stages of the project if the brief is not well done.

The other problems include 'lack of adequate manpower to assist with scope preparation (p-value of 0.001 and mean of 2.2), consistent with the skills problems in SA, 'uncertain level of information to include in the brief' (p-value of 0.001 and mean of 2.1) and 'lack of knowledge to evaluate tenders' (with p-value of 0.0136 and mean of 2.5). The uncertain level of information to include in brief has to do with the fact that it is very vital to include every detail in the brief. Owners have very limited influence on their projects during implementation, so a professional

should be engaged as he will know the right information to include, depending on the particular deliverables being sought.

6.4.2 Design phase

Table 4: Design phase results

No		mean	Std Dev	minimum	maximum	t-test	Sign(1 tail)
	Design phase						
2.1	**Lack of design knowledge**	2.4333	1.1651	1	5	-2.66	0.0125
2.2	**Lack of adequate insurance to cover both design and construction**	2.8	1.1861	1	5	-0.92	0.3633
2.3	**Poor communication**	2.6333	0.9643	1	5	-2.08	0.0462
2.4	**Design not to taste of owner**	3.1	0.9229	2	5	0.59	0.5575

From table 4 above, the first problem that respondents felt was serious in the design stage in design and build projects was that contractors do not have adequate design capabilities (p-value of 0.0125 and mean of 2.433). These results are in line with Schwager and Sullivan (1991) who find that one of the main problems with design and build is that projects are usually managed by people who do not have adequate design knowledge. The issue of design is a contentious one in construction and Jansens (1991) states that the upsurge in the number of hybrids of design and build is due to the amount of design responsibility that project owners like to retain.

The second problem in this phase was 'poor communication between the design and construction teams' (with p-value of 0.0462 and mean of 2.6333). Poor communication can be very disastrous especially in design and build where both stages usually overlap. When construction commences, it must be on designs that are certain of no changes required. This is crucial in order to avoid reworks that are costly and time wasteful.

6.4.3 Construction phase

From table 2, respondents did not deem any of the problems in the construction stage as serious, with all problems having p-values greater than 0.05 and means above 3 as shown in table two. This means they gave ratings of more than three on the scale from 1 to 5.

6.4.4 Performance indicators

Table 5: Performance indicators results

No		mean	Std Dev	minimum	maximum	t-test	Sign(1 tail)
	Performance indicators						
4.1	**Time management**	2.5	0.9377	1	5	-2.92	0.0067
4.2	**Budget management**	2.7	1.0222	1	5	-1.61	0.1188
4.3	**Quality**	2.3333	1.0613	1	5	-3.44	0.0018
4.4	**Functionality**	2.9333	0.9444	2	5	-0.39	0.7019
4.5	**Safety**	3.0333	1.0662	2	5	0.17	0.8652

Performance indicators give an indication of the entire project success or failure to meet set aside standards. The indicators chosen for this study include time, budget management, quality, functionality and safety. From table 5 above, respondents felt that two (time and quality) of the five performance indicators when design and build is used, perform poorly. The result for time (p-value of 0.0067 and mean of 2.5) was consistent with another study done in SA by Grobler and Pretorius (2002) who also found time management to be a problem in design and build projects but quite contrary to what most other studies have predicted in other regions of the world. Shorter project time and better time management are some of the most advanced advantages of design and build. This study did not seek to find reasons for this anomaly but it is probably a potential area for future research, as it could greatly increase the number of projects that use design and build as the construction procurement method of choice.

The results for quality (p-value of 0.0018 and mean of 2.3333) are very consistent with those of several other studies that found the quality of design and build projects to be either poor or not different from other methods. While Akintoye (1994) finds that there was no significant change in quality when either method was used, Gidado and Arshi (2004) contradict it with results that showed 54% of their respondents accepted that there was an improvement in the quality of projects when design and build was used, as compared to the traditional procurement method. Konchar and Sanvido (1998) find that design and build outperforms the traditional methods in every other aspect but the quality of the final output.

6.4.5 Effect of including a project manager by the project owner

Table 6: Effects of including a project manager in design and build processes

No		mean	Std Dev	minimum	maximum	t-test	Sign(1 tail)
	Will including project manager in design and build processes increase use of the method?	1.7333	0.6915	1	3	-10.03	<.0001

Table 6 shows that the respondents all agreed that allowing the project owner to include a project manager in the design and build project will improve the output of design and build projects. The t-test carried out yielded a p-value of 0.0001 and a mean of 1.733, which is way below the average of 3.000. This is in line with Ling and Poh (2007) who find that including the owner's project manager in the process allays some of the fears of owners, avoids several reworks and makes sure that the project is to the specifications of the owner.

7 Chapter Seven: Summary, Conclusions and recommendations

7.1 Summary of findings

The following are the major findings from this study:

Firstly, it is found that there are several problems encountered when design and build is used as the procurement method of choice in all stages of construction projects in South Africa. The first objective of the study was to investigate the constraints associated with design and build in South Africa. Problems encountered in the tender preparation and evaluation include lack of knowledge by owners to prepare requests for proposal, lack of manpower to assist project owners with tender preparation and evaluation, uncertain level of information to include in briefs and lack of knowledge to evaluate tenders. These problems show that the major constraints of design and build in the initial stages of construction projects in South Africa have to do with the skills shortages plaguing most sectors and also the fact that the method is not yet well known in South Africa.

Constraints found in the design and construction phases included the fact that contractors do not always have adequate design knowledge, consistent with Schwager and Sullivan (1991) who found that most design and build contractors attempt to handle both design and construction without any real design competencies. Poor communication between the design and construction teams within the design and build organization was also highlighted as a major constraint.

Secondly, in order to further highlight some of the constraints of using design and build in construction projects in South Africa, a number of performance indicators of construction projects were investigated. These included time management, budget management, functionality, quality and safety. It was found that time management was a problem as most projects using design and build were not completed on time. Also, respondents felt that the quality of projects were lower when design and build was used as the procurement method of choice.

Finally, respondents overwhelmingly agreed that it was important to allow the project owner to include his own project manager in the design and build process because most project owners in South Africa do not possess the right technical skills, and also to look after the interests of the owner by making sure that the project reflects the specifications set out by the project owner.

7.2 Research findings

The research goals and objectives of this study were achieved. The first hypothesis was set as follows; there are several constraints in the design and build process in South Africa. This was accomplished as many constraints were found in all phases of implementing design and build.

The second hypothesis was to investigate whether including a project manager by the owner would improve project output in design and build projects. This was also accomplished as every single respondent thought it would be a very good idea to allow project owners to include their own project managers in the process.

7.3 Conclusions

The first aim of this study was to investigate the problems faced in South Africa when design and build was used as the procurement method of choice in construction projects. The results obtained show that problems are encountered in all phases at implementation level. The problems are also found to be more serious with issues around human capital or lack thereof. Owners tend to struggle to find adequate help in the drafting of their briefs and also with the evaluation of tenders, and selection of the right contractor. This means use of design and build in construction projects in South Africa continues to lag behind other regions like Europe and North America due to the unavailability of technical assistance to project owners.

A major part of this project was to recommend solutions to some of the problems highlighted. To this effect, it was generally accepted by most respondents that including a project manager by the

owner in the design and build process would allay some of the fears of the owners, and thus increase its use as the procurement method of choice in South Africa. This is consistent with results found by Ling and Poh, 2007 in a study done in Singapore. Project owners are still skeptical about using design and build because they feel that they have little say in the running of their projects as they do not have any member on the project team. They fear they could be taken advantage of. Allowing project owners to include their own project manager in the process would allay these fears and thus increase use of design and build for construction projects.

7.4 Recommendations

The recommendations presented in this section were obtained from the test carried out on what respondents thought would be the effect of including a project manager in the design and build process (Table 2, last row) and also some open-ended questions posed to them. Other additional comments made by respondents were also included. From the recommendations presented in table 2, the following points seem to have been emphasized by the respondents:

7.4.1 Project owners should include their project managers in design and build projects

The test on whether to include project managers by the owners was overwhelmingly agreed by respondents, saying it would improve the design and build process. There was also no respondent with a maximum number above three as shown in columns 4 and 5, meaning not a single respondent disagreed that including a project manager would increase the project outcome of design and build projects. Respondents emphasized that project owners, especially those not knowledgeable in design and build processes, should engage a project manager early on in the project. The project manager should help the owner with issues around preparing the brief and evaluating and selecting the building team. Ling and Poh (2007) find that most construction project owners do not have the required technical knowledge and must therefore engage the right professionals.

7.4.2 Clear communication lines between all parties

The respondents felt that for design and build to be successful, the lines of communication must be made clear right from the start of the project. Every party must know where to go in order to get any information that they require. Teams must also work in a well coordinated way in order to reap the benefits that design and build has to offer. It is very important for communication to be good among various teams as design and construction tend to overlap. In order to avoid several reworks and mistakes, the design team must work closely with the construction team.

7.4.3 Proper planning

Adequate time must be spent planning the process as a whole. Because the aim of most design and build processes is to shorten project time and hence deliver the project faster, it is important to dedicate enough time to planning. Also, the fact that design overlaps with construction means it is important to plan the sequence of events to near perfection. The owner must ascertain firstly that design and build is the right procurement method for his project. Appointing the right team is also of paramount importance, as the owner has less influence on the entire process compared to other construction methods like the traditional construction method.

7.4.4 Well prepared brief or Request for Proposal

The owner must include in no uncertain terms, all the specifications of the required outcome he desires in the brief that he sends out to contractors for tendering. Because owners in design and build projects have considerably less influence compared to other methods, it is very important that his needs are well understood right from the beginning. This will avoid issues of poor functionality of the end product, low quality and cost and time overruns. It is recommended that owners with little or no knowledge, especially of the technical aspects should seek help from the required professionals or stay away from the method.

7.4.5 Engage the right teams/companies

Respondents insisted on the fact that owners must engage only contractors that are ISO and OHS complaint in order to avoid several problems as the project progresses. This will ensure that processes are only performed once, leading to the project being completed on time. Also, safety, quality and functionality problems are all avoided. It is strongly advised that owners not only focus on the cost of the project, but on the final output they desire.

7.5 Areas for further study

This study focused on the constraints of using design and build in South Africa, and the environment that leads to the management issues that arise when design and build is used. There are however other issues that have not been explored and could be done in future. These include the following:

- Firstly, work can be done on how design and build performs amongst various sectors of the economy. These could include the private or public sectors, or the type of product being procured which could be commercial or private property. This is important as design and build could be better suited to certain types of projects or sectors and would be information for companies wanting to use the method.
- Secondly, this study finds that project owners should appoint a project manager to be part of the process but not the effects of doing so. It could be good to do a study of the role of project managers in projects procured through design and build.

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Appendix

Appendix 1: Questionnaire

University of the Witwatersrand

Faculty of Engineering and the Built Environment

School of Construction Economics and Management

Research survey

THE CONSTRAINTS OF USING DESIGN AND BUILD FOR THE PROCUREMENT OF CONSTRUCTION PROJECTS IN SOUTH AFRICA

Project executed by: Ndonwi Gerald Mfongeh

Section A: Demographic information

(Please tick the appropriate box (x)

What profession do you identify yourself with?

☐ Architect ☐ Project owner

☐ Engineer ☐ Quantity surveyor

☐ Project/Construction manager ☐ Contractor

☐ Other (please specify): _____

In which sector do you operate?

☐ Private sector ☐ Public sector ☐ Both

Section B: Possible constraints in the design and build procurement system in construction projects

Constraints refer to the possible issues experienced by various stakeholders in various stages of the design and build process in construction.

<u>Stage1: Constraints in tender preparation and evaluation</u>

Please kindly tick the appropriate box (x)

Listed below are possible problems that could be experienced using design and build as the procurement method in construction. Please kindly indicate the seriousness of the following problems associated with the tender preparation and evaluation process in design and build projects.

***Level of seriousness: 1= Strongly agree(SA); 2= Agree(A); 3= Neutral(N); 4= Disagree(D); 5= Strongly disagree(SD)**

Table 1: Project inception phase

	***Level of seriousness**				
	SA	**A**	**N**	**D**	**SD**
	1	**2**	**3**	**4**	**5**
1.1 Owners lack sufficient knowledge to prepare detailed scope of work					
1.2 Owners lack enough manpower to help with the preparation of detailed scope of work					

1.3 The level of detailed information to provide in the scope of work is not certain					
1.4 lack of adequate knowledge to evaluate tenders					
1.5 Cost of tender preparation and evaluation is high					
1.6 Time taken to prepare and evaluate tenders is too much					
1.7 Other (Please specify)					

Stage2: Design Phase

Please kindly tick the appropriate box (x)

Listed below are possible problems that could be experienced in the design stage of design and build projects in construction. Please kindly indicate the seriousness of the following problems:

***Level of seriousness: 1= Strongly agree(SA); 2= Agree(A); 3= Neutral(N); 4= Disagree(D); 5= Strongly disagree(SD)**

Table 2: Design phase

	***Level of seriousness**				
	SA	**A**	**N**	**D**	**SD**
	1	**2**	**3**	**4**	**5**

2.1 Contractors lack adequate design knowledge					
2.2 Contractors often fail to secure adequate insurance to cover both design and construction					
2.3 Poor communication between design team and owner					
2.4 Design usually not to owner's taste					
2.5 Other (please specify)					

Stage3: Construction Phase

Please kindly tick the appropriate box (x)

Listed below are possible problems that could be experienced in the construction stage of design and build projects in construction. Please kindly indicate the seriousness of the following problems:

***Level of seriousness: 1= Strongly agree(SA); 2= Agree(A); 3= Neutral(N); 4= Disagree(D); 5= Strongly disagree(SD)**

Table 3: Construction phase

	***Level of seriousness**				
	SA	**A**	**N**	**D**	**SD**
	1	**2**	**3**	**4**	**5**
3.1 Owners don't get enough information on the progress of their project					

3.2 Price tends to be uncertain due to increase in change orders					
3.3 Delays in construction commencement due to owner's disapproval of design outputs					
3.4 More difficult to coordinate due to larger team size					
3.5 Other (Please specify)					

Section C: Performance indicators

I

This section investigates if the performance indicators in construction projects are still issues when design and build is used as the procurement method of choice. These indicators include time, budget management, quality, functionality and safety and security.

Please kindly tick the appropriate box (x)

***Level of seriousness: 1= Strongly agree(SA); 2= Agree(A); 3= Neutral(N); 4= Disagree(D); 5= Strongly disagree(SD)**

Table 4: Performance indicators

	*Level of seriousness				
	SA	**A**	**N**	**D**	**SD**
	1	**2**	**3**	**4**	**5**
1.1 Time management is still a problem in design and build projects					
1.2 Budget management still poses a problem in design and build projects					
1.3 Quality issues still arise in design and build projects					
1.4 Functionality is still a problem in design and build projects					
1.5 Safety and security is still a problem in design and build projects					
1.6 Other performance indicators (please specify)					
1.7					

II

This section provides potential solutions on how the outcome of the above-mentioned performance indicators could be improved.

Respondents who chose **1 and 2** above for any indicator should please explain how they think the outcome of those performance indicators could be improved.

Section D: Effect of including an owner or his adviser (project manager)

This section investigates whether including an owner or his adviser (project manager) could improve the design and build process.

Please kindly tick the appropriate box (x)

***Level of seriousness: 1= Strongly agree(SA); 2= Agree(A); 3= Neutral(N); 4= Disagree(D); 5= Strongly disagree(SD)**

Table 5: Effect of including an owner or his adviser

	***Level of seriousness**				
	SA	**A**	**N**	**D**	**SD**
	1	**2**	**3**	**4**	**5**
Including a knowledgeable owner or his adviser (project manager) in the design and build process will improve it					
Other ways to improve the design and build process (Please specify)					

2.1 How can time management be improved in design and build projects?_____
_____
_____
_____
_____

2.2 How can budget management be improved in design and build projects?_____
_____
_____
_____
_____

2.3 How can the quality of design and build projects be improved?_____
_____
_____
_____
____

2.4 How can the functionality of design and build products be improved?_____
_____
_____
_____
____

2.5 How can safety and security be improved in design and build projects?_____
_____
_____
_____
_____

Appendix 2 Collated data

Profession	Sector	Knlfor scope prep	Manpowfor scope prep	levelofinfo	knowltoeval	costofpreplandeval	timetopreplandeval	lackofdesignknowl	lackadequinsurance	poorcommunication	designnotto taste	ownersdon'tgetinfo	priceuncertain	delaysincontstart	largerteamdiffto coordinate	time	budgetmanagement	quality	functionality	safety
5	1	3	2	2	4	3	4	4	3	3	4	4	3	3	4	3	2	2	3	3
6	2	1	2	1	2	2	5	4	4	2	3	4	2	1	3	2	1	3	3	4
4	1	1	2	1	3	3	3	3	2	2	3	3	5	5	3	3	4	3	3	3
3	1	2	3	2	2	4	4	2	5	3	4	4	4	4	4	2	2	2	3	3
5	1	3	3	3	4	5	4	2	2	4	4	3	4	4	4	2	3	3	2	2
4	1	1	1	2	3	3	4	1	2	2	3	3	4	3	3	4	3	2	2	3
4	1	1	2	1	2	1	2	1	3	2	2	2	4	2	5	3	3	1	2	5
5	2	2	2	3	2	3	4	2	2	2	3	3	2	3	3	2	2	3	3	2
1	1	2	3	4	5	3	3	2	4	5	5	4	3	5	5	2	4	4	5	5
1	2	2	2	2	2	2	2	4	4	3	4	4	4	2	4	2	2	2	4	2
3	2	1	4	1	1	1	4	4	4	3	3	2	3	2	2	1	1	1	3	2
4	2	2	2	2	3	2	3	2	2	1	2	2	1	1	2	2	1	1	2	3
5	2	1	1	2	2	2	2	2	1	2	2	2	2	2	3	2	3	2	2	2
6	2	2	2	1	1	2	2	4	4	3	2	3	2	2	4	4	4	4	4	4
1	1	2	3	2	3	2	4	2	3	2	2	2	3	3	3	1	1	1	2	3
4	1	2	2	3	2	4	4	2	2	3	2	2	1	3	4	2	2	2	2	2
2	1	3	3	2	4	4	4	1	1	2	3	4	4	4	2	2	3	1	3	2
5	1	3	2	2	2	1	1	4	4	4	4	5	5	5	5	4	4	4	5	5
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1	1	2	2	3	1	2	2	2	3	2	4	2	2	3	3	2	3	2	3	3
4	1	1	2	1	3	3	3	3	2	2	3	3	5	5	3	3	4	3	3	3
3	1	2	3	2	2	4	4	2	5	3	4	4	4	4	4	2	2	2	3	3
5	1	3	3	3	4	5	4	2	2	4	4	3	4	4	4	2	3	3	2	2
4	1	1	1	2	3	3	4	1	2	2	3	3	4	3	3	4	3	2	2	3
4	1	1	2	1	2	1	2	1	3	2	2	2	4	2	5	3	3	1	2	5
5	2	2	2	3	2	3	4	2	2	2	3	3	2	3	3	2	2	3	3	2
4	1	2	2	3	2	4	4	2	2	3	2	2	1	3	4	2	2	2	2	2
2	1	3	3	2	4	4	4	1	1	2	3	4	4	4	2	2	3	1	3	2

Appendix 3 **Recommendations to design and build constraints**

Problem	Recommendations
Tender preparation and evaluation	
Lack of Knowledge for scope preparation	• **Engage a project manager/consultants early on** • **Full team to be put in place by owners for big and complex projects**
Lack of manpower for scope preparation	• **General problem in SA today. Available but scarce so owners who cannot afford professionals should consider other methods**
level of information required in Request for proposal not certain	• **An experienced PM will have the information required and also what to include in the RFP depending on the nature of the project.**
Lack of knowledge to evaluate tender	• **Very important to chose the right contractor in design and build so owners without knowledge must get enough support.**
Design phase	
Builders lack adequate	• **Owners should be allowed to bear more design responsibility** • **Owners should have the right to hire professionals to approve**

design knowledge	**designs**
Poor communication	• **Lines of communication should be made clear from the beginning** • **Each party must know where to go to get and supply all information** • **A communication model to be adopted throughout the project**
Construction phase	
Larger team diff to coordinate	
Performance indicators	
Time	• **Let owner be part of process to avoid several reworks and changes** • **Stiff penalties included in contracts for each party** • **Better coordination and communication among teams. Specify in contract who performs what function clearly** • **Schedule time to fit resources using CPA and other models.** • **Appoint an independent time manager to put everyone in check on time issues** • **Integrated documents control system and milestones based pay system**
Budget management	• **Budgets should be fixed for DB as it is contractor's responsible for all aspects** • **Enough time dedicated to planning** • **Valued engineering and scoping exercises**

Quality	• **Owner's brief should be very detailed with all specifications clear** • **Take time to hire the right team that is qualified and has right equipment** • **Quality control audits to be carried out** • **Design must be reasonably complete before building starts to avoid several reworks**
Functionality	• **Adequate input from client as it will be used by him** • **Needs of owner must be well understood**
Safety	• **Include safety specifications in contract** • **Clients should engage contractors that are ISO and OHS compliant and have DIFR figures that are acceptable**

Appendix 4 T-test outputs

Test results from SAS

t Test

The TTEST Procedure

Statistics

Variable	N	Lower CL Mean	Mean	Upper CL Mean	Lower CL Std Dev	Std Dev	Upper CL Std Dev	Std Err	Minimum	Maximum
Knl for scope prep	30	1.594	1.8667	2.1394	0.5816	0.7303	0.9817	0.1333	1	3
level of info	30	1.8002	2.1	2.3998	0.6395	0.803	1.0795	0.1466	1	4
knowl to eval	30	2.1108	2.5	2.8892	0.83	1.0422	1.4011	0.1903	1	5
time to prep and eval	30	2.9059	3.3	3.6941	0.8405	1.0554	1.4187	0.1927	1	5
cost of prep and eval	30	2.3831	2.8333	3.2836	0.9603	1.2058	1.621	0.2202	1	5
lack adeq insurance	30	2.3571	2.8	3.2429	0.9446	1.1861	1.5945	0.2166	1	5
lack of design knowl	30	1.9983	2.4333	2.8684	0.9279	1.1651	1.5663	0.2127	1	5
poor communication	30	2.2733	2.6333	2.9934	0.768	0.9643	1.2963	0.1761	1	5
design not to taste	30	2.7554	3.1	3.4446	0.735	0.9229	1.2407	0.1685	2	5

Statistics										
Variable	N	Lower CL Mean	Mean	Upper CL Mean	Lower CL Std Dev	Std Dev	Upper CL Std Dev	Std Err	Minimum	Maximum
owners don't get info	30	2.7279	3.0667	3.4054	0.7225	0.9072	1.2195	0.1656	2	5
delays in constr start	30	2.7089	3.1333	3.5578	0.9052	1.1366	1.528	0.2075	1	5
price uncertain	30	2.7464	3.2	3.6536	0.9675	1.2149	1.6331	0.2218	1	5
larger team diff to coordinate	30	3.1364	3.5	3.8636	0.7755	0.9738	1.3091	0.1778	2	5
Manpow for scope prep	30	1.9332	2.2	2.4668	0.5689	0.7144	0.9604	0.1304	1	4

T-Tests			
Variable	DF	t Value	Pr > |t|
Knl for scope prep	29	-8.50	<.0001
level of info	29	-6.14	<.0001
knowl to eval	29	-2.63	0.0136
time to prep and eval	29	1.56	0.1303

T-Tests			
Variable	**DF**	**t Value**	**Pr > |t|**
cost of prep and eval	29	-0.76	0.4551
lack adeq insurance	29	-0.92	0.3633
lack of design knowl	29	-2.66	0.0125
poor communication	29	-2.08	0.0462
design not to taste	29	0.59	0.5575
owners don't get info	29	0.40	0.6903
delays in constr start	29	0.64	0.5256
price uncertain	29	0.90	0.3746
larger team diff to coordinate	29	2.81	0.0087
Manpow for scope prep	29	-6.13	<.0001

Generated by the SAS System (Local, XP_PRO) on 06JAN2010 at 1:18 PM

Results for performance indicators

t Test

The TTEST Procedure

Statistics

Variable	N	Lower CL Mean	Mean	Upper CL Mean	Lower CL Std Dev	Std Dev	Upper CL Std Dev	Std Err	Minimum	Maximum
time	30	2.1499	2.5	2.8501	0.7468	0.9377	1.2606	0.1712	1	5
budget management	30	2.3183	2.7	3.0817	0.8141	1.0222	1.3741	0.1866	1	5
quality	30	1.937	2.3333	2.7296	0.8453	1.0613	1.4268	0.1938	1	5
functionality	30	2.5807	2.9333	3.286	0.7522	0.9444	1.2696	0.1724	2	5
safety	30	2.6352	3.0333	3.4315	0.8491	1.0662	1.4333	0.1947		

T-Tests

Variable	DF	t Value	Pr > |t|
time	29	-2.92	0.0067
budget management	29	-1.61	0.1188
quality	29	-3.44	0.0018
functionality	29	-0.39	0.7019
safety	29	0.17	0.8652

Results for the effects of including a project manager by the owner in projects

t Test

The TTEST Procedure

Statistics

Variable	N	Lower CL Mean	Mean	Upper CL Mean	Lower CL Std Dev	Std Dev	Upper CL Std Dev	Std Err	Minimum	Maximum
includint proj man	30	1.4751	1.7333	1.9915	0.5507	0.6915	0.9296	0.1262	1	3

T-Tests

Variable	DF	t Value	Pr > |t|
includint proj man	29	-10.03	<.0001

Generated by the SAS System (Local, XP_PRO) on 06JAN2010 at 1:25 PM

Appendix 5 Del Siegel output for Cronbachps Alpha computation

Cronbach's Alpha	0.84		**Reliability Calculator**																
Split-Half (odd-even) Correlation	0.82		**created by Del Siegle (dsiegle@uconn.edu)**																
Spearman-Brown Prophecy	0.9																		
Mean for Test	52.2																		
Standard Deviation for Test	9.65																		
KR21	2.09		Questions	Subjects															
KR20	2.13		19	30															
	Question 1	**Question 2**	**Question 3**	**Question 4**	**Question 5**	**Question 6**	**Question 7**	**Question 8**	**Question 9**	**Question 10**	**Question 11**	**Question 12**	**Question 13**	**Question 14**	**Question 15**	**Question 16**	**Question 17**	**Question 18**	**Question 19**
Subject 1	3	2	2	4	3	4	4	3	3	4	4	3	3	4	3	2	2	3	3
Subject 2	1	2	1	2	2	5	4	4	2	3	4	2	1	3	2	1	3	3	4
Subject 3	1	2	1	3	3	3	3	2	2	3	3	5	5	3	3	4	3	3	3
Subject 4	2	3	2	2	4	4	2	5	3	4	4	4	4	4	2	2	2	3	3
Subject 5	3	3	3	4	5	4	2	2	4	4	3	4	4	4	2	3	3	2	2
Subject 6	1	1	2	3	3	4	1	2	2	3	3	4	3	3	4	3	2	2	3
Subject 7	1	2	1	2	1	2	1	3	2	2	2	4	2	5	3	3	1	2	5
Subject 8	2	2	3	2	3	4	2	2	2	3	3	2	3	3	2	2	3	3	2
Subject	2	3	4	5	3	3	2	4	5	5	4	3	5	5	2	4	4	5	5

9																			
Subject 10	2	2	2	2	2	2	4	4	3	4	4	4	2	4	2	2	2	4	2
Subject 11	1	4	1	1	1	4	4	4	3	3	2	3	2	2	1	1	1	3	2
Subject 12	2	2	2	3	2	3	2	2	1	2	2	1	1	2	2	1	1	2	3
Subject 13	1	1	2	2	2	2	2	1	2	2	2	2	2	3	2	3	2	2	2
Subject 14	2	2	1	1	2	2	4	4	3	2	3	2	2	4	4	4	4	4	4
Subject 15	2	3	2	3	2	4	2	3	2	2	2	3	3	3	1	1	1	2	3
Subject 16	2	2	3	2	4	4	2	2	3	2	2	1	3	4	2	2	2	2	2
Subject 17	3	3	2	4	4	4	1	1	2	3	4	4	4	2	2	3	1	3	2
Subject 18	3	2	2	2	1	1	4	4	4	4	5	5	5	5	4	4	4	5	5
Subject 19	2	2	3	2	4	4	5	5	5	5	4	4	4	5	5	5	5	5	5
Subject 20	2	2	2	1	1	1	4	3	2	3	2	2	3	2	2	3	2	3	3
Subject 21	1	1	2	2	4	4	2	2	2	2	4	4	2	4	3	3	3	4	3
Subject 22	2	2	3	1	2	2	2	3	2	4	2	2	3	3	2	3	2	3	3
Subject 23	1	2	1	3	3	3	3	2	2	3	3	5	5	3	3	4	3	3	3
Subject 24	2	3	2	2	4	4	2	5	3	4	4	4	4	4	2	2	2	3	3
Subject 25	3	3	3	4	5	4	2	2	4	4	3	4	4	4	2	3	3	2	2
Subject 26	1	1	2	3	3	4	1	2	2	3	3	4	3	3	4	3	2	2	3
Subject 27	1	2	1	2	1	2	1	3	2	2	2	4	2	5	3	3	1	2	5
Subject 28	2	2	3	2	3	4	2	2	2	3	3	2	3	3	2	2	3	3	2
Subject 29	2	2	3	2	4	4	2	2	3	2	2	1	3	4	2	2	2	2	2
Subject 30	3	3	2	4	4	4	1	1	2	3	4	4	4	2	2	3	1	3	2