EVALUATING THE FACILITY MANAGER'S ROLE IN PROJECT DESIGN

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Declaration

I declare that this research report is my own unaided work. It is being submitted for the Degree of Masters in Building (Property Development and Management) at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

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(Keaikitse Tladi)

_______th day of March 2012

Dedication

To my God almighty who guides me all my life and to my parents, Presser Tladi and Banabotlhe Tladi for their awesome support and love.

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Abstract

The aim of this research is to investigate the role of facility managers in project design. Facility managers play a crucial role in ensuring the continuous sustainable performance of facilities. They are responsible for the planning and management of facility operations and maintenance to ensure that these are done in a cost-effective manner. Despite the crucial role that they play, the facility design process tends to leave out facility managers. This results in designs that are not easy to operate and maintain. In order to improve facility maintainability there is a need for input from facility managers at the project design stage; involving facility managers in project design should result in designs and material choices that make facilities easy and cost-effective to operate and maintain.

The research relied on secondary sources, which included books, journals and online resources. These secondary data sources were used in the literature review to identify the functions of facility management, and these functions were linked to the design process. Questionnaires were then used to get primary data from selected respondents (purposive sampling was used in this research). The analysis of collected data revealed that design considerations and building material choices made at the project design stage have a bearing on the ease and cost-effectiveness of facility operation and maintenance. Therefore, decisions made at the project design stage must take into account facility management functions to ensure that operation and maintenance of facilities are cost-effective. The main conclusion from the research is that facility manager involvement in project design should lead to better designs in terms of facility operation and maintenance, particularly for large complex facilities. The choice of procurement methods and design processes also has a bearing on project design, and choices made in this regard must allow for all stakeholders in the project design stage (including facility managers) to provide input in project design.

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CHAPTER 1: INTRODUCTION

1.0 Introduction

Buildings have a large direct and indirect impact on the environment as they require a lot of resources to construct, operate and maintain. From project conception, design, construction and post construction phases of the facility life-cycle, there is a need to design for simple and cost-effective maintenance of the facility. Much has been written about the role of facility managers in relation to existing facilities, but their role in project design is less well documented. This research is aimed at analysing how facility designers and facility managers can influence facility design in terms of cost-effectiveness of facility management, operation and maintenance. It examines the role and impact of facility managers in the facility design process. Given the key role that facilities designers and managers play in ensuring the continuing sustainable operations of facilities, there is a need for guidance to better address the link between both (facility designers and facility managers) in facility sustainability (Bosch and Pearce, 2003).

1.1 Aims of the research

This research discusses the link between building design and maintenance, and examines the relations between facility designers and facility managers. It also aims to show that facility managers have a role to play in the project design process, and that their involvement at the design stage should lead to designs that are cost-effective to operate and maintain.

1.2 Problem statement

Buildings require a lot of natural resources to construct and maintain. Designing buildings that require less non-renewable resources to construct and maintain is a way of preserving natural resources and reducing negative impacts of buildings on the environment. This also leads to easier and cost-effective facilities maintenance. In developing countries, the construction industry accounts for significant resources consumption (40 percent of all material use and about 40 percent of waste and greenhouse gas production) with the built environment, in particular the existing facilities, consuming as much as 45 percent of produced energy to run and 5 percent used during the construction phase (Elmualim et al, 2009b). Ngowi (1999) also notes that construction projects, particularly buildings, are major contributors to environmental problems as they require a lot of resources to build and they also generate significant waste amounts. Since facility managers have the responsibility of ensuring the smooth operation and maintenance of facilities, they can play an important role in the built environment. They have an opportunity to contribute to the sustainability agenda by assisting in the design of cost-effective facilities that require less resources (such as power, water, and cleaning materials) to operate and maintain. Ensuring that facilities are run with less operation and maintenance expenses reinforces the facility manager's significant role in the sustainability agenda.

Increasing environmental concerns and the need to reduce operation and maintenance costs requires facility managers and facility designers to adapt technologies and innovations so that they come up with facility designs as well as operation and maintenance requirements that use fewer natural resources to build and operate and also produce less emissions. Since facility managers are involved with the daily operations and maintenance of buildings, they have acquired knowledge to contribute at the design stage that can inform operation and maintenance requirements. They may have solutions, in terms of design considerations, materials used, and even building methods, that will ensure cost-effective facility operation and maintenance.

Barret and Baldry (2003) argue that while the building process normally includes designers, clients and end-users, there is usually very little communication between the end-users and the other two groups (designers and clients). This leads to designers and clients making decisions for the end-users and this may result in facilities that do not suit the end-users. Similarly, facility designers are not involved in the facility delivery process (from project inception to the completed structure), resulting in facilities that are not easy or cost-effective to operate and maintain.

There is a need for facility managers to appreciate how design decisions are made, and for facility designers to appreciate the impact of their designs on operations and maintenance. Facility managers are responsible for operations and maintenance. In this regard, they are exposed to daily contact with end-users, daily operations and maintenance issues. Their accumulated knowledge can be invaluable in the planning of new buildings, provided they are consulted during the design process and included in design teams.

Some barriers to the involvement of facilities managers in the design process have been identified. According to Jensen (2009) there is a perception that facility managers can only play a limited role within their own organisations and within design teams and that they are generally seen as not suitably qualified to be equal partners in the design process. There should be a shift from this kind of perceptions and the various roles that facility managers can play in the facility design should be explored. Facility managers acquire valuable knowledge from their intimate exposure to operation and maintenance of facilities and this can be used in the design of new facilities. In addition, ensuring adequate training and qualifications will facilitate their involvement in the project design process.

Elmualim et al (2009a) argue that even though theoretical and practical tools for sustainable design have been developed, little impact is realized due to the omission of facility management expertise from the project design processes. In order to fully ensure that sustainable design is taken on board at the project design stage, it is vital that knowledge and expertise from building maintenance is carried into new designs or refurbishments. Facility managers are best placed to contribute in this regard because of their daily involvement with building operations and maintenance.

1.3 Hypothesis

The hypothesis of this research is that facility managers have a role to play in the project design process, from project inception/conception stage through to final design. Their involvement in the design process should lead to better, cost-effective designs in both capital and maintenance costs.

1.4 Research question

The main research question is as follows:

- What is the impact of facility manager's role in the project design process?

1.5 Research objectives

The objectives of this research are:

- Assess the role of facility managers in facility design.
- Assess the impact of involving facility managers at the project design stage.

1.6 Importance of study

Facility managers play an important role in ensuring the sustainable operations and maintenance of facilities, hence the need to leverage their expertise and engage them more directly in the facility procurement process. Increasing energy prices and environmental awareness are among the main driving forces behind 'green building' designs that use fewer resources to build, operate and maintain. Developers are also concerned with the long-term expenses incurred by facility maintenance, hence the need to invest in sustainable buildings, from construction to operation and maintenance.

1.7 Limitations and scope of the research

Facility managers have a wide range of duties that include maintenance operations, financial management, administration services and space planning. This research is limited to assessing their role and impact on the facility design process. Furthermore, the research focuses on the facility management role within relatively large and complex buildings that require professional facility management services.

1.8 Structure of the research report

The research report is divided into five chapters. Chapter 1 provides an introduction to the research report and states the aims and objectives of the report. It also states the research questions, the hypothesis and the research context. Chapter 2 contains the literature review, which discusses the critical aspects of current knowledge and approaches to the facility manager's role in project design. Chapter 3 provides the research methodology and describes the framework within which the study was conducted; research procedures, methods and tools used in the study. It also rationalises the chosen research methods and tools. Chapter 4 presents the data analysis and it includes data analysis, interpretation and presentation. It also includes a discussion on the key findings and what these findings signify. Chapter 5 offers the conclusions and recommendations of the research report to give guidance on how to best involve facility managers in project design.

CHAPTER 2: LITERATURE REVIEW

2.0 Introduction

The review of literature indicates that a lot has been written on project design and on the role of the facility manager after facilities have been constructed. However, not much has been written on the role of facility managers at the project design stage. Despite this, the research report provides as much as possible the link between the design of facilities and the role that facility managers can play in project design.

With growing indications that sustainable design and construction produces energy efficient, cost-effective, and environmentally friendly and occupant friendly facilities, organisations are seeking guidance on how to integrate concepts of sustainability into their capital projects (Bosch and Pearce, 2003). Rwelamila et al (2000) assert that buildings require significant amounts of natural resources to construct and maintain and that they also generate large amounts of waste, hence need for careful and considerate building designs and careful choice of building materials and technologies to ensure environmental sustainability and cost-effective operation and maintenance. Producing facility designs that take into consideration environmental concerns as well as operation and maintenance costs is of importance. In order to maximise facility performance, both in cost and performance, it is necessary to utilise all information available at the conceptual and design stages. This requires input from all stakeholders involved, including facility managers.

Buildings can last a very long time and it is better to design for efficiency and cost-effective operations and maintenance from the beginning. With the world facing the challenges of natural resource depletion, global warming and rising utility costs, there is a need for stakeholders in the built environment to contribute to the sustainability agenda by designing facilities that use less resources to build, operate and maintain. Ensuring that all stakeholders assess the environmental, operation and maintenance issues at the project design stage is key.

Lehrer (2002) argues that while many designers and architects are aware of minimum environmental requirements such as energy codes and environmental impact assessment (EIA) requirements, few projects are designed to surpass these standards. This indicates that facility design does not take into account maintenance implications or environmental concerns of the designed facilities. However, the building industry is a consumer of significant amounts of natural resources; hence there is a need to ensure that it takes into account maintenance and environmental issues when undertaking projects.

McDonald (2005) states that "green building" is a term used to describe facilities designed for minimum impact on the environment. Principles of green building can be applied to the design of facilities with the view of making them cheaper and easier to operate and maintain. Recurring measures such as refurbishments and renovations may be used as opportunities to gradually make a building more environmentally friendly and cost-effective to operate and maintain. However, changes made at the design stage generally give more returns than when modifications are made after building completion (Greed et al, 2000).

Green buildings offer a viable alternative to conventional buildings in that they are relatively cheaper to construct and operate (McDonald, 2005). Lehrer (2001) notes that some of the major considerations that are taken into account by green buildings include occupants' health and comfort, impacts of new projects on infrastructure, environmental impacts of building materials and ecological footprints. These considerations are also important from the facility management perspective as they impact on the ease and cost of facility operation and maintenance.

The design team composition and procurement methods used can also impact the project design process. When selecting the design team, there must be an undertaking to attain a balance between technical knowledge and skills of the team members (Barret and Baldry, 2003). A survey conducted by Hibberd and Djerbani (1996) in the United Kingdom revealed that poorly composed design teams accounted for 25 percent of the problems associated with procurement methods. Other problems identified include frequently changing project requirements, communication issues, cost control, unclear delineation of responsibilities, inadequate supply information, and quality and design faults. Early collaboration from project conception by a larger, more diverse professional team should help design teams deliver projects that are both sustainable and cost-effective. The procurement method should also be one that allows professionals with different skill sets to come together at project inception and design, thereby encouraging more meaningful and balanced contributions to all design aspects.

2.1 An overview of facility management

Table 2.1: Typical facility management activities

Facility planning	**Building operations and maintenance**
• Strategic space planning • Set corporate planning guidelines and standards • Identify user needs • Furniture layouts • Monitor space use • Select and control use of furniture • Define performance measures • Computer-aided facility management	• Run and maintain plant • Maintain building fabric • Manage and undertake adaptation • Energy management • Security • Voice and data communication • Control operating budget • Monitor performance • Supervise cleaning and decoration • Waste management and recycling
Real estate and building and construction	**General/office services**
• New building design and construction management • Acquisition and disposal of sites and buildings • Negotiation and management of leases • Advice on property investment • Control of capital budgets	• Provide and monitor support services • Office purchasing (stationery and equipment) • Non-building contract services (catering, cleaning etc.) • Reprographic services • Housekeeping standards • Relocation • Health and safety

Source: Barret and Baldry, 2003

Facility management has been defined as a multidisciplinary profession that covers diverse areas of expertise such as engineering, architecture, design, accounting, finance, space planning and management, and behavioural science (Springer, 2001). It is concerned with the operations and maintenance of large facilities (mainly commercial or institutional). These include commercial complexes, industrial complexes, office complexes, sports complexes and schools.

Facility management covers a wide range of knowledge areas such as real estate, space planning and management, and facility operation and maintenance as indicated in **Table 2.1**. It is the role of the facility management team to ensure proper operation of the facility and in order to be effective, the team needs to be adequately trained and have a maintenance plan.

2.1.1 Managing the electricity account

It is important that the property manager is familiar with the electrical distribution system of the property; they must know the position of the various distribution boards, understand what areas the boards feed and ensure electrical layout plans are kept up to date (Cloete, 2002). It is of great importance that the facility manager keeps updated drawings showing electrical fittings and the whole electrical network system. According to Cloete (2002) important aspects in designing the electrical network include:

- **Budget limitations**: Cloete (2002) argues that electrical engineers must be consulted on electrical systems and the impact of allocating different users to different parts of the building in order to meet any special tenant needs. Accommodating special user requirements has an impact on the design and on the resulting capital and operation costs of the electrical system.

- **Operating costs**: While it is important to keep capital costs low, there is also a need to keep ongoing operation costs down. There must be a strike to balance cost-cutting measures and efficiency (Cloete, 2002). It is important for the property manager to keep electricity consumption low, as high electricity costs can lead to increased rental rates, which may in turn result in reduced building occupancy levels.

- **Emergency power supply**: The property manager is also responsible for uninterruptible power supply (UPS) systems and standby generators for the building. When designing emergency power reticulation, it is important that the safety of tenants and effective evacuation plans are the prime considerations (Cloete, 2002). Cloete (2002) also notes that it is crucial that emergency power covers areas such as escape passages and smoke ventilation systems, as these are essential during emergencies to facilitate evacuation and adequate smoke ventilation.

Several design strategies are available to reduce the energy consumption of electrical lighting systems in a facility (Lehrer, 2001); these include the use fluorescent lamps instead of incandescent lamps, and the use of daylight sensors to automatically facilitate an optimal combination of natural and artificial light. It is therefore important to explore the different options and come up with one most appropriate and suited to the proposed facility.

2.1.2 Environmental conditions: heating ventilation air conditioning (HVAC)

Cloete (2002) asserts that this is the process of manipulating the air within a facility with the aim of controlling its temperature, humidity, cleanliness and distribution and that the selection criteria used when selecting HVAC systems includes:

- **Performance and capacity needs**: The facility's heating and cooling requirements must be established in order to ascertain the capacity of the required HVAC system: cooling and heating plants, air distribution systems and equipment (Cloete, 2002). The HVAC system chosen must meet the required energy consumption and comfort levels.

- **Space requirements**: The space requirements of different HVAC systems are an important consideration; some require relatively more space and some require internal units in each rental unit (Cloete, 2002). This has an impact on maintenance as such internal units must be serviced within the tenant's space and the maintenance team must have access to these areas.

- **Capital cost**: While the capital cost of the HVAC is important, consideration should also be given to operating costs; over time, an expensive system may be more cost-effective to maintain than a relatively cheaper system (Cloete, 2002).

- **Dependability**: The dependability and life-cycle of the HVAC system is a crucial attribute as these factors may influence maintenance and replacement cycles of the system (Cloete, 2002).

- **Flexibility**: Some systems are adaptable to changing requirements while others cannot accommodate changes in requirements that may be required by tenants (Cloete, 2002).

- **Ease of maintenance**: Ease of maintenance is an important consideration; some HVAC systems make it difficult to apportion electrical operation and maintenance costs to the different tenants in the facility (Cloete, 2002). The location of maintenance activity is important, as all installations need to be easily accessible by maintenance teams.

- **Environmental concerns**: Air conditioning systems that make use of chlorofluorocarbons (CFCs) are not recommended as they are known to harm the ozone layer and preferred systems use absorption cycle air conditioning that operates without the use of CFCs (Cloete, 2002).

Cloete (2002) argues that distribution systems and physical space must be designed to easily accommodate any additional equipment required for future expansion or changes. HVAC systems must therefore be flexible and adaptable in order to accommodate changes that may need to be undertaken. It must also be easy to and cost-effective operate and maintain. The building size, design and client/user requirements will influence the type of HVAC system.

2.1.3 Transportation, access and circulation

Transportation, access and circulation are important to the smooth daily operations of any facility. Adequate access points and circulation must allow for ease of movement for motorised traffic as well as pedestrian traffic. Vehicle circulation should cross pedestrian walkways as little as possible and pickup areas (such as for customer or boarding vehicles) and parking areas, should also be clearly defined and marked (Cloete, 2002). These will inform pedestrians where to walk and avoid vehicles.

2.1.4 Servicing and waste disposal

The delivery and dispatch of goods from a building, as well as refuse collection, is vital to the operations of a building and needs to be carefully planned well in advance to adequately serve the property (Cloete, 2002). Cloete (2002) also argues that service roads must be provided with adequate loading/offloading bays and adequate access for emergency vehicles such as fire fighting vehicles must be provided. Planning for these services at the project design stage will enhance the facility operations, particularly adequate access for delivery and emergency vehicles.

The refuse facilities must be strategically located to allow both tenants and refuse collection vehicles easy access (Cloete, 2002). In addition, adequate refuse disposal facilities should be strategically located within facilities for the clients (i.e. for shoppers in shopping malls) to discourage littering. Cloete (2002) also asserts that the property manager must be acquainted with the different options available for refuse removal systems and should consult with relevant stakeholders such as the local municipality before deciding on an appropriate system. Such communication will ensure that adequate waste disposal operations are selected.

2.1.5 Water services

The flow of both hot and cold water is controlled by a series of taps, valves and cocks and these must be positioned so as to isolate the complete hot or cold water systems or some sections of it to ensure that the system or appropriate sections can be shut down for maintenance, repairs, and in case of emergency (Greed et al, 2000). All water services must be readily accessible as they need to be regularly serviced to ensure that they work properly (Cloete, 2002).

The water systems design should consider the ease and costs of operation and maintenance. A number of design strategies such as low flush toilets may be implemented to conserve water (Lehrer, 2001). The choice of materials such as copper, stainless steel or a variety of plastics should be carefully considered and durable, environmentally friendly material that is easy and cost-effective to maintain must be used. Another important factor is the necessity to boost pressure with the aid of pumps where pressure is low or if the building is tall (Greed et al, 2000).

Facility managers, because of their involvement in regular maintenance of the water system, are familiar with the advantages and disadvantages of different pipe network systems and equipment options and materials. They can use such information for the benefit of design teams at the design stage to ensure easy and cost-effective operations and maintenance.

2.1.6 Maintenance, cleaning and ground maintenance

Property maintenance has been defined as work undertaken in order to keep, refurbish or renovate a property; including every part of the site, building and its contents in an acceptable state and it is aimed at preserving the condition of the property while keeping operating expenses low (Kyle et al, 2000).

Kyle et al (2000) assert that maintenance is done mainly for:

1. **Preservation and enhancement of property value**: A comprehensive maintenance programme can preserve and enhance value of the facility.
2. **Minimising operating costs**: Regular inspections should be carried out and these will disclose any problems before major repairs become necessary and this in turn helps reduce corrective maintenance cost.
3. **Tenant retention**: Inadequate maintenance will lead to poor tenant satisfaction and cause them to leave. This will lead to high vacancy rates and high expenses from turnover of rental space.

The maintenance requirements may depend on the size, location and design of the property and the level of services required will establish whether to hire on-site maintenance staff or contract out (Kyle et al, 2000). The building condition and ease of access also affects maintenance; a building that has been poorly maintained and with difficulty in accessing areas that need maintenance and cleaning will have higher maintenance and cleaning costs than buildings that have been well maintained and have adequate accesses to areas that require maintenance and cleaning. A facility should have a maintenance plan that covers the physical structure, equipment, interior and external (grounds) elements (Kyle et al, 2000). A well planned operation and maintenance plan will help attract and retain tenants and will also ensure that the facility runs the course of its intended life-span.

2.1.7 Communication and control systems

These may include the following:

- **Communication systems**: These are a crucial requirement and they include public address systems required to communicate emergency procedures and for use during activities such as promotions and marketing, especially in large shopping centre (Cloete, 2002).

- **Control and monitoring systems**: For efficient running of especially large and complex buildings, an extensive network of control systems is necessary (Cloete, 2002); such control systems may be manual and labour intensive, with little or no electronic back-up, or they may be fully automated. Cloete (2002) notes that a control system may include the following:
  - A security system with or without a closed circuit television (CCTV) system
  - A fire and smoke detection system
  - External non-public door monitoring (including fire escape and delivery entrances)
  - Two-way radio equipment for communication
  - Megaphones (for emergencies and public control)

2.1.8 Building management systems (BMS)

Building management systems (BMS) are computer based control systems that link various subsystems in a building, such as lighting control, public address systems, smoke and fire alarms (Cloete, 2002). It can automate lighting and HVAC in a building, enhance security though the use of digital surveillance, monitor safety measures (by using smoke, fire, motion and occupancy sensors), and communicate alerts by means of email or text messages (Cloete, 2002). These systems also help make facility operation and maintenance easier and efficient by linking the various subsystems to a centralized control system.

2.1.9 Security and life safety

Safety and life safety measure needs vary with the design of the centre (Kyle et al, 2000). In a small facility tenants may handle their own security while in large centres a full complement of security officers (in-house or outsourced) may be deployed. Kyle et al (2000) also note that facilities security requires constant watchfulness and a well-judged use of cameras and clear and visible evacuation routes for safety and emergencies.

Cloete (2002) asserts that other safety features that are required in facilities include:

- **Smoke and fire detectors**: Smoke and fire detectors, required to detect fires and smoke, should be located on each floor and should be tested regularly.
- **Sprinkler systems for fire fighting**: A fire sprinkler system includes a water supply and a pipe system onto which fire sprinklers are attached.
- **Paging systems**: A paging system should be available to permit the broadcast of messages to tenants within the facility.
- **Intrusion alarm systems**: Security intrusion detectors (alarms) may be activated by sound or motion and sent to a centralised system that can indicate the specific area of intrusion to the security personnel for appropriate action.

Lehrer (2001) asserts that gas extinguishing systems are also a crucial part of safety devices; materials and furnishings that emit toxic products must be avoided and appropriate steps taken to prevent pollutants from entering a building's airstream. Appropriate measures must be put in place to mitigate against any possible gas emissions in a facility.

These safety features should be tested regularly to ensure that they work and regular drills undertaken to ensure that these systems, as well as the emergency and evacuation procedures employed work smoothly (Cloete, 2002). The facility manager is in charge of the security and life issues and if these issues are not taken into account at the design stage and planned for in advance, it will be hard for the facility manager to carry out these duties effectively. Such systems need to be set up such that they allow for easy and cost-effective maintenance, while also retaining their effectiveness.

2.1.10 Life-cycle costing (LCC) and churning

1. **Life-cycle costing**: Throughout the project design stage, the developer is confronted with choices between different types of systems and materials relating to fire prevention equipment, security systems, HVAC equipment, and finishing materials (Cloete, 2002). There is a need to weigh the advantages and disadvantages of the different systems and make the appropriate choice. Preference should be given to materials and equipment that are durable, cost-effective to operate and maintain and have a long life-span. Even though it is difficult to change life-cycle costs for existing facilities, the facility manager can take measures throughout the life of the facility to ensure that these are kept to a minimum (Klaamt, 2001). Because of lessons learnt during daily operation and maintenance of facilities, the facility manager can play a crucial role during the design process by providing accurate information on long-term operational costs and introducing feasible and proven design and construction alternatives. Life-cycle costing is crucial in any development. For example, it is not cost-effective to recapitalize a building after two or three years of construction; a developer would rather-choose a recapitalization period of ten or more years

2. **Churning**: A key concern in the life-cycle energy analysis of a facility’s equipment and furniture is the “churn rate”; which is how often an item is replaced over the life of a facility (Treloar et al, 1999). This information is useful for facility managers and designers because it brings into perspective the implications of the replacement of fixtures, fittings and furniture in buildings (Treloar et al, 1999). The facility manager needs to keep precise

information on the building's furniture and equipment as this will assist in planning for their eventual replacement (Erdener, 2003).

Table 2.2: Churning rates for buildings

Building element	Churn rates %	Building element	Churn rates %
Upper floors	0	Columns	0
External walls	10	Wall finishes	400
Substructure	0	Fire protection	20
Electrical	20	Plumbing	20
Floor finishes	200	Ceiling finishes	100
Internal walls	10	Other	20
Air conditioning	20	Fixtures, fittings & furniture	560

Note: *A churn rate of 0 percent indicates that the element is not replaced during the building's life, while a churn rate of 100 percent means the element is completely replaced once during the building's life, and so forth.*
Source: Treloar et al, 1999

Table 2.2 shows the churn rates for different building elements. Maintenance planning and churn rates of building components need to be planned for in advance to assist the facility manager in planning for maintenance and replacement of the different building elements. The various churn rates of fixtures, fittings and furniture necessitates that from the project design stage there must be consideration towards materials and equipment selection to ensure that churn rates are kept to a minimum.

Churning also refers to the facility management activities associated with the relocation and reconfiguration of worker space and this calls for greater emphasis to be given to configuration of workstations (Treloar et al, 1999). The relocation of personnel from one workstation or from one office to another may be necessitated by factors such as changing workstation or office requirements. If such office or workstation reconfiguration and relocation is frequent it will impact on the cost-effectiveness of operation of the building, hence careful thought should go into planning and designing of workstations.

2.1.11 Post occupancy evaluation (POE)

POE is the process of determining whether or not building designs perform to the expectations of those who use the facility (Ilesanmi, 2010). It can be used to identify problem areas in the performance of existing facilities and to identify areas for improvement in the design of future facilities (Preiser, 1995). Facility managers can also use this tool to check and improve the quality and performance of facilities and to collect information for feedback at the design stage (Mohammed and Hassanain, 2010). **Table 2.3** summarizes the common set of problems in building performance.

Table 2.3: Common set of problems in buildings

health and safety problems	security problems
leakage	poor signage
poor air circulation and temperature control	handicapped accessibility problems
lack of storage	lack of privacy
hallway blockage	aesthetic problems
entry door problems with wind and accumulation of dirt	inadequacy of designing space for equipment (like copiers)
maintainability of glass surfaces (e.g. sky-walks or inaccessible skylights)	

Source: Preiser, 1995

Since the facility manager is involved with operation and maintenance of all the services related to building, public safety and emergency services, they can ensure that these elements are not overlooked at the design stage of the project.

2.1.12 Space planning and management

Hassanain (2010) asserts that the planning, design and management of space is one of the main responsibilities of the facilities manager. Space refers to any part of a facility and it may be classified as interior or exterior and such spaces could be enclosed by walls or partitions or they may just be open (Hassanain, 2010). Therefore, both exterior and interior spaces need to be planned for and used efficiently to ensure that they are used in a cost-effective manner. It is necessary that workplaces are properly planned and managed and put to their best possible use (Hassanain, 2010).

Hassanain (2010) contends that a crucial consideration in space planning is planning for future changes in the organization's space requirements. Therefore, space design should offer flexibility; space design that can be modified easily and cost-effectively when requirements change should be explored. From the project design stage, space planning and management must be forecast.

There is need to consider space planning and management at the project design stage to ensure that operation and maintenance considerations are taken on board when planning for space use. It is the duty of the facility manager to manage internal and external space and decisions made at the design stage will impact on the management of space.

2.1.13 Benchmarking

Benchmarking is the process of measuring the specific activities that give an organisation maximum performance in a specific area and adapting and applying these to one's own establishment (Rondeau, 2001). Benchmarking allows organisations to identify areas that require to be improved and the organisation must be prepared to work on these areas to ensure that they are at par with best practices.

According to Williams (1996), target areas for benchmarking include capital and operating costs. The capital costs for a construction project are the expenses related to the initial establishment of the facility, while operating costs refer to the cost of running and maintaining the facility. These costs must be kept at a minimum to ensure project sustainability and viability. Both capital costs and operation costs can be benchmarked with those of similar facilities to ensure that the proposed facility compares favourably.

Loosemore and Hsin (2001) indicate that measurement of facilities performance must include the physical performance, functional performance and financial performance:

1. **Physical performance**: refers to the building's structure and includes physical properties such as structural integrity, heating, lighting, maintainability and durability (Loosemore and Hsin, 2001).
2. **Functional performance**: refers to how the building impacts its occupiers and includes issues such as space, layout, ergonomics, communications, health, safety and flexibility (Loosemore and Hsin, 2001).
3. **Financial performance**: arises from the physical and functional performance of the building and comprises capital and operation and maintenance expenditures (Loosemore and Hsin, 2001).

Williams (1996) also argues that space can be benchmarked and all of a building's cleaning costs and floor areas need to be known for the purpose of benchmarking maintenance and cleaning costs. The effectiveness of facility management activities needs to be compared with best practices in the field to ensure that they are at par with competitors and that they meet the required levels for cost-effective operations and management.

2.2 An overview of construction procurement systems and their possible impacts on the design process

2.2.1 Introduction

Facilities are expensive to construct and maintain and may need constant adjustments to function effectively over their life-cycle. It is important to consider all design factors and input from all stakeholders to ensure that a holistic approach is taken when designing facilities. For successful conclusion of a project, the resulting facility needs to be suitable for the purpose for which it is acquired and also be cost-effective to build, operate and maintain.

The design process is just one part of the facility procurement system. Facility or building procurement systems refer to the whole process of designing and constructing facilities. It is difficult to explore design without mentioning the construction procurement system as a whole because different procurement systems may have different impacts on the design process. Masterman (1996) classifies project procurement systems into several categories based on the interaction between design and construction responsibilities:

1. Separated and cooperative systems
2. Integrated Systems (also referred to as 'design and build')
3. Management Oriented Systems

2.2.2 Separated and cooperative systems

This is also known as the 'Traditional Construction Procurement System' (TCPS) (Rwelamila et al, 2000). In these systems the primary elements of the facility delivery process (design and construction) are the responsibility of different or separate organisations and funding is the responsibility of the client, who also has to deal with all members of the procurement team (Masterman, 1992). Rwelamila et al (2000) observe that the TCPS follows a chronological path of four key steps; preparation, design, preparation of tender documents and construction:

i. **Preparation**: This is the first stage where the client identifies the need for the project. The client establishes their requirements and appoints a project manager (PM), who is in most cases an architect (Rwelamila et al, 2000). The design team, consisting of different professionals is then appointed.

ii. **Design**: Once the preparation activities are complete, the design team, led by the PM produces schematic designs through a series of sub-phases; briefing, feasibility, pre-design and detailed design (Rwelamila et al, 2000).

iii. **Preparing tenders**: Tender documents normally consist of drawings and specifications and a bill of quantities prepared by a quantity surveyor on the basis of details in the final design drawings and tenderers use these bills of quantities and detailed design drawings to cost their bids (Rwelamila et al, 2000). Rwelamila et al (2000) also observe that for the TCPS to be successful, it is crucial that the designs are completed before the bills of quantities are prepared and the tendering process started.

iv. **Construction**: Construction starts after the selection and engagement of a contractor. Rwelamila et al (2000) observe that the client and the contractor will sign a contract that describes what is to be constructed and the roles of the various stakeholders involved. After construction the facility is handed over to the client/user for occupation

2.2.2.1 How the separated and cooperative systems can influence the design process

de Silva et al (2004) assert that some of the issues that lead to facility maintenance problems under the TCPS include inadequate construction knowledge, insufficient inspection during construction, and design and material limitations. Mohammed and Hassanain (2010) also argue that most maintenance problems in a facility are due to design problems. In this regard lack of cooperation amongst stakeholders involved, particularly the contractor and design team, at project design is the main contributor to the problem of facility maintenance in the separated and cooperative systems. In this system the contractor's knowledge and experience in construction is not taken on board because design is separate from construction; this denies the facility designers, construction professionals and the operation and maintenance team the chance to work together to consider design options. This also means that the client is denied the chance to make informed decisions regarding design alternatives at the design stage. Greed et al (2000) reinforce the argument that the separation of design and construction is a disadvantage of the TCPS as the construction company has had no input into the design process.

2.2.3 Integrated systems

Under this system one organisation is appointed to undertake both design and construction of the facility (Masterman, 1996). This view is supported by Turina et al (2008) who argue that under these systems the two basic elements of design and construction are combined and are undertaken by a single entity which may be, but is not always the contractor. Masterman (1996) notes that there are two main variants of this system; various forms of design and build; and build, operate and transfer methods.

i. **Design and build (D & B)**: Turina et al (2008) observe that under this system the processes of design and construction are contracted for with a single organisation which has all the required design and construction expertise as well as the necessary resources to undertake the project. Turina et al (2008) also observe that in this system, activities of design and construction can be combined. Therefore the design phase and construction phase of the project may overlap.

ii. **Build, operate and transfer**: Masterman (1996) asserts that these include Public Private Partnerships (PPPs). PPPs have been adopted by several countries in recent years and can be defined as a partnership or an alliance by a government and the private sector in carrying out developments and these initiatives have enabled governments to use finance and expertise from the private sector in the acquisition of public infrastructure through a variety of models such as Design Build Finance and Operate (DBFO), Build Own Operate (BOO) and BOT (Chege and Rwelamila, 2001).

Table 2.4: Build Operate and Transfer project procurement structures

Contract type	**Characteristics**
Build Own Operate Transfer (BOOT)	The service provider is responsible for design and construction, finance, operations, maintenance and commercial risks associated with the project. The service provider owns the project throughout the concession period The asset is transferred back to the government at the end of the term, often at no cost.
Build Own Operate (BOO)	Similar to BOOT projects, but the service provider retains ownership of the asset in perpetuity. The government only agrees to purchase the services produced for a fixed length of time.
Design Build Operate (DBO)	A design and construction contract linked to an operation and maintenance contract. The service provider is usually responsible for financing the project during construction. The government purchases the asset from the developer for a pre-agreed price prior to (or immediately after) commissioning and takes all ownership risks from that time.
Lease Own Operate (LOO)	Similar to a BOO project but an existing asset is leased from the government for a specified time. The asset may require refurbishment or expansion.

Source: Arndt, 1999 as cited in Chege and Rwelamila, 2001

Table 2.4 outlines the BOT option and its variants, outlines some qualities of these different options and shows the linkages between them as well as the financial aspects of the project. Financing of the projects under the BOT arrangement and its variants is done by the private sector and in South Africa the DBFO variant that has been adopted is comparable to the BOOT model outlined in **Table 2.4** (Chege and Rwelamila, 2001).

2.2.3.1 How the integrated systems approach can influence the design process

Greed et al (2000) assert that the integrated systems variants may be considered as variants and hybrids of the D & B package as they all have a common offering of a package deal with a single point of contact for the client. The client therefore has only one organisation to deal with as they can engage a single organisation to design, manage and construct the entire project from project inception (Turina et al, 2008). From the project design viewpoint, the appeal of this system is that it removes the separation of the design process from the construction process, thus enabling the contractor to contribute to the design process.

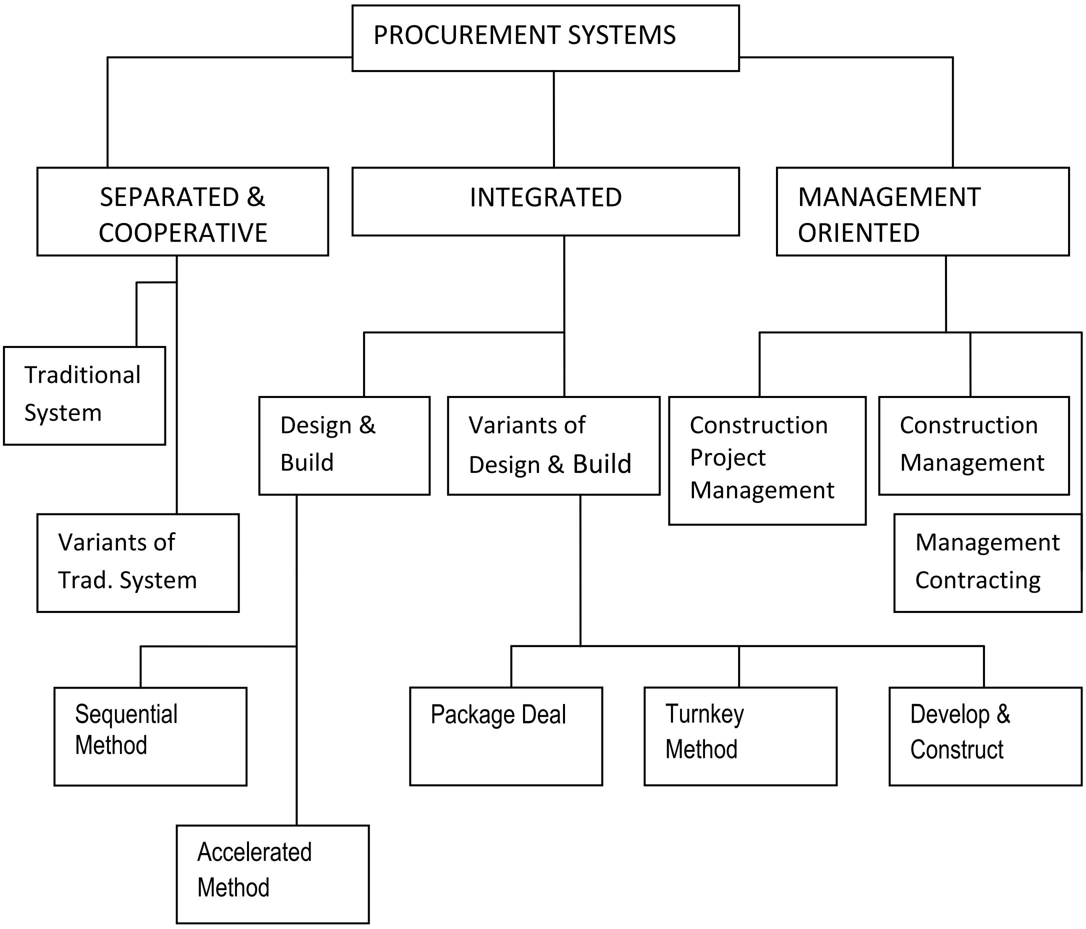
According to de Silva et al (2004) the D & B system benefits from the contractor's expertise and experience at the project design stage. This view is reinforced by (Turina et al, 2008) who observe that this system provides the required multi-disciplinary approach to the design process as it accommodates the interaction between the design and construction teams at the design stage, hence allowing both teams to work together. The close interaction between the design team and construction team starts early on in the design process and this allows for shortcomings in the design to be identified before the implementation phase. The D & B system therefore has the advantage of accessing a larger pool of knowledge, as it draws from the contractor's expertise and experience at the design stage. The end result is a facility that is easy and cost-effective to operate and maintain.

2.2.4 Management oriented systems

Under management oriented systems, the management of the procurement process is carried out by one organisation in conjunction with the project designer and other appointed consultants to produce the design and also manage and coordinate the operations carried out by selected contractors (Masterman, 1996). The different categories of construction project procurement systems are shown in

Figure 2.1. Masterman (1996) asserts that there are three types of management methods for procurement of construction projects:

Figure 2.1: Category of building procurement systems



Source: Masterman, 1996

i. **Management contracting**: Under management contracting, a management contractor manages the project delivery process by overseeing construction work done by appointed contractors (Masterman, 1996). The management contractor is appointed at the project design phase and as such has the opportunity to be part of the design team and make contributions at this stage.

ii. **Construction management**: In this method a construction manager is appointed as a consultant by the client to manage the project by selecting, engaging and managing packages of construction work done by appointed subcontractors (Masterman, 1996).

iii. **Construction project management**: This refers to the appointment of a project manager to carry out the whole planning and coordination of a project from conception to completion, including site acquisition, design commissioning and construction (Masterman, 1996). Alternatively, the project manager may be appointed as a consultant working with the client, rather than assuming total responsibility on behalf of the client.

2.2.4.1 How the management oriented approach can influence the design process

Greed et al (2000) argue that under this procurement system there is no clear definition of where design of the facility comes into the procurement process; the client may provide initial designs and the final design may be completed by the appointed management company. However, in most cases the appointed management company provides a preliminary design that meets the client's approval and construction is done according to this initial design (Greed et al, 2000). This system does not separate the design and construction phases of the project; construction starts before the building design is concluded. This offers more flexibility as the design is not necessarily completed when construction begins (Greed et al, 2000). This makes it easier to change or modify some aspects of the design during the construction process.

2.2.5 Construction procurement methods in South Africa

Most of the construction procurement systems (CPSs) are used in South Africa. Currently, the most common CPS of the construction industry is the traditional or separated and cooperative systems (Rwelamila and Smallwood, 1999). Other building procurement methods in use include D & B. According to Grobelar and Pretorius (2002), about 29 percent of construction projects in South Africa are procured through the use of the D & B approach. The Government of the

Republic of South Africa, recognising the need to involve the private sector in service delivery provision, has undertaken a number of PPP initiatives in various sectors and selected pilot projects have been structured along the DBFO approach (Chege and Rwelamila, 2001).

2.2.6 The design process

Bosch and Pearce (2003) assert that the successful incorporation of sustainable strategies depends on an integrated project design approach. Using this approach, stakeholders such as facility managers, operations and maintenance staff, and members of the local community take part in the design process as early as the pre-planning phase to ensure that sustainability goals are achieved (Bosch and Pearce, 2003). The participation of facility managers during planning, design and construction phases is to ensure that sustainable and cost-effective operations and maintenance design strategies are not undermined.

Larsson (2002) states that even though there are many exceptions, there is a traditional design process that is usually undertaken by the client, their architect and mechanical and electrical engineers; under this system, the architect and the client provide a design concept and then engineers are required to implement the design and come up with suitable systems. Larsson (2002) also argues that even though this may be a simplified description, such a process is one that is followed by many design firms, and it generally limits the interaction of the design team.

Larsson (2002) further argues that the design features that result from such a process seldom take advantage of the possible benefits offered by natural resources such as sunlight, resulting in greater use of electricity and high operating costs. Due to inadequate attention to environmental aspects conventional/traditional design processes tend to frequently result in facilities with high operating and maintenance costs and these in turn may reduce property values (Larsson, 2002).

McDonald (2005) asserts that the integrated design process, which is seen as a collaborative method for designing buildings, is critical to cost-effective building design. In the traditional design process, the design team members tend to think in compartments and members do not approach the design in relation to the entire project; there is no commitment to a single shared goal as design and construction professionals work independently within their respective areas of expertise and this leads to inappropriate design decisions as there is no common vision for the project as a whole (Larsson, 2002).

The integrated design process requires a multi-disciplinary approach and the inclusion of all key stakeholders and design professionals from project inception to construction (Bosch and Pearce, 2003). This approach to design enables all stakeholders to be part of design teams and offer meaningful contributions during the design process. It deviates from the traditional design approach as it leverages the collective expertise of the design and construction teams early on in the design process (Larsson, 2002). By bringing all the stakeholders early on in the design process, there is a chance for them to collaborate and come up with appropriate and innovative design strategies. There must be a shift towards the integrated design process as it allows the design team to establish project goals together while engaging in a productive exchange of ideas.

2.2.6.1 Inception stage

According to Best and De Valence (1999), the decision to construct a facility may be based on several premises such as owner occupation or investment. Smith et al (2000) emphasise that a project is initiated because of dissatisfaction with the status quo that may require construction of a new facility or modification of an existing facility. Requirements of the client must be thoroughly assessed to ensure that the decision to modify an existing facility or build a new one is the most appropriate decision. The inception process must therefore come up with a decision that is cost-effective and meets the client’s requirements.

2.2.6.2 Briefing stage

According to Yu et al (2007) problems in buildings often start at the briefing stage of the procurement process. This view is emphasised by Smith et al (2000) who argue that there are problems at the briefing stage mainly because not enough effort is put in assessing the needs of the client, stakeholders and the design team at this stage. Adequate resources must be availed at this stage as this is where the client's requirements need to be clearly stated and communicated to all stakeholders.

According to Best and De Valence (1999) identifying constraints that cannot be controlled by the design team such as plot location and shape, budget limitations and legislative constraints such as zoning and planning restrictions is key to the preparation of a complete and comprehensive brief. These constraints have a direct impact on the project and identifying them will allow the design team to mitigate against them early on in the deign process.

2.2.6.3 Pre-design stage

Brown and Nash (1988) note that at this stage attention is given to civil, mechanical, and architectural design and the preparation of drawings to communicate these design concepts. A preliminary design report is prepared at this stage; this describes the structural components and mechanical processes of the facility and will consist of drawings as well as an outline of materials and equipment specifications which will be used as a basis for revising the initial construction and operating cost estimates (Brown and Nash, 1988). This stage is key as it gives the client the chance to review different options relating to the project and ensure that options that best meet their requirements are met.

Brown and Nash (1988) assert that in some instances it may be discovered at the preliminary design phase that the project is not economically viable and this may necessitate termination of the project or revision the project goals. It is important that the inception stage and briefing stages are given appropriate attention so that any major potential issues that may render the project unviable are identified early on in the design process.

2.2.6.4 Final design stage

At the final design stage the detailed architectural and engineering drawings of all physical components of the project are produced and these are accompanied by a written final report with specifications of equipment requirements, construction and machinery requirements (Brown and Nash 1988). The initial designs from the pre-design stage are refined and completed into full detailed building drawings. Brown and Nash (1988) argue that all design problems must be identified and attended to before the end of the final design stage and that adequate detail must be provided by the drawings and the final report to allow for a more detailed cost estimate of construction and operating costs.

Brown and Nash (1988) assert that even at the final design stage there is a need to ensure that the project is still viable and that if it is not it should be revised or terminated. Brown and Nash (1988) further note that any changes at this stage may be costly; hence the preceding design stages must be thoroughly implemented to avoid mistakes. The aim of this design stage is to finalise all design decisions before proceeding with other stages of the procurement process.

2.2.7 The design team

Modern facilities can be complex, and their operation and maintenance complicated. Best and De Valence (1999) argue that it is important that all members of the design team be incorporated in the project design process as soon as the process starts, and participation and input from all team members be actively sought and facilitated from the very beginning of the process. It is therefore crucial that from the design stage, operation and maintenance considerations are taken into account and knowledgeable and experienced facility managers can contribute in this regard. In order to ensure that all members of the team provide substantial benefits to the project, an effort must be made to select the best qualified and competent personnel for project design teams.

2.3 Role and rationale of the facility management expertise in the project design process

Ilesanmi (2010) asserts that while evaluation of buildings is crucial for improving design quality, architects rarely receive feedback about the performance of completed buildings. Jensen (2009) argues that the facilities management profession can be used to as a linkage between the facilities management and facility design processes. Facility managers are responsible for operations and management of buildings and are in constant contact with facility users. This allows them to obtain in-depth knowledge about the needs of facilities and this knowledge can be very valuable in the planning of new buildings and justifies the inclusion of facility managers in design teams (Jensen, 2009). Backed by adequate training and a clearly defined role in the design process, facility managers can provide valuable insight at the project design stage. This view is also supported by Mohammed and Hassanain (2010) who argue that the direct participation by facility managers at the project design stage can reduce problems of maintenance as facility managers gain experience from the various responsibilities they perform during the facilities operation phase that can be utilised during the design process to identify any design decisions that may affect facility maintainability. Okoroh et al (2003) contend that the facility management profession has developed to some extent through demand-led elements such as the need for cost reduction in the operation and maintenance of buildings. The facility manager's focus is therefore to ensure that the operation and maintenance of facilities is cost-effective.

Tay and Ooi (2001) assert that while the architect is typically associated with the design stage of facilities and the facility manager with the operation and maintenance aspects, the latter's input is essential at design stage. This view is also supported by El-Haram and Agapiou (2002), who also argue that there is need to involve facility managers in the project design process. Facility manager involvement in project design can have an impact on how buildings are designed, built, commissioned and refurbished, ensuring that proper steps are taken to design for efficient and cost-effective operation and maintenance.

Barret and Baldry (2003) contend that an organisation will come up with appropriate designs that meet their requirements when time is invested in the briefing process. They argue that through effective briefing, the requirements of the client and other relevant stakeholders are effectively developed and translated. A design brief should outline the client's requirements and justify any decision to develop a new facility or refurbish an existing one. Given their intimate knowledge of their organisations, facility managers can play a vital role in the briefing process as they are the best placed professionals to get the clients/users involved in the design process by explaining to them the various options available (Barret and Baldry, 2003). In the event that there is no in-house facility manager, facility management expertise may be outsourced.

Private Finance Initiative (PFI) is used in the United Kingdom and refers to the use of private finance and resources to deliver projects usually provided by the government (El-Haram and Agapiou, 2002). In this system the private sector plays a major role in the construction and operation of facilities, while the government is mainly concerned with regulation (El-Haram and Agapiou, 2002). El-Haram and Agapiou (2002) also note that facility managers have two roles in PFI, in both tender document preparation and design processes, as well as in the operation and maintenance of the facility. This indicates that the PFI system allows facility managers to participate in the design process.

Brown et al (2001) assert that alternative professions should be considered to manage design and construction processes, in particular facility managers, as they have close interaction with the facilities that they manage, as well as continuous contact with other professions involved in the built environment industry. However, this may require that the facility manager's skills be augmented with the necessary skills such as project planning and execution. Jensen (2009) identifies the main facility management specific duties in facility design and planning as:

1. **Use of experiences from existing buildings**: there is need to learn from experiences drawn from existing buildings and incorporate the lessons learned into new buildings.
2. **Integration of considerations for operation and sustainability**: when designing new buildings there is need to incorporate operation and maintenance into the designs.
3. **Requirements for documentation about the new building:** all documents including plans and operation and maintenance documents should be produced and kept safely.
4. **Considerations for user needs**: the needs and requirements of those who are going to use the building must be taken into account.
5. **Planning and organisation of the building operation**: there is need to plan for the operation of the proposed building.
6. **Interior and move planning**: the interior configuration of the building needs to be designed with a flexibility that accommodates changing space requirements and allows ease of movement.

These tasks are further specified in relation to the different phases of a building project shown in **Table 2.5**: The most important task in the table in relation to facility design is the incorporation of consideration for ease of operation, facility sustainability and meeting needs of the facility user (Jensen, 2009). The design process should therefore ensure that the facility serves its intended purpose and that it will be easy to operate and maintain.

The responsibility to maintain and service facilities goes on for the entire life of the building. Facility managers can play an important role in the design of facilities for easy, cost-effective, efficient maintenance. By interacting with facility managers, designers can appreciate what will make the building function most efficiently and cost-effectively. They can also get information that has many benefits regarding design options as well as operation and maintenance requirements.

Table 2.5: Facility management-specific tasks in building project phases

BUILDING PROJECT PHASE	FACILITY MANAGEMENT-SPECIFIC TASKS
Decision	Incorporating real estate strategies Information on space needs, etc. Estimation of impacts on cost of facility management
Briefing	Organisation of user involvement Formulation of considerations for operation and sustainability Overall requirements for documentation
Design	Incorporation of considerations for operation, sustainability and user needs Formulation of operational concept Formulation of requirements for building automation systems
Construction	Interior planning Prepare commissioning Contracting-out operational tasks
Occupation	Move Handling former building(s) Implementation of operational procedures

Source: Jensen, 2009

Facility design and interior finishes can necessitate the use of harmful cleaning products and processes (Lehrer, 2001). This can create negative impacts on the building occupants and the external environment. Facility designers must therefore specify materials and devices that reduce such impacts. Lehrer (2001) notes that many facility designers are not familiar with conservation devices that reduce the use of chemical cleaning products and hence reduce the cost of operations and maintenance.

Facility managers have a role to play at all facility procurement phases; from the project briefing stage, design stage, construction stage, and up to the operation and maintenance stage. Their involvement from project inception through all the project design stages is crucial in developing designs that are easy and cost-effective to build, operate and maintain.

2.4 Best practices - involving facility managers in facility design: the DR project in Denmark

Jensen (2009) observed the benefits of facility managers' input on facility design when he undertook a case study of the DR project in Denmark. The DR is a national public service television and radio broadcasting corporation and in this project, considerations for facility management and environmental aspects had a high priority from the start, and the briefs for the architectural competitions included requirements and evaluation criteria relating to these aspects (Jensen, 2009). The design and construction brief included a chapter on the environment and a chapter on operations and management including the following topics: layout and planning, cleaning, energy consumption, optimal management and monitoring, and accessibility of services (Jensen, 2009). These topics cover many of the facility management functions that are influenced by design choices. Clearly articulating these aspects ensured that operation and maintenance considerations were taken into account at the design stage.

The internal facility management and environmental departments (including health and safety representatives) were active both in formulating the brief documents and in follow-up during schematic design and conceptual design (Jensen, 2009). The client organisation was facilitating the groups and external consultants were involved to assist the groups (Jensen, 2009).

The facility management team was involved in designing the building management system (BMS) and the central management systems (CMSs) to monitor and control the technical supply systems for electricity, heating, and ventilation and cooling. Besides developing the brief requirements in relation to facility management and the BMS, the facility management group was also responsible for follow-up during design, including reviewing and commenting on design documents (Jensen, 2009).

The team also worked to develop an overall operational strategy. This strategy included the implementation of a new information and technology-based operation and management system to be used as part of the handover of the operational documentation (Jensen, 2009).

The design architect responsible for the master plan was responsible for this project with reference to the facility management group. Life-cycle costing was also undertaken as it is mandatory for all state buildings in Denmark (Jensen, 2009).

The experiences from the DR Project reflect the importance of intensive consultation with the building client when defining requirements and procedures so that the considerations for operation and sustainability are taken seriously by the design teams. It also demonstrates the valuable role facility management expertise can play in the design process.

2.5 Facility manager involvement in project design in South Africa

In South Africa, facility manager involvement from project inception is gaining acceptance. The draft tender example below seeks a transaction advisor for a PPP project involving the provision of resources, design, building and operation of an appropriate facility to accommodate the different departments that make up the KwaZulu Natal (KZN) Provincial Government:
"*Invitation to submit a proposal to act as the transaction advisor to the KZN provincial treasury for the accommodation facilities of the KZN provincial government*".
Draft Tender Treasury No: PPP No 081. (KwaZulu Natal Provincial Government, 2006).

The terms of reference of the tender specified that the prospective consortium must consist of a team of suitably qualified and experienced financial, legal, and technical specialists, including facility management experts, quantity surveyors, architects, civil engineers, town planners, environmental experts, human resources and change management professionals, socio-economic appraisal experts and a property specialist (KwaZulu Natal Provincial Government, 2006).

One of the client requirements includes an analysis of the whole life-cycle approach to the project, including how to get improved design and construction efficiencies from the use of a life-cycle facility management approach (KwaZulu Natal Provincial Government, 2006). The client contemplated a PPP because they believed that this approach, managed with appropriate risk transfer gives value for money (KwaZulu Natal Provincial Government, 2006). The involvement of facility manager expertise early on in the project was to assist the team in incorporating operation and maintenance issues into the project design, including life-cycle costing.

2.6 Impediments to involving facility management expertise in the design process

According to Jensen (2009) attempts to involve facilities managers with a background of building operations in the building design process are not always successful due to inadequate competences. Building maintenance staff are usually trained as craftsmen and technicians with a largely practical education, hence their theoretical understanding and knowledge of design concepts and considerations are largely inadequate, thus their ability to use their practical-based understanding from the operation and maintenance of existing buildings to the abstract context of building design is often limited and hence their contribution in the design process inadequate (Jensen, 2009).

Jensen (2009) also notes that there is a perception that facility managers can play only a limited role within their own organisations and in the design process. The argument is that facility managers are in general not suitably trained and qualified to be accepted as equal partners and stakeholders in the construction procurement process, including the design process. Since insufficient training and qualifications seems be one of the main problems that prohibit meaningful facility manager contributions in design issues and prevents them from being accepted as part of design teams, it is important that all members of a design team, including facility managers, have adequate training and experience that will assist them in making meaningful contributions to the design process.

Rounce (1998) argues that the design process is negatively influenced by the unwillingness of some design team members to work with other members from different disciplines. This view is further reinforced by Jensen (2009) who asserts that the facility designers in charge of the design team process tend to neglect or ignore the staff responsible for operation and maintenance. Providing facilities managers with the necessary education required to participate in building design is the first step in levelling the playing field. The mindset of all project design team members also needs to change to accommodate different views and accept other disciplines into the project design processes.

When choosing a design team, it is important that the competences of each team member are taken into account. The team members must possess the appropriate training and experience to contribute effectively to the design process. Facility managers with hands-on experience are a great resource for both construction and maintenance knowledge. They can point out areas of concern in a design plan before construction is initiated. The overall organisation of a particular project should inform appropriate team selection, and adequate mechanisms must be in place to capture all relevant input from the team. Jensen (2009) argues that building clients must take a leading role in defining and setting up requirements and procedures for their projects and that while the involvement of facility managers in the design process is an obvious strategy to integrate facility management in the design process, increased environmental awareness and adequate competences amongst facility designers and maintenance staff is also essential.

Elmualim et al (2009a) assert that inadequate understanding of the key concepts of sustainability and a lack of practical experience has a negative impact on the effectiveness of sustainable practice in facility design and the facility management profession. This, they argue, coupled with fragmentation of the design and construction processes and the asymmetry of practical information during the design and operation of facilities, impedes acceleration of the sustainability agenda. The lack of information and understanding of the key issues may hinder the implementation of sustainability in the facility management industry, undermining the benefits of sustainable design (Elmualim et al, 2009a). Shortcomings in knowledge and processes within the sustainable facility management practice must be addressed in education and training, not only for facility management professionals, but also for all design and construction management professionals.

2.7 Conclusion

Even though the role of the facility manager at the project design stage is not well documented, the literature review illustrates the processes involved in project design, the main functions of facilities management and how these are influenced by design decisions made at design stage. It also indicates that even though facility managers are usually excluded in the design process, they can positively contribute in project design.

Information from earlier projects and buildings can be harnessed and incorporated into design considerations for new facilities and one way of utilising information from past building projects is to involve facility managers at the beginning of the project design process (Jensen, 2009). Their knowledge and involvement with building operations and maintenance can be useful if they are involved in the design process and their contributions can lead towards designs that are easier and cost-effective to operate and maintain.

Emmitt (2007) as quoted by Jensen (2009) emphasises the role of the facility manager from the perspective of organisational efficiency:

'*The rapidly evolving field of facilities management has helped to emphasise the link between buildings and organisational effectiveness. Greater attention to the value of buildings in a commercial setting has also helped to re-emphasise the link between the managers of the facility and the designers*.'

The statement shows the importance of increased collaboration between facility managers and designers to ensure that designs produce buildings suitable for the intended use and that they are also easy to operate and maintain. Jensen (2009) also stresses the need to harness information from the facility user and make follow up on the building brief during design. Facility managers are ideally positioned to gather and manage these sources of information.

According to Elmualim et al (2009b) information and practical guidance on a wide range of issues may be helpful in contributing to the implementation of sustainable facility management. Developing sustainability policies for organisations, preparing development proposals that incorporate social, environmental and economic benefits, waste management and recycling, energy management and the specification of sustainable products and services are all aspects of facility management which require expertise (Elmualim et al, 2009b). Facility managers are well-versed in many of these issues and can provide useful input during the design process.

In order to achieve facilities that satisfy all stakeholders there is need to involve all the parties, from project inception to completion. The choice of a design team that strikes a balance between technical knowledge and skills is critical to the success of a project. Procurement methods must accommodate participation of all stakeholders and design considerations must be clearly communicated and understood by all involved. Facility managers, because of their technical and organisational knowledge, as well as their familiarity with facility maintenance issues are ideally positioned to ensure that clients and users appreciate design considerations that allow for easy and cost-effective maintenance.

Facility managers must be included in design meetings from project inception to conclusion. Their early and continued involvement ensures that maintainability considerations are assessed throughout the project. With the strong involvement of facility management professionals, projects will yield designs that are sustainable, are suited to the intended use, and are easy and cost-effective to build and maintain.

CHAPTER 3: RESEARCH METHODOLOGY

3.0 Introduction

This chapter describes the research beliefs and research techniques used in this report, including sampling procedures, data collection procedures and the selection of respondents. It also describes the tools and techniques used to analyse the data collected as well as tools used to check the data for reliability.

3.1 Research methodology and design

Research methodology refers to the processes within which research is carried out and it may be categorised into qualitative and quantitative research (Amaratunga et al, 2002). This study adapts a mixed approach as both the qualitative and quantitative approaches were used. The two approaches both have different strategies to collect data and also have different strengths and weaknesses as summarised in **Table 3.1**. Questionnaires were used to collect the data and descriptive statistics used for analysis of the data.

3.1.1 Qualitative and quantitative research

Qualitative research: Qualitative research involves the gathering and analysis of documented material acquired from observation and is used in the investigation of situations as experienced by individuals (Malterud, 2001). It is concerned with verbal expressions and observations to convey reality and tries to get an in-depth understanding of human behaviour (Amaratunga et al, 2002). In contrast, the quantitative approach places significant faith in numbers (Amaratunga and Baldry, 2002). Qualitative research explores different situations through methods such as observation, interviews or focus groups. Qualitative data are usually collected over a continuous time phase and this makes it appropriate for studying processes and it also has strong probability to test hypotheses and whether predictions can hold up (Amaratunga et al, 2002).

Table 3.1: Comparing of strengths and weaknesses of quantitative and qualitative research

Theme	Strengths	Weaknesses
Positivist (Quantitative paradigm)	• They can provide wide coverage of the range of situations • They can be fast and economical • Where statistics are aggregated from large samples, they may be of considerable relevance to policy decisions	• The methods tend to be rather inflexible and artificial • They are not very effective in understanding processes or the significance that people attach to actions • They are not helpful in generating theories • Because they focus on what is, or what has been recently, they make it hard for policy makers to infer what changes and actions should take place in the future
Phenomenological (qualitative paradigm)	• Data gathering methods more as natural than artificial • Ability to look at changes and processes over time • Ability to understand people's meaning • Ability to adjust to new issues and ideas as they emerge • Contribute to theory generation	• Data collection can be tedious and require more resources • Analysis and interpretation of data may be more difficult • Harder to control pace, progress, and end-points of research process • Policy makers may give low credibility to results from qualitative approach

Source: Amaratunga and Baldry, 2002

Quantitative research: Some of the characteristics of quantitative research include amongst others a focus on testing of theories, explanation of phenomena, standardised data collection, and statistical analysis while in contrast qualitative research is concerned mainly with exploration, generation of theories, the researcher as the main tool of data collection, and qualitative analysis (Johnson and Onwugbuzie, 2004). Johnson and Onwugbuzie (2004) further assert that data gathering using quantitative approaches is relatively fast and results in quantitative, numerical data that is analysed through the use of statistical software, which also makes data analysis relatively quicker. Quantitative research generates data through surveys such as questionnaires and interviews (Amaratunga et al, 2002).

3.1.2 A mixed approach

Amaratunga and Baldry (2002) argue that qualitative and quantitative approaches are not totally different in terms of their impact on research, and that both approaches need a convincing argument that the findings are valid before these findings are accepted. This view is supported by Amaratunga et al (2002) who argue that both types of research are complementary and should be mixed in different kinds of research. Both qualitative and quantitative research approaches have their advantages and disadvantages and it is more useful to see these two approaches as balancing out one another rather than as two opposite extremes that cannot be used together (Amaratunga et al, 2002).

Qualitative methods can be used to complement quantitative methods and the combination of both can be used to study the same phenomenon in a process known as triangulation (Amaratunga et al, 2002). The fundamental notion of triangulation is that qualitative and quantitative research can be complementary; while qualitative research can identify the presence or absence of a characteristic in a particular circumstance, quantitative research can quantify the presence of the feature (Amaratunga et al, 2002). Qualitative techniques such as observation and interviews can be used to provide a description and understanding of a situation while quantitative research complements qualitative research through the collection of numerical data that is then subjected to statistical analysis.

3.1.3 Inductive and deductive research

Deductive reasoning starts with an established hypothesis and attempts to observe whether the hypothesis applies to specific situations while inductive reasoning is a theory building process that starts with observations and seeks to establish generalisations about the incidents being researched (Hyde, 2000). Deductive reasoning starts with a theory and then affirms the theory through observations while inductive reasoning on the other hand works the other way, taking detailed observations and expanding them to broader generalisations.

3.2 Research methods and tools used in this research

A mixed approach of quantitative and qualitative research was used, involving an analysis of literature and the use of questionnaires to generate data. The research is deductive in nature in that it attempts to prove that the involvement of facility managers from project conception stage leads to better designs for the client and end-users; it started with a theory and a hypothesis, which were then confirmed through observation.

3.2.1 Survey research

The survey approach was chosen because **s**urveys have the advantage of being relatively inexpensive and quick. Through the use of appropriate sampling procedures, the study assumed that the sample's responses to the questionnaire would adequately represent the target population. The collected data was evaluated using descriptive statistics. **Table 3.2** was used as a guide in choosing the research method. The main research question was aimed at determining what roles facility managers can play in the design process, and what impact their involvement has in the project design process in terms of cost-effectiveness of operations and maintenance of the facility.

Table 3.2: Choosing a research strategy

Strategy	Form of research question
Experiment	How, why
Survey	Who, what, where, how many, how much
Archival analysis	Who, what, where, how many, how much
History	How, why
Case study	How, why

Source: Rowley, 2002

3.2.2 Reliability

Reliability refers to the extent to which an investigation or process produces the same outcome under the same conditions on all occasions (Yin, 1994 as cited by Amaratunga et al, 2002). Basically, reliability refers to the accuracy of a given measurement and is aimed at reducing the errors and biases in a study (Amaratunga et al, 2002). Cronbach's alpha was used to test reliability of the data acquired. Conbach's alpha is a key tool in the evaluation of questionnaires and is the most widely used objective measure of reliability; it was developed in 1951 by Lee Cronbach to provide a measure of the internal consistency of a test or scale (Tavakol and Dennick, 2011). Internal consistency is how much all the items in a test measure the same concept while reliability refers to the ability measure consistently (Tavakol and Dennick, 2011). Alpha coefficient values in ranges from 0 to 1 are used to describe reliability of factors acquired from multi-pointed questions or scales (i.e. questions that required rating responses on a scale of 1 to 5; 1 = not important to 5 = very important). The higher the Cronbach's alpha scores the more reliable the data.

3.2.3 Sampling

Purposive sampling was employed in this research. In this method the researcher selects the sample they believe will provide the most accurate information in order to meet the research objectives and answer research questions. This was chosen as it enabled the researcher to draw a sample of knowledgeable respondents with proven or verifiable experience and proficiency in facility management. It allowed the researcher to obtain information from individuals who have specific expertises.

There was a total response of 29 out of 35 questionnaires randomly distributed (indicating a response rate of 82.86 percent) to facility management companies in the city of Johannesburg in Gauteng Province, South Africa. The respondents to questionnaires were deliberately selected such that it ensured representation of professionals or stakeholders in the facility management process. Veltman (2011) notes that 358 facility managers are registered with the South African Facility Managers Association (SAFMA) in the Johannesburg area. A sample of 35 from a population of 358 was deemed a reasonable representative of the population. This represented 10 percent of the population and because of limited resources such as time and funding only a limited sample could be reached for the questionnaire survey.

3.2.4 Data collection and analysis

Table 3.3 summarises the structure of the data requirements for the research. A structured questionnaire was used to collect data and the respondents were professionals involved in facility maintenance. The aim was elicit their views on the design considerations that have an impact on the operation and maintenance of facilities, and what role the facility manager can play in the project design process.

The Statistical Package for The Social Sciences (SPSS) was used to compile and analyse data as is an extremely potent data analysis tool that can process large amounts of data (Pallant, 2001). The resultant frequencies and percentages are presented in tables in Chapter 4. The averages ratings of the different design considerations at different stages of the design process were calculated to get the overall response, and the standard deviation was also calculated to measure dispersion of the data sets from their mean.

Further analysis using cluster analysis was carried out to find out if there were any differences in responses according to training, work experience and workplace responsibilities. To determine the importance of each variable where questions required ranking, the two step cluster analysis was carried out. The main aim of cluster analysis was to assign individuals (cases) into groups (clusters) in such a way that two individuals from the same cluster are more similar than two individuals from different clusters. When clustering cases, the intention is to understand how important the different variables are for the formation of the cluster.

Table 3.3: Summary of data requirements

Method	**Data Details**	**Respondents**
Questionnaire Survey	• Important design considerations at different design stages and to what extent may they impact facility operation and maintenance: project inception, project brief, pre-design and final design stages. • To what extent should the different operation and maintenance considerations be considered at project design stage • Whether facility managers may influence the project design process to come up with designs that are simple and cost-effective to maintain	Facility Managers

Source: Author

For categorical variables, SPSS calculates a chi-square value that compares the observed distribution of values of a variable within a cluster to the overall distribution of values. Within each cluster, the observed distribution is compared to an expected distribution based on all cases. The items with the higher chi-square values are regarded as more important than those with lower chi-square values.

3.2.5 Conclusion

This research used both the qualitative and quantitative approaches; it relied on secondary sources, mainly books and journals. These secondary data sources were used to identify the functions of facility management, and these functions were linked to the project design process. Questionnaires were then used to collect primary data from selected respondents though purposive sampling. The use of questionnaires for primary data collection proved to be effective in obtaining the required information pertaining to facility manager involvement in project design. The data was checked for reliability and analysed in Chapter 4.

CHAPTER 4: DATA ANALYSIS

4.0 Introduction

This chapter presents an analysis of all the data collected. All the data analysis is exploratory, and the Statistical Package for The Social Sciences (SPSS) was used. Cluster analysis was also used for data analysis and Cronbach's alpha was used to check the data for reliability.

4.1 Frequency distribution of demographics

Section 1 of the questionnaire consisted of information on respondents' qualifications, organisational type and work experience. The main aim of this section was to determine whether the respondents had relevant qualifications and experience in project design or facility management.

- **Training/qualification, workplace experience and positions at work**

Table 4.1: Training/qualifications of respondents

		Responses	
		N	**Percent**
Training Qualification	Quantity Surveyor	6	18.2%
	Facility Manager	4	12.1%
	Property Manager	4	12.1%
	Engineer	2	6.1%
	Town planner	4	12.1%
	Architect	6	18.2%
	Project Manager	4	12.1%
	Other	3	9.1%
Total		33	100.0%

Source: Author

There was a total response of 29 out of those that were sent to the respondents. **Table 4.1** identifies the different professionals who responded. The total number of responses increases to 33 because some respondents had acquired more than one type of training; all the facility managers who responded were also trained as property managers.

For the responsibilities at the workplace indicated in **Table 4.2,** there were 49 responses, indicating that some of the respondents were multi-skilled and handled more than one responsibility in their workplaces.

Table 4.2: Responsibilities of respondents in their workplaces

		Responses	
		N	**Percent**
Fields covered/Responsibilities	Quantity Surveying	4	8.2%
	Facility Management	7	14.3%
	Property Management	7	14.3%
	Engineering	2	4.1%
	Town planning	6	12.2%
	Architectural/building design	6	12.2%
	Project Management	9	18.4%
	Property development	8	16.3%
Total		49	100.0%

Source: Author

Table 4.3 shows the current employment positions of the respondents. 22 were employees, 5 were directors and 1 was a partner in their organisation.

Table 4.3: Workplace positions of respondents

Rank/Position		
	Frequency	**Percent**
Partner	1	3.4
Director	5	17.2
Employee	22	75.9
Other	1	3.4
Total	29	100.0

Source: Author

Table 4.4 shows the work experience of the respondents. 65.5 percent had less than ten years experience, 34.5 percent had less than five years of work experience and 31 percent have five to ten years work experience.

Table 4.4: Frequency of distribution of work experience

Years worked		
	Frequency	**Percent**
< 5yrs	10	34.5
5 - 10yrs	9	31.0
11 - 15yrs	4	13.8
>15yrs	6	20.7
Total	29	100.0

Source: Author

Analysis of this section of the questionnaire (Section 1) concluded that the respondents had adequate training and experience. They were also involved in project design and facility management. They were therefore qualified to participate in the survey for this research report.

4.2 Reliability analysis

The data obtained from the questionnaire was assessed for reliability. One of the most common measures of internal consistency of a questionnaire data, the Cronbach's alpha coefficient, was used to test for reliability. The range of the alpha is from 0 to 1. As a rule of thumb, the alpha of a scale equal to 0.70 or greater is acceptable for items to be reliable, although lower values are sometimes acceptable.

4.2.1 Reliability of the data obtained on the four stages of the design process

Table 4.5 shows the results of the reliability analysis for each stage of the design process. The respondents ranked each of them on a scale of 5 to 1 according to how important they were from the facilities operations and management perspective. The importance declined from a high importance of 5 to not important at 1. This data is from based on responses to question 5 in the questionnaire (See questionnaire, **Appendix A**). At more than 0.7 (70 percent) on Cronbach's alpha for all the four listed design stages, the conclusion is that the data is reliable.

Table 4.5: Reliability of data on the four different design stages

	Reliability Statistics	
Design Stage	**Cronbach's Alpha**	**No. of Items**
Conception/Inception	0.805	4
Briefing	0.703	8
Pre-design	0.742	13
Final design	0.846	14

Source: Author

- **Reliability of data on facility management duties and their importance for consideration at project design stage**

Table 4.6 shows that the data collected from question 6 of the questionnaire is 0.49 (49 percent) on Cronbach's alpha scale. This indicates that the data collected here is unreliable. The 13 items are not reliable, altogether, in assessing the construct. A factor analysis was subsequently carried out to create segments of reliable items.

Table 4.6: Reliability of data on facility management duties and their importance for consideration at project design stage

Reliability Statistics	
Cronbach's Alpha	**No. of Items**
0.49	13

Source: Author

4.2.2 Factor analysis

Factor analysis was used to investigate possible relations among many variables. The related variables were condensed into components/factors which are comprised of combinations of the variables. This segmentation allows the separation of groups of variables in developing strategy. The results of the factor analysis are indicated in **Table 4.7** (see **Appendix B** for the complete factor analysis). The items listed below now showed they are reliable at 0.776 on Cronbach's alpha scale:

- Servicing and waste disposal
- Maintenance, cleaning and ground maintenance
- Water services
- Transportation, access and circulation
- Benchmarking
- Communications and control systems

Table 4.7: Results from factor analysis showing reliability of data on facility management duties and their importance for consideration at project design stage.

	Cronbach's Alpha	No. of items
Servicing and waste disposal	0.776	6
Maintenance, cleaning and ground maintenance		
Water services		
Transportation, access and circulation		
Benchmarking		
Communications and control systems		
Building management systems (BMS)	-0.371	3
Safety and life safety		
Life-cycle costing and churning		
Environmental conditions/Heating Ventilation Air Conditioning (HVAC)	0.726	2
Managing the electricity account including emergency power systems		
Post occupancy evaluation (POE)	0.595	2
Space management and furniture		

Source: Author

The reworked reliability also indicates reliability for the data for the following two items is now 0.595 (59.5 percent) on Cronbach's alpha scale:

- Post occupancy evaluation (POE) and
- space management and furniture

Even though this is less than 70 percent this was accepted as it is not too far off from 70 percent. However for the three items listed below the data collected is unreliable:

- Building management systems (BMS)

- Safety and life safety
- Life-cycle costing and churning

The unreliability may be due to misunderstanding of the items by the respondents.

4.3 Importance/ranking of individual variables

Table 4.8A, Table 4.8B, Table 4.8C and Table 4.8D show the average ratings of the different design considerations at different stages of the design process. This covers sections 2 and 3 of the questionnaire. The respondents rated the level of importance these factors may be from the facility management perspective. The levels of rating were ranked from 5 (Very important) to 1 (Not important).

Assuming $H_o \geq 3$ (null hypothesis) means an item is important, with an average rating above 4, it can be concluded that generally all items are very important from the facility management perspective and should be considered at project design stage. The rating above 3 was chosen as it is the middle value in the ranking of importance of then items.

Assuming $H_1 < 3$ (alternative hypothesis) means the item is not important then all items are considered important as they all average above 3. Therefore it can be concluded that all the identified design considerations at the different stages of the design process are deemed important. Standard deviation was used to measure the spread of data sets from their mean. The greater the data spread is, the greater the deviation (greater variability is evidenced by a larger standard deviation).

Table 4.8A: Average ratings of different design considerations at project inception stage according to their importance for consideration from the facility management perspective

Design considerations at different stages of the design process	Average Score	Standard Deviation
Information on space needs, etc.	4.34	0.72
Design criteria e.g. Indoor comfort conditions, noise levels e.t.c	3.97	0.82
Estimation of impacts on cost of facility management	3.97	0.82
General layout and circulation on spatial requirements	4.07	0.84

Source: Author

Table 4.8A shows the average ratings of the different design considerations at the inception stage of project design. All the considerations have an average score of above 3. Therefore it can be concluded that all the identified design considerations at the inception stage of the design process are deemed important and will impact on the ease and cost of facility operations and management.

Table 4.8B: Average ratings of different design considerations at project briefing stage according to their importance for consideration from the facility management perspective

BRIEFING STAGE	Average Score	Standard Deviation
Organisation of user involvement	4.14	0.79
Formulation of considerations for operation and sustainability	4.14	0.58
Overall requirements for documentation	4.00	0.89
Analysis of client's needs and establishment of best way to meet them	4.31	0.54
Waste disposal	3.83	0.80
Energy efficiency	4.07	0.70
Utility costs	4.07	0.75
Land use, urban form and transport	3.83	0.85

Source: Author

Table 4.8B shows the average ratings of the different design considerations at the briefing stage of project design. All the considerations have an average score of above 3. This means that all the identified design considerations at the briefing stage of the design process are deemed important and will impact on the ease and cost of facility operations and management.

Table 4.8C: Average ratings of different design considerations at the pre-design stage according to their importance for consideration from the facility management perspective

PRE-DESIGN	Average Score	Standard Deviation
Safety and security of buildings (persons and assets)	4.07	0.65
Energy and resource consumption (electricity, heating, cooling, water e.t.c.)	4.14	0.52
Formulation of requirements for building automation systems	3.69	0.81
Ease of cleaning and maintaining the building and surrounding areas	4.03	0.78
Flexibility and adaptability in relation to changing use over time	3.90	0.72
Building orientation	4.07	0.59
Basic materials and finishes schedule	4.34	0.77
Familiarisation with site, its layout, accessibility and access to services e.t.c.	3.93	0.75
Preliminary design and the design linkage to the site	4.00	0.65
Logistics in terms of internal communication, transport and distribution	3.83	0.71
Analysis of environmental requirements	3.83	0.66
Ease and possibilities to reuse and replace building parts	3.86	0.83
Solutions to ensure considerations for the disabled and elderly	4.17	0.71

Source: Author

Table 4.8C shows the average ratings of the different design considerations at the pre-design stage of project design. All the considerations have an average score of above 3. Therefore all the identified design considerations at the pre-design stage of the design process are deemed important and will impact on the ease and cost of facility operations and management.

Table 4.8D: Average ratings of different design considerations at final design stage according to their importance for consideration from the facility management perspective

FINAL DESIGN	Average Score	Standard Deviation
Incorporation of considerations for operation, sustainability and user needs	4.34	0.55
Detailing of building automation systems	4.24	0.87
Detailed working drawings (architectural, structural and services)	4.14	0.79
Detailed electricity circulation and lighting	4.17	0.71
Final HVAC equipment requirements, sizes and layout	4.17	0.80
Environmental considerations and waste management	4.07	0.65
Detailed waste disposal system	4.07	0.80
Bill of quantities	3.90	0.90
Life-cycle costing and churning	3.97	0.87
Finalise construction techniques and materials and specifications	4.17	0.76
Engineering and technical measures for safety and emergency issues	4.14	0.74
Accurate construction budget	4.21	0.62
Access, servicing, circulation and transportation (vehicular and pedestrian)	4.45	0.57
Solutions to ensure considerations for the disabled and elderly	4.07	0.53

Source: Author

Table 4.8D shows the average ratings of the different design considerations at the final design stage of project design. All the considerations have an average score of above 3. Therefore all the identified design considerations at the final design stage of the design process are deemed important and will impact on the ease and cost of facility operations and management.

Table 4.9: Average ratings of facility management functions according to their importance for consideration at the project design stage

Possible facility management functions that to be considered at project design stage	Average	Standard deviation
Managing the electricity account including emergency power systems	4.10	0.56
Heating Ventilation Air Conditioning (HVAC) maintenance	4.45	0.63
Transportation, access and circulation	4.07	0.65
Servicing and waste disposal	4.07	0.75
Water services	3.97	0.68
Maintenance, cleaning and ground maintenance	3.72	0.70
Communications and control systems	3.97	0.82
Building management systems (BMS)	4.03	0.68
Post Occupancy Evaluation (POE)	3.83	0.71
Security and life safety	4.14	0.69
Life-cycle costing and churning	3.90	0.72
Space management and furniture	3.93	0.53
Benchmarking	3.66	0.66
OVERALL TOTAL	3.99	0.68

Source: Author

Table 4.9 shows the average ratings of the importance of considering the different facility management functions at the design stage.

Assuming $H_o \geq 3$ (null hypothesis) means an item is important, with an average rating of 3.99, it can be concluded that all items are very important from the facility management point of view and should be considered at project design stage. Assuming $H_1 < 3$ (alternative hypothesis) means the item is not important, then all items are considered important as they all average above 3. The design team must therefore take these functions listed in **Table 4.9** into consideration during the project design process.

Table 4.10 shows the average responses as to whether the facility manager has any role to play in the project design process. The respondents rated on a level ranging from 1 (strongly agree) to 5 (strongly disagree). With an assumption that an average response of less than 3 indicates the respondents generally agree with the question, it can be concluded that operation and maintenance considerations should be considered at the project design stage and that facility managers are the best placed professionals to ensure that all these items are not overlooked. It can also be concluded that respondents believed that involving facility managers at the project design stage can assist in developing designs that are more cost-effective to operate and maintain. It can also be observed from **Table 4.10** that, with a standard deviation ranging from 0.49, 0.72, and 0.50, the variability was generally low for the three questions, and respondents generally responded in the same manner to the questions.

Table 4.10: Average responses to questions relating to the relevance of the facility manager's role in the design process

Question	Average Score	Standard Deviation
Do you think that operation and maintenance considerations should be considered at the design stage of the building process?	1.62	0.49
Do you think facility managers are the best placed professionals to bring the operation and management considerations on board at the design stage?	2.34	0.72
Do you think involving facility managers at the design stage would assist in coming up with designs that are more cost-effective to operate and maintain?	1.97	0.50

Source: Author

Table 4.11 further shows support for facility manager involvement in the project design process. All the respondents agreed that facility management functions were important and that design considerations should take these into account to ensure project sustainability. 19 of the 29 respondents (66.5 percent) agree or strongly agree that the facility manager is the best placed professional to bring the operation and management considerations forward at the design stage, while 2 disagreed (6.7 percent) and 8 were neutral (27.6 percent). 26 of the respondents

(89.7 percent) believed that involving facility managers at the design stage would assist in developing designs that are more cost-effective to operate and maintain, while 3 respondents (10.3 percent) were neutral. This shows that most respondents believe that the project design team should have facility management functions in mind when making design decisions at the design stage. They also believe that facility managers should be part of design teams to ensure that design considerations that allow for easy and cost-effective facility management are incorporated into projects.

Table 4.11: Responses to questions relating to the relevance of the facility manager's role in the design process

Question	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Total
Do you think that operation and maintenance considerations should be considered at the design stage of the building process?	11	18	0	0	0	29
Do you think facility managers are the best placed professionals to bring the operation and management considerations on board at the design stage?	2	17	8	2	0	29
Do you think involving facility managers at the design stage would assist in coming up with designs that are more cost-effective to operate and maintain?	4	22	3	0	0	29

Source: Author

4.4 Cluster analysis

Further analysis using cluster analysis was carried out to identify any differences in responses according to training, work experience and workplace responsibilities. Cluster analysis was applied to sections 2 and 3 of the questionnaire. No bias was discovered in responses according to training, work experience and workplace responsibilities. To establish the significance of variables for each question that required ranking, the two step cluster analysis was carried out. This is one method of cluster analysis that handles categorical as well as continuous data. The clustering was done to identify the importance of the different variables in the formation of the cluster.

Project conception/inception stage

For the project conception stage the respondents were grouped into 3 clusters (see **Table 4.12**). For each of the 3 clusters responses were similar; they ranked the importance of the design considerations at this design stage in the same manner. The characteristics of the clusters can be seen (**Appendix C**). All the three clusters are made up of professionals with different workplace responsibilities, training and work experience. Therefore, it can be concluded that there was no training-specific responses. The workplace responsibilities and work experiences are also evenly distributed amongst the three clusters

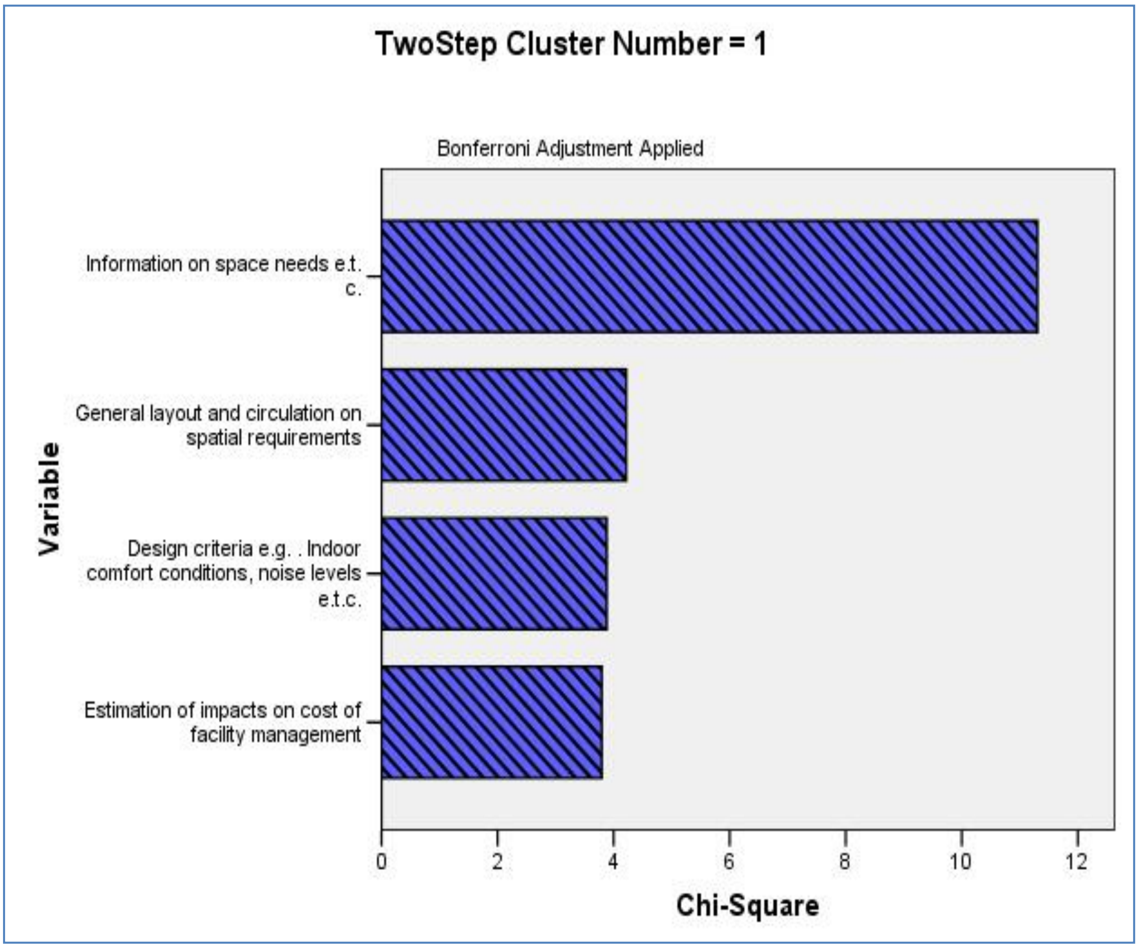
Table 4.12: Clustering of respondents according to how they responded to design considerations listed at the conception stage

Cluster Distribution			
		N	**%**
Cluster	**1**	12	41.4%
	2	10	34.5%
	3	7	24.1%
	Combined	29	100.0%

Source: Author

Figure 4.1 shows how Cluster 1 ranked the different design considerations at the project conception stage. The items with the higher chi-square values are regarded as more important than those with lower chi-square values.

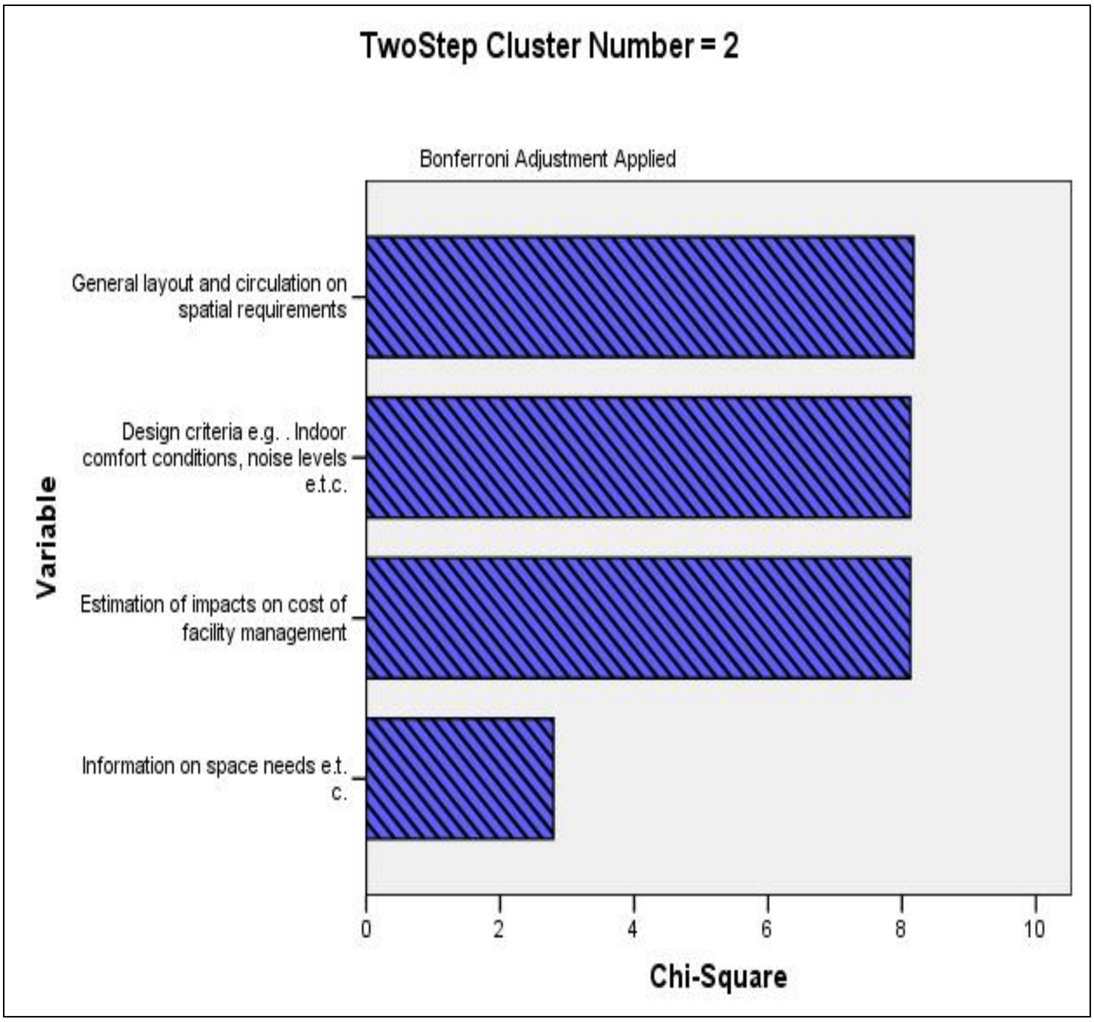
Figure 4.1: Cluster 1 response to items at conception stage



Source: Author

Figure 4.2 shows how Cluster 2 ranked the different design considerations at the conception stage. The items with the higher chi-square values are regarded as more important than those with lower chi-square values.

Figure 4.2: Cluster 2 response to items at conception stage



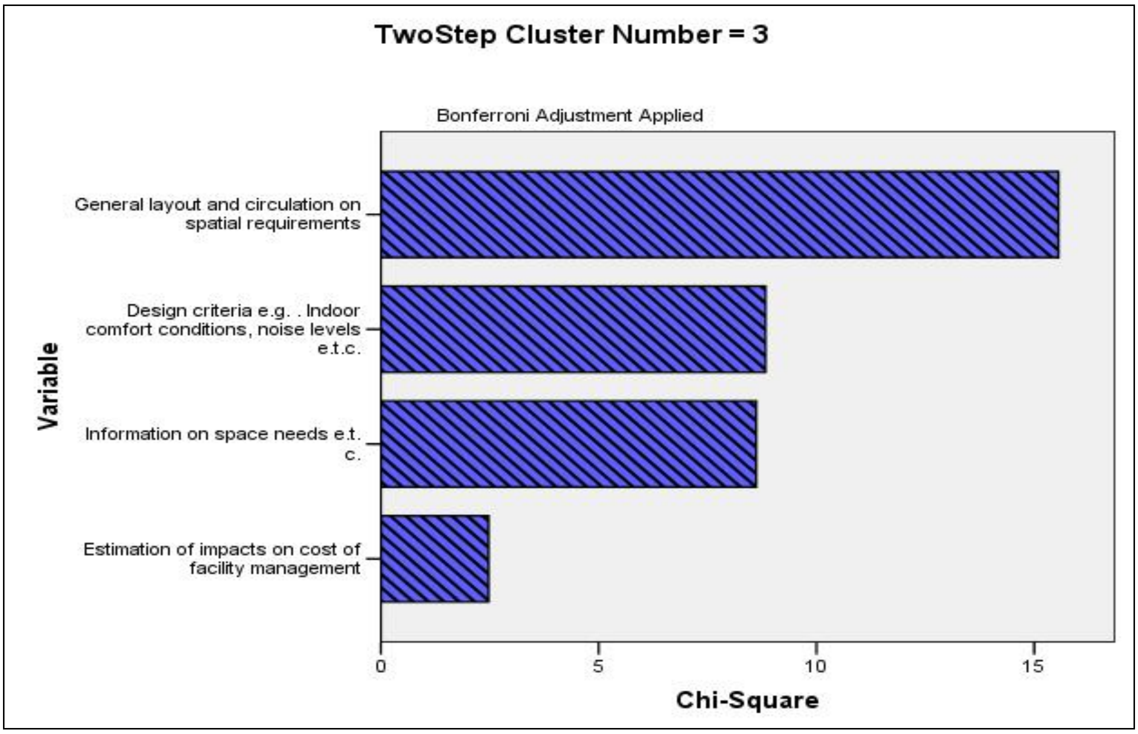
Source: Author

It can be concluded from **Figure 4.2** and **Figure 4.3** that the respondents ranked the following in order of importance as the most important factors at this stage of the design process from the facility management:

1) Information on space needs
2) General layout and circulation on spatial requirements
3) Estimation of impacts on cost of facility management
4) Design criteria e.g. indoor comfort conditions and noise levels

Figure 4.3 shows how cluster 3 ranked the different design considerations at the conception stage.

Figure 4.3: Cluster 3 response to items at conception stage



Source: Author

Briefing Stage

At the briefing stage, the respondents were also clustered into 3 clusters. The 3 clusters each show similarity in their responses to the items listed at this stage (see **Table 4.13**). All 3 clusters responded as shown in **Figure 4.4, Figure 4.5 and Figure 4.6**. The cluster characteristics are shown in **Appendix D**. The characteristics of the clusters do not show any difference in response due to age, employment characteristics, work experience and training/qualifications.

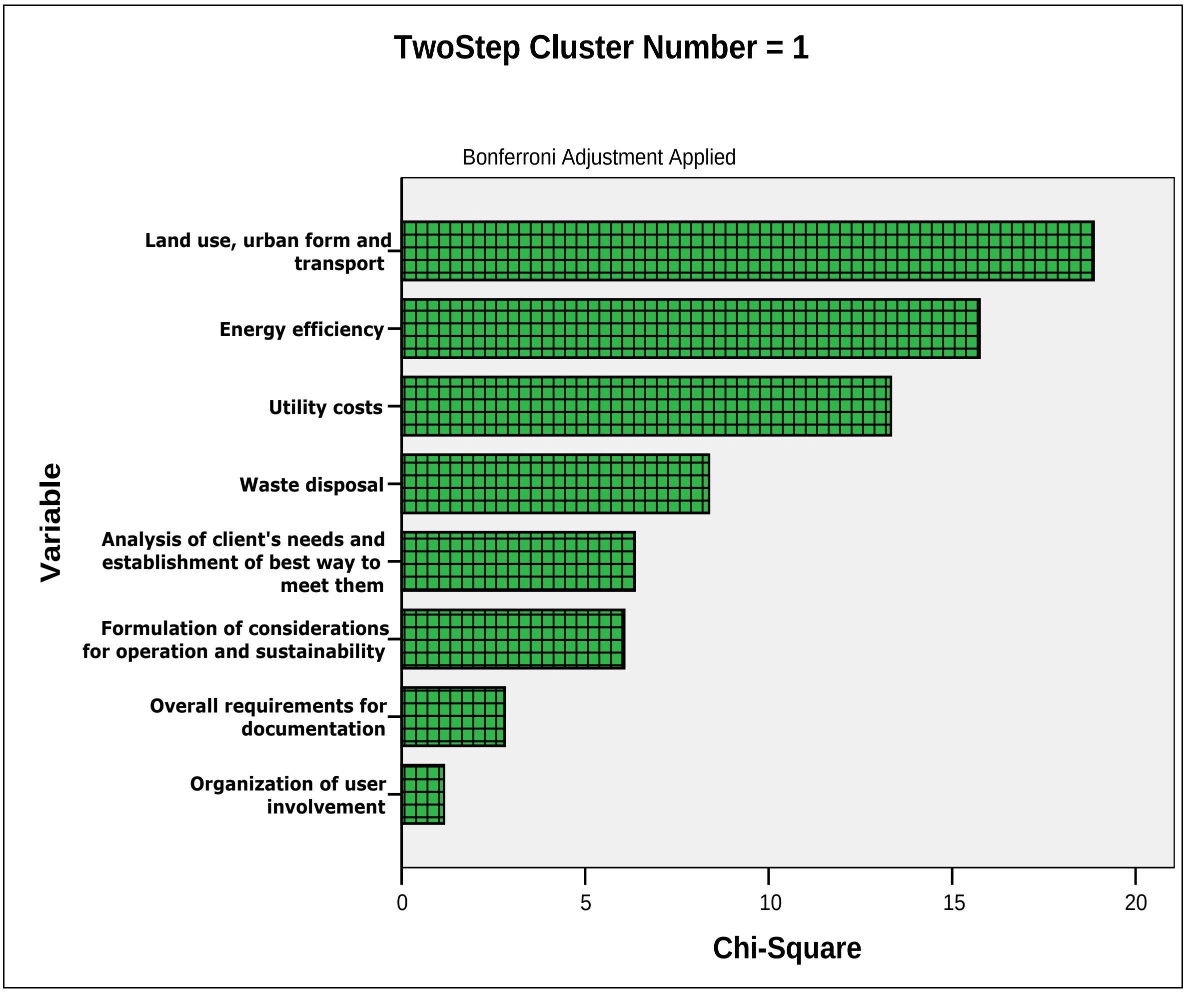
Table 4.13: Clustering of respondents according to how they responded to design considerations listed at the briefing stage

Cluster Distribution			
		N	%
Cluster	**1**	6	20.7%
	2	14	48.3%
	3	9	31.0%
	Combined	29	100.0%

Source: Author

Figure 4.4 shows how Cluster 1 ranked the different design considerations at the briefing stage. The items with the higher chi-square values are regarded as more important than those with lower chi-square values.

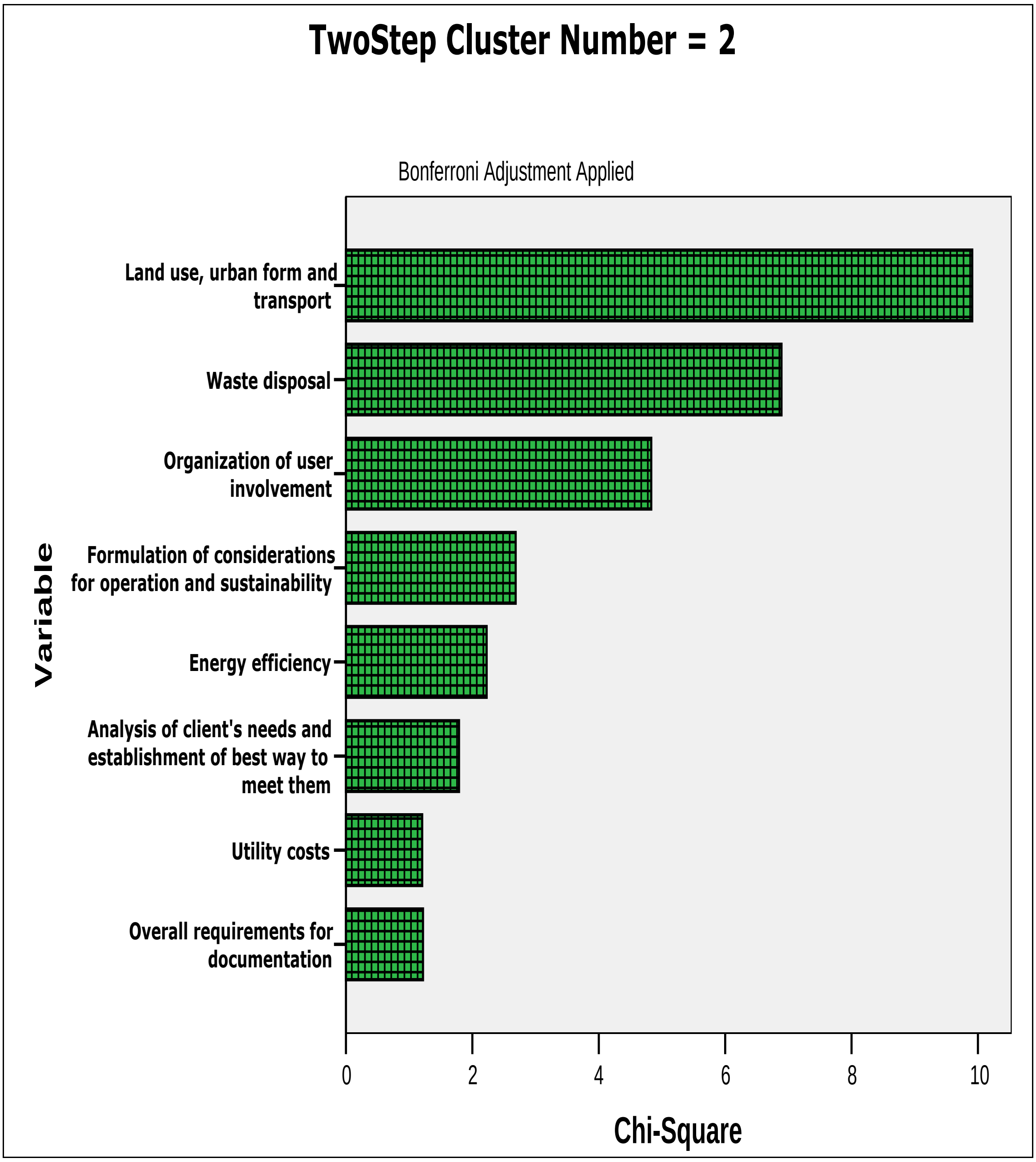
Figure 4.4: Cluster 1 response to items at the briefing stage



Source: Author

Figure 4.5 shows how Cluster 2 ranked the different design considerations at the briefing stage. The items with the higher chi-square values are regarded as more important than those with lower chi-square values.

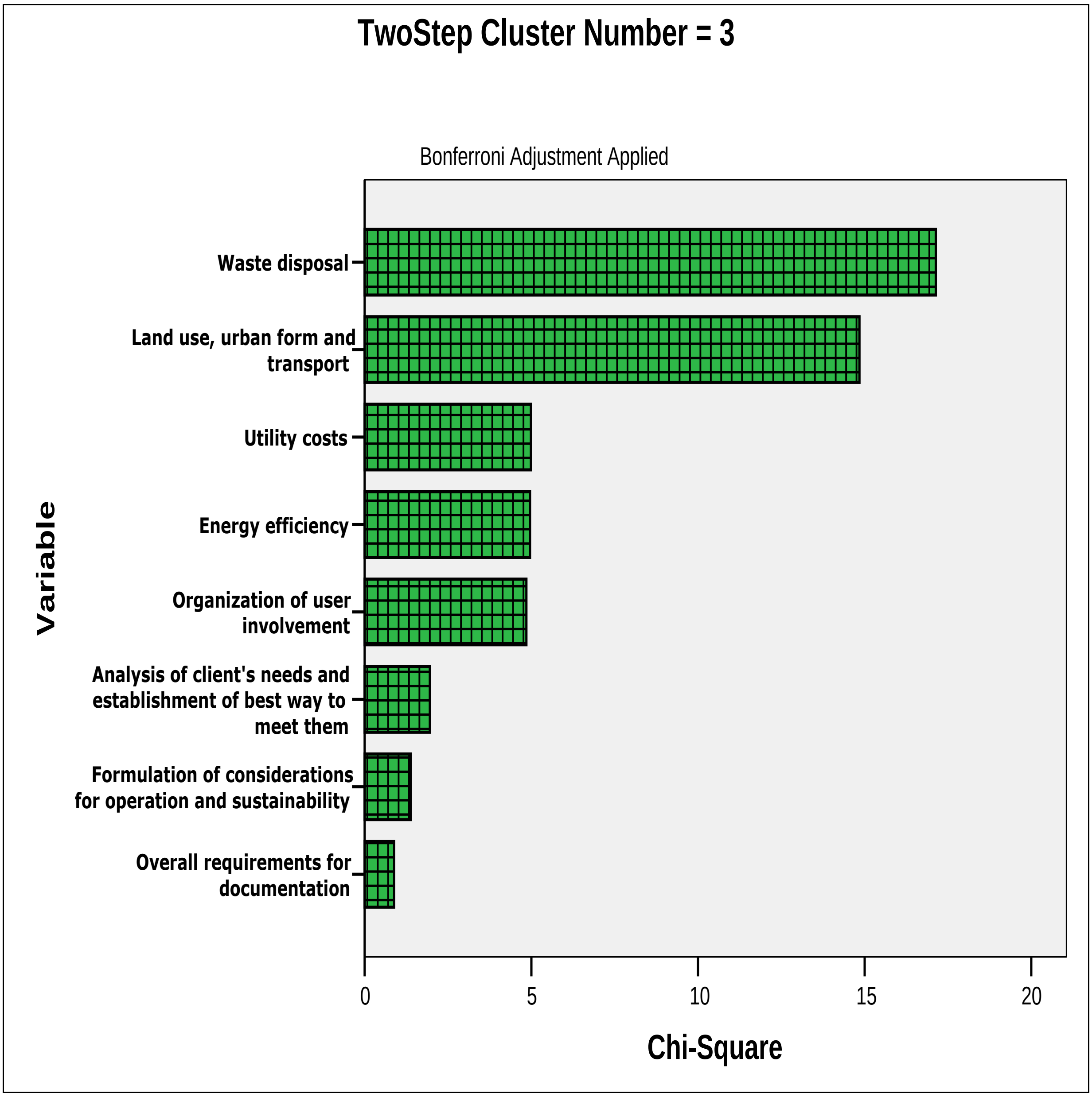
<u>Figure 4.5: Cluster 2 response to items at the briefing stage</u>



Source: Author

Figure 4.6 shows how Cluster 3 ranked the different design considerations at the briefing stage. The items with the higher chi-square values are regarded as more important than those with lower chi-square values.

Figure 4.6: Cluster 3 response to items at the briefing stage



Source: Author

From all three figures (**Figure 4.4, Figure 4.5 and Figure 4.6**) it can be concluded that the different clusters differed in how they ranked the importance of the design items. Overall, all design considerations at this stage are all considered important from the facility operations and management perspective.

Pre-design stage

For this section respondents were clustered into only 2 clusters of 11 and 18 respondents each (See **Table 4.14**). The characteristics of respondents do not show any difference in response due to age, employment characteristics, work experience and training/qualifications (See **Appendix E**).

Table 4.14: Clustering of responses to items at the pre-design stage

Cluster Distribution			
		N	**%**
Cluster	**1**	11	37.9%
	2	18	62.1%
	Combined	29	100.0%

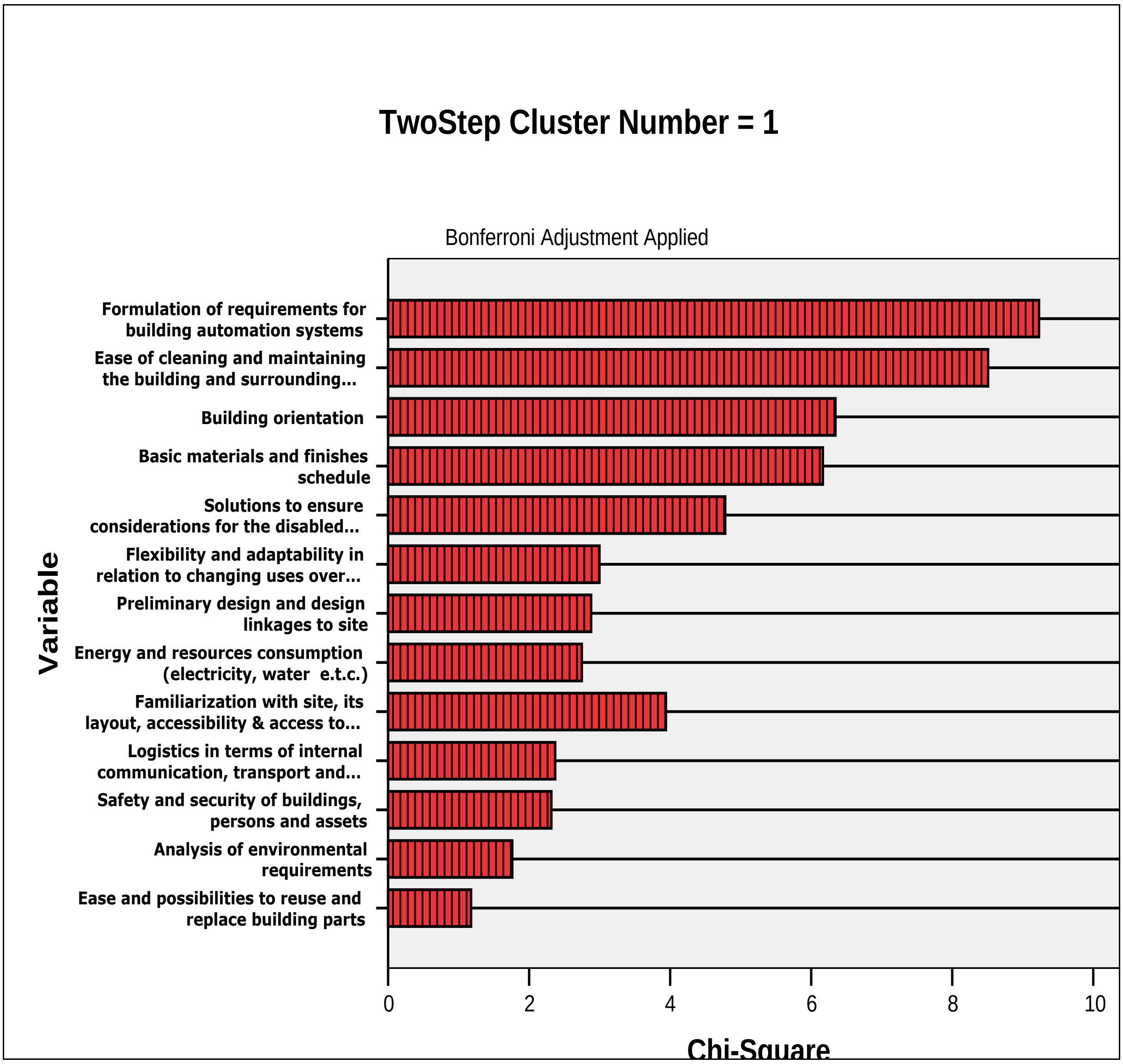
Source: Author

Figure 4.7 shows how Cluster 1 responded to items at the pre-design stage. The items with the higher chi-square values are regarded as more important than those with lower chi-square values. The ranking of the items according to this group of respondents is as follows:

1. Formulation of requirements for building automation systems
2. Ease of cleaning and maintaining the building and surrounding areas
3. Building orientation
4. Basic materials and finishes schedule
5. Solutions to ensure considerations for the disabled and elderly
6. Familiarisation with site, its layout, accessibility and access to services
7. Flexibility and adaptability in relation to changing use over time
8. Preliminary design and the design linkage to the site
9. Energy and resource consumption (electricity, heating, cooling and water)
10. Logistics in terms of internal communication, transport and distribution
11. Safety and security of buildings (persons and assets)

12. Analysis of environmental requirements
13. Ease and possibilities to reuse and replace building parts

Figure 4.7: Cluster 1 response to items at the pre-design stage



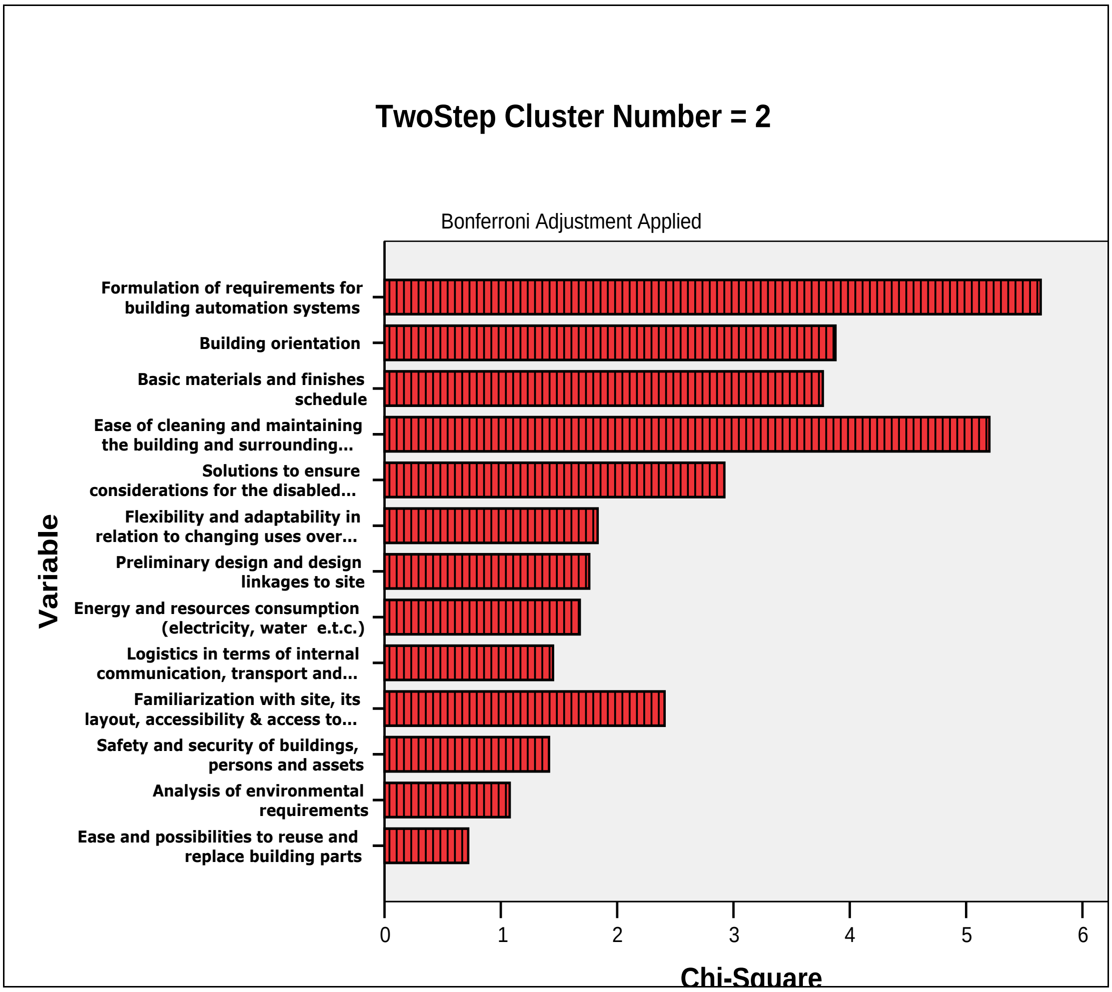
Source: Author

The ranking for Cluster 2 is different from that of Cluster 1. The results are listed below and shown in **Figure 4.8**:

1. Formulation of requirements for building automation systems
2. Ease of cleaning and maintaining the building and surrounding areas

3. Building orientation
4. Basic materials and finishes schedule
5. Solutions to ensure considerations for the disabled and elderly
6. Flexibility and adaptability in relation to changing use over time
7. Preliminary design and the design linkage to the site
8. Energy and resource consumption (electricity, heating, cooling and water)
9. Logistics in terms of internal communication, transport and distribution
10. Familiarisation with site, its layout, accessibility and access to services
11. Safety and security of buildings (persons and assets)
12. Analysis of environmental requirements
13. Ease and possibilities to reuse and replace building parts

Figure 4.8: Cluster 2 response to items at the pre-design stage



Source: Author

Figure 4.8 shows how Cluster 2 responded to items at the pre-design stage. The items with the higher chi-square values are regarded as more important than those with lower chi-square values.

Detailed design stage

For the final design stage there are 2 clusters as indicated in **Table 4.15**. Again, the responses show no particular differences in characteristics of the respondents according to profession, work experience or workplace responsibilities (See **Appendix F**). **Figures 4.9** and **4.10** show how the two clusters ranked the items.

Table 4.15: Clustering of responses at detailed design stage

Cluster Distribution			
		N	**%**
Cluster	**1**	15	51.7%
	2	14	48.3%
	Combined	29	100.0%
Total		29	

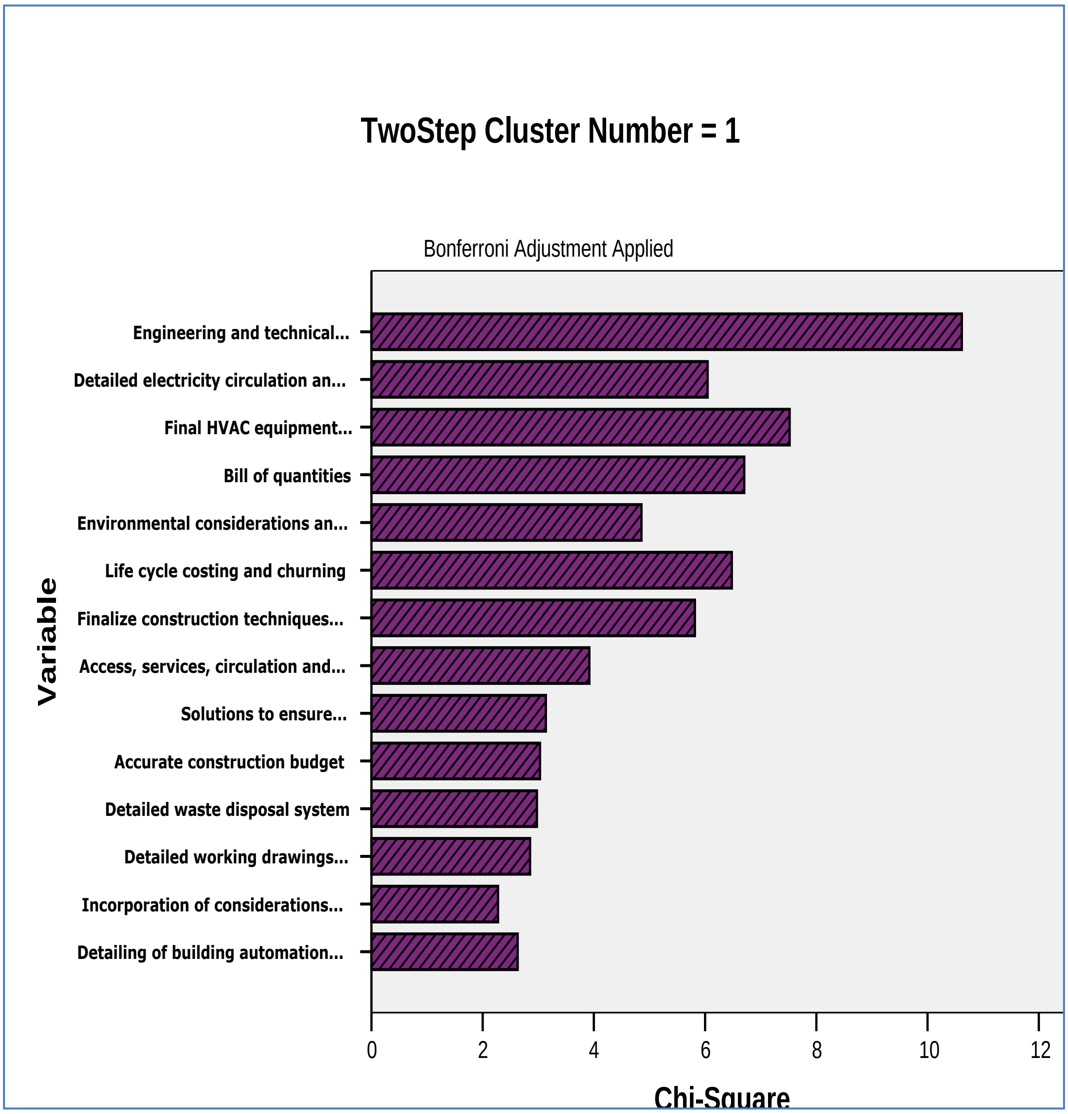
Source: Author

Figure 4.9 shows how Cluster 1 ranking of items at the detailed design stage. The items with the higher chi-square values are regarded as more important than those with lower chi-square values. The items are listed according to the order of importance below:

1. Engineering and technical measures for safety and emergency issues
2. Final HVAC equipment requirements, sizes and layout
3. Bill of quantities
4. Life-cycle costing and churning
5. Finalise construction techniques and materials and specifications
6. Environmental considerations and waste management
7. Access, servicing, circulation and transportation (vehicular and pedestrian)
8. Solutions to ensure considerations for the disabled and elderly
9. Accurate construction budget

10. Detailed waste disposal system
11. Detailed working drawings (architectural, structural and services)
12. Detailing of building automation systems
13. Detailed electricity circulation and lighting
14. Incorporation of considerations for operation, sustainability and user needs

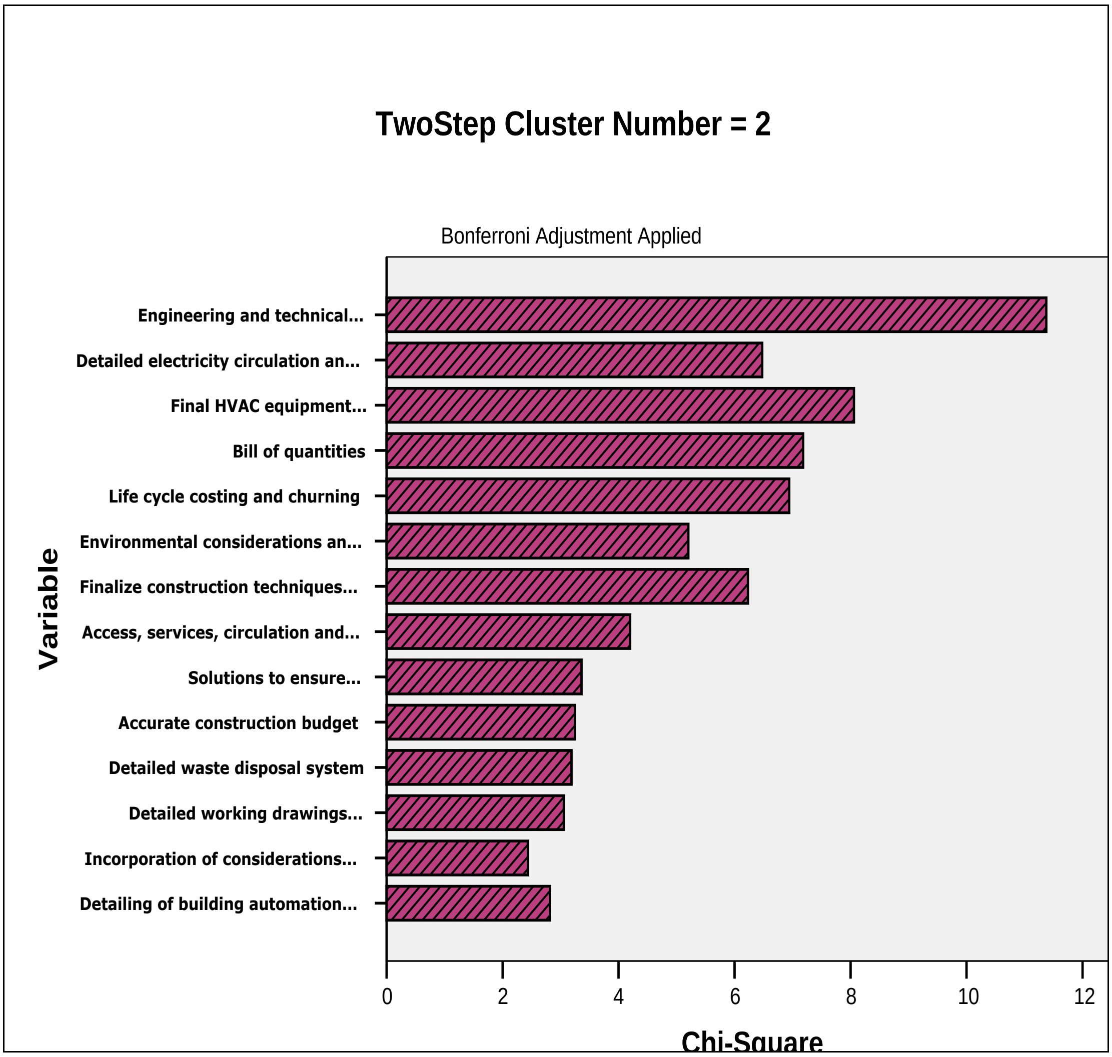
<u>Figure 4.9: Cluster 1 response to items at the detailed design stage</u>



Source: Author

Figure 4.10 shows how Cluster 2 responded to items at the detailed design stage. The ranking for Cluster 2 is similar to that of Cluster 1, indicating both clusters responded in the same manner. Although the clusters included different professionals with different training and work responsibilities and differing workplace experiences in terms of number of years worked, they responded in a similar fashion to the questionnaire.

<u>Figure 4.10: Cluster 2 response to items at the detailed design stage</u>



Source: Author

Cluster analysis reveals no differences in responses according to training, number of years worked, workplace responsibility or position at work. All the design considerations at the different design stages were deemed to be important from the facility operation and maintenance perspective.

4.5 Conclusion

This research was aimed at identifying linkages between facility design and maintenance. The data analysis indicates that respondents believed that facility management functions are important from the facility management perspective. These functions are influenced by design choices made at the project design stage, hence the need to make design decisions which have a positive impact on the ease and cost of operation and maintenance. It was also evident that the respondents believed that facility managers can assist project design teams to develop designs that better address the requirements for enhanced facility operations and maintenance.

The cluster analysis showed no indication of differences in responses according to training, number of years worked, workplace responsibility or position at work. All the design considerations at the different design stages were deemed to be important from the facility operation and maintenance point of view. There was also consensus that including facility managers in the design process would yield buildings that are easy and cost-effective to operate and maintain. The main conclusions, recommendations and areas for further research are elaborated more in Chapter 5.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The objectives of this research were to assess the role of facility managers in project design and the impact of involving them at project design stage. The literature review suggests that facility managers have a role to play in project design. In fact, facility managers can make significant contributions in the whole project delivery process; from project design through tendering to construction project management. However, this research was limited to only the facility managers' role in the design process. Four stages of the design process were identified and different design considerations at the stages were also identified. All the design considerations at the different stages were deemed important from the facility management perspective, indicating that design decisions regarding these issues must address the ease and cost of operations and maintenance to ensure sustainability of the project.

The different facility management functions identified were also deemed important from the facility management point of view, hence the need to make design decisions and choice of materials with such functions in mind to ensure optimal operations and maintenance.

The facility management functions to consider at project design stage include:

- Managing the electricity account including emergency power systems
- Heating, ventilation and air conditioning (HVAC) maintenance
- Transportation, access and circulation
- Servicing and waste disposal
- Water services

- Maintenance, cleaning and ground maintenance
- Communications and control systems
- Building management systems (BMS)
- Post occupancy evaluation (POE)
- Security and life safety
- Life-cycle costing and churning
- Space management and furniture
- Benchmarking

These reflect the day-to-day duties of the facility manager. Decisions at the project design stage must result in design and materials selection that will simplify these functions for the facility manager, and bear in mind the operation and maintenance costs at all times.

The research question (to determine the impact of facility managers' role in the project design) was answered by identifying the above-mentioned facility management functions and linking these functions to the design process. For these functions to be taken into account at the design stage, the facility manager must be integrated into the design process. They can assist in identifying design considerations and material choices that will make these functions easy and cost-effective.

The hypothesis of this research is that facility managers have a role to play in the project design process and their involvement in the design process should lead to better designs for the client and end-user, both in terms of suitability for the intended use and cost-effectiveness (capital and maintenance costs). The respondents believe that involving facility managers in the design process should lead to designs that are easier and more cost-effective to maintain. However, some of the respondents felt that facility manager involvement was best limited to large projects, in particular large scale developments that require fully-fledged facility management teams. Some of the respondents also noted that successful facility manager involvement depended on the facility manager having sufficient experience and qualifications in facility management. Facility managers who outsourced many of the day-to-day operations and management functions would have an inadequate level of experience to provide valuable contributions in the design process.

It is evident from the literature review that, although little has been written about the facility's managers' role in the construction industry apart from the management of built facilities, it is clear that they do have a role in project design and other construction procurement stages. Tay and Ooi (2001) argue that facility managers should be involved in project design as decisions made at this stage will have a direct impact on their duties. This view is also supported by El-Haram and Agapiou (2002) who agree that the facility manager can make a meaningful contribution to the design process. The facility manager can play major roles such as managing the whole design and construction process. This view is supported by Brown et al (2001), who argue that with adequate training, facility managers can be project managers in the construction industry. Mohammed and Hassanain (2010) also argue that every design has to be checked for maintainability before its final approval for implementation and that the facility manager is well placed to do this. Both the literature review and the analysis of the primary data collected support the view that the in-depth knowledge and experience of facility managers makes them excellent candidates for participation in project design teams. Their expertise in facility management duties can add value to the construction industry as a whole.

5.2 Recommendations

Facility managers must be involved in the design process, either as in-house experts (if employed by the company), or as external consultants with relevant training and experience. Such involvement will result in designs that are efficient and cost-effective to build, operate and maintain. The survey results support this recommendation. However, only those facility managers with adequate training and experience and are actively involved with daily operations and management of facilities can make meaningful contributions to project designs.

When choosing the design team, the size and scope of the development may dictate the composition of the design team. Large, complex developments are likely to have a large design team of different professions. For large scale developments that require fully-fledged facility management teams, the involvement of facility management expertise in the design process is especially recommended.

The choice of the procurement method should also be carefully considered. The literature review identified that traditional procurement methods are fragmented, separating design from construction. This leads to the contractor's knowledge being neglected at the design stage. Procurement methods such as Public Private Partnerships on the other hand allow all parties to be involved as early as the project design stage; this allows all experts, including facility managers to make input at the design process.

The design process also has an impact on the design team. An integrated design process brings all the stakeholders to the design process early, and promotes intensive analysis and in-depth investigations in search of complementary and innovative design strategies. The integrated design process allows the design team to establish project goals together and engage in a productive exchange of ideas.

5.3 Study limitations and areas for further research

There were some limitations experienced during the exercise. The limited time frame prevented a more detailed exploration the role facility managers can play in the whole procurement process, from project inception to construction and maintenance. In addition, the literature review revealed that the role facility managers can play in project design has not been extensively documented. Much of the literature review therefore focuses on designs, systems and operations of facilities rather than on what role the facility manager can play during project design.

In light of the above mentioned limitations, there is a need for further research on this topic. There is a need for research on the facility managers' role at project design stage, as well as how their extensive knowledge can be fully utilised in the whole procurement process, not just facility management. Their expertise and experiences can assist during other procurement processes such as construction and tendering. More research into training needs for of facility managers will address the gaps in knowledge not only for facility management professionals but also for all design and construction management professionals. Effective structures and educational processes for integrated design, construction and facility management are needed if sustainability and cost-effective operation and maintenance of facilities are to be achieved.

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Appendix A - Questionnaire and introduction letter

University of the Witwatersrand
Faculty of Engineering and the Built Environment
School of Construction Economics and Management
Johannesburg

To: Whom it may concern (Architects, Project Managers, Facility Managers, Property Managers, Property Developers, Quantity Surveyors, Engineers, Town Planners e.t.c.)

Re: Participation in a research project

Research topic: Evaluating the facility manager's role in project design

This serves as a request for your participation (by filling the attached questionnaire) in the research project on the above mentioned topic. The research is an academic exercise and will enable the researcher to fulfil requirements for obtaining a Master of Science (Property Development and Management) with the University of the Witwatersrand. All information given will be treated in strict confidence.

The research explores whether the involvement of facility managers in the building design process can result in designs that are easier and more cost-effective to operate and maintain.

Your cooperation and input into this research through the short time requested in filling the questionnaire is much appreciated.

By: Keaikitse Tladi (Mr)

Tel: **0729322516**

Email: **keaikitse@yahoo.com**

Faculty of Engineering and the Built Environment
School of Construction Economics and Management
University of the Witwatersrand

Research Survey: Evaluating the facility manager's role in project design
By: Keaikitse Tladi

SECTION 1: INTRODUCTION

Please tick the appropriate answer (√)

1. What is your training/qualification?

☐ Quantity Surveyor ☐ Facility Manager
☐ Property Manager ☐ Engineer
☐ Town planner ☐ Architect
☐ Project Manager
☐ Other (Please specify) ____________________

2. Please indicate your rank/position in your current organisation

☐ Partner ☐ Director ☐ Employee
☐ Other (please specify) ________________________

3. Which field(s) would you say covers your responsibilities in your current position?

☐ Quantity Surveying ☐ Facility Management
☐ Property Management ☐ Engineering
☐ Town planning ☐ Architectural/building design
☐ Project Management ☐ Property development
☐ Other (Please specify) ____________________
____

4. How long have you been working in your current position?

☐ < 5yrs ☐ 5 – 10yrs ☐ 11 – 15yrs ☐ >15yrs

SECTION 2: POSSIBLE DESIGN CONSIDERSTIONS THAT COULD BE IMPORTANT FOR THE FACILITY MANAGER TO CONSIDER AT DESIGN STAGE

5. The following are design considerations that are considered at the different stages of the building design process (conception, briefing, pre-design and detailed design stages).

Kindly rate the level of importance these factors may be from the facility management perspective or point of view *(Please tick the appropriate answer* (√))

Levels of importance:	5=Very Important (VI); 4=Important (I); 3=Moderately Important
(MI)	2=Low Importance (LI); 1=Not Important (NI)

Factors considered at the conception stage that may impact facility operations and management activities during the building life time	VI 5	I 4	MI 3	LI 2	NI 1
Information on space needs, etc.					
Design criteria e.g. Indoor comfort conditions, noise levels e.t.c.					
Estimation of impacts on cost of facility management					
General layout and circulation					
Other (please specify ____________					
____________					

BRIEFING **Factors considered at the briefing stage that may impact facility operations and management activities during the building life time**	**Level of of importance**				
	VI	I	MI	LI	NI
	5	4	3	2	1
Organization of user involvement					
Formulation of considerations for operation and sustainability					
Overall requirements for documentation					
Analysis of client's needs and establishment of best way to meet them					
Waste disposal					
Energy efficiency					
Utility costs					
Land use, urban form and transport					
Other (please specify)____________					

PRE-DESIGN **Factors considered at the pre design stage that may impact facility operations and management activities during the building life time**	**Level of of importance**				
	VI	I	MI	LI	NI
	5	4	3	2	1
Safety and security of buildings (persons and assets)					
Energy and resource consumption (electricity, heating, cooling, water e.t.c)					
Formulation of requirements for building automation systems					
Ease of cleaning and maintaining the building and surrounding areas					
Flexibility and adaptability in relation to changing use over time					
Building orientation					
Basic materials and finishes schedule					
Familiarisation with site, its layout, accessibilty and acesss to services e.t.c.					
Preliminary design and the design linkage to the site					
Logistics in terms of internal communication, transport and distribution					
Analysis of environmental requirements					
Ease and possibilities to reuse and replace building parts					
Solutions to ensure considerations for the disabled and elderly					
Other (please specify)____________					

Levels of importance: 5=Very Important (VI); 4=Important (I); 3=Moderately Important (MI)
2=Low Importance (LI); 1=Not Important (NI)

DETAILED DESIGN **Factors considered at the detailed design stage that may impact facility operations and management activities during the building life time**	**Level of of importance**				
	VI	I	MI	LI	NI
	5	4	3	2	1
Incorporation of considerations for operation, sustainability and user needs					
Detailing of building automation systems					
Detailed working drawings (architectural, structural and services)					
Detailed electricity circulation and lighting					
Final HVAC equpment requirements, sizes and layout					
Environmental considerations and waste management					
Detailed waste disposal system					
Bill of quantities					
Life cycle costing and churning					
Finalise constructiontechniques and materials and specifications					
Engineering and technical measures for safety and emergency issues					
Accurate construction budget					
Access, servicing, circulation and transportation (vehicular and pedestrian)					
Solutions to ensure considerations for the disabled and elderly					
Other (please specify)________________					

Levels of importance: 5=Very Important (VI); 4=Important (I); 3=Moderately Important (MI)
2=Low Importance (LI); 1=Not Important (NI)

Any comments ____

____

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SECTION 3: CONSIDERATION OF OPERATION AND MAINTENANCE ISSUES AT DESIGN STAGE

6. The following are some issues that the facility manager deals with when the facility is operating. Please rate the level of their importance for consideration at the building design stage. *Please tick the appropriate answer* (√)

Possible facility management functions to be considered at design stage	**Level of Importance**				
	VI	I	MI	LI	NI
	5	4	3	2	1
Managing the electricity account including emergency power systems					
Heating Ventilation Air Conditioning (HVAC) maintenance					
Transportation, access and circulation					
Servicing and waste disposal					
Water services					
Maintenance, cleaning and ground maintenance					
Communications and control systems					
Building management systems (BMS)					
POE (Post occupancy evaluation)					
Security and life safety					
Life cycle costing and churning					
Space management and furniture					
Benchmarking					
Other (please specify)________________					

Levels of importance: 5=Very Important (VI); 4=Important (I); 3=Moderately Important (MI)
2=Low Importance (LI); 1=Not Important (NI)

Any comments____
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____

Please tick the appropriate answer (√) to the questions below

7. Do you think that operation and maintenance considerations should be considered at the design stage of the building process?

☐ STRONGLY AGREE ☐ AGREE ☐ NEUTRAL ☐ DISAGREE ☐ STRONGLY DISAGREE

8. Do you think is facility managers are the best placed professionals to bring the operation and management considerations on board at the design stage?

☐ STRONGLY AGREE ☐ AGREE ☐ NEUTRAL ☐ DISAGREE ☐ STRONGLY DISAGREE

9. Do you think involving facility managers at the design stage would assist in coming up with designs that are more cost-effective to operate and maintain?

☐ STRONGLY AGREE ☐ AGREE ☐ NEUTRAL ☐ DISAGREE ☐ STRONGLY DISAGREE

Any comments on how facility managers can be incorporated into the design process

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THANK YOU

Appendix B – Factor analysis for data on facility management duties and their importance for consideration at project design stage

	Component			
	1	2	3	4
Servicing and waste disposal	.787	-.121	.199	-.148
Maintenance, cleaning and ground maintenance	.692	.217	-.109	.225
Water services	.658	.520	.093	-.341
Benchmarking	.642	-.021	.024	.323
Transportation, access and circulation	.625	.117	.434	-.003
Communications and control systems	.583	-.347	.231	.189
Building management systems (BMS)	.148	-.883	.108	-.243
Safety and life safety	.183	.715	-.068	.070
Life-cycle costing and churning	-.057	.682	.497	-.084
Environmental conditions/Heating Ventilation Air Conditioning (HVAC)	.095	-.186	.789	.390
Managing the electricity account including emergency power systems	.171	.054	.765	.016
POE (Post occupancy evaluation)	-.019	.041	.239	.861
Space management and furniture	.416	.256	-.014	.645

	Cronbach's Alpha if Item Deleted
Servicing and waste disposal	.712
Maintenance, cleaning and ground maintenance	.737
Water services	.746
Transportation, access and circulation	.726
Benchmarking	.758
Communications and control systems	.772

Cronbach's Alpha	N of Items
0.776	6

Cronbach's Alpha(a)	No. of Items
-0.371	3
The value is negative due to a negative average covariance among items. This violates reliability model assumptions.	

Reliability Statistics	
Cronbach's Alpha	**No. of Items**
0.726	2

Cronbach's Alpha	No. of Items
o.595	2

Appendix C – Clustering of respondents according to their responses to items at the conception stage

		Rank/Position				Total
		Partner	Director	Employee	Other	
Cluster Number	1	0	1	11	0	12
	2	1	2	6	1	10
	3	0	2	5	0	7
Total		1	5	22	1	29

		Training/Qualification								Total
		Quantity Surveyor	Facility Manager	Property Manager	Engineer	Town planner	Architect	Project Manager	Other	
Cluster Number	1	3	1	1	1	2	2	1	2	12
	2	2	2	2	1	1	3	0	1	10
	3	1	1	1	0	1	1	3	0	7
Total		6	4	4	2	4	6	4	3	29

		Fields covering your responsibility								Total
		Quantity Surveying	Facility Management	Property Management	Engineering	Town planning	Architectural/building	Project Management	Property development	
Cluster Number	1	2	2	2	1	4	2	3	4	11
	2	2	3	3	1	1	3	3	1	10
	3	0	2	2	0	1	1	3	3	8
Total		4	7	7	2	6	6	9	8	29

		Years worked				Total
		< 5yrs	5 - 10yrs	11 - 15yrs	>15yrs	
Cluster Number	1	5	4	1	2	12
	2	2	4	2	2	10
	3	3	1	1	2	7
Total		10	9	4	6	29

Appendix D – Clustering of respondents according to their responses to items at the briefing stage

		Rank/Position				Total
		Partner	Director	Employee	Other	
Cluster Number	1	0	2	3	1	6
	2	0	1	13	0	14
	3	1	2	6	0	9
Total		1	5	22	1	29

		Training/Qualification								Total
		Quantity Surveyor	Facility Manager	Property Manager	Engineer	Town planner	Architect	Project Manager	Other	
Cluster Number	1	1	0	0	0	0	2	2	1	6
	2	4	3	3	1	3	2	1	0	14
	3	1	1	1	1	1	2	1	2	9
Total		6	4	4	2	4	6	4	3	29

		Fields covering your responsibility								Total
		Quantity Surveying	Facility Management	Property Management	Engineering	Town planning	Architectural/building	Project Management	Property development	
Cluster Number	1	0	1	1	0	0	2	3	2	6
	2	3	5	3	1	4	2	3	2	1
	3	1	1	3	1	2	2	3	4	10
Total		4	7	7	2	6	6	9	8	29

		Years worked				Total
		< 5yrs	5 - 10yrs	11 - 15yrs	>15yrs	
Cluster Number	1	3	0	0	3	6
	2	4	7	2	1	14
	3	3	2	2	2	9
Total		10	9	4	6	29

Appendix E – Clustering of respondents according to their responses to items at the pre-design stage

		Rank/Position				Total
		Partner	Director	Employee	Other	
Cluster Number	1	1	0	10	0	11
	2	0	5	12	1	18
Total		1	5	22	1	29

		Training/Qualification								Total
		Quantity Surveyor	Facility Manager	Property Manager	Engineer	Town planner	Architect	Project Manager	Other	
Cluster Number	1	3	1	1	2	1	1	2	1	11
	2	3	3	3	0	3	5	2	2	18
Total		6	4	4	2	4	6	4	3	29

		Fields covering your responsibility								Total
		Quantity Surveying	Facility Management	Property Management	Engineering	Town planning	Architectural/building	Project Management	Property development	
Cluster Number	1	3	3	2	2	2	1	5	4	11
	2	1	4	5	0	4	5	4	4	18
Total		4	7	7	2	6	6	9	8	29

		Years worked				Total
		< 5yrs	5 - 10yrs	11 - 15yrs	>15yrs	
Cluster Number	1	5	3	1	2	11
	2	5	6	3	4	18
Total		10	9	4	6	29

Appendix F – Clustering of respondents according to their responses to items at the final design stage

		Rank/Position				Total
		Partner	Director	Employee	Other	
Cluster Number	1	0	3	12	0	15
	2	1	2	10	1	14
Total		1	5	22	1	29

		Training/Qualification								Total
		Quantity Surveyor	Facility Manager	Property Manager	Engineer	Town planner	Architect	Project Manager	Other	
Cluster Number	1	3	2	2	1	3	3	2	1	15
	2	3	2	2	1	1	3	2	2	14
Total		6	4	4	2	4	6	4	3	29

		Fields covering your responsibility								Total
		Quantity Surveying	Facility Management	Property Management	Engineering	Town planning	Architectural/building	Project Management	Property development	
Cluster Number	1	3	4	3	1	5	3	3	3	15
	2	1	3	4	1	1	3	6	5	14
Total		4	7	7	2	6	6	9	8	29

		Years worked				Total
		< 5yrs	5 - 10yrs	11 - 15yrs	>15yrs	
Cluster Number	1	5	6	2	2	15
	2	5	3	2	4	14
Total		10	9	4	6	29