DEVELOPING A FRAMEWORK TO ENHANCE BUILDING HANDOVER PRACTICES IN PUBLIC SECTOR CONSTRUCTION PROJECTS IN THE KINGDOM OF SAUDI ARABIA

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Developing a Framework to Enhance Building Handover Practices in Public Sector Construction Projects in the Kingdom of Saudi Arabia

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DECLARATION

I hereby declare that this research is based on an original investigation and complete acknowledgment is given of all sources used. This research has not been previously submitted for a degree or a similar award at any institution. To the best of the researchers' knowledge, this work contains no material previously published or written by another researcher where due reference is not made in the work itself.

LIST OF ABBREVIATIONS AND ACRONYMS

AEC	Architecture, Engineering and Construction
AHP	Analytical Hierarchical Process
AIA	American Institute of Architect's
BCA	Building & Construction Authority
BIFM	British Institute of the Facilities Management
BIM	Building Information Modelling.
BIS	Business, Innovation and Skills (department)
BSRIA	The Building Services Research and Information Association
BWA	Bernard Williams Associates
CAD	Computer Aided Design
Capex	Capital expenditure
C&A	Commissioning Authority
CDM	Construction Design and Management
CGI	Computer Generated Images
CIBSE	The Chartered Institution Of Building Services Engineers
CIOB	The Chartered Institute of Building
COBie	Construction Operations Building Information exchange
CSO	Case Study Organization
CURT	Construction Users Roundtable
DWG, DGN	Drawing and Design format
EIR	Employer's Information Requirements
FM	Facilities Management
GDP	Gross Domestic Product
GSL	Government Soft Landings framework
HOBO	Handover of Office Building Operations
HVAC	Heating Ventilate and Air Conditioning

IFC	Industry Foundation Class
IPD	The Integrated Project Delivery
IT	Information Technology
JCT	Joint Contracts Tribunal
KSA	Kingdom of Saudi Arabia
LEED	Leadership in Energy and Environment Design
NIST	National Institute of Standards and Technology
M & E	Mechanical and Electrical
MEP	Ministry of Economy and Planning
O&M	Operations & Maintenance
OPR	Owner Project Requirements
Opex	operational expenditure
PCC	practical completion certificate
PFI	Private Finance Initiatives
POE	Post occupancy Evaluation
PPP	Public Private Partnerships
QA	Quality Assurance
QR –codes	Quick Response codes
RFI	Requests for Information
RGEC	Research Governance and Ethics Committee
RIBA	Royal Institute of British Architects
SL	Soft Landings
SPSS	Statistical Package for the Social Sciences
TQM	Total Quality Management

List of publications

1. Hijazi, S. and Aziz, Z., (2013) *Improving Building Information Handover Practices in Saudi Public Sector Construction Projects*, IPGRC 2013, ISBN-978-1-907842-40-5.
2. Hijazi, S. and Aziz, Z., (2014) “Total Quality Management (TQM) of projects in the Saudi Arabia Construction Industry: A critical review”, *Global Conference on Engineering and Technology Management*, GCETM, Istanbul, Turkey, 23-26 June, 2014

ABSTRACT

Many public sector construction projects in the Kingdom of Saudi Arabia (KSA) are marred by communication and coordination problems, with owners having to pay a high price for schedule delays and cost overruns. The process by which building information is conveyed to owners lacks standardisation, a holistic approach, and consistency. This often results in KSA public sector owners receiving building information in a variety of formats, resulting in buildings operating at sub-optimal levels and relevant building data being unavailable at required times to support decision-making and optimal operations and maintenance. Existing systems of data management within KSA public sector projects cannot match the demand of operations and maintenance, as buildings are becoming more complex, in terms of space management, energy demand management, and addressing environmental concerns, due to the functional requirements of modern infrastructure. This research focuses on investigating key technology and process-related challenges in order to ensure smoother transition of information from project design and construction to maintenance and operation phases of a building's lifecycle. This research aims to develop a framework to enhance data management in building handover practices of public sector construction projects in the KSA. This framework helps improve the operation and maintenance of buildings by establishing a relationship between the project design and construction team, and the operations and project maintenance team. The research identifies key data requirements for effective building handover from a Saudi client perspective.

In order to achieve the research aim, an empirically based systems analysis of a single detailed case study organization of Al Madinah Al Munawwarah, Regional Municipality in KSA was carried out. Substantial fieldwork was undertaken using both qualitative and quantitative methods to match specific research questions. The questionnaire survey provides a wider view of building handover practices in the KSA, while the qualitative study provided an in-depth understanding of the state-of-the-art in practice. Many tools were used to collect the data, including semi-structured interviews supplemented by survey questionnaires together with documentation review. The implementation of more than one method to collect the data was used in order to

achieve data triangulation, to explore implementation of data management in building handover practices, and to provide a more an in-depth understanding.

The finding of this research concludes some unique factors that affect the implementation of actual building handover practices within the public sector construction industry in KSA. These factors include: high manager turnover; lack of knowledge and experience; lack of use of technology; lack of training; lack of communication during project data at the Handover Stage; unclear responsibilities. However, the finding indicates that it is important for all managers in public sector construction to understand that the handover is started already at the beginning of the project. Furthermore, early handovers must be reviewed and strengthened during the final project handover.

Also, the research findings confirmed that the lack of communication was possibly because of the fact that the project team is big and multi-cultural. Thus, the individuals were afraid to ask any questions as they assumed others would think that they were too inexperienced to understand some technical specifications. Hence, it is highly critical to define and use a clear communication procedure. Every manager is responsible for communicating internally and externally about status and issues. These findings will strengthen the existing literature on effective data handover at project completion stage and will narrow the gap in knowledge in KSA studies in particular and to Arab studies in general. Therefore, significant recommendations to the policy, practitioners, and researchers, within both the public and private sector projects, are made to aid and improve construction industry practices.

This research provides specific original findings, which include an in depth understanding of factors that affect the facilitation of data management in building handover practices of construction projects in the KSA via a case study conducted within the KSA public sector construction context. This research is the first study in KSA regarding issues that affect data management in building handover practices of construction projects in the KSA. It is also the first academic study of the Al Madinah Al Munawwarah, Regional Municipality in KSA.

CHAPTER ONE: INTRODUCTION

1.0 Introduction

A key focus of this research effort is to enhance building handover and lifecycle data management practices within public sector construction projects in KSA. This introductory chapter provides the context and background of the research topic. Also, it discusses the research problem, the aim and objectives, research questions, and the significance of the research. It presents the expected contributions to knowledge that might emerge from the completion of the research, a brief indication of the methodology, and the overall structure and layout of the thesis.

1.1 Research Background

The KSA is the second largest Arab state in Western Asia and is the majority of the Arabian Peninsula. The country is bounded by Jordan and Iraq to the north, by Kuwait on the northeast, by Bahrain, Qatar emirate and UAE (United Arab Emirates) to the east, by Yemen republic to the south, by the sultanate of Oman to the southeast, and the Red Sea and the Arabian Gulf to the west (Figure 2.8). The population of the kingdom is estimated at 29.65 million. Riyadh, which is the capital of the KSA and also the biggest city in the kingdom, is home to about seven million people (WPR, 2015).

Petroleum is an essential part of the Saudi economy. The country has the biggest oil and a natural gas reserve in the world; it is about 70% of the government's revenue and 95% of its exports yearly (Saudi Arabia Economy Profile, 2014). To lessen the country's heavy dependence on oil, economic policy has emphasized developing other industries, especially those coming from the non-oil segment, such as tourism and the construction industry, in order to decrease the heavy dependence on oil (El Malki, 2013).

The KSA has one of the fastest growing construction industries in the Middle East, fueled by a rising demand for commercial, residential, and retail projects. The KSA construction industry represents 8% of the Gross Domestic Product (GDP), it employs about one and a half million workers and is a major consumer of manufacturing and service goods, with an estimated total value of projects planned currently at $732 billion

(Ventures Middle East, 2013). Growth within the construction industry is often attributed to oil industry profits. These profits have also facilitated the growth of major infrastructure projects, such as: King Abdulaziz Airport Expansion, , Prince Mohamed Bin Abdulaziz Airport, Dammam port expansion, Jeddah monorail, Kingdom Tower, Jeddah Social Housing, Jubail Industrial City, new Universities, Hospitals, and modern cities to meet the demands of the commercial, residential and governmental clients (Ministry of Economy and Planning, 2012). Growth in the KSA construction market is also influenced by the presence of two holy mosques, in Makkah and Al-Madinah, attracting millions of pilgrims each year.

The construction industry in KSA has various distinctive characteristics. It employs a multi-cultural and multi-lingual workforce from developing countries, such as India, Bangladesh, Pakistan, and Egypt (Ventures Middle East, 2013). The Saudi construction workforce is very diverse in terms of its education, culture, practical skills, training, and language. This diversity creates issues, as the workforce is often trained in various standards and procedures (Kattuah, 2013). Even though Arabic is widely spoken in the country, the construction workforce (because of differences in pronunciation and accent) does not always understand it, leading to communication and co-ordination challenges. The multi-cultural background of the workforce also means that the way in which different technical terms are documented and interpreted, and the way in which business is conducted, varies a great deal from one project to another. The industry is highly fragmented and characterised by poor communication and co-ordination (Mitra and Tan, 2012).

The construction industry of KSA is affected by various problems, which are well documented in literature (Hijazi and Aziz, 2013; Hartman et al., 2008; Abaoud and Veziroglu, 2002). Public sector projects in KSA are procured using traditional routes. In traditional ways, the project delivery, designers, and contractors have minimal involvement after building commissioning. The design and construction team have limited responsibility once building handover has been completed. Also, it involves a wide range of professionals from multiple disciplines that utilise and develop data at various project lifecycle stages, resulting in a remarkable loss of information in the project handover stage. Manual handling of data and human errors further increase such information loss (Eastman et al., 2011). Accordingly, this often results in communication gaps between designers, contractors and owners. Inefficiencies resulting from such communication and coordination problems are well documented in the recent literature. For instance, Abdul-Hadi and Al-Sudairi (2005) describe how the Saudi construction industry is affected by problems in innovation, productivity, rework, slipping schedules, mistakes, disputes, and increased construction costs. Falqi (2004) suggested in his article that the rate of delay in the KSA is about 200%, with similar findings supported by Assaf and Al-Hejji (2006), suggesting an average time overrun of 10-30% of the project duration. Such delays can be seen as indicators of the overall ineffectiveness of industry to deliver its services as agreed.

Literature reviews indicate that, like construction industries elsewhere in the world, the industry in KSA can also be characterized by its low productivity, slow pace of change, waste, and fragmented processes (Qurnfulah, 2015). Fragmentation of construction processes lead to poor flow of data through the lifecycle. This is particularly evident when buildings or infrastructure are handed over from contractors to owners. A lack of a standardised approach in lifecycle data management often results in project clients/owners receiving piles of documentation at the handover stage in a variety of different formats, such as 2D drawings and specifications (Jordani, 2010; Hashmi and Al-Habib, 2013). The use of 2D drawings is still the most common medium of information exchange at building handover (Hijazi and Aziz, 2013). Many experts have highlighted the inadequacy of 2D drawings to communicate complex construction information and resolve conflicting issues interfering with construction. The literature review indicates following key challenges in existing practice.

1.1.1. Lack of an Integrated Approach for Building Lifecycle Data Management

The lack of a clearly defined framework for building lifecycle data management often results in buildings operating at sub-optimal levels during their lifecycle (Hartman *et al.*, 2008). Even in cases where contractors transfer a rich data set to owners during building handover (such as warranties, manuals, equipment details), there may be a gradual degradation of the information over the building’s lifecycle, resulting in building facilities being under-utilised. The high cost of building operations within KSA is also attributed to a very hot climate and the lack of a holistic approach to building design, construction, and operation. Within the UK, there have been efforts by the government to integrate design and construction of an asset, leading to better asset performance (Government Construction Strategy, 2011). The lack of an integrated approach is also evident through the lack of participation of building users in early lifecycle decision-making. This lack of clear definition of information requirements at the initial stage could provide a barrier to benefit realization at the project's completion (Kasprzak, 2012). Similar efforts in a KSA context could help better integrate the process. Currently, there is lack of clarity on what information is required by owners to effectively maintain the facility, often leading to wide variation on various public sector projects, in terms of their approach. There is a need to develop a better understanding of the challenges of developing an integrated approach to building lifecycle data management within a KSA context.

1.1.2. Lack of Standardization & Public Sector Strategy on Building Data Management

A review of global best practice indicates that the need for effective lifecycle data management has crystallized in the form of standards, such as BS PAS 55 (2015) (i.e., Asset management - Specifications for the optimized management of physical assets), BS 1192:2 (2015) (i.e., Specification for information management for the capital/delivery phase of construction projects using BIM), and ISO 55000 (2013) standards. Jordani (2010) highlighted how information supplied through various lifecycle stages of a building is fragmented. The effective operation and maintenance of a facility is heavily dependent on the retrieval of documents collected particularly in design and construction stage. Teicholz (2013) highlighted how existing approaches rely excessively on handover of hard copies and 2D CAD drawings to owners upon project completion. Such approaches are constrained (e.g. lack of accessibility, inability to update information on 2D drawings, etc).

As part of the UK government's Digital plan of Work (PAS 1192-2:2013), specifications for information management for the capital/delivery phase of construction projects using building information models are being adhered to (BIM Task Group, 2016). These specifications indicate that the handover process needs to start by documenting Employer's Information Requirements (EIR). EIR is included in a pre-tender document. These standards (Figure 1.1) promote a collaborative working environment in which information is produced using standardised processes and agreed standards and methods. Standardisation of information allows for information to be used and reused without interpretation or change. Thus, a collaborative working environment is produced using defined standards.

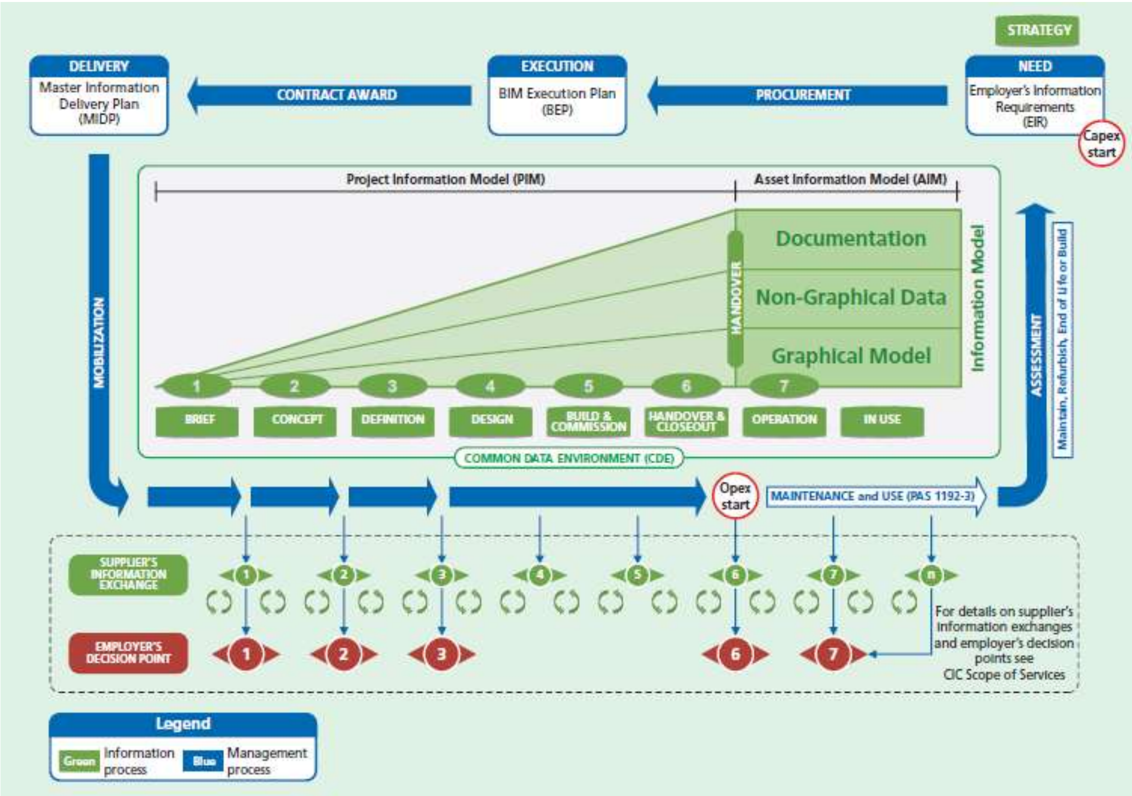

Figure 1.1: Information Delivery Cycle as specified in PAS1192:2. (BIM Task group, 2016)

Industry within the KSA is lacking in terms of process development and lacks a clear strategy from the Government in terms of what data is required for public sector buildings and how it must be collected over a lifecycle. Even though there is massive investment in developing world-class infrastructure, this is often not supported by corresponding development processes (Madichie, 2013). Relevant building information, as a result, is locked in data silos (e.g. CAD drawings) or in differing file formats and media (e.g. excel sheets, images), creating problems in accessing information to support the operations and maintenance stage of a facility. This research, therefore, focuses on identifying factors and gaps relating to lifecycle data management in the Saudi construction industry with a view to devise guidelines for narrowing the gap between the design and construction phase, and the maintenance and operation phases. This will facilitate the later development of a framework that can help in filling this gap and, thus, enable lifecycle management of building data. Lifecycle data management is particularly pertinent in light of recent initiatives by the Saudi government that focuses on sustainability and a reduction of energy-consumption (Abaoud and Veziroglu, 2002).

The increasing complexity of construction projects increases the difficulties in the process of information gathering and documentation (Jordani, 2010). Many researchers have highlighted the loss of information from the project design and construction phase to the operations and maintenance phase of a building. Bew and Underwood (2010) argue that there are information losses associated with handling a project from the project design team to the construction team and the building owner/operator. This information loss has a negative impact on asset lifecycle. A review of the UK construction industry indicates various efforts (e.g. BIM Task Group, Government Soft Landing Initiatives) to improve standardisation and public sector data management. However, a review of academic and industry literature emerging from KSA indicates a lack of awareness in this context. Loss of information because of poor data management has been documented in various reports. The study of the National Institute of Standards and Technology (NIST), entitled "Cost Analysis of Inadequate Interoperability in the United states. Capital facilities industry" (Fallon and Palmer, 2007), highlighted that key stakeholders in the public sector infrastructure facilities, including designers, contractors, product suppliers, and owners, incur huge financial losses by validating and recreating information that should be available in first place (Fallon and Palmer, 2007). The report highlighted that the industry pays extra to repeat surveys and collect information about already existing assets.

1.1.3 Lack of Adequate Exploration of Emerging Possibilities in Improving Quality of Asset Data Using BIM

Hardin (2015) defines BIM as a use of tools, processes, and behaviours to leverage efficiencies in the construction industry. Building handover information typically includes as-built drawings, O&M manuals and warranties. Owners' BIM may contain all the information required for space management, equipment data, finishing, installations, and critical warranties (Hardin, 2015). Mendez (2006) highlighted that there is "additional and valuable information for the owner generated through the design and construction phase and that goes unrecorded or not passed onto the owner". This is often attributed to a reliance on legacy formats, such as CAD drawings in DWG or DGN formats. According to Gallaher et al. (2004), a loss of $15.8 billion was incurred by US public sector clients because of the inadequate interoperability of CAD and other document formats. BIM allows for the presentation of information in an analytical format ensuring consistent data flow. Thus, new opportunities to address traditional communication and co-ordination challenges are becoming possible because of technologies and process-related improvements, such as Building Information Modelling (BIM), Management information systems, and integrated approaches to project delivery (e.g. Concurrent Engineering, Integrated Project Delivery). In this context, Love (2013) observes that BIM could provide a catalyst of change, due to its ability to reuse information that could be used during project design and construction stage for lifecycle management of infrastructure.

There is an increasing realization across developed countries for a need to better manage information across the building and infrastructure asset lifecycle. Teicholz (2013) views that the initial cost of project design and construction accounts for less than 15% of the total expenditure, while about 85% of the remaining cost is spent during the operational and maintenance phase of the project. In this context, Lamb et al. (2009) argue that building information models can be valuable in all aspects of asset management and construction in all phases of a lifecycle of a specific model. This spans from the conception of the project right up until demolition. Therefore, the benefits can be vast. There is increasing evidence that construction clients are asking for services beyond traditional project design and construction (e.g. Clayton et al., 1999). This is often referred to as a shift in focus on project delivery to a focus on services delivery. This is clearly being reflected by various governmental initiatives across the world, making the use of BIM mandatory as part of public procurement strategy (e.g., UK Government Construction Strategy, 2011). The UK Construction Strategy (2011) highlights the potential of reducing construction cost by 20% and enhancing sustainability with BIM. BIM provides an effective approach to integrate people, processes, information, and business systems (Shen et al., 2010). Similarly, there are initiatives across the world to standardise data formats and handover processes by integrating them in procurement processes (Whyte, 2010) with an ultimate aim to achieve asset lifecycle data management. A recent global survey of major client establishments revealed that 61.7 per cent of infrastructure owners held the view that BIM could deliver better results for FM (BIM4FM Survey, 2016).

The use of BIM-based approaches offers considerable benefits when compared with traditional approaches (Eastman et al., 2011). BIM addresses both technological and process challenges, to allow for a consistent approach to data management through the asset lifecycle. Eastman et al. (2011) indicate some of the benefits of BIM during the operations and maintenance stage of a facility including predictive or preventive maintenance, space management, reduced time to locate relevant information, and energy analysis. Figure1.1 illustrates the various levels of BIM maturity with an eventual goal of having a fully integrated interoperable data (level 3), thereby enabling clients to gain an advantage through better management of knowledge and organisational learning. The majority of construction firms in KSA are still operating at Level 0 and Level 1 of maturity (Figure 1.2), with 2D CAD still being the most prevalent method of data exchange. This research focuses on identifying key challenges and developing a roadmap to enable firms to operate their assets in an optimal manner.

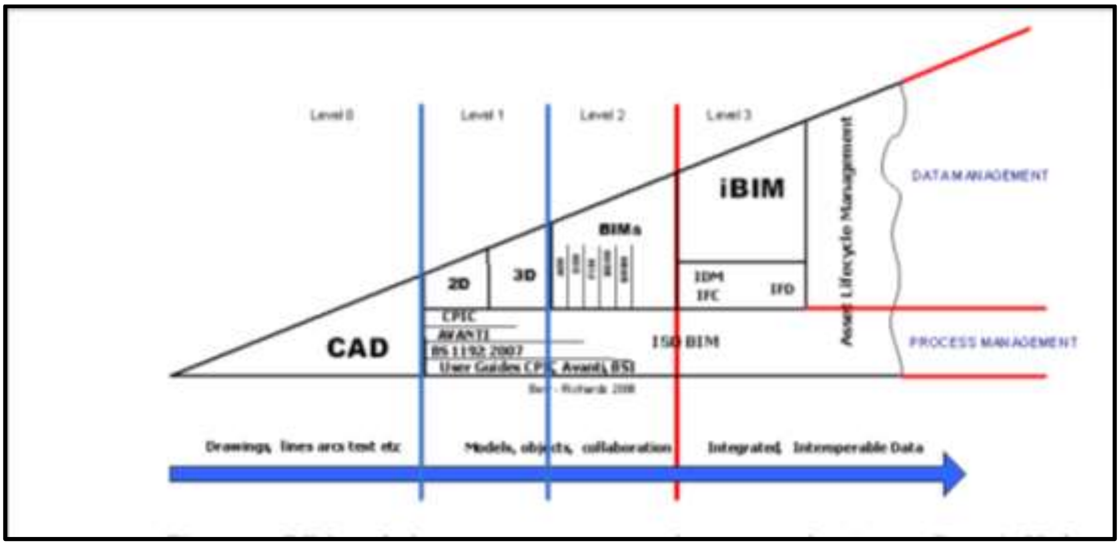

Figure 1.2: Building information model Evolutionary Map-Constructive Perspective. (Bew and Underwood, 2010).

1.2 Research Rationale and Key Research Questions

There are many reasons that make this study a valuable investigation. A review of recent literature suggests significant problems in the delivery of major building projects and civil infrastructure projects in KSA (e.g. Falqi, 2004; Assaf and Al-Hejji, 2006). Data related to major facilities is often held using ad hoc approaches. The limitations of traditional approaches to design and construction are often reliant upon 2D Computer Aided Design (CAD) based information exchange as a building moves from construction to operations and facility phase; a major loss of information occurs as a result of changes of roles and teams. Handling of data and human errors further intensify such information loss. Eastman et al. (2011) highlighted the need for an integrated approach to data management encompassing all project stages from design to construction to project maintenance and operation stages of a building/infrastructure lifecycle (Figure 1-3). Moreover, there are also economic losses incurred during the operations and maintenance stage of the facility and not in the construction stage. The majority of the cost of an asset is spent through the operation of that asset and not in its capital cost at the design and construction phases (Bew and Underwood, 2010).

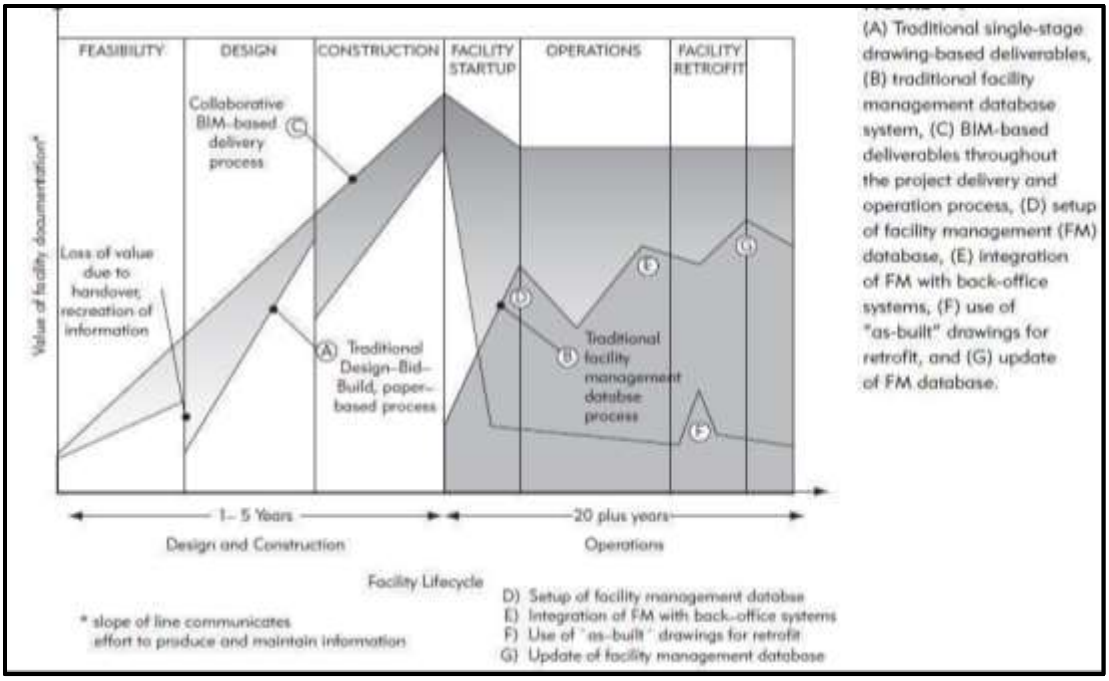

Figure 1.3: Data loss over lifetime of a construction facility (Eastman et al., 2011).

A US study highlights the remarkable cost to building owners and operators (Table 1.1), due to inadequate interoperability, such as the fragmented processes in the construction industry, the paper-based nature of information processing, the lack of use of advanced Information Technology (IT), and the absence of clear protocols or frameworks to organise the information handover between stakeholders during, and after, the final phase of the project (Gallaher *et al.,* 2004). As a result, many public sector buildings operate at a sub-optimal level and are unable to meet design expectations. This results in buildings operating at a high cost, often resulting in client dissatisfaction (Mitra and Tan, 2012). During the asset management phase of a building, numerous trades, people, processes, and technologies work together (Hardin, 2015). Within a KSA context, extremely high temperatures and wear and tear of public infrastructure, coupled with the increasing complexity of buildings, could lead to high maintenance costs. Similar views are expressed by Hardin (2015), who maintain that buildings are becoming increasingly complex in nature because of their functional design, environmental issues such as sustainability, and financial issues with energy.

Table 1.1: The costs of insufficient interoperability by Stakeholder Group, by lifecycle phase in $millions. (Gallaher, 2004)

Stakeholder group	Planning, engineering, and design phase	Construction phase	Operations and maintenance phase	Total
Architects and Engineers	$1,007	$147	$15.71	$1,169.9
General Contractors	$486	$1,265	$50	$1,801
Specialty Fabricators and Suppliers	$442	$1,762	—	$2,205
Owners/ operators	$723	$898	$9,027	$10.648
Total	$2,658	$4,072	$9,093	$15,824

Figure 1.4 illustrates the Royal Institute of British Architects' (RIBA) plan of work approach to information flow and key workflows. Project reviews at key handover stages of each phase involve due diligence to ensure information quality going forward. As a result, every stage handover ensures that standards are being met (Design Box, 2013). In contrast, an inconsistent approach in the building handover stages can result in building data being maintained in a variety of different formats, such as drawings, photos, manuals, 2D CAD drawings, and specifications. As the size of building/infrastructure related data grows, it becomes unmanageable and is seldom used to support decision-making.

The value of this information diminishes over the lifecycle of a building and often information is not readily accessible during the operations and maintenance phases as required. Thus, there is a need to develop a holistic approach to manage, capture, and transfer building information (Kandeil *et al.*, 2010).

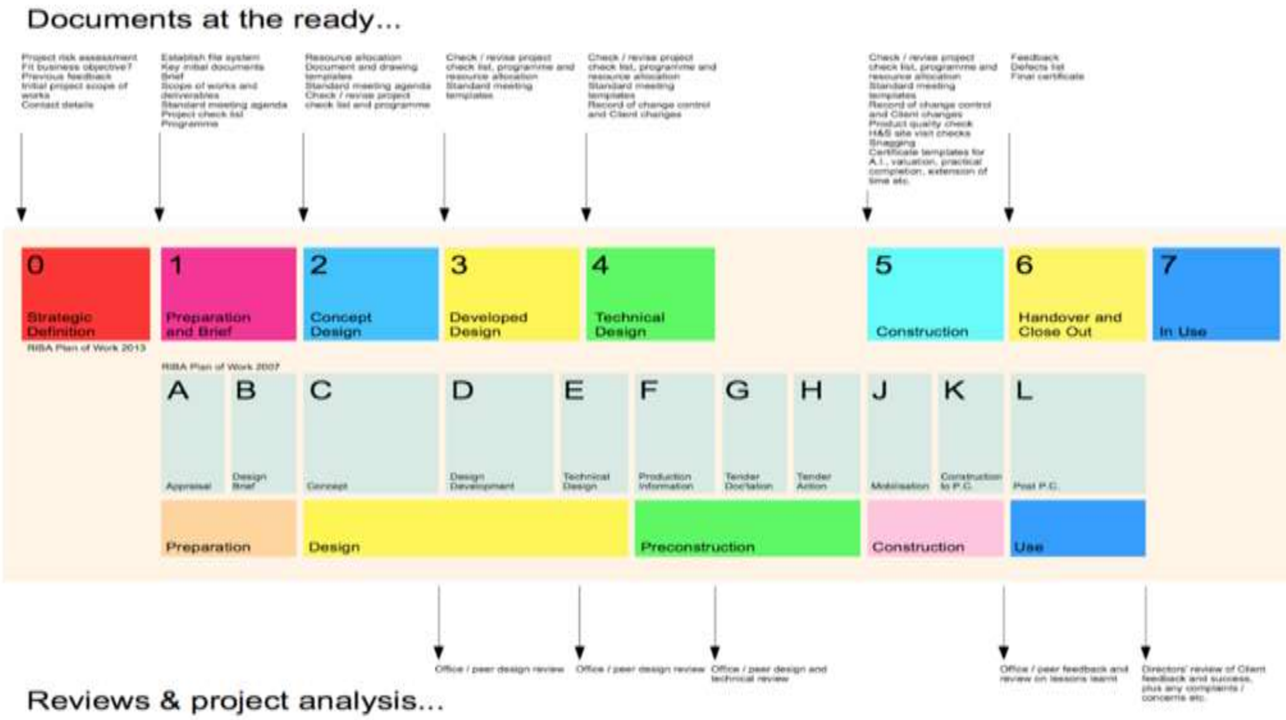

Figure 1.4: RIBA Plan of Work and Smooth Information Flow (Design Box, 2013).

A critical review of literature provides increasing evidence of buildings not performing as intended by designers, resulting in owner dissatisfaction (Figure 1.5). Likewise, there is general lack of communication in the building operations and maintenance phase, as the designers and contractors have minimal involvement after building commissioning. The design and construction team carry limited liability once building handover has been completed.

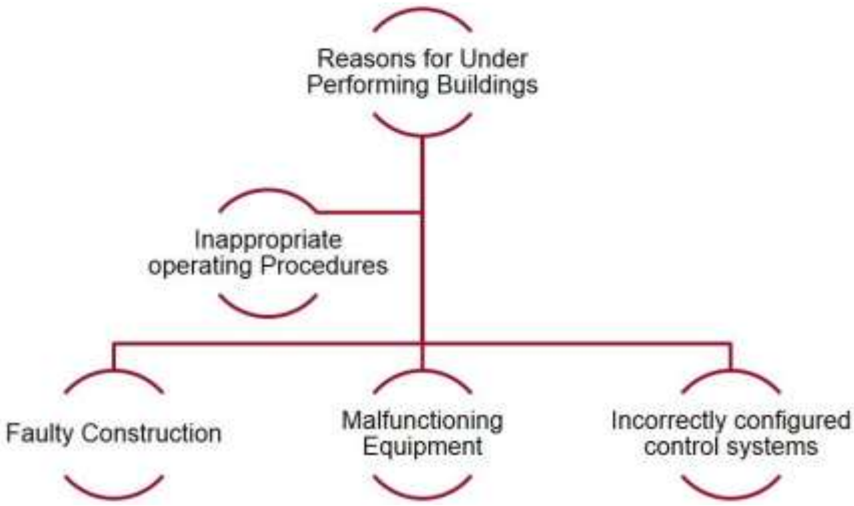

Figure 1.5: Reasons for underperforming buildings. (Adapted from Haves et al., *2001)*

There is an increasing interest in developed countries in the use of building information models in facilities management for consistent, coordinated, and computable building information/knowledge management through a building's lifecycle. BIM helps to streamline the data collection processes by helping engage with a variety of stakeholders due to its user-friendly 3D visualization. Evidence from best practice projects indicates that consistent information flow as enabled through BIM could help reduce project costs by up to 20% (BIM Task Group, 2016).

In the KSA context, there is a scarceness of published literature and a knowledge gap concerning areas where BIM-related information could be utilised to support building maintenance (Ghosh et al., 2015). In addition, there is a lack of information in the policy guidelines in the area of lifecycle building data management and building handover practices in the literature. There is a need for efficient and effective building handover with less loss of data in the process. Despite the lack of studies in the literature, and to the best of the author's knowledge, none of those studies has been carried out in a Saudi Arabian context. So this research will be an addition to knowledge in this area.

All of the above revealed issues highlight the need to address the factors that facilitate life cycle data management and analyse the challenges that face building handover within KSA. From the discussion above, the following key research questions are identified:

- What are the global developments, trends and best practices in building life-cycle data management and handover practices?
- What are the existing building handover practices in the public sector construction projects in KSA?
- What are the key challenges in the existing handover process within KSA and how can be it improved?
- What role can BIM-related technologies and processes play in improving lifecycle data management within public sector construction in KSA?

- How should the KSA government drive its strategy on building handover in the public sector?

1.3 Research Aim and Objectives

The main aim of conducting this research is to develop a framework to enhance data management in building handover practices of public sector construction projects in the KSA.

To meet the aim of the research and to answer the research questions, the specific objectives of the research will be:

- To identify the relevant concepts of building information handover practices and its requirements via a comprehensive review of the related literature;
- To critically examine the status of existing building handover practices within the public sector in the KSA;
- To analyse the challenges faced by clients and facilities management teams in management of public sector infrastructure within the KSA context;
- To develop a framework based on identified factors that enhance lifecycle data management within public sector buildings within the KSA;
- To provide recommendations to the KSA Public Sector to enhance its management of infrastructure via improved handover practices.

1.4 Research Methodology

There is no specific rule as to which methodological paradigm to select when starting research as the most suitable one will depend on the nature and scope of the research. Easterby-Smith et al. (2004), Collis and Hussey (2014), and Yin (2009) all indicated that selecting the research philosophy depends on the scope and nature of the thesis, the research questions and hypotheses or proposal, the source of the data, the constraints and scope of the research, and the overall research aim. This research adopts both positivist and interpretavist paradigms using qualitative and quantitative methods to match specific questions of the research.

The research began with an extensive review of the current literature on project handover practices. Then, it is supported by an empirical data survey and interviews with construction organisations in the KSA construction industry. Questionnaires are designed based on the literature review to reach a large target group in an efficient and practical way. The interviews are used to obtain detailed information about personal perceptions, feelings, and opinions of key stakeholders (Naoum, 2003) in the KSA public sector construction industry. Qualitative data from interviews are analysed using the NVivo software package and data from the questionnaires is analysed using the (SPSS) software package. A detailed research methodology is presented in Chapter 4. Findings from the survey and qualitative analysis are used to develop a framework to support building information handover in KSA.

1.5 Expected Contribution to Knowledge

This is the first empirical study that addresses and identifies the challenges faced in public sector building handover information management within the KSA context. Little research has been done on public sector construction project handover within the KSA construction industry and this study will fill that gap in the literature serving as a reference material for both informal and formal higher education programs in the built environment.

Empirical data (both quantitative and qualitative data) collected as part of this research yields new insights into building handover processes within the KSA public sector. The research also helps to inform and guide how public sector construction projects are handed to the operations or the facility management team in the KSA. This research also contributes to the emerging debate of how BIM should be implemented within the KSA. Both quantitative and qualitative data collected as part of this research contributes to this debate and helps narrow the knowledge gap in this field. Existing literature does not address the barriers and challenges within public sector construction.

1.6 Structure of Thesis

This thesis is divided into following chapters.

Chapter 1: Introduction

This chapter introduces the thesis and provides the related background and context of the research topic. It discusses the research problem, the research aim, objectives, question, and the significance of the research. Also, it explains the scope of the research and provides outline research approach.

Chapter 2: Literature Review

In this chapter, a review of the current literature is presented. The theoretical base of the research is developed in this chapter. Chapter two explores the concept of the building handover process in the construction industry locally and internationally in KSA. It is followed by a review of the application of the state-of-the-art technologies to improve the information flow and the relationship between the construction phases in the construction industry in the Kingdom of Saudi Arabia. It also reviews key data management practices and factors affecting the handover process within the KSA construction industry. Also, this chapter affords an in-depth understanding of the KSA construction with a special focus on the lifecycle of data management in this industry in general.

Chapter 3: Research Methodology

This chapter offers and rationalizes the philosophical stance for the research and the adopted methodology. It discusses the methods of research and data collection methods in construction management research, and presents the selected methods and the justification for them. It adopts a mixed method approach using both quantitative and qualitative techniques, and their protocols, which are discussed together with the triangulation methods as a means for data validation. It also describes the conceptual framework development process and issues of ethics relating to the research.

Chapter 4: **Analysis of Qualitative Data**

This chapter consists of the analysis and interpretation of the qualitative data obtained from the case study. Qualitative data is collected from semi-structured interviews and an analysis of documentation related to building handover process.

Chapter 5: **Quantitative Data Analysis**

This chapter presents the main findings from the survey and the interview based on the research objectives and presents the prototype, which will serve as a technology demonstrator.

Chapter 6: **Framework Development and Validation**

The chapter presents an analysis of both quantitative and qualitative data collected through questionnaires and semi-structured interviews. It discusses the statistical analysis used in the survey study. It uses Statistical Package for the Social Sciences (SPSS) software in analysing the information generated from survey. It also provides a summary of the interview design strategy and findings from semi-structured interviews. Analysis of interview data is also presented.

Chapter 7: **Conclusions, Limitations and Recommendations**

This final chapter presents conclusions from the research and highlights the limitations, the key contributions to knowledge, and the recommendations for further research.

1.7 Exclusions, Constraints and Limitation

This research was conducted to investigate issues on how to facilitate effective data management in building handover phases of public sector construction projects in the KSA. The private sector is excluded from this research. The private sector has different dynamics, often driven by short-term Return on Investment; thus, the need for long-term data management is often overlooked. Also, the research did not include the civil infrastructure sector (e.g. Transportation, Airports, Dams, etc.). Including civil infrastructure would have dramatically increased the scope of the research, given the individual requirements of each of the civil infrastructure sectors. Interviews done as part of qualitative data collection were not recorded.

As part of qualitative data collection, interviews were not tape-recorded. The failure to record interviews because of cultural restraints is considered a limitation; subsequently, this may have led to significant information being lost. So as to overcome this limitation, the researcher tried to write as much information as possible during the interview and, immediately after each interview, write down all the pieces of information and ideas and converted them into a form of written record while they were still easy to remember (Yin, 2009). Then, these records were confirmed by the interviewee. Also, there is lack of published literature on the data management related to building handover practices within the public sector construction projects in the KSA. This matter was considered as a limitation of the research.

1.8 Chapter summary

This chapter has offered an insight into the research study, emphasized the justification why this study is valuable for building handover in the KSA and, therefore, why it should be conducted. It has considered the research aim, objectives, and questions to be achieved. The expected contributions to knowledge have been identified, and an indication of the methodology to be adopted has been provided. Finally, it identified an outline of the structure of the thesis. The next chapter focuses on the background that is related to exploring the aim of the current project and on the literature review related to the state-of-the-art in building lifecycle data management practices with a specific focus on building handover.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter offers the background to the research and critically examines existing literature to establish the state-of-the-art in building lifecycle data management practices, with a specific focus on building handover. This chapter explores the need for effective building handover practices and reviews key focal literature in this area. It covers the issues on data management and building handover principles and procedures, as well as the building handover protocol, improving the project handover process, and BSRIA soft landing framework. Furthermore, it focuses on the concept, origin, and growth of BIM in data handover, the challenges of interoperability in project delivery, and challenges in existing handover practices. This chapter also presents the geographic and economic background that influences the construction sector in Saudi Arabia with a special focus on the lifecycle of data management in this industry in general. Finally, a summary is presented to integrate different perspectives of the literature, which have been presented in this chapter.

2.2. Building Handover Principles and Procedures

One of the most important stages in the project lifecycle is the handover of the project to the client at the end of construction; it is essential that a well-organized, efficient and effective transfer of project information to the client be undertaken (Whyte *et al*., 2010). Generally, the handover of the ownership of the project from the contractor to client can affect the health and safety, reliability, standards of operation, maintenance, and operational cost of the built assets. The project handover period can be a very busy period for all stakeholders, from the contractors' staff to the building owners and end-users. The contractor is typically responsible for the handover of key project-related documents as described in the contract, including built drawings, schedules, cost, spare lists, maintenance requirements, installed systems, and equipment details (Fallon and Palmer, 2007).

In the construction industry, the term "Handover" refers to an essential point at the end of a construction management after the completion of the physical construction of the project. The term is often associated with main contractors responsibility to inform the client that the building is ready for occupancy by the end users (CIBSE, 2000). Generally, the interlinking between the project completion and handover is essential and inevitable (CIOB, 2010). The Joint Contracts Tribunal (JCT) (2011) argues, from the contract point of view, that the finishing of the project has to be certified using Practical Completion Certificate (PCC), which should be issued by the Architect/Contract Administrator. A PCC is generally issued in the last stage of the project where the contractor delivers back the responsibility of the construction site to the owners. At this phase, the owner receives the completed project and takes the full responsibility for the insurance, security, operation, and maintenance of the built asset (CIBSE, 2000). Whyte *et al*. (2010) believe that clients have regulatory requirements to ensure that there is high quality data about their built assets for safe operation. In this context, it is important to ensure data precision and extensiveness and that the data is up-to-date for continuing use in operations. However, the data types used for operations and facilities management vary from those used in ventures and this produces challenges for the handover processes.

The relation between the owner and the principal contractor forms, in essence, the handover process. The project manager or the appointment of a commissioning management specialist represents the contractor. This representation is based mainly on the project's complexity and/or staff experience. Complex projects, where the work is carried out by several companies (in some stages, different companies work in the same package), face a serious issue to collect, organise, and deliver handover information by a single company. The distribution of the work and information can lead to some contractors being uninformed or updated on a huge amount of information. Sub-contractors who are responsible for specified components and manufacturers do not have to accept the mentioned arrangements beforehand (East and Brodt, 2007).

There is a need to collaborate more during big projects in terms of commissioning a champion who will fundamentally coordinate the collection and collation of the project information from the different sub-contractors. The handover of a project can be considered the most sensitive period for all of the parties participating in the project, especially the owner who is usually preparing to move into the completed built asset.

However, Saulles (2005) revealed that the contractor is obligated to accomplish the project on time according to contractual terms. The fragmentation of the construction industry, in addition to the time limits, can lead to an inadequate project completion process (Saulles, 2005). As a result, the emerged gaps in the procedure can produce poor levels of documentation. East and Brodt (2007) noted that the common practice of collecting the project information at the end or near end of the project could lead to gaps in the required information, although the information is available at the start of each stage of the venture to be applied and delivered by the sub-contractors. Generally, the most common factors that produce poor deliverables are the pressures and time constraints due to the waiting time until the end of the project (East and Brodt, 2007).

One of the main reasons for time-consuming activities in the project handover process is the heavy reliance on the use of 2-D paper drawings (Wu and Issa, 2012). Whyte *et al.* (2012), however, identified that leaving some experts in the project before the completion and before the project handover has deep negative effects. According to Wu and Issa (2012), such negative effects will generate difficulties that will be experienced by the owners throughout the building's lifecycle and whenever there is a need to extract data from maintenance and operation manuals. The use of BIM will, therefore, reduce or eliminate these challenges. The instruction of BIM on all construction projects will help capture data that can be accessed by all parties to the project during the pre-construction and post-construction phases of the project.

2.3 Impact of Information Loss at Handover Stage

The literature review indicates a wide range of reasons being cited for loss of information at handover stages. These include:

- The very nature of construction project delivery involves a wide range of disciplines and professionals through different stages, resulting in poor information flow (Whyte et al., 2010)

- Excessive reliance on paper based information delivery mechanisms results in loss of data as project moves from design to construction phase or to the handover stage (Eastman et al, 2008)
- There exists an absence of a clearly distinct framework for building lifecycle information management (Hartman, 2008)
- Losing a massive quantity of money looking for, confirming and/or re-forming facility information that should be readily obtainable (Fallon & palmer, 2007)
- An absence of interoperability between various software used for design, construction and Operations (Whyte et al, 2011)
- Lack of availability to extract useful information from CAD Drawings (Eastman et al, 2008).

2.4 Data Requirements for Effective Facilities Management

Facilities management, according to the "British Institute of the Facilities Management" (BIFM), is a practice of harmonising the physical workplace with the individuals and work of an organisation. BWA (1994) describes facilities management as a management process that includes systematic approaches used to control and provide the approved levels of service that are needed to cope, maintain, operate, as well as to upkeep a facility in an excellent environment at a proper price to meet the business necessities. Likewise, Becerik-Gerber et al. (2011) argue that facilities management is a discipline of design, planning, building, and managing space, in each form of construction, from office building to practice plant.

Facilities management (FM) in general ensures that a building functions smoothly throughout its operational life. It is a comprehensive function affecting performance, productivity, and costs. This includes practical and general features: for instance, systems as heating at the same time as making sure that the building is kept clean, post is under control and the building is maintained (East, 2013). The industry best practice review trends towards involving facilities managers in early stages of project design for early identification of future maintenance problems.

Missing information at the facilities management stage could adversely impact decision-making processes, leading to a disorganised system (Lucas et al., 2011). In this context, owners in 2002 spent $4.8 billion for data confirmation and validation, $613 million to transmit the data to a single applied communication format, $6.9 billion on interoperability, and $1.5 billion on information postponements and during lazy time of workers due to the absence of 'as-is' information (Gallaher *et al.*, 2004). However, usage of a computer modelling system like BIM can mitigate these problems. So as to join the practical and organizational processes into an exact database management scheme, the required data must be first identified.

2.4.1 Challenges in Facilities Data Handover

Starting from the conceptual design of facility to its final completion, lots of information is generated; however, most of this data is valuable in the later phases (Yu et al., 1998). Effectively maintained and iteratively built handover processes can enhance facilities management decision-making (East et al., 2013). According to East et al. (2013), the specifications for facility handover data at present need contractors to produce and supply a set of documents that provide practical value to the facility managers.

Review of industry best practice indicates use of a wide range of practices, such as linking maintenance manual (O&M manual) and operation, as it contains the information required for the maintenance, operation, decommissioning, and demolition of a building in .PDF format file, alongside elements in the BIM model. Also, quick response codes (QR–codes) are being used to track equipment and connect to the BIM and O&M data by using a hand-held tablet, via laser scanning, to validate any changes during project construction and producing an exact picture of the built asset at handover (Foster, 2010). Likewise, Construction-Operations Building Information Exchange (COBie) is being used as a technique to collect data and is progressively becoming the standard way to exchange data handover in industry. Also, various solutions use the COBie datasheet offered by the Contractors or Owners (Starkov et al., 2012). COBie is being developed as a standard for sharing non-graphic data of the asset. Whereas the accuracy of the handover information is vital, it is also important to address the correct type, technique, format, and roles for collecting these data types (Whyte *et al*., 2010). Also, to supplement a correct information management system, there must be a network that can capture the data, as well as the share information on an as needed basis (Chasey and Ghosh, 2013).

2.5 Need for Effective Building Handover

There are several concerns about the continued declining performance of the construction industry, such as usage of in-adequate management practices, staying away from other industries in taking advantage of novel technologies, projects phases being plagued by change orders, high costs, rework, claims, adversarial relationships, and slipping schedules, constructed facilities becoming more complex and difficult, owners and stockholders wanting to get the maximum benefit of their investments, and competition fiercely working to seize the moment by developing organisations that are customer oriented, dynamic, and innovative (Adrian, 2004; DeSimone, 2013).

Similarly, problems faced by the UK construction industry are well documented and have been highlighted in various government reports. These problems include poor image, competitive tendering procedures, over-specification (over design), late payment and cost overruns, changes of design during construction, time constraints and/or delays, low productivity and late completion, absence of labour, excessive overtime, and wastage (Government Construction Strategy, 2012; Proverbs and Holt, 2000). Likewise, the Cabinet Office (2011) explained clearly that the UK is struggling in some aspects in public sector construction. They argue that poor handovers of project data after projects' completion has a negative impact on the asset performance and that will generate finical pressure. The cost of the disputes could put more pressure on the financial situation (report of Cabinet Office, 2011). Moreover, the report clarified that even in the absence of faults, it is still difficult to find a completed built asset that perform to the design requirements, especially from an energy point of view (Ibid).

The UK government is currently proposing the implementation of the Government Soft Landings framework (GSL) as a mechanism to ensure the smooth transition of data from design and construction team to facilities management team at the building handover stage (Cabinet Office, 2013). The GSL protocol sets out rules of engagement between owners/clients and designers/contractors, and explains that owners/clients will be supported by designers/contractors in the first few months of occupancy. This ensures that owners are familiar with the building and its systems, and can operate it in an optimal manner (Cabinet Office, 2011). The construction industry is still lagging in terms of providing good value for money to its clients, often leading to dissatisfied clients (Chen and Li, 2006). Most problems in huge construction projects could be attributed to the lack of planning and communication among the project parties to ensure effective management (Kandeil *et al.*, 2010). Lifecycle building data management has the potential to enhance client satisfaction.

2.5.1 Building Handover Protocols

Although the Handover/commissioning process could be managed using agreed and specified guidance (CIOB, 2010; Dicks, 2002; CIBSE, 2000), the flexibility in the guidance regulations is necessary to adapt to suit each project situation. From the historical point of view, fulfilling the controlling legislation is the main reason for gathering the project information and the handover to the owner, according to the Construction Design and Management (CDM) regulations (CIBSE, 2000). One of the main legal responsibilities for owners, architectures, and contractors is the legislation and the general objectives of the process to secure a well-designed project based on a safe process according (Griffiths, 2007).

A clear definition for the responsibilities and procedures, including the health and safety rules, should be mentioned in the regulations. The health and safety rules are considered a very important part of the required information to the owner, as well as the maintenance and operations phase, and throughout the lifecycle of the building. The rules can be documented in a separate file and form a base for the O&M manuals. The aim of the Operation & Maintenance manuals is to provide the required data during any repair/alteration process, to carry out the process safely (CIBSE, 2000). The required information should include building drawings and specifications, operation rules, maintenance timetables and details, emergency details and manufacturing details (CIBSE, 2000; Saulles, 2005). Generally, the overall performance is neglected because the owner's occupancy for the building is not considered; that is due to the fact that the O&M details are determined to specific areas (Saulles, 2005).

2.5.2 Improving the Project Handover Process

The advent of new procurement strategies, such as Public Private Partnerships (PPP) and Private Finance Initiatives (PFI), is the main reason for the increased importance about the quality of the information that should be handed over to clients (CIBSE, 2000). CIBSE (2000) argue that there is a serious need to let the contractor carry a contentious responsibility for maintenance and operations. It is worthy to provide clients with complete and accurate information considering the valuable results that could be achieved in terms of decision-making with regard to general costs (Whyte *et al.*, 2012).

The development in Information Technology (IT) facilitates the integration of different and multiple sets of data and increases the efficiency of work (ICE IS Panel, 2008; Jackson, 2010). The probability of missing information in handovers using documents is higher than using integrated data (Whyte *et al.*, 2012). There is a shared view by different professional bodies, which states that the handover process should be determined in the feasibility study stage to secure the success of the project (CIBSE, 2000). However, East and Brodt (2007) argue that the building delivery process must not be seen as simply passing insurance liabilities since the contactor to the building's new owners, or providing data and details to the end users but rather it must be seen as a continuous procedure that starts at the tendering phase through to a period of practical achievement.

Building owners' satisfaction of built assets is likely to be affected if handing over is not properly done. Clients may waste energy and other resources because of inefficient and inappropriate use of the completed built assets. However, a new protocol developed under the Partners in Innovation Programme; Handover of Office Building Operations (HOBO) encourages delivery to be seen as a method of several activities, with emphasis on data exchange (East and Brodt, 2007). In this context, many owner organisations have developed comprehensive guidelines to manage the building handover processes (e.g. Figure 2.1). According to CIBSE (2000), the poor understanding of how the systems lead to poor forward plans results in underperformance. However, Kennett (2009) argued that the owners should sign a contract, which guarantees that everything will work as intended as soon as they are handed over the completed project. From this point of view, Wu and Issa (2012) mention that the building commissioning has been known as a period measure to determine that the building performs as planned. It is therefore important to undertake qualitative evaluation of all the performance issues to eliminate the problem of underperformance (Curry *et al.*, 2012).

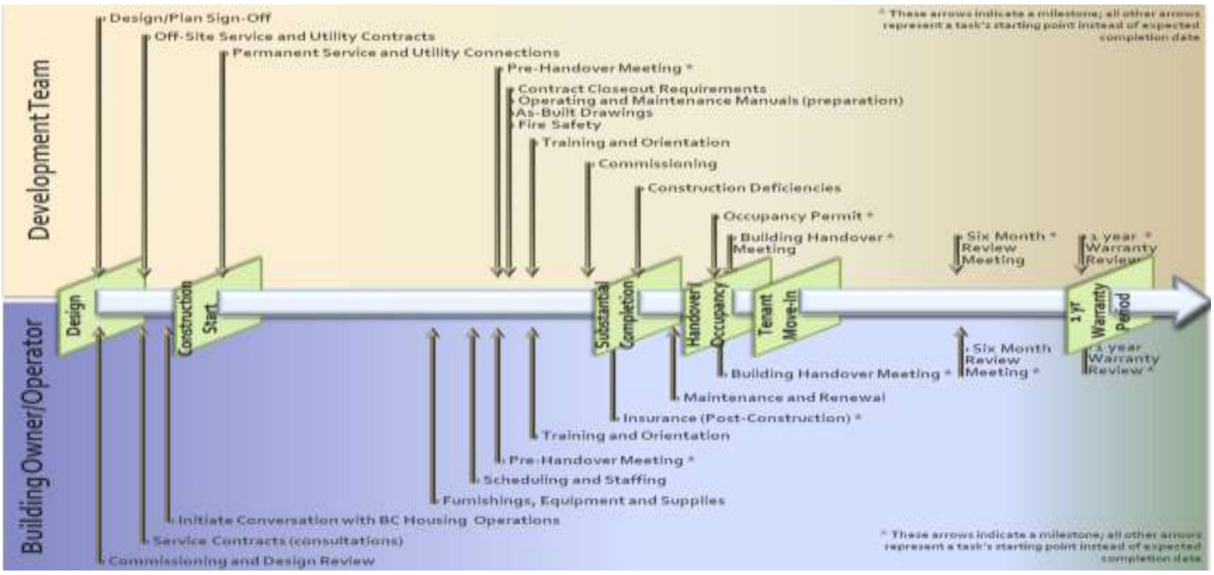

Figure 2.1: Building Handover framework (BC Housing, 2012).

2.5.3 BSRIA Soft Landings Framework

The handover of a built asset, involving phased deliveries, training of staff, commissioning, or other factors essential to the effective occupation of the building, demands well documented strategies. The Building Services Research and Information Association (BSRIA) Soft Landings framework is typically used as the foundation for framing strategies for project handover and POE (BSRIA, 2009). Soft Landings (SL) is a novel theory that purposes to concentrate upon customer requests and usage to design superior buildings, which are given to the client complete for operation (BSRIA, 2009).

According to BSRIA, there are five main stages for soft landings as described and illustrated in Figure 2.2.

Stage 1: Inception and briefing - The liaising between the owners, architects and contractors is an essential point to establish a clear view about the owners' requirements.

Stage 2: Managing expectations during design and construction - The identification of the owners' objectives should be addressed clearly at this phase considering the financial responsibilities.

Stage 3: Preparing for handover - Clear instructions to end users regarding the systems and technology that facilitate the building before the handover should be provided.

Stage 4: Initial aftercare in the weeks immediately after handover - The contractors have to visit the site after the handover to ensure the introduced instructions are followed and to provide further advice or observations to prevent any issues before they happen.

Stage 5: Extended aftercare - Regular assessments to ensure instructions are applied and the gap between design expectations and reality is minimised (BSRIA, 2009).

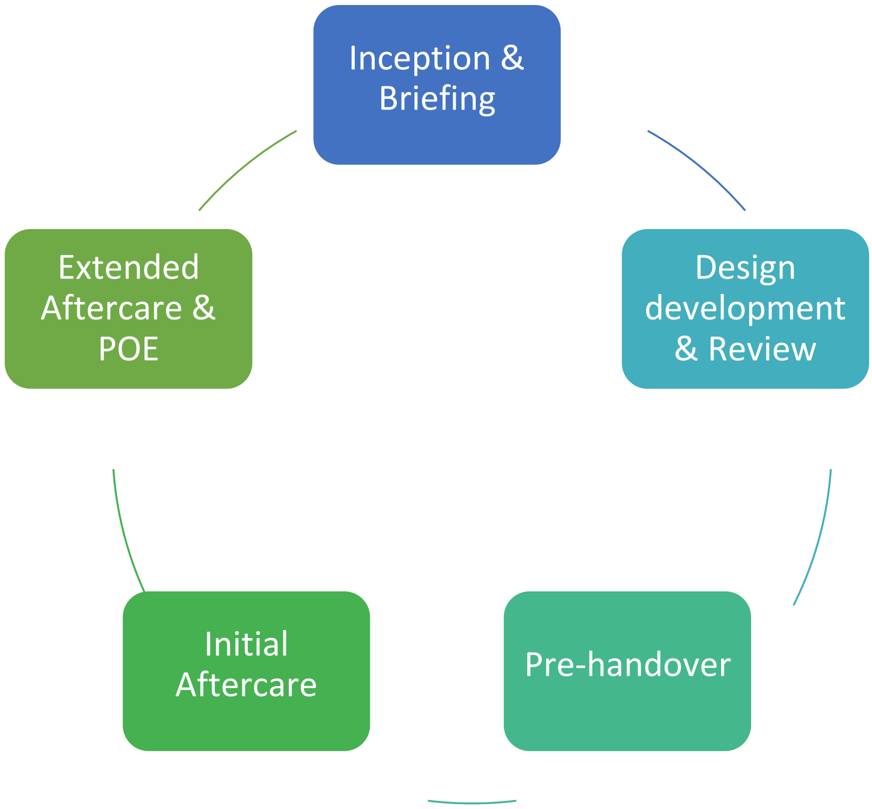

Figure 2.2: The Five Stage Soft Landing process (BSRIA, 2009).

From the start of the project, the main objective of SL is to establish a solid level of cooperation and integration to fill the gaps in the areas that need interoperability. Therefore, the main advantage of the regular evaluation of the building is to ensure the owner or client's satisfaction (BSRIA, 2009; Usable Buildings Trust, 2009). Due to the high level of diversity of contracts and process in the construction industry, the SL team does not have the willingness to design a new alternative. Kennett (2009) believes the 'Golden Thread', which is an alternative to soft landing guidance, allows information use hand-in-hand depending on the type contract. The main advantage of the Golden Thread is the possibility of information being shared, analysed, and executed. The availability of the gathered information will support the evaluation and improvement of systems and standards that lead to end users' satisfaction. The Soft Landings framework is a complete process that brings together best practice at all stages of a project and serves as a tool for engaging with results through the method of briefing, design and supply. The Soft Landings framework (SLs) has been developed to help all the relevant stakeholders (clients, designers, builders, managers, and end users) achieve an improved performance for end users (BSRIA, 2009). The key principles of soft-landing framework are presented in Figure 2.3.

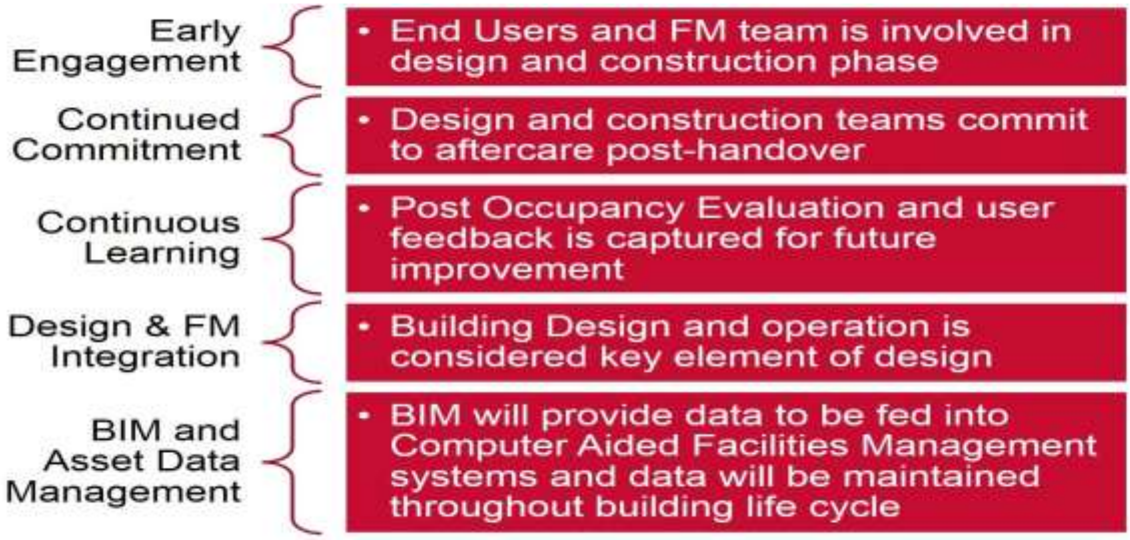

Figure 2.3: Key principles of soft-landing framework.

The unclear boundaries between the owners', architects', and contractors' responsibilities are the main reason for BSRIA to avoid using financial penalties to any failure in the contract requirements. This point is addressed in (BSRIA, 2009; Usable Buildings Trust, 2009) as follows:

> "… due to the cost of setting-up a legally defensible structure, uncertainties around metrics, the problems in sharing any responsibility for results among all the parties concerned (not least the occupiers and facilities managers)".

Consequently, BSRIA introduces the bonuses as encouragement for good achievement and as an alternative methodology to penalties as means of punishments for failures. According to BSRIA (2012), the following steps should be applied to guarantee the success of a project:

- Apply the process completely.
- Ensure the interoperability.
- Define the end-user objectives.
- Define the tasks and responsibilities clearly with shared risk.
- Feedback cycle to ensure endurance and aftercare.

- The Feedback cycle, in terms of operational outcomes, should involve both end users and building managers

2.5.4 Data Requirements for Handover Process

Data is developed at various stages during the design and delivery of built assets involving different professionals (Whyte *et al.*, 2010). In a qualitative study by Whyte (2010), involving interviews with leading clients and delivery firms, the results highlight the need to emphasise precise information for hazard management and compliance, for good decision-making about investment in the physical groundwork, such as capital expenditure (Capex) and operational expenditure (Opex). Utility providers, such as Highways, Railways, Stations, Airports, and Hospitals, have regulatory necessities to confirm safe and on-going operations and, for this reason, pay attention to gaining excellent information about their physical assets. They also emphasise the significance of precise data necessary for the maintenance of an asset during the operational life cycle, which may be through forty and eighty years (Whyte, 2010).

To achieve accurate and correct decisions regarding expenses during the operation and maintenance phase in general, it is of great importance to gain value from data about the asset. Therefore, to ensure the enduring utilize of data for operations, owners require comprehensive, correct and updated project data considering the building commissioning. However, the difference in the data types used in the design and constructions phases from those used in the operations and maintenance phase is causing difficulties, which face owners and engineers to handover data from projects into operations.

Bew and Underwood (2010) describe the ability of handing over data from design levels to operation and maintenance levels by using progressive procedures and principles. East (2009) outlines a number of data varieties that are required at handover. This project data or information is normally exchanged in a variety of different formats and includes commission plans, daily reports, ground plans and drawings, manufacturer product, data insurance, quality control documentation, photographs, cost estimates, equipment list, fabrication drawings, invoices, operations and maintenance manuals, progress schedules, and requests for information (RFIs)

However, Jordani (2010) categorised project data valuable for operations and facilities management into five main groups:

- Asset management information
- Geographic data
- Constructers’ reference data
- Environmental, Health and Safety, guarantee and security
- Geometric model and drawing data

Jordani (2010) also observes that to produce additional accuracy of information that is usable in the life cycle of a construction, the alignment of business perspectives of a design/construct team and an owner/FM for the long-term value of the building asset and a translation of BIM data formats and/or demonstrations are essential. The data taken in BIMs should be channelled into various FM software structures. The next section presents the concept, origin, and growth of BIM and its uses as a main process that has potential value for efficient data handover.

2.6 The Concept, Origin, and Growth of BIM

BIM is the acronym of “Building Information Modelling" in English. It is prepared of smart construction components, which contain data features and parametric guidelines for each object (Moon *et al.*, 2015). The launch of set standards for object-based data modelling was announced by the International Alliance for Interoperability in 1995, where multiple sellers would be able to access a building model to deliver information to the engineers and architects in a 3D space (Kuehmeier, 2008).

BIM is a practice of computer-generated design and construction during the lifecycle to share knowledge and communicate between the project members developing the Building Information Model. It provides harmonized views and images the digital model containing reliable information for every view, which, in turn, saves designers’ time, as each view is harmonized through the integral intelligence of the model (Moon *et al*., 2015).

BIM, according to the National BIM Standard (2010), is a digital image of the physical and practical characteristics of a facility and a mutual knowledge resource for data about a facility, creating a reliable foundation for decisions throughout its lifecycle; it is defined as existing from earliest conception to demolition. However, BIM does not get hold of the full potential value, for example, an architect could choose to design a BIM and use it for imagination and energy examination; they might choose to provide the sketches in two dimensions and constrain the BIM access. This would obstruct the involvement of the building manager, except he will create a new model (Vardaro et al., 2009).

Practically, the "social" BIM allows for the sharing of the model among the architect, engineer, building manager, and subcontractors, and can use the building data models to create constructability reports, design, schedule, and cost estimation. According to Hergunsel (2011), before implementing BIM, many concerns regarding implementation on construction projects must be addressed (e.g. the purpose of use, information that requires providing value to each project participant, existence of proficiency to bring up-to-date work, numbers of models there will be, whether the models are going to be interoperable, by what means they to be shared, the tools to be used, and the contract language in the project). However, these concerns are depending on the needs of the project team.

2.6.1 Use of BIM in Building Management

There are numerous uses of BIM for projects. In the period of the design phase, the usage of BIM can exploit its influence on a project when the budget is high. Thus, the team could generate some ideas and make solutions to minimize the issues that produce the high expense of the project. This can be recognised through the collaboration and coordination of the whole project team. Also, the use of BIM mainly improves the supportive efforts of the team in the project, as the engineer and architect can check their design including energy investigation so the building manager can deliver constructability, value and engineering reports. Furthermore, they could start 3D direction among vendors and subcontractors through initial phases of design (Bedrick, 2008). In addition, the vendors can visually see whether the design is what he is in search of. Generally, the BIM stimulates of all of the projection associates.

Throughout the construction stage, the price in a project decreases as the building progresses. Also, through the post construction stage, maintenance arrangement, space management, building system analysis, tracing, disaster design, and recorded models can help to maintain the construction throughout its lifecycle. Further, construction system investigation, including lighting, energy, and mechanical, can be used to examine a construction's performance. Subsequently, promotions might be initiated to different equipment and components of the construction (Bedrick, 2008). BIM can decrease the building time and decrease the expenses on operation and overhead budget (Yan and Damian, 2008). By using a BIM, the collaboration with contractors will lead to reductions in insurance costs and fewer opportunities for claims (Becerik-Gerber, 2010). Furthermore, the BIM implements will create difficulties for a substantial number of errors to filter through to location and several will be recognised, whereas they are still inexpensive to repair.

However, BIM will not solve all problems that have a cost influence; experience has revealed that improving data quality and increasing union through cooperation can make projects more expectable (Zghari, 2013). Based on Becerik-Gerber (2010), there are numerous benefits of BIM (figure 2.4). These include helping to detect potential technical hitches early, which usually are only discovered when construction has started onsite. Avoiding these complications would lead to time-saving and allow in-time delivery of materials and equipment to the site, which in turn reduces storage and related costs. Also, the BIM approach creates a completely integrated practice, where engineers, architects, and contractors work for the same organisation. However, the use of BIM requires substantial training and, as with any other software program, there are expenses associated, such as training, purchasing, and licensing. Consequently, this will lead to higher fees in the businesses. In addition, BIM can disrupt the building process when ordering materials that need an extensive time: for instance, when a supplier wants to order material depending on the dimensions of the design, ordering these items could take a long time. When the dimensions change, which usually occurs when several contractors provide information into a model on a continual basis, the contractor may be left with not enough time to order the required items (Carlin, 2010).

Figure 2.4: General benefits of BIM.

On the other hand, and according to Yan and Damian (2008), the application of BIM may face large obstructions, such as requiring a lot of time, a large workforce, and specifically trained employees. Also, there is lack of evidence of the financial benefit of BIM and it may face resistance to change, due to social and habitual factors, as many of architects are pleased with old-style methods to design their projects.

2.6.2 Building Information Management in Data Handover

The Architecture, Engineering and Construction (AEC) industry is facing a revolution like to the one that occurred in the aerospace engineering and manufacturing sectors with the lean process, needing process changes, and a model shift from 2D-based documents and staged supply processes to a digital pattern and cooperative workflow (Eastman *et al*., 2011). The basis of BIM is a more coordinated and data-rich building model with abilities to virtual prototyping, virtual construction of a project and analysis (Eastman *et al*., 2011). These implements generally strengthen today's CAD abilities with an improved capability to relate design data to business procedures – for example, assessing, operations, and sales forecasts. These implements are based on a cooperative rather than split tactics to project procurement (Eastman *et al*., 2011; Howard and Bjork, 2007). This situation is not achievable in KSA until up-to-date technology is commonly used. Therefore, this will economically affect the projects sections lifecycle. Figure 2.5 illustrates project information value loss throughout the project cycle.

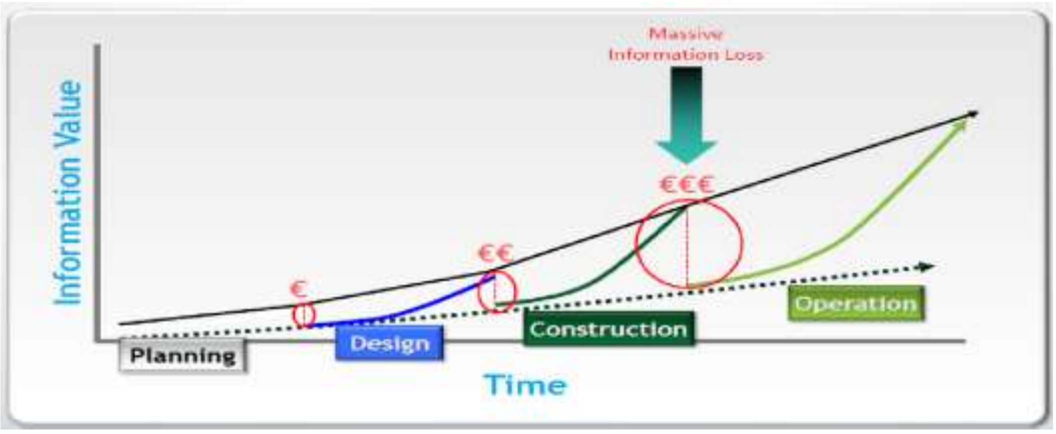

Figure 2.5: Lifecycle information loss. (Foster, 2010).

However, Whyte et al. (2010) observe that this combination is mostly not accomplished in practice, with some phases of the project more integrated than others. With BIM-based procedures, the vendor can theoretically achieve a greater return on investment as an outcome of the enhanced integrated design procedure, which raises the value of project data in each stage and makes possible better efficiency for the project teamwork. In a simultaneous way, owners can gain extra in the quality and cost of the project, as well as the future operation of the facility (Hassan Ibrahim, 2011).

There is considerable business and policy concentration in BIM, and research has been conducted in the policy agenda of a UK context (BIS/Industry Working Group, 2010), with the declaration that government procurement will need the use of BIM and management. Research also draws on growing policy agendas in Denmark, the USA, Canada, and Australia. Denmark and USA, along with Norway and Sweden, have signed a 'Washington Agreement to support open BIM standards' (Whyte et al., 2010). Forbes and Ahmed (2010) describe BIM as a method to produce and manage building data throughout its lifecycle allowing a continuous and immediate availability of information with respect to project design's scope, schedule, and cost. BIM inspires incorporation of the roles of all stakeholders on a project and has the ability to endorse greater efficiency and proficiency (Azhar *et al*., 2012), allowing substantial alterations in the workflow and project supply procedures (Hardin, 2015).

The innovative Integrated Project Delivery (IPD) method to procure construction projects aims to achieve close cooperation between all associates of the project team (Eastman *et al*., 2011). There has been considerable research, such as that by Bouchlaghem et al. (2000), Avanti (2006), and ICE IS Panel (2008), to improve new tools and methods for data management through the lifecycle of projects. The reason for integration of phases, disciplines, and systems within the project, is associated to Integrated Project Delivery (Grilo and Jardim-Goncalves, 2010) and related tools and methods, such as BIM (Whyte *et al*., 2010). Grilo and Jardim-Goncalves (2010) supposed that BIM has a possible use in all stages and phases of the project lifecycle; it can be used by the vendor to understand project requirements, by the design team to analyse, design and develop the project, by the contractors to manage the structure of the project and by the facility managers throughout process and decommissioning stages. According to Foster (2010), application of BIM in project information handover offers a number of benefits, including:

- Increased speed of preparing Asset Management System
- Reduced labour for building commissioning
- Improved asset management throughout lifecycle
- Better tracking of installation and testing
- Better collaboration between project stakeholders
- Better predictability of parts based on actual data

2.7 Building Commissioning

Building commissioning can be described generally as a quality assurance that a construction and its technical patterns meet the requirements well-defined in the owner's project desires (OPR) (Agustsson, 2010). The commissioning process is defined in more detail in the ASHRAE Guideline (2005) as:

"A quality focused process for enhancing the delivery of a project. The process focuses upon verifying and documenting that the facility and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the owner's Project Requirements".

However, the National Conference on Building Commissioning report in 1993 defines building commissioning as:

"A systematic process of assuring that the building performs in accordance with the design intent and the owner's operational needs".

The general ideology behind the commissioning process has been around for decades and can be traced back to the early years of shipbuilding, where ships' equipment and systems were tested in a controlled environment to verify they worked as intended before they were taken on actual journeys (Augutsson, 2010).

The idea that the usual quality assurance procedures require more development was derived mostly from the dissatisfaction of construction owners resulting from the fact that their constructions rarely fulfilled their initial requirements or operational essentials and the time it took to work out the errors were overlooked in the building procedure (Grodnzik, 2009). In this regard, one of the things that commissioning has over other quality assurance processes is that it forces discoveries of mistakes and problems to be revealed as early as possible under controlled conditions and at a time when massive negative consequences are least likely to occur.

Among the aforementioned countries, the one where commissioning is closest to becoming ordinary practice is the United States. Commissioning is not a new thought, nor is building commissioning. The first time commissioning was used in relation to constructions relatively similar to the practice today happened between 1977 and 1993. The first users and suppliers of construction commissioning were commonly from the public sector. In 1994, the U.S. government issued an executive order stating that all federal constructions undertake commissioning. From 1999, one of the main gains for commissioning is the presence of commissioning in Leadership in Energy and

Environmental Design (LEED), which has made commissioning compulsory for a construction to obtain LEED certification. Besides that, there have been evolvements with additional guidelines, energy standards, commissioning associations, and white papers have been made and published (Portland Energy Conservation, 2010).

The research results from the US and the evaluation of the two shopping malls in Denmark (Agustsson, 2010) point out that the use of building commissioning throughout the building process is likely to reach substantial reductions in energy consumption. However, companies offering building commissioning services still have difficulties convincing building owners about the value that commissioning adds to the built assets and the reduction in operations and maintenance costs. A potential solution to this is to improve data collection of commissioning projects and to analyse the collected data to establish certain facts regarding the positive outcomes that commissioning has achieved. The subsequent points further define what building commissioning involves (Heinz and Casault, 2004; California Commissioning Collaborative, 2006; Grondzik, 2009):

- Enforces collaboration between members of the building process.
- Encourages and documents communications amongst owners, designers, contractors, and operations and maintenance personnel.
- Documents all difficulties that oppose the OPR and the solutions in a structural way.
- A systematic quality assurance procedure that through investigation and verification ensures the building meets the OPR.
- Ensures that operations and maintenance personnel are delivered with required training to be able to maintain the construction at the owner's intended performance level.
- A process that emphases on result first, and then what equipment is used to achieve the result.

Berkely Lab (2010) provides an overview of the commissioning process that outlines the activities undertaken at each phase of the building project commissioning process. Figure 2.6 illustrates the key commissioning activities, the key documents produced in every stage of the construction project, the purpose, and the data that should be included at each phase.

Figure 5: Commissioning process Overview. (Berkeley Lab, 2010).

The role of the Commissioning Authority (CxA) is to handle all of the communications required for the commissioning team to the owner, unless otherwise delegated to members of the commissioning team some of the direct communication activities (Agustsson, 2010). A Commissioning Authority (CxA) is a professional who is knowledgeable in the building, design, and operation of systems. It determines the responsibilities and objectives of the teams involved in the commissioning process, like the commissioning and design teams and produces documents, logs, reports and plans and update them, makes checks of systems and equipment, and trains operation and maintenance personnel (Agustsson, 2010). The CxA hold regular meetings with the different AEC players involved in the project delivery and operations and submit the documents produced according to specific deadlines and according to specific contractual commitments (Agustsson, 2010).

Finally, the CxA ensures the project is delivered on time, according to the budget, and that all that is built corresponds to the design (Agustsson, 2010). Equipment and system confirmation is still one of the most significant parts of the commissioning procedure due to the important focus on increasing efficiency of systems to achieve lower energy consumption. How detailed the verification process can be varies from one project to another but a complete and comprehensive verification process should be carried out to verify the delivery, installation, and function of equipment and systems (Grodnzik, 2009).

2.8 The Challenges of Interoperability in Project Delivery

A major challenge to effective handover and lifecycle data management is a lack of interoperability between various software applications. A McGraw-Hill Construction report on interoperability in the construction industry found that organisations are addressing the requirement for more efficiency in the construction environment by reconsidering traditional concepts of project delivery (Young Jr., *et al*., 2008). Interoperability is fundamental in building, as there are various and diverse groups working in the same project (Whyte *et al*., 2010). The dearth of interoperability results in many difficulties, for example, re-entering information manually from application to application and duplication of business tasks (Young Jr., *et al*., 2008).

The requirement for new approaches for interoperable working and the traditional difficulty of individuals working in silos are emphasised in the 2007 report of the American Institute of Architects (AIA). The use of BIM is understood as a way of increasing interoperability (AIA, 2007). The need to perceive standards in the building industry is emphasised consequently that value can be achieved during the project and during the construction cycle (Nisbet and Dinesen, 2010). This value has the largest possible value for facility managers, as the specialists are responsible for the as-built asset over a longer cycle than construction/design teams (Jordani, 2010).

The use of BIM and other project management frameworks, such as IPD, increases closer cooperation and more operational communication (Eastman *et al*., 2011). These have the potential of decreasing the time required for documentation of the project and, hence, produce useful project results (Bryde *et al*., 2013). By adopting the use of BIM, the data flow between parties in a construction project can be improved and made more effective because data is kept in one place only (Jensen and Johannesson, 2013). Clients use a variety of applications and express challenges in moving information between applications that are widely used in building and the applications they practice in operations like asset management systems (Whyte, 2010).

At the same time, dependence on proprietary designs and systems can constrain the client's and main contractor's capability to choose the best supply teams. According to Whyte (2010), errors in the information are mainly introduced in translation and open exchange standards often start in translation from propriety project software into the open format and then a second translation into proprietary asset and facility management tools.

Fundamentally, BIM provides data about a construction and its spaces, systems and constituents, equipment O&M manuals, commissioning information, and performance. This data can be accessed more easily making it simple for facility managers and maintenance workers to access the necessary information significant for the effective operation of the built asset (Azhar *et al*, 2012).

In the USA and Europe, there are initiatives to promote open standards, with governments starting to use their role as clients to formalise the procedure of information exchange between software tools at the end of projects. The US Army Corps and General Services Administration (GSA – Major USA public owner organisation), for instance, use an open standard, COBie (the Construction Operations Building information exchange), to import data into Maximo, maintenance management software. This data exchange standard is used to capture and supply digital information from construction, design, and commissioning into operations (East, 2009; AIA, 2007), through the structured transmission of data from project software to asset management systems. Moreover, Dubler *et al*. (2010) have also been developing guidelines for clients and project teams on the way BIM information can be structured for different applications and its uses for operations and maintenance. COBie allows for the exchange of IFC-based facility management information (Jordani, 2010) and captures this data, incrementally, throughout the design and construction stages (Fallon and Palmer, 2007).

Whereas the literature defines BIM as the central data source to be provided to clients at handover, this remains an aspiration (Whyte, 2010). No reports that present examples of the usage of BIM generated during project delivery in operation were found, even though work did capture its use in facilities management (Whyte, 2010). Many studies refer to the possible worth of BIM in relations to costs and productivity that can result from BIM in operations (Kymmell, 2008; Becerik-Gerber, 2010; Eastman *et al.*, 2011; Hardin, 2015). According to Bew and Underwood (2010), BIM could be used to minimise the data loss usually related with the handing over of projects from the design team, to the construction team and the building owner/operator. BIM also allows every party in the project to add to and reference back to all data they gain during their period of contribution to the project.

Jordani (2010) argues that the design/construct stage is considerably shorter than the operational stage and even small data gains in facilities management can result in a very substantial improvement. Remarkable efforts have been made to improve BIM directly for facilities management systems and increase the benefits of BIM for maintenance and operations (Whyte, 2010). Nisbet and Dinesen (2010), however, add that BIM allows built assets to be analysed for both their energy use and influences on carbon emission during their lifecycles. Other environmental impacts, such as water consumption and pollution, could be assessed to increase the accuracy of data hand-over.

2.9 Challenges in Existing Handover Practices

There are currently a number of difficulties in the handover of information from the project into operations. Putting together handover information at the end of a project is a costly and often inefficient business because information is usually scattered across the project and needs to be brought together to enhance interoperability (DeSimone, 2013). The use of BIM is very important in the post-construction stage, providing the information about the completed project as it evolves through the project's lifecycle: planning, design, and construction. Facility managers thus make operations and maintenance of the completed project extra proficient, passing data from projects downstream for use (Azhar *et al.*, 2012).

One challenge is the need for construction contractors to recreate and collate project data at the completion of the project. Most of the time, this is information that has been created by other parties in the project and could results in data errors. In addition, project contractors are not normally the authors of the majority of the project information and the wait until the completion of the building contract to get the data often results in a smaller amount of satisfactory deliverables, many of which are presented earlier in the project, but are not taken. Finally, data provided is normally in formats that are not user-friendly to allow effective exchange and use. Often, data cannot be easily updated and not enough to ensure that replaced equipment can be specified to ensure compliance with design specifications (DeSimone, 2013).

In summary, the current project handover practices present a number of challenges as outlined below:

- Responsibilities of various project team members are unclear, especially post-occupancy (DeSimone, 2013);
- Not enough time for operations training;
- Actual handover process are often an afterthought;
- Maintenance manuals and keys are often missing;
- Concerns about warranties (coverage, voiding, etc.);
- Societal influences;
- Societies not involved in choice of building systems;

Fallon and Palmer (2007) identified a number of challenges in the project handover process that include; deep-rooted expectations, commercial issues, undeveloped technology, inadequate technology infrastructure, and resistance to change. Commercial challenges involve issues, such as contradictory business models of various project team members, resulting in problems in defining appropriate expectation or deliverables for the project. To ensure successful project handover, the focus should be more on the human issues and the quality of relationship; strong leadership is required from both the client and the project teams. Fallon and Palmer (2007) further add that the following should be considered to ensure successful project handover:

- Transparency and accessibility of project data for all project team electronically;
- Capability to use the data across the design/ construction team;

- Suitable quality assurance approaches and procedures;
- Cooperation that includes the contractor trades;
- Shared trust and recognition of new project roles, for instance data manager.

However, Whyte *et al*. (2010) add that the main challenges at handover arre those of data accuracy and entirety. There is the need to ensure that clients and end-users get access to project data. The current practices of facility management and the impact of BIM is illustrated in Figure 2.7.

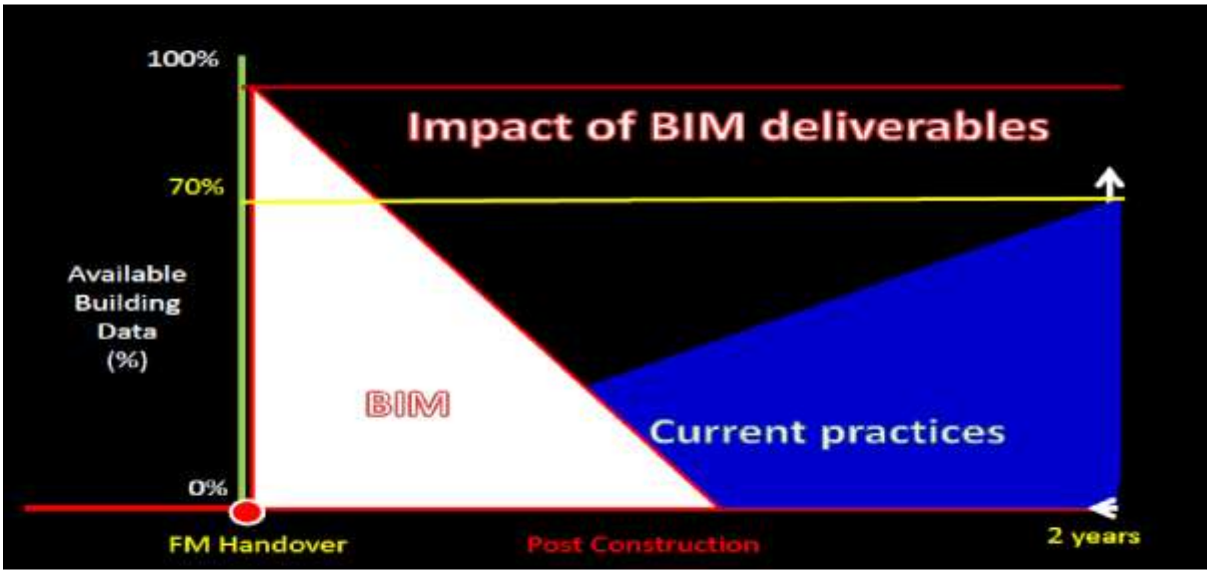

Figure 2.7: FM Handover: Current Practices. (Foster and Fattor, 2012)

Moreover, the challenges of software interoperability result in complications, for example, re-entering information manually from application to application and duplication of business roles (Young Jr., *et al*., 2008). This problem is due to the lack of standardisation in the interoperability of the industry; there is necessity for new techniques for interoperable working and the traditional practice of those working in silos should be avoided. The use of BIM is seen as a method of increasing interoperability (AIA, 2007).

The need to observe criteria in the building industry should be enforced so that value can be achieved throughout the project progression (Nisbet and Dinesen, 2010). This value has the biggest possibility for facilities managers as the experts who are accountable for the as built asset over a longer phase than design/construction team (Jordani, 2010). There is also lack of a regulatory framework in the construction industry and the use of such regulatory requirements will ensure safe and current operation, resulting in high-quality data about their physical assets. Enhancing the quality of data during project handover will ensure that building data be utilised to enhance building operations, maintenance and related decision-making.

2.10 Overview of the Construction industry in Kingdom of Saudi Arabia

The Kingdom of Saudi Arabia (KSA) is the second largest Arab state in in Western Asia (see Figure 2.8) and it is the biggest construction market in the Middle East. It is expected to continue its growth over the next few years driven by Saudi Arabia's strong demographic growth, high oil prices, and a government-backed capital investment programme. KSA looks to continue its dominance in the region as the largest construction market for the following years (El Malki, 2013). This sector is ranked second after oil in Saudi Arabia's economy and contributes around 8% of total GDP, with a value of around CAD $48 billion a year (Construction Sector Profile, 2014). The sector became the fastest growing in the Kingdom's economy in 2015; this growth is attributed firstly to oil income. These profits have helped the growth of infrastructure projects, such as modern cities, Airports, Universities, and Hospitals, to meet the demands of the commercial, residential, and governmental clients (MEP, 2012). Secondly, this growth in the KSA construction market is also attributed to the presence of two holy mosques, in Makkah and Al-Madinah, which attract millions of pilgrims each year.

Figure 2.8: Map of Kingdom of Saudi Arabia. (infoplease, 2015.)

According to the country report of KSA (2013), the main strength of the construction sector was:

- KSA has the largest construction sector in the Middle East;
- Efforts are being made to increase private investment;
- The government plan for development was set out (US$385bn) for the year 2010 to 2014 to invest in economic infrastructure;
- Ministry of housing was set out (US$70bn) to build 500,000 social housing units during the next seven years.

However, the country report (2013) also illustrates the weaknesses of this sector, as follows:

- The industry is dependent on government contracts more than on the private sector;
- Saudi banks have played a limited role in mortgage financing, considering the current global economic depression and existing legislation. Consequently, this leads to increased pressure in obtaining reasonable housing.
- Licences for construction and development require a long process, which postpones projects.

The rapidly-growing population is exerting pressure on existing infrastructure. As a result, the government has initiated a number of large investments in this sector for the coming years (Construction Sector Profile, 2014).

The government is highlighting the use of presented resources and projects that ensure balanced growth, plus more employment opportunities and job creation. Emphasis will be specifically on health, education, social services, housing, security services, municipal services, water and sewage services, roads, airports, metros, railways, and related transportation systems (Construction Sector Profile, 2014).

The KSA public sector construction industry relates to the government ministries responsible for infrastructure and national development projects. Project handover is one of the most important stages in a project cycle and it is undertaken at the end of construction management after completing the physical construction of the project. Increased emphasis on sustainability and cost reduction has increased the need to improve the quality of the data/information that should be handed over to clients. Inefficient handover of project data after completion has a negative impact on the built asset's performance.

However, according to Practical Law Company (2013), the main reasoning behind the developments within the construction sector in Saudi Arabia is as follows:

- The government shows that the concern with growing the Saudi infrastructure will keep on at the forefront of Saudi decision making;
- Increasing growth of the population with a housing shortage in Saudi Arabia;
- Due to the number of ongoing and new projects, the Ministry of Industry and Commerce reports SAR 3 billion in capitalisation for the building of three to four cement plants over the next three years.

Many major projects are the construction of infrastructure, such as Aldara hospital in Riyadh, King Fahad Medical City Hospital, the expansion of the King Khalid International Airport in Riyadh, Jeddah Corniche, the construction of a 65-storey hotel in Jeddah, and the construction of Abraj Kudai in Mecca. This Abraj will contain residential apartments, hotels, a shopping mall, restaurants, a conference centre, bus station, and a car park. Also, there is the construction of the King Abdullah Financial District Museum, the Luxury Jeddah hotel in the northern district of Jeddah, and the King Saud University extension and improvement of its arts education department.

However, despite fast development in the project construction field, a number of negative issues still affect the building projects. These include poor communication and co-ordination and a lack of a consistent approach in building construction (as the workforce in KSA is very different in terms of their language and cultural background), which affects the construction industry's interpretation and infrastructure life cycle data management. This results in unplanned decision-making in operations and maintenance phases (Mitra and Tan, 2012). In other words, the lack of a consistent approach to building lifecycle data management will lead to the building owners receiving less value for their investments. However, the existing information handover practices in KSA are yet not discovered (Hijazi and Aziz, 2013).

2.11 Building Handover and Data Management Practices in the Construction Industry

The asset lifecycle handover represents the most important stage in any project. It is indicates the completion of construction. This includes the transfer of control of the physical asset from suppliers and contractors to the operations team. It also includes the transfer of important paper documents of the project, which describe all aspects of the asset and its systems. All the information that is generated throughout the design, construction, commissioning, mechanical completions, and maintenance leading up to handover is greatly significant (Sanins, 2011).

However, it must be taken into consideration during initial handover planning that the way of managing and understanding the relationships of the data has an important effect on the whole handover process. The handover of a project to the client at the completion of the building stage is very significant to the project and is critical to the accomplishment of the facility's operation (Hassan et al., 2010). In addition, organised effective handover of information from the contractor to the client is necessary. The handover of the project from the contractor to the client are vital on the safety standards of operation and maintenance to the client. The handovers and perfection of progression can seriously affect the business of the client if not managed in an organised way.

However, according to Hartman et al., (2008), Hijazi and Aziz, (2013), and Abaoud and Veziroglu, (2002), the problems that face the construction industry need to be to addressed and are mainly exist due to information handover practices in KSA, which are not yet explored, as well as the lack of a consistent approach to building lifecycle data management where building owners receiving poor value for money for their investments. The identified problem is theoretically challenging, given the recent attempts by the industry to address the problems of fragmentation and enhance collaborative working.

In general, the building handover information usually contains built drawings, and operating and maintenance manuals. The information that is created throughout the design and construction phases is often not passed onto the owner (Mendez, 2006). However, there is a chance to address such challenges by technologies and process-related improvements, such as BIM. There is an increasing awareness by various governmental initiatives across the developed world for a need to manage beyond traditional design and construction information transferal from a focus on project delivery to a focus on service delivery (Clayton et al., 1999). The UK government Construction Strategy (2011) mentions the potential of decreasing construction cost by 20% and enhancing sustainability with BIM. As well as this, it will incorporate people, processes, information, and business systems (Shen et al., 2010). In the same way, across the world, there is an approach to plan data and handover processes through integrating them in procurement processes to achieve asset lifecycle data management (Whyte, 2010).

There are various levels of BIM maturity, ranged from 0 to 3. Fully integrated interoperable data is level 3; the clients will gain advantage through better management of knowledge and organisational learning (Richards, 2010). However, the majority of construction firms in KSA are still operating at Level 0 and Level 1 of maturity, with 2D CAD still the most prevalent method of data exchange.

Building owners' satisfaction of built assets are likely to be affected if handing over is not properly done. "Soft Landings" is a new idea that aims to focus on client requirements, consisting of five stages: design development and review, pre-handover, primary aftercare, extended aftercare, and post occupancy assessment. Managing and handing over project information from the design and construction stage to the operation and maintenance stage requires progressive procedures and principles. The use of BIM and other integrated project delivery approaches can be used to collaborate, integrate all stakeholders on a project, and manage building data throughout its lifecycle. It will allow a continuous and immediate availability of project data with respect to project design, scope, schedule, and cost. To ensure better quality data handover on completion of the project, total quality management procedures should be implemented throughout the whole project.

The problem of interoperability is a big issue in the building industry, as there are various different parties working on the project. This results in complications, such as re-entering information manually from one application to the other and the duplication of business tasks. However, there are a number of challenges in handing over data from completed project into operations, such as collating handover information at the end of a project. Project information is usually scattered across the project and improving interoperability is costly. Contractors usually recreate project data, which has been created by other parties to the project at the end of the project, and this could result in data errors. There is the need for a building handover framework that could bridge the gap between contractors, clients, and end users thereby enhancing owners' familiarity with the built assets.

2.12 Initial Conceptual Framework

Framework can be defined as conceptual models that make reasonable sense of the relationship between a numbers of factors that has been identified as important to the problem (Sekaran, 2003). Also, Collis and Hussey (2014) mention that the theoretical framework assists to organise and direct data collection and analysis.

This section provides a framework, which was established by the researcher from the literature review (figure 2.9). The framework is built on the factors that affect lifecycle data management. The establishment of the framework will play a substantial part in the process of choosing the suitable methodology, which is the case study research strategy. Furthermore, the role of framework in this research is to articulate a clear concept that could be used to accomplish the aim of the study through the key factors that could facilitate data management in building handover practices. Therefore, this research will compare the findings in the case study organisation with a number of themes identified in literature review. These themes are not assuming casual links and are not assuming ranking. Subsequently, all themes are considered equal in their importance. These themes include:

Training: training sessions that incorporate all building systems and match the staff's level of expertise are of particular importance to building procedures and equipment installations. However, suitable and operational training must be arranged for early, partial, or staged handovers. The lack of knowledge on technology or project management among clients might be improved by completing training courses related to construction projects (Sargeant et al., 2010).

Use of technology: The use of technology as a BIM tool is helping professionals all over the world collaborate; this collaboration is accelerating designs while reducing errors and costs.

Effective facilitate management team: Once teamwork has been formed it should stimulate the effectiveness of this team to facilitate a consistently high performance. This can be achieved firstly by improving the individual by assisting on on-going job training, promoting skills regularly, and offering opportunity for personal progress. Secondly, it can be achieved by design teams building programmes and practical workshops, which provide regulation on such issues as team performance, structure, and teamwork. Thirdly, it can be achieved by observer progress and developing approaches to distinguish and reward both the team and the individual in order to inspire, encourage, and stimulate them to perform.

Cooperative relationship: the main benefits of building good working relationships with contractors, designers, and societies is helping develop working practices to understand the points of view of all parts and it spreads good practice throughout an organisation as well as improving networking skills and cooperative solutions to an organisation's goals, plus increased organisational effectiveness.

Facility budget: A budget is a statement of the amount of money that is available to spend on a building. Facility budgets determine what is reasonable and should be set as early as possible. It is important that they are based on evidence and that they are realistic. It is facilitated by a valuation of expected income and expenses through the life of the venture and by comparison with similar ventures. They facilitate budget covers, calculation of the funds available, pre-design analysis of necessities, and analysis of initial design options. The budget might contain: the construction cost, land or property purchase, approvals fees, scheduling costs, financing costs, site studies, fittings, and equipment. However, it is common on projects that the project budget and the project brief diverge over time and it is for this reason that careful cost control is important.

Transparency: One of the most powerful instruments for the building industry is transparency. It is the ability to see what is truly happening to the entire or any part of the project at any point in time, under any circumstance, in any level of detail (Shaposhnikova, 2015). Cmcs (2015) mentioned that despite the kind or size of a venture, if a venture lacks transparency then complications, like lost project data, disappearance of significant project documents, project financial ambiguity, review and approval bureaucracy, conflicts among stakeholders, cosmetic performance reporting, lack of real life project data, inadequate decisions, among many others that are usually labelled as project fraud, are almost bound to happen.

Clear responsibilities: in the project, the project manager should have full authority and responsibility of the design, implementation, and closing of the organization (Tonnquist, 2008). Main project management responsibilities contain generating clear and achievable project objectives, building the project necessities, and managing the triple constraint for projects, which is quality, cost and time (Ibid).

Legislations: Managers of the projects emphasise that all engineering infrastructure that has been designed, installed, and commissioned should be done in accordance with legislated and design requirements and that they are in full operational modes, before the installations are deemed to be practically completed. Larger, experienced clients may already have handover procedures and checklists, but these still need to be designed in a uniform manner (Utas, 2012).

Knowledge and experience: knowledge and experience has been recognised to be an important organisational resource, which, if used well, can provide competitive benefits. Information of applied concepts and initiatives used in the current construction industry are crucial in knowing how the building industry works. Dave and Koskela (2009) argued that, due to the fragmented nature of the building industry, capture and reuse of valuable information and experience collected during a construction project pose a challenge. Given the nature of building projects, cooperative knowledge management seems to be the most suitable solution to capture project based information. However, with years of experience in the field, it could provide the most effective handover system in the market (Dornan, 2012).

Protocol of lifecycle: Protocol of lifecycle data is very powerful for conveying the environmental attributes of processes, products and services (Howard and Sharp, 2010). In construction, the protocol of lifecycle gives guidance on applying life cycle data fittingly and appropriately to buildings, particularly highlighting areas that may be overlooked (but are significant) and can potentially lead to erroneous conclusions and decisions (Ibid).

Communication network: Effective communication is significant to the successful end of any construction project. It improves coordination and leads to better project collaboration. However, a lack of communication may lead misunderstandings, delays, and problems down the road (Jones, 2015). Communication is defined by Jones (2015) as the exchange of information in order to convey a message and good communication involves being able to transmit and receive, as well as being understood by the intended recipients.

Feedback cycle to ensure endurance and aftercare: The feedback allows lessons learnt from the end of the project to be contained to later develop and enhance the current processes and information management for each stage of the project (Kagioglou et al., 1998). The whole feedback from all stages will contribute and develop the project delivery strategy, necessities, type of procurements, and the execution of the project. It is increases cooperative decision-making and control, which will improve each stage's output not only for the present project but also for the future ventures (Ibid).

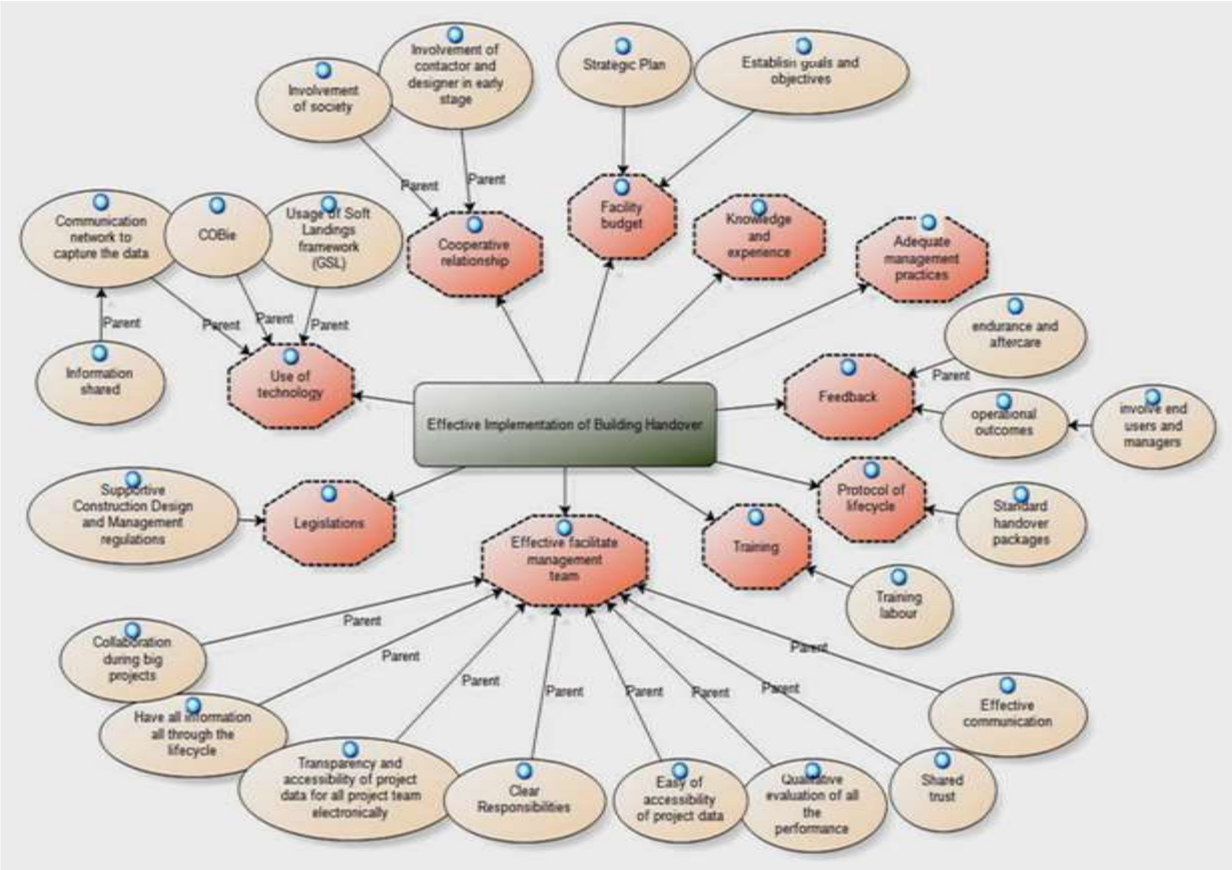

Figure 2.9: Initial conceptual framework derived from literature review

2.13 Chapter Summary

The literature review in this chapter presented building lifecycle data management practices, philosophy, and the related issues; these include facilities management and data handover for construction facility management, the building handover principles and procedures, and the need and improving for effective building handover protocols. Also, it provided a description of the soft landings framework and requirements for the handover process, as well as identifying the concept, origin, and growth of BIM and its uses in construction management. The cost and advantages and disadvantages of BIM, the potential barriers facing implementing BIM have also been highlighted. Furthermore, building information management in data handover and building commissioning have been discussed. Also, in this chapter, a review of the challenges of interoperability in project delivery and in existing handover practices were presented. Further, the current construction industry in the KSA has been highlighted. The subsequent chapter will discuss the methodology adopted to accomplish the aim and objectives of this research.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter provides a comprehensive explanation of the methodological issues regarding this research. Saunders, et al. (2012) clarified that the research aim and objectives are the key elements that determine an appropriate research methodology and research method. However, this chapter describes the whole methodology and processes applied to do this research. It presents the philosophies, approaches, strategies and techniques of data collection used in research indicating the rationale behind using these various patterns in a particular study.

The researcher has chosen a problem from his work experience and intends to draw upon recent innovations in the area of management information systems: IT based process improvement and construction management, to find practical solutions to the problem. As highlighted by Crotty (2004), the very essence of applied science lies in preparing theoretically-grounded solutions for practical problems. From this perspective, this research adopts an interpretivist qualitative philosophy for the most part of the research. However, a quantitative philosophy was also used to validate the collected data. Mixed inductive and deductive methods, and single case study methodology were used, using semi-structured interviews, a questionnaire, and documentary evidence analysis as the data collection tools. The rationale for this choice is presented below.

The research began with a comprehensive review of literature on the areas related to project handover practices. It is supported by practical data survey and semi-structured interviews with construction organisations in the KSA building industry. Data from interviews was analysed using computer software (NVivo) and data from the survey questionnaires was analysed by the Statistical Package for the Social Sciences software package (SPSS). The adopted research process is presented in Figure (3.1).

3.2 Definition of Research Methodology

Collis and Hussey (2014) stated that there is no consensual definition of what research is. However, the concept ‘research’ is defined in the literature in different ways.

Saunders *et al.* (2012) explain research methodology as: "*Something that people undertake in order to find out things in a systematic way, thereby increasing their knowledge*". Similarly, Crotty (2004) describes the research as the tactic, plan of action, procedure, or design setting behind the select and use of specific methods and linking the select and use of approaches to the desired results. Likewise, Collis and Hussey (2014) point out that research methodology mentions to the general approach to the research process, which starts with the theoretical basis to gathering data and ending with the analysis of the data. Overall, research methodology is the systematic approach a researcher works using suitable procedures to gather and analyse data and to find issues to be discussed.

3.3 Research Design

Considerate research design is problematic as most researchers vary on the name and the nature of research steps, as supported by Crotty (2004) and Saunders et al. (2012). While Saunders *et al.* (2012) separated research to contain philosophies, approaches, strategies, choices, time horizons, and techniques; Crotty (2004) limited them down to epistemology, theoretical perspective, methodology, and methods.

To accomplish the research aims and objectives, it is of great importance to identify the methods of the research that are available in literature and analyse them to address the most suitable approaches to be applied by the author. Referring to Saunders *et al.* (2012), research can be classified according to its purpose. In the area of social science, there are three types of research:

1) Descriptive research, which aims to explain problems that are under investigation. This type of research helps researchers to understand and analyse subjects in depth.

2) Exploratory research aims to provide better understanding and improved explanation for a case that has not been defined or understood properly.

3) The explanatory research aims to discover the reasons/cause of the case under investigation. It is conducted to answer the research questions based on particular techniques (Cargan, 2007).

The current research is an exploratory study and aims to develop a framework to enhance data management in building handover practices of public sector construction projects in the Kingdom of Saudi Arabia.

Saunders *et al.* (2012) stated that the research process could be described as an "onion" with five layers. The outer layer is the philosophy of the research, the second layer is the research approach, and the third layer is research strategy, then time horizons, and lastly, data collection. To set up the research methodology for this study in an appropriate context, the researcher adopted the Saunders *et al.* (2012) research "onion" to present a holistic and systematic method to the study. The following section illustrates the philosophy of the research, the research approach, the research strategy, and the data collection techniques, as shown in Figure 3.1.

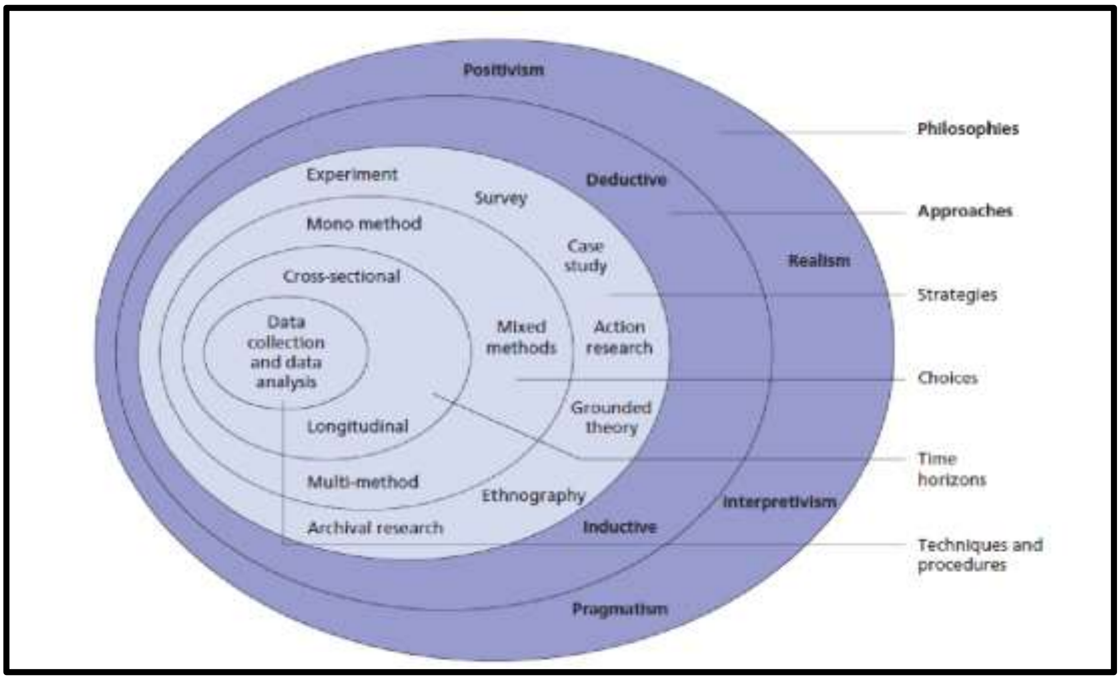

Figure 3.1: The Research Onion. Source: Saunders et al., 2012

3.4 Research Philosophy

The research philosophy refers to the way the researcher thinks about the increase of knowledge (Saunders *et al.*, 2012). It is a scientific practice constructed on assumptions about the world and the nature of knowledge (Collis and Hussey, 2014). However, there is no certain rule of which philosophy should be selected when starting research, as it is based on the nature of the research, the research aim and objectives, along with research questions and methods of data collection (Yin, 2009).

According to many authors, including Collis and Hussey, (2014), Easterby-Smith *et al.*, (2004), and Hussey and Hussey, (2003), there are principally two contrasting extremes in research philosophies, known as interpretivism and positivism. On the other hand, Saunders *et al.* (2012) expand the classification of philosophies by recognizing another aspect of philosophy, realism, which falls within the two extremes. However, each of these philosophies is made from five philosophical assumptions namely: ontological, epistemological, axiological, methodological, and rhetorical assumptions. Table 3.1 by Collis and Hussey (2014) summarized the features of these assumptions under each philosophy.

Table 3.1: Philosophical assumptions of the main philosophies. Source: Collis and Hussey (2014).

Philosophical assumption	Positivism	Interpretivism
Ontological assumption: the nature of reality (what is knowledge)	Reality is objective and singular, separate from the research	Reality is subjective and multiple, as seen by the participants
Epistemological assumption: what constitutes valid knowledge (how we know it)	Researcher is independent of that being researched	Researcher interacts with that being researched
Axiological assumption: the role of values (what values go into it)	Research is value-free and unbiased	Research is value laden and biases are present
Methodological assumption: (the process of research) (the process for studying it)	Process is deductive Study of cause and effect with a static design. Research is context free. Generalisations lead to prediction, explanation and understanding. Results are accurate and reliable through validity and reliability	Process is inductive Study of mutual simultaneous shaping of factors with an emerging design. Research is context bound. Patterns or theories are developed for understanding. Findings are accurate and reliable over verification
Rhetorical assumption:(the language of research) (How we write about it)	Researcher writes in a formal style and uses the passive voice, accepted quantitative words and set definitions	writes in an informal style and uses the personal voice, accepted qualitative terms and limited definitions

However, Collis and Hussey (2014) and Creswell (2007) clarify that the first three assumptions are correlated, whereas the other two assumptions are complementary. Therefore, the researcher will focus on defining the first three main assumptions, which will aid in defining the philosophy of this study.

The ontological assumption deals with the nature of reality. It is an overall set of assumptions around the definition of reality (Aouad, 2011):

- The Positivist approach (Quantitative approach) considers that reality is steady and can be seen and described from an objective perspective. It can only be gained from direct experience and observation, such as in the area of natural sciences (Collis and Hussey, 2014). Thus, it trusts that there is only one truth that exists independent of human perception, reality (truth) experienced by us all (Sutrisna, 2009). The positivist approach attempts to explore the phenomena under research and discovery of logical evidences or causes with little regard to the subjective state of individual.

- In contrast, the interpretivist approach (Qualitative approach) believe that reality can completely be understood only through the subjective interpretation of and intervention in reality. Using the research process, the researcher produces a theory or pattern of meanings (Creswell, 2007). The interpretivists consider that the world holds an unknowable reality, as in the field of social sciences, where each person has his/her own sense of reality (Collis and Hussey, 2014). Consequently, interpretivists believe that many realities exist (Collis and Hussey, 2014) and since reality is socially built (Ticehurst and Veal, 2000) it means that people build reality in different ways (Sutrisna, 2009).

The epistemological assumption is an overall set of assumptions about the way we gain knowledge about the world (Sexton, 2008). Epistemology is a theory of knowledge with specific reference to the limits and strength of knowledge, which seeks to answer the question: "how do I know what is true?" (Cope, 2002):

- A positivist approach is concerned with the theory of knowledge, particularly its approaches, 'validation', and the possible ways of gaining knowledge (Sutrisna, 2009). Furthermore, this includes an analysis of the link between the researcher and what is researched (Collis and Hussey, 20014). Epistemologically, the researcher and research are independent bodies. A researcher can consequently study a phenomenon without any influence (Sale et al., 2002)

- Conversely, interpretivists focus on the sense, instead of the measurement of social reality, since they try to understanding the phenomena (reality) in depth to answer the questions: what, why, and how (Collis and Hussey, 2014). Also, the researcher is a part of what is being examined and is not independent of it (Sutrisna, 2009). Thus, interpretivists trust that reality can only be understood and that researcher has a tendency to depend on the views of the research contributors of the state being examined (Ibid). These assumptions are usually found in the fields of social sciences, which effect both researchers and those participating in the research (Collis and Hussey, 2014).

The axiological assumption is involved with the role of values, what values go into it:

- In positivist research, the researcher identifies that research is value-free and unbiased, as positivists think through that they are independent from what they are studying (Collis and Hussey, 2014).

- In contrast, interpretivists consider that the process of research is value laden, which means that the researcher is interacting with what is being investigated (Collis and Hussey, 2014). In other words, they are influenced by personal beliefs.

Depending on the features of these philosophies and the nature of this research (where the researcher investigates developing a framework to enhance data management in building handover practices of public sector construction projects in the KSA), the qualitative attitude has been selected for the most part of this study, whereas a quantitative attitude was used to validate and confirm the collected data in addition to enhancing the research value. The approach adopted in this research is explained in the next section.

3.5 Research Approach

The main research approaches are deductive and inductive approaches. The aim and objectives along with the research questions play a significant role in the selection of the research approach (Saunders *et al.*, 2012). The deductive approach is used mainly in the positivist philosophy. It is a theory testing procedure that starts with a recognized theory or generalisation and looks to establish by observation whether it applies to particular cases. Gill and Johnson (2010) describe the deductive approach as a process of logic to an entity thought to be true after which a theory is derived and then tested in an empirical way in different situations and contexts. On the basis of the evidence, the theory can be provisionally confirmed, amended or discarded altogether. However, the inductive approach is a theory-building procedure, beginning with direct observation of particular cases and seeking to create generalisations about the phenomenon under examination. It is more suited to an interpretivist research philosophy (Hyde, 2000). Saunders *et al.* (2014) summarise the main differences between deductive and inductive approaches in Table 3.2.

Table 3.2: The differences between deductive and inductive approaches (Saunders, et al., 2012)

Deduction	Induction
Moving from theory to data	Moving from data to theory
Used more in natural sciences	Used more in social sciences
A highly structured approach	Flexible structure to permit changes
Explain causal relationships between variables	Understanding of meanings humans attach to events
Select samples of sufficient size to generalise conclusions	Less concern with the need to generalise

Hussey and Hussey (2003) argue that the researcher can move between an inductive and deductive approach. Likewise, Sekaran (2003) and Saunders *et al.* (2012) suggest that adopting deduction and induction is not only possible in the same research, but is often a beneficial approach.

Therefore, the researcher in this research has elected to use both the deductive and inductive approaches; a conceptual framework was first established from the literature, which was then examined in the case study. A list of factors, necessary to investigate the issues affecting the building handover practices of public sector building projects in the KSA, were derived from the literature and then examined in the case study organizations (deductive). Afterwards, the findings from the empirical study will be integrated into the existing theory (inductive).

3.6 Research Strategy

Research strategy can be defined as a procedure to structure the research. It is the overall plan of the way in which the researcher will go about answering the research questions with the purpose of satisfying the research aim and objectives (Saunders *et al.*, 2012). Naoum (2007, p37) define research strategy as: "*a way in which research objectives can be questioned. It is dependent on the purpose of the study and the type and availability of the information which is required."* Yin (2009) identifies that the choice of strategy should be reliant on the research area. However, there are many research strategies in social science research, including surveys, experiments, historical analysis, and case studies (Yin, 2009; Velde *et al.*, 2004). Table 3.3 summarises these research strategies.

Table 3.3: Different Research Strategies. (Yin, 2009).

Strategy	Form of Research Question	Requires Control of Behavioural Aspects	Focuses on Contemporary Events?
Experimental	How, Why?	Yes	Yes
Survey	How, What, Where, How many, How much?	No	Yes
Archival analysis	How, What, Where, How many, How much?	No	Yes/No
History	How, Why?	No	No
Case study	How, Why?	No	Yes

3.6.1 Case Study Strategy

The use of case study strategy has become extremely prevalent in social science research. A case study is a perfect methodology when a holistic, in depth analysis is required (Yin, 2009). It is also suitable if the researcher has little control over the events, focuses on contemporary events, and wants to gain rich information and deep understanding of the situation into real life. It plans to take out the details from the perspective of the participants by using several sources of data. It enables a researcher to closely study the data within a specific situation (Yin, 2009). In this method, evidence is collected systematically by observation and/or interview.

However, as in all strategies, case study has advantages and disadvantages. The main advantages of case study are that it allows the researcher to use a multiple sources of data; also, it is beneficial if the research has a qualitative orientation (Denscombe, 2003). However, the disadvantage of case study is that the conclusions drawn may be specific to the certain organisations studied and may not be generalizable (Yin, 2009).

As a research strategy, the case study might be used in management studies and organisational; in the academic disciplines; in conducting research theses in the social sciences; plus in professional areas for instance management science and business administration (Yin, 2009).

Yin (2009) specifies that the case study is the best suitable strategy when 'why' or 'how' questions are being posed. This lets researcher explain not only what happened but also how it happened. Referring to the above discussion, the case study strategy has been adopted, as it is the most suitable research strategy to identify and investigate facilitates data management in building handover practices of public sector construction projects in the KSA and to answer the research questions. The occasion is contemporary and the researcher has no control over this phenomenon.

3.6.2 Multiple Cases or Single Case

The main distinction to make when implementing a case study strategy is among multiple case and single case designs. Yin (2009) declares that multiple case studies are usually used to replicate results and maintain theoretical generalisations and also increase the external validity of the research. On the other hand, Yin (2009) gives five justifications for implementing a single case study: critical case, unique case, representative or typical case, a revelatory case, and longitudinal case. However, a single case study has a shortage on the generalizability of conclusions drawn (Voss et al., 2002). Thus, the researchers must have a strong justification if they choose a single case study as a research strategy.

Referring to Yin, (2009) the single case study strategy can be used when the case is a representative or typical case. In this rationale, the case may represent a typical project among many different projects, a factory is supposed to be typical of many other factories in the same industry, or a representative school. The lessons learned from these cases are supposed to be useful for the experiences of the average individual or organization. Dependent on the above discussion, the researcher implemented the single case study design, where the context is the Al Madinah Al Munawwarah, Regional Municipality in the KSA as the case.

Al Madinah Al Munawwarah, Regional Municipality in the KAS can be used as an effective case study and has sufficient scale for the study. As a representative case and one of the large cities experiencing significant growth in the field of construction, this is a good choice; it will provide answers to the research questions and will give a rich understanding about the influence of obstacles that affect lifecycle data management in new airports, universities, hospitals, and modern cities. The presence of the holy mosque in Al-Madinah, which attracts millions of pilgrims each year, leads to the growth of the economy and the construction market in this city. Additionally, from the research point of view, there is a lack of published literature in data management in building handover practices of public sector construction projects in the Saudi Arabia. The choice of a single case study will allow for an in-depth analysis. Thus, the lessons and knowledge that could be obtained from studying and investigating the data management in building handover practices from Al Madinah Al Munawwarah, Regional Municipality will be chosen, and results will be extrapolated to other municipalities across KSA.

Logistically, accessibility to the Al Madinah Al Munawwarah, Regional Municipality is undemanding, as the researcher was working at this organisation and has good relationships with decision-makers and other staff in the organisation. Thus, according to the importance of social relations in Arabic society, the researcher will benefit from an in-depth understanding of some of the key projects undertaken recently in this municipality. In this context, the researcher's contacts will help arrange interviews with some of the high level managers, and will be able to convince the targeted managers within Al Madinah Al Munawwarah, Regional Municipality to assist in the data collection process, thus saving the researcher's time in searching for organizational documents and approvals. Also, Al Madinah Al Munawwarah is where the researcher lives; consequently, from the time, effort and cost view, it is suitable.

Another potential strategy for this kind of research is that of the survey, which is commonly linked to the deductive approach. It tends to be used in the collection of a large quantity of data from a huge population in a highly inexpensive way, and is mainly achieved by using a questionnaire through appropriate selection of a representative sample. Furthermore, the survey strategy research may also add greater confidence in the generalizability of the in-depth results found in a case study. Results from survey analysis will be combined with case study analysis to achieve better insights (Saunders *et al.*, 2012).
However, the methodological plurality can generate a comprehensive result with a useful level of detail. Based on the above discussions, a two-research strategy case study and survey have been implemented in this research. Combining these two research strategies will help overcome some of the weaknesses and limitation of a singularly method.

3.7 Data Collection Techniques

There is a number of research data collection techniques used to gather the necessary qualitative and quantitative data. These include focus group, literature review, documentation questionnaires, archival records, interviews, and observations (Denscombe, 2007). Table 3.4 illustrates these techniques with their relevant strengths and weaknesses.

Table 3.4: Strengths and weaknesses of data collection techniques (Yin, 2009)

Techniques	Strengths	Weaknesses
Literature review	A great amount of data can be collected in short time and minimal cost; It offers a conceptual framework for the study.	Need high skills in recognizing and analysing the relevant information, and writing a meaningful summary.
Documentation	Provide exact details (Useful for exploration) that can support verbal interpretations	May be incomplete and representative only of one perspective; Access may be limited.
Archival Records	Available on a wide variety of topics; Ease of data analysis	May not be available for the research questions of interest to you; accessibility may limit due to privacy reasons.
Interviews	Insightful; Useful for exploration and confirmation; provide in-depth information	Response bias; expensive and time consuming; Reactive effects
Focus group	Can examine how participants react to each other; exploring ideas and concepts.	Discussion may be dominated by one or two participants; Measurement validity may be low.
Observation	Reality: discover what is occurring in actual time; Contextual: covers situation of case	Data analysis can be time consuming.
Questionnaire	Inexpensive; Data is easily analysed and interpreted.	Low Response rate; Lack of clarify questions if the respondent misunderstand

However, there is not one technique that fits all studies; the nature of the research, as well the philosophy, approach and strategy of the research, along with the aim of study will determine the suitable techniques to use (Yin, 2009). Referring to Collis and

Hussey (2014), there are two main kind of data gathering: primary and secondary data. The primary data is concerned with the data that was collected precisely for the purpose of this research. However, the secondary data is the data that collected for another purpose but then linked to the topic of the research, and which the researcher has collected to generate conceptual framework for the study. This data were principally from reference books, articles, scientific papers, theses, and Internet research.

On the other hand, there are five tools for data gathering in the case study: document review, direct and participant observation, interviews, archival records, and physical artefacts. These tools might be used in balancing or in cycles. Accordingly, a case study strategy has to use several sources of data collection, on the condition that they are relevant to the research (Yin, 2009).

In this research, secondary and primary data was used. Due to the nature of the research questions and time constraints, interviews and documentation review were adopted to gather in-depth knowledge from the case study. In addition to the survey, questionnaires were also used. The reason to use a questionnaire is the facility to reach a big target group in a practical and effective way. The questionnaire provides a wider view of building handover practices in the KSA, while the qualitative study provided in-depth understanding of the state-of-the-art practice. Based on the above discussion, triangulation has been engaged in this research, as a solo method is not sufficient to explain the problem of several factors under study. Besides, this method enhances the reliability and validation of collected data. It also enhances the opportunity to generalize results.

3.7.1 Interviews

An interview is one of the methods that could support researcher to collect valid and truthful data. It is a suitable and valuable method to gain detailed information about particular personal feelings, views and opinions. Furthermore, it can also confirm that the interviewee understands what the interviewer is actually asking, therefore improving the final value of information (Carmona, 2013). However, using interviews can be associated with bias due to different lines of questioning based on the skill of the interviewer (De Silva, 2009). There are many types of interviews, which are varied in their style and are based on the choice of the researcher and on the nature of the problem under study. However, Saunders *et al.* (2012) thought that interviews could be categorized into three groups:

1. Unstructured interviews;
2. Structured interviews;
3. Semi-structured interviews.

Unstructured interviews: In this form of interview, the questions are not prepared or planned; therefore, the interviewer uses his/her previous experience to drive the interview. The main advantages of the unstructured interview are that it can be carried out in a short-time notice and there is flexibility because questions can be asked in different areas. On the other hand, since the questions are unstructured, the collected information could be irrelevant to the subject of the research and/or useless.

Structured interviews: planned questions are considered in advance and generally cover all the problem's aspects. The main advantage of this approach is when the same questions are asked to each selected individual, the researcher achieves a well-trusted collected data that participate on robust results. The main disadvantage of this approach is the inflexibility to explore areas of interest/concern that may arise during the interview.

Semi-structured interviews: This includes a mix between the interviewer's experience and planned interview questions. Key advantages of semi-structured interviews include:

- Flexibility in asking questions and explore more areas of the research;
- Much freedom is given to the interviewer;
- Allows the researcher to explain ambiguity, or incomplete answers that may face the interviewees.

Key disadvantages of semi-structured interviews include being expensive and time-consuming, especially when large number of participants are present. Also, the mood of the interviewer could affect the interaction with the interviewee and, hence, may affect the validity and reliability of the research. A semi-structured interview technique was selected in this research because it is a data collection process that allows the researcher to use previous information of the topic to be examined while producing rich qualitative data about the phenomenon under study (Sekaran, 2003). According to Easterby-Smith *et al.* (2004), the primary reason of the interviews was to get understandings of the meanings of interviewees to the matters under investigation within contexts that were not organized in advance by the researcher. The same author recommends the avoidance of a completely unstructured style, as an unstructured method would surely end in the interviewees having no picture in mind of what issues or matters the researcher was concerned about, and the researcher would have no clear understanding of what questions the interviewee was answering. Consequently, some structure for the interviews is necessary.

In this study, all interviews were conducted at the workplace to facilitate the process. In accordance with the ethical approval for this study, all participants were given anonymity (Appendix 1).

3.7.1.1. Development of the Interview Protocol

The reliability and internal validity of the data depends on the design of questions and the strictness of the pilot testing (Saunders *et al*., 2012). Therefore, having all the above mentioned facts in mind, questions were established according to the subsequent techniques:

- The interview questions were developed from the survey results and the literature review;
- Questions were modified subsequent to a pilot study;
- Directing the final reviewed questions.

3.7.1.2. The Interviewees (Research Sample)

In qualitative research, the number of interviews is flexible and there is no need to be exact with the number of respondents before starting the research, it is all dependent on the replication reasoning. In this context, many experts in the area of methodology, such as Yin (2009), Saunders *et al.* (2012), and Collis and Hussey (2014), mention that the qualitative researcher must carry on interviewing respondents till the researcher reaches saturation point or replication. Overall, in qualitative research, the guiding principle for choosing the sample size should be the concept of saturation (Mason, 2010).

According to the above discussion, the researcher continued interviewing without knowing exactly how many respondents would be interviewed until the study reaches saturation point and the obtained information is satisfactory. To reduce the problem of bias, which is usually associated with interviews, the information from interviews have been triangulated with other sources of information.

In this study, interviews were conducted with leading industry practitioners, approximately 10 managers who are involved in projects. Interviews with managers were used to better understand data requirements at various lifecycle stages of a building (e.g. for energy management of a building, for optimise spatial utilisation of a facility). Table 3.5 presents the details of those 10 interviewees interviewed for the case study.

Table 3.5: Interviewee Groups

The Interviewees and Their Positions	**Location (Organisation)**
Senior Executive	Al Madinah Regional Municipality
Executive Engineer	Al Madinah Regional Municipality
Assets Manager	Al Madinah Regional Municipality
Senior Administrator, Buildings	Al Madinah Regional Municipality
Manager, Operations and Maintenance	Al Madinah Regional Municipality
Manager, Project Implementation Unit	Al Madinah Regional Municipality
Director, Operations and Maintenance	Al Madinah Regional Municipality
Assistant Manager, Maintenance and Operations	Al Madinah Regional Municipality
Facilities Manager, Project Implementation Unit	Al Madinah Regional Municipality
Director of Project Management	Al Madinah Regional Municipality

3.7.2 Questionnaire

The questionnaire survey is a good technique to collecting data from persons, and is often associated with quantitative research (Oppenheim (2005). Sekaran (2003) describes the questionnaire as "*A pre-formulated written set of questions to which respondents record their answers*".

It can be administered by several means, such as e-mail attachments or by publishing on a website (Burgess, 2001). The use of an e-mail or internet-based questionnaire offers more benefits than the traditional mailed surveys. The questionnaire differs from an interview, as that the respondents answer the questionnaire anonymously without the influence of the researcher (Sekaran, 2003).

There are numerous benefits of implementing questionnaires, for example, ease of administration, they are cheaper and offers significant time saving, and they allow for large populations to be surveyed more efficiently than other tools, such as interviews (Saunders *et al*., 2012). However, Bryman (2011) asserts many weaknesses, such as the difficulty of designing and planning of questions, low response rates compared with interviews, and the one who fills in the questionnaire may lack the required expertise. The basic process of survey research is illustrated in Figure 3.2, below.

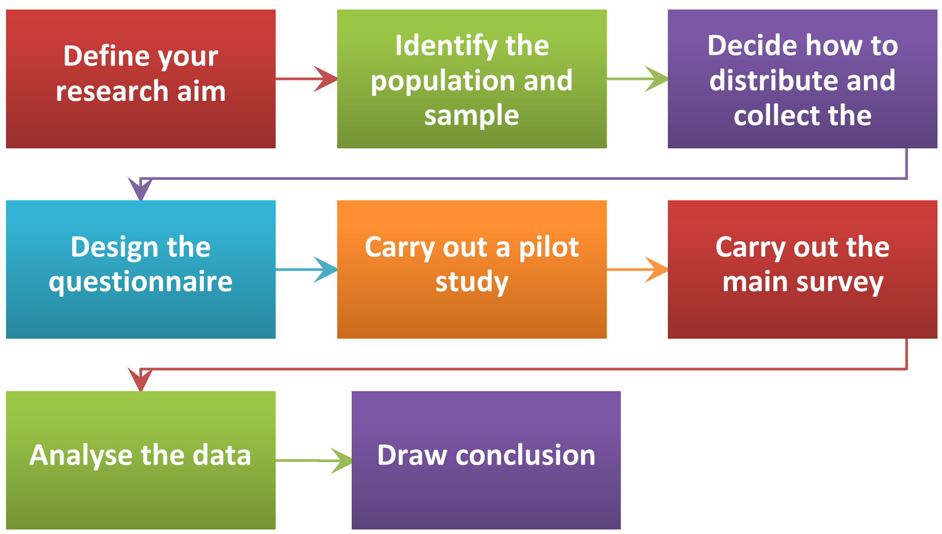

Figure 3.2: Questionnaire design process (Burgess, 2001).

3.7.2.1 Population and Sample

The population is the participants that the researcher is interested in studying, whereas the sample is a population that is generally chosen to serve as a representation of the views of the population. It is not practical to study the whole population due to lack of time, money, and other resources (Burgess, 2001). However, the size of the sample must primarily be guided by the aim and question(s) of the research and the research design (Onwuegbuzie and Collins, 2007).

3.7.2.2 Questionnaire Design

This questionnaire was issued to all stakeholders involved in the handing over in the public sector construction industry to obtain a general picture. The questionnaire was planned and treated according to the following procedures:

- Before starting, the respondents signed a formal description agreement of the research;
- The questionnaire consisted of both qualitative and quantitative style;
- It was written in the Arabic, the official language of the KSA;
- The anonymity for responses was guaranteed in advance;
- The respondents were being given the right to withdraw from the study without having to provide a reason for that;

The study was based on 500 questionnaires, which were distributed to respondents from clients, contractors, consultants, and facility managers from the Al Madinah Al Munawwarah, Regional Municipality. This covers all the relevant stakeholders involved in the handing over process in the public sector construction industry and provides enough data for analysis and generalisation of the results. Electronic copies of the questionnaire (Appendix 2a, Appendix 2b) were emailed to respondents, whilst others were distributed manually. Some of the companies have the contact details on their website, whilst others were obtained by contacting the companies by telephone. Two weeks after the distribution of the questionnaires, a reminder message was sent to the participants drawing their attention to the time constraints for their response. This was done to increase the response rate (Golland, 2002). However, of the 500 questionnaires dispatched to the selected sample, only 350 were returned and 42 of them were ignored for technical issues. As such, a response rate of 70% was achieved.

3.7.3 Documentation

Documentation is a method of research that several qualitative researchers considered useful and meaningful in the context of their research strategy. It helps to validate evidence from other sources and obtaining some basic realistic information about the case at hand. Furthermore, it was used as a supplementary method to semi-structured interviews and the questionnaires survey. Furthermore, it will provide a means of triangulating data collection methods. The documentation review is expected to be related to every case study subject (Yin, 2009).

To overcome the possible low reliability of the data produced from the questionnaire and interviews in this study, the researcher was able to copy some of the organisation's documents for example built drawings, building standards, and policy documents such as clauses in construction contracts. In addition, annual reports, government legislation, financial report.

3.8 Triangulation

The combination of methods in the data collection techniques of the same study is identified as triangulation. Findings of qualitative research can be improved by joining participant with observation, questionnaire and interviews, in addition to documentary sources in a single case (Collis and Hussey, 2014). Similarly, the results of this research are strengthened by combining questionnaires, interviews, and document review. Data triangulation in a single case is important to support validation in the lack of the contrast case. Using multiple data sources (likewise in this research), creating an identifiable chain of evidence.

In this research, a several validity supporting means were implemented in the present research throughout the personal interviews. Incidentally, semi-structured interview strength refers to the fact that the researcher has grown complete entrance to the meanings of knowledge (Easterby-Smith *et al*., 2004). At this point, it is significant to recognise that questions of interview were revised and reviewed several times then piloted before actual interviews arranged. Data gained through these techniques was also used to test interviewees' answers for validity and reliability of the research.

3.9 Ethical Approval

According to Saunders *et al*. (2012), ethics in the research mentions to the appropriateness of the researcher's performance and behaviour in relation to the rights of those who are influenced by it. It is the behaviour that leads to truthful choices about the behaviour and relationships with others. Therefore, social researchers should be ethical in their activities (Ibid).

In this esteem, the policy of the University of Salford requires researchers to apply for ethical approval before starting empirical studies. Consequently, the researcher applied for ethical approval before conducting the empirical study. The Research Governance and Ethics Committee (RGEC) later granted the researcher the ethical approval to start the data collection.

3.10 Pilot Study

Several specialists in the area of methodology recommend that the questions, either through questionnaires or interviews, must be exposed to primary checks, which is known as a pilot Study. It is an effective way to identify and rectify any anomalies within the questions in terms of the quality, clarity, time scale, unambiguous, etc. (Naoum, 2003). It is piloting the questions of the questionnaire on a small sample to identify any mistakes in the questionnaire and correct them before the main survey to help maximise response rate and minimise error rate on answers.

In this research, a pilot study was conducted for the questionnaire with 10 managers in a construction company in Al Madinah Regional Municipality and a few alterations were made to the design and arrangement of the questionnaire before it was sent out. To hurry up the procedure of the pilot study, a link to the web-based questionnaires was directed to the respondents.

An additional pilot study was done with the 5 employees working in the area of building construction regarding the interview questions to modify the language of some questions in order to make them clear, unambiguous, and understandable. Afterward, the feedback from two pilot studies was used in revising the questions. The researcher affirmed that the feedback from two pilots was actually useful and, accordingly, some changes were made, for example: language adjustments, re-phrasing some questions and improve the design and structure in order to be more clear and understandable, and re-arrange some questions and put them under certain themes.

3.11 Reliability, Validity and the Ability to Generalise

Reliability and validity for research means that data collection can be repeated with the same findings (Yin, 2009). To accomplish reliability and validity in this research, the researcher has attempted to be reliable and consistent at all times and has constructed a clear research plan and implemented proper procedures that give great internal reliability. In data collecting, attention was given to the most suitable techniques for the specific study. In addition, all the research steps were operational as possible, plus all procedures and methods were properly documented. In addition, to avoid bias in the interviews, the researcher attempted to improve the opinions of respondents by constructing a good connection with the participants and providing a good overview of the study.

3.12 Conducting the Case Study

The interviews were conducted during the period from November to December 2013 in Al Madinah Al Munawwarah, Regional Municipality, KSA. The researcher phoned the participants to get their agreement prior to the interviews and then arranged the most suitable time to interview them. Interviewees were knowledgeable about the aim of the research and had the right to withdraw at any time without having to give a reason; this is done through the informed consent form (Appendix 3). The period allocated for each interview differed from one respondent to another.

All interviews were conducted onsite at their offices, which permitted the researcher to access good official papers. To keep the possibility of misunderstanding to a minimum, all interviews were conducted in the respondents' and researcher's language, Arabic, which helped the researcher to precisely understand each meaning and expression through the interview. Hardly any interviews were tape recorded; speech tape was difficult for the reason that the respondents did not feel relaxed with this; it may be due to political or cultural respects. Thus, the researcher simply wrote notes from their answers in each interview; hence the critical pieces were not lost and photocopied any documented evidence such as archival records, regulations, organisational charts, and statistical reports.

The researcher followed the guidance of Yin (2009) in leaving enough time among the interviews to write notes, think about data, and probably discover some issues that arise. Each interview was transformed into a written record, usually on the same day. Finally, the researcher transcribed each interview and then the transcripts were passed to each interviewee in order to obtain validation of the content as being a correct reflection of what transpired during the interviews. As a final point, the researcher translated all the interview transcripts into English via an Arabic/English translator. However, it is difficult to evaluate the truthfulness and precision of the answers of interviewees, the general feeling was that the interviewees were friendly, supportive, and gave the impression that they were acutely concerned with the results of this research.

3.13 Data Analysis Techniques

Data analysis of research is an important stage. The aim of data analysis is to use the evidence collected in depth to produce substantial logical conclusions and eliminating any alternative interpretations (Yin, 2009). However, there are two parts of analysis of data: analysis of quantitative data and the qualitative data. Saunders *et al*. (2012) argue that there is no typical process to analyse data in qualitative research. However, Collis and Hussy (2014) stated that qualitative data could be categorized into quantifying methods, such as content analysis, and the non-quantifying methods, such as general analytical procedure.

A quantitative statistical analysis has been adopted in this research on data relevance to the handover. A number of statistical approaches are used, starting with Cronbach's Alpha test for reliability of data collected from questionnaire. Cronbach's Alpha is used to check the reliability of the items in the questionnaire. The Cronbach's Alpha values for the internal consistency of the scale and the items were all above standard agreed measures (0.8) for good internal consistency. Alpha was developed by Lee Cronbach in 1951 to provide a measure of the internal consistency of a test and it is expressed as a number between 0 and 1 (Tavakol and Dennick, 2011). Per cent distributions and histogram diagrams have been applied in this study to illustrate different parameters and variables of the quantities and qualitative data and information.

Measures of variation, associations, correlation analysis, and a statistical hypothesis test as analysis of variance (ANOVA test) based on SPSS software program are used in this study. While an ANOVA test can tell the researcher whether groups in the sample differ, it cannot tell the researcher which groups differ (Tobin and Begley, 2004). A series of ANOVA has been carried out to examine whether there was an association between the variables. This is relevant to the most significant challenge to effective building handover practices in the KSA public sector construction industry and nine different benefits of total quality management in the KSA construction sector project. Also, the ANOVA used examines whether there was an association between the variables on the importance of number of benefits project data at the handover stage, as well as the most affected parameters that were affected by the building handover process and factors that are relevant to the Building Information Modelling (BIM) in the KSA construction sector.

The Chi Square statistic compares the tallies or counts of categorical responses between two (or more) independent groups. In this study, a Chi square (X^2) statistic is used to investigate whether distributions of categorical variables differ from one another. In this study, with respect to the results of questionnaire parts D, E and F, it is supposed that the variable A has *r* levels, and variable B has *c* levels. The Chi Square distribution is very important because many test statistics are approximately distributed as Chi Square. In this study, the test has been used to find out the significant association within an amount of general information, the specific information related to the BIM and the importance of the project handover stage to the organisation, and all other variables of academic qualification - number of years of building handover experience in the KSA public sector construction industry, size of organisation, and the company's principal business activity.

In this study, the test has been used to find out the significant association within a number of general information and the specific information related to the handover.

Moreover, a Tukey test has been applied to determine which groups in the sample differ. The Tukey test is most commonly used in other disciplines. This test has some advantages is to keep the level of the Type I error (i.e., finding a difference when none exists) equal to the chosen alpha level (e.g., $\alpha = .05$ or $\alpha = .01$) (Abdi and Williams, 2003). In order to identify which of the means are significant (after a one-way ANOVA finds a significant difference in means, a Tukey test was applied in this study for the most significant challenge to effective building handover practices in the KSA public sector construction industry) to the total quality management in the KSA construction sector project, as well as the importance of a number of benefits of project data at the handover stage. It is clear to see that the "most important" was the largest group in general, as it used the parameters most affected by the building handover process.

In qualitative data, the reading and re-reading of the interviews to find similarities and differences in order to create themes and to develop categories is one of the methods to analyse qualitative data. However, there are many computer programmes that can be used for the analysis of qualitative data, such as: ATLAS.ti, NUD*DIST N6, and NVivo.

Kumar and Promma (2005) mention that researchers should use one of these computer programmes if their data is suitable for such analysis. NVivo is one of the most popular programmes used for qualitative data analysis. NVivo has many advantages, which include importing and code written data, editing the text without affecting the coding, retrieving data, searching for combinations of words in the text, reviewing and being more secure in the case of data backup.

In this study, the qualitative data from the interviews has been analysed using a general analytical procedure and NVivo software, according to the following:

- Keeping the aim and objectives of this study at the front of the mind,
- Converting the oral interview to hand writing record;
- Importing written records to the sources document folders in NVivo;
- Collecting the information for each theme and each question;
- Coding the main information related to each question in the free nodes file (Figure 3.3).

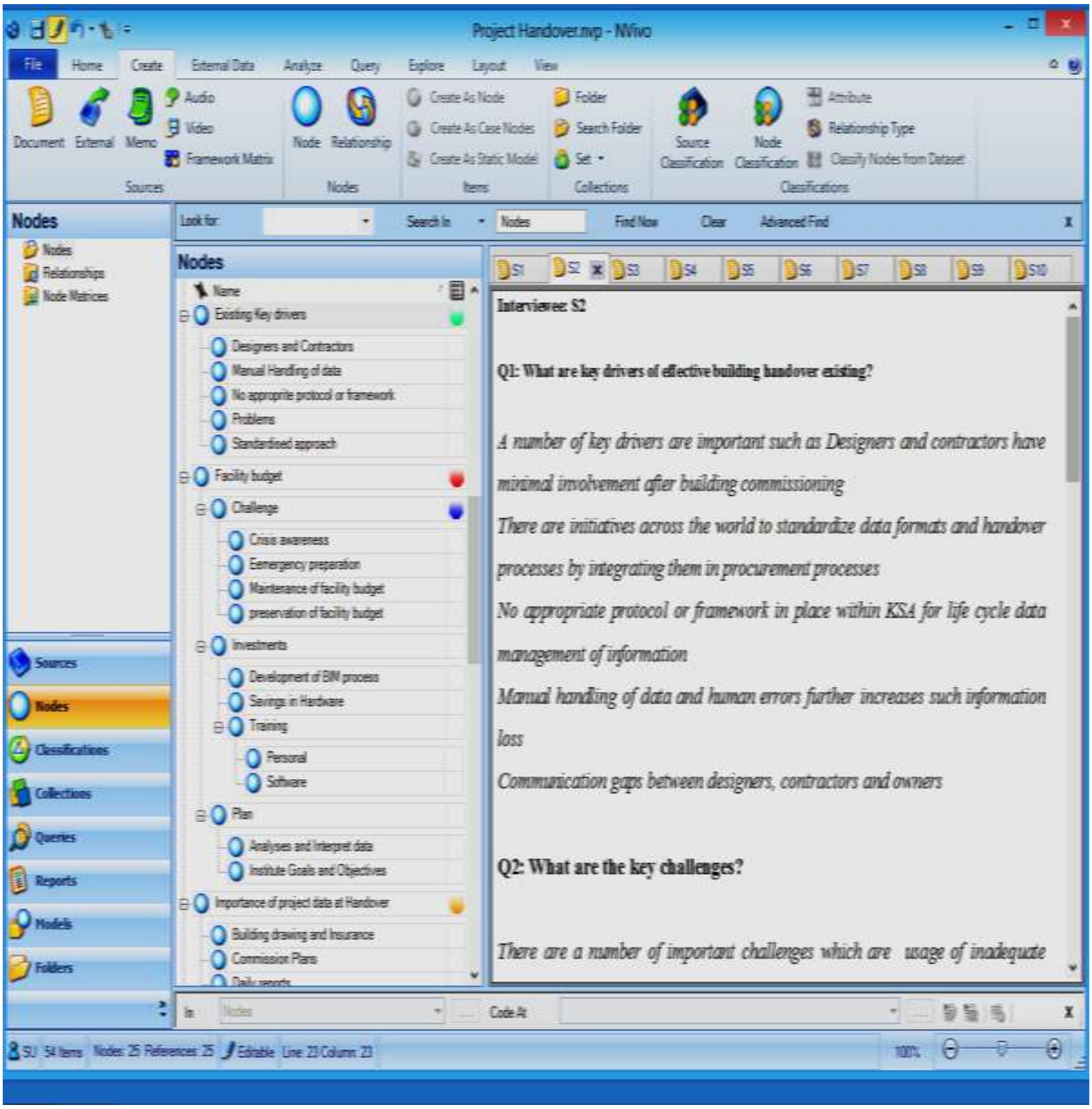

Figure 3.3: NVivo screen shot of tree nodes with Interviewee

However, the quantitative data, which was collected from questionnaires was analysed using the Statistical Package for the Social Sciences (SPSS) software version 16. SPSS is a powerful, user-friendly software package, usually used for the statistical analysis of data. This software package is principally useful for research in the area of psychology, sociology, psychiatry, and other behavioural sciences (Landau and Everitt, 2004) and is commonly used in quantitative analysis.

3.14 Relation between Research questions and objectives and data collection methods

The aim of this section is to summarise the key research methods used in addressing the research questions and objectives as presented in Table 3.6, below. It shows the research questions to be answered in this study and the specific objectives towards the achievement of the research aim. It indicates the techniques used for gathering data in answering each specific research question.

Table 3.6: Research questions and objectives with corresponding data collection methods

RESEARCH QUESTIONS	RESEARCH OBJECTIVES		CASE STUDIES	
		Literature	Interviews	Questionnaire
What are the global developments, trends and best practices in building life-cycle data management and handover practices?	To identify the relevant concepts of building information handover practices and its requirements via a comprehensive review of the related literature.	√		
What are the existing building handover practices in the public sector construction projects in KSA?	To critically examine the status of existing building handover practices within public sector in KSA.	√	√	√
What are key challenges in existing handover process within KSA and how it can be improved?	To analyse challenges faced by client and facilities management teams in management of public sector infrastructure within KSA context.	√	√	√
What role can BIM-related technologies and processes play in improving life cycle data management within public sector construction within KSA?	To provide recommendations to the KSA Public Sector to enhance its management of infrastructure via improved handover practices.	√	√	√
How should the KSA Government drive its strategy on building handover in the public sector?	To develop a framework based on identified factors that enhance life cycle data management within public sector buildings within KSA.		√	√

3.15 Chapter Summary

This chapter presented the research methodology and procedures adopted in this study in order to achieve the research aim and objectives. It provided an account of the procedures used for data collection and analysis, including issues of validity, reliability, and ethical considerations. Both quantitative and qualitative methods with data triangulation are identified as the most appropriate method for data collection. It helped in carrying out an in-depth study of the building handover practices phenomenon. The research process began with a comprehensive review of literature, followed by a questionnaire survey and interview. The questionnaire design and administration was carefully done while a schedule of interviews helped to ensure accuracy in data collection from participants. The questionnaire data collected is to be analysed using the Statistical Package for Social Sciences, while qualitative data from the interviews are analysed using general analytical procedure and NVivo data management software.

CHAPTER FOUR: QUALITATIVE DATA ANALYSIS

4.1 Introduction

This chapter consists of the analysis and interpretation of the data that was collected using semi-structured interviews and analysis of documents related to building handover process obtained from the field study. The rationale and basis for choosing in-depth semi-structured interviews as the main data collection technique was presented in the methodology chapter (chapter 3). The interviews were with conducted with 10 leading experts involved in the management of KSA public infrastructure handover process (table 4.1). The researcher targeted industry experts from diverse public sectors. The analytical technique used to analyse interview data has previously been described in Section 3.7.1.

Table 4.1: The position of interviewees

No	Participants	Time	Position
1	(S1)	63.54	Senior Executive
2	(S2)	58.33	Executive Engineer
3	(S3)	62.58	Assets Manager
4	(S4)	82.10	Senior Administrator, Buildings
5	(S5)	80.25	Manager of Operations and Maintenance
6	(S6)	65.50	Manager, Project Implementation Unit
7	(S7)	64.63	Director of Maintenance and Operations
8	(S8)	58.80	Assistant Manager, Maintenance and Operations
9	(S9)	68.65	Facilities Manager, Project Implementation Unit
10	(S10)	61.65	Director of Project Management
Average		**66.60**	

4.2 Analysis of the Participant's Interviews

The data collected from interviews is categorised into themes. The findings from the case study are presented in relation to the research aim and objectives. The following six key thematic areas were defined (Table 4.2):

- Challenges to effective building handover practices in the KSA public sector construction;
- Recognition of the importance of project data at Handover Stage;
- Recognition of BIM Technology and Process benefits within KSA context;
- Key drivers of effective building handover;
- Facility budget for operation and management;
- Steps of developing the public sector projects.

Table 4.2: Themes and question for interviews

Themes	Interview question
1. Challenges to effective building handover practices in the KSA public sector construction industry	*What is the most significant challenge to effective building handover practices in the KSA public sector construction industry?*
2. The important of the project data at the Handover Stage	*What are the most important benefits for the project data at the handover stage?*
3. BIM and Technology benefits	*What are the important benefits and roles of technology and BIM in the Saudi Arabia construction sector*?
4. Existing Key drivers of effective building handover	*What are key drivers of effective building handover existing?*
5. Facility budget for operation and management	*How do you plan facility budget for operation and management?* *What is your biggest facility challenge?* *What investments are necessary to ensure effective implementation of Building Handover?*
6. Steps of developing the public sector projects	*What are steps that developing the existing public sector projects?*

The qualitative collected data from the interviews was analysed by using general analytical procedure. NVivo software was used as a tool for qualitative data analysis. Oral interview records and notes taken during interviews were first transcribed and converted onto word processing software. Imported written records were converted to the source document folders in NVivo. Data was collected under each of the key thematic areas and coded. The main information related to each question is kept in a free node file.

The NVivo software (version 10) for Windows was used for data analysis (see Figure 4.1). As highlighted by Edhlund and McDougall (2013), NVivo software offers numbers of benefits and advantages. According to Rowe (2007), one of the key advantages of using NVivo software is its facility to decrease the problems and difficulty of ‘a drowning in data’ by allowing data to be separated into nodes and categories; this provides a simpler structure for discovering emergent themes. The responses of the ten interviewees captured from the semi-structured interviews were copied and transcribed. This was followed by the identification of key themes and coding. Then, the coded themes with their outcomes findings were grouped into families in nodes - called tree nodes - and graphically presented as a network system of relationships (Appendix 4).

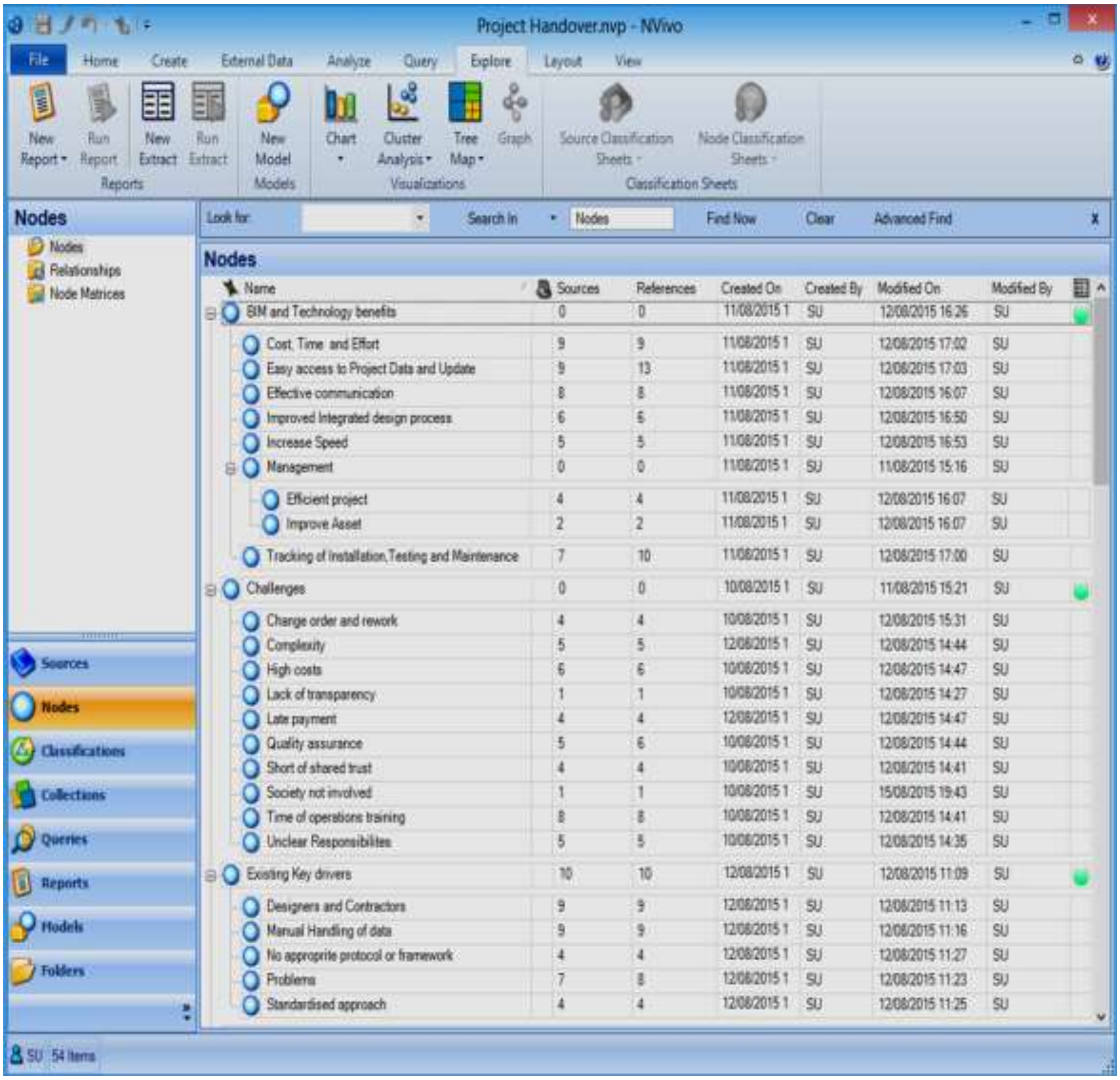

Figure 4.1: NVivo screen shot of tree nodes

4.2.1 Theme 1: Challenges to effective building handover practices in the KSA public sector construction industry

The questions posed to the interviewees were open-ended, i.e: “*What is the most significant challenge to effective building handover practices in the KSA public sector construction industry?”* Through the interviews, the themes used under discussion were elaborated upon using laddering techniques in order to avoid short, standard replies. According to Grunert and Grunert (1995), laddering techniques are a tool for uncovering subjective causal chains in qualitative interviews. The laddering technique involves a series of consecutive probes to allow respondents to develop causal chains.

The majority of the interviewees highlighted certain key challenges including high manager turnover, changing orders and rework during construction, the complexity of projects, lack of knowledge and experience, lack of communication, lack of transparency, unclear responsibilities, time of operations training, accelerated completion, and encouraged national labour are the most significant challenges in building handover practices in the KSA public sector construction industry (Figure 4.2). Figure 4.3 shows a sample of the transcripts.

In relation to high managers turnover, it was found that the majority of the participants (80%, 8Nr) believe that high projects manager turnover is the most important problem in the public construction sector in KSA. When a new manager is allocated, it would change the previous date set for the completion of a project by setting an earlier date as oppose to the agreed date. Also, a lack of clearly defined procedures means that documentation required towards end of the project could vary greatly from one manager to other. Lack of clearly laid out processes and procedures further enhance the impact of individual management styles.

Considering the lack of knowledge and experience, all interviews highlighted that there is a lack of knowledge and experience within Case Study Organisations. However, the interviewees' opinions confirmed the need for effective training to enhance understanding and existing procedures of handover practices in the KSA public sector projects.

Four respondents (40%) highlighted poor integration (communication) between designers, contractors, and owners leading to high number of change orders and reworks. One of interviewees (S1) said:

> *From my point of view, the key challenges are changing orders and rework, construction and building projects are troubled by adversarial relations, high costs, claims, and also constructed facilities becoming complex.*

Another interviewee agrees with his colleague and adds that the changes of design during construction, changing orders and rework are the key challenges in the subject.

In terms of complexity, 50% (5Nr) cited this factor about the constructed facilities; one of the interviewees (S4), from his point of view, mentioned it among another factor and said:

> *In my opinion, the main challenges are construction and building projects being troubled by adversarial relations, changing orders and rework, claims, wastage, and the constructed facilities becoming more and more complex. All of this impacts information flow.*

However, another respondent (S5) stated from his experience:

> *According to my experience, the key challenges are over-specification (i.e. over planning), changes of design during construction, this often leads to low productivity and delays in project completion, and also loss of information as the facility is handed over to clients.*

The majority of interviewees (60%, 6Nr) mentioned the "High Cost" factor amongst key challenges, affecting building handover; as one of the interviewee (S7) said:

> *Competition is often fierce amongst sub-contractors and owners have their own set of inefficiencies, resulting in high costs, waste and the late payment and cost overruns. Investing in improving communications is often not a priority.*

Besides high costs, some of respondents (40%, 4Nr) mentioned the issues related to late payments; one of interviewees stated that:

> *I think there are five important challenges facing our company, which are high costs, late payment and cost overruns, absenteeism of labour, excessive overtime, wastage. All of this has an impact on the increasing complexity of overall constructed facility.*

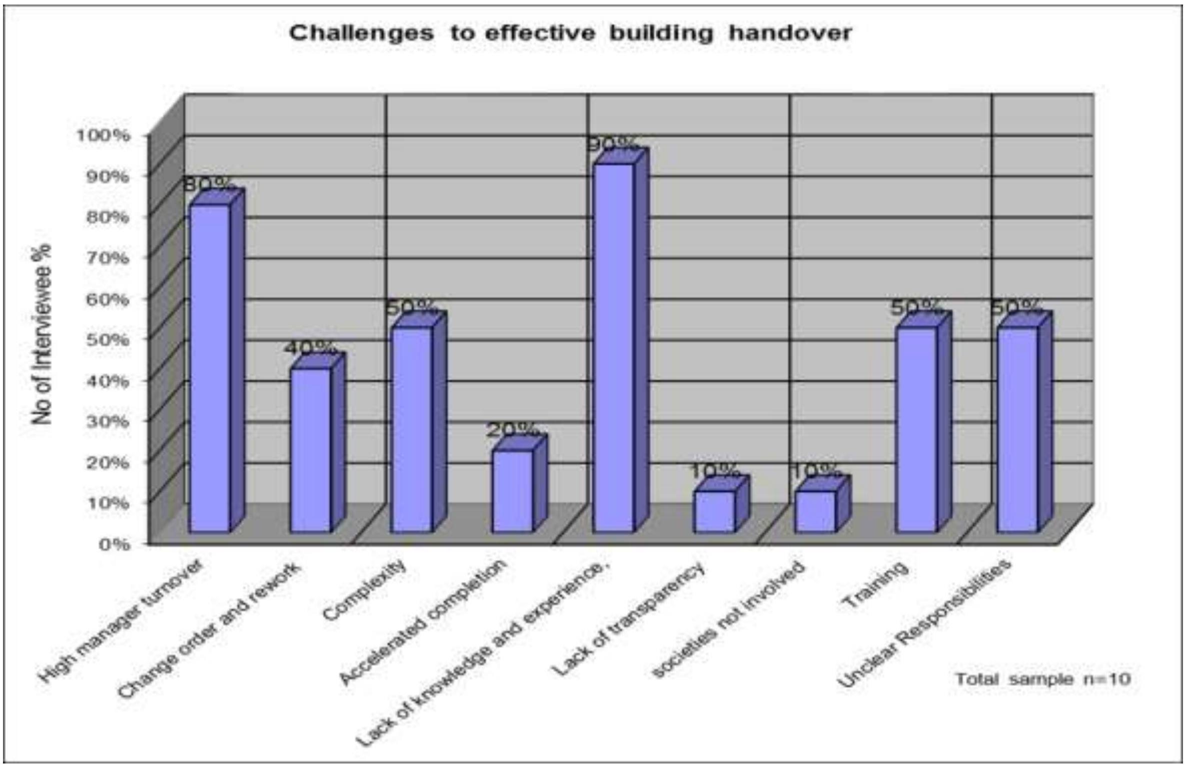

Figure 6: Most significant challenge to effective building handover practices in KSA

A lack of transparency and accessibility of project data for all the project team electronically is considered as one of the most significant challenges to effective building handover, as one of the interviewees (S5) said:

> *In general, there are significant challenges to effective building handover practices, which include a lack of transparency and accessibility of project data. Each contractor chooses their own application of choice and there is no single unified approach".*

Another interviewee added, "*we are still lagging behind other industry sectors in technology adoption."*

Aggregate	Classification	Coverage	Number Of Coding References	Reference Number	Coded By Initials	Modified On

Internals\\S9

No		0.0928	1			
				1	SU	12/08/2015 14:35

I think that the most significant challenge to effective building handover practices in the KSA public sector construction industry are not enough time for operations training, responsibilities of various project team members are uncertain, possibility to use the information across the design/ construction team

Nodes\\Challenges\Unclear Responsibilites

Document

Internals\\S10

No		0.0769	1			
				1	SU	12/08/2015 14:35

The main significant challenge to effective building handover practices in the KSA public sector construction industry are actual handover process is often event, not enough time for operations training, responsibilities of various project team members not clear

Internals\\S5

No		0.0769	1			
				1	SU	12/08/2015 14:32

Actually there are significant challenge to effective building handover practices which are the responsibilities of various project team members are unclear, small of mutual trust and ability to use the information across the design/ construction team

Internals\\S6

No		0.0853	1			
				1	SU	12/08/2015 14:29

From my point of view there are only two most significant challenge to effective building handover practices in the KSA public sector construction

Figure 4.3: Interviewee comments on unclear responsibility definition

Four interviewees (40%) identified a lack of transparency as one of the most important factors. S3 commented on challenges faced by the company with whom he was working as:

> *I think that within our division, there are three main challenges impacting on effective building handover practices. Firstly, there is a lack of shared trust, secondly, a lot of staff involved in operations and maintenance are not well*

trained and thirdly, there is lack of understanding of capability to use the information across the design/construction teams.

One of respondents (S1) mentioned that the society is not involved amongst some factors when he replied to the questions about challenges:

I think that the most significant challenge to effective building handover practices in the KSA public sector construction industry is that owners are not driven. There is a lack of appreciation of what effective operations of critical infrastructure means and value that data can bring. This can be attributed to a lack of training.

Although the training is considered an important factor when implementing any new system, only (50%, 5Nr) highlighted training as one of the key challenges in handover. (S6) from his point of view specified two challenges:

From my point of view, there are only two main significant challenges to effective building handover practices in the KSA public sector construction industry. These include tasks of various project team members not clearly defined and uncertain, as well as a lack of a concerted effort towards operatives training.

Another interviewee (S10) mentioned:

The main challenge to effective building handover practices in the KSA public sector comes from the client side, with lack of clear definition of handover requirements, lack of concerted effort towards training and lack of clear definition of responsibilities

Five of the respondents (50%) indicated unclear definition of responsibilities as a key factor:

Actually, there are significant challenges to effective building handover practices. There is lack of clarity on who is doing what. Also, tight profit margins for contractors often mean lack of mutual trust. There is lack of

> *appreciation of how effective information sharing between designers, contractors and asset management teams could enhance the overall process.*

In the same context, another interviewee (S7) said, "… *not enough time is dedicated for operations training and, responsibilities of various project team members are unclear*".

4.2.2 Theme 2: Realisation of Importance of Project Data at Handover Stage

Under this heading, the questions posed to the interviewees were opening-ended questions, i.e. "*What are the most important benefits that could be obtained from the project data at the handover stage?"*

The majority of the interviewees mentioned various aspects of existing practice that could be enhanced through effective data management including Commission Plans, Building Drawing and Insurance, Daily reports, Equipment List, Manufacturing Products Data, Operations and Maintenance, and Quality Control Documents. The aforementioned were highlighted as key factors that could be enhanced through effective usage of project data at the handover stage (Figure 4.4).

Interviewees (S4) mentioned that:

> *From my point of view, manufacturer products data, data, commission plans, daily reports and quality control documents are the most important documents at the handover stage*.

In the same manner, another Interviewee (S1) suggested such key benefits as:

> *I suggest that commission plans, building drawings and insurance, manufacturer products data, and quality control documents, as well as equipment lists are the most important benefits from viewpoint of project data at the handover stage*.

During the questions session, another key factor highlighted was the transfer of building drawings and insurance. One interviewee (S3) highlighted the significance of building drawing and insurance, besides quality control documents and daily reports, as one of the most important factors.

The most important benefits for the project data at the handover stage are building drawings and insurance, quality control documents and daily reports.

Another interviewee agreed with previous interviewee and said:

There are a number of important benefits for the project data at the handover stage which include building drawings and insurance, equipment lists and daily reports.

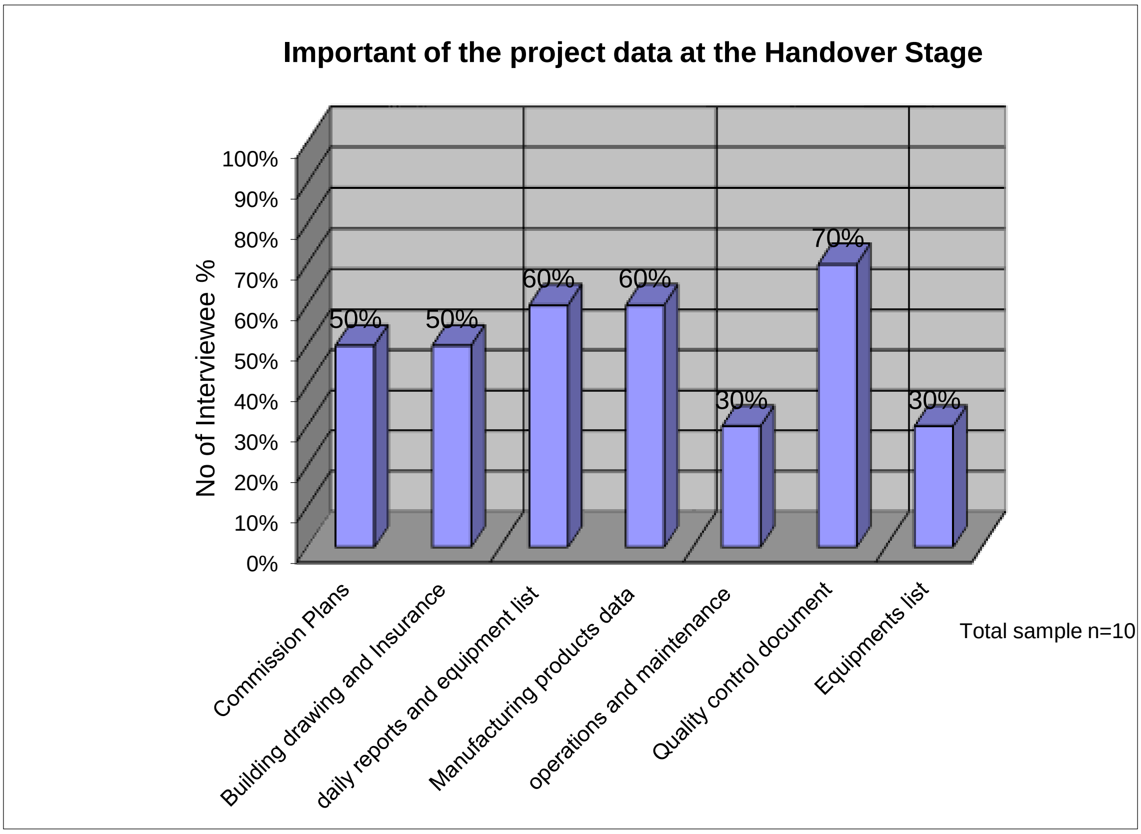

Figure 4.4: Key project documents required at Handover stage

Most of the respondents mentioned daily reports and equipment lists (S8) as key contributing factors, identifying the following two key points:

I believe that the most important benefits for the project data at the handover stage are equipment lists, operations, and maintenance, and daily reports.

Another interviewee (S7) mentioned daily reports among the list and said:

Manufacturer products data, building drawings and insurance, daily reports and commission plans are some of the key documents we will require at handover".

The majority (60%, 6Nr) of interviewees agreed that in building and manufactured component data such as systems of Heating Ventilate and Air Condition (HVAC), Air-conditioning Unit), Quality Control documents (70%, 7Nr) are some of the key data elements required at the handover stage. Some of interviewees shared the same two themes in one answer (5Nr), as one of the interviewees (S10) stated:

> *Progressive data collected by design and construction teams could be used for a wide range of objectives for instance improving operations and maintenance, quality control etc.*

*A*nother interviewee (S2) mentioned:

> *Given we continuously operate air conditioning, effective use of air conditioning data could help us improve our operations*.

In the same context, interviewee (S9) said:

> *Effective building data handover could bring benefits in number of different areas including better record of building drawings and insurance, better audit of products installed within a building, better quality control.*

Most of the interviewees demonstrated awareness of how the capture of building data could help bring various benefits throughout project life cycle.

4.2.3 Theme 3: BIM and Technology benefits

The next question posed to the interviewees was: "*What are key benefits of Building Information Modelling (BIM) technology and processes within KSA construction context?"* The majority of the interviewees highlighted key benefits that BIM can bring to the overall process, including cost, time, and quality management. There was general recognition of the fact that overall management of project data can be improved using BIM and it will allow for easier updates to data. S2 highlighted lack of training and awareness of BIM software and tools. Figure 4.5 provides a summary of key benefits of BIM highlighted during interviews.

The majority of the respondents (90%, 9Nr) reveal that there is a lack of using technology, such as BIM, and considered the benefits in terms of Cost, Time, and Quality as key advantages of BIM. One of interviewees (S5) mentioned:

Many of our projects are delayed and over-budget. If BIM could help us reduce our costs and help deliver projects in time, I would rate it as the biggest benefit.

In addition, another one (S4) added the following points:

By using BIM, we can reduce time and effort expended on our projects. Also, overall maintenance and reporting can be improved substantially.

The potential of using BIM to enhance quality of buildings and improved data management through operations and maintenance phase was also highlighted.

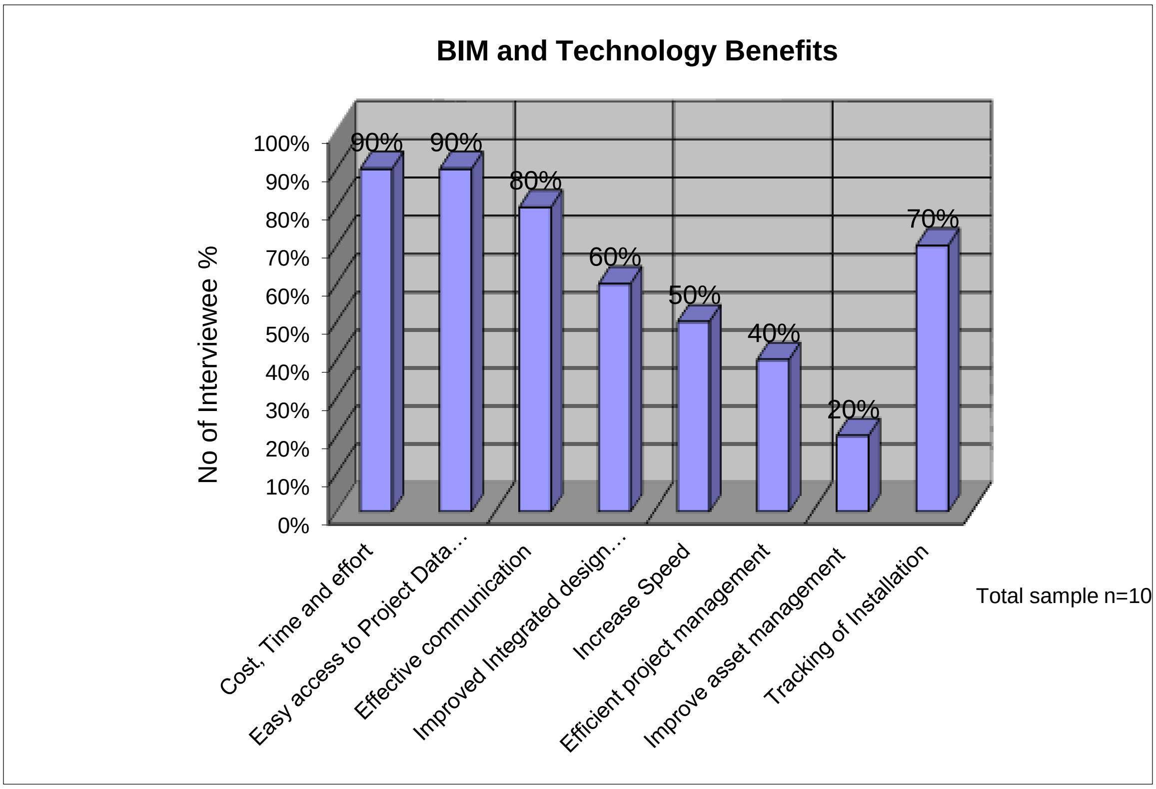

Figure 4.5: Role of BIM in improving information handover within KSA

The easy access to project data and easy updating (90%, 13Nr) are considered the key benefits of BIM, as S9 from his experience said:

Our existing processes are manual, which are prone to lot of errors. BIM can play a key role in automating various manual tasks. Also, it could help enhance credibility of available information

S6 highlighted:

BIM could enhance our division in various roles, such as ease of maintenance, better reporting, improving data flow and providing an ability to update *information easily.*

In the case of effective communication, the majority (80%, 8Nr) agree that it is an important factor that BIM technology can play in the KSA constructions sector. In this context, S2 stated:

> *Improved integrated design process, better collaborative planning and useful communication and closer collaboration are the important benefits and advantages of BIM in the Saudi Arabia construction sector*.

Another respondent (S8) mentioned effective communication and close collaboration amongst the key benefits of BIM, highlighting the fact that:

> *The* k*ey benefits and advantages of BIM in the Saudi Arabia construction sector are effective communication and closer collaboration, improved tracking of installation and testing and improved integrated design process*.

Also, improved integrated design process is one key factor, with the majority of interviewees (60%, 6Nr) (S5) suggesting,

> *BIM provides good visualization that could help bring key project stakeholders, help increase speed of preparing documents, help support asset management processes*.

As well as this, increased speed is very important factor, half of the respondents (50%, 5Nr) stated that in their answer, as (S1) mentioned:

> *I suggest that the important benefits and advantages of BIM in the Saudi Arabia construction sector are raise speed of preparing, asset management, efficient project management and effective communication and closer collaboration*.

In the same subject, some respondents talk about BIM and technology benefits in efficient project management (40%, 4Nr), and improved asset management (20%, 2Nr). One of interviewees (S9) mentioned this with another related point to the theme:

> *I think a decrease in error and omission, better collaboration between owners and firms, and increase speed of preparing asset management, as well as efficient project management are the main important advantages of BIM in the kingdom*.

The Tracking of Installation, Testing and Maintenance is considered one important benefits of BIM technology in the KSA construction sector (70%, 10Nr). One of the interviewees (S10) said from his point of view and experience:

> *According to my experience, the benefits of BIM in the KSA are better tracking of installation and testing, simple access to project data Information, easy access to project data information and improved integrated design process*.

4.2.4 Theme 4: Key drivers for effective building handover

The question posed to the interviewees under this theme was: "*What are the key drivers of effective building handover within KSA?*" All of the interviewees answered this question (10Nr) and key factors highlighted by interviewees included designers and contractors (90%) (i.e., being involved in early stages of project could influence downstream data management), manual handling of data (90%) (i.e., excessive reliance on paper-based procedures), no appropriate protocol or framework (40%) (i.e., lack of understanding of what data already exists and in what format), resolving problems in productivity (70%), and standardized approach (40%) (Figure 4.6).

The interviewee S2 said:

> *A number of key issues must be addressed. For instance, Designers and contractors have minimal involvement after building commissioning. There are initiatives across the world to standardize data formats and handover processes by integrating them in procurement processes. No appropriate protocol or framework in place within KSA for life cycle data management of information. Manual handling of data and human errors further increases such information loss and communication gaps between designers, contractors and owners*.

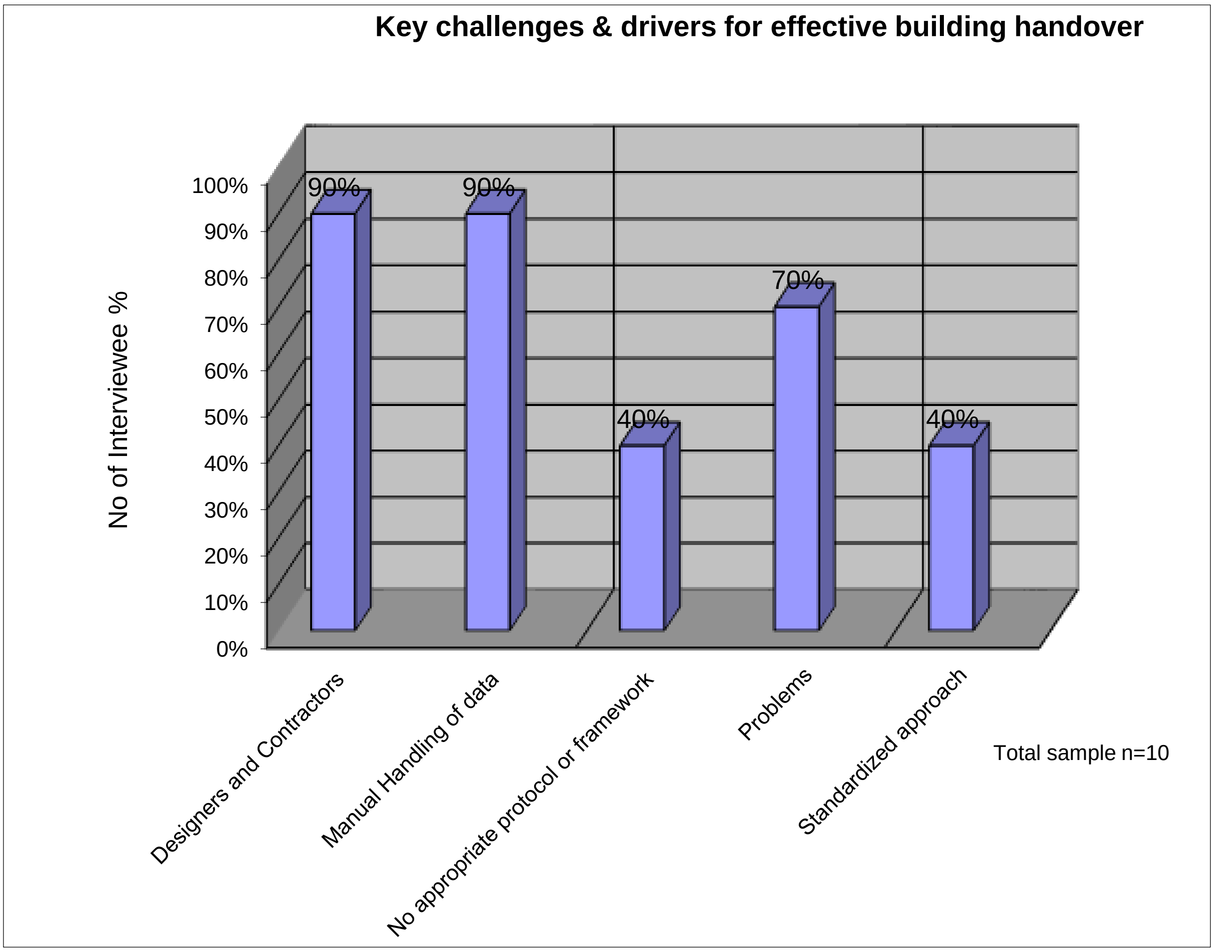

Figure 4.6: The key drivers of effective building handover existing

Moreover, most interviewees (70%, 7Nr) mentioned some problems for effective building handover.

In this context, S1 says:

> *Problems are in productivity, such as rework and mistakes, innovation, disputes, slipping schedules, and increased construction costs.*

Also, (S6) mentioned data loss over the lifetime of a construction:

> *There are significant problems in the delivery of public sector construction, which is involve a wide range of professionals from multiple disciplines that utilize and develop data at various project lifecycle stages resulted in data loss over the lifetime of a construction facility.*

4.2.5 Theme 5: Facility budget for operation and management

The questions posed to the interviewees were: "*How do you plan facility budget for operation and management? What is your biggest facility challenge? What investments are necessary to ensure effective implementation of Building Handover?"*

In the case of how to plan facility budget for operation and management, the majority of interviewees agreed that it is through Institute Goals and Objectives (70%, 7Nr), and Analyses and Interpretation of data (90%, 9Nr) (Figure 4.7). One of the interviewees (S1) says:

From my experience, I supposed that to plan facility budget for operation is mainly based on institute facility goals and objectives, analyse data and examine and interpret data.

In addition, another interviewee (S5) stated:
Increased strategic plans, budgets, and collecting and analysing data are the main important elements important for plan facility budget for operation and management.

Moreover, another interviewee (S2) said:
*I think planning facility budget for operation and management based on three main factors are; analyse data, interpret data, and create facility goals and objective*s.

In the case of the challenge of facility budget, some respondent mention that crisis awareness (10%, 1Nr), emergency preparation (80%, 8Nr), maintenance of facility budget (90%, 9Nr), and preservation of facility budget (20%, 2Nr) are the main challenges (Figure 4.7).

In this context, S3 said:

> *I suggest that there are two main facility challenges, the first is benefit management and maintenance and the second is crisis awareness*

S5 stated:

> *Actually there are a number of facility challenges, where the biggest are: asset management and maintenance, emergency preparedness*.

S7 confirms that:

I can confirm that the two biggest facility challenges in my point of view are the maintenance of facility budget and emergency preparedness.

S10, from his experience, said:

From my experience as an employee in private company, I think that asset management and maintenance, and emergency preparedness are the biggest facility challenges.

In the case of investments being necessary to ensure effective implementation of Building Handover, the majority of interviewees see that the Development of BIM process (50%, 5Nr), Investment in Hardware (30%, 3Nr), Personnel training (10%, 1Nr), and Software training (70%, 7Nr) are most necessary investment in this matter (Figure 4.7).

One of interviewees (S1) mentions development of BIM and investments in hardware and said:

In general, there are a number of investments that are necessary to ensure effective implementation of building handover development of BIM processes savings in hardware, e.g. Mobile Devices.

Another interviewee (S10) included the training in software with development of BIM:

I think that there are important investments that are necessary to ensure effective implementation of building handover, which are development of BIM processes and Training in use of software.

Another respondent (S4) stated:

According to my experience, the most important investments are necessary to ensure effective implementation of building handover are investments in hardware (e.g. Tablets, Mobile) and development of BIM Processes.

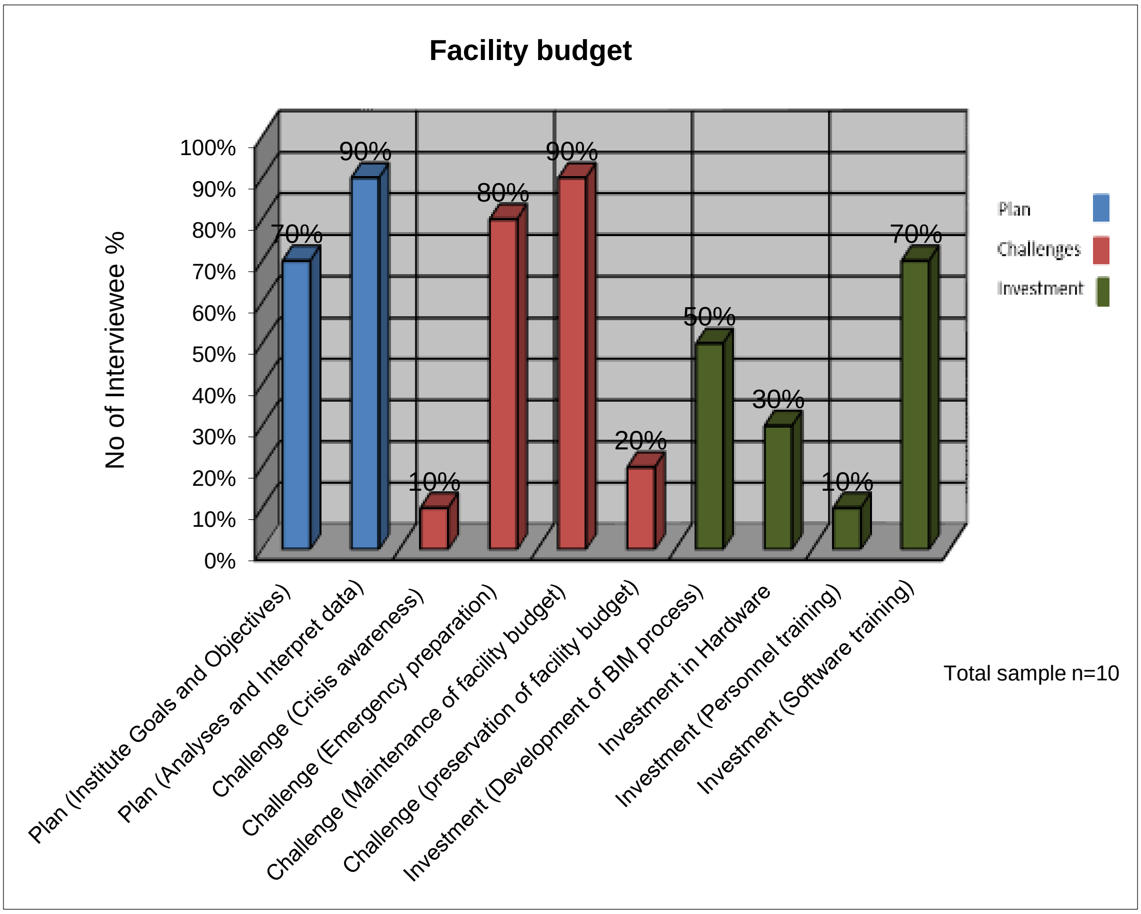

Figure 4.7: Facility budget Plan, Challenges and Investment

Moreover, in training, only one respondent (10%, 1Nr, S7) mentioned personnel training with investment in hardware and said:

> *The main investments that are necessary to ensure effective implementation of building handover are training of personnel and investments in hardware (e.g., mobile Devices). But the problem in training workers in the projects is that most labourers are foreigners and turnover is high.*

4.2.6 Theme 6: Steps of developing the public sector projects

The question posed to the interviewees was: "*What steps are necessary for enhancing Data Handover Practices in existing public sector projects?*"

All the interviewees answered this question (10Nr) and most of the respondents highlighted that the need to rely less on an immigrant workforce and encouraging Saudi nationals to join this sector (90%, 9Nr), transformation through technology (BIM) (50%, 5Nr), and training (40%, 4Nr) are the steps that should be taken within existing public sector projects (Figure 4.8). One of interviewees (S1) indicated:

> *One of the most important steps that should be taken is transformation of technology and promotion of such BIM, training courses, knowing the positions of flaw, and recognizing the positions of weakness.*

Another interviewee (S2) said:

> *In my opinion, the main steps that should be taken are to benefit from the expertise of other resources available and training courses, knowing the positions of faults.*

Another interviewee (S10) added:

> *I think that there are some important steps that should be taken within the existing public sector projects in our company, using technology and benefiting from BIM, benefiting from the expertise and experiences of other resources on hand.*

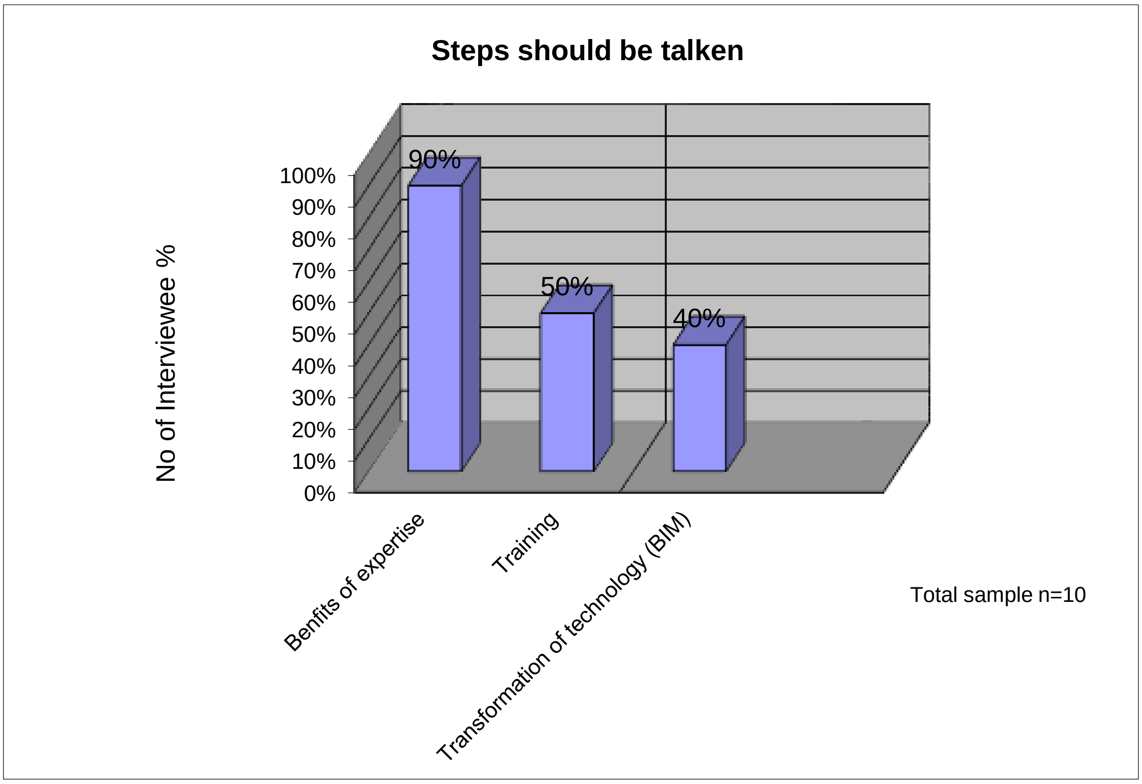

Figure 4.8: Steps necessary for enhancing data handover practices in existing public sector projects

4.3 Documentary analysis

The analysis of documents enhances the research's qualitative findings hence, in doing so, provides more of the advantages and benefits of case study research. However, in this research, the role of documentary investigation and analysis, although notably smaller, is still of importance to support the research qualitative findings and objectives and is included within this thesis. According to Yin (2009), information is expected to be relevant and significant to every case study subject. Documents that have been examined in this study were some of the organisations' documents, such as built drawings, building standards, and policy documents such as clauses in construction contracts. In addition, annual reports, government legislation, and financial reports were examined. All these stated documents are reviewed in detail in the case study and have been examined to triangulate and support the statements made via the interviews.

4.4 Chapter Summary

Chapter four has presented the qualitative findings that had emerged from the semi-structured interviews and documentary review. These different sources of evidence provided much valuable in-depth information on the issues enabling facilitate data management in building handover practices of construction projects in the KSA public sector, it also enhances the external generalisation of this research. The main findings of this chapter were a lack of knowledge and experience with technology, training, communication, and transparency along with unclear responsibilities and complexity of projects, as well as a high manager's turnover and accelerated completion. It also found the need to encourage national labour and maintain order in societies not involved. These findings will be thematic, classified into categories, and will be discussed thoroughly in chapter 6 in the light of the research aim. Analysis of data will link and contrast the findings of the case study with those of previous studies that have been presented in the chapter two.

The next chapter presents the finding from quantitative data, which assists to add reliability and validity to the results from the qualitative data.

CHAPTER FIVE: QUANTITATIVE DATA ANALYSIS

5.1 Introduction

This chapter presents the analysis and interpretation of the quantitative data collected as part of this research study. As discussed in Chapter 3, this study used an online survey as the key mechanism for collecting quantitative data. The survey targeted clients, consultants, and facility managers involved in KSA public sector construction. A total of 308 participants participated in the survey. Section 5.2 presents survey demographics (e.g., age, academic qualifications). There were various questions asked on various aspects of the building handover process (outlined in detail in this chapter). The results were gathered into three sections. Towards the end of this chapter, there is a data summary developed from the analysis that highlights and concludes the main findings of the quantitative data analysis. Also, various statistical tests undertaken to ensure data validity are explained.

5.2 Section 1: Survey Demographics

Section one presents the aims of the survey's first three questions for the 308 employees of different construction companies in Saudi Arabia. In this first part, the following enquiries are mainly concerned with the personal respondents. All these questions are relevant to the age of participant, academic qualifications, and satisfaction with the quality of information that is handed over to project owners towards the completion of the project.

5.2.1 Age

The largest portion of survey respondents was in the 30-40 years age group (122 respondents from the whole sample of 308), representing approximately 40% of the whole sample. The second largest representative age group was between 40 and 50 years old, representing 30% of the sample. Approximately 15% of respondents were in the over-50 age bracket and a similar percentage of respondents (~15%) were less than 30 years old. Age demographics reflect on the relatively high experience of respondents. Age distribution is shown in Figure 5.1.

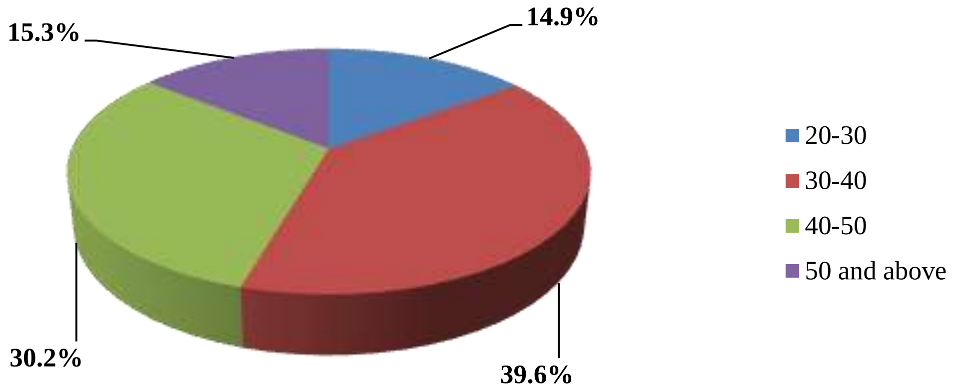

Figure 5.1: Respondents' distribution of age

5.2.2 Educational qualification

As seen in Figure 5.2, the largest group (i.e. 153) of the employees who answered the survey hold a graduate degree, representing slightly lower than half (49.7%) of the entire surveyed population. The result also shows that the employees who had high school and diploma degrees were relatively similar, with 14.6% and 14.0% of respondents, respectively. The remaining respondents (22.4%) hold postgraduate qualifications.

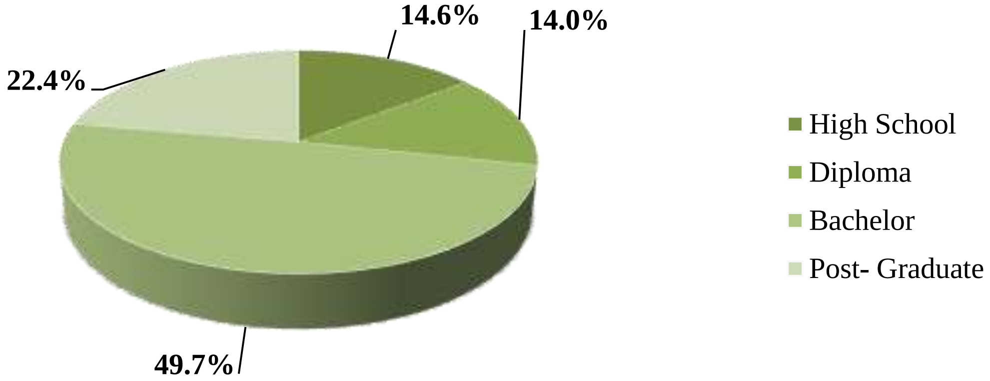

Figure 5.2: Distribution of survey respondents' academic qualification

5.3 Section 2: General information

This section presents a summary of the next six questions asked as part of the survey. This section of the questionnaire pertained to satisfaction with the quality of information that is handed over to project owners towards the end of the project. Covered topics included challenges in adoption of good data handover practices, drivers for change, clarity of data requirements at handover, and perceptions on role of Building Information Modeling (BIM) in supporting the handover process.

5.3.1 Satisfaction with quality of information handed over to project owners.

Under this theme, the researcher asked the respondents' opinions concerning their satisfaction with the quality of information that is handed over to project owners towards the end of the project. The finding of this theme reveals that there is a strong distribution of survey respondents close to symmetric distribution, with slightly higher than 83% (Figure 5.3) of the sample population (308) being unsatisfied with the quality of information that is handed over to project owners towards the end of the project. However, 17% of respondents were satisfied with the quality of information that is handed over to project owners towards the end of the project.

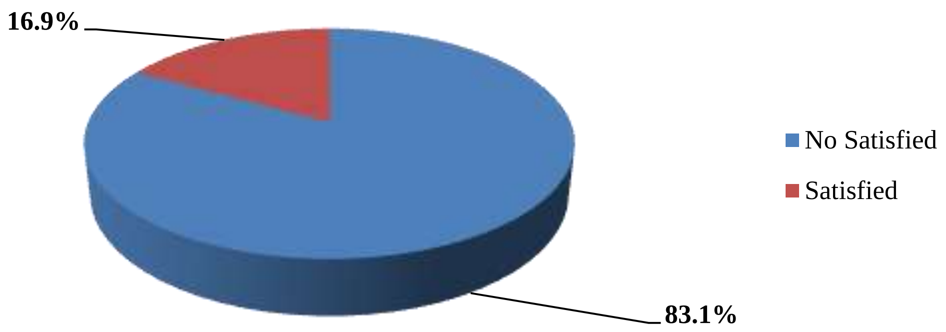

Figure 5.3: Distribution of survey respondents' Satisfaction with quality of information handed over to project owners

5.3.2 Number of years of building handover experiences

The respondents of the survey were asked to describe their experience level in the building handover process in order to establish whether they have the right level of experience to manage the building handover process in their respective organizations. The results are presented graphically in Figure 5.4. It is indicated that the result was more evenly distributed when compared to previous question (Section 5.3.1). More than 100 respondents (slightly less than 34%) had over 20 years of related experience in building handover processes. However, about 21% of the survey respondents had less than five years of experience at the building handover stage, with 17.2% having 16-20 years, followed by slightly less than 16% with 11-15 years, and 12% with 6-10 years of experience.

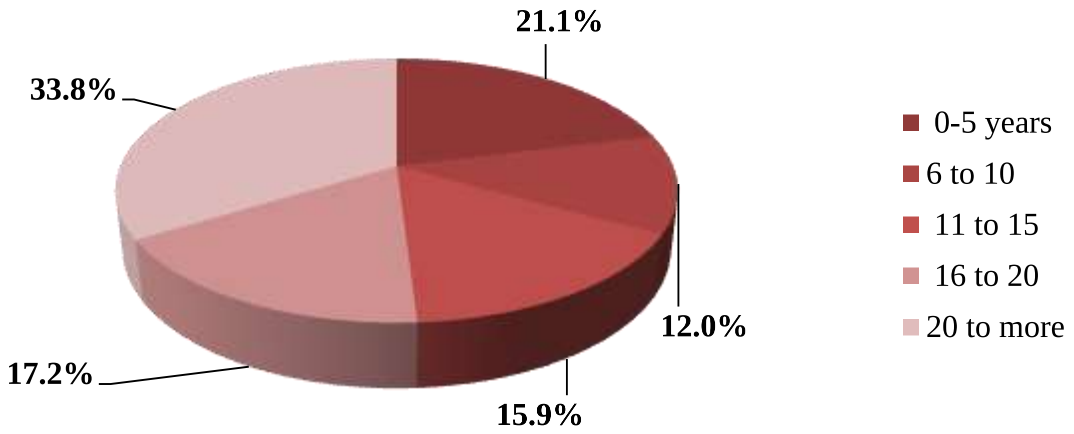

Figure 5.4: Respondents years of experience at the building handover stage

5.3.3 Description of the company's principal business activity

The results of the survey indicate that the largest portion (56.8%) of respondents were from public sector client organizations (i.e. government), followed by slightly more than 17% representing facility management firms. This was followed by slightly less than 16% of respondents representing private clients. The smallest portions (5.5% and 3.9%) were contractors and consulted-designers of facility management firms in the KSA public sector construction organisations (Figure 5.5). There was a relatively small difference in the number of respondents representing private client and facility management organisations.

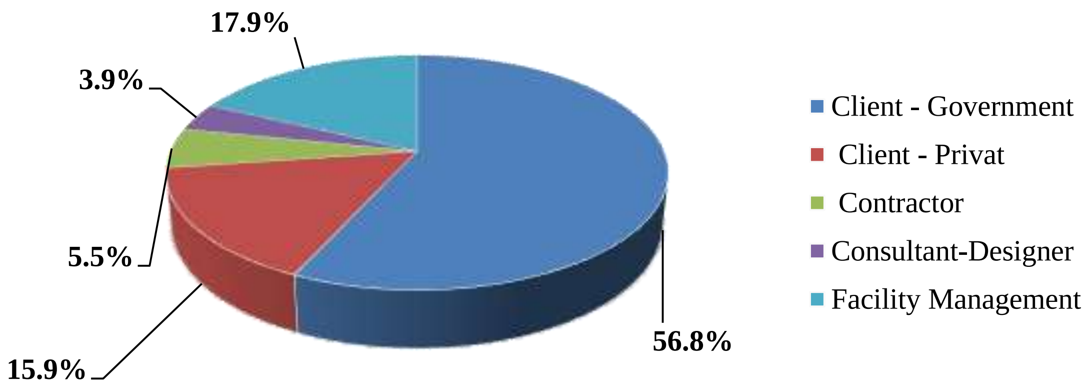

Figure 5.5: Types of Organisations represented by Respondents

5.3.4 Description of Respondents' Company

The respondents were asked about how they would best describe their company/organization's principal business activity. Three given options were: a) contracting company, b) consulting organization, or c) client organization (private or government) company. The detailed results are represented graphically in Figure 5.6. As can be seen, the large proportion (47.7%) of respondents represented the Government Client category, followed by 33.4% of respondents representing private client companies. Contracting organisations represented 11.4% of respondents, whereas the smallest percentage of respondents (7.5%) belonged to consultant companies.

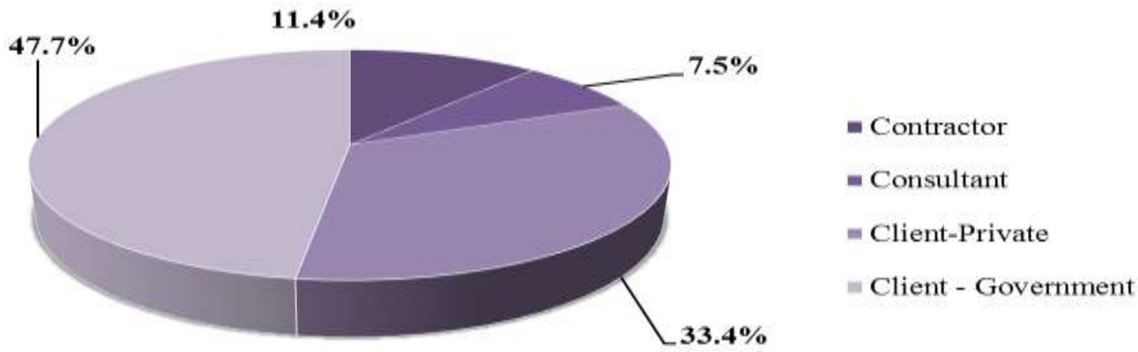

Figure 5.6: Description of the companies

5.3.5 Period of time that organisation has been using BIM

The survey respondents were asked about length of time that their organisations had been using BIM. There were four given options: a) not using BIM at all, b) from 1 to 2 years, c) from 3 to 5 years, and d) for more than 5 years. The results indicated that none of the responding companies had been using BIM for more than 2 years. More than 163 respondents (slightly less than 52.9%) answered that their companies are not using BIM. However, as many as 47.1% of companies indicated that they had used BIM for the past 1-2 years (Figure 5.7). These results indicate that the application of BIM technology in the construction Saudi companies is starting to be explored. Another key factor could possibly be the fact that the survey targeted respondents with more involvement in project handover. In handover phase of the project, usage of BIM within KSA is still in its early stages.

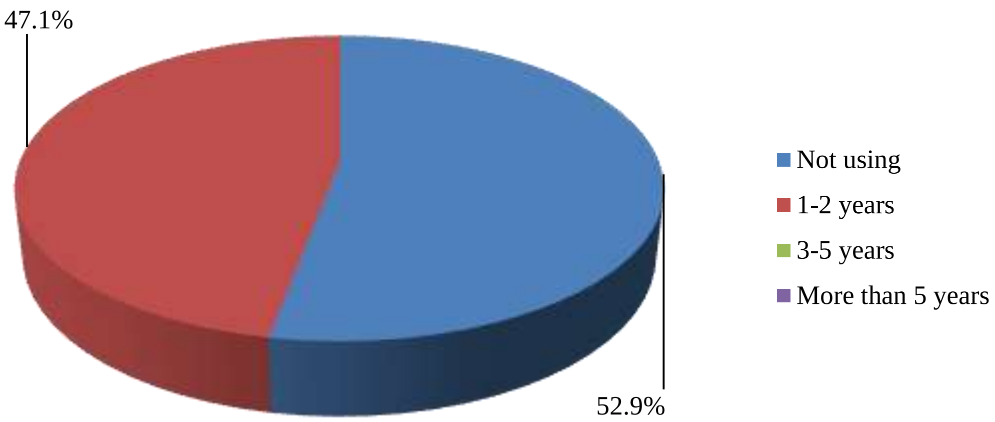

Figure 5.7: Distribution of survey respondents' Period of time that organisation has been using BIM

5.3.6 Classification of the organisation in terms of size

The respondents were asked to classify their organizations in terms of size (based on number of employees). The detailed results are represented graphically by (Figure 5.8). The respondents ranged between medium-to-large organizations. However, most respondents were situated in large organizations, with slightly less than 290 respondents. This equated to 89.0% of the total. The remainder shows that slightly less than 7% of respondents belong to organizations employing a medium number of employees, whereas the smallest percentage (3.9%) of respondents belonged to organizations employing a small number of employees.

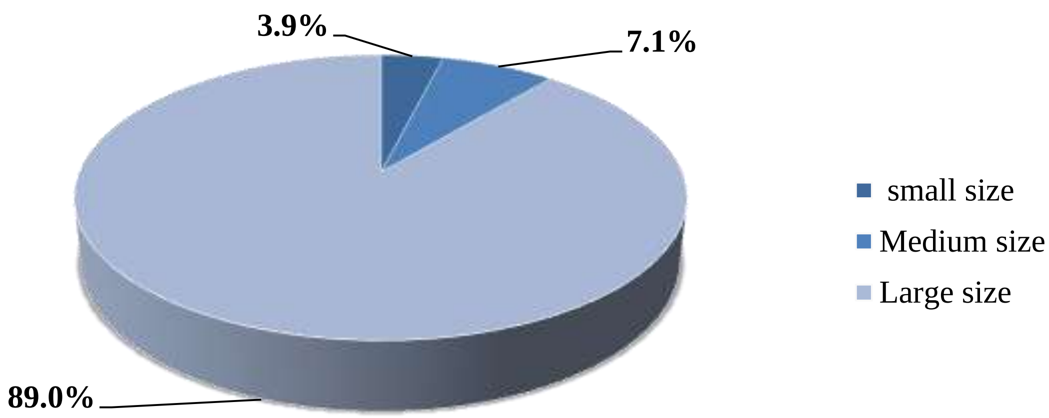

Figure 5.8: Size of Respondents' organisation

5.3.7 Recognition of the Importance of the Project Handover Stage

Figure 5.9 illustrates the respondents' views on importance of the project handover stage to the organisation and client. The response was distributed similarly between very important (45.8%) and important (43.5%). Other options (slightly important, least and others) represented smaller percentages, not exceeding 6.2% (slightly important) and 4.5% (least important) of the total responses. This illustrates that the significance of the handover process is recognized by the respondent group.

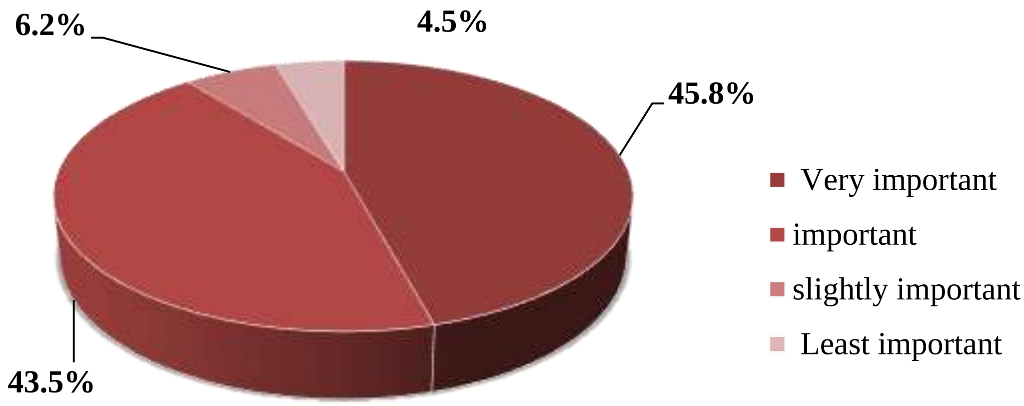

Figure 5.9: Importance of the project handover stage to the organisation and clients

5.4 Section 3: Specific and characteristics of Information required for Building Handover

This section illustrates the findings from a number of questions that were presented in the questionnaire, with the aim to develop a better understanding of key perceptions within KSA. In addition, this section summarized the remaining questions that were relevant to the building handover process. These questions are recognized as following: challenges to effective building handover practices in the KSA public sector construction industry, benefits of effective building handover in the KSA construction sector, project data at the handover stage, most affected by the building handover process, statements of the benefits of using BIM, benefits of BIM in the KSA construction sector, the development of Information Technology, responsibility for building information handover to each of the following parties, information about the process of project, whether maintenance was performed in-house or outsourced, the sort of services, access to all construction drawings, plumbing and electrical installations, ability to track energy consumption, easy access to all documents, planning of facility budgets for operations and management, facility challenges, and investments necessary to ensure implementation of effective building handover.

5.4.1 Significant challenges to effective building handover practices in the KSA public sector construction industry

This question was posed to respondents about the most significant challenge to effective building handover practices in the KSA public sector construction industr*y*. It included nine different challenges with five options, as listed in Table 5.1. From the frequency of the data (Table 5.1), it is clear to recognize that "most significant" choice was repeated 869 times as an answer to the previous nine questions. It has exceeded "significant" by about 1%, which is recorded 859 times representative of roughly 62% of the total sample. The remaining choices: neutral, slightly significant, and least significant recorded lower frequencies with 607, 304 and 133, respectively. The data shows that the "most significant" option had the widest data range (between 16% and 52%), followed by "neutral" (range between 10.1% to slightly higher than 64%).

Table 5.1: Percentage (%) of the most significant challenge to effective building handover practices.

	Most significant	Significant	Neutral	Slightly significant	Least significant
Societies not involved	38.96	24.03	30.52	4.87	1.62
Lack of transparency	15.58	58.44	21.10	2.27	2.60
Inappropriate quality assurance method	24.03	35.39	36.69	1.62	2.27
Lack of and accessibility of project data for all project team electronically	30.84	20.78	20.78	26.30	1.30
Not enough time for operations training	15.58	3.25	22.40	32.14	26.62
Responsibilities of various project team members are unclear	69.94	3.25	10.13	15.06	1.62
Maintenance manuals and keys are often missing	16.88	11.36	64.61	3.90	3.25
Ability to use the information across the project design/construction team	15.58	51.95	10.06	21.10	1.30
Actual handover process is often event	52.27	20.13	20.13	4.87	2.60

It is clear to see that the “most important”, “significant”, and “neutral” were the largest groups in general, which respondents chose as a response to various different challenges. “Most significant” ranged between slightly higher than 15% (Not enough time for operations training and ability to use the information across the project design/construction team) to the slightly higher than 69.94% (Responsibilities of various project team members are unclear). The “Significant” option ranged from slightly higher than 3% (Not enough time for operations training and Responsibilities of various project team members are unclear to Lack of mutual trust) to slightly higher than 58% (Lack of mutual trust). “Neutral” ranged between about 10% (Ability to use the information across the project design/construction team) to 64% (Maintenance manuals and keys are often missing) of the total respondents of the survey, respectively. Frequency of data under each key option is presented below.

- **Societies not involved**

From the frequency of the data, it is clear to see that 39% of the respondents selected societal factors as the most significant challenges to effective building handover, with 24% presenting it as a “significant” factor and 30.5% selecting it as neutral option. Only a small percentage of respondents selected the “slightly significant” or “least significant” options (Figure 5.10). This highlights how a wide range of societal factors is seen to influence the handover process.

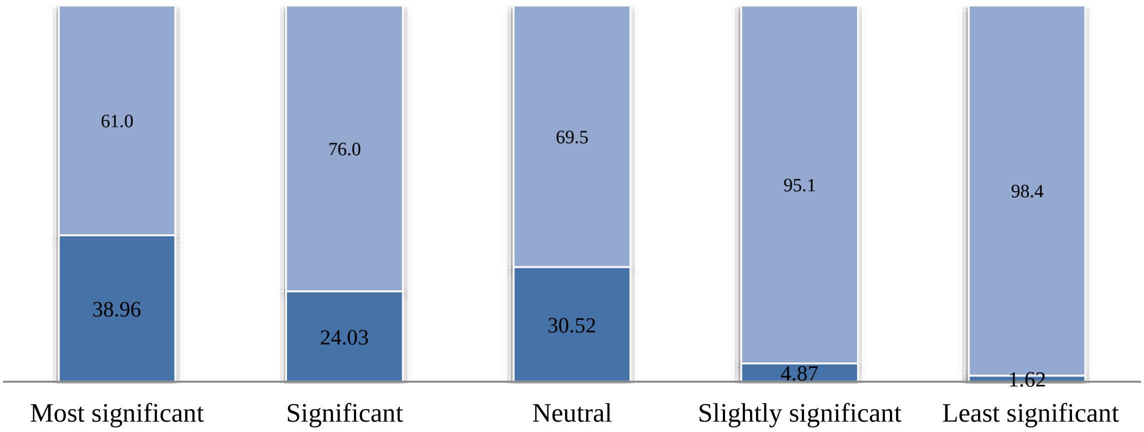

Figure 5.10: Frequency distribution of “societies not involved” question (Dark shade indicating % of respondents selecting the option, whereas light shade indicating those having not selected the option).

- **Lack of mutual trust and recognition of new project roles, such as information manager**

The lack of transparency of value that lifecycle data management could bring is attributed as a "significant" (58%) barrier to the implementation of effective handover practices within the KSA. 21% of respondents selected a neutral answer to this question (Figure 5.11). This highlights how a lack of transparency and true team play, coupled with a lack of recognition of value that good information management practices could bring leads to poor information flow throughout the building lifecycle.

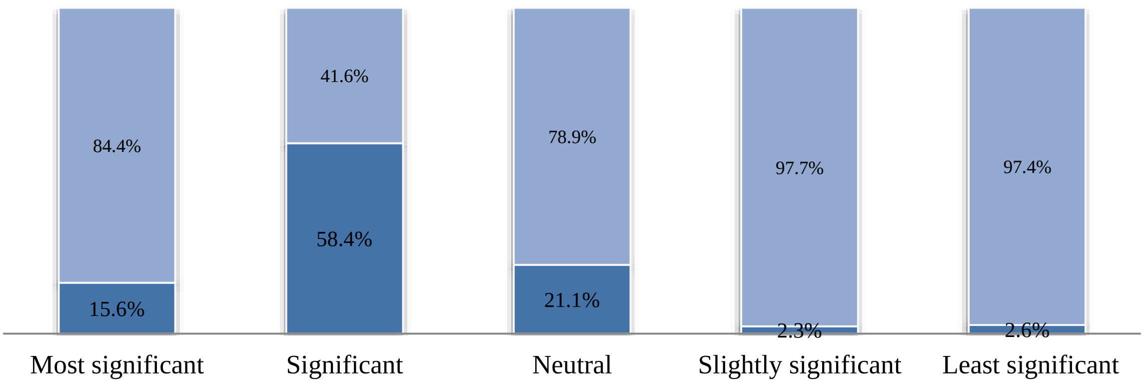

Figure 5.11: Frequency distribution of "lack of mutual trust and recognition of new project roles, such as information manager"

- **Inappropriate quality assurance method and procedures**

Respondents recognized the issues of inappropriate quality assurance methods and procedures within the KSA context as a significant barrier to effective building information handover. 24% of respondents selected "Most Significant", whereas 35.4% selected significant option, 36.7% remained neutral on this choice (Figure 5.12).

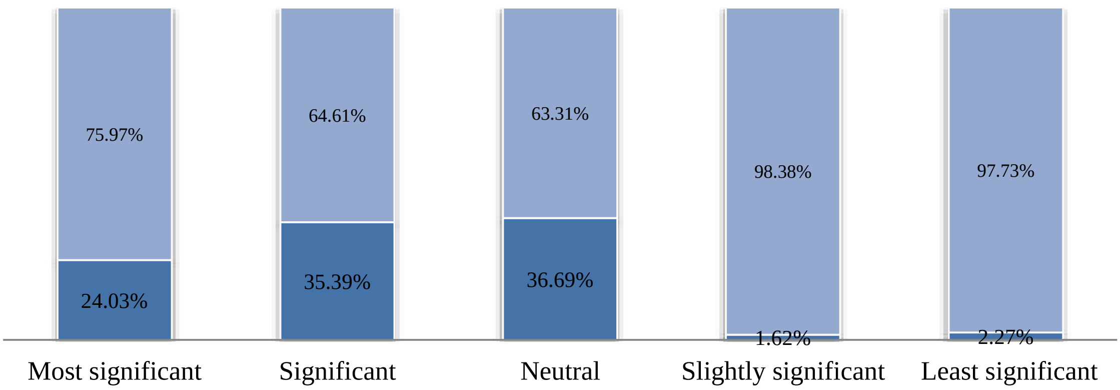

Figure 5.12: Frequency distribution of "inappropriate quality assurance method and procedures"

- **Lack of transparency and accessibility of project data for all project team electronically**

The answers of the employees who responded to the survey on this statement are close to a symmetric distribution. Approximately 31%, claimed "most significant" and slightly less than 21.1% selected both "significant" and "neutral", respectively (Figure 5.13).

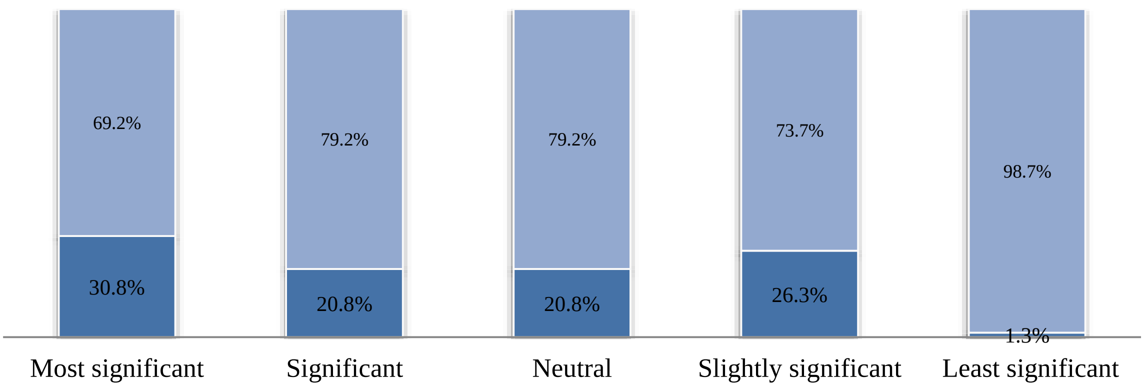

Figure 5.13: Frequency distribution of "lack of transparency and accessibility of project data for all project team electronically"

- **Not enough time for operations training**

Only about 16% find that there is not enough time for operation training as the "most significant" and slightly less than 23% choose a neutral option. The largest part, about one-third of the whole respondents choose the "slightly significant" option, followed by slightly less than 27% selecting "least significant" (Figure 5.14).

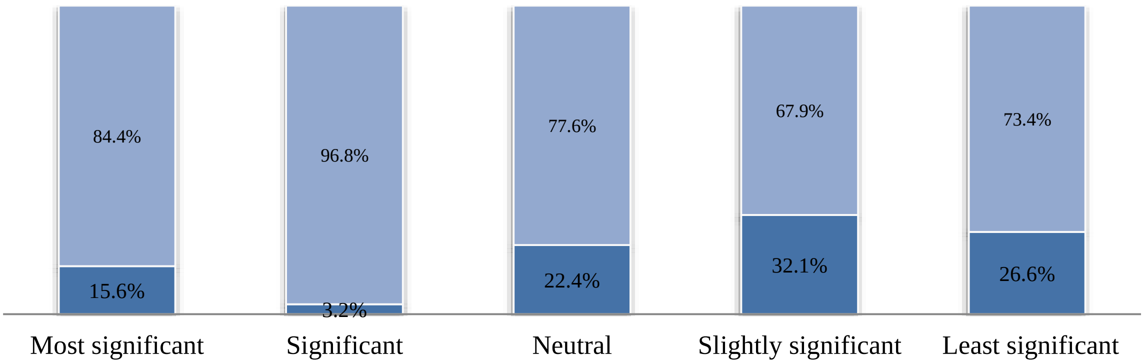

Figure 5.14: Frequency distribution of "not enough time for operations training".

- **Responsibilities of various project team members are unclear**

Also, a large percentage (70%) of respondents claimed the "most significant" option, specifying that the responsibility of the project team is unclear followed by slightly higher than 10% choosing neutral and 15.1% choosing "slightly significant" (Figure 5.15).

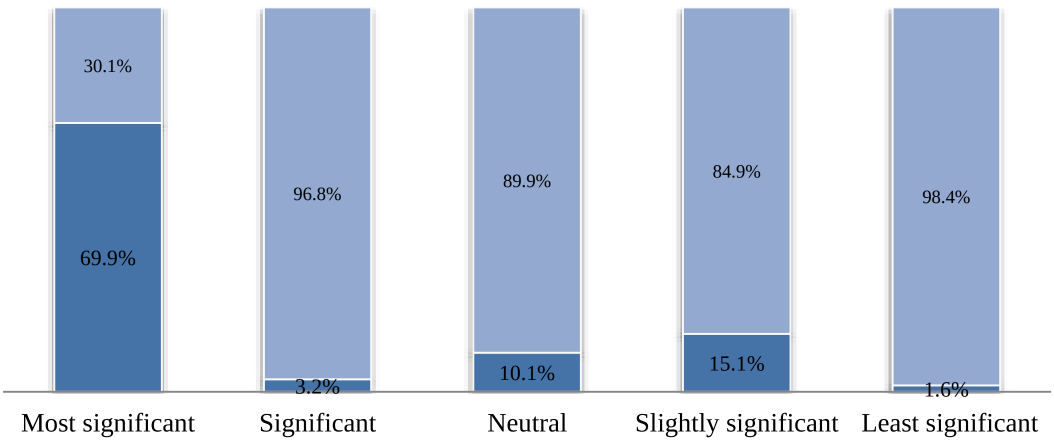

Figure 5.15: Frequency distribution of responsibilities of various project team members is unclear.

- **Maintenance manuals and keys are often missing**

For the statement of "maintenance manual and keys are often missing", 64.6% of the respondents were neutral, followed by slightly less than 17% (most significant), with only about 11% choosing the "significant" option (Figure 5.16).

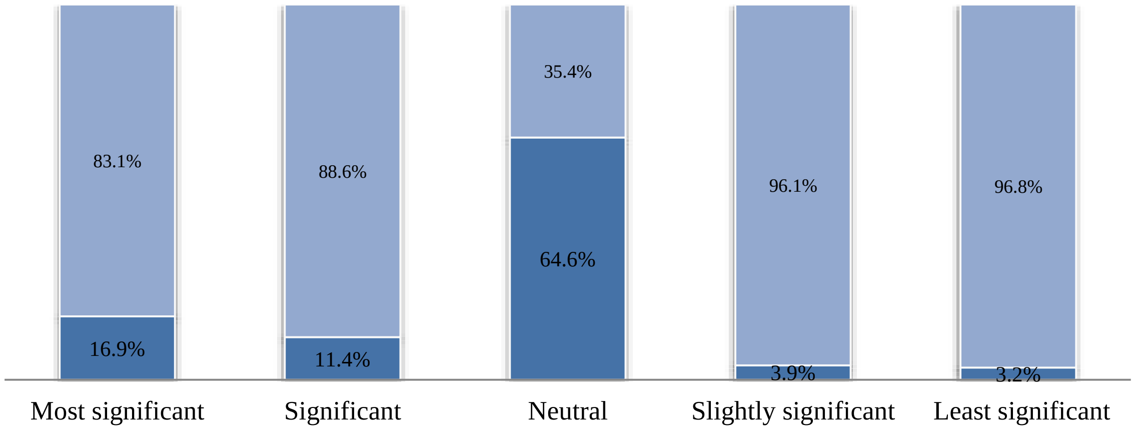

Figure 5.16: Frequency distribution of maintenance manuals and keys are often missing.

- **Ability for use the information across the design/construction team**

Slightly less than 52% of the respondents to the survey chose "significant" in response to the statement of ability to use the information across the design/construction team. The remainder was divided into three main parts: 21.1%, 15.6% and 10.1% for "slightly significant", "most significant" and "neutral", respectively (Figure 5.17).

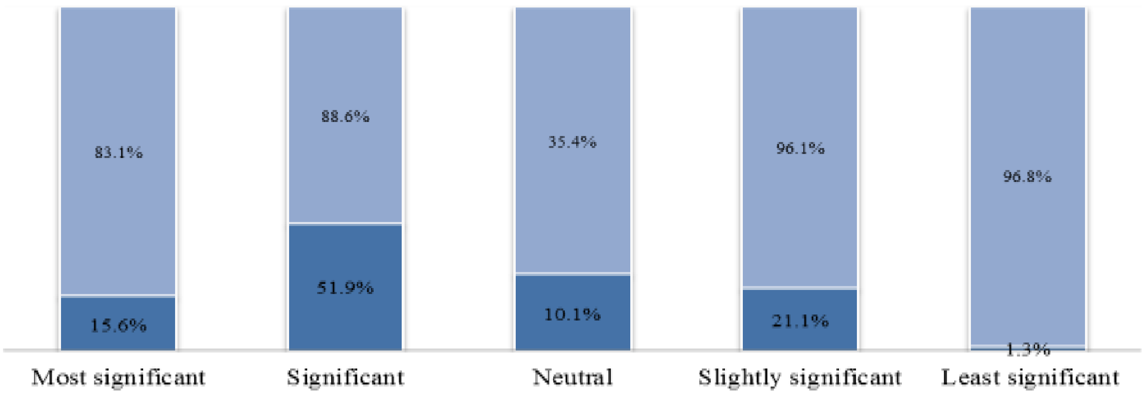

Figure 5.17: Frequency distribution of ability to use the information across the design/construction team

- **Actual handover process is often an Afterthought event**

A large number of respondents (52.3%) thought that handover process is an afterthought and there is a lack of proactive planning. Approximately 20.1% find that lack of proactive planning is a significant factor, as well as another 20.1% respondents who remained neutral in expressing their views (Figure 5.18).

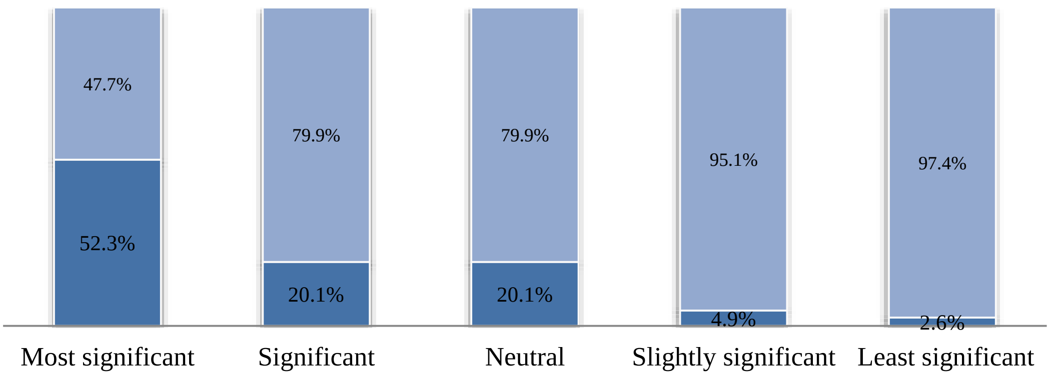

Figure 5.18: Frequency distribution of respondents' perception on building handover as being an afterthought process

5.5 Statistical associations

In order to see whether there is a significant association within those nine statements that related to the significant challenges to effective building handover practices, a series of ANOVA tests were carried out. The research specifically set out to test whether or not there is a significant difference between the groups at confidence level (95%). The statistical result shows that there were significant differences in the variables as shown in Table 5.2.

Table 5.2: Significant association (ANOVA) within the challenge to effective building handover practices

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F critical*
Rows	2.91E-11	8.00E+00	3.64E-12	1.42E-15	1.00E+00	2.24E+00
Columns	3.44E+04	4.00E+00	8.60E+03	3.35E+00	**2.1E-02**	2.67E+00
Error	8.21E+04	3.20E+01	2.56E+03			
Total	1.16E+05	4.40E+01				

However, in order to identify which of the means are significant (after a one-way ANOVA finds a significant difference in means) a Tukey test was applied in this study. The results showed that statistical relationships are found between majorities of variables, with exception of nine cases, as listed in Table 5.3.

Table 5.3: Significant relationships for the most significant challenge to effective building handover practices in the KSA public sector construction based on Tukey test

Comparison	Absolutely differences	Critical differences	Results
Societies not involved & Lack of transparency	0.156	0.231	Not Significantly Different
Societies not involved & Inappropriate quality assurance method	0.221	0.231	Not Significantly Different
Societies not involved	0.532	0.231	Means Significantly Different
Societies not involved & Not enough time for operations training	1.643	0.231	Means Significantly Different
Societies not involved & Responsibilities of various project team members are unclear	0.623	0.231	Means Significantly Different
Societies not involved & Maintenance manuals and keys are often missing	0.688	0.231	Means Significantly Different
Societies not involved & Ability to use the information across the design	0.468	0.231	Means Significantly Different
Societies not involved & Actual handover process is often event	0.266	0.231	Means Significantly Different
Lack of & Lack of transparency & Inappropriate quality assurance method	0.065	0.231	Not Significantly Different
Lack of transparency	0.377	0.231	Means Significantly Different
Lack of mutual trust & Lack of & Not enough time for operations training	1.487	0.231	Means Significantly Different
Lack of mutual trust & Responsibilities of various project team members are unclear	0.468	0.231	Means Significantly Different
Lack of mutual trust & Maintenance manuals and keys are often missing	0.532	0.231	Means Significantly Different
Lack of mutual trust & Ability to use the information across the design	0.312	0.231	Means Significantly Different
Lack of mutual trust & Actual handover process is often event	0.422	0.231	Means Significantly Different
Inappropriate quality assurance method & Lack of transparency	0.312	0.231	Means Significantly Different
Inappropriate quality assurance method & Not enough time for operations training	1.422	0.231	Means Significantly Different
Inappropriate quality assurance method & Responsibilities of various project team members are unclear	0.403	0.231	Means Significantly Different
Inappropriate quality assurance method & Maintenance manuals and keys are often missing	0.468	0.231	Means Significantly Different
Inappropriate quality assurance method & Ability to use the information across the design	0.247	0.231	Means Significantly Different
Inappropriate quality assurance method & Actual handover process is often event	0.487	0.231	Means Significantly Different
Lack of transparency & Not enough time for operations training	1.110	0.231	Means Significantly Different
Lack of transparency & Responsibilities of various project team members are unclear	0.091	0.231	Not Significantly Different
Lack of transparency & Maintenance manuals and keys are often missing	0.156	0.231	Not Significantly Different

Table 5.3: Continues…

Comparison	Absolutely differences	Critical differences	Results
Lack of transparency& Ability to use the information across the design	0.065	0.231	Not Significantly Different
Lack of transparency & Actual handover process is often event	0.799	0.231	Means Significantly Different
Not enough time for operations training& Responsibilities of various project team members are unclear	1.019	0.231	Means Significantly Different
Not enough time for operations training & Maintenance manuals and keys are often missing	0.955	0.231	Means Significantly Different
Not enough time for operations training & Ability to use the information across the design	1.175	0.231	Means Significantly Different
Not enough time for operations training & Actual handover process is often event	1.909	0.231	Means Significantly Different
Responsibilities of various project team members are unclear & Maintenance manuals and keys are often missing	0.065	0.231	Not Significantly Different
Responsibilities of various project team members are unclear & Ability to use the information across the design	0.156	0.231	Not Significantly Different
Responsibilities of various project team members are unclear & Actual handover process is often event	0.890	0.231	Means Significantly Different
Maintenance manuals and keys are often missing & Ability to use the information across the design	0.221	0.231	Not Significantly Different
Maintenance manuals and keys are often missing & Actual handover process is often event	0.955	0.231	Means Significantly Different
Ability to use the information across the design & Actual handover process is often event	0.734	0.231	Means Significantly Different

5.6 Relationship between key demographic questions with most significant challenges to effective building handover

This analysis was done to determine the relationship between key survey demographics (e.g. respondents' experience, organisation description and size of the organisation) with key factors. Also, an objective was to explore whether the statistical difference between expected and observed values was actually significant. The results obtained by the chi-square indicated that the P values were less than the significance level (0.05), in the majority of cases, with the exception of two cases (i.e. classify size of organisation and maintenance manuals and keys are often missing, and between type of organisation and actual handover process is often an afterthought event). This means that there is statistical association between all variables (Table 5.4).

Table 5.4: Chi-square statistic compares the dependent and independent variables

Variables	P-Value
Societies not involved/ Experience	0.000
Societies not involved/ Describe Org.	0.000
Societies not involved/ Classify size	0.000
Lack of mutual trust/ Experience	0.000
Lack of mutual trust/ Describe Org.	0.000
Lack of mutual trust/ Classify size	0.035
Inappropriate quality assurance method/ Experience	0.000
Inappropriate quality assurance method/ Describe Org.	0.000
Inappropriate quality assurance method/ Classify size	0.000
Lack of transparency of project data / Experience	0.000
Lack of transparency of project data / Describe Org.	0.000
Lack of transparency of project data / Classify size	0.000
Not enough time for operations training/ Experience	0.000
Not enough time for operations training/ Describe Org.	0.000
Not enough time for operations training/ Classify size	0.000
Responsibilities of various project team members are unclear/ Experience	0.000
Responsibilities of various project team members are unclear/ Describe Org.	0.000
Responsibilities of various project team members are unclear/ Classify size	0.000
Maintenance manuals and keys are often missing/ Experience	0.000
Maintenance manuals and keys are often missing/ Describe Org.	0.000
Maintenance manuals and keys are often missing/ Classify size	0.115
Ability to use the information across the design/ Experience	0.000
Ability to use the information across the design/ Describe Org.	0.000
Ability to use the information across the design/ Classify size	0.010
Actual handover process is often event/ Experience	0.000
Actual handover process is often event/ Describe Org.	0.990
Actual handover process is often event/ Classify size	0.000

5.7 Key benefits of effective building handover

Respondents were asked the importance of a listing of nine different benefits from their perspective. It is clear to see that the "most significant" was the largest group in general selection, in comparison with other benefits. It ranges between 16% (legislation and legal requirement) and slightly higher than 72% (minimizing defects). This is followed by choice of the "significant" option, with the highest percentage (63.3%) recorded at resource efficiency and driving out waste. The "least significant" was the smallest proportion of overall response. The most visible choice was selection of "Least Significant" by 6.5% respondents on relevance of Handover for "save time" choice (Table 5.5). The percentages of the "neutral" choice ranged from 10.1% (minimize defect and improve quality and client satisfaction) to 31.2% (save time).

Table 5.5: Percentage (%) of the most significant benefits of effective building handover in the KSA construction sector

	Most significant	Significant	Neutral	Slightly significant	Least significant
Minimize defects	72.1	15.6	10.1	1.3	1.0
Cost reduction	26.3	52.3	19.5	0.6	1.0
Improve quality and client satisfaction	62.3	27.6	8.8	0.6	0.6
Control construction process	26.6	50.6	3.2	16.6	2.9
Save time	46.8	15.6	31.2	1.6	4.9
Legislation and legal requirements	15.6	51.9	1.0	27.6	1.0
Stakeholders influence	44.2	26.6	25.3	1.6	1.3
Resource efficiency and driving out waste	15.6	60.4	21.1	1.3	1.6
Moral and ethical obligations	15.6	60.0	21.1	1.3	1.6

- **Minimization of Defects as Handover Benefit**

Frequency distribution of the "minimize defect" option is shown in Figure 5.19. Most of the respondents (72.1%) selected the "Most Significant" option. This was followed by slightly less than 16% selecting the "significant" option, followed by slightly higher than 10% selecting "Neutral". The remaining 2.3% opted for the "slightly significant"

(1.3%) and "least significant" (1%) options. Thus, minimization of potential defects through effective building handover is seen as an important benefit of effective building handover within the KSA construction sector (Figure 5.19).

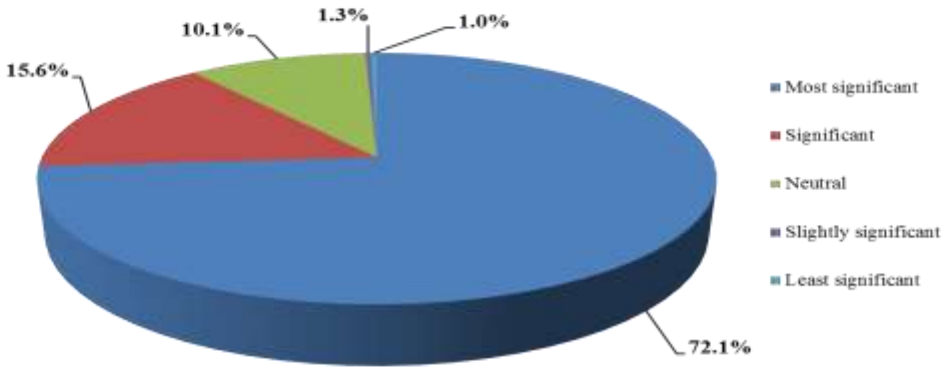

Figure 5.19: Frequency distribution of "minimize defect".

- **Cost reduction**

The largest percentage 52.3% (Figure 5.20) of those who responded on this statement selected the "significant" option, followed by slightly less than 27% ("most significant"), followed by slightly less than 19.5% ("Neutral"). Thus, remaining respondents (less than 2.0%) were split between least significant (1.0%) and slightly significant (0.6%) options.

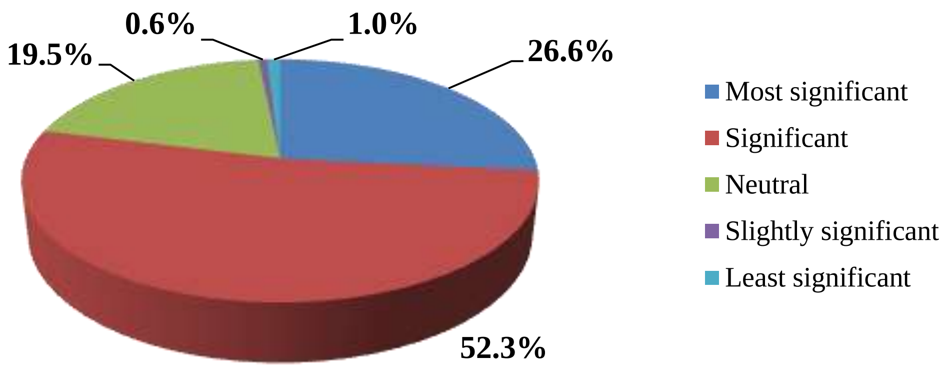

Figure 5.20: Frequency distribution of "cost reduction".

- **“Improved quality and client satisfaction” through Effective Building Handover**

Approximately two-thirds of the respondents (308) opted for the “most significant” option, followed by slightly less than 28% selecting the “significant” option, and slightly less than 9.0% opting for “neutral”. The remaining 1.2% was distributed between slightly significant (0.6%) and least significant (0.6%) options (Figure 5.21).

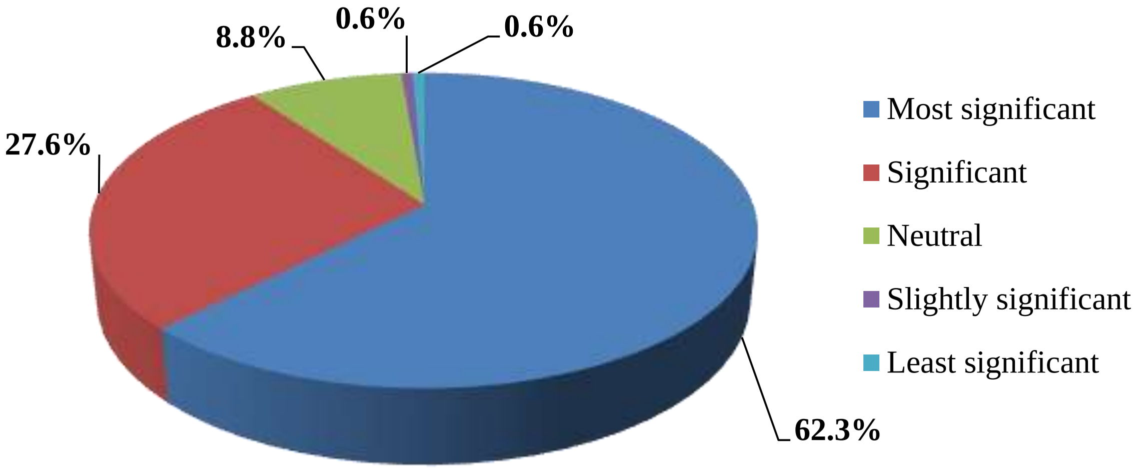

Figure 5.21: Frequency distribution of” improve quality and client satisfaction”.

- **Control construction process**

For the control construction process, it clear to see that the largest group (50.6%) opted for the “significant” option, followed by approximately 27% and 17% of the respondent population selecting the “most significant” and “slightly significant” options, respectively. Only 3.2% and 2.9% of the employees who responded to the survey selected the “neutral” and “least significant” options, respectively (Figure 5.22)

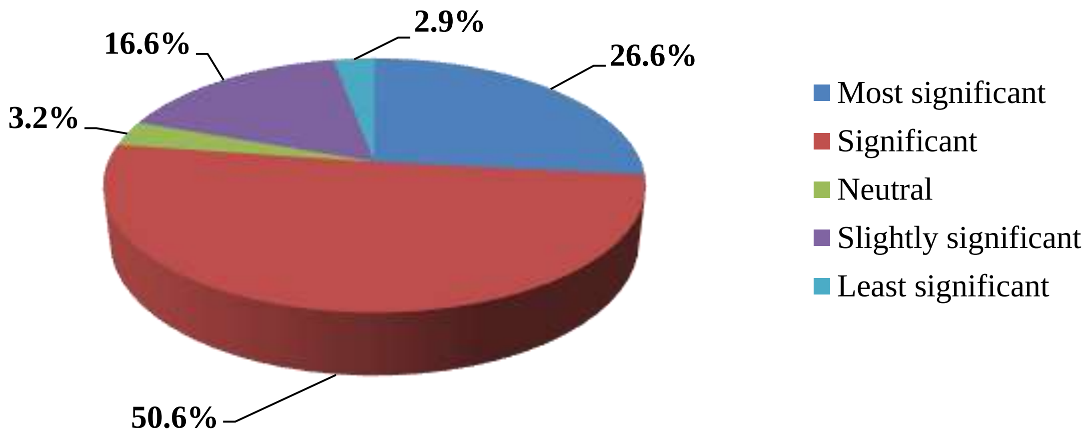

Figure 5.22: Frequency distribution of "control construction process".

- **"Save time" through Effective Building Handover**

For the "save time" as a significant benefit of effective building handover in the KSA construction sector, it is clear to see that (Figure 5.23) the respondents were distributed among all the options, ranging from 1.6% (slightly significant) to slightly less than 47% opting for the "most significant" option. Approximately one third of employees who responded to the survey on this statement were neutral, with about 16% selecting "significant" and the remaining 4.9% of employees who responded to the survey opting for the "least significant" option.

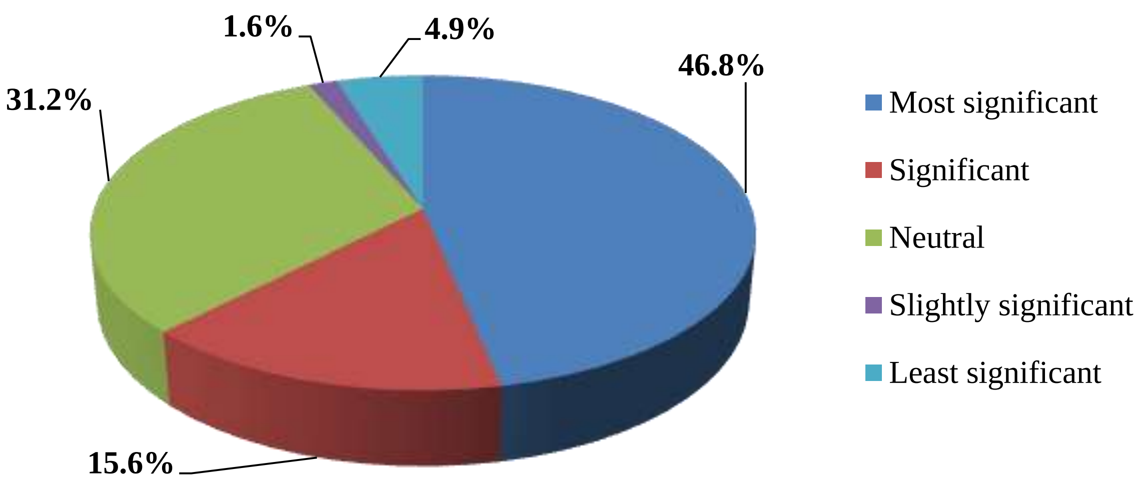

Figure 5.23: Frequency distribution of "save time"

- **Legislation and legal requirements**

For the statement of legislation and legal requirement, the respondents were mainly distributed between the "significant" (51.9%), "slightly significant" (27.6%) and "most significant" (15.6%) options. The remaining 2.0% of employees who responded to the survey were divided into 1% for "neutral" and 1% for "least significant" (Figure 5.24).

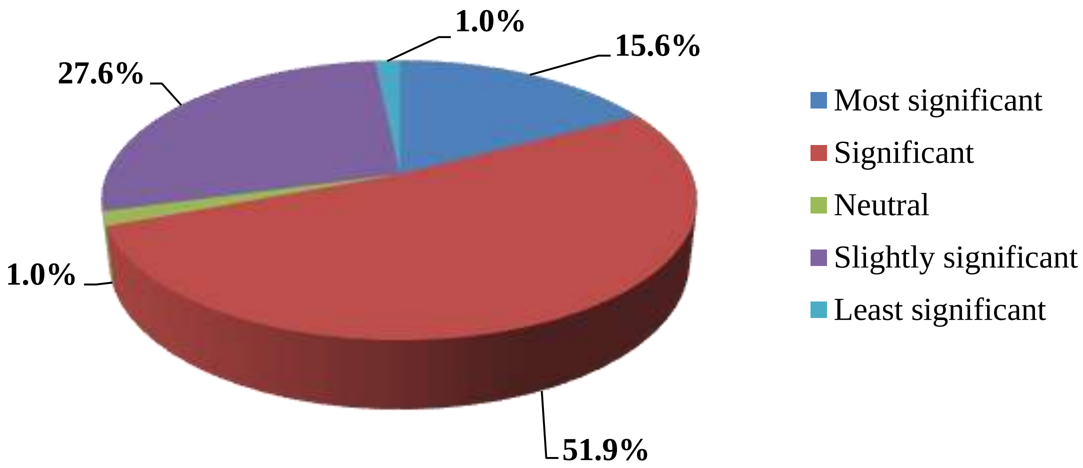

Figure 5.24: Frequency distribution of legislation and legal requirements

- **"Improving Stakeholders influence" as benefit of effective Building Handover**

The result of this statement was somewhat different (Figure 5.25), where slightly higher than 44% of survey respondents selected the "most significant" option and about 51% of respondents split into "significant" (26%) and "neutral" (25.3%) options. The remaining 2.9% of employees who responded to the survey opted for the "slightly significant" (1.6%) and "least significant" (1.3%) options.

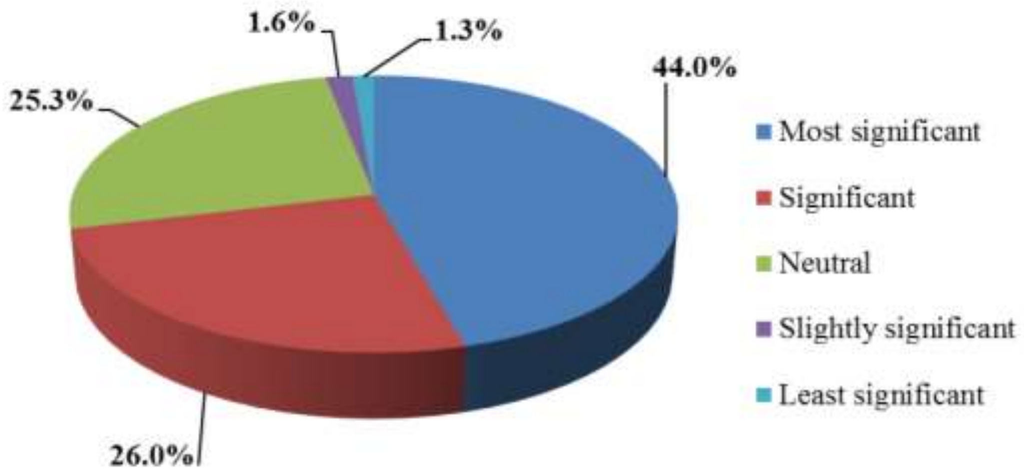

Figure 5.25: Frequency distribution of "Stakeholders influence"

- **"Resource efficiency and driving out waste"**

In the responses to this statement, approximately two-thirds of the survey respondents opted for "significant", followed by 21.1% and 15.6% of respondents selecting "neutral" and "most significant", respectively (Figure 5.26). The remaining was similar to the previous statement, where 1.3% of employees who responded to the survey selected "slightly significant" and 1.6% selected "least significant".

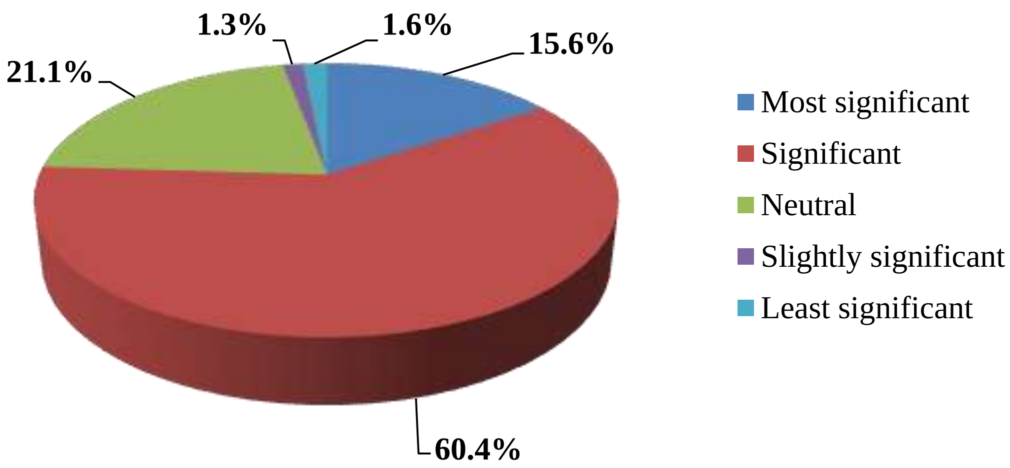

Figure 5.26: Frequency distribution of "resource efficiency and driving out waste".

- **Moral and ethical obligation**

Slightly higher than 60% of survey respondents opted for "significant", followed by "neutral" and "most significant" (21.1% and 15.6%, respectively) (Figure 5.27). The remaining 1.6% and 1.3% of employees who responded to the survey selected "least significant" and "slightly significant", respectively.

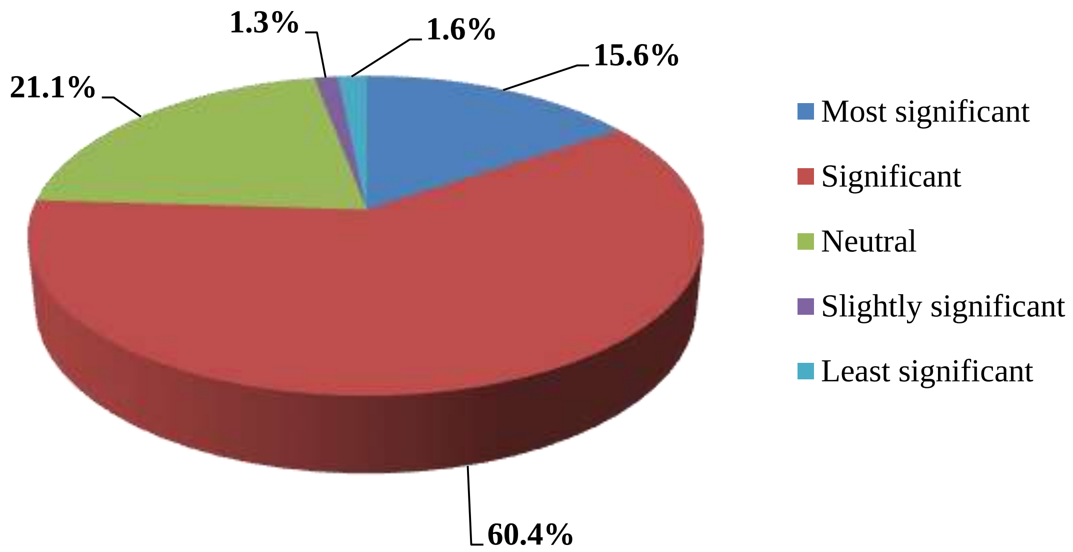

Figure 5.27: Frequency distribution of "moral and ethical obligation" as key benefit of achieving effective building handover

5.8 Statistical significant relationships of the following benefits of effective building handover in the KSA construction sector.

A key aspect of the respondents' profile was further analysed carefully in this section to establish any relationships between the following benefits of effective building handover in the KSA construction sector and their importance: minimize defects, cost reduction, improve quality and client satisfaction, control construction process, save time, legislation and legal requirements, stakeholders influence, resource efficiency and driving out waste, moral and ethical obligations. A series of ANOVA tests were carried out to test whether there was a relationship between the variables.

The research specifically set out to test whether or not there is a significant difference between the groups at confidence level (95%). The statistical result shows that there were significant differences in the variables, as shown in Table 5.6.

Table 5.6: Significant association within the challenge to effective building handover practices (ANOVA)

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F critical*
Rows	5.82E-11	8	7.28E-12	2.63E-15	1	2.244396
Columns	88912.36	4	22228.09	8.043233	**0.000132**	2.668437
Error	88434.44	32	2763.576			
Total	177346.8	44				

However, in order to identify which of the means are significant (after a one-way ANOVA finds a significant difference in means) a Tukey test was applied in this study. Moreover, the results showed that statistical relationships are found between majorities of variables with exception of nine of whole (36) cases, as listed in Table 5.7.

Table 5.7: Significant associations of the significant benefits of effective building handover in the KSA construction sector based on Tukey test

	Comparison	Absolutely Diff.	Critical Diff.
Minimize defects & Coast reduction	0.643	0.221	Means Significantly Different
Minimize defects & improve quality	0.217	0.221	Not Significantly Different
Minimize defects & control construction process	0.765	0.221	Means Significantly Different
Minimize defects & save time	0.736	0.221	Means Significantly Different
Minimize defects & legal requirements	1.130	0.221	Means Significantly Different
Minimize defects & stakeholder influence	0.502	0.221	Means Significantly Different
Minimize defects &Resource efficiency	0.762	0.221	Means Significantly Different
Minimize defects & Ethical obligation	1.134	0.221	Means Significantly Different
Cost reduction &Improve quality	0.426	0.221	Means Significantly Different
Cost reduction & control construction process	0.123	0.221	Not Significantly Different
Cost reduction & save time	0.094	0.221	Not Significantly Different
Cost reduction & legal requirements	0.487	0.221	Means Significantly Different
Cost reduction & stakeholder influence	0.141	0.221	Not Significantly Different
Cost reduction &Resource efficiency	0.119	0.221	Not Significantly Different
Cost reduction & Ethical obligation	0.491	0.221	Means Significantly Different
Improve quality &Control construction process	0.549	0.221	Means Significantly Different
Improve quality & save time	0.520	0.221	Means Significantly Different
Improve quality & legal requirements	0.913	0.221	Means Significantly Different
Improve quality & stakeholder influence	0.285	0.221	Means Significantly Different
Improve quality &Resource efficiency	0.545	0.221	Means Significantly Different
Improve quality & Ethical obligation	0.917	0.221	Means Significantly Different
Control construction process & Save time	0.029	0.221	Not Significantly Different
Control construction process & legal requirements	0.365	0.221	Means Significantly Different
Control construction process stakeholder influence	0.264	0.221	Means Significantly Different
Control construction process &Resource efficiency	0.004	0.221	Not Significantly Different
Control construction process & Ethical obligation	0.368	0.221	Means Significantly Different
Save time & Legal requirements	0.394	0.221	Means Significantly Different
Save time & stakeholder influence	0.235	0.221	Means Significantly Different
Save time &Resource efficiency	0.025	0.221	Not Significantly Different
Save time & Ethical obligation	0.397	0.221	Means Significantly Different

Table 5.7 Continues…

	Comparison	Absolutely Diff.	Critical Diff.
Legal requirements & Stakeholder influence	0.628	0.221	Means Significantly Different
Legal requirements & Resource efficiency	0.368	0.221	Means Significantly Different
Legal requirements & Ethical obligation	0.004	0.221	Not Significantly Different
Stakeholders influence & Resource efficiency	0.260	0.221	Means Significantly Different
Stakeholders influence & Ethical obligation	0.632	0.221	Means Significantly Different
Resource efficiency & Ethical obligation	0.372	0.221	Means Significantly Different

Relationships between Respondents' experiences, organisation types and classify size of the organisation with the significant benefits of effective building handover in the KSA construction sector.

The objective was to investigate whether there is a significant association between "experience", "describes organisation" and "classify size of the organisation" with the significant benefits of effective building handover in the KSA construction sector (minimize defects, cost reduction, improve quality and client satisfaction, control construction process, save time, legislation and legal requirements, stakeholders influence, resource efficiency and driving out waste, and moral and ethical obligations), and also to decide whether there is an significant difference between expected and observed values. The obtained results by chi-square show that P-values are less than the significance level, which is (0.05), in all cases; this means that there are statistical association between all variables (Table 5.8).

Table 5.8: Chi-square statistic compares the dependent and independent variables

Variables	P-Value
Experience & Minimize defects	0.000
Experience & Cost reduction	0.000
Experience & Improve quality	0.000
Experience & Control construction process	0.000
Experience & Save time	0.000
Experience & Legislation	0.000
Experience & Stakeholders influence	0.000
Experience & Resource efficiency	0.000
Experience & Moral and ethical obligations	0.000
Describes organisation & Minimize defects	0.000
Describes organisation & Cost reduction	0.000
Describes organisation & Improve quality	0.000
Describes organisation & Control construction process	0.000
Describes organisation & Save time	0.001
Describes organisation & Legislation	0.002
Describes organisation & Stakeholders influence	0.003
Describes organisation & Resource efficiency	0.000
Describes organisation & Moral and ethical obligations	0.001
Classify size & Minimize defects	0.620
Classify size & Cost reduction	0.002
Classify size & Improve quality	0.003
Classify size & Control construction process	0.000
Classify size & Save time	0.001
Classify size & Legislation	0.001
Classify size & Stakeholders influence	0.000
Classify size & Resource efficiency	0.001
Classify size & Moral and ethical obligations	0.003

Importance of the following project data at the handover stage

This question was asked about the importance of different types of project data at the handover stage. It is clear to see that, the “most important” was the largest group in general, in response to this statement (Table 5.9).

Table 5.9: Frequencies distribution (%) of importance of the project data at the handover stage

	Most significant	Significant	Neutral	Slightly significant	Latest significant
Commission plans	26.3	22.1	0.6	30.8	20.1
Building drawings specification	51.9	15.6	31.2	0.6	0.6
Insurance	37.0	31.8	18.8	11.0	1.0
Manufacturer products data	66.6	7.5	24.0	1.0	1.0
Quality Control documents	35.7	61.7	0.6	1.0	1.0
Operations and Maintenance	50.0	11.0	37.7	0.6	0.6
Equipment lists	35.1	22.1	11.0	31.2	0.6
Daily reports	48.7	27.6	1.0	1.6	21.1

"Most important" ranged between 35.7% at quality control documents and slightly higher than 66.6% at manufacturer products data. This is followed by "significant" with the highest percentage (61.7%) recorded at quality control documents. The "least significant" was the smallest proportion with the highest at daily reports (21.1%) and at commission plans (20.1%; Table 5.9).

This aspect of the respondents' profile will be further analysed carefully in this section to establish any relationships between the following project data at the handover stage. In order to see if there is a significant association within the variables (Table 5.10), a series of ANOVA tests were carried out to test whether there was a relationship between the variables. Specifically, the research set out to test whether or not there is a significant difference between the groups at confidence level (95%). The statistical result shows that there were significant differences in the variables.

Table 5.10: Significant association (ANOVA) within the importance of the project data at the handover stage

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F critical*
Rows	70054.4	4	17513.6	7.927883	0.0002	2.7140758
Columns	0.2	7	0.025	1.13E-05	1	2.3592599
Error	61855.2	28	2209.114			
Total	131909.8	39				

In order to identify which of the means are significant (after a one-way ANOVA finds a significant difference in means), a Tukey test was applied in this study. Moreover, the results showed that there were no any significant differences between the variables that have been listed in Table 5.11.

Table 5.11: Significant associations of the significant benefits of importance of the project data at the handover stage based on Tukey test

	Comparison	Absolutely Diff.	Critical Diff.
Commission plans & Building drawings	1.182	0.255	Means Significantly Different
Commission plans & Insurance	0.877	0.255	Means Significantly Different
Commission plans & Manufacturer products data	1.364	0.255	Means Significantly Different
Commission plans & Quality Control documents	1.318	0.255	Means Significantly Different
Commission plans & Operations	1.097	0.255	Means Significantly Different
Commission plans & Equipment lists	0.584	0.255	Means Significantly Different
Commission plans & Daily reports	0.841	0.255	Means Significantly Different
Building drawings & Insurance	0.305	0.255	Means Significantly Different
Building drawings & Manufacturer products data	0.182	0.255	Not Significantly Different
Building drawings & Quality Control documents	0.136	0.255	Not Significantly Different
Building drawings & Operations	0.084	0.255	Not Significantly Different
Building drawings & Equipment lists	0.597	0.255	Means Significantly Different
Building drawings & Daily reports	0.341	0.255	Means Significantly Different
Insurance & Manufacturer products data	0.487	0.255	Means Significantly Different
Insurance & Quality Control documents	0.442	0.255	Means Significantly Different
Insurance & Operations	0.221	0.255	Not Significantly Different
Insurance & Equipment lists	0.292	0.255	Means Significantly Different
Insurance & Daily reports	0.036	0.255	Not Significantly Different
Manufacturer products data & Quality Control documents	0.045	0.255	Not Significantly Different
Manufacturer products data & Operations	0.266	0.255	Means Significantly Different
Manufacturer products data & Equipment lists	0.779	0.255	Means Significantly Different
Manufacturer products data & Daily reports	0.523	0.255	Means Significantly Different
Quality Control documents & Operations	0.221	0.255	Not Significantly Different
Quality Control documents & Equipment lists	0.734	0.255	Means Significantly Different
Quality Control documents & Daily reports	0.477	0.255	Means Significantly Different
Operations & Equipment lists	0.513	0.255	Means Significantly Different
Operations & Daily reports	0.256	0.255	Means Significantly Different
Equipment lists & Daily reports	0.256	0.255	Means Significantly Different

Which of the following could be affected most by the building handover process?

This question asked about the most affected parameters (listed in Table 5.12) of the building handover process. It is clear to see that "most important" was the largest group in response to this statement, with an average of 60.5%. It ranges between 35.7% (Reliability of equipment) and slightly higher than 93% (Cost of operations) of the total respondents to the survey of the statement. This is followed by "significant" with an average of 22%, ranging from only 6.5% at cost of operations to about 33% at Reliability of equipment. The "slightly significant" was the smallest proportion with the highest (21.1%) at cost of maintenance (21.1%; Table 5.12).

Table 5.12: Percentage (%) of the factors that have most affected by the building handover process

	Most significant	Significant	Neutral	Slightly significant	Least significant
Health and safety	42.21	32.14	15.58	10.06	0.00
Reliability of equipment	35.71	33.12	31.17	0.00	0.00
Standard of operations	62.34	31.17	6.49	0.00	0.00
Cost of operations	93.51	6.49	0.00	0.00	0.00
Cost of maintenance	68.83	10.06	0.00	21.10	0.00

The aspect of the respondents' profile will be further analysed carefully in this section to establish any relationships between the factors that are most affected by the building handover process. As well as, in order to identify whether there is a significant association through the variables (Table 5.13), a series of ANOVA tests were carried out. Specifically, the research set out to test whether there is a significant difference or not between the groups at confidence level (95%). The result shows that there were not any significant differences between the variables, that have been listed in Table 5.13, with a p-value higher than 0.05.

Table 5.13: Significant association within the of the factors that have most affected by the building handover process

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F critical*
Rows	106229.3	4	26557.3	12.26402	0.0009	3.006
Columns	0.16	4	0.04	1.84E-05	0.999	3.006
Error	34658.2	16	2166.1			
Total	140887.8	24				

To what extent do you disagree or agree with the following statements of the benefits of using BIM

The question was set to analyse the nine sub-questions: better planning, cost savings, information at every stage, better use of resources, time saving, following international standards, sustainability, lifecycle costing and management of energy consumption (Table 5.14). It is clear to see that "agree" was the largest group that responded to these statements, it ranged from 62% (management of energy consumption) to 100% of the whole (308) respondents who took the survey on lifecycle costing. However, it is clear to see that the great importance of both lifecycle costing and time savings to the benefits of using BIM (Figure 5.28).

Table 5.14: Frequency distribution of the benefits of using BIM

	Agree	%	Disagree	%
Better planning	243	78.9	65	21.1
Information at every stage	288	93.5	20	6.5
Better use of resources	239	77.6	69	22.4
Cost savings	280	91.0	28	9.0
Time savings	303	98.4	5	1.6
Following internet standards	257	83.4	51	16.6
Sustainability	212	68.8	96	31.2
Life cycle costing	308	100.0	0	0.0
Management of energy consumption	192	62.3	116	37.7

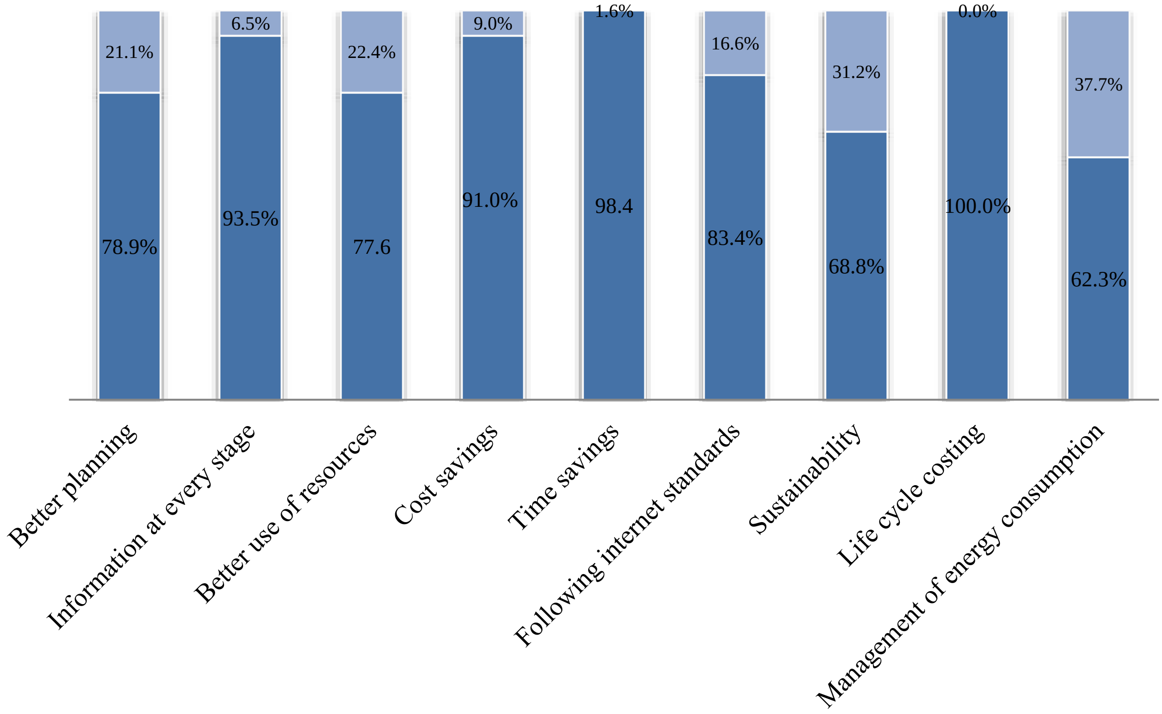

Figure 5.28: Frequency distribution of the benefits of using BIM

5.9 The importance of the following benefits of BIM in the KSA

This section analyses the findings from the eleven sub-questions that have been presented in the question above. Data shows that the option of “most significant” with the total options of this statement had the largest portion ranged between about 35% (improve asset management) and slightly less than 84% (enhanced information), with an average of about 48% of the whole (308) respondents who took this survey. This is followed by “significant”, with an average of 25.6% and a range from only 3.9% at “easy access to project data” to 59.4% at “better tracking of installation and testing” (Table 5.15).

Table 5.15: Percentage (%) of the benefits of (BIM) in the KSA construction sector

	Most significant	Significant	Neutral	Slightly significant	Least significant
Reduced labour	35.39	13.96	9.42	37.01	4.22
Improved integrated design process	35.06	24.68	36.36	1.62	2.27
Better tracking of installation and	35.39	59.42	1.62	1.95	1.62
Enhanced information	83.77	11.69	1.30	1.95	1.30
Encourages the integration	45.45	49.68	1.62	1.30	1.95
Easy access to project data	58.44	3.90	34.42	1.62	1.62
Increase speed	44.48	15.58	1.62	33.12	5.19
Improve asset management	35.71	26.62	10.06	21.10	6.49
Efficient project management	49.68	21.10	21.10	6.49	1.62
Better collaboration owner/design firm	58.44	21.10	16.56	2.27	1.62
Effective communication	53.57	33.12	10.06	2.60	0.65
Reduction in error					

This aspect of the respondents' profile will be further analysed carefully in this section to establish any relationships between the factors that are most affected by the building handover process. So as to know if there is a significant association through the variables, an ANOVA test was carried out to test whether there was a relationship between the variables. Specifically, the research set out to examine whether there is a significant difference or not between the groups at confidence level (95%). The result shows that, there were significant differences within the variables (Table 5.16).

Table 5.16: Shows the Significant association within benefits of BIM in Saudi Arabia construction sector (ANOVA)

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F critical*
Rows	-2.32E-10	11	-2.116E-11	-1.06E-14		2.01404
Columns	134916.2	4	33729.058	17.03406	**0.000**	2.58366
Error	87124.16	44	1980.0946			
Total	222040.4	59				

In order to state which means are significant (after a on-way ANOVA finds a significant difference in means), a Tukey test was applied in this study. Moreover, the results showed that statistically significant relationships are found between 69% of the variables of whole (55) cases, as listed in Table 5.17.

Table 5.17: Significant associations of the important benefits of BIM in the KSA

	Comparison	Absolutely Diff.	Critical Diff.
Reduced labour & Improved integrated design process	0.487	0.242	Means Significantly Different
Reduced labour & Better tracking of installation	0.864	0.242	Means Significantly Different
Reduced labour & Enhanced information	1.396	0.242	Means Significantly Different
Reduced labour & Encourages the integration	0.974	0.242	Means Significantly Different
Reduced labour & Easy access to project data	0.753	0.242	Means Significantly Different
Reduced labour& Increase speed	0.221	0.242	Not Significantly Different
Reduced labour & Improve asset management	0.065	0.242	Not Significantly Different
Reduced labour & Efficient project management	0.146	0.242	Not Significantly Different
Reduced labour & Effective communication	0.964	0.242	Means Significantly Different
Reduced labour & Reduction in Error	0.974	0.242	Means Significantly Different
Improved integrated design process	0.377	0.242	Means Significantly Different
Improved integrated design process	0.909	0.242	Means Significantly Different
Improved integrated design process	0.487	0.242	Means Significantly Different
Improved integrated design process	0.266	0.242	Means Significantly Different
Improved integrated design process	0.266	0.242	Means Significantly Different
Improved integrated design process	0.552	0.242	Means Significantly Different
Improved integrated design process	0.341	0.242	Means Significantly Different
Improved integrated design process	0.477	0.242	Means Significantly Different
Improved integrated design process	0.487	0.242	Means Significantly Different
Better tracking of installation	0.532	0.242	Means Significantly Different
Better tracking of installation	0.110	0.242	Not Significantly Different
Better tracking of installation	0.110	0.242	Not Significantly Different
Better tracking of installation	0.643	0.242	Means Significantly Different
Better tracking of installation	0.929	0.242	Means Significantly Different
Better tracking of installation	0.718	0.242	Means Significantly Different
Better tracking of installation	0.101	0.242	Not Significantly Different
Better tracking of installation	0.110	0.242	Not Significantly Different
Enhanced information	0.422	0.242	Means Significantly Different
Enhanced information	0.643	0.242	Means Significantly Different
Enhanced information	1.175	0.242	Means Significantly Different
Enhanced information	1.461	0.242	Means Significantly Different
Enhanced information	1.250	0.242	Means Significantly Different

Table 5.17: Continues…

	Comparison	Absolutely Diff.	Critical Diff.
Enhanced information	0.432	0.242	Means Significantly Different
Enhanced information	0.422	0.242	Means Significantly Different
Encourages the integration	0.221	0.242	Not Significantly Different
Encourages the integration	0.753	0.242	Means Significantly Different
Encourages the integration	1.039	0.242	Means Significantly Different
Encourages the integration	0.828	0.242	Means Significantly Different
Encourages the integration	0.010	0.242	Not Significantly Different
Encourages the integration	0.000	0.242	Not Significantly Different
Easy access to project data	0.532	0.242	Means Significantly Different
Easy access to project data	0.818	0.242	Means Significantly Different
Easy access to project data	0.607	0.242	Means Significantly Different
Easy access to project data	0.211	0.242	Not Significantly Different
Easy access to project data	0.221	0.242	Not Significantly Different
Increase speed	0.286	0.242	Means Significantly Different
Increase speed	0.075	0.242	Not Significantly Different
Increase speed	0.744	0.242	Means Significantly Different
Increase speed	0.753	0.242	Means Significantly Different
Improve asset management	0.211	0.242	Not Significantly Different
Improve asset management	1.029	0.242	Means Significantly Different
Improve asset management	1.039	0.242	Means Significantly Different
Efficient project management	0.818	0.242	Means Significantly Different
Efficient project management	0.828	0.242	Means Significantly Different
Effective communication & Reduction in Error	0.010	0.242	Not Significantly Different

The development of IT facilitates the integration of different and multiple sets of data and increase efficiency.

The question has been set to see how the respondents agree with the statement "the development of Information Technology facilitates the integration of different and multiple sets of data and increase efficiency". It is clear to see that "strongly agree" and "agree" were the largest groups that responded to these statements, with 54.5% and 39.3%, respectively. The remaining (slightly higher than 6%) respondents who took the survey are distributed between "disagree" (3.2%), "strongly disagree" (1.9%) and "neither agree nor disagree" (1.0%; Figure 5.29).

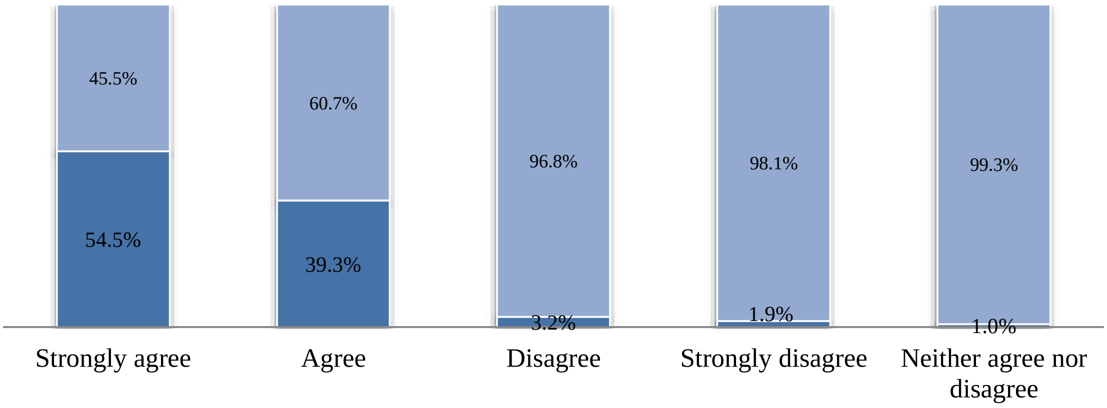

Figure 5.29: Frequency distribution of the development of Information Technology facilitates

How would you assign most responsibility for building information handover to each of the following parties?

This question is related to the assigning of responsibility for building information handover to each of the following parties. A large percentage (57%) of the respondents thought the owner is the most responsible for building information handover, with slightly less than 37% saying that the contractor is the most responsible for building information handover (Figure 5.30). The remaining (6.5%) of the respondents thought that the designer is the most responsible for building information handover.

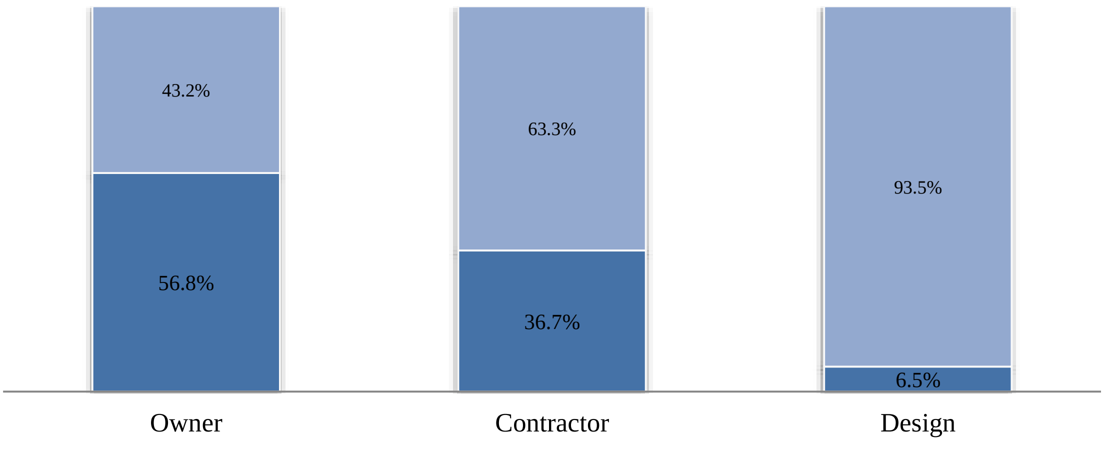

Figure 5.30: Frequency distribution of the responsibility for building information handover to each of the following parties

Do you get the necessary information about the process of projects at every stage of operation?

For the statement about the necessary and essential information about the process of project at each stage of operation, Figure 5.31 indicates that slightly less than 21% of the whole respondents (308) believed that getting all information about the process of project at each stage of project operation is necessary.

Is the facility maintenance outsourced or do you perform this function in-house?

According to Figure 5.31, slightly higher than 72%, of the whole respondents (308) believed that facility maintenance is performed via outsourcing, while about 28% stated that this function is performed in-house.

For operations and maintenance of key equipment and facilities, what sort of services you perform?

The sort of services (preventive, reactive, and predictive) that the employees perform for operations and maintenance of key equipment and facilities is shown in Figure 5.31. Data shows that about two-thirds of the respondents performed preventative services followed by slightly higher than 33% of them preforming predictive services. The remaining (4.6%) (Figure 5.31) they performed reactive services for operations and maintenance of key equipment and facilities.

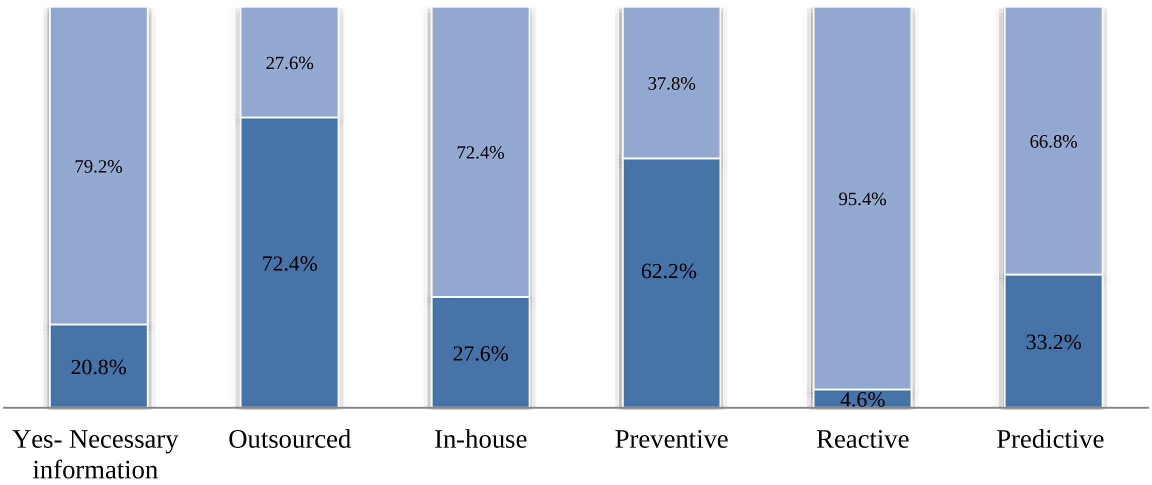

Figure 5.31: Frequency distribution of operations and maintenance of key equipment and facilities

Do you have easy access to all construction drawings, which are revised and updated?

According to the "access to all construction drawings, which are revised and updated" question, about 69% of the respondents to the survey stated that they have easy access to all construction drawings, which are revised and updated (Figure 5.32), with the remaining 31% stating no.

Have you got drawings to indicate location of your key Mechanical, Plumbing and Electrical Installations?

With respect to the availability of drawings to indicate locations of the key mechanical, plumbing and electrical installations, approximately 83% of the whole respondents' answer was no, with only less than 17% saying yes (Figure 5.32).

Do you track energy consumption and perform energy benchmarking?

For the following energy consumption and perform energy benchmarking, data showed that the majority (62.3%) of the employees who responded to the survey said no, with the smallest percentage (37.7%) saying yes (Figure 5.32).

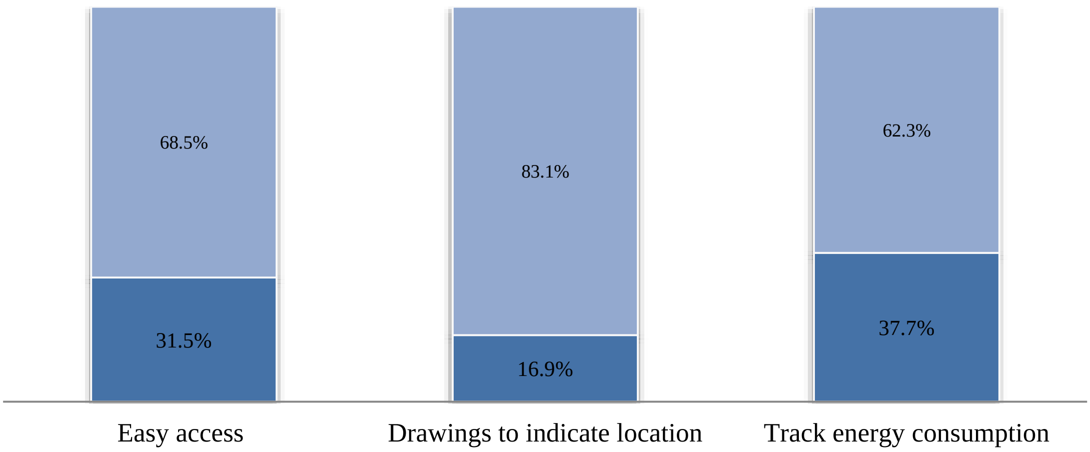

Figure 5.32: Frequency distribution of easy access, drawings to indicate location and track energy consumption

Do you have easy access to all documents below?

This question asked about the possibility access to a number of important documents (listed in Table 5.18). It is obvious to see that responses about these documents were different between yes and not from case to case. Approximately two-thirds of the employees who responded to the survey answered no, where about 31.5% of the employees who responded to the statement of specifications answered yes. Slightly less than 28% and slightly more than 16% of the employees answered yes for both statements of emergency management plans and warranty information, respectively.

Table 5.18: A number of the possibility of easy access to all documents

Important documents	Yes	No
Specifications	97	211
Warranty information	50	258
Service contracts	205	103
Spare parts data	21	287
Equipment Purchase Dates	9	299
Emergency Management Plans	86	222

The data shows that only 6.8% of the employees who responded to the statement of spare parts data answered yes, with majority (97.3%) of the employees answered no for the statement of equipment purchase dates (Figure 5.33).

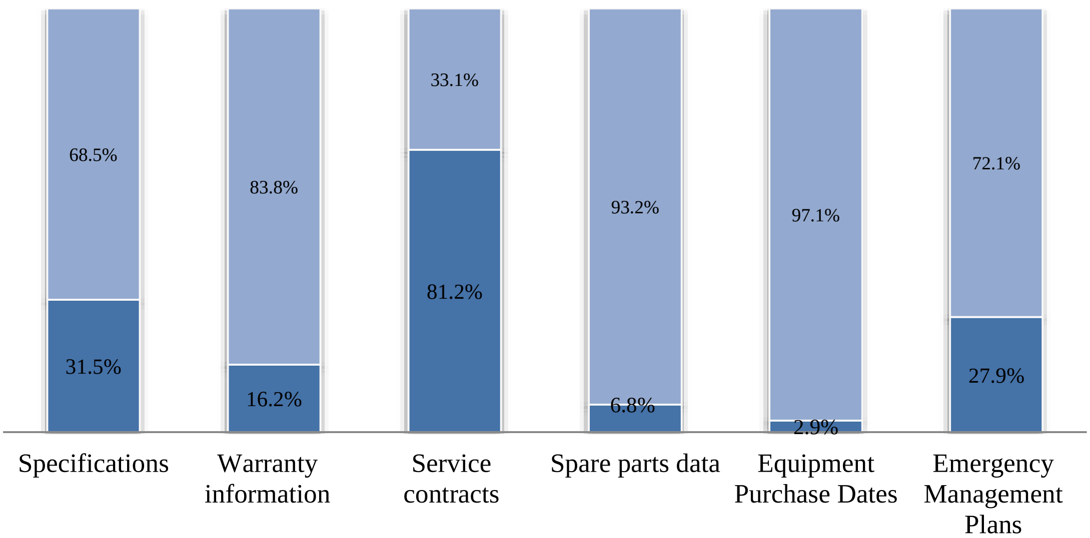

Figure 5.33: Distribution of investments

This aspect of the respondents' profile will be further analysed carefully in this section to establish any relationships between the possibilities of access to some documents as listed in Table 5.19.

So as to know if there is a significant association through the variables, a series of ANOVA were carried out. Specifically, the research set out to examine whether there is a significant difference or not between the groups at confidence level (95%). The result shows that there were significant differences within the variables (Table 5.19).

Table 5.19: The Significant association within the possibility of easy access to all documents (ANOVA)

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F critical*
Between Groups	95.8	8.0	11.977	75.7	0.000	1.9
Within Groups	436.6	2763.0	0.158			
Total	532.5	2771.0				

In order to identify which of the means are significant (after a one-way ANOVA finds a significant difference in means), a Tukey test was applied in this study (Table 5.17). Moreover, the results showed that statistically significant differences are found between easy access & service contracts, easy access & equipment purchase dates, drawings to indicate location & service contracts, track energy consumption & spare parts data, track energy consumption & equipment purchase dates, specifications & service contracts, specifications & equipment purchase dates, warranty information & service contracts, service contracts & spare parts data, service contracts & equipment, and between service contracts & emergency (Table 5.20).

Table 5.20: Significant associations of the possibility of easy access to all documents based on Tukey test

Comparison	Absolutely Diff.	Critical Diff.	Critical Diff.
Specifications & Warranty information	0.153	0.307	Not Significantly Different
Specifications & Service contracts	0.357	0.307	Means Significantly Different
Specifications & Spare parts data	0.247	0.307	Not Significantly Different
Specifications & Equipment Purchase Dates	0.312	0.307	Means Significantly Different
Specifications & Emergency Management Plans	0.036	0.307	Not Significantly Different
Warranty information & Service contracts	0.510	0.307	Means Significantly Different
Warranty information & Spare parts data	0.094	0.307	Not Significantly Different
Warranty information & Equipment Purchase Dates	0.159	0.307	Not Significantly Different
Warranty information & Emergency Management Plans	0.117	0.307	Not Significantly Different
Service contracts &Spare parts data	0.604	0.307	Means Significantly Different
Service contracts & Equipment	0.669	0.307	Means Significantly Different
Service contracts & Emergency	0.393	0.307	Means Significantly Different
Spare parts data &Equipment	0.065	0.307	Not Significantly Different
Spare parts data &Emergency	0.211	0.307	Not Significantly Different
Equipment Purchase Dates & Emergency	0.276	0.307	Not Significantly Different

How do you plan facility budget for operation and management? Please tick if following processes are included in the process?

This question asked about the planning facility budget for operation and management included in a number of processes in the process (Table 5.21). It is clear to see that responses about these documents were different between yes and not from case to case.

5.10 Plan facility budget for operation

According to the plan facility budget for operation, slightly higher than 51%, of the whole respondents (308) chose “capture and analyse data”, followed by slightly less than 21% of them who chose “develop strategic plan and budget” as the plan facility budget for the operation. “Establish facility goals and objectives” and “analyse and interpret data” have been chosen by a smaller percentage of respondents with about 17% and 10%, respectively, with 0.3% who responded “create and test alternative” (Figure 5.34).

Table 5.21: Distribution of planning facilities

Plan facility budget for operation	Number	%
Establish facility goals and objectives	54	17.5%
Capture and analyses data	158	51.3%
Analyses and interpret data	31	10.1%
Create and test alternative	1	0.3%
Develop strategic plan and budget	64	20.8%

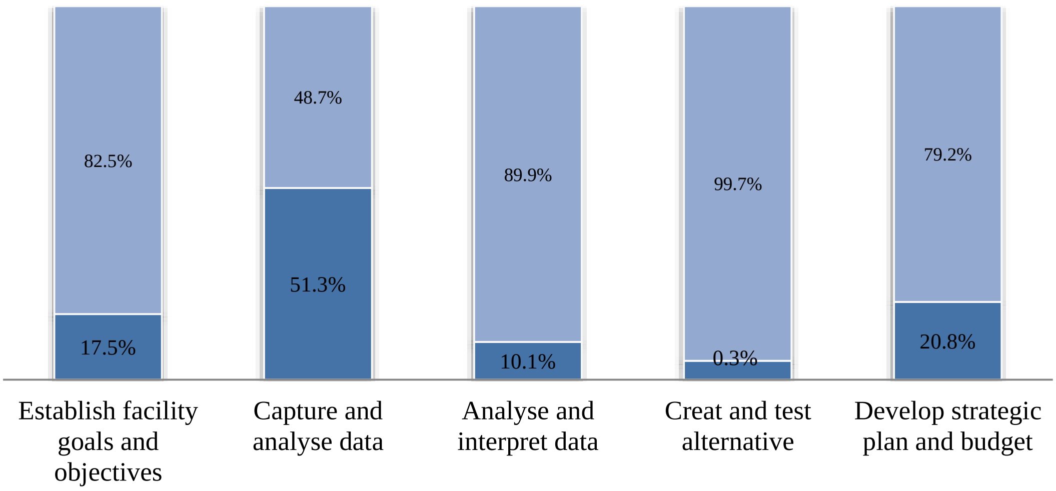

Figure 5.34: Distribution of plan facility budget for operation

5.11 Biggest facility challenge

According to the biggest facility challenge, slightly less than 68% of the whole respondents (308; Table 5.22) chose asset management and maintenance, followed by slightly higher than 30% of them who chose the maintenance of facility budget, with only slightly higher than 1% choosing emergency preparation (Figure 5.35).

Table 5.22: Distribution of biggest facility challenges

Biggest facility challenge	Number	%
Maintenance of facility budget	95	30.8%
Asset management and maintenance	209	67.9%
Emergency preparation	4	1.3%

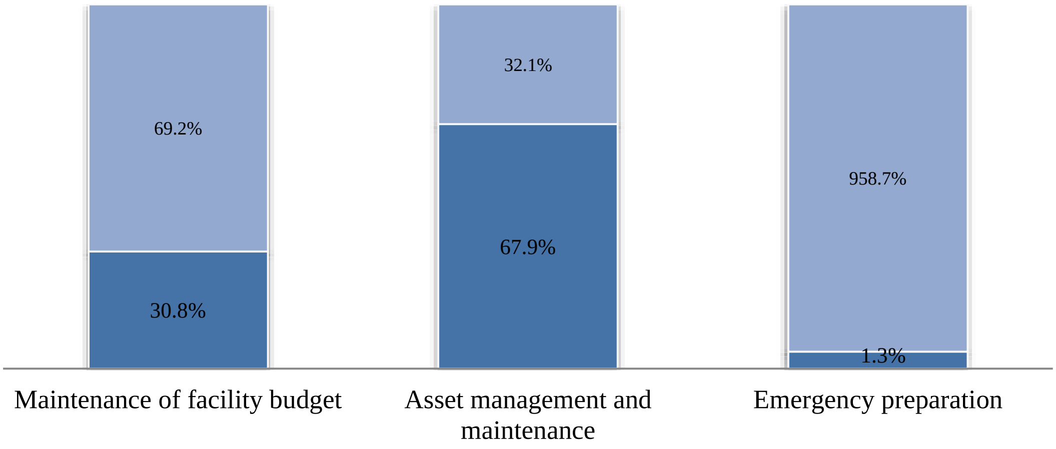

Figure 5.35: Distribution of Biggest facility challenge

Investments that are necessary to ensure effective implementation of Building Handover

According to "necessary investments to ensure and confirm effective implementation of Building Handover" (Table 5.23), it is clear to see that responses were distributed between all parameters, with the highest percentage 66.8% (development of BIM Processes) followed by (11.8%) at investments in Hardware, with the remaining ranged from 7.4% at training of personal, and 4.8% at training in use of software (Figure 5.36).

Table 5.23: Distribution of investments necessary to ensure

Investments are necessary to ensure	Number	%
Development of BIM Processes	206	66.8%
Training of personal	22	7.1%
Training in use of software	15	4.8%
Investments in Hardware	36	11.8%
Development of custom 3D libraries	13	4.30%
Addressing software customization	16	5.20%

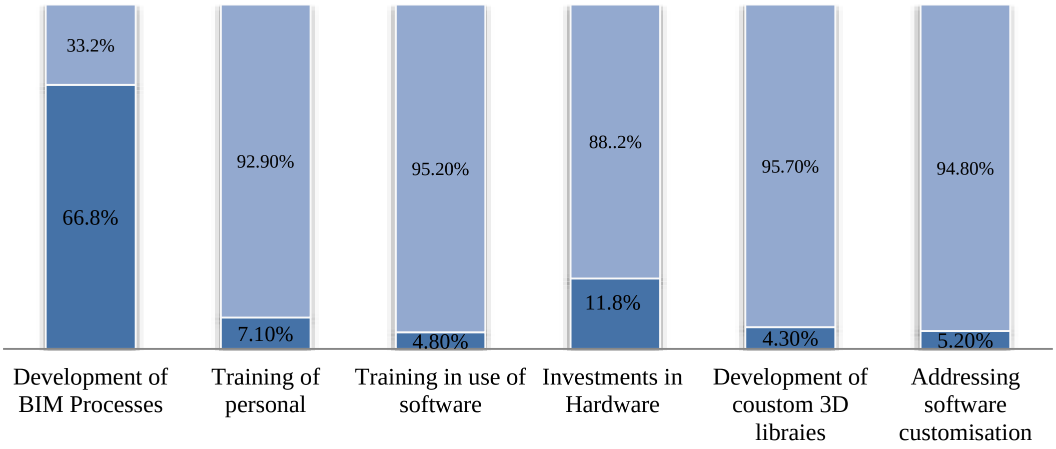

Figure 5.36: Distribution of the necessary investments to ensure effective implementation of Building Handover

5.12 Summary of Quantitative Finding

The procedures, methods, and data processing techniques used in this research together with data analysis techniques applied are discussed. The sections of this chapter have identified that the used data requires a comprehensive and complete awareness of many different statistical tests and tools available. A number of approaches are available to analyse the questionnaire data, as identified within this chapter. The descriptive approaches have been applied as represented by a list of approaches and tests, such as, histogram, and percentage. Also, analytical approaches are used to assess and measure the data trends and significant level. A quantitative analysis has been applied in this research on statistical data relevant to the handover, initially with test of Cronbach's alpha for reliability of data, also measures of variation, associations and analysis of correlation and a hypothesis tests as ANOVA. The next chapter discusses the qualitative and quantitative results in the light of the literature review.

CHAPTER SIX: FRAMEWORK DEVELOPMENT AND VALIDATION

6.1 Introduction

This chapter presents the empirical findings of the research and draws the results of the research supported by proof from the literature, questionnaire results (quantitative results) and interview data (qualitative results). The significance of this study subsists on the possible impact of the spreading of the research findings and applying them to enhance building handover practices within public sector construction projects in KSA. In this chapter, qualitative and quantitative findings and their implications, associated with a comparison of what has been written in the literature review, will be discussed.

In order to accomplish the research aim and objectives, the findings from the qualitative and quantitative data were presented. Thus, this chapter provides the discussion and presents the implications of these findings. The interview and questionnaire questions were based on the concepts of data management factors.

6.2 General information

6.2.1 Characteristics of the respondents in the questionnaire

Most of the respondents of this questionnaire were aged 30-40 years. They were involved in public sector handover processes within the KSA, in some form or capacity. Most of them held a graduate, and some a PhD, a few of the participants had high school and diploma degrees and were relatively similar. These results indicate that most of them are well educated. Respondents had different working experience in public sector construction, ranging between 5 and 20 years of experience. This means they had the right level of experience to manage the building handover process in their organizations. Most of the respondents were from client-government, followed by facility management firms, then client-private. However, the smallest number was from contractor and consultant-designer of facility management firms in the KSA public sector construction organisations. In relation to the size of participants' organisations, the detailed results show that the company size ranged between medium and large sizes. However, most respondents were situated in large organizations. Further, more than half of the respondents answered that their companies did not use BIM.

6.2.2 Characteristics of the Participants in the Interviews

The interviews were conducted with leading industry practitioners. The researcher interviewed ten managers involved in large construction projects: These included senior administrators from Al- Madinah Regional Municipality including Senior Executive, Executive Engineer, Assets Manager, Senior Administrator, Buildings Manager of Operations and Maintenance, Manager, Project Implementation Unit, Director of Operations and Maintenance, Assistant Manager, Maintenance and Operations, Facilities Manager, Project Implementation Unit and Director of Project Management. Interviews with these experts helped in thoughtful discussion on data requirements and challenges at various lifecycle stages of a building.

This discussion of quantitative and qualitative data is built on six themes, which were developed from the literature review. The base of this discussion will be the contradictions and similarities between each of these themes that originate from the literature review and the corresponding outcomes in the case study organization. In relating these findings to the previously reviewed literature, it is hoped to achieve a better understanding of the similarities and contrasts among the case study in the KSA. These six key themes of the research included:

- Challenges to effective building handover practices in the KSA public sector construction industry;
- Realisation of the Importance of the project data at the Handover Stage;
- BIM and Technology benefits;
- Existing Key drivers of effective building handover;
- Facility budget for operation and management;
- Steps of developing the public sector projects.

6.3 Satisfaction with current building handover practices within the KSA public sector

The main problem of this research is that a major loss of information occurs at building handover in the KSA public sector construction industry. The research discussion gives a complete picture of how Saudi Arabia will manage this goal in terms of facilitating data management in building handover practices. It was revealed from research findings that the respondents' satisfaction with quality of information handed over to project owners towards completion of the project was not high. This resonates with findings of the report CURT (2014), Integrated Information, Collaboration, and the Project Life Cycle in Construction Design, and Construction and Operation, which makes it clear that there is a necessity to improve venture delivery (Fallon and Palmer, 2007). Users and clients are expecting better and more performance from the buildings they buy and occupy. However, most users and clients are abandoned by the project and development team after handover, just when they are likely to need the most help. The project post-handover period is the most neglected phase of building, often looked upon as a trouble and a disturbance (Way, 2005).

6.4 Theme 1: Challenges to effective building handover practices in the public sector construction industry in the KSA

As mentioned in the above section, the public sector construction industry faces problems and challenges due to loss of information at building handover. Hadley (2012) pointed out that the NIST estimated yearly losses of $15.8 billion from information-related issues in projects. These losses were experienced as direct results of inadequate interoperability between project data and the information systems used in the asset lifecycle, particularly between design, construction, handover, and the systems used to support asset operations. Many experts agree that the loss is usually due to poorly managed information handover and can exceed one per cent of the total project expenses. For instance, a $1 billion project could avoid a cost of more than $10 million (Hadley, 2012). However, including the accurate forms of the suitable information is a serious challenge.

According to the qualitative and quantitative finding, there is a general agreement that there are many challenges in building handover in the KSA public sector construction industry. These challenges were varied from changing order and rework, complexity, lack of transparency, short of shared trust, society not involved, time of operations training, lack of knowledge and experience, lack of communication, lack of use of technology, accelerated completion, lack of protocol or framework in place for life cycle data management, maintenance manuals and keys, and unclear responsibilities. In relation to the changing order and rework factor, about half of the interviewee respondents mentioned this factor when they talked about challenges. In this regard, Mitchell (2012) pointed out that changing orders always occur; even with the best preparation, changes will happen. However, his advice is to accept it, know it, and ensure to keep it at a minimum.

According to the dominant view from the literature, increasing complexity might be an important reason in the failure and success of projects (Brady and Davies, 2014; Meier, 2008; Williams, 2005; Flyvbjerg et al., 2003). However, according to Kujala et *al*. (2014), there is little empirical research on how these complexity characteristics affect specific management processes. Findings about this factor revealed that the majority of respondents affirm that the constructed facilities are becoming more complex and complexity is considered one of the main challenges in construction projects. However, the results also demonstrate that the key challenges are over-specification, such as over planning and changes of design during construction.

Some interviewees also mentioned absenteeism of labour and excessive overtime as a consequence to late payment. However, improving procurement can be achieved through improving the skills of the client; thus, the cost of public sector construction will be reduced (Baldry, 2012).

Governments should offer a leadership academy for major project leaders; however, changing performance in the public sector cannot be underestimated. A shift of cultural norms is also necessary for public sector clients if they want to develop sustainable behavioural improvement, and the government must be committed to the necessary support and resources to make this happen (Ibid).

In relation to the lack of transparency, and according to the respondents of this study, the lack of transparency and accessibility of project data for all project team electronically is considered a significant challenge that affects the building handover. In this regard, the respondents mentioned that the lack of transparency and accessibility of project data for all plan groups electronically are not disclosed. However, through transparency, the transaction costs may be reduced in the public sector construction industry (Schapper et al, 2006). Other challenges to handover practices in the public sector construction industry include unclear responsibilities of project team. Finding about this factor revealed that unclear responsibilities are a substantial challenge to effective building handover practices, as the responsibilities of various project team members are unclear. Mutual trust and capability to use the data across the design/building team is required. When it is unclear who is responsible for what area of a project or task, conflict can occur. This result agrees with Xianzhi (2014), who mentions that the full understanding of what necessity be done and who must take the consequences of responsibility through project designing and maintaining the function structure and the relationship between duties and authority can overcome the difficulties and problems caused by the confusion and unclear responsibility and start to establish harmonious working environment (Xianzhi, 2014).

In this respect, the finding shows that the most of the respondents thought that the owner has the biggest influence on building information handover process, while some believe that the contractor has the most influence on building information handover. A few of the respondents thought that the designer is the most responsible for building information. With regards to societies' involvement, the finding of qualitative data reveals that the most significant challenge to effective building handover practices in the KSA public sector construction industry are societies not being involved in choice of building systems. Project implementers should know that societies involvement always make expectations, and failing to meet these expectations might cause disappointments and even project failure. Hence, the societies should be involved when it is relevant, and they should receive continuous feedback. Respondents also identified various other challenges, such as not enough time for operations training, inappropriate quality assurance method, over-specification (over planned), shared trust, capability to use the information across the project design/construction team, and not enough time to understand requirements during the operations and maintenance stage of the facility.

The quantitative outcomes showed high agreement regarding the most significant challenge to effective building handover practices in the KSA public sector construction industry. These challenges were: societies not involved, lack of mutual trust, inappropriate quality assurance method, lack of transparency and accessibility of project data for all project team electronically, not enough time for operations training, responsibilities of various project team members are unclear, maintenance manuals and keys are often missing, and ability of using the information across the project design/construction team. Figurer 6.1 summarizes the Challenges that face building handover practices in the KSA public sector.

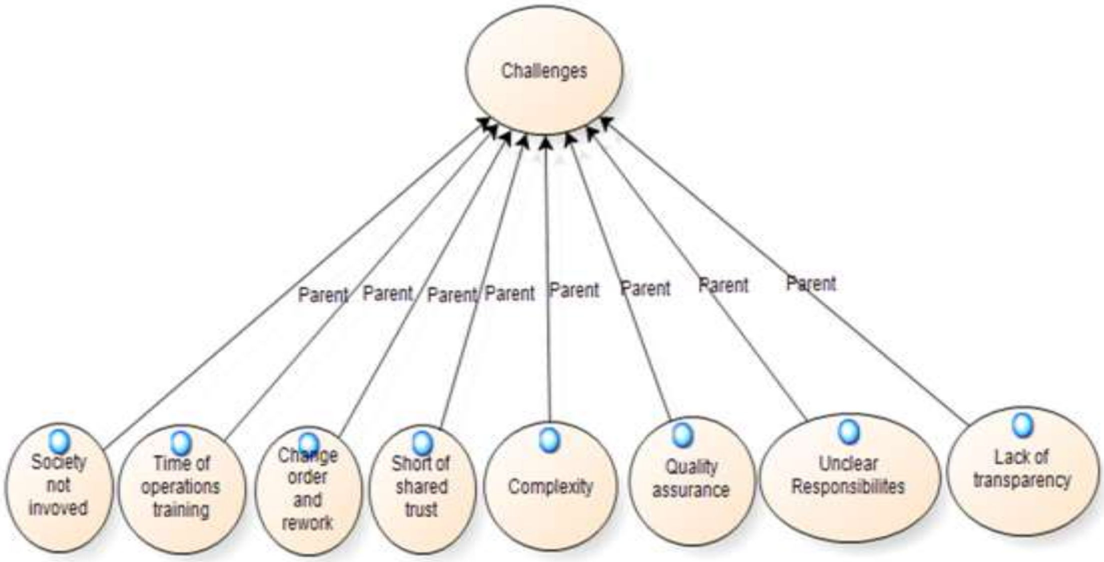

Figure 6.1: Challenges to effective building handover practices in the KSA public sector construction industry

6.5 Theme 2: Realisation of the Importance of the project data at the Handover Stage:

The majority of the participants in this study mentioned that commission plans, building drawing and insurance, daily reports, equipment list, manufacturing products data, operations and maintenance, quality control documents are the most significant benefits for the project data at the handover stage (Figure 6.4). However, clients are looking for data continuity; capturing statistics data from projects is vital not only for large projects but also for smaller projects, including renovation projects, which are often numerous and need to be associated into the same maintenance system (Whyte *et al*., 2012).

Referring to the commission plan, it is considered as an arrangement made in which people are paid based on performance. Findings on this theme reveal that the commission plans are one of the most significant benefits for the project data at the handover stage. This agrees with the European Commission (2014), which indicated that commission plan developed framework consisting of core indicators, such as fundamental methods, is to be used to evaluate the environmental performance of buildings all over their lifecycle. Then the commission will invite stakeholders, for example public authorities, architects, investors, insurers, and contractors, to discuss issues related to objectives and indicators for assessing the buildings.

As mentioned above, building drawing and insurance is part of the significant project data at the handover stage, as it is a document that the contractor provides to the owner and acts as a proof of insurance coverage. This concurs with what was found by Bell *et al*. (2010); they approve that daily reports should be treated as the most significant document on a construction project, and should be used to write the daily work performed, workers on site, differing site conditions, problems faced, delays experienced, etc. Comprehensive daily reports provide an upper hand in a dispute, while poor daily reports are considered a disadvantage. Also, work equipment could be considered important data in handover. It should be maintained in a safe place and in good condition; where any machinery and tools has a maintenance record, the record is kept up to date and the maintenance operations on work equipment and tool can be carried out carefully and safely.

With regards to the operations and maintenance, findings from research participants concur with Fallon and Palmer's (2007) views, where they mention that information requirements for the project operations and maintenance phase contain financial, legal, and physical aspects of the facility. Handlers of this information usually include operators (property managers and facility managers), vendors, owners, tenants and service providers. Moreover, the maintenance and operations phase generates its own information, which is used to increase facility performance data and inform decisions about expanding or stopping of the facility. This information includes maintenance programmes, service requests, production or occupancy levels, inspection reports, work orders, equipment downtime, and operating and maintenance costs.

Other factors of importance at the handover stage according to respondents included Quality Control documents. Actually, the importance of this factor is behind its policies that are designed to record project activities on a daily basis. However, the elements of the quality control are a matter of judgment and influenced by numerous factors. According to Olin, (2009) the quality control documents include deviations from the required project material specifications, numbers of personnel, scheduled actions taken to correct the problems, types of tests performed and results of these testing, weather conditions, nature of defects or cause for rejection, delays encountered and health and safety issues, or deficiencies/shortages, and how they were determined and resolved. In terms of the quantitative results, the responses to this question of the importance of the project handover stage to the organisation were distributed almost equally between “very important” and “important”. However, the smallest percentage of the whole response was the options of “slightly important”, “least important” and others.

In relation to the operations and maintenance, and according to the question about what sort of services that their organisation performs, the majority of participant believe that their company performed preventive services, while some preformed predictive. However, few performed reactive. Hence, all the participants of this study believe in the importance of the project handover stage to the organisation. Figure 6.2 summarizes the important of the project data at the handover stage in the KSA public sector.

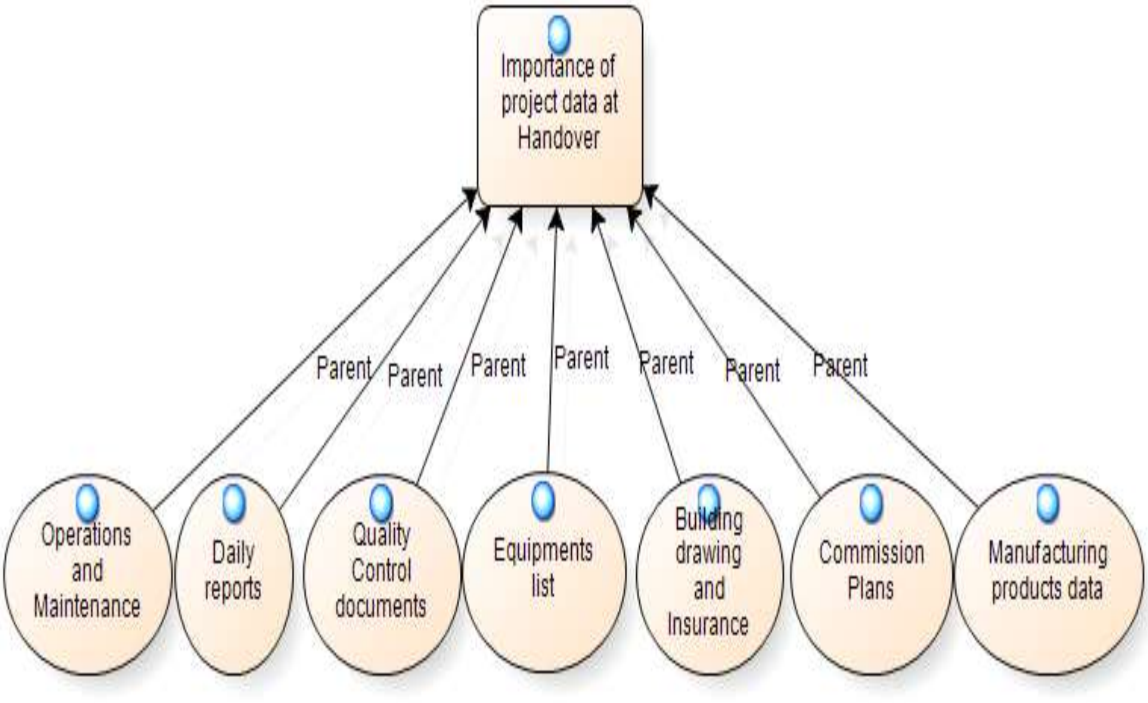

Figure 6.2: The important of the project data at the handover stage

6.6 Theme 3: BIM and Technology benefits

Building information modelling is more than simply software; it is a process that involves stakeholders that could be impacted by its utilization (Barlish and Sullivan, 2012). Findings of this theme reveal that the majority of participants were acquainted with the benefits and roles of BIM and technology. They mentioned the cost, time and effort, easy access to project data and updates, effective communication, improved integrated design process, increase speed, in management, and tracking of installation, testing and maintenance. However, some of the participants believed whose organisation had been using BIM believed that using technology plays an important role in improving building maintenance and reduces cost, time, effort and allows easy access to project data and updates, leading to improved quality of performance, help in data and information updated. In relation to Cost, Time and Effort, and according to Azhar (2011), at any phase of the project design, BIM technology and tools can cut an accurate bill of spaces and quantities that can be used for cost assessment. In the first stages of a project design, the estimates of cost are based primarily on the unit cost per square foot or meter. In the progression of the design progresses, new details are coming and can be used for more precise cost estimates. Consequently, it is possible to make better design decisions regarding budgets using BIM, instead of a paper-based system. Likewise, Zuppa et al. (2009) confirmed about the finding of this research where, in their study, they found that BIM-based design and pre-fabrication could significantly reduce the project time, from project approval to facility completion. The component parametric nature of BIM makes design changes easier and the resulting updates of records automatic.

In the case of effective communication, the majority of respondents believe that BIM technology can play a role in improving the integrated design and communication in the KSA construction sector. This finding can be compared to Eastman et al. (2011), in a study of BIM implementation for Owners, Managers, Designers, Engineers, and Contractors, which indicated that for creating and editing a design and export of data in various formats to support integration with other applications and workflows by two approaches, the use of one software seller's products or use software from various sellers that can exchange data using industry standards. The first approach allows for tighter integration among products in multiple directions. For instance, changes to the architectural model will generate changes to the structural model, and vice versa. However, this needs that all of design team to use software delivered from the same seller. The second approach uses either exclusive source or open source. This approach offers additional flexibility at the cost of interoperability, particularly if the various software programs used for a given project do not support the same exchange standards.

Concerning BIM and technology benefits in efficient project management, most of respondents think that BIM asset management and efficient project management improved integrated design process, as well as increasing speed and tracking of installation, testing and maintenance. This result conforms with Eastman et al., (2008) where they mention that the BIM supports monitoring of real-time control systems and offers a natural interface for sensors and remote operating management of facilities. However, lots of these capabilities have not developed, but BIM provides an excellent platform for their deployment.

Findings of quantitative data reveal that enhanced information, improve quality and client satisfaction and stakeholders' influence are the most significant benefits of using BIM and technology, followed by improved asset management, then easy access to project data. Moreover, the participants mention to these benefits of BIM and technology: reduced labour, improved integrated design process, better tracking of installation, enhanced information, encourages the integration, easy access to project data, increased speed, efficient project management, improved asset management, effective communication, reduction in error, and improved quality and client satisfaction.

However, the quantitative findings about the possibility access to a number of important documents were different between yes and not from case to case. For example, the majority of the responded declare that access to the specifications, warranty information, spare parts data, equipment purchase dates, and emergency management plans was not easy. However, the majority of the responses declare that access to service contracts is easy. These results emphasise that the most important documents were not easy to access without using technology, such as BIM. In addition, it was found in the quantitative results that legislation and legal requirements are considered as a significant benefit of BIM technology and processes.

Although BIM is not currently a legal requirement for KSA construction industries, this benefit can accrue in the future if the government of KSA enacted legislation regarding BIM in working process in most public sector contracts. Setting out the legal issues in the adoption of BIM will ensure that the industry can collaborate without the worry of adverse legal consequences. However, the quantitative results specified that the period of time that organisations in the KSA had been using BIM from 1 to 2 years and they were only a few companies; the majority of the respondents answered that their companies had not used BIM at all. These results indicate that the application of BIM technology in the Saudi companies did not exceed 2 years.

From another point of view, the quantitative consequences refer to the moral and ethical obligation as important benefits of BIM and technology. Vee and Skitmore (2003) found in a study about ethics in the construction industry that there is some degree of unethical conduct, in the form of unfair demeanour, negligence, carelessness, conflict of interest, collusive tendering, fraud, confidentiality and propriety breach, corruption, and damage of environment. The construction sector should implicate their moral commitments with the project stakeholders and agree in the results how it can influence the business case and consider good ethical practice to be an important organisational goal. Business ethics should be driven or governed by personal ethics. A balance of both the requirements of the client and the impact on the public should be maintained. Figure 6.3 shows the most important benefits of the BIM and Technology at the handover stage in the KSA public sector.

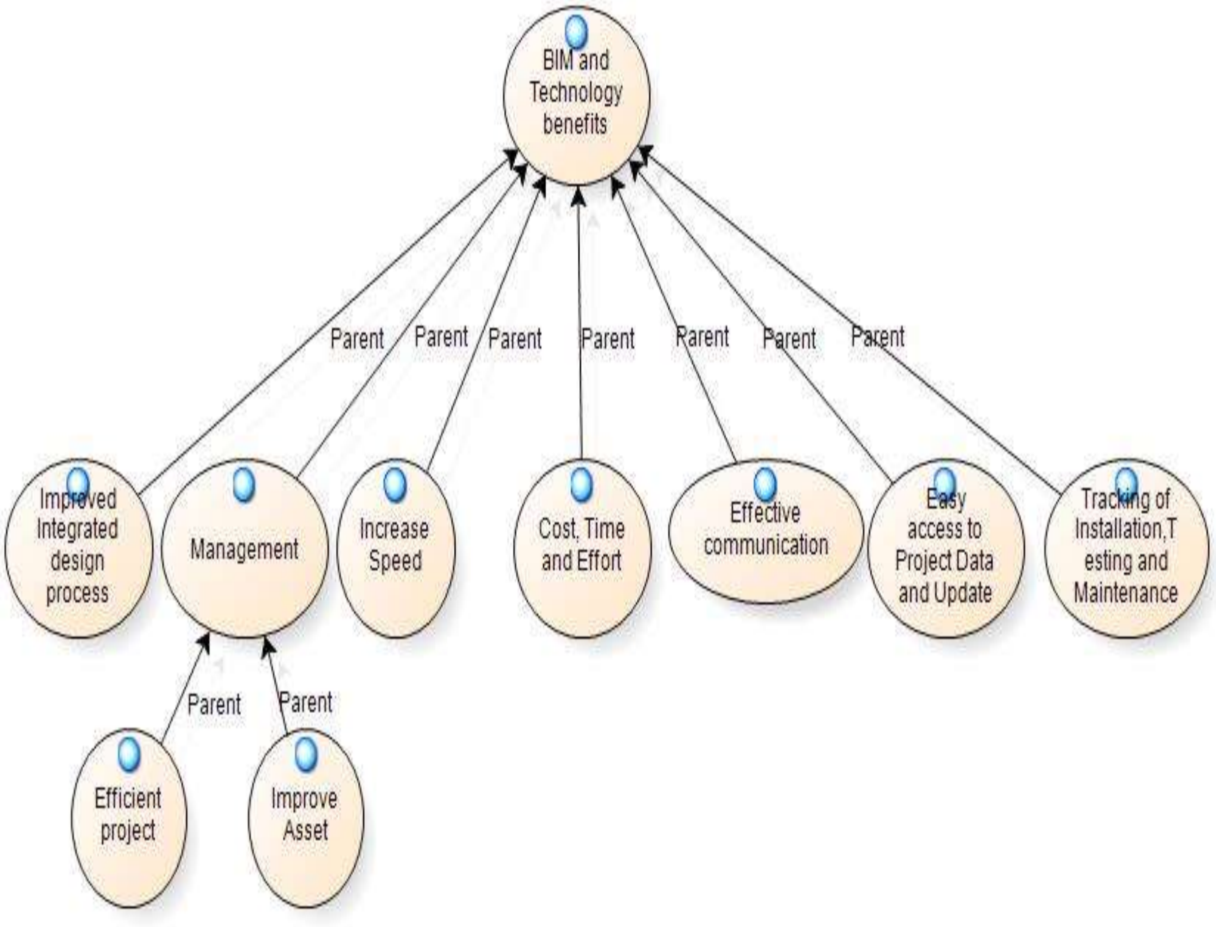

Figure 6.3: Benefits of the BIM and Technology at the handover stage in the KSA public sector.

6.7 Theme 4: Key drivers of effective building handover

Research findings for this theme revealed that the entire group of respondents agreed that the designers and contractors, manual handling of data, absence of appropriate protocol or framework, problems and standardized approach, are the key drivers of effective building handover (Figure 6.6). The respondents clarified that designers and contractors have minimal involvement after building commissioning. In addition, there is no appropriate protocol or framework in place within KSA for lifecycle data management. The communication gaps between designers, contractors and owners and the handling of data manually usually resulted in human errors and further increased such information loss. They further added that the significant problems in the delivery of public sector construction involve a wide range of professionals from multiple disciplines that utilize and develop data at various project lifecycle stages, resulting in data loss over the lifetime of a construction facility. However, Hatem (2008) thought to ensure that any designers or contractors that are engaged on the project are experienced and adequately resourced.

Likewise, Waddoups and May (2014) declared that a contractor should be identified firstly in the project to give them enough time to design the work and detect any risks to health and safety. It must manage and monitor all work carried out by themselves and their labourers, considering the risks to any person who might be affected by it (including members of the public) and the measures needed to protect them. In the context of manual handling of data, Navon *et al*. (1994) suggested that processing data and rewriting it in a different format is a potential cause of numerous human errors. The automation of this data handling and processing can reduce these errors to zero. To obtain adequate and effective building handover, it is recommended that the KSA implement BIM in the construction industry for lifecycle data management and for other benefits of this system.

In relation to framework as a key driver of effective building handover, Yusof and Aspinwall (2000) described framework as a comprehensive implementation strategy defining what the organization must do, what it is trying to do and how it is going to do it, and make sure that every step builds on the previous one. In regard to the absence of appropriate protocol, which can be considered as a factor influencing effective building handover, the importance of this factor is due to its allowances of all processes to be carried out in a standard manner and leads any member of project produce same/similar results (repeatable and reproducible). Overall, the protocol is a fixed standardised process of performing a job.

Other key drivers that were mentioned by participants were resolving problems in productivity such as rework, innovation, slipping schedules, mistakes, and disputes.
Problems in rework can affect individuals, organisations and project performance and productivity. Rework means failing on the achievement of quality standards within the construction industry. This problem usually happens when a process was incorrectly implemented the first time and needed effort to redo (Love et al., 2002). However, the management of construction is a complex function with changes that usually happen such as design, specification, and client requirements. However, to manage rework effectively, project managers should have detailed planning to integrate the work activities of consultants, subcontractors, and suppliers.

The adverse significances of rework include reduced earnings, loss of market share and reputation, increased turnover of management and workers, lower productivity, and cost of legal action between participants over responsibility for overruns and delays (Eden et al., 2000). According to Rotimi (2013), lower productivity can be increased by a reduction in the cost of defects compared to the value of the constructed product.

The participants also mention other problems: slipping that occurs in the lack of evidence-based design guidelines, and current architects trying uncommon stair designs and different materials that may increase hazards or balance problems (Kim and Steinfeld, 2013). Verma, et al. (2011) suggest some factors that cause a slip accident such as kinds of flooring, contamination on the floor by means of water, oil or dust, type of the footwear, environmental influences such as lighting, and the aptitudes of the individual who slips. Figure 6.4 illuminates the existing key drivers of effective building handover practices in the KSA public sector.

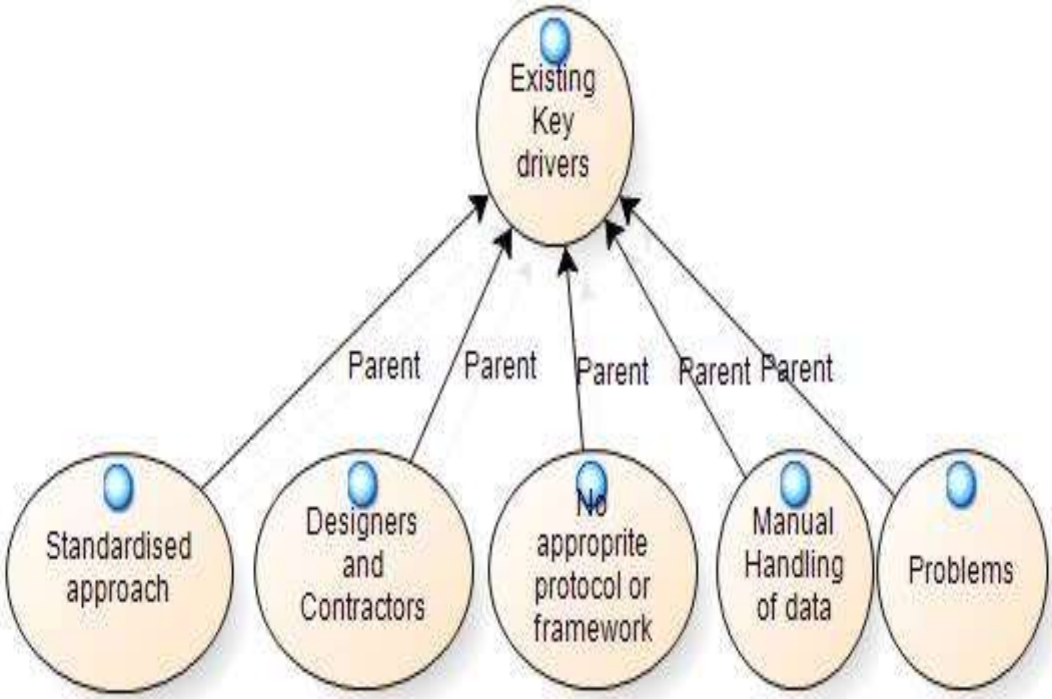

Figure 6.4: Existing Key drivers of effective building handover in the KSA public sector

6.8 Theme 5: Facility budget for operation and management

This theme concerned the planning facility budget for operation and management, as well as the biggest facility challenge and the investments that are necessary to ensure effective implementation of building handover.

Qualitative results reveal that the majority of interviewees agree that planning facility budgets for operation and management would be achieved through institute goals and objectives, and analyses and interpretation of data. In contrast, Dude (2013) recommends that it is essential to have responsible staff that will provide facilities managers with comprehensive images for various operating departments in construction. By employing a skilled person in each operational sector, they can monitor the consumption in their department, research in the market costs for pieces in need of repair or replacement, and then make maintenance suggestions. Then, the general director in construction can investigate these suggestions and pass it to a supervisor for secondary assessments of all equipment. With this data, a manager can then make an appropriate budget plan. Furthermore, Lubach (2013) suggests that the managers over each of the operating units in the department should provide input on their upcoming budgetary needs. The managers track resource consumption and market value then plan their requirements accordingly.

From another point of view, Enoma (2005) supposes that the project team must eliminate unnecessary spending and get the optimum balance between cost, time and quality. In relation to challenge of facility budgeting, the finding reveals that the majority of respondents thought that the maintenance of facility budget is the main challenge to ensure effective implementation of building handover, followed by emergency preparation. However, a few of respondents believe that preservation of facility budget and crisis awareness are the most important challenges of effective building handover. In case of investments that are necessary to ensure effective implementation of building handover, the majority of participants believe that software training and development of BIM process, followed by investment in hardware and personnel training respectively are the most important.

In terms of quantitative results, it was found that the established facility goals and objectives, capture and analyse data, analyse and interpret data, create and test alternative and develop strategy were the most important processes to facility budget. However, the majority of participants thought that capturing and analysing data were effective for facility budget for operation and management, while some chose developing a strategic plan as facility budget for the operation and management. However, a few of respondents have chosen goals and objectives of the institute as plan for facility budget for the operation and management.

In relation to the biggest facility challenges, findings reveal that they were maintenance of facility budget, asset management and maintenance, and emergency preparation. Similarly, Xaba (2012) reported that facility management for organisation should link to the strategy of the overall organisation and then they should develop goals, objectives, and action plans to achieve that. Managed effectively, however, the budget allows managers to maximize the financial resources the organization has assigned to the department. It forms the basis for strategies that confirm facilities operate energy efficiency, cost-effectively, and safely. Hence, a solid budget has an important role for ensuring departments work efficiently and cost-effectively.

Regarding investments that are necessary to ensure effective implementation of building handover, it was found that the development of BIM processes, training of personal, training in use of software, investments in hardware, development of custom 3D libraries and addressing software customisation are the main investments that ensure effective implementation of building handover. Overall, the quantitative findings reveal that the majority of participants believe that the investment that is necessary to ensure effective implementation of building handover was the development of BIM Processes. Building Information Modelling (BIM) allows designers, architects, engineers, manufacturers, Computer Generated Images (CGI) experts, developers and contractors to work in collaboration (Ku and Taiebat, 2011). Figure 7.5 demonstrates the Facility budget for operation and management.

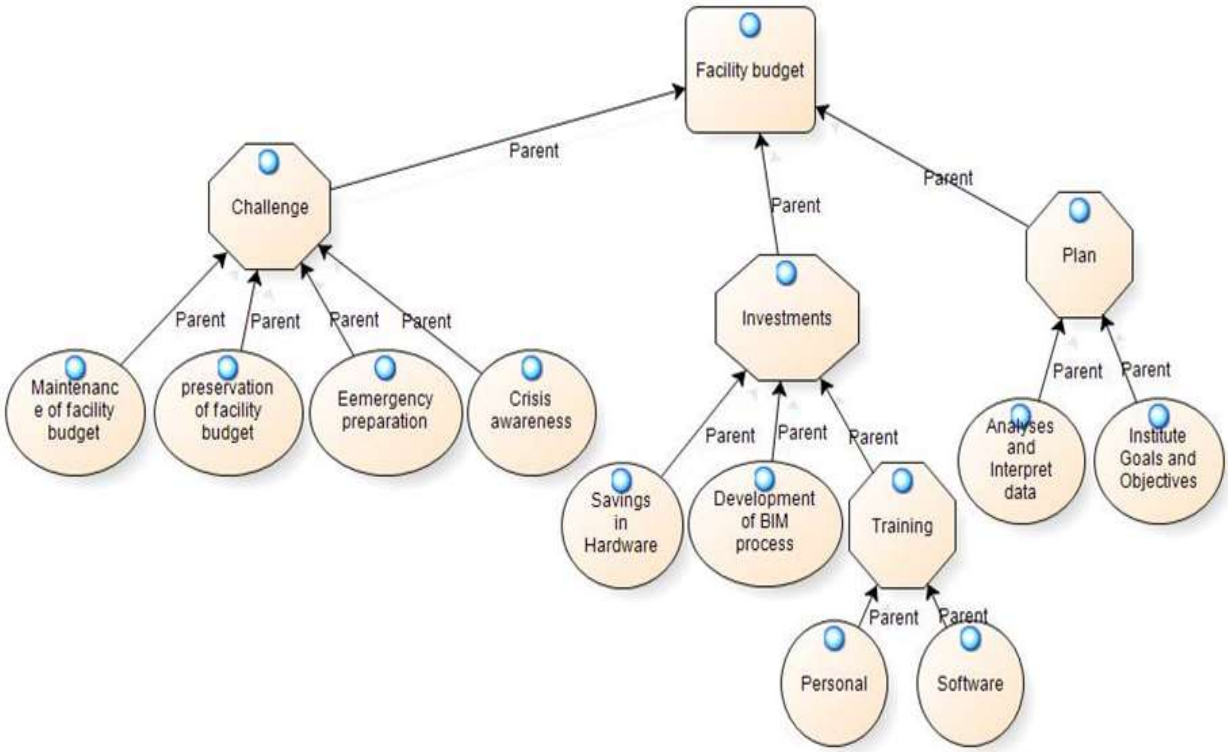

Figure 6.5: Facility budget for operation and management

6.9 Theme 6: Steps of developing the public sector projects

According to the steps that should be taken to develop the existing public sector projects, the results indicate that the majority of respondents believe that the presence of expertise is a fundamental issue in developing the public sector projects, as well as transformation to technology such as BIM. However, some of the respondents consider training courses for employers to recognize the positions of weakness and strength and identify key aspects of required operational performance.

In relation to the benefits of expertise, this finding can be compared to that of Boyer (2015) in a study about developing government expertise in strategic contracting for public–private partnerships. It indicated that the lack of internal skills threatens contracting performance. As well as this, Crawford and Lewandowski (2013) mentioned that the lack of expertise in construction procurement has been raised by stakeholders in England. Hence, the researcher emphasizes the importance of training managers of construction projects. The managers in all kinds of projects play a critical role and influence projects' success (Crawford, 2005). In this regard, a study by Jalocha *et al*. (2014) maintained that the role of managers in public sector projects is distinctive, due to the fact that public sector deals with various stakeholders whose thoughts, beliefs and point of view can strongly influence the project. Growth in the public sector led to growth in developing competences such as skills, knowledge, and attitudes for managers in public sector projects.

In accordance to transformation to technology as a way to develop the public sector projects, the Strategy Paper for the Government Construction strategy in the UK (2011) declared that the measurable benefits of technology, such as BIM, might be brought to the construction and post-occupancy management of assets (buildings and infrastructure) through the intensified use of BIM. The benefits in applying BIM effectively cannot be ignored and are gradually being recognised by businesses across the globe.

The UK Government is a client encouraging the adoption of BIM methods to develop project delivery and operational performance, as well as improvement in cost and value (Government Construction strategy in UK, 2011). As BIM, if correctly installed, would be a key enabler of the integration process. However, the choice to implement BIM involves change in three parts: people, technology, and process. The people factor is considered a major difficulty; supply chain partners need to work transparently and collaboratively as they contribute to the combined model. Designers have to know how to use and create a BIM (Dinesen and Thompson, 2010).

On the other hand, adopting BIM requires rigorous training and skills, and encouragement for the design and approaches. As the project works through the process, it is necessary to give people sufficient time and support. Acceptance of BIM requires investment in software, hardware, plus training for employees. Departments and construction may therefore wish to review the abilities of their current software and hardware, as well as its capability to create and receive BIM project information (Ku and Taiebat, 2011). Initial training should be done by a professional; it is recommended to secure the services of a certified professional tutor most likely from the vendor, whose product the practice has decided to use. This is to ensure that the tools used correctly. By so doing, the practice can be certain to derive the maximum benefits that the tools can provide as promised by the vendor.

The competent authorities in the public construction sector in KSA should ensure appropriate training programmes provided to allow each authority to be confident at using technology. This programme should provide a proper combination of learning in professional procurement and construction disciplines, together with project, programme and contract management. In relation to proposing training for employers, the finding of this research demonstrates that training in facility data management in building handover practices are needed by all employees working in public sector construction projects in the Kingdom of Saudi Arabia due to a lack of awareness about building handover practices in the case study. However, Crawford and Lewandowski (2013) demonstrate that learning academic skills for construction procurement professionals would be necessary and the gaps in construction knowledge should be identified and addressed via training and support mechanisms. Figure 6.6 illustrates the steps of developing the public sector projects in KSA.

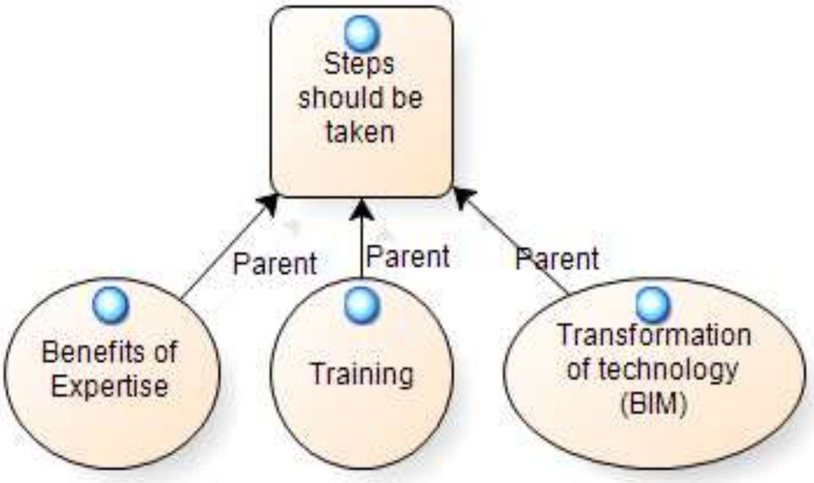

Figure 6.6: Key steps in developing the public sector construction projects.

The above paragraphs represent the details of a framework that enhance facilitates lifecycle data management.

By matching the conceptual framework (conclusion from literature review) that is shown in (Figure 2.9) with those that arise from the case study organisation, a substantial amount of consistency was found, such as:

- Lack of knowledge and experience;
- Lack of use of technology;
- Lack of training;
- Lack of communication during project data at the Handover Stage;
- Unclear Responsibilities;
- Complexity of projects;
- Lack of transparency;
- Societies not involved.

However, after examining and discussing the information collected throughout the empirical study, new issues relating to the facilitating data management handover practices in the KSA context were discovered. These issues were summarised as:

- Encouraging national labour;
- High Manager Turnover;
- Accelerated completion;

- Maintaining order;
- Lack of protocol or framework in place for life cycle data management;
- Maintenance manuals and keys are often missing;

These outcomes are summarised by Figure 6.7. This figure shows the influences affecting the issues relating to data management employment in public sector construction projects within the KSA. However, the researcher, after launching this research and through the facts related to data management in public sector construction, was able to suggest recommendations to help the KSA government to commence effective implementation of building handover. These government recommendations are given in next chapter.

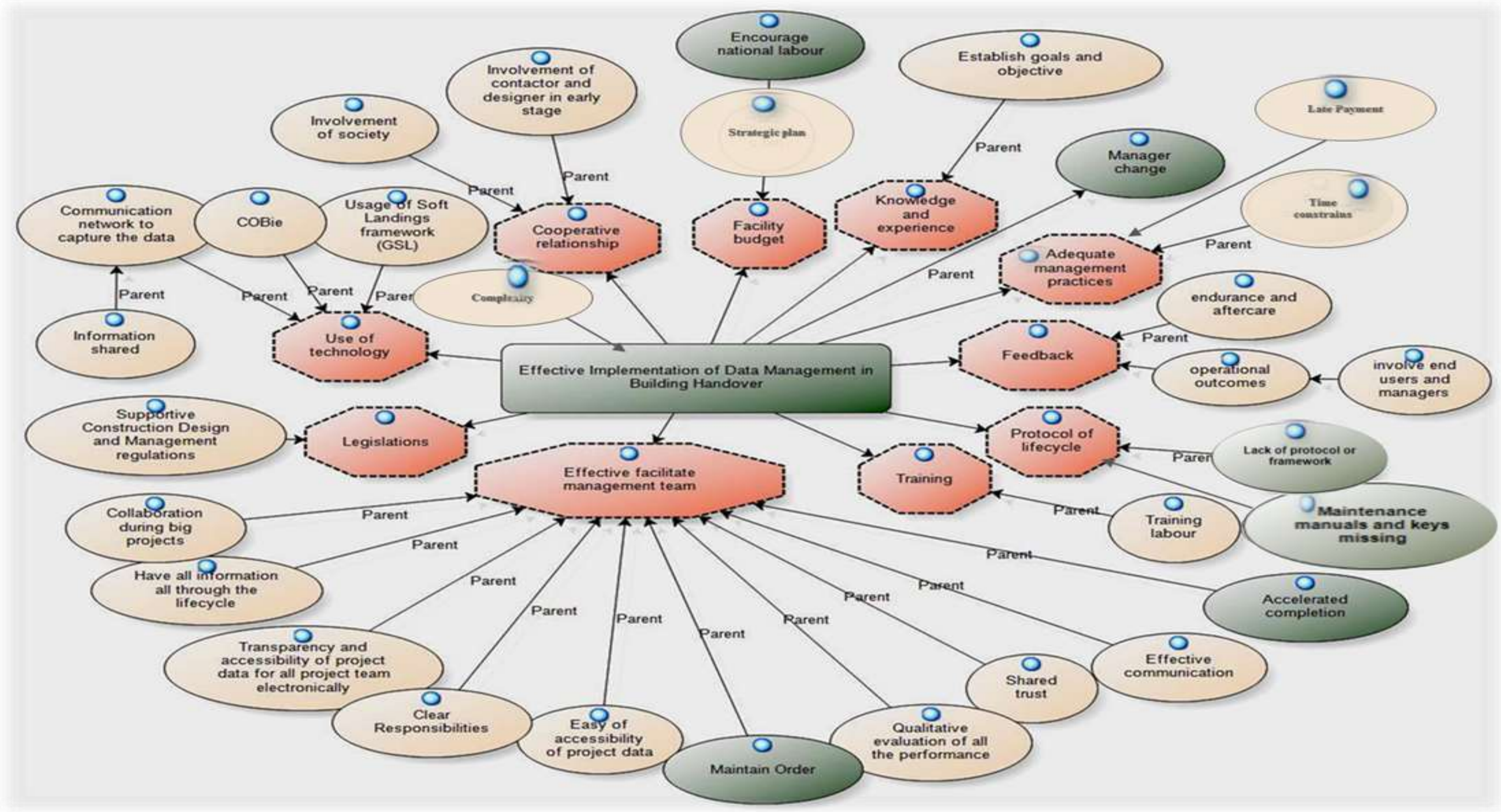

Figure 6.7: A summary of elements that influence effective implementation of building handover within KSA public sector construction industry. (using NVIVO 10).

6.10 Validation of the Final Result of the Qualitative and Quantitative Data

As clarified in chapter 4, several validity-enhancing techniques were applied in the present research as the researcher has tried to be consistent and has constructed a proper vigorous research methodology that gives high internal reliability. Also, all the research procedures and methods were well documented. In addition, during the personal interviews the researcher improves the ideas of participants by building a good relationship in order to avoid bias and enhance the validity of the interviews. Besides, the questions of the questionnaire and interview were reviewed and piloted in advance (before the collection of data). Moreover, documentation review and questionnaires were used to validate the research findings.

In addition, the proposed results were sent to six Saudi project managers, contractors, and clients who have experience in housing design and construction and they were invited to validate the findings.

After discussion (by e-mail) (appendix 5) between the researcher and the experts, they all agreed on the information provided in the finding (taking their comments into consideration).

6.11 Chapter Summary

The research findings from the case study organisation have been discussed in this chapter in light of the literature review. There are a number of important issues that have been highlighted, which affect data management in building handover practices in the case study organisation.

The research methodology was sensibly developed so that it supported the researcher to carry out a solid study and this, therefore, has enabled the researcher to deliver the research aim and objectives.

The subsequent chapter will conclude the thesis by presenting general conclusions and justifying how the research has accomplished its aim and objectives, contribution through the study, and suggesting recommendations for further research in this arena.

CHAPTER SEVEN: CONCLUSIONS AND RECOMMENDATION

7.1 Introduction

The previous chapters have discussed the main findings of this study. This chapter presents the results and a discussion of the questionnaires and interviews, as well as analysis of the supporting documentation to draw conclusions on the adopted methodology and the status of building handover practices in the KSA. This research has studied the issues that enable and affect the facility data management in building handover practices of public sector construction projects in the Kingdom of Saudi Arabia; it used Al Madinah Al Munawwarah, Regional Municipality as a case study.

This will be structured all over every objectives and the aim of the research. Consequently, contribution to knowledge and recommendations will be suggested for the future improvement of the handover practices of Saudi construction industry, proposing methods for improving public sector construction projects in the Kingdom of Saudi Arabia.

7.2 The Success of the Research Process

This study has investigated the data management in building handover of construction projects in the Kingdom of Saudi Arabia. It aimed to develop a framework to enhance data management in building handover practices of public sector construction projects using Al Madinah Al Munawwarah, Regional Municipality as a case study. To maximise the quality of the research findings, there was a need to choose the most appropriate methodology by which the research aim and objectives would be achieved. Selection of the proper methodology for this study came after a review of the literature on the research area, alongside an investigation of the literature on research methodology.

The methodology adopted in this study was consequently of both positivist and interpretivist paradigms, using quantitative and qualitative methods to match specific research questions (section 3.4). As justified in section 3.6.1, the case study was carefully chosen as the greatest strategy for this study and within the case study strategy, a single case was chosen, according of the recommendation of Yin (2009) about the suitability of this strategy.

The required data was collected to accomplish the research aim and objectives via two sources of data: secondary data through a rigorous literature review to understand the issues related to data management in building handover practices and the primary data through semi-structured interviews, survey questionnaires, and document review to investigate data management in building handover practices in the case study organisation. The multiple sources of data collection were found to be beneficial in reducing uncertainty, as the researcher could consult documents to validate the answers provided and then compare this to other methods of data collection.

The method of data analysis for qualitative findings was based on a general analytical procedure and NVivo software. The method of data analysis for quantitative findings used the Statistical Package for the Social Sciences (SPSS) software, version 16.

7.3 Achieving the Aim and Objectives of the Research

The main aim of this study was to develop a framework to enhance data management in building handover practices of public sector construction projects in the KSA. Eventually, this aim has been achieved effectively through the research objectives being fulfilled. The specific objectives of this research are defined accordingly as:

The first objective of this research was: “To identify the relevant concepts of development building handover practices and its requirements via review of the related literature”. To achieve this objective, a critical review of literature was conducted in Chapter 2. This presented the definition of the handover, its principles and procedures, facilities management, data handover for construction facility management, the need for effective building handover, building handover protocols and improving the project handover process, data requirements for handover process, and a review of the soft landings framework. Also, the concept, origin, and growth of BIM has been covered, alongside the use of BIM in construction management and in data handover, the challenges of interoperability in project delivery, plus the challenges in existing handover practices were identified. Therefore, the first objective was successfully accomplished.

The second objective was: "To critically examine the status of existing building handover practices within public sector in KSA". To satisfy this objective, a case study was conducted to collect related information about the situation of the building handover practices within the case study organisation. Questionnaires were distributed to respondents from clients, contractors, consultants, and facility managers from the Al Madinah Al Munawwarah, Regional Municipality. This covers all the relevant stakeholders involved in the handover process in the public sector construction industry and provides enough data for analysis and generalisation of the results.
Furthermore, semi-structured interviews were conducted with leading industry experts - approximately 10 managers involved in projects such as highways, airports, and hospitals. Interviews with these managers helped in understanding data requirements at various lifecycle stages in building handover practices. Finally, these interviews were triangulated with supporting documentation, which improved the research validity.
The questionnaire survey provides a wider view of building handover practices in the KSA while the qualitative study provided in-depth understanding of the state-of-the-art in practice. It should be confirmed that achieving this objective was greatly based on the first objective having been achieved.

The third objective was: "To analyse the challenges that face building handover from client's and facilities management team perspective in KSA context". To achieve this objective, the findings from the qualitative and quantitative results obtained from the case study organization were classified and analysed to deduce and present them in a meaningful form. Triangulation of data was accomplished and the challenges were well known, accordingly achieving the third objective.

The fourth objective was: "To develop a framework based on factors that enhance facilitates life cycle data management and provides recommendations to the administration of the KSA Government to address these factors". To meet this objective, these factors have been identified from the previous review of literature.

Those factors were presented in the theoretical framework themes (Figure 2.9). In order to understand those factors, the findings derived from the previous objectives were discussed using a comparison approach with the literature in order to gain an inclusive and in-depth understanding of the factors that affect lifecycle data management in public sector construction projects in the KSA.

This process allowed the researcher to explore which factors were consistent with the literature and the ones that emerge from the empirical work (unique). Also, by using the questionnaires and semi-structured interviews, plus various documents, data triangulation was often achieved. Thus, the factors affecting lifecycle data management in building handover practices provided by case study are identified. Hence, the fourth objective of this research was successfully achieved.

The fifth objective was: "To provide recommendations to the KSA Public Sector to enhance its management of infrastructure via improved handover practices". To reach this objective, the conclusions from the case study findings were categorized and then analysed to produce a list of recommendations that will help the government, researchers, and practitioners to enhance management of infrastructure via improved handover practices.

In conclusion, by reaching the fifth research objective, the main aim was achieved by investigating factors that facilitate data management in building handover practices of public sector construction projects in KSA. Consequently, the research questions were also answered.

7.4 Main Factors Affecting Building Handover Practices of public sector construction projects in KSA

The main factors that affect and limit the effective building handover practices of public sector construction projects in KSA were identified in this study. They are:

7.4.1 High Manager Turnover

Significantly, high project manager turnover is a significant problem in the public construction sector in KSA, as when a new project manager is assigned, he would change the previous date set for the completion of a project by setting an earlier date as oppose to the agreed date. As a result, the project was delivered without documents or the documentation is poor. Consequently, a lack of documentation is more likely to be the operational tasks failures. Besides, the conditions, scope, and design inside the projects can change. This in turn has an effect on factors, such as the cost, client relations, schedule, quality, resources, safety, maintainability, and operability of the projects. Furthermore, undocumented changes in a project and framework for controlling the change process are some of the main causes of failure.

Changes of manager are expected. However, to overcome the complications associated with this change, the new manager and project team must be capable to manage by reducing the effects of the change, schedule, and implementation plan.

7.4.2 Lack of knowledge and experience

One of the factors that facilitate data management in building handover practices in the KSA public sector construction industry was knowledge and experience. However, the findings show that there is a lack of knowledge and experience amongst participants in the case study. This serious lack of knowledge and experience leads to insufficient decision-making in the early stages of design plus a lack of ability to communicate clearly; weak training leads to failure to identify the project regulations and responsibilities, inadequate personal, and low expertise in design and construction.

However, the public sector construction in the KSA should be secured that the organisations they involve in their construction projects have the essential knowledge and experience, as well as an awareness of their responsibilities. The contractors also should have sufficient resources and the necessary proficiency to accomplish their responsibilities. However, to be proficient they must have sufficient experience, knowledge, and suitable skills to succeed in their duties. Besides, the public sector construction in the KSA must make accurate enquiries to certify that the contractor is knowledgeable and experienced to look after the work.

7.4.3 Lack of use of technology

Transformation to technology not only incorporates BIM, simplifying procedures and processes, but human factors are vital too, as the human resources are the most valued assets within organisations in Arabic countries. Managers in public sector projects dealing with construction industry need to be highly qualified. Transformation to technology also continuously changes and improves communication. BIM technology can play a role in improving the integrated design and communication in the KSA constructions sector. Therefore, managers need to be qualified and possess appropriate knowledge and skills in order to support the development and implementation of a successful transformation to technology. These required skills are information management skills, technical skills, communication skills, and project management skills. Given that such skills are not easy to acquire, it requires a great amount of investment and time. However, implementation and usage of technology, such as BIM, involves other requirements such as project decision support to identify project needs in terms of people, practices and resources, plus matrices for variety of tools to be used by every collaborating partner depending on project requirements and technological capabilities and limitations of dependent collaborators.

7.4.4 Lack of training

The experienced specialists in the public construction sector in the KSA should ensure appropriate training programme are provided to allow each authority to be confident in using technology. This programme should provide a proper combination of learning in procurement and construction professional disciplines, together with project, programme, and contract management.

However, the conclusions of this research specified that no employees or managerial staff in the CSO had received any appropriate training programmes. Thus, the apparent lack of skills of the data handover management was the expected result of not having the chance to train.

The contractor should organize sample training information documentation of installed drawings and operation and maintenance manuals as the basis for training, as well as using only qualified and competent trainers who are knowledgeable, familiar, and experts about the installations/systems. Effective training must be agreed for early handovers. These early handovers must be reviewed and strengthened during final project handover training program development.

7.4.5 Lack of communication during project data at the Handover Stage;

Findings on this theme showed a deficiency in communication. The communication gaps between designers, contractors and owners, and the handling of data manually, usually resulted in human errors and further increased information loss. Consequently, the lack of communication is in the building operations and maintenance phase, the designers and contractors have minimal involvement after building commissioning. The design and construction team carry limited liability once building handover has been completed.

Once there is a lack of communication, information does not transfer and operational tasks fail. Projects may be successful, however, when the project is finished and the knowledge of the new product or system does not reach the end user or process owner, it is more likely that the handover fails.

It is important for managers in public sector construction projects in KSA to recognise that the handover is taking place by the beginning of the project. Also, it is essential for the mangers to be clear about what comes about once the project is closed and the production starts. Also, the practice tasks must be defined before, during, and after the project. Besides, the procedure must be transparent for the entire project and not only have a limited number people knowing what is happening in the project.

However, the lack of communication in this research is possibly because of the fact that the project team is huge, multi-cultural, and the individuals were afraid to question as they assumed others might think that they were too inexperienced to understand technical specifications. Hence, it is highly critical to define and use a clear communication procedure. Every manager is responsible for communicating internally and externally about status and issues.

7.4.6 Unclear Responsibilities

One of the impediments to operational handover practices in the public sector construction industry is that there are unclear responsibilities in the project team. Assigning responsibility to project teams and the ability to use and list all the information across the design/construction is considered to be a very important step needed in projects to improve data handover practices.

Unclear system responsibilities, end user documentation, and controlling the phase after the project are the major issues at project handover.

Based on the interviews results, it was found that there is a difficulty in the project handover, as sometimes the strategies for the following stage were lost and, throughout the whole project, duties and responsibilities were unclear. For instance, from the interviews result, it was unclear who the project manager was. However, this poor approach may be due to the reason that there was not enough knowledge to manage the project.

It is essential to identify these main factors that lead to good lifecycle data management and enhance building handover practices of public sector construction projects in the KSA. Thus, efforts can be focused on those factors in order to reduce them and improve the current practices and taking it forward.

7.5 Originality of the Research

There are many previous studies related to the data management in building handover practices of construction projects in a KSA. However, data management in building handover practices around the world generally, and the Arab world specifically, has been paid little attention. This study is also the first empirical research that detects and addresses the issues that affect the data management in building handover practices of construction projects in the KSA. Furthermore, in the entire literature, no case study research has studied this topic in the KSA. Thus, it is expected that this research offers a foundation for the improvement of scientific research in the construction industry area.

Thus, this research has made significant original contributions to knowledge by investigating factors that affect the data management in building handover practices of construction projects in the KSA by the case study within the KSA public sector construction context.

Therefore, this research has reduced the gap in knowledge in the KSA construction industry context specifically, and in the Arabic construction industry in general.

Furthermore, other researchers in the construction sector industry would benefit from this research.

Fourteen factors affecting facility data management in building handover practices in the KSA public construction industry were identified in this study. They are:

- Lack of knowledge and experience.
- Lack of use of technology.
- Lack of training.
- Lack of communication during project data at the Handover Stage.
- Complexity of projects.
- Lack of transparency.
- Societies not involved.
- Unclear Responsibilities.

However, four were unique factors in context of KSA that are:

- Encouraging national labour.
- High Manager Turnover.
- Accelerated completion.
- Maintaining order.
- Lack of protocol or framework in place for life cycle data management.
- Maintenance manuals and keys are often missing.

7.6 Further Contributions to Knowledge

The foremost contribution is that the study identifies the factors that affect data management in building handover practices in the construction projects industry in KSA.

As stated above, the aim of this study was to develop a framework to enhance data management in building handover practices of public sector construction projects in the KSA. Hence, recommendations from this research may help the KSA government to address these factors.

This study is the first study in KSA construction industry sector to focus on the issues that affect data management in building handover practices of public sector construction projects. Therefore, it has reduced the gap in knowledge in KSA studies and in Arabic studies, in general (due to the similarity of cultural and environmental contexts).

There is an identification of unique factors that affect data management in building handover practices in the KSA culture context.

There is a lack of empirical research on data management in building handover practices in Arabic countries specifically, and other countries all over the world. Thus, this research contributes to this field by adding to the limited studies in literature.

This research has revealed similarities in some factors affecting data management in building handover practices identified by other researchers from different national contexts. Thus, these findings will strengthen the existing literature.

The identification of factors that affect data management in building handover practices would improve the construction industry sector and lead to improvements for KSA society.

This study highlights the significance of data management in building handover for the construction industry, thereby increasing the ability to train people from the industry on the data management practices and its practical application.

The research is a valuable resource for academics, researchers, and specialists who have a strong attention in understanding data management in building handover practices. Hence, this research is to be a considerable body of knowledge for assisting and supporting construction project decision-makers in the KSA to understand the different factors that could affect construction industry activities, allowing them to work towards improving the quality of their provided programmes related to this industry.

7.7 Recommendations

The recommendations of this research are clarified below. These recommendations have been intended for policy, practices, and research.

7.7.1 Recommendations for policy

- The Agency of Studies and Supervision of Projects in the Secretariat in Al Madinah Al Munawwarah, Regional Municipality should build in training and education of all construction workforces to develop construction industry practices and support the implementation of any advanced technology, such as BIM. Also, it should provide effective leadership training to ensure effective application of industry guidelines.

- It is very recommended to consider integrating the administration of all construction industry in KSA to ensure effective progressions in this important sector.

- Building laws should be changed and should include strict rules that designers and users should follow to reduce improper procedures in the general buildings sector.

- Post-occupancy evaluation should be mandatory on all public sector projects to assessing performance in order to determine good and bad design practice and help inform other design decisions.

- Encouraging KSA national labour to join this sector by enhancing the wellbeing of workers and improved working environments will stabilise the construction industry and reduce the turnover of national labour.

7.7.2 Recommendations for practitioners

- The manager of the projects must participate in detecting best practices in data handover for their construction projects, principally in terms of information forms and presentations.

- The project managers should investigate procurement practices and regulatory, contractual requirements and insurance, which present hindrances to data flows. These outcomes should be used to describe work performs and project delivery.

- They should use advanced technology to avoid the data loss related when passing a project from the design group, to the building group, operator, and the construction owner.

- Experienced labour should be provided in all public sector building projects in the KSA.

- The findings suggest the importance of assigning responsibilities of various project team members and enhancing the mutual trust and capability to use the data through the design team and construction team.

7.7.3 Recommendations for researchers

- Scientific researchers should be encouraged to develop sophisticated techniques to develop the public sector projects.
- They should enhance the construction sector through the application of known modern construction research, including facilities data management, creation of engineering workshops specialized in designs, maintenance, and other relevant facilities for development of this sector in general.
- They should establish technical and vocational building institutions for Saudi youth to provide a qualified and well-trained national labour force.

7.8 Limitations of the Research

According to Yin (2009), every research is limited by the restrictions placed upon the researcher and this research is no exception. The limitations of this research are:

- The research is limited to only one case study, as designated research strategy.

Therefore, the findings can only be generalised with theory without any certainty. However, this research is not concerned with generalisation towards other cases as this study was the first to investigate data management in building handover practises of public sector construction projects in the KSA, so there was nothing to compare it with.

- Some of supporting documents were constrained inside the case study organisations and the researcher was only able to check them on the buildings. In addition, there is a large number of documents and some of these documents were private. This has decreased the capability to endorse answers from interviewees.
- There was a lack of literature on data management in the building handover context. Besides, the literature based on studies conducted in Arabic countries and in the KSA was also lacking.
- In addition, there is more limitation related to the inability to record the interviews because of cultural restraints. This may cause some essential information to be missing and less concentration on the interviews; however, the researcher tried to tackle this constraint by taking as detailed notes as possible during the interview. Also, after each interview, the researcher wrote all of the information and thoughts while they were still easy to think of.
- The size of study was limited by the time available for the analysis. Hence, a substantial amount of information developed from this study can be used for future research.

7.9 Suggestion for Further Research

Supplementary work should be conducted to examine and understand the issues affecting the facility data management in building handover practices of private sector construction projects in the KSA. This study has presented the results by categorising them into several themes. Supplementary studies may need to take that further; every theme might be studied independently in order to gain a deeper understanding of factors that come across within every theme. More research is needed to find the barriers that face projects at every stage of the building construction and to develop effective involvement strategies.

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APPENDICES

Appendix 1: Ethical Approval

Academic Audit and Governance Committee

College of Science and Technology Research Ethics Panel (CST)

MEMORANDUM

To	**Sultan Ahmad Hijazi (and Dr Zeeshan Aziz)**
cc:	**Prof Charles Egbu, Acting Head of School of SOBE**
From	**Nathalie Audren Howarth, College Research Support Officer**
Date	**12 November 2013**

<u>Subject:</u> **Approval of your Project by CST**

<u>Project Title:</u> **Developing a framework to enhance data management in building handover practices of public sector construction projects in Kingdom of Saudi Arabia.**

<u>REP Reference:</u> **CST 13/106**

Following your responses to the Panel's queries, based on the information you provided, I can confirm that they have no objections on ethical grounds to your project.

If there are any changes to the project and/or its methodology, please inform the Panel as soon as possible.

Regards,

Nathalie Audren Howarth

College Research Support Officer

Appendix 2a: E-mail Invitation for Questionnaires

Dear Sir/Madam,

Invitation to participate in research study

My name is Sultan Hijazi and currently doing my PhD on developing a framework to enhance data management in building handover practices of public sector construction projects in the Kingdom of Saudi Arabia at the School of the Built Environment, The University of Salford, Manchester, UK.

The research focuses on developing frameworks to improve the building handover processes and smooth the information flow between the construction phase and operation and maintenance phase.

I would like to invite you to complete the attached questionnaire. The questionnaire will approximately take 15 minutes. The Ethics Committee of University of Salford has granted ethical approval for this study.

If you decide to participate, please see the attached Participant Information Sheet. If you have any questions or concerns about the study, please contact me.
+447856999095;
Email: S.A.S.Hijazi@ed.salford.ac.uk
Your participation is highly appreciated.

With kind regards,

Sultan Hijazi
PhD Candidate

Appendix 2b: The Questionnaire

Developing a framework to enhance data management in building handover practices of public sector construction projects in the Kingdom of Saudi Arabia

By completing this form, I, agree to give consent to my participation in the research project, entitled "Developing a framework to enhance data management in building handover practices of public sector construction projects in the Kingdom of Saudi Arabia".

- I confirm that I have read and understood the Participant Information Sheet explaining the above research study and that I have had the opportunity to ask questions about the project.
- I agree to take part in the above research study
- I understand that my participation is voluntary and that I am free to withdraw at any time, without providing a reason
- I understand that, if I decide to participate in this study, then the results obtained from this study, may be kept for possible use in future studies
- I understand that my anonymity is assured and that only the researchers involved in this study at the University of Salford Manchester, UK, will use the data. I thus give permission for these individuals to use this information as they wish within academia If they agree to preserve the confidentiality of the information as requested in this form

* Required

SECTION 1: GENERATION INFORMATION

Your Age?

- ◯ 20 to 30
- ◯ 30 to 40
- ◯ 40 to 50
- ◯ 50 and above

Please indicate (the equivalent of) your highest academic Qualification?

- ◯ High school
- ◯ Diploma
- ◯ Bachelor
- ◯ Postgraduate
- ◯ Other: ________

How many years have you been working in public sector construction?

- ◯ 0 - 5 years
- ◯ 5 - 10 years
- ◯ 10 - 15 years
- ◯ 15 - 20 years
- ◯ 20 and above

What kind of organisation you are currently worked in?

- ◯ Client - Government

- Client - Private
- Contractor
- Consultant – Designer
- Facility Management

Which of the following best describes your company's principal business activity?

- Contractor
- Consultant
- Client

Length of time your organisation has been using Building Information Modelling?

- Not using
- 1-2 years
- 3-5 years
- 5 or more years.

What is your organisational maturity in BIM Usage?

- Beginner
- Moderate
- Advanced
- Expert

Are you satisfied with quality of information that is handed over to project owners towards completion of the project?

- Yes
- No

How would you classify your organisation in terms of size?

- Small Size (50 or less employees)
- Medium Size (250 or less employees)
- Large Size (Above 250 employees)

SECTION 2: BUILDING HANDOVER PRACTICES

How important is the project handover stage to your organisation and your clients

- Very important
- Important
- Slightly important
- Least important
- Other:

Which of the following present the most significant challenge to effective building handover practices in the KSA public sector construction industry? *

Please score on a scale of 1-5, where 1 is "most significance challenge" and 5 is "least significant challenge"

	1	2	3	4	5
Societies not involved in choice of building systems	○	○	○	○	○
Lack of mutual trust, and recognition of new project roles, such as information manager	○	○	○	○	○
Inappropriate quality assurance methods and procedures	○	○	○	○	○
Lack of transparency and accessibility of project data for all project team electronically	○	○	○	○	○
Not enough time for operations training	○	○	○	○	○
Responsibilities of various project team members are unclear	○	○	○	○	○
Maintenance manuals and keys are often missing	○	○	○	○	○
Ability to use the information across the design/ construction team	○	○	○	○	○
Actual	○	○	○	○	○

	1	2	3	4	5
handover process is often an afterthought event					

How significant are the following benefits of effective Building Handover in the KSA construction sector *
Please rank on a scale of 1-5, where 1 is 'most significant benefit' and 5 is 'least significant benefit'

	1	2	3	4	5
Minimize defects	◌	◌	◌	◌	◌
Cost reduction	◌	◌	◌	◌	◌
Improve quality and client satisfaction	◌	◌	◌	◌	◌
Control construction process	◌	◌	◌	◌	◌
Save time	◌	◌	◌	◌	◌
Legislation and legal requirements	◌	◌	◌	◌	◌
Stakeholders influence	◌	◌	◌	◌	◌
Resource efficiency and driving out waste	◌	◌	◌	◌	◌
Moral and ethical obligations	◌	◌	◌	◌	◌

How important is the following project data at the handover stage *
Please score on a scale of 1-5, where 1 is 'most important role' and 5 is 'least important role'

	1	2	3	4	5
Commission plans	◌	◌	◌	◌	◌
Building drawings and specification	◌	◌	◌	◌	◌
Insurance	◌	◌	◌	◌	◌
Manufacturer	◌	◌	◌	◌	◌

	1	2	3	4	5
products data					
Quality Control documents	○	○	○	○	○
Operations and Maintenance manual	○	○	○	○	○
Equipment lists	○	○	○	○	○
Daily reports	○	○	○	○	○

Which of the following could be affected mostly by the building handover process *
Please rank on a scale of 1-5, where 1 is 'most affected' and 5 is 'least affected'

	1	2	3	4	5
Health and safety	○	○	○	○	○
Reliability of equipment	○	○	○	○	○
Standard of operations	○	○	○	○	○
Cost of operations	○	○	○	○	○
Cost of maintenance	○	○	○	○	○

To what extend do you agree or disagree with the following statements of the benefits of using BIM *

	Agree	Disagree
Better planning	○	○
Information at every stage	○	○
Better use of resources	○	○
Cost savings	○	○
Time savings	○	○
Following international standards	○	○
Sustainability	○	○
Life cycle costing	○	○
Management of energy consumption	○	○

How important is the following benefits of Building Information Modelling (BIM) in the KSA construction sector *
Please rank on a scale of 1-5, where 1 is 'most important benefit' and 5 is 'least important benefit'

	1	2	3	4	5
Reduced labour for building commissioning	○	○	○	○	○
Improved integrated design process	○	○	○	○	○
Better tracking of installation and testing	○	○	○	○	○
Enhanced information flow between project parties	○	○	○	○	○
Encourages the integration of project stakeholders	○	○	○	○	○
Easy access to project data and information	○	○	○	○	○
Increase speed of preparing Asset Management System	○	○	○	○	○
Improve asset management throughout lifecycle	○	○	○	○	○
Efficient project management	○	○	○	○	○
Effective communication and closer collaboration	○	○	○	○	○
Reduction in Error and Emissions	○	○	○	○	○
Better collaboration	○	○	○	○	○

	1	2	3	4	5
between owners/design firm					

How do you agree with the statement: "The development of Information Technology facilitates the integration of different and multiple sets of data and increase efficiency"?*

- Strongly agree
- Agree
- Disagree
- Strongly disagree
- Neither Agree nor Disagree

How would you assign most responsibility for building information handover to each of the following parties?

- Owner
- Contractor
- Design

Do you get necessary information about the process of project at every stage of operation?

- Yes
- No

Is your facility maintenance outsource or do you perform this function in-house?

- Outsourced
- In-house

For operations and maintenance of key equipment and facilities, what sort of services you perform?

- Preventive
- Reactive
- Predictive /Proactive

Do you have easy access to all construction drawings, which are revised and updated?

- Yes
- No

Have you got drawings to indicate location of your key Mechanical, Plumbing and Electrical installations?

- Yes
- No

What is perceived impact of effective Building Handover policy on Return on Investment (ROI)?

- Very Positive ROI
- Moderately positive ROI

- Break-Even ROI
- Negative ROID

Do you track energy consumption and perform energy benchmarking?

- Yes
- No

Do you have easy access to all documents below?

	Yes	No
Specifications		
Warranty information		
Service contracts		
Spare parts data		
Equipment Purchase Dates		
Emergency Management Plans		

How do you plan facility budget for operation and management? Please tick if following processes are included in the process.

- Establish facility goals and objectives
- Capture and analyse data
- Analyse and interpret data
- Create and test alternatives
- Develop strategic plan and budget

What is your biggest facility challenge?

- Maintenance of facility budget
- Asset management and maintenance
- Emergency preparedness

What investments are necessary to ensure effective implementation of Building Handover?

- Development of BIM Processes
- Training of personnel
- Training in use of software
- Investments in Hardware (e.g. Tablets, Mobile Devices)
- Development of Custom 3D libraries
- Addressing software customisation/Interoperability Issues
- Other:

Appendix 3: Research Participant Consent Form

Name of Researcher: Sultan Hijazi

Name of Supervisor: Dr. Zeeshan Aziz

1. I confirm that I have read and understood the information sheet for the research and what my involvement will be.	**Yes**	**No**
2. I have been given the opportunity to ask questions (face to face)	**Yes**	**No**
3. I agree to take part in the interview	**Yes**	**No**
4. I agree to the interview being tape recorded	**Yes**	**No**
5. I understand that my participation is voluntary as well I can withdraw from the study at any time without any reason	**Yes**	**No**
6. I agree to take part in the above research	**Yes**	**No**

Name of respondent

Signature

Date

Name of researcher: Sultan Hijazi

E-mail S.A.S.Hijazi@ed.salford.ac.uk

Appendix 4: The sample of coded themes

Coding Summary By Node

Project Handover

15/02/2015 11:33

Aggregate	Classification	Coverage	Number Of Coding References	Reference Number	Coded By Initials	Modified On

Node

Nodes\\BIM and Technology benefits\Cost, Time and Effort

Document

Internals\\S1

No		0.0803	1			
				1	SU	12/08/2015 16:49

The main roles technology play in improving building maintenance and handover in our company are reduces the effort expended, ease of follow-up maintenance, reporting and follow-up plans, lead to raising the quality of performance, help in data and information updated

Internals\\S10

No		0.0719	1			
				1	SU	12/08/2015 17:02

Overall i think that the main Reduce the time roles technology play in improving building maintenance and handover in our company are, Reduce the effort expended, Lead to raising the quality of performance and Help in data and information updated

Internals\\S2

No		0.0813	1			
				1	SU	12/08/2015 16:53

I believe that there are many roles that technology plays in improving building maintenance and handover reduce the cost, reduce the time, reporting and follow-up plans, lead to raising the quality of performance and help in data and information restructured

Appendix 5: Sample of e-mailed letter to validate the results

University of Salford MANCHESTER

Dear Mr\

I send to you a briefly result of my research study to look at it very carefully, regarding to the terms of the validity and accuracy of information and it is integrated the scientific, academic and recording any comments or observations or investigations in this research.

I would appreciate it

Regards

Researchers: Sultan Hijazi