Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Economics and Management
Dept. of Industrial Economics and Technology
Management

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Investigating the importance and barriers connected to the Integrated Technical Building installations (ITB) managerial role in building company

A qualitative case study of a building and construction company in Norway

Master's thesis in Project Management
Supervisor: Ola Edvin Vie, IØT
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Kunnskap for en bedre verden

PREFACE

This thesis is written to fulfil the master's degree program requirements of NTNU subject, TIØ4920 Project Management, Master's Thesis. The topic for the thesis was chosen based on the collaborative efforts between the case company, academic supervisor and the author. The author's passion for researching into the "The application of Integrated Technology Building installations (ITB) in construction projects", is fuelled by his career desire to investigate into the use of technologies to improve business processes. This passion can also be seen in his previous research (project thesis) where he looked into the "Digital competence of construction project managers". The initial plan was to use the literature review conducted in his project thesis as a theoretical foundation for his master thesis. However, the topic for his master thesis was changed, so a new literature review was conducted.

The author sincerely wishes to thank his academic supervisor, Associate Professor, Ola Edvin Vie, for his remarkable and discerning feedbacks, patience, commitment and valuable suggestions during the autumn of 2019, and the whole year of 2020. Ola Edvie's theoretical and methodological insight has been an important inspiration and contribution to the development and direction of the study.

The author is grateful for the interviewees participating with information and their experience with ITB application. The author especially wants to show sincere appreciation to Hans-Olav Endal for his generous efforts and contribution to ensuring that the interviews with Rambøl was a successful one considering the challenges that were encountered during the coronavirus disease outbreak.

Finally, the author wishes to genuinely thank Dr Samuel Senanu (Research Scientist at SINTEF) and Zawadi Mdoe (PhD candidate at NTNU) for reviewing and proofreading his thesis to improve its clarity.

Abstract

The production of functional buildings has currently been a demanding requirement for building companies and builders who invest a significant amount of money into building structures and want to gain competitive advantages in the building industry. It appears that some building companies are not able to meet the increasing demands of builders and regulators who request for sustainable, error-free, and environmentally friendly buildings. The root cause of this problem is related to the absence of technical program managers who ensure holistic-thinking and provision of integrated technology solutions to produce functional and cost-effective buildings; this is where the role of an Integrated Technology Building installations (ITB) manager is needed. The ITB manager serves a focal point that coordinates the activities of the individual technical disciplines to ensure smooth simultaneous operations of the integrated technical systems.

The purpose of this thesis is to investigate the application of ITB role in building projects. The objectives are to discover some challenges influencing the deployment of ITB roles and to investigate the extent to which the ITB role is beneficial to the building industry. These objectives are achieved by providing answers to the main research question *"How does a construction company like Rambøl perceive the ITB role"*. To answer this question, a descriptive, explorative, and explanatory case study of a single organization was conducted by performing eight (8) semi-structured interviews with employees from the project management, technical and engineering departments of Rambøl. The literature review involved the evaluation of pieces of literature that describe the challenges and benefits of using ITB role in projects.

In Rambøl, the ITB role is found to be very important to building projects considering the increasing number of building's technical systems and their related characteristics (building's complexity). The implications of the systems' interdependencies require the need for multidisciplinary technical coordination to guarantee the delivery of functional and sustainable buildings. Per the findings, the lack of contractual authority and the late involvement of ITB managers in projects are some of the pressing challenges affecting the ITB role. The findings recommend the amendment of the general contract standard (NS 8407) to include the ITB roles and mandates. Besides, it recommends the involvement of ITB managers throughout the project's development lifecycle to perform cost-effective and efficient work. The resolution of these challenges and other relating challenges is assumed to improve the effectiveness of the ITB role in the building industry. Based on the information received from Ramøl, it can be assumed that the ITB concept is the future for the building industry.

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Abbreviations

Abbreviations	Meanings
AITB	Advisory Integrated Technical Building installation
BAS	Building Automation System
BDC	Building Design and Construction
BIM	Building Information Model
BREEAM	Building Research Establishment Environmental Assessment Method
Building's LCC	Building’s Life Cycle Cost

EMS	Energy Monitoring systems
HVAC	Heating, Ventilation, Air-Conditioning
ICE	Integrated concurrent Engineering
ITB	Integrated Technical Building Installation
NS	Norwegian Standard
NS 3935	ITB Design, implementation, and commissioning
NS 6450	Commissioning and testing of technical building installations
NS 8407	General contract for general terms
NZEB	Nearly Zero Energy Building
OSW	Open Source Workplace
SN	Standards Norway
SSB	Statistics Norway
VDC	Virtual Design and Construction.

1 INTRODUCTION

The construction and building industry around the world has a huge potential to improve its performance in terms of constructing buildings that meet the specifications of builders and regulators (NS3935, 2019, Abdel-Wahab and Vogl, 2011, Ingvaldsen et al., 2004). In Norway, the construction of completed buildings with specialized technical facilities (such as heating, ventilation, air-conditioning systems, etc.) contributes to the great performance of the construction industry (statistics Norway, 2018).

Currently, the construction industry is facing ever-increasing complexities in terms of the increasing number of technical systems and their interdependencies (Johansen and Hoel, 2016, Integra, 2011). According to these authors, the current buildings possess high-level technologies compared to buildings constructed a few decades ago. These technology facilities include heating systems, cooling systems, ventilation systems, fire and alarms systems, lighting, motion sensors, etc. The increased technical complexity implies that those who plan and execute building projects need to deal with a significantly larger amount of information than was previously experienced. Also, there is a need for a higher degree of interdisciplinary interactions and understanding between the actors involved in the project (Integra, 2011).

In managing the complexities with regards to technical facilities, many builders or construction companies seek for minimum optimal solutions combined with a lack of integration between the various technical facilities and actors, resulting in inefficient buildings (Mazzucchelli and Lucchini, 2012, Integra, 2011, Milosevic et al., 2007). During simultaneous operation of technical systems, the technical systems have adverse effects on each other because they are not properly integrated. These buildings provide unfavourable conditions such as too low or high temperatures, acoustic problems, poor visual comfort, etc. These unfavourable conditions lead to numerous complaints from end-users and builders, which call for the need to correct these errors. Making changes after the building is completed increases the overall cost of the building because additional resources such as budget, time, etc. are required (Johansen and Hoel, 2016, Integra, 2011, Samset, 2010). It is therefore advisable to include integration roles early in the project to ensure that the right things are done, and cost-effective changes are made before the project is completed. Sometimes, ideal solutions are not developed to make effective changes, resulting in the waste of additional resources, and ineffective completed buildings (Integra, 2011, Citherlet et al., 2001).

Good and functional buildings must have efficient and flexible operations, which demands the focus on holistic and integrated technical solution (NS3935, 2019, Integra, 2011, Citherlet et al., 2001). Buildings are no longer simple concrete structures for housing people, but they currently consist of additional technical facilities which need to be installed to provide suitable environmental conditions. Thus, properly installed integrated systems improve productivity and occupants' comfort, reduce energy consumption, extend the life cycle of the utilities, etc. (OSW, 2019, Temidayo et al., 2018, Integra, 2011).

Improving the technical situation of a building does not relate only to new buildings, but it also includes old buildings that need rehabilitation (OSW, 2019, Integra, 2011). According to Integra (2011), today's public and private tenants are making huge demands for buildings with specific technical requirements. They have indicated

that they will only rent buildings that meet the minimum specified requirements related to functionality, indoor climates, energy consumptions, etc. (Integra, 2011). To meet the continuously changing demands of building owners and regulators, construction companies are urged to continuously upgrade and develop their real estate portfolio and technical facilities (Integra, 2011).

According to Johansen and Hoel (2016), the concept of systematic completion can be used to ensure that the final product (i.e. the building) meets all the functional specifications and has technical systems working as described. *Systematic completion* is defined as a "certainty that the project meets all the functional requirements within the given time, cost, and quality requirements, planned and verified through a structured process managed from planning to acquisition" (Johansen and Hoel, 2016,p.8). The application of systematic completion ensures that (1) errors are detected and corrected throughout the project's development life cycle before the expensive phase of operation; (2) it ensures better-quality buildings with effective integrated technical systems; (3) more accurate Lifecycle cost (LCC) and better indoor climate of buildings (Johansen and Hoel, 2016).

As part of the process for carrying out systematic completion, the technical systems need to be effectively managed by applying integrated solutions (Bai et al., 2009, Integra, 2011, Citherlet et al., 2001). The figures from the prognosis centre show that technical components constitute 36-46 % of the value of a modern building (Integra, 2011). Therefore, construction companies and builders who want to achieve optimal benefits from their investments in current and new technical facilities must focus on holistic or integrated technical solutions (Integra, 2011, Citherlet et al., 2001). This is where the concept of Integrated Technical Building installation - ITB comes into the picture (Integra, 2011, NS3935:2011, 2011). Effective integration of the technical facilities in buildings ensures smooth and effective communication between the systems when they are operating concurrently, without having adverse effects on each other (Integra, 2011, Bai et al., 2009, Citherlet et al., 2001).

To ensure that the technical integration process is carried out as specified by the contract or builder, ITB related standards have been established. In Norway, Standards Norway has defined standards such as ***NS 3935*** - ITB designing, implementation and commissioning; ***NS 6540*** - Commissioning and testing of technical building installations; ***NS 8407*** – General conditions of contract for design and build contracts, etc. However, the provision of standards in documents does not significantly guarantee that the defined and expected procedures for designing and installing the integrated system will be carried out (Integra, 2011). Therefore, a dedicated ITB manager needs to be employed to ensure that is someone responsible for the integration process. In organisations where dedicated ITB managers are not employed, the integration role is shared between the functional teams (Integra, 2011, Milosevic et al., 2007). This works perfectly in a well-planned and executed projects, but there are difficulties regarding who is supposed to be held accountable for integration issues when problems begin to surface (Integra, 2011, Milosevic et al., 2007). This is where the presence of a dedicated ITB manager is needed. The ITB manager assumes complete responsibility of the integrated systems, and ensures that the processes defined in the NS 3935 and 6450 are carried out, and documented for future maintenance and changes in the building (NS3935, 2019).

This thesis investigates the application of ITB concept in construction projects. It explores the extent to which ITB role is needed in building projects. In addition, it investigates some challenges (such as ITB-contract challenges,

high cost attributed to implementing ITB roles, late involvement of ITB manager in a building project, etc.) hindering the application of ITB role in building projects. It further provides suggestions to employees in the building industry on how to address these challenges. The thesis also describes some regulatory standards (such as NS 3935, NS 8407, NS 6450, etc.) which are relevant to the application of the ITB role. This will assist readers to be aware of the available standards, their implications, and challenges. Conducting this research is assumed to help improve the awareness and application of ITB roles in building projects. The research comprises of a literature study, followed by empirical data analysis.

1.1 Research Objectives

The research is conducted to explore the ITB concept, gain in-depth skills and knowledge which can be relevant to the building and construction industry. Also, the study is carried out to understand the extent to which building projects need to apply ITB concept; explore some challenges hindering the application of the concept, and provide some suggestions to address these challenges. The concerned case company, Rambøl is also interested in increasing awareness and application of ITB concepts in building projects.

The thesis presents theories, expectations and research questions before proceeding with the semi-structured interviews with employees in the construction industry. A top-level research question is considered to be the leading theme of the thesis, and it is based on the application of ITB concept in construction building projects. Based on the title of the master thesis, the following problem statements are presented:

How does a construction company like Rambøl perceive the ITB concept?

The above central problem statement can be restated in the following subordinate research questions:

i. RQ1 To what extent is ITB role beneficial to building projects?
ii. RQ2 What are the relationships between the various ITB standards used in building projects?
iii. RQ3 What are some of the challenges hindering the application of ITB role in building projects?

In order to explain RQ1, the thesis addresses the topic of dependency. Thus, to which degree does building projects depends on the implementation of the ITB concept. In answering this question, theories and empirical data describing the benefits of integrating the building's technical facilities and employing ITB managers were reviewed and presented. In the concluding section of this thesis, Chapter 7.1.1 presents the solutions to RQ1.

In answering the RQ2, Literature and empirical data describing the relationship between the various ITB related standards was investigated. The collection of literature data involved reviewing related ITB standard publications presented by Standards Norway (SN). The gathering of empirical data involved interviewing experienced ITB employees (experts and non-expert interviews) in Rambøl to gain practical presentation of the ITB standards. This aspect of the research will help readers to know the various ITB related standards that are frequently used in building projects and their interdependencies. The answers to RQ2 are presented in Chapter 7.1.2 of the concluding section of this thesis.

To provide answers to RQ3, the thesis investigated some challenges facing the ITB role. Challenges relating to exclusion and late involvement of the ITB role in building projects, contractual authority of the ITB manager, etc. were investigated. Relating theories and empirical data were collected to answer this question. The answers to RQ3 are provided in Chapter 7.1.3 of the concluding section of the thesis.

1.2 Layout of the thesis

The structure for writing the thesis adopted the procedures described by (Bryman, 2012). These procedures are described in the table below:

Table 1. 1 Structure for writing the thesis (Bryman, 2012,p.686 - 691)

Chapter	Procedures	Description
1	Introduction	The section describes the problem statement and the objectives for conducting the research. It further discusses the research questions that drive the passion to conduct the research.
2 - 3	Literature review	This chapter presents discussions of how the topic (ITB concept) is perceived in literature. Different views of authors are discussed. The section presents the propositions that were developed during the literature evaluation process.
4	Research Methodology	This division describes processes relating to the research design, sampling approach, transcription, coding and analysis, etc.
5	Empirical data	This chapter discusses the empirical findings or results retrieved from the data collection process.
6	Discussion	It involves a deductive analysis of my findings where the empirical data were compared with theoretical findings to confirm whether the data supports or dismisses the theoretical propositions.
7	Conclusion	This chapter relates my findings and discussions to my research questions. It indicates whether the research questions have been answered or not. In addition, it proposes areas for further research based on my findings.

1.3 The contribution

It can be concluded that the topic, Integrated Technical Building installations – ITB, is not adequately investigated based on the literature study conducted. Few publications such as “ITB profitable for builders” (Integra, 2011), “Integration in building physics simulation” (Citherlet et al., 2001), etc. describe the ITB concept, and they provide different perspectives based on academic or professional backgrounds.

Based on the literature study, it was discovered that the ITB concept is not only for those with a science background even though it revolves around the use of scientific-technical knowledge. The concept can be viewed from other perspectives such as business, social sciences, etc. From these perspectives, researchers can look into the socio-economic implications of deploying ITB concept in construction projects; thus, how ITB concept improves the financial and non-financial performances of building and construction companies and the construction industry as a whole; how it affects the employment situations and living standards of people within an economy, etc. From a business strategy perspective, the ITB concept can be explored to determine how it can provide competitive advantages to construction companies. A product or solution is assumed to provide a source of competitive advantages when it adds values to the company's business processes (De Wit, 2017). With the application of ITB concept in projects, the likelihood of delivering functional buildings are assured, which provides documented productivity effects (Johansen and Hoel, 2016, Integra, 2011). Therefore, it is assumed that construction companies who make extensive use of ITB concept have the potentials of ensuring the provision of functional buildings to their clients, which can serve as a source of gaining competitive advantages in the building industry.

As mentioned in Chapter 1.1 - *Research objectives*, the aim for conducting this research is to gain insight into ITB concept, and discover some challenges that contribute to its minimal use in building projects. By helping to address the challenges, the thesis provides some recommendations in Chapter 7.3.1 – *Recommendations*, which are based on the research findings and discussions in Chapter 5 – *Empirical Data* and Chapter 6 – *Discussion*. By conducting this research, I am contributing to using technology to address some of the challenges facing the business processes of companies within the building and construction industry. Besides, the research increases the focus on ITB concepts and its related standards, and contributes to the increased number of academic publications.

1.4 Definition

In chapter 2, a literature review is conducted to gain in-depth insight into the theoretical concept of ITB application in construction projects. The literature review was performed to gain varying perspectives on how different authors have presented the concept in literature. This thesis defines the research opportunities regarding leveraging the importance of using ITB concepts in construction projects. To set the scope and boundaries of the research, the following definitions are made in alphabetical order for easy identifications:

i. **Advisory ITB (AITB)** – It refers to a person who is responsible for ensuring that specifications prepared by the ITB manager are executed in the engineering phase. In the Norwegian language, advisory ITB is referred to as "Rådgivende" ITB – RITB. The term "Advisory ITB" will be used in the thesis since the language of instruction of the thesis is the English language.
ii. **Builder:** It refers to a project/building owner or the end-user of the building.
iii. **Building Automation System (BAS):** It is an intelligent system consisting of both hardware and software which connects heating, venting and air conditioning (HVAC) systems, lighting, security, and other systems to communicate on a single platform. The main function of the BAS is to maintain the heating,

cooling, and ventilation conditions within a particular range, humidity control, lighting depending on an occupancy schedule, proper functioning of the elevators, fire prevention, security and other critical systems in the building (OSW, 2019).

iv. **Business or strategic objectives**: In the context of ITB organisation, the business or strategic objectives refer to the overriding goals of the builder, which involves the production of functional buildings with better working integrated technical system. Achievement of these objectives are the ultimate responsibilities of the ITB manager.

v. **Contracting:** It involves making a legal agreement between two or more people. For example, the contract between the building owner (builder) and the contractor.

vi. **Contractor:** refers to a person who performs the project work in a building project.

vii. **Construction Industry:** This is a sector of an economy that involves the construction and maintenance of commercial and residential buildings, roads, and infrastructures; involving other areas such as the mining, oil, railway and energy sectors (Prince, 2019). The scope of the research is limited to the building sector of the construction industry. The focus is further limited to the Norwegian building industry even though some statements will involve a description of the industry from the world perspective.

viii. **Construction phases:** It defines the time-limited periods in a construction project. The content of the various phases might differ depending on the complexity of the tasks involved. Concerning the ITB application, the building phases include engineering, installation, commissions (subsystems), integrations and test operations (NS3935, 2019, NS6450:2016, 2016).

ix. **Departmental Integration:** Refers to the measure of coordination among departments with similar structure, task and goals. Departments with varying structure, task and goals are classified as differentiated departments (Hellriegel and Slocum, 1996). Based on this definition, the thesis defines technical integration as the coordination between the various technical facilities/disciplines with similar goals such as the provision of functional and environmentally friendly buildings.

x. **ITB role:** The role involves the coordination of the activities of the various technical disciplines to ensure a functional integrated system is designed and installed. In an ITB organisation, the ITB role is performed by an ITB manager and an Advisory ITB (AITB). The thesis will frequently make use of the term "ITB role" which basically refers to the ITB manager. In Norway, the term "ITB responsible" is commonly used in the building industry, which refers to the ITB manager (NS3935, 2019, Integra, 2011). To ensure a good flow of the text within the thesis, the thesis will make use of the term "ITB manager".

xi. **Managerial competence**: Managerial competence is defined as the skills, knowledge and attitudes that managers demonstrate in action to assist in the achievement of business objectives (Watson, 2006, Arditi et al., 2013).

xii. **Nearly Zero Energy Building (NZEB):** It refers to a very high energy performance building in which the energy demand is very low or almost equal to zero (Mazzucchelli and Lucchini, 2012).

xiii. **Professional advisers:** These refer to advisors in architecture, electrical, ICT, safety, automation, plumbing, ventilation, acoustics, etc.

xiv. **Program manager**: Refers to a manager is who responsible for coordinating the activities or projects of the various functional units to support the achievement of the client's business objectives (Milosevic et al., 2007). In the context of ITB applications, the program manager refers to the ITB manager.

xv. **Stakeholder**: A person or group of people affected by or able to influence the project (Andersen et al., 2004)

xvi. **Success factors**: these are ground rules that projects must be complied with to increase the likelihood of success (Hussein, 2018).

xvii. **System integrator:** It refers to an organisation or contractor who is responsible for designing and integrating products and service components provided by a variety of external suppliers into a functioning system for an individual customer (Davies et al., 2007). This person ensures that the functional systems are integrated and tested (NS3935, 2019).

xviii. **Tender:** It refers to a written offer presented to contractors that describe projects/products which need to be delivered within a fixed period, and as per the agreed contract conditions. By making distinctions between the contract and the tender, the tender is given to many contractors as possible to get the lowest price while the contract is only signed by contractors with the lowest tender rate. Besides, while a contract binds a contractor to complete assigned work within the agreed specifications, a tender does not.

2 THEORETICAL BACKGROUND

In Chapter 2 and 3, theories describing Integrated Technical Building installations (ITB) application, its importance and challenges will be reviewed and discussed. In addition, pieces of literature describing relevant ITB standards such as NS 3935 - ITB Design, Implementation and commissioning; NS 6450 - testing operations, and NS 8470 - general contract, etc. will be defined as well. Before describing the ITB concept, the next sections of this chapter present a brief description of the construction industry and how the performance of the building and construction industry is related to the application of the ITB concept.

2.1 Construction Industry

The construction industry started many years ago when the first human beings had to shelter themselves from bad weather conditions. Currently, the industry is made of complex construction projects; it involves the construction and maintenance of commercial and residential buildings, roads, and infrastructures relating to the mining, oil, railway and energy sector.

The industry is seen to be one of the most important sectors of a country's economy (Squicciarini and Asikainen, 2011, Hillebrandt, 2000). It generates substantial benefits in terms of social and economic benefits. Thus, it employs the largest number of people in a geographical area, and it contributes a significant portion of a country's overall goods and services produced, which is also known as Gross National Product – GNP (Hillebrandt, 2000). The gross output of the construction industry is the value of all the buildings and works produced by the industry in a given time, normally a year (Hillebrandt, 2000). In 2017, the construction industry employed 15 million people in the EU (Squicciarini and Asikainen, 2011). Buildings constructed by the industry makes use of a significant share (42%) of the total EU final energy consumptions, and it represents about 35% of all greenhouse emissions (Communities, 2007). In Norway, the construction sector generates about two-thirds of all investment goods, and employs about one-tenth of the total labour force (Ingvaldsen et al., 2004, Albriktsen and Førsund, 1989).

Considering the above-described benefits of the construction industry, it assumed that resolution of its pending challenges, as briefly presented in the introduction chapter, might significantly increase the impact it has on an economy. By conducting a study in the building and construction industry, I believe my research might contribute to making positive impacts by presenting some recommendations (see Chapter 7.3.1) to technical integration challenges experienced in building projects.

2.1.1 Productivity of the Construction Industry

This chapter will briefly describe the performance of the construction industry, and how the application of ITB concept can be used to improve the performance of the building and construction industry.

Definition of productivity and Performance

The terms “productivity” and “performance” are often used interchangeably even though they have different meanings (Andersen and Langlo, 2016). Productivity describes the measure of how inputs are efficiently transformed into outputs, whereas performance describes how well something accomplishes its purpose (Page and Norman, 2014). Takim et al. (2003) broadly defined performance measurement as the frequent use of information to determine the efficiency and usefulness of projects to improve organisational programme. From the above definitions, it can be deduced that performance has a broader definition compared to productivity, and it includes the description productivity. Thus, productivity is seen as one aspect of performance (Andersen and Langlo, 2016). The thesis will make use of the term “performance” since it has a broader concept than productivity.

Performance of the Construction Industry

There are varying perspectives describing the performance of the construction industry around the world and in Norway. Some authors perceive the industry around the world to be underperforming in the recent years (Temidayo et al., 2018, Agarwal et al., 2016, Johansen and Hoel, 2016, Albriktsen and Førsund, 1989). In Norway, similar issues are seen in the construction industry based on figures reported by research and regulatory bodies such as from SINTEF and Statistics Norway-SSB (Johansen and Hoel, 2016, Andersen and Langlo, 2016, Albriktsen and Førsund, 1989), as seen Figure 2.1. Some authors dispute the performance measurement since it is difficult to come up with empirical studies explaining this situation, let alone the analyses of why productivity is slow in this sector than others (Andersen and Langlo, 2016, Albriktsen and Førsund, 1989). Andersen and Langlo (2016) perceive the statistics provided by SSB to be flawed and certainly not 100% reliable. They argue that not every organisation within the construction industry was included in the statistical report and that some organisations were included in other industries such as oil and gas. Secondly, they stated that “these figures are very high-level and fail to capture activity-level improvements” (Andersen and Langlo, 2016,p.2). According to these authors, the industry requires a conventional measure or tools to measure how performance and productivity falls and improve over time. Research has shown that the industry has some great potentials for performance improvements (Abdel-Wahab and Vogl, 2011, Ingvaldsen et al., 2004), and numerous efforts have been put in place to realise these potentials (Andersen and Langlo, 2016)

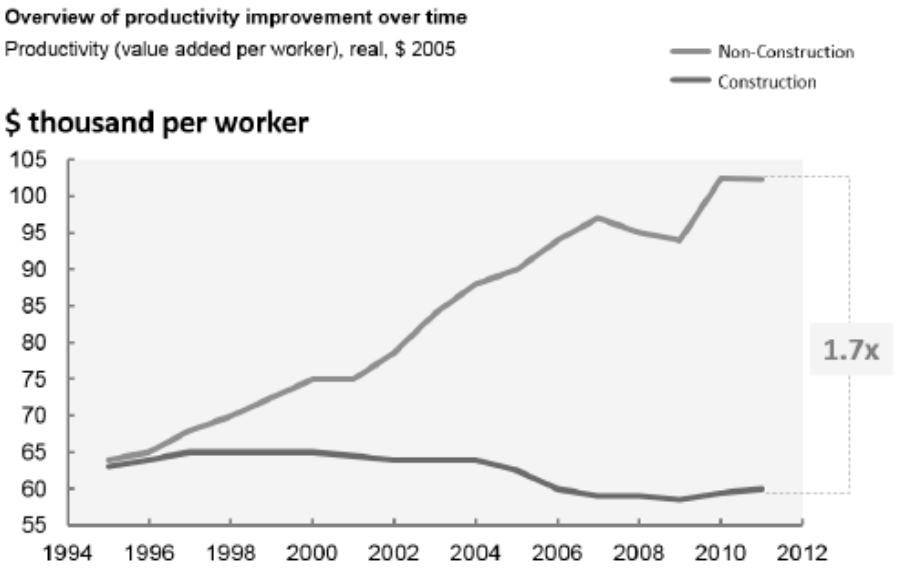

Figure 2. 1 Periodic Performance of the construction industry (Andersen and Langlo, 2016)

Concerning the industry's poor performance, some factors contribute to the low performance of the industry. These factors include the lack of digital tools used in construction projects (Temidayo et al., 2018, Agarwal et al., 2016), and the absence of holistic or integrated technical solutions (NS3935, 2019, Integra, 2011, Citherlet et al., 2001). According to statistics Norway, the strong growth of the construction industry is supported by the construction of completed buildings with specialised building works such as electrical installations, heating, ventilation, lighting, and other installation works (statistics Norway, 2018). These technical facilities are installed to provide acceptable indoor environment qualities – IEQ (Studer, 2012, Integra, 2011). However, there have been numerous complains form public and private tenants regarding the poor functionality of these facilities; these technical facilities produce overheating, poor visual comfort, acoustic problems, etc. instead of providing suitable indoor climates and good energy consumptions (Integra, 2011, Citherlet et al., 2001).

For construction companies to be able to provide acceptable and functional buildings for builders, and to make the most out of their investments, they need to focus on holistic or integrated technical solutions (NS3935, 2019, Integra, 2011, Citherlet et al., 2001). The European Union expects all residential buildings to become NZEB by December 31, 2020, and it plans to achieve this by integrating the technical services of a building body (Johansen and Hoel, 2016, Integra, 2011). The extensive use of dedicated ITB managers increases the likelihood of delivering functional buildings; since they are primarily responsible aligning of the activities of the various technical service to support the builder's business objectives (NS3935, 2019, Integra, 2011). They serve as program managers (Milosevic et al., 2007).

From the above description of the construction industry and its relations to the application of ITB, it appears that the performance of the construction industry is expected to improve when construction companies involve ITB role in their building projects. There is a likelihood to experience an improvement in the assurance of achieving optimal administration of technical facilities, substantial energy savings, and delivery of functional and acceptable

buildings, resulting in the economic gains of builders and construction companies. Based on these theoretical findings, the thesis proposes that:

1. *The building industry is expected to experience performance improvement when the technical systems in a building are integrated.*

In the following sections, theories describing ITB concept will be discussed into detail including its related standards. The challenges and extent to which construction companies need to implement ITB concept in their building projects will also be discussed in Chapter 3, which will provide theoretical answers to research questions 1 and 3 (RQ1 and RQ3). Chapter 2.6 will describe ITB related standards and relations; this will provide theoretical answers to research questions 2 (RQ2), as stated in Chapter 1.1 – *Research Objectives.*

2.2 What Is ITB Concept?

ITB is an acronym which stands for ***Integrated Technical Building installations***. It refers to the interaction and coordination between the building's technical systems to ensure that business, environmental and safety requirements are satisfied (NS3935, 2019, Integra, 2011). The objectives for carrying ITB functions in projects are to ensure optimal administration of the building's technical system as well as to achieve economy, functional and security throughout the building's life cycle (Mazzucchelli and Lucchini, 2012, Integra, 2011). The concept of ITB is among one of the most important concepts for builders who want to make most out of their investment in technical facilities (Integra, 2011). ITB is a comprehensive and complex task which ensures that technical facilities provided by different suppliers communicate, interact and function appropriately (NS3935, 2019, Integra, 2011).

The ITB concept is poorly covered in literature considering fewer publications describing the concept (Eklo et al., 2016, Integra, 2011). These authors argue that ITB is not a new concept, yet it has experienced fewer applications in the building and construction industry. Based on the literature search and review, the term "ITB" is not commonly used among employees in the construction industry around the world, even though some building projects involve the coordination or integration of technical facilities. The term is adopted and commonly used by the Norwegian construction industry (NS3935, 2019, Integra, 2011). Based on discussions with employees within the Norwegian construction industry and academic professors, the term "ITB" is in interchangeably used with other terms such as "Systematic Completion" and "System Integration" because of their similarities, even though there are distinctions between them. The three terms (ITB, systems integration and systematic completion) are similar in a way that they describe the process of ensuring that the technical systems in the building are well installed and integrated in accordance with agreed specifications (NS3935, 2019, Johansen and Hoel, 2016, Mazzucchelli and Lucchini, 2012, Integra, 2011). The similarities between ITB and System Integration is that both concepts are responsible for the physical components coordination, and resource and knowledge coordination or even sequential inter—project couplings where integration is needed (Integra, 2011, Brusoni et al., 2001, Miller et al., 1995). By differentiating the three terms, Systematic Completion (also known as "systematisk

Ferdigstillelse" in the Norwegian language) is seen to be a broader concept which encompasses ITB and System Integration; it describes the process of ensuring that the building meets its technical and non-technical requirements, whereas the ITB and System Integration are mostly focused on the technical aspects of the projects (Mazzucchelli and Lucchini, 2012, Studer, 2012, Integra, 2011). ITB concept is limited to the building industry, whereas Systematic Completion and System Integration concepts are applied in industries that involve the integrations of technical systems. The new ITB standard - NS3935:2019 also provides distinctions between the ITB and System Integration based on their position within the project organisation. Those who perform ITB roles are seen to occupy both managerial and functional departments of an ITB organisation, whereas the System Integration roles reside only within the functional department (see Figure 2). From a structural theory perspective, ITB manager possesses more positional authority than System Integrator in the functional structure of the ITB, as shown in Figure 2 (NS3935, 2019, Bolman and Deal, 1984).

There are several varying publications describing the integration of technical systems in a building based on reviewed literature. From a technical point of view, some authors describe how the technical facilities in a building can be integrated to ensure smooth operation when the systems are operating simultaneously (Studer, 2012, Bai et al., 2009, Citherlet et al., 2001). From the management and economic perspective, other authors describe how the ITB role or technical coordinating functions can be managed in projects to ensure that the completed buildings meet the requirements specified by tenants, builders and regulators (NS3935, 2019, Liu et al., 2017, Johansen and Hoel, 2016, Mazzucchelli and Lucchini, 2012, Integra, 2011).

The focus of this thesis is to investigate the concept from a management perspective, which involves studying how the ITB role can be managed to improve its effectiveness and application in projects. Therefore, the thesis investigates and explores the ITB concept to discover the extent to which the role is important or beneficial to building projects. In addition, it finds out which challenges are affecting the effectiveness of the role, and finally provide some suggestions that might be used to address these challenges. Therefore, does not investigate the engineering or technicalities that involves the designing and installation of the integrated system, but it focuses on improving the effectiveness of ITB role in projects.

2.3 Why ITB Concept

Currently, private and public builders often end up with poor functionality of the buildings' technical facilities (Johansen and Hoel, 2016, Mazzucchelli and Lucchini, 2012, Studer, 2012, Integra, 2011). The introduction of smart building technologies such as HVAC systems, lighting, security and other technical facilities are poorly configured and installed, which lead to the poor performance of completed buildings (Studer, 2012, Integra, 2011). The cause of the poor performance of technical devices is related to the absence of holistic thinking and integration between different disciplines within the construction project (Integra, 2011, Bai et al., 2009), Citherlet et al. (2001). Therefore, there is a need for coordination and monitoring for maximum efficiency and operation throughout the development life cycle of the project (NS3935, 2019, Studer, 2012, Integra, 2011, Bai et al., 2009).

During the coordination activities, the various actors can see how the technical systems function independently and interconnectedly. Greater and optimal functionality of the integrated systems are achieved when the activities of the various actors are coordinated (Integra, 2011, Wheelwright and Clark, 1992). According to Mazzucchelli and Lucchini (2012,p.878), to "achieve service system efficiency, optimal control and better microclimate indoor conditions with much lower energy need, the building and its technical services must work as a unique integrated system to hold the energy demand down while providing the optimum internal conditions according to the outdoor climate, uses, presence of both people and equipment, etc". Mazzucchelli and Lucchini (2012) states two main goals for integrating technical services. Firstly, to achieve functional coordination of the different technical systems which maximises their overall performance and control. Secondly, technical integration is done to achieve spatial coordination of the different subsystems and particularly their positions to ease installation and maintenance in coherence with the needs of the periodic total or partial replacement of their components" (Mazzucchelli and Lucchini, 2012,p.879).

To ensure that the technical integration is done properly, it requires good and adequate planning and designing processes, and proper installation and maintenance of the integrated systems over its lifetime (Studer, 2012, Integra, 2011, Davies et al., 2007). Integration network has to be set up and maintained, and this requires a lot of planning and expertise (Studer, 2012, Integra, 2011). There is a need for a function to be responsible for counselling, for coordination, integration and optimization (Studer, 2012, Integra, 2011). The main task of such function is to control the interface between the various contractors' technical systems in a building project, as well as ensuring that the integrated system is functioning as per specified requirements (NS3935, 2019, Integra, 2011). The function also includes verification and ensuring that the necessary communication of data and signals between the various technical systems are taken care of, and can be realized in an appropriate way (Eklo et al., 2016, Studer, 2012, Bai et al., 2009). According to NS3935 (2019) and (Integra, 2011), this is where the roles of ITB (ITB manager and Advisory ITB – AITB) becomes important. The next sections of this chapter discuss the role of ITB manager within the structure of an ITB organisation.

2.4 Structure of an ITB organisation

Hellriegel and Slocum (1996) describes an organisational design as the process of defining the structure and power relationships for an entire organisation, and as a way of implementing strategies and plans that embody the firm's objectives. The figure below shows an example of a functional structure describing an ITB organisation (NS3935, 2019). The structure shows the functions ITB, AITB and other functions needed for carrying out the integration functions. In this thesis, the focus will only be ITB and AITB functions. Figure 2.2 will be used to explain the roles of the ITB manager, its relationship with other functions in the organisation, and the form of authority that ITB managers need to influence the project.

- **Positional authority of the ITB manager**

From figure 2.2, it can be seen that the ITB manager is located at the upper level of the organisation (managerial position) whiles the AITB operates within the functional departments (NS3935, 2019). According to NS3935 (2019), the ITB manager should be visible within the project organisation and must have the necessary mandate to carry outs his integration functions. The ITB standard states that ITB role should be supplemented with AITB and system integrator provider(s). The AITB ensures that the requirements and instructions provided by the ITB manager are implemented as required (NS3935, 2019, Hitt et al., 1989). Based on the managerial position occupied by the ITB manager, it can be assumed that the ITB manager has positional authority to make and implement decisions (Nelson, 1993, Bolman and Deal, 1984). According to Bolman and Deal (1984,p.116) "the higher an individual's position in an authority hierarchy, the more power the individual typically has". From a structural theorist perspective, the instructions of the ITB manager cannot be challenged or resisted by his subordinates due to this form of authority (Nelson, 1993, Bolman and Deal, 1984, Hitt et al., 1989).

To some extent, in an integrated system such as an ITB organisation where the planning, designing and installation of the technical integrated systems require the coordinated efforts of the various technical disciplines, this source of authority and its usage must be managed in such a way that it does not impede the achievement of coordination and organisational needs (Bolman and Deal, 1984). Some authors argue that initiatives or suggestions from subordinates should be taken into consideration so that there will no bias in decision making, which can lead to poor performance and management (Bolman and Deal, 1984, Hitt et al., 1989). Human theorists suggest that there should be a focus on forms of influence that promotes mutuality and collaboration in decision making; thus, managers and workers should be able to make decisions to meet the needs of the involved parties (Bolman and Deal, 1984). However, in some situations where critical decisions need to be made, the ITB manager can use his positional authority to have a final say (Nelson, 1993, Bolman and Deal, 1984).

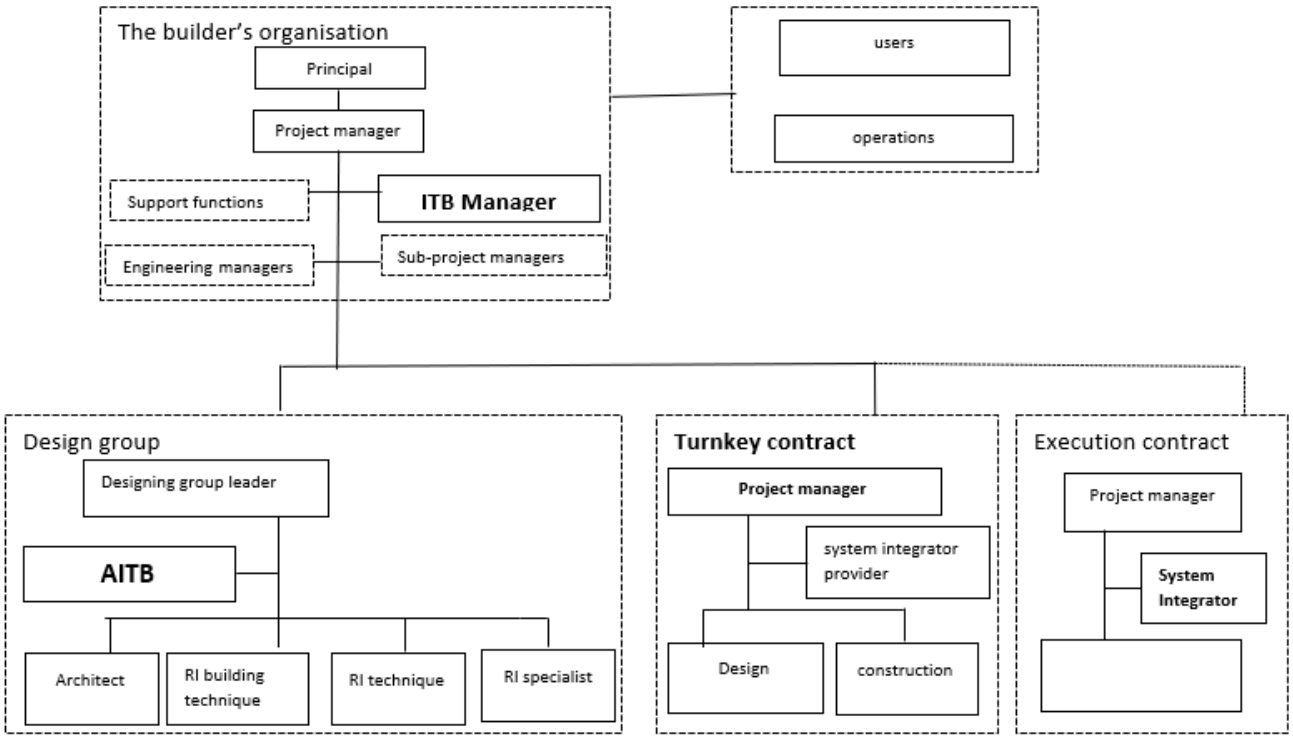

Figure 2. 2 Example of an ITB organisation (NS3935, 2019,p.4)

2.5 Roles of ITB

The roles of the ITB manager is clearly described by the new ITB standard NS3935:2019, and it involves planning, coordination, quality assurance of installation and integration of complex systems (NS3935, 2019). Technically, the role consists of several different integration tasks relating to links, communication, interface, function testing, etc. (NS3935, 2019, Integra, 2011). In terms of multidisciplinary coordination, the role involves the coordination of activities between varying disciplines such as electro, automation, ventilation, pipes, etc. It ensures that integration, construction and testing activities are carried out according to contractual specifications (NS3935, 2019, Integra, 2011).

According to NS3935 (2019), the ITB function is performed by two distinct people; an ITB manager and an advisory ITB (AITB). The ITB manager is concerned with ensuring that the technical integration processes are carried out and documented as described in the ITB standard documents – NS 3935 and NS 6450. AITB is responsible for ensuring that the specifications stipulated by the ITB manager are executed in the engineering phase. This implies that the AITB reports to the ITB manager. In carrying out the integration functions, the ITB manager works collaboratively with AITB, system integrator as well as other disciplines (NS3935, 2019).

To ensure optimal administration and performance of an integrated system, the ITB manager performs the following functions (NS3935, 2019):

- Responsible for setting up the organisation for ITB works, and overall description of the integration process so that the principal's objectives and requirements are safeguarded.

- Ensures that plans for testing and training are present, etc.
- Accountable for the aligning the activities and objectives of the functional teams to correspond with the builder's specification and objectives.
- Ensures that selection of the AITB and system integrators with suppliers takes place.
- Responsible for setting up and documentation of meetings used for clarification and decision-making.
- Documentation of the entire business processes ensures that there are histories for all phases of the ITB process (NS3935, 2019, Eklo et al., 2016, Studer, 2012), which will be needed for future works and maintenance.

With the respect new ITB standard – NS 3935:2019, there are three different roles based on the organisations involved (NS3935, 2019). There is one ITB role for the builder's organisation, one for the contractor organisation, and one for the engineering organisation. The number of ITB managers needed to perform a particular ITB role depends on projects form, size and complexity (NS3935, 2019, Eklo et al., 2016, Integra, 2011). For example, in more complex projects, the contractor' organisation can have more than one ITB managers depending on the number of ITB roles that the need to be performed. However, two or more different ITB roles can be handled by one ITB manager in a less complex project (Eklo et al., 2016, Integra, 2011). This is more of an assigned role, and there might be a change of ITB manager during the building process (Eklo et al., 2016, Integra, 2011). The builder's ITB manager is responsible for the overall coordination and quality assurance of the entire ITB processes (NS3935, 2019, Integra, 2011). The client's ITB manager works collaboratively with other ITB personnel to ensure that the technical systems are integrated according to contractual specifications (NS3935, 2019).

From the reviewed literature, it was discovered that the ITB manager is not primarily responsible for the technicalities that lie between the various disciplines (such as pipes, electricals, automation, ventilation, etc) since he is not expected to be an expert in technology solutions, and system integration (Integra, 2011). However, the role should not be a sleeping pad for other players in the construction industry (Integra, 2011).

In a nut-shell, ITB role involves doing the right things and asking suppliers, contractors, and advisors the right questions to clarify functional requirements, interfaces, utility, integrations and preventing typical faults (Integra, 2011). Based on theoretical findings from the literature review on ITB role and the structure of an ITB organisation, the following proposition is made:

2. *The ITB manager can influence the project using his positional (managerial) authority.*

2.6 Norwegian Standard

This chapter presents the various related ITB standards that are frequently used in the building industry. It further describes the relationships that exist between these standards, which will provide theoretical answers to RQ2:

"What are the relationships between the various ITB standards used in building projects?"

From reviewing standards that apply to the ITB role, it was discovered that there three standards are frequently used in building projects, which are established by Standards Norway (SN, 2019). These standards include:

- NS3935 - ITB Design, implementation, and commissioning
- NS6450 - commissioning and testing of technical building installations
- NS8470 - General contract for general terms.

The standards stipulate what should be involved in the contracts both for the client and contracting parties. Although standards are required to be used, and are referred by law and regulations, but it is not required by law in Norway to forcefully apply the standards to employers' business operations (Eklo et al., 2016). The next sections will present brief descriptions of the NS 3935, 6450 and 8407, and the relationships that exist between them.

2.6.1 ITB standard NS 3935 (ITB Design, Implementation, and Commissioning)

As mentioned earlier on, ITB is not a new concept, and it was first introduced in 2005 and later revised in 2011. The latest ITB revision of the standard was established in 2019, to meet the limitations of the previous standard which was created in 2011 (NS3935, 2019). In this thesis, the description of the NS 3935 is limited to the newly established standard; thus, NS 3935:2019. The statements below show the reasons why the new ITB standard was established:

i. Assume that the performance of the ITB administrator is described in the contract.
ii. Create an explicit understanding of the process that guarantees a good execution of ITB procurements.
iii. Assume that the project provides a comprehensive technical solution with performance description so that this can be fixed between the principal and the supply contractually.

The Importance of NS 3935:2019

The following statements describe the importance of using NS 3935 in building projects:

i. It ensures better interactions between the actors in design and execution of technical building installations, which is essential for optimal administration of the technical systems (SN, 2020, NS3935, 2019, Integra, 2011).
ii. It provides a comprehensive task to guarantee that systems provided by different suppliers communicate and operates acceptably (NS3935, 2019).
iii. It places huge demands on collaboration and holistic thinking across disciplines and between various companies (SN, 2020, NS3935, 2019).
iv. It stipulates detailed guidelines that the ITB manager must consider in business processes such as design, planning, procurement, installation, testing, documentation and commissioning of integrated technical building installations (SN, 2020, NS3935, 2019).

According to Eklo et al. (2016), the ITB process has nine different phases. The descriptions of these phases are used in discussing the relationship between the different ITB standards in Chapter 2.6.4.

- Phase 1: Preparation of business program
- Phase 2: Adoption of a construction program
- Phase 3: Pre-project
- Phase 4: Detailed design
- Phase 5: Tendering
- Phase 6: Contracting
- Phase 7: Construction
- Phase 8: takeover
- Phase 9: first operation period- complaint time

According to NS 3935:2019, the ITB manager must adopt these different phases of the construction project to the ITB roles defined in the NS 3935 (NS3935, 2019). The standard recommends that the ITB role should be involved throughout the phases of the project.

2.6.2 Commissioning and Test operation of technical building installations (N6450:2016)

This standard provides advanced technical building installation according to the specification "right code" (NS6450:2016, 2016). It defines the various testing operations that need to be carried out by the ITB manager before the building is handed over to the builder (see figure 3). It shows the developer what to consider when developing his requirements for the test operations, and it gives examples of technical facilities that should be tested as well as the suggested period of the test operations. Besides, it ensures that the building is fully tested, and errors are corrected before the trial operation period commences. When the building is completed, a trial operation period of 6 months or 1 year is allowed to test the technical systems (NS3935, 2019). The builder and ITB manager ensure that NS 6450 is followed and used in the project. The standard is designed to be applied to different forms of constructions and for all different building process (NS6450:2016, 2016). However, the focus of the thesis is on the testing operations organised and managed by the ITB manager.

Figure 2.3 and Table 2.1 present descriptions of the various testing operations and activities performed by the ITB manager during the different phases of the project.

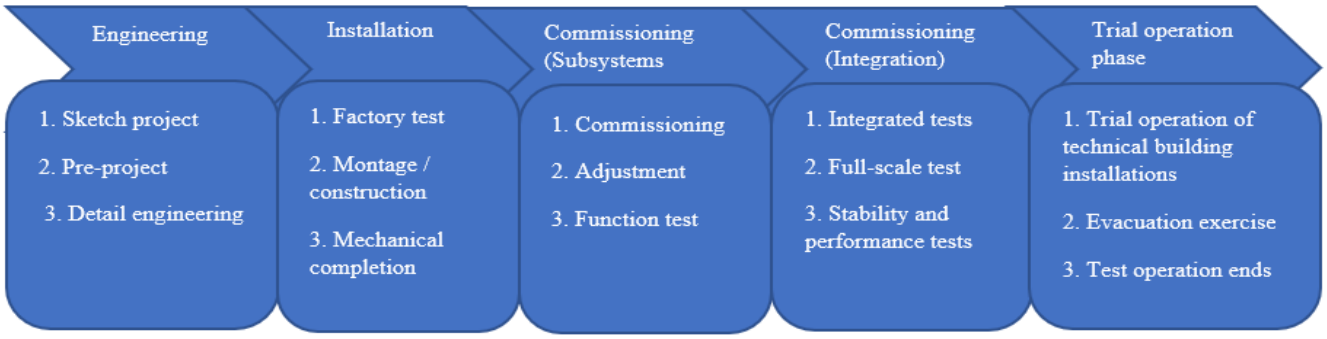

Figure 2. 3 Phases in the construction process (NS6450:2016, 2016,p.5)

Table 2. 1 Responsibilities of ITB manager during the testing phases of the building process (NS3935, 2019)

Building phases	ITB manager responsibilities
Engineering	• Early preparation of main governing ITB documents and plans for systematic completion. • ITB manager works with the project manager to prepare an overall plan as an underlying layer for the project's final phase of testing and verification.
Installation and commissioning	• The ITB manager, operation manager and suppliers work in collaboration to organise and conduct table tests
Commissioning and Test operation Phase	• Recommendation of the test plan for integrated and full-scale test according to NS 6450. Detailed applicable benefits in these phases are described.

2.6.3 General contract terms for general contracts (NS 8407)

This contract is also known as the Turnkey Contract Agreement. The NS 8407 is applied in contracts where the contractor carry out all or substantial aspects of the design and execution of a building work for the client (SN, 2013, Anskaffelser, 2013, NS8407, 2011). Based on the communication with employees in the building industry, the NS 8407 is commonly referred to us the *general contract* and it is frequently used in building projects even though there are other contracts such as the NS 8417, which relates to the subcontractor. Hence, the thesis will place much focus on NS 8407. The general contract - NS 8407 is a comprehensive standard that regulates the contractual relationship between the contractor and builder (NS8407, 2011). It describes how the two parties relate to each other during the contract conclusions, execution of building project and after the project. This standard contract deals with violations, disagreement, and resolution of conflicts client (SN, 2013, Anskaffelser, 2013, NS8407, 2011).

2.6.4 Relationship between NS 3935, NS 6450, NS8407

From reviewing the ITB standards described above, some differences, similarities and interdependencies were noticed. These relationships are described as follows:

The three standards (thus, NS 3935, 6450 and 8407) describe the various stages in the construction project. The NS 8407 states the contractual responsibilities of the various actors during the phases of the project but does not describe the actual phases of the building processes as defined in NS 3935 and 6450. Besides, it describes the obligations of the various parties before, during and contracting. It also discusses testing operations which are defined in the NS 3935 and 6450. Regarding the nine ITB phases described above, the phase 5 and 6 (tendering and contracting) can also apply to the contractor when he needs to associate with subcontractors. The builder is directly involved in phase 1 to 3, but it is not described in detail in the NS 8407. As seen in figure 3, the NS 6450

describes five phases involved in the building process but does not specify the acquisition of the building. Even though it is not stated in the NS 6450, it used as a milestone between commissioning and trial operation.

Based on the description of NS 8407, it is considered as a more legal standard compared to the NS 3935 and 6450. Therefore, contract participants are forced to comply with the terms and conditions of the contract. On the other hand, the NS 3935 and 6450 are just seen as normal standards which have no contractual implications. The actors in the projects cannot be compelled to strictly adhere to the description of these standards; since strict adherence to standards is not allowed in Norway (Eklo et al., 2016).

Based on my discussions with building engineers, the NS 3935 and 6450 are very important standards that need to be used in building projects. According to these engineers, these standards are not frequently used because they are not specified in any legal documents such as the NS 8407. The NS 8407 describes testing operations but does not describe it in detail. It is assumed that NS 3935 and 6450 can be made effective when they are clearly defined in the NS 8470. It appears this initiative will establish a direct relationship between the three different standards. The following proposition is made based on the examination of literature which describes the interdependencies between the above-described standards:

3. *The NS 3935 and 6450 are ineffective and not frequently used in building projects because they are not defined in NS 8407.*

4. *The ITB manager lack contractual authority to influence the project because its role and mandate are not specified in the NS 8407.*

3 IMPORTANCE AND CHALLENGES OF ITB ROLE

This chapter will describe some benefits and challenges that are related to the ITB role. In describing the ITB challenges, the chapter will present some recommendations or success factors that can be used to address the challenges.

3.1 ITB Benefits

This section presents discussions regarding the extent to which ITB application is beneficial to building projects. It describes the reasons why the building industry needs to consider the use of ITB role in their project. The section will provide answers to RQ1:

"To what extent is ITB role beneficial to building projects?"

In a business ecosystem, the various departments/organisations within a supply chain network (value chain) are seeking for integrative strategies to achieve optimal administration of the value chain (Christopher, 2011, Haspeslagh and Jemison, 1991, Porter, 1985). They cooperatively work together in developing innovative business or technical solutions, transferring capabilities and competencies across departmental boundaries to create value as well as creating and sustaining competitive advantages (Christopher, 2011, Haspeslagh and Jemison, 1991, Porter, 1985). These forms of benefits can also be achieved when the concept of interdisciplinary coordination is applied to the installation of technical systems with interrelated objectives. For the private sector of the construction industry, a well-functional integrated technical facility is an essential precondition for gaining competitive advantage in the market, and it is a prerequisite for satisfying the acceptable indoor climates and functionalities of the building (Integra, 2011). Further detailed descriptions relating to the benefits of deploying ITB role in construction projects are presented as follows:

3.1.1 Multidisciplinary Coordination

Traditionally, technical systems in buildings operated independently because of their stand-alone microprocessors (Bai et al., 2009, Hellriegel and Slocum, 1996). Currently, the clients and end-users' demands have compelled the manufacturing industries to produce technical systems that have communication network protocols to enhance their cooperation during the operation phase (Integra, 2011, Bai et al., 2009). Modern building projects have become more complex and complicated due to the increasing number of technical systems and their interdependent relationships (Johansen and Hoel, 2016, Integra, 2011, Schoderbek et al., 1990). This implies that the various functions and objectives of these interdependent systems must be effectively coordinated to achieve an outstanding product development (NS3935, 2019, Integra, 2011, Milosevic et al., 2007, Wheelwright and Clark, 1992). This is where the role of the ITB manager is needed for effective multidisciplinary coordination (NS3935, 2019, Integra, 2011). The ITB manager serves as a focal point who aligns the varying objectives of functional technical disciplines to support the achievement of the builder's business objectives (NS3935, 2019, Integra, 2011).

Some organisations are making use of dedicated ITB managers, whiles are not (Integra, 2011, Milosevic et al., 2007, Wheelwright and Clark, 1992). These authors argue that outstanding performance is achieved in organisations where the ITB roles are used, compared to areas where the roles are not used. In organisations where the ITB role is not used, the accountability and ownership of the integration roles are shared between the functional units as the product moves through its development cycle (Milosevic et al., 2007). The challenge with this approach of working is that there is a lack of accountability when a problem surfaces (Milosevic et al., 2007). Besides, the functional units operate with a silo thinking /tunnel vision where much focus is placed in achieving functional objectives at the expense of the business objectives (Integra, 2011, Milosevic et al., 2007, Hellriegel and Slocum, 1996). According to Hellriegel and Slocum (1996,p.341), "organisations that are highly differentiated require a greater number of integrating devices and tactics to achieve a coordinated effort". Besides, the NS 3935 describes the roles of an ITB manager which are meant to improve the coordination effects between the technical units (NS3935, 2019).

In summary, the deployment of ITB role in projects helps to promote and improve multidisciplinary coordination, which helps to develop and deliver an effective integrated product (De Wit, 2017, Milosevic et al., 2007). This integrated solution becomes the means by which the business objectives are achieved (De Wit, 2017, Milosevic et al., 2007). The following paragraph describes some important tools (BIM and VDC) that can be used by ITB manager to improve the performance of his/her coordinating activities.

- **Digital tools for Multidisciplinary coordination (BIM and VDC)**

There have been extensive discussions about the value and practical application of collaborative digital technologies within the construction industry (Building Design and Construction, 2017). Building Information Modelling (BIM) and Virtual Design and Construction (VDC) are some of the digital tools that can be used to promote effective collaboration between the various disciplines involved in a project (Building Design and Construction, 2017, Kunz and Fischer, 2012, Azhar, 2011). These models show a computer-based description of the building (Kunz and Fischer, 2012, Azhar, 2011). The tools are used for integration design, planning, construction, operation and maintenance of facilities (Kunz and Fischer, 2012, Azhar, 2011). Besides, they provide a cost-effective and interoperability means of managing integrated data between the various technical disciplines. If a change is made in one aspect of the data, the integrated models can highlight or change the dependent aspect of the related data (Kunz and Fischer, 2012, Azhar, 2011).

In terms of their differences, the VDC has more functions compared to the BIM tool, and it encompasses the BIM model (Kunz and Fischer, 2012). It is seen as an advanced version of the BIM model. Based on the analysis of the VDC and BIM models, it was discovered that the VDC model provides a more efficient and effective means of managing data collaboratively than the BIM model. Thus, the stakeholders are engaged in a single meeting (using the ICE Integrated Concurrent Engineering - ICE platform) where they used data to collaboratively plan, design and execute the projects, whereas, in the BIM model, the various stakeholder operate separately; thus, when they are accessing and using data from the BIM model (Kunz and Fischer, 2012). Therefore, the VDC is seen to promote more interdisciplinary coordination than the BIM model.

Concerning the ITB manager, he/she can use ICE Integrated Concurrent Engineering (ICE) platform of the VDC to engage all the stakeholders in a single meeting where he can present and ask the right questions to the right group (Kunz and Fischer, 2012).

3.1.2 Cost Reduction:

The application of ITB role in projects is expected to increase the probability of reducing the project cost by 3-5% and operational cost by 10-20% (OSW, 2019, Johansen and Hoel, 2016, Integra, 2011). In construction projects where ITB role is not used, it is expected to experience an increase in cost due to lack of coordination efforts, resulting in duplication or parallel systems, more cabling than necessary, poor functionality of systems, and an increased need for last-minute testing, troubleshooting, correction or changes (Mazzucchelli and Lucchini, 2012, Integra, 2011). Integrating different technical facilities onto a single platform or central location (as seen in the application of BAS systems) helps to effectively manage the information sharing, reduce redundancy, expedite system acceptance testing and reduce installation cost (Studer, 2012). For example, in an integrated system, a single sensor can be used to control alarm, access control, light, heat, cooling, etc. (OSW, 2019, Integra, 2011). This reduces the cost and energy consumptions when a single sensor is used to control and regulate different technical systems. With the use of ITB role, cost reduction can also be achieved by integrating all of the technical facilities in over 100 buildings onto a central operational control system such as an Energy Monitoring Systems (EMS). This initiative reduces the number of operating personnel needed in each building; thus, one central control and monitoring system remove the need to have single operating personnel in each building, leading to substantial cost reduction(Integra, 2011). ITB is a profitable investment when there is a need for efficient operation and reduction in investment cost and the number of errors.

However, from a socio-economic perspective, the reduction of employees can result in loss of jobs which in-effect can negatively impact the employment sector of an economy. Therefore, the use of ITB role to reduce the number of employees should be effectively managed so that the employment sector is not affected negatively.

3.1.3 Energy consumption:

The application of ITB in building projects appears to ensure the use of energy-efficient plants that are expected to reduce the energy consumption to a considerable level (Johansen and Hoel, 2016, Studer, 2012, Integra, 2011). In Italy, about 80% of old residential buildings built in the early 1980s are seen to averagely consume 150-250 kWh/sqm/year of energy in the heating season due to poor or lack of coordination between technical facilities (Mazzucchelli and Lucchini, 2012). This calls for technical solutions to significantly reduce energy consumption in a reasonably short time (Mazzucchelli and Lucchini, 2012). According to the authors, to ensure better microclimate indoor conditions with much lower energy need, the technical services must function as a unique integrated system to reduce the energy demand while providing conducive and optimum internal conditions corresponding to outdoor environmental conditions, users and equipment. The EU aims to achieve NZEB for all public buildings in Europe by the end of 2020, and it intends to achieve this by developing a new approach to building design and integrating the technical facilities in a building body (Mazzucchelli and Lucchini, 2012, Integra, 2011). Integrating the technical facilities of building installations “combines the achievement of the

needed energy savings with the fulfilment of high standard of comfort, health and safety in the internal space (Mazzucchelli and Lucchini, 2012,p.878).

3.1.4 Delivery of functional building:

According to Samset (2010), the constraints of any type of project (including building projects) include time, cost and quality. Thus, projects are expected to be completed within a specified time and cost, and they must meet the specifications given by clients and/or regulators. In a competitive environment, there is a pressure to complete and handover buildings at a specified time which results in many building projects being handed over with facilities not tested or run-in (Studer, 2012, Integra, 2011, Milosevic et al., 2007). In some instances, testing operations are carried out without considering the interactions between the various technical facilities. This leads to completing building with integration faults and errors. Test operations or run-in of plants which are conducted after the takeover can extend over several months or years (Studer, 2012, Integra, 2011). During the testing or run-in periods, it is common to discover numerous errors, faults or missing. The cost related to providing ideal solutions after the discovery of the errors or making changes are most often catered by the building owner or the tenants. To prevent this situation, the builder must set aside sufficient time to functionally and fully test the facilities to ensure that they are installed based on the agreed design, specifications, and owners' operational needs (Studer, 2012, Integra, 2011). This role can be effectively be performed by an ITB manager. With the involvement of an ITB role, iterative test operations are conducted throughout the project to ensure that the final or completed building meets the specified requirements (NS3935, 2019, Integra, 2011). The ITB managers ensure that the system is tested after each phase before the nest next phase is started. This guarantees that a functional building is completed and handed over with no or fewer errors (NS3935, 2019, Johansen and Hoel, 2016).

In the process of using ITB manager to deliver functional buildings, builders can certify their buildings to improve their value. The BREEAM certification has different ratings (ranging from unclassified to outstanding) depending on the performance and quality of the building (BREEAM, 2014). Per the BREEAM requirements, the building must be sustainable, secured and environmentally friendly to achieve a higher rating. It appears that the use of ITB manager can increase the probability of achieving a higher rating (such as very good, excellent or outstanding) since he/she guarantees the delivery of an acceptable and environmentally friendly building.

In summary, it has been discovered that projects in the building industry are experiencing ever-increasing complexities with regards to the increased number of interrelated technical systems and disciplines. To have a whole system where the different systems can effectively coordinate and communicate together without adverse effects, it is assumed that a dedicated ITB manager will be needed to perform coordinating and integration functions. This is believed to ensure that the various disciplines understand how their activities affect each other, and to find a unique approach to achieving the whole system's objectives. By reviewing the NS 3935:2019 in section 2.6.1 – *ITB standard NS 3935*, it was discovered that the standard emphatically describes how the ITB role can be used to achieve effective multidisciplinary coordination. Therefore, it is assumed that with the use of ITB managers to meet the specifications described in the NS 3935, there is an increased probability of achieving

improved multidisciplinary coordination. This can result in the development of integrated solutions which can be used to ensure the delivery of functional, error-free and cost-effective buildings. Based on these theoretical findings, the thesis presents the following propositions:

5. *The application of ITB roles in building projects will increase the likelihood of improving the:*
    - i. *coordination between the various disciplines involved in the project*
    - ii. *reduction of energy consumptions,*
    - iii. *reducing the building's Lifecycle cost"*
    - iv. *delivery of functional buildings*

3.2 Challenges related to ITB Role

This section describes some challenges that hinder the successful implementation of ITB roles in building projects. It will describe challenges relating to ITB manager's authority, late involvement of ITB, cost attributed to ITB role etc. This section will provide theoretical answers to RQ3:

"what are some of the challenges hindering the application of ITB role in construction projects?"

3.2.1 Lack of Authority

According to Studer (2012), there is a need for authority having jurisdiction (AHJ) to determine the acceptable system configuration and operation of the coordinated system. This implies that the ITB manager needs to have the required form of authority to perform his coordinating functions effectively. From reviewing literature on the legitimacy sources of authority, it was discovered that the ITB manager might be able to influence the project based on his charismatic, positional contractual sources of authority (Nelson, 1993, Bolman and Deal, 1984, Weber and Parsons, 1964). According to Paul and Jean (2007), the legitimate source of authority and subordinates' sense of consent determines the extent to which superior's instructions will be adhered or resisted. However, most organisations consider contractual or rational-legal as the principal foundation, as it has been explicitly and implicitly described in many pieces of literature (Nelson, 1993). This implies that there is a likelihood that the instructions of the ITB manager given based on charismatic and positional authority can be resisted by the other technical disciplines (Paul and Jean, 2007, Nelson, 1993).

From the examination of the general standard in Chapter 2.5.3- *General contract terms for general contracts (NS 8407)*, it can be assumed that the ITB manager is expected to experience challenges in influencing the project because his role and mandates are not defined in the general contact. Thus, he lacks contractual authority to make and implement bold decisions even though he might have charismatic and positional authority.

3.2.2 High cost related to ITB role

Some project organisations have dedicated ITB personnel who perform ITB functions whiles others do not because they consider the employment of an ITB manager as an additional expense item or cost (Integra, 2011). Those without dedicated ITB managers argued that the responsibilities of an ITB officer/manager can equally be

well performed by an entrepreneur or collective efforts of other advisors, suppliers, and contractors (Integra, 2011, Milosevic et al., 2007). So, there is no need to allocate a budget to the ITB role. These authors argue that this perception is correct as far as theory is concerned, but not in practice. The authors highlight that it is uncommon in practice that the integrating roles are given much attention in new buildings and renovation projects (Integra, 2011, Citherlet et al., 2001). This is partly because various disciplines, contractors and subcontractors are facing challenges in getting the most out of their budgeted framework and meeting other project's constraints; thus, time and quality (Integra, 2011, Citherlet et al., 2001, Hellriegel and Slocum, 1996). It appears that they are focused on achieving individual objectives, at the expense of the whole project's objectives (i.e. silo-thinking). The lack of focus on systems integration results in the delivering of inferior buildings where the technical systems have adverse effects on each other during the operation phase. The technical solutions provided by the independent disciplines are frequently characterised by technical compromises and lack of holistic thinking and integrations (Integra, 2011), which results in technical delivery failures leading to increase in installation and maintenance cost (Integra, 2011, Bai et al., 2009, Citherlet et al., 2001). Some authors argue that it takes many resources (time and money) to develop ideal solutions to correct the errors.

The value of the technical systems in a building constitute about 46% of the overall cost of the building (Integra, 2011). This implies that builders who want to higher investment gains need to employ dedicated ITB manager to ensure that the building cost is improved. With the employment of an ITB manager, the focus will be placed on getting the most possible out of budget and not most out of budget (Integra, 2011). There is also a reduction in the building's overall investment cost by avoiding system duplications or redundancies since the ITB manager has a complete overview of the integrated system (Johansen and Hoel, 2016, Studer, 2012).

3.2.3 Late involvement of ITB manager

From reviewed literature, another challenge associated with the ITB role is late involvement of ITB managers in building projects (Eklo et al., 2016, Integra, 2011). Thus, the ITB manager comes later in the project, especially after the contracting phase of the project or when the building is completed and handover with errors (Eklo et al., 2016, Studer, 2012, Integra, 2011). In such situations, it becomes difficult to make changes or implement ideal solutions to correct the errors (Hussein, 2018, Integra, 2011, Samset, 2010). Besides, the ITB manager is not able to fully understand the whole project's definition scope (Hussein, 2018, Integra, 2011, Samset, 2010).

To resolve this challenge, it is recommended that ITB managers are involved throughout the development life cycle of the project; thus, from planning and design phase throughout the engineering, completion and handover phase (NS3935, 2019, Integra, 2011). This will provide an opportunity to fully understand the project's objectives and definition, and be able to make cost-effective changes while the project evolves (NS3935, 2019, Studer, 2012). The overall cost of the project is expected to significantly reduce when ITB role is applied throughout the life cycle of the project (Studer, 2012, Integra, 2011, Samset, 2010). This is because errors, faults and missing will be rectified early enough and be corrected (Integra, 2011). Frequent testing of the integrated systems will ensure that a well and fully functional buildings are developed and handed over to builders and tenants (NS3935, 2019, Studer, 2012).

With much focus on ITB role from planning to handover, the builder gets the most out the investment, and he or she is assured that the desired functionality is delivered and works, and the technical systems interact (Integra, 2011). Besides, he/she can change the way the technical plants are planned, installed, integrated, and tested (Integra, 2011). The builder is also able to take advantages of opportunities related to integration such as reduced cost since the subsystems are seen as a whole and linked together on a common platform.

3.2.4 Lack of technical competence

According to Integra (2011), the ITB manager is not responsible for the technicalities that lie between the various technical teams since he is not expected to be an expert in providing technical solutions. This notion is supported by some academic publications who did not include technical competence on their definitions of managerial competences (Dulewicz and Higgs, 2004). In contrast, other authors argue that the managers need to possess technical competence to be very effective in the managerial role especially in areas where the role involves interactions with technical systems (Knowledge@Wharton, 2016, Lester, 2006). From the literature review, it was discovered that ITB roles consist of technical tasks such as to links, communication, interface, function testing, etc. which required technical competence to be able to effectively perform them (NS3935, 2019, Integra, 2011).

Based on the function of the System Integrator who is responsible for the technicalities the lie between the various technical system, the thesis supports the notion that ITB managers do not need to possess technology competence to be effective in coordinating the role of the different technical disciplines. Besides, it supports the Organisational Development definition of managerial competencies which places significant emphasis on the behavioural aspects of management, but less focus on technical or engineering aspects of management (Crawford and Nahmias, 2010, Dulewicz and Higgs, 2004)

In summary, ITB manager experiences challenges in making bold decisions even when he has charismatic or positional authority because he lacks contractual authority. Also, it was discovered that the ITB manager's role is considered to be less important because of the cost related to it. However, proponents of the ITB concept argued that cost related to ITB role is a minor cost considering the economic and technical benefits that come with employing ITB manager in a project. Finally, section 3.2.4 presents the theoretical implications relating to the lack of technical competence and the late involvement of ITB managers in building projects. Based on these theoretical findings, the thesis proposes that:

6. *The ITB manager needs contractual authority to be effective at decision making and implementation.*

7. *The employment of an ITB manager should be considered more of an asset than an expense item.*

8. *Late involvement of ITB managers in building projects makes it difficult and expensive to make changes, and provide ideal solutions.*

9. *The competence of the ITB manager does not extensively depend on his expertise in technology solutions and system integration.*

3.3 Review of theoretical propositions

As highlighted in section 1.1 – *Research objectives*, the three research questions (RQ1, RQ2 and RQ3) are related in such a way that they provide answers to the main research question **"How does a construction company like Rambøl perceive the ITB concept?"** In this chapter, the propositions developed during the literature review process will be examined. Some propositions will not be considered for analysing in the discussion chapter because of the difficulties in comparing them with empirical findings. Other propositions will be merged because they are closely related. The table below presents a summary of the theoretical propositions that were developed throughout the literature review process.

Table 3. 1 Recap of Theoretical propositions

No.	Proposition
1	The building industry is expected to experience performance improvement when the technical systems in the buildings are integrated.
2	The ITB manager can influence the project by using his positional (managerial) authority.
3	The NS 3935 and 6450 are mostly ineffective and not frequently used in building projects because they are not defined in NS 8407
4	The ITB manager lack contractual authority to influence the project because its role and mandate are not specified in the NS 8407
5	*The application of ITB roles in building projects will increase the likelihood of improving the:*
	i. coordination between the various disciplines involved in the project.
	ii. reduction of energy consumptions,
	iii. reducing the building's Lifecycle cost
	iv. delivery of functional buildings
6	The ITB manager needs contractual authority to be effective at decision making and implementation.
7	The employment of an ITB manager should be considered more of an asset than an expense.
8	Late involvement of ITB managers in building projects makes it difficult and expensive to make changes and provide ideal solutions.
9	The competence of the ITB manager does not extensively depend on his expertise and knowledge in technology solutions and integration.

!) the propositions in the above are developed based on literature review, therefore, it can apply to any building projects or companies that make use of the ITB concept or role. However, in Chapter 6 – Discussions, the discussions or analysis of the propositions will be limited to the case company (Rambøl AS) since they were used for the data collection process.

Theoretical proposition 1 will not be included in the verification process because it needs massive efforts to confirm the effectiveness of using ITB roles to improve the industry's performance. One approach is to conduct an extensive realistic assessment of the whole building industry to confirm if the proposition is valid or not. For

example, the collection of quantitative data which depict the performance of building companies concerning how the application of ITB role has impacted their business performances either financially or non-financially. Another approach involves the use of a case company as a "representative case" where the characteristics of the case company accurately reflect the traits of the whole building industry (Bryman, 2012,p.715). In order to achieve this, there have to be practical evaluations of the case company and the whole industry find common traits to be used as variables for the studies. In this thesis, such evaluation has not been performed between the case company (Rambøl AS) and the Norwegian building industry, therefore, Rambøl cannot be considered as a representative case. Performing these forms of evaluations will increase the complexity of the thesis in term of the number of tasks that have to be completed before the final thesis is submitted. Besides, these approaches of verifying proposition 1 are beyond the scope of the research. Due to the time limit to submit the final thesis, it will not be feasible to perform such evaluations. Therefore, proposition 1 will be dropped.

By reviewing proposition 2 and 6, it was discovered that the propositions are related in terms of the definition of authority, so they need to be merged into one proposition. In discussing the different forms of authority, it was discovered that the ITB manager needs to possess contractual authority in addition to his positional and charismatic authority to be effective in influencing the project. It is assumed that the absence of one form of authority might render the ITB manager less effective in the project. Thus, an ITB manager might be perceived as ineffective and inexperienced in handling his role when he has only contractual authority, but lacks charismatic and managerial authority. Likewise, the ITB manager with charismatic and managerial authority, but not contractual authority might be perceived to lack the principal or legal form authority to instruct other entrepreneurs. Human theorists suggest that there should be a focus on forms of influence that promotes mutuality and collaboration in decision making; thus, managers and workers should be able to make decisions to meet the needs of the involved parties (Bolman and Deal, 1984). Based on these evaluations, the two propositions will be merged to form a resulting proposition which states that:

ITB managers need charismatic, positional and contractual authority to be effective in influencing the project.

In addition, the propositions 5 (iii) and 7 are closely related in such way the ITB manager's role can be assumed to be an asset that brings value to the project by increasing the likelihood of improving the failures in the technical deliveries. This contributes to the cost reduction of the project as described in Chapter 3.2.2. The role is assumed to generate more revenue than its related cost due to the increase in the assurance of delivering a functional building (Studer, 2012, Integra, 2011). As an asset is defined as an item that provides value by generating more revenue than its related cost (Tollington, 1997, Schuetze, 1993). Therefore, the two propositions will be merged into one proposition. The resulting proposition will be:

"The application of ITB role increases the likelihood of improving the overall cost of a building".

The analysis of the above proposition will be based on qualitative data received from the case company. However, quantitative data could have been the preferred option to assess this proposition since it provides a more reliable

approach of conducting objective analysis using hard figures or statistical data (Bryman, 2012). Nevertheless, this is beyond the scope of the research, so it will not be used.

Finally, proposition 3 and 4 will also be combined to form a single proposition due to the impact that the three standards (NS 3935, 6450, and 84079) have on each other. From the literature review, it was discovered the ITB manager needs the NS 6450 to test the technical systems that have been designed and installed by using NS 3935 (NS3935, 2019). Besides, the effectiveness of the NS 3935 and 6450 depends on their definition in the general contract – NS 8407. The effectiveness and legitimacy of roles and mandates in a project depends on their detailed specifications in a project charter or contract documents (Hussein, 2018, Weber and Parsons, 1964). Based on these theoretical discoveries, the resulting proposition will be

"The NS 3935 and 6450 are mostly ineffective because they are not defined in NS 8407".

3.4 Summary of Revised Propositions

The table below shows a summary of the revised propositions. These propositions will be compared and verified with the empirical data in chapter 6 – *Discussion*. The order numbering of the propositions will be changed into a new order in which discussion will be done in Chapter 6. Based on the theoretical findings, a total of 6 propositions will be analysed. The table below provides a summary of the revised proposition

Table 3. 2 Overview of revised propositions in relations to the research questions (RQ)

No.	Proposition	RQ
1	*The application of ITB roles in building projects will increase the likelihood of improving the:*	
	i. coordination among the various disciplines involved in the project.	RQ1
	ii. the reduction of energy consumptions,	RQ1
	iii. the delivery of functional buildings	RQ1
2	The application of ITB role increases the likelihood of improving the overall cost of a building	RQ1, RQ3
3	ITB managers need charismatic, positional and contractual authority to be effective in influencing the project.	RQ3
4	The competence of an ITB manager does not extensively depend on his expertise and knowledge in technology solutions and integration	RQ3
5	The NS 3935 and 6450 are mostly ineffective because they are not defined in NS 8407	RQ2, RQ3
6	Late involvement of ITB managers in building projects makes it difficult and expensive to make changes and provide ideal solutions.	RQ3

!) the propositions in the above are developed based on literature review, therefore, it can apply to any building projects or companies that make use of the ITB concept or role. However, in Chapter 6 – Discussions, the discussions or analysis of the propositions will be limited to the case company (Rambøl) since they were used for the data collection process.

4 RESEARCH METHODOLOGY

Chapter 4 describes the research strategy and designs that have been used to answer the overall research question: *"**How does a construction company like Rambøl perceive the ITB concept?"*** The chapter explains how the research was planned and carried out; thus, how it went from the initial research questions to conclusions (Yin, 2018). To give the reader an insight into how the research was carried out including data collection and applications, it is imperative to document the entire process (Tjora, 2019, Bryman, 2012). According to these authors, documentation of choices, changes, the process for recruiting participants, theories applied, faced challenges, etc. makes the research work more transparent. The layout of the thesis will follow a consecutive order to ensure that the reader has the same insight as the researcher. The thesis intends to present ideas clearly and transparently, and conceptually precise and credible (Bryman, 2012, Brinkmann and Kvale, 2009). It presents a complete discussion of qualitative research, case study design method, and qualitative analytical method used in the thesis. The chapter has been adjusted to increase readability, allow readers to adapt the perception of the researcher, and to appreciate my sampling choices (Yin, 2018). Detailed descriptions of the research process make it easier to assess the research, compare it to other studies. Besides, it does not create problems for researchers when they conduct relating research in the future (Bryman, 2012, Attride-Stirling, 2001).

I have adapted the seven research phases described by (Brinkmann and Kvale, 2009) to my research: (1) thematising, (2) Research strategy and design, (3) Research interview, (4) transcribing, (5) Coding and Analysing, (6) Verifying, and (7) Reporting.

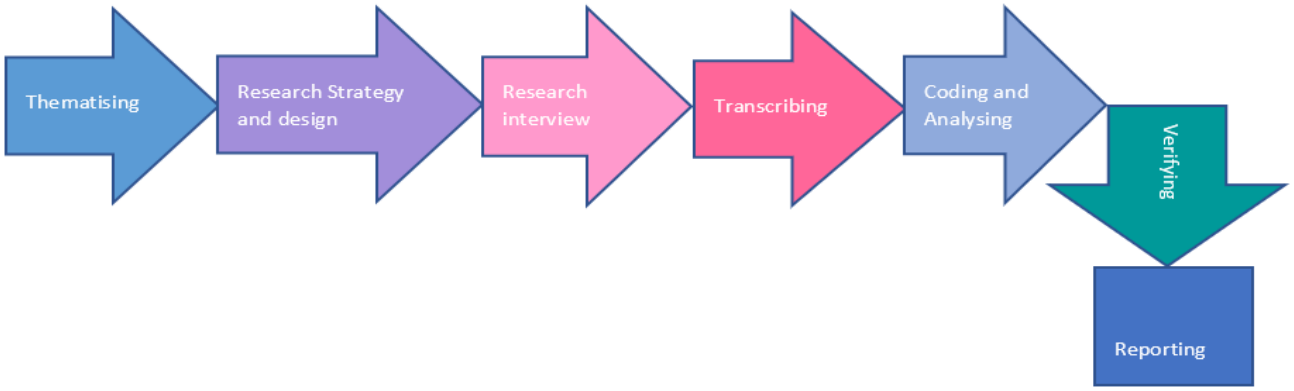

Figure 4. 1 seven stages of research (Brinkmann and Kvale, 2009,p.103-104)

The purpose of performing this research was to develop insight into ITB phenomenon, and permitting the insight to be verified with the development of theory. To gain rich data, detailed answers and insights into informants' thoughts, feelings and own experiences, a qualitative interview was considered to be suitable for this research (Bryman, 2012). A comprehensive literature study was conducted to gain in-depth knowledge and insight into the topic. This helped to understand how the research topic has been presented in varying perspectives. The insight gained from disciplinary literature regarding the research topic will be presented (Brinkmann and Kvale, 2009, Bryman, 2012). The plan for gathering data and ensuring that the research is validated will include literature review, including both theory and methodology on the topic (Bryman, 2012).

In conducting the research, measures were put in place to ensure that quality interviews are conducted. Besides, the quality of the interview was assessed based on the knowledge delivered by the interview participant, and the objective of the research was to understand topics from the subject's daily world views (Bryman, 2012, Brinkmann and Kvale, 2009). Instead of arriving at generic opinions, the data were investigated and analysed to describe separate phenomena to explore their common principles. This helped in arriving at meaningful and concrete conclusions. Additionally, the thesis presented procedures for completing data collection, and how data analysis contributed to making conclusions. Suggestions were presented to actors involved in the application of ITB concepts, enforcing them to apply the concept in building projects and increasing awareness of the ITB standard – NS 3935.

The initial plan was to use the literature review conducted in the project thesis as a theoretical foundation for the master thesis, but the topic for the master thesis has been changed from "Digital competence of construction project manages" to "The importance and barriers connected to the Integrated Technical Building installations (ITB) managerial role in building company". The methodology for conducting the literature study is similar to one described in my project thesis (Prince, 2019). Thus, I only present the methodology related to further studies related to the master thesis. In the master thesis, some documents were written in the Norwegian language, so they were translated into the English language for ease understanding. The next chapter describes how the new topic for the master thesis was developed.

4.1 Thematising

The topic for the master thesis was developed after several meetings with the case company and my supervisor. Two research areas as stated above were listed for selection; "Digital competence of construction project manages" and "The importance and barriers connected to the Integrated Technical Building installations (ITB) managerial role in building company". I finally decided to research into the latter topic since the case company and I found ITB role to be interesting and beneficial to building industry. Besides, the concept was not heavily studied, and less applied in building projects. Therefore, I decided to research into ITB to discover opportunities and relating issues affecting ITB role. I intended to gain deeper insight into the concept and discover how it is applied in the building industry. Relevant issues relating to the research area were discovered by reviewing existing literature, and discussions with my supervisor to develop research topics and questions (Yin, 2018, Bryman, 2012). Related kinds of literature were reviewed not to find answers about what is already known about the topic, but to develop sharper insight and more insightful issues related to the topic (Yin, 2018). The planning of the fieldwork began after the research questions were developed (Bryman, 2012). The research questions were improved as the study progresses (Bryman, 2012, Braun and Clarke, 2006). Brinkmann and Kvale (2009,p.105) described this "process of formulating research questions and theoretical clarification of the theme investigated" as *thematising*.

The field of study is new even though the idea of integrating technical services in a building has been in existence for the past few years. There are several academic publications (such as "integrating fire systems with HVAC

controls" (Studer, 2012), "integrating building physics simulation" (Citherlet et al., 2001), etc) technically describing the integration of technical building facilities. However, there are few other types of literature, such as technical reports, conference papers, etc. describing the management aspect of the concept. These publications describe how the ITB concept can be managed and harnessed to improve the performances of technical facilities in a building structure. The objective of this research was to understand the management aspect of ITB and not the engineering aspects. Therefore, analysing technical reports and conference papers were the main focus used for the literature review whiles supporting them with existing academic publications. Referencing academic literature is often considered as a tactical approach to persuade readers of the legitimacy of one's work (Gilbert and Gilbert, 1977).

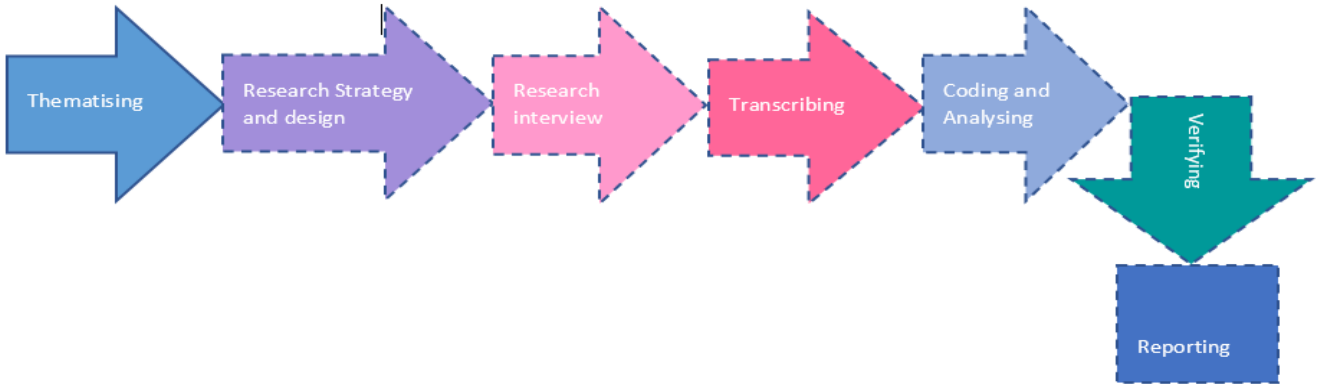

Figure 4. 2 seven stages of research - Thematising

4.2 Qualitative Research

Based on discussions with the case company (Rambøl) and reviewing of existing pieces of literature, it was discovered that ITB concept is not heavily studied and applied in building projects. Therefore, to explore the research area and to carry out exploratory, explanatory, and descriptive studies, qualitative research method was chosen to discover new dimensions in the research topic, and improvements of research questions in sections 1.1 were often done as more knowledge and new concepts were discovered. This thesis aims to develop deeper insight into ITB phenomenon and assist improve its application in building projects. Therefore, I considered qualitative research strategy be more suitable to be used compared to quantitative research strategy which emphasizes quantification in data gathering and analysis (Bryman, 2012). According to Brinkmann and Kvale (2009), qualitative research is considered prevalent and is here to stay, and the lacking theories regarding ITB defined my research as a descriptive study.

The decision of whether to use deductive approach by comparing empirical data to theories (Tjora, 2019, Bryman, 2012) or to focus on theory-building research by inductively explore the study (Tjora, 2019, Bryman, 2012) was also considered. Both approaches of collecting data are qualitative since the research area does not have enough prior research, minimal empirical data within the scope of the research, and the desire to conduct quality in-depth interviews to gain insight from interview subjects experience. A deductive approach was chosen to be used for the

thesis since it provides an avenue to test theories by comparing and analysing the relationship between theory and research data, compared to an inductive approach which focuses on the generation of theories (Bryman, 2012).

The generation of theories is not the focus of this research. The application of the deductive approach encouraged the engagement with literature prior to empirical data collection and analysis (Braun and Clarke, 2006). Based on my less experience with qualitative research knowledge, thorough literature reviews were conducted which inspired my research questions and assisted in specifying relevant variables in sorting empirical data.

4.3 Case study

Case study research is described as one of the five major types of designs and acceptable variants for conducting qualitative research, and its gaining spotlight in social research due to its frequent usage (Yin, 2018, Creswell and Poth, 2016, Bryman, 2012). According to Yin (2018), an opposing perspective states that case study research might be separated from qualitative research based on its customised procedures for defining and selecting case(s) to be studied. Other authors such as (Pettigrew, 1973) says that case study research makes use of quantitative data to study the phenomena in their context, rather than independent of their context. The issue of whether to consider a case study as part of qualitative research or not needs further explication (Yin, 2018) which is not the focus of this study. This thesis considers case study research as part of qualitative research since it permits intensive investigations of a contemporary situation from a real-world perspective (Yin, 2018). This is an objective of conducting qualitative research (Bryman, 2012).

There are other varying perspectives describing the use of case study research, and how its interviews should be conducted. Even though some authors state that case study research is only appropriate for exploratory studies, Yin (2018) argue that case study research is appropriate for exploratory, explanatory and descriptive studies. The focus of my research is to explore, describe and explain what ITB concept is, so the thesis adopted the use of the case study described by (Yin, 2018). Since the ITB concept is not heavily studied and applied in building projects, the exploratory strategy was employed to explore and discover more interesting areas related to ITB. The descriptive method included many works of literature and data analysis. The explanatory approach involved expert and non-expert interviews using a semi-structured approach. These approaches helped to obtain an in-depth understanding of the ITB concept and to retain a holistic and real-world perspective (Yin, 2018). Other alternative research designs (such as cross-sectional, longitudinal, and comparative research designs) could have been used to explore, explain and describe the ITB phenomenon to achieve deeper and comprehensive insight, but they are time-consuming and difficult to conduct intensive analyses (Yin, 2018, Bryman, 2012). Regarding the procedures for conducting interviews for case study research, some authors (Yin, 2018, Brinkmann and Kvale, 2009) states that there are standard guidelines, choice and techniques applied at the different stages of an interview examination, whiles other authors (Eisenhardt, 1989) stipulate that there are no specific guidelines. This knowledge was used to adapt the case study design to fit the research in any way possible.

Concerning my research questions stated in section 1.1, the goal of the study is to understand **what** ITB is, **why** is it important in building projects, **how** it works and perceived in a real-world contextual environment (Yin, 2018). The use of the phrases "what", "why" and "how" in case study research provided the opportunity to conduct detailed description of a contemporary case from respondents' perspective where the researcher had minimal control over the empirical data (Yin, 2018). A "case" can refer to an organisation, location or an event which is under study (Bryman, 2012). In this thesis, the case refers to "*how building and construction companies like Rambøl perceives the application of ITB role in building projects?"* The thesis focused on perspectives, performance, and behaviours of the case company, and conducted interviews with its employees. That is the focus of the research investigation (Tjora, 2019).

A case study can either be a single- or multiple-case study to investigate a phenomenon (Yin, 2018, Bryman, 2012). Instead of performing and analysing several case studies of different companies, the approach of analysing different cases within one organisation - the nested approach was adapted (Bryman, 2012, Yin, 1994). Multiple-case studies or comparative research are time-consuming and difficult to perform intensive analysis, so a single-case study was considered to be more suitable. Besides, the outbreak of the coronavirus disease made it difficult to involve multiple organisations to perform extensive analysis. Even though the chosen approach will not easily allow for generalisation of findings based on statistic or population, generalisation (transferability) was made from an analytical perspective where generalisation is referred from the empirical observation to theory (Yin, 2018). The discussions were done by analysing the different perspectives presented by the respondents and comparing that with existing theory.

4.3.1 Sampling

The decision to select the right kind of sample suited to the topic to be investigated was given much consideration (Bryman, 2012). One of the criteria used in the selection process was the knowledge and experience related to the research topic. This was done to ensure that the right, rich and quality data were collected (Bryman, 2012). The building engineers of Rambøl were selected to be used as the sample for the data collection process. Rambøl was considered to be suitable because they were readily available, and were part of the fourteen companies that contributed to the provision of the updated version of the ITB standard – NS 3935 (NS3935, 2019).

Concerning the sample size, eleven (11) respondents were initially planned to be interviewed. Unfortunately, the sample size was reduced to eight (8) due to the outbreak of the coronavirus disease resulting in difficulties in accessing lots of interviewees. Even though the reduction of sample size has the tendency of affecting the possibilities of gaining comprehensive views and generalising findings based on population, the quality of data collected does not necessarily depend on the number of people to be interviewed (Bryman, 2012). The generalisation of my findings will place much emphasis on analytical data, and less on population (Onwuegbuzie and Leech, 2010). The use of a small sample size increased my chances of getting close involvement with the interviewees, and enhance the validity in producing fine-grained data and in-depth inquiry findings (Crouch and McKenzie, 2006). Besides, it provided the advantage of easily immersing myself in the data sets (by repeated and active reading), which helped in the coding and analysing process (Braun and Clarke, 2006). The respondents

were located in Trondheim and Oslo, Norway. It also included one interviewee from a client/builder organisation. Since building owners are those who determine the operational success/effectiveness of building projects (Samset, 2010, Hussein, 2018), the addition of client organisation made me to understand the application of ITB from a client perspective.

The final sample was made up of ITB experts, project managers, and other technical engineers whose experience are related to ITB-projects. In the context of management, the experts are distinguished from non-experts through their experience and tacit knowledge (Tsoukas, 2009). In this research, the experts are described as those persons who are responsible for job activities, knowledge, experience, and authorities related to ITB application. The research applied both expert and non-expert interview-based approaches. This implies that the interviews did not only involve managers who possess expertise in ITB, but it also includes managers who have witnessed the application of ITB in their projects. To ensure that the right respondents were selected in terms of ITB knowledge and experience, the selection of the respondents was done by the contact person to Rambøl.

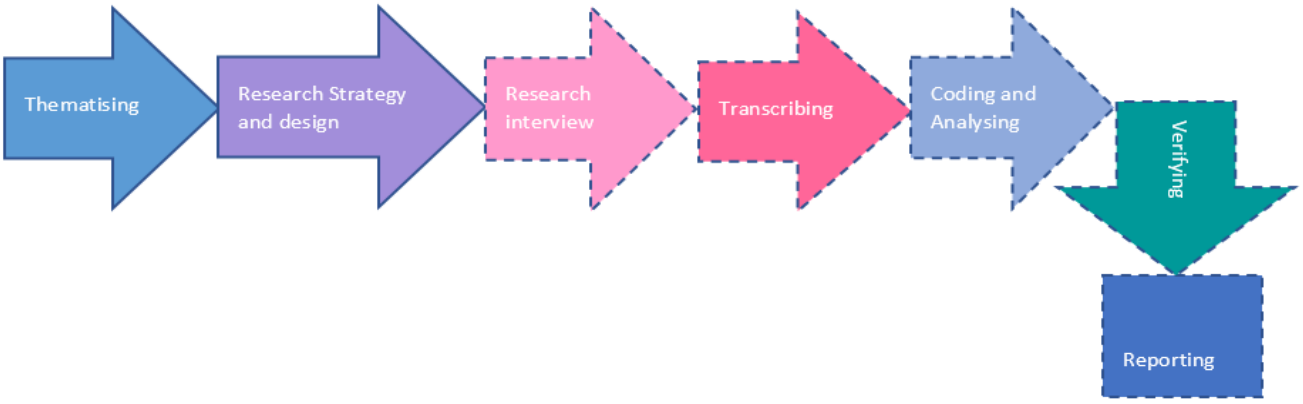

Figure 4. 3 Seven stages of research – Research Strategy and Design (Qualitative and Case Study)

4.4 Research Interview

Research interview is one of the research instruments used for empirical data collection (Bryman, 2012). I chose to use research interviews approach because I intend to elicit information from respondents and understand the meanings that they assign to their activities based on their views, motives, experience, norms, and values (Lindlof and Taylor, 2017, Bryman, 2012, Stromer-Galley, 2003). This approach assisted to uncover unexpected information when they presented their information about the research area (Tjora, 2019). These are benefits that are difficult to be achieved in other methods of data collection process such as observation, ethnographic studies (participation), document studies, etc (Bryman, 2012).

My research interviews were conducted using a face-to-face communication medium and computer-mediated platform. Out of eight interviews that were performed, only one was conducted using face-face communication at the respondent's location, and the rest were personal online interviews. By conducting a face-to-face interview, I was able to easily establish rapport, engagement, and trust with respondents (Bryman, 2012). Besides, I was able

to assess respondents' information based on what they say and how they say it by using their visual cues (Bryman, 2012). These benefits are difficult to be achieved in computer-mediated interviews such as synchronous and asynchronous online interviews (Bryman, 2012, Mann and Stewart, 2000). Nevertheless, video-conferencing can be used to assess respondents' presented information based on visual signals, but it is likely to be affected by internet interruptions resulting in poor video and sound quality (Bryman, 2012).

Unfortunately, there was a pressing demand to change from face-to-face to online personal interview (synchronous online interview) because of the outbreak of the coronavirus disease, and people were advised to keep "social-distancing". Asynchronous online interviews, such as email communication, could have been used as an alternative approach, but it takes a longer time to receive responses depending on respondents' cooperativeness, and it requires consistent follow-up (Bryman, 2012). Even though personal online interviews makes it difficult to maintain engagement with respondents due to distractions which I had no control over (Illingworth, 2001), it provided the opportunity for the interview to be conducted at participant's neutral locations such as home and personal offices (Bryman, 2012). This made it possible for individuals to keep their personal space and whereabouts private (Hanna, 2012). Besides, cost (time and money) related to travelling to respondents' office were saved (Wikipedia, 2019, Bryman, 2012).

The interviews were semi-structured with an interview guide to make sure that preferred questions are discussed with respondents. Compared to the structured interview, the use of semi-structured interviews provided flexibility to depart from the interview guide that is being used, and moved in a direction which was taken by the interviewee (Bryman, 2012). Besides, flexibility made it easy to update the interview guide as more related concepts or information are developed. The challenge related to using semi-structured interview was that it presented difficulties in maintaining reliability and validity as there are no standard procedures for conducting the interviews as seen in structured interview approach. Conducting a standard interview with stringent rules was not the focus of my interview. In planned to conduct flexible interviews where respondents could feel comfortable and open-minded to freely express their views. With my chosen approach, I was not compelled to follow the order in which the interview questions were designed and arranged (Bryman, 2012). Therefore, I asked questions based on the respondent's background of speciality and this saved time. A detailed description of how the interview guide was developed and structured, how research ethics that were observed, and how the interviews were executed will be discussed in section 4.4.2 and 4.4.3.

4.4.1 Research Ethics

Before conducting the research, certain ethical principles were developed and adhered throughout the research process. These principles ensured that research participants consents were sought, they were not harmed (physically, stress, reputationally, etc.), invasion of privacy, and deception. Safeness and privacy of respondents were assured by keeping their identities and records confidential. Some of the measures used to protect the confidentiality of participant data include: not storing respondents' name on hard drives, safely keeping copies of transcripts on my computer; ensuring that participants names were not included in the transcripts; storing the list of respondents and their identifier codes in a separate locked cabinet; assuring anonymizing of the interview

subject, and damage of recorded data after completion of master thesis. Besides, I received approved permission from the Norwegian Centre for Research Data AS - NSD to process data based on acceptable procedures (see Appendix C). To ensure that respondents were aware of my research objectives and their consents were acknowledged, agreement letters were sent to the interviewee to read carefully and sign (see Appendix B).

NB: Please note that the attached document in Appendix C is an NSD confirmation of my first research topic that was later changed. Per the requirement for making changes, NSD stated that there is no need to seek new approval when making changes in the research topic (NSD, 2019).

4.4.2 Interview guide

An interview guide was prepared using the approach described by (Bryman, 2012). Interview themes were developed based on reviewed pieces of literature related to ITB, and interview questions were organised under these themes. The interview questions were formulated based on the research questions stated in Chapter 1.1 - *Research Objectives*. The interview questions were developed to ensure that the questions cover the areas that I needed to investigate (Bryman, 2012). The guide was made flexible to provide avenues for enquiries during the interviews (Bryman, 2012). The English language was used medium for communication for both my interview guide and the interview. According to Bryman (2012), a language that is understandable and easily spoken by the interviewee should be used as the medium for communication. However, in my situation, the interviewees were very comfortable speaking and understanding their native language (i.e. the Norwegian language) compared to the English language. This posed a challenge for some interviewees to speak fluently and make a clear statement. Further description of the challenges relating to language barrier will be described in Chapter 4.8.2 – *Personal Reflection*. This challenged was resolved by asking propping questions where necessary to confirm and understand respondent's statement. The interview guide was structured based on the following questions:

- Warm-up questions which were precise, short and simple.
- Reflection questions explaining important areas of the research topic.
- propping questions or follow-up questions were used when necessary to confirm and clearly understand what the interviewee said. They were also used to seek in-depth information (Bryman, 2012).
- Rounding off questions were used to seek for recommendations to improve the application of ITB and increase its awareness.

In preparing the interview guide, I first designed the questions and later asked my supervisor to review and advise. Changes were made to ensure that the interview guide had the right questions, and they investigate what I intend to investigate (construct validity). Final review of the questions was done with the contact person to Rambøl and one ITB manager. After the research question was prepared, it was pilot-tested with an ITB manager from the case company. Reviewing and pilot testing of interview questions were done to ensure that the interview guide was credible, valid and prepared within the scope of my research (Bryman, 2012). After preparation of the interview guide, discussions were made with the company's contact person to schedule dates for the interviews. The table

below shows how the interview questions were categorised. The interview questions were divided into four areas: (1) Background information (2) ITB concept (3) ITB context and (4) Recommendation.

Table 4. 1 Classification and example of questions from the interview guide.

Classification	Objective/focus	Sample questions
Background information	Brief introduction questions which are less stressful and easy to talk about. This valuable information describes the interviewee and his/her position in the project	Name? Educational and working experience?
ITB concept	The focus is to get insight and understanding of the research topic (ITB) and some ITB related challenges from a practical perspective.	How will you describe ITB in your words? Based on your experience with ITB application, what are some challenges related to the ITB role?
ITB context	The objective here is to understand some contextual factors that influence the application of ITB role in building projects.	What is the general contract agreement (NS 8407) and how it related to ITB? Describe how the BIM and VDC relates to the application of the ITB role in building projects?
Recommendation	Talk about some recommendations that can be used to deal with the challenges and increase awareness of the concept in questions.	What are your recommendations for dealing with ITB challenges, or increasing awareness of the ITB role?

!) Full reading of the interview guide can be found in Appendix A – Interview guide. Please note that the questions were created to be applied to building employees and managers within the engineering and project management departments of Rambøl, but all questions can be applied to other building and constructing organisations that use ITB in their building projects.

There may be some similarity with the questions, and the purpose was of this strategy was to ensure that the respondents get the chance to reflect on the subject several times. The themes and questions were designed based on the research questions presented in section 1.1 – *Research objectives*, as shown in the table below:

Table 4. 2 Research questions

No.	Research Question
RQ1	To what extent is ITB role beneficial to building projects?
RQ2	What are the relationships between the various ITB standards used in building projects?
RG3	What are some of the challenges hindering the application of ITB role in building projects?

4.4.3 Interview execution

All the interviews were performed by me since I am the only person involved in this project. This allowed me to approach the data analysis with prior knowledge of the data, and some initial analytic interest or thoughts (Braun and Clarke, 2006). The use of a permanent interviewer in all the interviews guaranteed that the interview situations and completion were related as possible; compared to the use of different interviewers, which could undermine the quality of a project due to interviewer not participating in related interviews (Dalen (2004) as cited in (Hansen et al., 2015)). The interview was meticulously planned to ensure that fewer challenges were faced during the interview execution and to ensure respondents feel comfortable throughout the interview.

4.4.3.1 Before the Interview

Before the interview, measures were taken to ensure that my interview process was successful. Sample of interview questions were sent to respondents to inform them about my research and to get them prepared in order to be comfortable and committed to the research. The recording device (Samsung smartphone) which was used for the interview, was assessed to ensure it was working properly, durable, and had good sound quality (Bryman, 2012). To improve my interview skills and conduct successful interviews, I was involved in several interview training. For example, a pilot interview was done with an ITB manager from Rambøl to improve my interview competence and to ensure that my questions measure what I intend to investigate (that is, to ensure construct validity). I listened to the recorded interview with a colleague and we discussed my performance during the interview. I found the answers interesting as much as necessary to proceed using the interview guide unrevised. Feedbacks received from the pilot testing improved my experience and confidence in conducting the subsequent interviews. Before the day for the actual interviews, I read through the questions several times to become familiar with the interview questions and to know which ones I need to cover based on the speciality of the interviewee. This made the interview to flow naturally and ensured efficient use of time. Regarding the interview duration, forty-five minutes (45) was aimed to be the length of the interview but could last sixty minutes (60) when the interviewee is talkative. This was to ensure that the interviewee becomes comfortable and presents more detailed information relating to the research topic. However, it was managed to ensure that the interviewees do not become tired after the interview.

4.4.3.2 During the interview

During the interview, warm-up questions were used as introductory questions to make the interviewee feel less stressful and comfortable (Bryman, 2012, Eisenhardt, 1989). Besides, I used the first five minutes to introduce myself, my research objectives, and to inform them about how the recording and transcription will be done(Bryman, 2012). The interview was recorded due to the natural limitation of human memory and to provide an opportunity for secondary analysis by other researchers who want to assess the analysis I have conducted (Heritage, 1984). The recorded data was later transferred to my laptop for storage and transcription. Notes were also taken during the interview to reduce dependency on the recording device because of the possible data loss in case of device damage (Bryman, 2012). In order not to lose concentration on what is being said by the interviewee, much focus was placed on listening than getting down notes (Bryman, 2012). Moreover, I remained

highly alert to what is being said by following up on interesting points and using prompting and propping questions where necessary to make clarifications and draw attention to inconsistencies in interviewee' responses. In some interviews, the recording device was kept on even after the interview had ended, and the interviewee was still talking; it assumed that the interviewee 'opens up' and gives vital information at the end of interviews or perhaps when the recording device has been switched off (Bryman, 2012). By following ethical standards, I asked informants if post-interview information can be used for my research, and they agreed.

4.4.3.3 After the interview

After performing each interview, I set aside time to reflect on the interview experience and to update the interview guide based on new information that came up. I made field notes about my interview experience and my impression regarding the respondents (Bryman, 2012). In one of the interviews, one of the ITB experts presented a more detailed and in-depth description of ITB concept based on his several years of experience with the ITB role. This resulted in a longer interview compared to the others. From this particular interview, I gained an in-depth understanding of ITB from a practical perspective and appreciated its application in building projects. Another informant who is mostly involved in both road projects and building projects said that the principle of implementing ITB in building projects is similar to "systematic completion", which is implemented in road projects. In some interviews, the interviewees felt they could not give much information because they have less practical experience with ITB applications. Besides, they were not able to answer some of the contextual questions in the interview guide. However, they exhibited a good theoretical understanding of ITB concept. I guaranteed them that the structure of the interview made them to provide answers in such a manner, that was important for my research. These interviews were shorter compared to those who have much knowledge and experience with the ITB role. Besides, the poor internet connection affected the quality of the interview and the recording.

Table 4. 3 Details of Research interviews

Interview number	Interview Duration	Number of years of working experience
1	00:31:35	➢ 5 years
2	00:29:50	➢ 25 years
3	01:01:04	➢ 10 years
4	00:33:54	➢ 10 years
5	00:27:05	➢ 10 years
6	1:01:01	➢ 10 years
7	00:55:32	➢ 25 years
8	00:47:47	➢ 10 years

The table above presents detailed information about my research interviews. A total of 8 interviews were conducted. The first interview was a pilot test interview which made use of face-face communication medium.

The rest were conducted over the internet using skype for business and Microsoft teams. From the interviews, it was noticed that the informants possessed sufficient years of working experience within the construction industry, which made them provide practical information and examples relating to ITB applications and its challenges. In terms of interview duration, some interviews lasted longer than the others. With the longer interviews, the interviewees gave detailed descriptions of the subject under study based on their expert knowledge and practical experience. Some informants who are not ITB experts gave practical examples of challenges they had experienced when they were involved in ITB related projects. However, some challenges were encountered during the interviews that resulted in performing shorter interviews than expected. These challenges include:

- The informants who are not ITB experts were not able to answer some of the interview questions. They presented good theoretical knowledge of what of ITB is, its challenges and benefits, but we're not able to describe contextual factors (such as the ITB related standards, VDC, BREEAM, and BIM model) that influence the application of ITB role in projects. They advised that such questions should be directed to people who are experts in such areas.
- Secondly, the recording device was stopped when the interview was almost ending. The information which was presented after the recording was stopped were noted down. Lessons learnt from this experience were applied to subsequent interviews.
- Another factor that contributed to conducting shorter interviews was the use of the English language as the medium of communication during the interviews. Some respondents found it less comfortable to present their information in the English language compared to the Norwegian language. Therefore, they were not able to provide answers in a clear manner. This challenge slightly influenced my ability to interpret some of the transcribed data,

These interviews were short not because the respondents lacked cooperativeness or were anxious about their voice being recorded and preserved (Bryman, 2012). Instead, they were willing to cooperate and to provide information to their best knowledge. There were no interview refusals after the whole interview process.

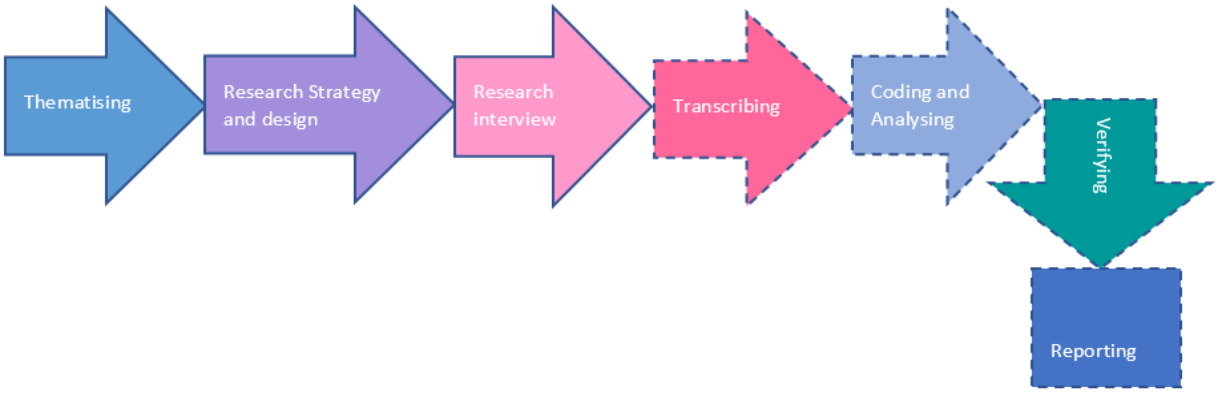

Figure 4. 4 Seven stages of research – Research Interview

4.5 Transcription

Transcription is a term that literally refers to the translation of spoken words/sounds into a written form (Bryman, 2012). It helps in keeping intact with both the interviewer and the respondents' words by pilling up the amount of text to be analysed (Bryman, 2012). After each interview was conducted, I transcribed the recorded data. To ensure that similar, objective and systematic transcriptions were done, I adapted the following transcriptions rules described by (Bryman, 2012) to my transcription process. These rules include:

- All spoken works should be written down including repetitive words (verbatim account). However, some statements were not transcribed because they seem to be irrelevant, uninteresting, and unlikely to be fruitful (Bryman, 2012).
- The symbol "???" should be used to replace phrase/words that were not heard clearly or missing. I perceive this will give the reader confidence in my data-collection process.
- Thinking sounds were not included unless it describes an important thought process or rephrasing during a spoken sentence. All spoken words were transcribed into the English language.

Average duration of five hours was used to transcribe interviews that lasted for approximately one hour. An online software ("otranscribe") was used to transcribe the recorded data. This software has buttons (similar to the pedals of a foot-operated transcribing machine) which was used to start and stop recordings (Bryman, 2012). All spoken words were transcribed to ensure that the transcribed data was "true" to its source except those that were considered irrelevant based on my research questions, to make the text easier to relate and making the data more comparable. Even though the transcription process was time-consuming, frustrating and sometimes boring, transcribing all the interviews myself provided great benefits of bringing me closer and familiarizing myself with the data, developing a thorough understanding of my data, encouraging me to begin to recognise key themes and to become aware of similar and different perspectives presented by the interviewees (Braun and Clarke, 2006). Some authors argue that transcription does not only involve the mechanical approach of simply putting spoken sounds on paper, but it also involves an interpretative act where meanings are created (Bird, 2005, Lapadat and Lindsay, 1999). After transcription, the transcript data were checked back against the original audio recording for accuracy (Braun and Clarke, 2006). After the transcription process, I had a certain amount of treated data for analysis. The next step involved coding and analysis of transcribed data where it involved the selection of relevant sections (themes).

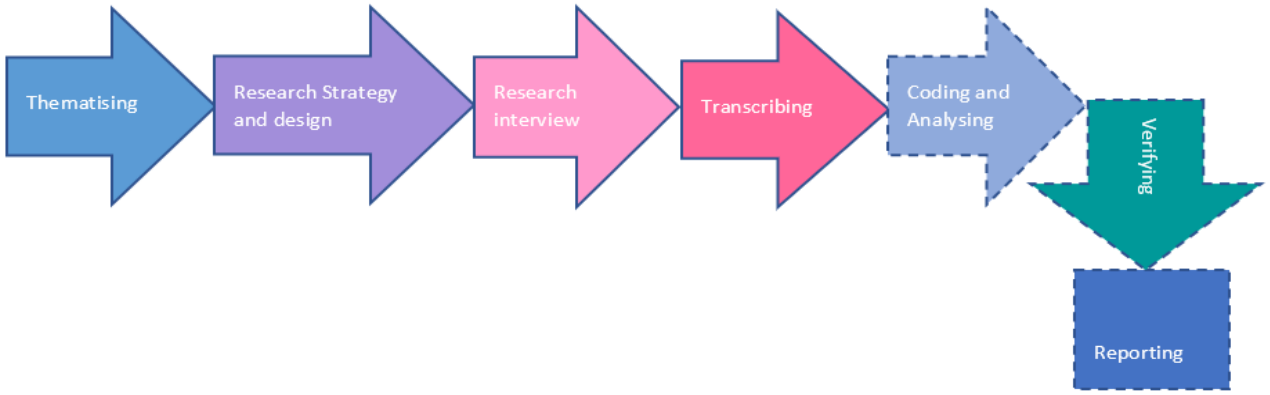

Figure 4. 5 Seven stages of research – Transcribing

4.6 Coding and Analysis

This section describes the qualitative analytic method used to code and analyse the transcribed data. It describes the stages which were involved in analysing the transcribed that were collected during the interviews.

In performing my qualitative data analysis and coding process, I made use of thematic analysis because of its flexibility and theoretical freedom, unlike the other approaches (such as Interpretative Analysis, Grounded theory, Content Analysis, etc.) which are theory bounded (Braun and Clarke, 2006). Thematic analysis is an extensively used qualitative analytic approach even though it is poorly defined and hardly acknowledged (Boyatzis, 1998). It provides an approach to identifying, analysing, and reporting patterns within data, and it minimally organises and describes data in rich detail and interprets various aspects of the research topic (Braun and Clarke, 2006, Boyatzis, 1998). Thematic analysis "provides core skills that are useful for conducting other forms of qualitative analysis" (Braun and Clarke, 2006,p.78). Opponents of thematic analysis argue that thematic analysis should not be considered as a specific approach or should not have its right because thematic coding is seen as a process performed within major analytic practices such as grounded theory (Ryan and Bernard, 2000, Boyatzis, 1998). However, other authors (Braun and Clarke, 2006) argue that it should be considered as an independent qualitative analytic tool and should have its right. This thesis supports the arguments made by (Braun and Clarke, 2006), and it considers thematic analysis as a specific method.

The qualitative data analysis will follow the six (6) stages of the thematic analysis described by (Braun and Clarke, 2006). The stages include: (1) Familiarizing myself with the data, (2) Generating initial codes (3) Searching for themes (4) Reviewing themes (5) Defining and naming themes, (6) Producing the empirical report

4.6.1 Familiarizing myself with the data

The data analysis process started with familiarizing myself with my data (Braun and Clarke, 2006). This stage involved immersing myself into my data by repetitive reading to get the depth and breadth of the data content (Braun and Clarke, 2006). The process of repetitive reading was time-consuming, but it helped in identifying possible ideas and patterns as I read through the data. The ideas and patterns were noted down since they were

important for the next phase. Identification of ideas and themes were influenced by the pre-conceptual knowledge gained during the literature review process. This stage was considered to be very important as it serves as a foundation for the rest of the analysis (Braun and Clarke, 2006).

4.6.2 Generating initial codes

After familiarising myself with the data and identifying themes and ideas, the next stage involved generation of initial codes. The process of coding is part of the analysis as one is organising his or her data into significant groups (Tuckett, 2005, Miles and Huberman, 1994). During the coding process, I approach the data with specific questions in mind that I wanted to code around, and this influenced how my codes and themes were generated. The production of codes was semantically done by identifying codes within the surface meaning of the data (Braun and Clarke, 2006). However, latent or interpretative analyses were done where necessary to identify underlying ideas, assumptions, ideologies, etc. (Braun and Clarke, 2006). In coding each data item, several codes were produced as much as possible since I never knew what might be interesting later. Some individual data items were coded into as many different themes as they can fit into. After coding the first data item, the same procedures were repeated for the remaining data items. New codes were generated when a new idea or patterns comes up. There were retentions of tensions and inconsistencies that appeared within and across the data set, and accounts which departed from the dominant story during the analysis. A computer software, “Nvivo 12 Pro”, was used for the coding process which involved tagging and naming selection of text within each data item. After coding the data set, the entire codes were reviewed; some codes were merged whiles others were refined and discarded. This reduced the number of codes that were initially developed.

4.6.3 Searching for themes

The next stage of the thematic analysis process involved searching for themes. The stage involves arranging and grouping all the codes into potential themes and organizing all relevant coded data extracts within the identified themes. At this point, I analysed my codes and considered how different codes blend to form a central theme. A visual representation such as table was used to sort the different codes into themes (see Appendix D). This involves thinking about the relationship between codes, between themes, between different level of themes (main and sub-themes). This stage was ended with a compilation of all candidate themes, sub-themes, and all data extracts that have been coded concerning them. At this stage, no themes or codes were discarded or abandoned since I was not certain whether some themes need to be combined, refined and separated or even discarded.

4.6.4 Reviewing themes

This involves evaluation of the individual themes (main and sub-themes) to decide which ones need to be combined, refined, separated, or abandoned. Some themes were merged into one theme whiles others were broken down into separate themes. At this stage, the reviewing and refining of developed themes involved two levels. With the first level, the coded data extracts for each theme were assessed to see whether they form a consistent pattern. If they do, then I move on to the second level. If they do not, then I had to consider if the theme is not valid (thus, reflects the content of the coded data), or whether some of the data extracts do not fit there. In such situations, the themes were worked on, new themes were created, and a new theme was developed for data

extracts that do not belong to the already-existing theme. Irrelevant themes were discarded from the analysis. Once I was satisfied that the candidate theme captures the meaning of the coded data, I moved to the next level where I consider the validity of the individual themes with the entire data sets. I read through the data entire data sets to confirm if the themes correlate to the data sets, and to code additional data within themes that have been missed in the earlier coding stages. Some themes which were not valid were refined and reviewed until I was able to devise a satisfactory thematic map. The coding data and theme generation were iteratively done until my refinement was not anything substantial (Braun and Clarke, 2006). The final developed themes or codes can be found in Appendix D – *Codes*.

4.6.5 Defining and naming themes

By defining the themes, the individual themes were intensively examined to determine their relevance and which aspect of the data each theme captures. Identified sub-themes were also defined to explain the hierarchical meaning within the data (Braun and Clarke, 2006). This process also involves identifying the story that each theme describes, and how it fits into the overall story that I am telling about the data, concerning the research question. The themes were defined to the extent that they were not too distinct and complex. The names of the themes were brief, effective, and immediately give the reader a sense of what the themes are about (Braun and Clarke, 2006). After the thematic analysis process, the following themes were developed: ITB description, ITB benefits, ITB challenges and success factors. The following table shows an example of how the response of an informant was coded and analysed when he was asked the question *" Based on your experience with the ITB roles, what are some of the challenges related to ITB role?":*

Table 4. 4 An example of the coding process

Informant's response	Meaning unit	Themes (code)*
"…If you are lucky the ITB standards are mentioned in the contract but often they are not… The problem is that the ITB responsible, he doesn't have any authority regarding the contract. Then I get some resistance doing all the ITB work because they haven't mentioned that in the tender... So they haven't the hours and the money to do the work…I think it's very important for a builder when they are making a tender that they are hiring an ITB responsible so he can describe all the systems and what kind of work they engineering group can expect… And also, is a challenge for people that haven't been part of ITB earlier to understand the benefits".	ITB roles are often not mentioned in the contract and tender resulting in resistance to ITB manager's authority during decision making and implementation, and lack of budget and working hours to do ITB work. ITB managers should be involved earlier in the project when preparing the tender. Building employees lacking the experience to understand the benefits of ITB roles.	Invisible ITB roles Lack of contractual authority Resistance to Authority Lack of ITB budget and working hours Early Involvement of ITB manager Lack of ITB experience

!) The term ITB responsible is also referred to as the ITB manager

**) I immersed myself into the data by actively reading the data to know the depth and breadth of its content. This helped to code different perspectives presented by the informants.*

**) The developed themes in Table 4.4 will be described in detail in chapter 5 – Empirical data. The report will provide how the informants from the case company perceive the application of ITB in building projects. Description of how the report will be written is presented in the next section – chapter 4.5.6.*

4.6.6 Producing the empirical report

The final stage of my data analysis process involves writing a report about the themes which were discovered during the coding and analysis process. This stage involves telling a "complicated story of my data in a way which convinces the reader of the merit and validity of your analysis" (Braun and Clarke, 2006,p.93). The report provides a brief, coherent, logical, interesting, and non-repetitive account of the story the data tell. The theme was interpreted to present the varying views of the interview subjects. Enough data extract was used to provide substantial evidence of the themes within the data, and to capture their importance. The report of that empirical data began by interpreting the themes that were present in the data. A detailed description of the themes can be found in the next chapter (Chapter 5- Empirical Data). Later, a distinction was made between relevant themes that support the propositions that were developed during the literature study and those that did not.

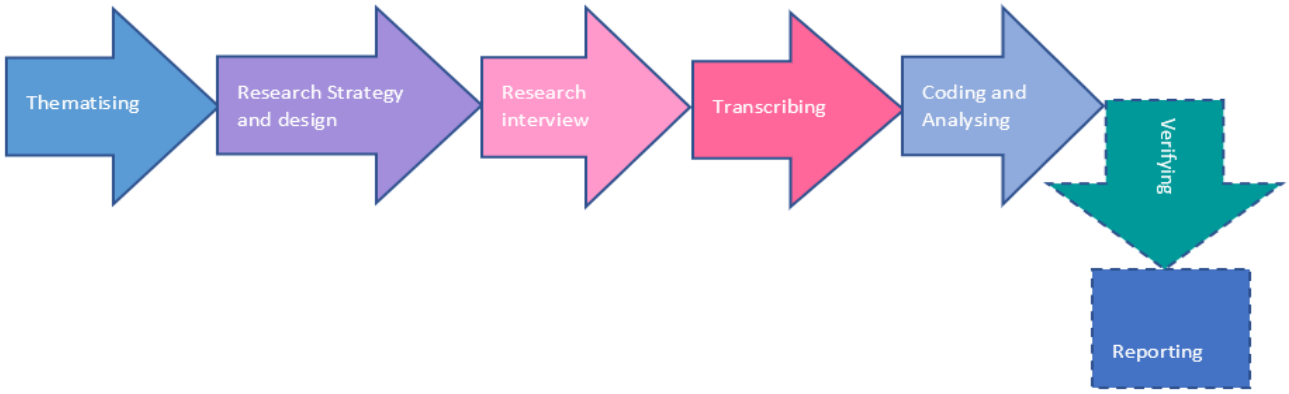

Figure 4. 6 seven stages of research – Coding and analysis

4.7 Evaluation of the Research Process

Bryman (2012) presents the three most renowned criteria for assessing social research: reliability, validity and replications. According to Bryman (2012), other researchers such as Guba and Lincoln (1994) developed other evaluation criteria which are mostly applicable to qualitative research, which is the kind of study I have conducted in relation to this thesis. These criteria include authenticity and trustworthiness. These two criteria are applied to my study in the following chapters, Chapter 4.7.1- *Authenticity* and Chapter 4.7.2 – *Trustworthiness*.

4.7.1 Authenticity

Authenticity refers to the extent to which the researcher has fairly presented varying viewpoints among the members of the social settings, and helps members to arrive at a better understanding of their social environment (Bryman, 2012). In my literature review and empirical data, I presented varying views of how the different authors and interview subjects perceive the application of ITB role. Even though it might be possible that my personal views/values could affect the way I presented my data, I tried as much possible to not allow my prior theoretical

knowledge, experience or values to influence my judgement at presenting the information. This approach of conducting the research made me gain a comprehensive understanding of the research area from different perspectives.

Besides, by complying to research ethic as described in Chapter 4.3.1 – *Research ethic*, made to receive honest answers from the interviewees even though a sample of the interview questions were given to them to prepare before the interview. From the interview executions, the informants provided practical information relating to how they perceive the ITB role. They were honest about concepts which did not relate to their area of expertise or experience.

4.7.2 Trustworthiness

Trustworthiness is made up of four evaluation criteria: credibility, transferability, confirmability and dependability (Bryman, 2012). The following sections describe how I applied these criteria to my research to demonstrate its trustworthiness:

- **Credibility:** Bryman (2012) described credibility as the process of ensuring that the research methods used were appropriate and the findings were correctly documented. Pertaining to my research, I believe I have properly documented the methods which I found appropriate to present my data and written it a way that convey the same meanings that the informants presented. I intended to further confirm the meanings to which I have attributed to the data by seeking for respondent validation, but it was not feasible to do so because of the difficulties in reaching informants due to the outbreak of the coronavirus disease. Besides, respondent validation was not possible to achieve due to the time limit to submit the final thesis.
- **Transferability:** Transferability is defined as the extent to which the research can be applied to different settings or context (Bryman, 2012). In my situation, it will be difficult to apply my research findings to the whole building industry since the data was collected from a case company (Rambøl) not the whole industry. Besides, the case company was not confirmed in the thesis as a representative case. While the outcome might not be the same when the research is carried out with a different case company, the same theory and research method can be applied to other fields. Modified or refined findings of research might be achieved when the outcome of this research is compared to a different filed or case company. Multiple case study or comparative studies could have been used to gain extensive ideas which be used to generalise my findings in terms of data quality and number. As mentioned earlier, the generalisation of my findings in terms of number is not the focus of this study. Besides, the outbreak of the coronavirus disease and time limitation to submit my final work will not permit me to involve several case companies in my research. However, the analysis of a single company provided an in-depth understanding and analysis of the situation facing the company. Besides, deeper insights and analyses would have been difficult to achieve if several companies were considered (Bryman, 2012).
- **Confirmability:** This evaluation criterion is concerned with ensuring that the research does not excessively allow his/her "personal values or theoretical inclinations to manifestly to sway the conduct of the research and the findings deriving from it" (Bryman, 2012,p.393). Right from the start of my research,

I acknowledged my personal values and bias, and made every effort to eliminate it throughout the research processes including my writing. An example of personal bias is to ask interview questions or analyse the data from a particular standpoint, or presenting the interview subjects in a way that does not truly reflect who they are.

- **Dependability:** This term is also referred to as reliability in quantitative research (Bryman, 2012). It describes how the whole research processes were performed to enhance the easy accessibility of its data (Bryman, 2012). Thus, how well the research process was performed, documented and followed (auditing approach). To enable easy accessibility of my research data, I kept records of my research process and documented my methods, as presented in chapter 4 – Methodology. Bryman (2012) recommend that an audit by a third party may be in order, but considering the small scale of this research, I noticed that such an audit is not relevant. In addition, weekly meetings were frequently organised with my supervisor to ensure that the thesis reflects what it wanted to achieve (construct validity), and to improve its dependability. Reviewing and pilot testing of interview questions were done to ensure that the interview guide was credible, valid and prepared within the scope of my research

4.8 Reflections

This chapter discusses the processes that were involved in conducting the research. It describes the lessons that were learned during the process as well as some challenges that were experienced. In addressing the challenges, measures that were used to address the challenges are also in this chapter. This chapter describes reflections relating to the overall process and my personal reflections.

4.8.1 Overall Process

The development of thesis spanned over five months. I initially had five months to submit my thesis, but concerning the global coronavirus disease outbreak, the period was extended to 6 months due to the difficulties experienced during the data collection.

I initially planned to investigate into the research area of "developing the digital competence of construction project managers" (Prince, 2019), with which I have already conducted a literature review in my project thesis. Nonetheless, after several meeting with the case company, reviewing literature, and meetings with my supervisor to decide which research topic I need to use for master thesis, I finally decided to look into "the importance and barriers connected to the Integrated Technical Building installations (ITB) managerial role in building company, I started searching for academic and other literature that describes the ITB concept, but it was hard to come by. I engaged my supervisor and other professors to assist with the literature search. It was discovered that the ITB concept is not new, but there are very few academic publications describing it. The available academic publications discussed the engineering aspect of the concept, but did not describe how ITB role is applied or can be managed in projects. Since the ITB role involves coordinating the activities of the various technical disciplines, I adopted an approach to search for literature that describes the role of a technical program manager. I supported

these pieces of literature with technical report and conference papers that describe the integration of technical systems in a building. This approach of literature search helped in writing a solid literature review for my thesis.

Whiles conducting the literature study, I started with my interview process. Since the interview process takes a longer time to complete and the difficulty in getting interviewees, I planned to start my interviews on time. I worked closely with the contact person from Rambøl to ensure that I get the right people and sufficient number to interview. The contact person to Ramøl was very collaborative throughout the period I worked with him. I followed the ethical standards as described in Chapter 4.3.1 – *Research Ethics*, to ensure the right research process were performed. Due to the benefits of conducting face-to-face interviews, as presented in Chapter 4.3 – *Research Interview*, I initially planned to use such a medium to conduct my interview. However, the outbreak of the coronavirus disease compelled us (interview subjects and me) to change to a personal online interview where Skype for business and Microsoft teams were used. The health authorities advised us to keep "social distancing", therefore, the best approach to conduct the interviews was to use personal online interviews (Bryman, 2012). Even though this new approach saves cost and time to travel to interviewees office, it created some challenges such as poor internet connections and communication software (Skype for business) failures, which resulted in difficulties in getting vital information from the informants. Sometimes, informants had to repeat the same sentence twice or thrice which appeared to be uncomfortable to the interview subjects. Despite these challenges, I ensured that all my interview questions were answered. I managed to obtain a sufficient amount of data which were relevant to my research questions. Based on the collaborative work with the company's contact person, I was able to conduct 8 interviews in all even though we were advised to conduct 3-5 interviews based on the coronavirus disease outbreak.

After the data collection process, I transcribed the data and further performed coding analysis (thematic analysis) to develop themes that I will use to present my empirical data in Chapter 5. Categorizing the data by themes assisted me to understand the theories I had already compiled, and analyse the propositions in Chapter 6- Discussion. Collecting the data whiles conducting my literature was very helpful because the interview subjects provided new concepts which I was encouraged to investigate. Besides, I had the opportunity to review my propositions and develop new ones. The propositions indicate knowledge sharing theories and my opinion about how some factors might apply to knowledge transfer before data collection.

As presented in Chapter 1.3 – Layout of the thesis, description of the remaining chapters, Chapter 6- Discussion, Chapter 7- Conclusions, were based result from the evaluation of theory and data.

4.8.2 Personal Reflections

Considering the level of my competence to perform social research prior to writing my project and master thesis, I can confirm that there has been an improvement in my competence in performing social research. Initially, I had limited competence in conducting social research and writing a good report. Based on these limitations, I always feared to conduct individual research. However, with the good supervision from my academic supervisor and my commitment to producing a good master thesis, I have seen an improvement in my competence in performing social research. The commitment to the project and master thesis is fuelled by my passion to use technology

solutions to improve business processes and provide competitive advantages. Even though my supervisor sometimes sees himself to be harsh in providing the right advice, I believed I needed such form of coaching to ignite my weakness and find ways to improve them.

Conducting individual research in both my project and master thesis, have boosted my confidence and competence in conducting research compared to when writing in a group. The challenge with conducting individual research is that I had to perform all the tasks relating to the studies alone, and I did not have the opportunities to gain different perspectives from colleagues regarding the topic and how to conduct the research study. However, frequent meetings with my supervisor helped to gain comprehensive views of writing a good project and master thesis. Besides, writing individual research has enabled me to discover my weakness and improve upon them.

Concerning the data collection process, the use of a semi-structured interview approach gave me the flexibility to ask questions compared to using the structured interview. The interviewees also had a flexible approach to providing answers to my interview questions, which allowed me to obtain comprehensive views of how they perceive the ITB role or concept from a practical perspective. I have no doubt that the interviewees provided honest answers because they informed me of areas that they lacked experience or were not related to their field of speciality. My consistent follow-up with the Rambøl made be to building a good rapport with the interviewees especially with the contact person to the company. Due to the coronavirus disease outbreak, we were urged to conduct 3-5 interviews, but consistent follow-up and collaboratively working with the company's contact person helped me to conduct more interviews than expected, and gaining substantial answers to my interview questions. I all I conducted 8 interviews.

In terms of the challenges faced during the research process, I experienced three difficulties that were related to language barriers. These difficulties relate to (1) literature review, (2) Interview execution. Concerning the literature review process, some pieces of literature were written in the Norwegian language, and they were difficult to understand. The term "ITB" appears to be used in only the Norwegian building and construction industry. Therefore, most publications have been written in the Norwegian language. In dealing with this challenge, I used a google software application to translate the documents into the English language. Even though google translate has limitations in providing the exact meanings to the source of information, I noticed that there were consistencies in the translated documents, and the translated pieces of information were similar to the information received from the interview subjects. This improved my confidence in the translated documents I have collected. Secondly, regarding the interview execution process, I noticed that some interviewees could not express themselves much better with the English language than they would have done when using their native language, i.e. the Norwegian language. This supports the claims of Bryman (2012), who argue that language for instructing the interview guide and interviews should be a language that is familiar with interviewees. Even though these interviewees were not proficient with the English language, they were able to express themselves and present the information they wanted to.

As mentioned, several times in the thesis, the ITB is not a new concept, but it has received minimal considerations in academic publications. By dealing with this challenge, I made use of technical and conference reports that

describes the ITB role, and supported them with academic literature that describes similar roles such as program manager. According to Gilbert and Gilbert (1977), referencing academic literature is often considered as a tactical approach to persuade readers of the legitimacy of one's work. I informed my supervisor about the situation, and he supported my initiative and advised me to explicitly describe how I have conducted the literature review process in the methodology section of my thesis, which I have done. Short duration of some interviews was another challenge that I experienced during the interview execution process. This was due to the reasons that some informants had limited knowledge in areas such as the ITB related standards, BIM and VDC models, etc. Besides, the interviewees showed difficulties in expressing themselves with the English language, which also contributed to the short interviews.

In summary, the entire research process has been a learning process for me, and I am grateful for the new knowledge and competencies developed. I believe there are more rooms for improvement, and I am committed to learning and developing skills in conducting better research in the future.

5 EMPIRICAL DATA

This chapter presents my empirical data based on the following themes that were developed during the coding process. The developed themes include ITB description, ITB benefits, ITB challenges and success factors. The themes were developed based on the research questions which drive the research. Chapter 5 presents information demonstrating how the informants perceive the ITB role, based on its definition, benefits and challenges. To provide valid and reliable written report, sufficient data extracts or vivid examples from the data will be used to support and demonstrate the prevalence of the themes within the data.

5.1 ITB Description

According to the interviewees, the ITB concept has been in existence over the past decades even though the term "ITB" is not commonly used to describe the integration of technical systems. They confirmed that issue relating to ITB unawareness currently exist because some contractors and clients still do not have an experience with ITB applications. Thus, they lack the experience to understand the use of ITB and its implications. They pointed out that the technical integration roles are performed by technical functional teams. These teams lack the competence to integrate different technical systems. Thus, the functional units are not multi-disciplined. This implies that there was no dedicated ITB manager in the project to manage the integrating and coordinating roles.

From the semi-structured interviews, the informants provided similar but quite different definitions of the term "Integrated Technical Building installation (ITB)". Some informants described ITB as a coordinating and integrating function which coordinates the various technical interfaces or systems in a building to ensure that they effectively communicate with each other when they are operating simultaneously. The above definition is illustrated by the statements below:

"ITB is a coordination of the interfaces between all the technical systems in a building" [Peter].

By elaborating on the coordination function of ITB role, few of the informants mentioned that the ITB role promotes an interdisciplinary relationship between the various disciplines, who are urged to work together to ensure that the technical systems are independently and interconnectedly installed. These informants stated that the technical systems are closely related in such a way that they can have adverse effects on each other when they are not properly integrated. Therefore, the ITB manager is needed to ensure that the various technical teams work together to achieve functional integrating system. The statement below indicates a comment made by an informant:

"it usual to actually have this role [ITB role] just to get more coordination between the different disciplinaries… [you will] achieve a higher functionality when you have the when you ITB in the project. " [Daniel].

Another respondent described ITB as a quality assurance tool that ensures that the technical systems are properly installed based on agreed specifications, and it significantly reduces the number technical errors or faults that might be observed after the building project is completed. His statement is exemplified by the statement:

"it's a way of ensuring that we that get the qualities that are requested, so it makes sure we have a system that the contractor is doing the work to have a system to ensure that the client gets the quality that he has required in the contract" [Ivan].

Some informants described ITB as a planning and testing framework which ensures that the technical integrated system is properly planned and executed, and the technical installations are tested during the project execution phase and after the building is completed. They said that the testing process is a vital process which guarantees that the building is handed over to the builder/clients with minimal or no errors. A few interviewees described ITB as a training tool which ensures that end-users or builders are trained to use and manage the integrated system after the building is completed. Informants who have worked in other sectors of the construction industry (such as roads, oil and gas sectors, etc.) mentioned that the ITB concept is similar to "systematic completion" which ensures that technical systems are properly installed before the project is handed over to the client. This is illustrated in the data extra below:

"I am working in highway project…We have ITB concept we are implementing that is called the more systematic completion. It is very different in all road projects than in a building. The nature of the project is different, but the principle might be similar" [Ivan].

However, other informants argued that the success of building projects does not necessarily depend on the ITB role since some projects have been completed successfully without the use of dedicated ITB managers. They added that it can be considered an extra expense because the roles can be shared between the functional technical disciplines. One of the informants mentioned that the ITB manager is the first person to be resigned from a project when a cost-reduction strategy is been carried out by builders or contractors. The proponents of ITB role argued that some projects have failed because minimal consideration was giving to integration functions during the project planning and execution phases, which resulted in several problems such as numerous technical errors, dissatisfied clients, project delays and the excessive increment of the project cost. These informants emphasised contractors and subcontractors who had integration technical role as additional responsibilities, often lost focus on the whole project's objectives because they were busy dealing with their individual objectives. Some interviewees highlighted that building contractors and clients are forced to employ ITB manager only when they experience technical challenges at the end of the project.

To a greater extent, the majority of the informants argued that projects' success extensively depends on ITB role since modern buildings are becoming more complex in terms of the increased number of technical systems. Therefore, there needs to be a dedicated ITB manager whose main focus is to ensure that the technical systems are properly coordinated, and they can function simultaneously during the operation phase of the building. The data extra below show the importance of having ITB manager is a complex building projects:

"I think now buildings or the construction projects are becoming so much complicated and complex because there are so many technical installations that must talk to each other and must function together… [you will]achieve a higher functionality when you have the when you ITB in the project" [Daniel].

Some informants added that employment of ITB manager should not be considered as a cost since the cost related to the ITB function is smaller compared to the cost incurred when there are failures in the technical deliveries of huge investment projects. The statement below illustrates a comment made by an informant when he was asked if the ITB role can be considered as an additional expense item:

"In large projects, we have bigger investments [that] the consequences of failure in technical deliveries are much larger than the cost of ITB functions" [Ivan].

The informants argued that it is very important to involve the ITB manager throughout the phases of the project so that technical challenges and demands are met before the building is handed over to the client. In describing the various ITB roles that are involved in building projects, two informants described three different ITB roles. These roles include one ITB role for the builder, one for the engineering organisation and one for the contractors or subcontractors. They elaborated that these roles have different tasks that need to be performed during the different phases of the project. However, they emphasized that the description of ITB role in the standard is not the same in practical life. Based on their working experience, an ITB manager can be made to handle more than one ITB roles in a less complex project. They also highlighted that two or more ITB managers can be employed by a contracting company in a high complexity project.

Overall, all the interview subjects highly recommended the use of ITB roles in projects considering the numerous benefits that are related to it. The next section discusses the benefits that are derived from using ITB role in building projects.

5.2 ITB Benefits

The interviewees expressed different views with regards to the benefits of employing ITB roles in building projects. The informants recommended the use of ITB roles since it comes with several benefits. During the thematic analysis process, the benefits of using ITB were classified into the following sub-themes: multidisciplinary coordination, technical benefits, economic benefits, Stakeholders' satisfaction, and achievement of BREEAM (Building Research Establishment Environmental Assessment Method) certificate.

5.2.1 Multidisciplinary coordination

Some informants pointed out that modern building projects are experiencing ever-increasing complexities and challenging due to the increased number of advanced technology systems that need to be installed by the various technical disciplines. They added that the technical systems are interrelated, so there needs to be a dedicated ITB role that will ensure effective coordination and integration between these technical systems. They highlighted that technical integration must be done properly since the technical systems contribute to a significant portion of the complete building cost. This is illustrated in the statement below:

"...the complete cost of a building is around 40-45% is the technical systems, but in the future, it going to be more like 60%. So, it [ITB role] is going to get more and more important" [Bjørn].

However, few of the informants acknowledged that dedicated ITB managers are often not used in client or project organisations because of its related cost and lack of awareness. They said that the integration roles are performed technical functional units where the integrating role is shared between these units. Other informants opposed this argument and stated that ITB roles should be managed by experts with a good experience and understanding of the coordination functions between the various technical systems. The statement below shows the response of an informant when he was asked whether ITB roles should be managed by technical functional units:

"You can't just put the two roles into one contractor because this is all interfaces between the systems and a contractor is specialized on. For example, the electrical discipline, he doesn't know about the fire, he doesn't know about the doors, so he needs multi-discipline understanding. So, my answer to that is No, I don't think so" [Bjørn].

Based on the above statement it means an ITB manager is needed to handle the coordination between the different functional teams because he is multi-disciplined. Another informant said ITB managers should not only be considered in high complexity but should be involved is less complex projects because of the need to ensure that the technical systems communicate smoothly without adverse effects in the building's operation phase. This is seen in the comment below:

"In my opinion, every project should have ITB role or manager even though it is just a small project or yeah like if there are two or three what do you call it like a disciplinaries, I think it usual to actually have this role just to get more coordination between the different disciplinaries" [Daniel].

Other proponents made a supporting statement stating that the employment of the ITB manager does not only ensures technical system coordination, but they also promote coordination between the various technical disciplines. This is illustrated in a statement made an informant:

"just coordinating them and making sure that they understand what they are trying to build and that they can work together" [John].

In summary, the proponents of ITB role argued that the extensive use of ITB managers in projects will improve both technical coordination and multidisciplinary coordination because they assume complete responsibility of ensuring the coordination between the technical functional teams is effectively managed to generate integrated solutions which are used to guarantee the delivery of functional and error-free buildings.

5.2.2 Technical benefits

The informants acknowledged that the use of ITB role in building projects helps to extensively reduce the number of technical errors that occurs at the end of the project. One interviewee said the use of ITB managers guarantee that error-free, user-friendly and sustainable buildings are developed. This is illustrated in the comment below:

"*The technical systems become more user-friendly, and they actually work as they were planned to do….[you will] achieve a higher functionality when you have them when you [have] ITB in the project"[Daniel].*

Another informant listed some of the technical problems that are expected to be experienced when ITB managers are not used in building projects. According to him,

"The biggest problem when you are not using ITB is that…the building has lots of errors, many technical systems are not working properly…the doors are not functioning as it should, the ventilation system is not functioning, it is hot in one room and cold in another room" [Bjørn].

Based on one informant's practical experience with ITB role, she mentioned that several technical errors or faults were experienced when ITB managers were resigned from their position, especially in situations when the builder was executing cost-reduction strategy. Many informants expressed positive impressions about using ITB managers to improve technical errors in a project, especially when ITB managers are involved throughout the development life cycle of the project. They emphasized that the ITB manager will ensure that technical integration activities are well planned, designed and executed. Besides, he will guarantee that different kinds of testing operations (such as individual system testing, integrated system testing, and full-scale testing) are performed and documented before the building is handed over to the client. One of the ITB managers stated that he experienced only one technical error when he was involved in a kindergarten building project as an ITB manager.

5.2.3 Economic Benefits

In terms of economic benefits, the interviewees pointed out that earlier involvement of ITB managers in projects enables them to make cost-effective changes as the project evolves. They highlighted that the cost to make changes as the project involves is less than the cost of making changes when the building is completed. According to an informant, the use of ITB managers in projects reduces the project cost by 5% because the builder does not have to make significant changes or corrections during the building's operation phase. This is because the ITB manager conducts testing and trial operations to ensure that buildings are completed with no or fewer errors. Some interviewees commented that there is an increase in the overall project's cost when building is completed with technical errors because additional resources might be needed to resolve these faults or errors. They argued that the presence of the ITB manager ensures these problems are effectively managed during the project planning and execution phase, resulting in the delivery of cost-effective buildings. The proponents of ITB role stated that higher economic gains are achieved when functional buildings are delivered, and this is assured by the use of ITB managers. The informant from the client organisation stated that the use of ITB managers to improve multidisciplinary coordination can result in the delivery of effective integrated solutions which assures the production of cost-effective buildings, which be sold at a good price to significant income.

In contrast, other informants acknowledged that ITB role can be considered as an additional expense since the role can be done by other disciplines who are not ITB experts. They said it costs lots of money to allocate budget and working hours to ITB managers. This is illustrated in the below information presented by one informant:

"it is a cost involved regarding myself [me] as ITB responsible. I have to use a lot of hours, so it's a cost related to me… it's [cost] also related to all the entrepreneurs and the engineering team because they need to attend my meetings and they need to produce documents I request. So, it a cost related to ITB" [Bjørn].

However, some informants classified ITB related cost as a minor cost considering the cost of technical failures in huge investment projects when ITB managers are not used. This is illustrated in the statement below:

"I can ensure you get what you pay for. In large projects, we have bigger investments [and] the consequences of failure in technical deliveries are much larger than the cost of ITB functions" [Ivan].

5.2.4 Stakeholders' Satisfaction

Interviewees differed in their opinions on stakeholder's satisfaction in three key aspects: top management satisfaction, technician satisfaction and clients' satisfaction.

The top managers such as project and design manager expressed their satisfaction in using ITB roles in the projects. Based on their experience, the use of ITB managers makes their work easier since the ITB manager will assume the responsibilities for ensuring that the technical systems are well-integrated and coordinated. Below is a statement made by one of the top managers:

"…I am very happy to use it [ITB manager*] because it makes my job as a design manager easier" [Paul].*

The informant from the client organisation expressed his satisfaction regarding the use of ITB manager is projects. According to him, the builder becomes dissatisfied when buildings are completed with technical faults or errors because they have to use extra resources to resolve these errors which take a long time or sometimes ideal solutions are not developed, rendering the building ineffective and useless. The informant related the cause of this problem to the absence of an ITB manager to ensure the technical systems are properly integrated, tested and tried. He emphasised that the builders become satisfied when functional, sustainable and environmentally friendly buildings are completed, and this is achieved by the use of an ITB manager. The following comment is a statement by the informant*:*

"…when we get new buildings if there are more errors then those errors they drag out… when the customers or clients are happier, then it is easier for them to work with…but if the clients are dissatisfied then every error becomes a bigger thing" [John].

Regarding the technicians and engineers, they also expressed their satisfaction in using ITB managers to construct buildings which results in minimal or no errors. One of the technicians stated that the technical teams give minimal consideration to integration issues when they are planning and designing the installation of technical systems. He said technical integration issues are pushed to the final phase the project which becomes difficult and expensive to make changes. According to this informant, the achievement of higher functionalities are realised when ITB manager are employed because they take care of integration problems throughout the phases of the project. The statement below shows an informants excitement for using ITB:

"I work with technical installations...there are so many technical installations that must talk to each other and must function together, and we do not take care of this when we are planning our buildings… I think the technical part is always pushed to late in the project [you will] achieve a higher functionality when you have the when you ITB in the project" [Daniel].

5.2.5 Achievement of BREEAM Certification

The informants defined BREEAM (Building Research Establishment Environmental Assessment Method) certificate as a certificate that indicates that building has been standardised based on its sustainability and environmental-friendliness. Based on their description of BREEAM, the building needs to score points to be considered as good, very good, excellent, or outstanding. The higher points the building scores, the higher the rating/grading of the building, and vice versa. According to one of the ITB managers, the BREEAM guide has two different manuals - man 04 and 05, and both relate to ITB. He said the manuals describe how the technical systems need to be installed so that they can function simultaneously without adverse effects. He continued by saying that the BREEAM is becoming a common rating scheme applied in Norway, and it is globally used in about 70 countries worldwide. Therefore, he suggested by saying that:

"If you want outstanding [rating]…this is all points regarding to ITB… If you have a building that is trying to get BREEAM certified, you need to have ITB responsible in that project" [Bjørn].

Another informant from a technical department confirmed the importance of using an ITB role to achieve a high rating of BREEAM. According to him, you need to have a good measure of the electric power that goes through every electric panel in the building in order to have the BREEAM certification. He said these are issues are not regarded during the early phase of the project, especially when ITB managers are not involved. He mentioned that the presence of an ITB manager ensures these technical demands are met, which make it easier to get the building certified. The above statement is indicated in the comment below:

"…you have to measure every circuit which is going out of the panel in order to get the highest BREEAM certification I think, and this is things you don't think about in the early project if you don't have the ITB manager because it is not usual or it's not usual to actually measure every circuit. we only measure may be in the main panels" [Daniel].

Based on the information received from the informants, it can be interpreted that the benefits of using ITB role are related and that the achievement of one benefit can lead to the other. This implies that the use of ITB roles ensure improvement of multidisciplinary coordination which guarantee the development of effective integrated solutions used for the production of functional and sustainable buildings. It appears that the development of functional building results in the achievement of economic gains, and increases the possibility of getting the building certified with higher BREEAM rating.

However, the informants stated some challenges that impede the successful implementation of the ITB role in projects. They argued that these challenges make it difficult to achieve the benefits described above. The next section of this chapter discusses the challenges presented by the informants.

5.3 ITB Challenges

From the data, the interviewees mentioned several different challenges that are related to ITB application. These challenges include ITB invisibility, Inexperience clients and contractors, ITB manager competence, Cost related to the ITB role, Late involvement of ITB manager, Change.

5.3.1 ITB Invisibility

ITB invisibility was one of the pressing challenges presented by the informants during the interviews, especially by project managers, design managers and ITB managers who have several years of working experience with ITB roles. The informants defined the term "ITB invisibility" as the absence or scanty description of ITB standard (also known as NS 3935) in the tender or general standard contract agreement (also known as NS 8407). This is illustrated in the statement below:

> *"If you are lucky the ITB standards are mentioned in the contract but often they are not; and also, if they mentioned in the contract, there is no detailed description of the work regarding to ITB"[Bjørn]*

The interviewees described the NS 3935 as the standard which describes the different roles of the ITB managers. Some informants described the NS 8407 as a turnkey contract in which the contractor has all responsibility for managing the engineering work, and it is one of the most used standard contracts in the Norwegian building industry. According to one of the informants,

> *"It's [NS 8407] the most used standard. Almost all the projects I have been involved in regarding to ITB has been NS 8407" [Bjørn].*

Some informants described NS 8407 as "Totalentreprise" in the Norwegian language which means "Turnkey contract" in the English language. The interviewees expressed different views regarding the impacts of ITB invisibility. These include: Ineffectiveness of NS 3935 and NS 6450, lack of contractual authority, and lack of budget and working hours to do the ITB work. Description of these challenges are presented in the following sections:

5.3.1.1 Ineffectiveness of ITB standard (NS 3935) and testing operation standard (NS 6450)

According to the informants, standards are not compelled to be used by companies in Norway. Therefore, companies can decide whether or not to abide by standards that are defined by regulatory bodies. However, an informant described NS 8407 as one of the most used standard contract agreements in the building industry even though it does not or scantly describe some relevant roles in building projects. Some of the interview subjects described the definition NS 8407 as incomplete because the NS 3935 and NS 6450 are missing or scantly described in the contract, resulting in their ineffectiveness and under-utilisation. They highlighted that to partially make NS3935 and NS 6450 effective, it must be included in every specification they prepare which is difficult to achieve. It appears that it would have been simple to effectively use the ITB role when it is mentioned clearly in the contract, and one does not have to go through the stress of including it in every specification. The informants pointed out that the absent or limited description of NS 3935and NS 6450 in NS8407 does not compel builders and contractors to effectively make use of ITB roles and its related standards.

Another elaborated the challenge by saying that even though the effectiveness of NS 3935 depends on the detailed definition of NS 8407, the two standards are handled separately because there is no defined direct relationship between them. In a nutshell, the NS 3935 and 6450 are ineffective because they are missing or scantly specified in the NS 8407. The following statements show the comments of an informant when he was asked about the definition of ITB standard or role in NS 8407:

"*No, it is not in the contract. So, you have to add in every specification that you want ITB" [Peter].*

5.3.1.2 Lack of Contractual Authority

Another challenge related to the ITB invisibility is the lack of contractual authority. Due to this challenge, the ITB manager appears to be ineffective in performing his coordinating roles. Some interviewees mentioned that the various disciplines have varying individual views and objectives with regards to the installation of the technical systems, and the ITB manager needs a defined contractual authority to coordinate these individual objectives to support the achievement of the technical specifications defined by the builder. Thus, he needs contractual authority to make and implement bold decisions.

Other informants said even though the ITB manager has positional authority from his title "manager", he still does not have a contractual mandate to make bold decisions. They highlighted that the lack of contractual authority results in subcontractors or contractors resisting the instructions given by the ITB manager. The subordinates decide to either adhere or rejects the ITB manager's instructions. They pointed out that the other technical disciplines will be compelled to follow the ITB manager's instructions when his/her mandates are defined in the general contract – NS 8407. This information can be seen in the following statement made an informant when he was asked about the implications of ITB manager possessing only positional authority:

"*The problem is that the ITB responsible, he doesn't have any authority regarding the contract. So, I [ITB manager] can ask the subcontractors to do what I say, but I can't demand…then I get some resistance doing all the ITB work because they haven't mentioned that in the tender or contract" [Bjørn].*

5.3.1.3 Allocation of budget and working hours

The other challenge experienced by the ITB manager which is related to ITB invisibility is the inability to allocate the right budget and working hours to ITB work. An informant mentioned that contractors are not able to rightly allocate budget and working hours to ITB work because the ITB role is invisible in both the contracts and tenders. He mentioned that this challenge makes it problematic for ITB manager to collaboratively work with other relevant disciplines such as BIM (Building Information Model) Managers to develop a comprehensive BIM model which is expected to provide a detailed description of all the technical systems in a building. He highlighted that the BIM is mostly known as a 3D (three-dimensional) model which does not contain detailed information of the technical systems. The interviewee argued that collaboratively working with BIM managers to develop a very detailed BIM model required enough time and funds which need to be defined in the contract. According to him, a detailed description of the BIM model will help the other disciplines to have comprehensive information about the technical systems which can later be used for maintenance purposes.

To deal with the above issues relating to ITB invisibility, the informants recommended that the NS 8407 should be amended and updated to include a detailed description of NS 3935. Based on this, the ITB managers can have the required contractual authority to carry out their activities. Besides, contractors and builders will be able to allocate the right budget and working hours to the ITB work, which will improve the effectiveness and efficiency of the ITB role. Besides, they added that the inclusion of NS 3935 in the NS 8407 will increase the effectiveness and awareness of the ITB role in building projects. Two informants recommended that the builder and contractor must involve an ITB manager earlier in the project to ensure that ITB roles and mandate are specified in the tender and a legal document such as the contract.

5.3.2 Lack of coordination between ITB and BIM Manager

From the semi-structured interviews, the informants who had a good understanding of the roles of the ITB and BIM manager expressed their views on how the building industry is losing opportunities in coordinating the ITB and BIM departments. These informants argued these departments are related in a way that they use different data management systems application (i.e. Microsoft excel and BIM model) to define and manage the same technical systems in a building. There is a likelihood that different names can be given to the same system which can create confusion during systems installations or maintenance. One of the informants mentioned that the lack of collaboration has resulted in the underutilisation of the BIM model which does not give detailed information about the systems in the building. This is seen in the data extract below:

"The problem today is that the BIM tool is not developed in such a way that we can use it in the ITB work. For ITB responsible, we need to know each detail for every technical component, we need how each component interacts. The problem is that the BIM is not developed in such detail, but it could be". [Bjørn]

The informants mentioned that the lack of coordination is due to the reasons that the ITB role and BIM model are in their early phase of operation, but they expect to see improvement in the future. They said that the coordination between these departments can improve the efficiency and effectiveness of the ITB role. This implies that the ITB manager can make use of the BIM model to manage data, which is much more preferred Microsoft excel because of its functionalities. The benefits of coordinating the BIM and ITB department is stated in the statement below:

"When we are designing our solutions with BIM, then we should be in contact with the ITB manager to do this more together…. if the ITB managers are more in the BIM model, they can probably utilise the BIM model and do his task more efficiently with little risks, so he would use the BIM model to get information".

5.3.3 Late Involvement

Late involvement of ITB manager was another crucial challenge that was presented by many of the informants. They argued that ITB managers are most often not involved in the early phase (design and planning phase) of the project. They said the ITB managers are mostly involved when everything has been engineered or the projects have been completed with lots of technical errors. Some of the informants mentioned that the contractors and builders only think about ITB when the projects fail, and the technical systems are not functioning properly.

By stating the effects of the late involvement of ITB managers, the informants argued that it becomes difficult and expensive to make changes to technical solutions or systems that have been purchased and installed. This implies that additional resources will be required to implement changes and ideal technical solutions which often increases the project cost. Besides, it creates difficulties for ITB manager to understand the overall project's objectives because the project's scope and objectives have already been defined in the early phase of the project. Also, the ITB managers are not able to build a strong rapport with the existing entrepreneurs. The difficulties to effect changes can result in the ITB manager been ineffective at his role. The implications of the late involvement of the ITB manager is described in the statement below:

"*They [ITB managers] often come too late into the project…the technical things are already decided on so it's hard to actually to change those solutions or principles, and then it is very hard for the ITB man to actually get the right functionality" [Daniel].*

In making recommendations, the interviewees mentioned that the ITB manager should be involved early in the project to achieve better planning and designing of the integrated systems; gain an opportunity to present and ask questions to reduce his uncertainties about the project; coordinate with other entrepreneurs to discover, define and solve problems; have a broad overview of the project's scope as the project evolves to understand the project, etc. Below statement illustrates the implications of the late involvement of the ITB manager:

"The earlier you in the project, the more you can influence because it's becoming last and oh this is already built, and we can't change it" [Peter].

In summary, the informants argued that earlier involvement of ITB managers in building projects might ensure cost-effective planning and execution of the integrating activities. Besides, the production of functional and error-free buildings will be achieved.

5.3.4 ITB manager's competency

According to some of the interviewees, the ITB manager needs to be an expert or have the technical competence to be effective at performing the ITB roles. These informants said the ITB manager need to be multi-disciplined to technically understand the operation of integrated systems. Other informants said the ITB manager needs to possess experience from previous ITB related projects to be able to convince the builders and contractors about his/her competence in managing ITB roles and to handling future ITB related. The statement below shows the competence required by the ITB manager:

"*for example, the electrical discipline, he doesn't know about the fire, he doesn't know about the doors …so he needs multi-discipline understanding – [Bjørn].*

Another informant said that the roles of an ITB manager should not be given to people who have just graduated from school with only theoretical knowledge of ITB. She argued that the role should be given to people who possess both theoretical knowledge and practical experience with ITB role.

To build the theoretical knowledge of ITB, the informants recommended that ITB related courses should be taught in universities and technical training schools. They said that separate classes should be organised for students who possess technical minds, and those who are involved in management study programs. They added that building and construction companies should also do their part in trying to build the practical knowledge of those who want to pursue a career in ITB role. The statement below shows the recommendation made by an informant:

"I think it [ITB concept] should be a sub-subject for technical minds. Also, in management, it should be a subject because it is so important" [Bjørn].

5.3.5 Lack of ITB Awareness

Some informants stated that some builders and contractors/subcontractors lack the awareness and the experience of using ITB concept in their projects. Therefore, they are not able to understand its implications, and are not encouraged to provide the needed support to ITB managers in performing their work, resulting in the exclusion of ITB roles in the contract or tender. This challenge was exemplified by an informant's comments which states that many contractors lack an in-depth understanding regarding the definition of the general contract (NS 8407). See the data extracts below:

"…What many contractors are not aware of is that this standard [NS 8407] actually describes testing…one of the most important works that the ITB responsible does is described, and that's regarding to testing – [Bjørn].

Many of the interviewees argued that these top managers (builders and contractors) only become aware of ITB when they are faced with technical integration challenges especially during project discussions, or when the project is completed with technical integration errors. According to an informant, top managers are only driven to use ITB role when they experience "sad events" and are later advised by consultants to involve the experts of an ITB manager. Other informants pointed out that some contractors are aware of the ITB role during the early phases of the project, but they push it towards the end of the project.

In dealing with builders/contractors' lack of awareness of ITB, an informant argued that those involved with building projects should have knowledge about the ITB standard document because it is very short and precise, and it is very easy to read and understand it. He added that the standard has been in existence for a while so building engineers/technicians should be familiar with it. According to him, contractors who do not understand the ITB role, or are not aware of ITB role, should not be considered as the right people for the building project. This is illustrated in his statement below:

"in my opinion, if the guys who are doing construction buildings or projects, if they don't know what an ITB manager is, I think they are not the right person for the job. I think everybody should know that. I think ITB has been a Norwegian standard since 2011 [Daniel].

Other participants argued that the motivation to use ITB concepts or roles in projects go beyond the simple understanding of the theoretical aspect of its application. They said that the clients and contractors need to gain practical experience and should be informed about the technical and socio-economic implications of using ITB

role as described in sections 5.2.2 – Technical Benefits and 5.2.3-*Economic Benefits.* A few of the informants recommended that ITB experts/managers should use their expertise to create and increase awareness of ITB role and its implications. Below is a statement made by an informant:

"you need awareness to the builders on how to implement ITB, and what the cost is and also what you achieve by using ITB…The problem is communicating this information. For myself, I am using a lot of opportunities I have to invite [inform and educate] the builders" – [Bjørn].

5.3.6 High-cost attributed to ITB role

Many informants acknowledged that cost that is related to the employment of ITB managers in building projects. According to these informants, there are different cost incurred when ITB managers are deployed; thus, the cost of hiring, cost of organising and attending meetings with various disciplines, etc. Due to these several costs that are related to employing ITB managers, some clients and contractors are not motivated to use ITB managers in projects, because of the assumption that role can be shared between the functional technical teams. Another informant mentioned that ITB roles are the first positions to be resigned from a project when builders or contractors are executing a cost-reduction strategy. This is illustrated in the comment below:

"they had an ITB manager in the start, but they decided to quit him to because they didn't want to have ITB. So, it was strange for us, but we I think it is about money" [Theresa].

In contrast, other participants regarded these forms of cost as minor cost regarding the huge amount cost savings that will be achieved after the project is completed with an ITB manager. They said that it is highly assured to reap more economic benefits compared to what was invested into ITB role. They argued that the cost related to the ITB role is smaller compared to the cost related to the consequences of failures in technical deliveries. The statement below shows the perception of an informants regarding the cost related to the ITB role

"…I can ensure you get what you pay for. In large projects, we have bigger investments, [and] the consequences of failure in technical deliveries are much larger than the cost of ITB functions" [Ivan]

He elaborated his point by saying that the absence of ITB manager in a project can result in technical failures, which might not be seen immediately after the project is completed. He said that these failures might appear several years after the project is completed, and this can be difficult and expensive to deal with. He added that the implementation of ITB role is about reducing the risk for bad quality. This statement is supported by other informants who argued that the failures in technical deliveries can considerably increase the project cost, and might result in facing difficulties in developing and implementing ideal solutions. As a result, the building can become useless or abandoned leading to a waste of resources. Another informant said the deployment of ITB roles helps to reduce the project cost by 5% since the extra cost is not needed to deal with technical failures after the building is given to the builders. See the data extract below:

"…I will say this is a minor cost if you think about what you save at the end of the project; you don't need to correct errors in the building [operation] phase, so I will think the total contract budget you can save around 5% using ITB " [Bjørn].

5.4 Success Factors (Recommendations)

From the above description of challenges, it can be noticed that some efforts must be put in place to ensure that the ITB roles are smoothly carried out in building projects. From the interview, the informants mentioned the following success factors or ground rules that need to be adhered by project stakeholders:

- ITB visibility
- Multidisciplinary coordination
- Early involvement of ITB managers
- Top Management support

5.4.1 ITB visibility

According to the informants, one of the factors to ensure that ITB roles are made effective and successfully deployed in building projects is the specification of the ITB roles and mandate in the general standard contract agreement (NS 8407) or tender. They emphasized that standards cannot be compelled to be used by building companies in Norway, so the ITB standard (NS 3935) does not have a maximum impact unless it is categorically defined in the contract. According to the informants, the visibility of ITB roles and mandate in the general standard contract will ensure the effectiveness of the ITB manager in making and implementing bold decisions to influence the project. This is seen in the statement below:

"if you have a contract with everything included and it is written in the contract that you should deliver ITB, then ??? they have to do it " [Bjørn].

Some informants argued that the two standards (NS 3935 and NS 8407) should not be handled differently, but a direct relationship should be established between the two standards by clearly defining the roles of ITB in the NS 8407. They also recommended that contractors and other consultants who have gained experience with ITB role can collaboratively work with client's ITB manager to prepare detailed contract/tender which includes the specification of ITB roles and mandates.

Other informants stated that the builder needs to understand the implications of implementing ITB roles in a project, since that will encourage him to ensure the visibility of ITB role and mandate in the contract/tender (Top management support). They emphasised that the builder is primarily responsible for ensuring the visibility of ITB roles and mandate in the contract or tender. This is illustrated in the extract data below:

"Everything starts with the builder. I think It depends on the builder and the tender and contracts he develops. So, you need awareness to the builders on how to implement ITB, and what the cost is and also what you achieve by using ITB" [Bjørn].

5.4.2 Coordination between ITB managers and other disciplines

Another means of ensuring that ITB roles are successfully deployed in building projects is the coordination between the various disciplines and the ITB manager. The informants stated that collaboration between the ITB managers and the other disciplines will assist in the joint definition, discovering and provision of ideal solutions to solve technical integration problems. They said the various teams can work together to design and install the integrated system with a common understanding and objectives.

In fulfilling this coordinating role, the informants suggested that VDC (Virtual Design and Construction) model and BIM model which can be used as digital tools to promote the collaboration between the various disciplines. The informants described the VDC and BIM models as follows:

VDC is "*a new framework that will help you design buildings better, faster and it will, or they have a lot of emphasis on interdisciplinary collaborations. They use they have this digital platform where they use BIM a lot, and it focuses on workflows and process in the building" [Daniel].*

BIM is "the digital model of the building where every shareholder such as architects and clients, engineering people, suppliers are working on and where all the information of the building is put into that BIM model" [Daniel].

Some informants recommended the use of VDC model to the BIM model because the VDC model has more functionalities and it encapsulates the BIM model. They said the VDC model promotes more multidisciplinary coordination compared to the BIM model. However, the said that the BIM model is an essential part of VDC. The data extracts below illustrate how an informant makes a distinction between VDC and BIM:

"The BIM model is an essential part of the VDC, but the VDC is so much more. It's how you are working, how you are doing the engineering work, how you are giving ??? to the contractors. It's more collaborations between all the parts" [Bjørn].

Other informants highlighted that the VDC model has a digital meeting platform called the ICE (integrated Concurrent Engineering) meeting where the various disciplines within the project use lots of metrics to measure different things in BIM model. They pointed out that the various teams can work with the top managers such as builder, contractors, and consultants to define the problems.

However, one of informant argued that the ICE platform of the VDC model is irrelevant to the ITB manager because the ITB manager does not have time to be present in all meetings. Based on her experience of using the VDC model, she said that:

"ITB manager, he is not involved in our meeting, so I don't think it very very important – [Theresa]".

In contrast, other the informants recommended the VDC model as an essential collaborative tool to the ITB manager. These informants argued that VDC provides an opportunity for ITB manager to participate in ICE meetings, where he meets the various technical disciplines including other relevant stakeholders such as the builder, to ask the right questions, and present the right information. They highlighted that the use of VDC saves time and provides cost-effective means of organisation meetings meeting with other project stakeholders. Besides, it provides a cost-effective means of managing data.

5.4.3 Early Involvement

Early involvement of ITB managers is another point raised by the informants in ensuring the effectiveness of the ITB role. Some informants said the ITB manager must be involved in the preparation of the tender contract and the hiring of contractors. According to them, this will ensure that the roles and mandates of the ITB managers are mentioned and described in detail, resulting in the presentation of valid contract price by the contractors. Other interviewees stated that the ITB manager should be involved early in the project to participate in the definition of the project problems and objectives with the other stakeholders. They said this will ensure that the ITB manager understands the project's definitions, scope and objectives, and will permit the collaborative generation of ideal technical solutions. Some other informants emphasised that cost-effective changes will be made when ITB managers are involved earlier in the project.

6 DISCUSSION

In this chapter, the revised propositions which were developed in the literature study, as presented in section 3.4 *Summary of revised propositions*, will be reviewed and compared with empirical data. The discussions will revolve around confirming whether the empirical findings support or dismiss the theoretical propositions (Bryman, 2012). The confirmation of the proposition will be based on the semi-structured interview conducted with Ramøl AS. This will form the basis to conclude the research questions in Chapter 7 – *Conclusion of the thesis.*

In chapter 5 - *Empirical data*, four themes were described relating to how Rambøl perceive the application of ITB role in building projects. These themes relate to the overall research question. These themes include: ITB description, ITB benefits, ITB challenges and success factors. To understand how building and construction companies like Rambøl perceive the application of ITB role in projects, the discussions will revolve around two major teams: ITB benefits and ITB challenges. These two themes will enable the reader to understand the extent to which ITB role is beneficial to the building industry and be aware of some challenges affecting the ITB role. The other themes will only be used to support the discussion of the main themes.

The discussion chapter will be separated into the two major sections: Chapter 6.1- *Discussions on ITB benefits*, and Chapter 6.2 - *Discussions on ITB Challenges*. The subsections of Chapter 5.2 – *ITB Benefits*, and Chapter 5.3 -ITB *challenges* will be used for the discussion process. The results of the propositions will be presented at the end of each discussion chapter indicating which propositions have been confirmed or dismissed.

6.1 Discussions on ITB benefits

The table below indicates a summary of propositions that relate to the benefits of using ITB role in building projects. The first part (thus, Chapter 6.1.1 to 6.1.4) will involve discussing the empirical findings that support or dismiss the propositions. In the end, I will discuss the theoretical implications of the analysis of the propositions in section 6.1.5. Finally, the results of the propositions will be presented in Table 6.2. Conclusions of these propositions will be used to answer the following research question in the conclusion section, Chapter 7.1.1:

RQ1: To what extent is ITB role beneficial to building projects?

The table below indicates a summary of propositions that relate to the extent to which the ITB role is beneficial to building projects.

Table 6. 1 Propositions on ITB benefits.

No.	Proposition
1	*The application of ITB roles in building projects will increase the likelihood of improving the:*
	i. coordination among the various disciplines involved in the project.

	ii.	reduction of energy consumptions
	iii.	the delivery of functional buildings
2	The application of ITB role increases the likelihood of improving the overall cost of a building	

6.1.1 Propositions 1(i) – Multidisciplinary Coordination

This proposition was introduced in section 3.1.1 - *Multidisciplinary Coordination,* to determine whether the employment of ITB role can increase the likelihood of promoting interdisciplinary coordination in building projects.

The proposition is built on the claims of authors (Bai et al., 2009, Milosevic et al., 2007, Hellriegel and Slocum, 1996, Hitt et al., 1989) that discusses the benefits of using ITB role as a technical program manager to achieve multidisciplinary coordination. These authors argue that multidisciplinary coordination allows the different systems/functions to collaboratively work together to achieve the builder's objectives.

From the findings in Chapter 5.2.1 - *multidisciplinary coordination*, many informants expressed positive views regarding the importance of using ITB role to coordinate the activities of the various technical teams in a project. They argued that there is increasing complexity in the modern buildings' projects due to the increasing number of technical disciplines who possess independent objectives and views for installing their respective systems. According to the interviewees, there is a need to coordinate these varying views and goals to achieve a common goal. The informants emphasised that these coordination functions are effectively handled when ITB managers are employed because they are multi-disciplined. Thus, they have a good understanding of how the various systems work together to achieve the agreed specified objectives.

In contrast, a few informants argued that these integration roles are sometimes equally managed by the functional technical units, where the integration role is shared between these units. So, there is no need to involve a dedicated ITB role. The proponents of using ITB role dismissed this opinion, and said that the probability of technical failures are high when ITB roles are not employed because (1) these people are not multi-disciplined, (2) they lose focus on integration activities since they put much focus on achieving individual objectives at the expense of the builder's objectives – Silo thinking, and (3) there is a debate of who is supposed to be held accountable for success or failure of the integrated system. Therefore, the informants recommended that there needs to be a dedicated ITB manager whose main focus is to coordinate the activities of the various teams to achieve the whole project's objectives.

Considering the increasing complexity of modern building projects and the need to align the activities of the various technical disciplines to produce the desired synergy effects***, the empirical findings support the proposition that: the use of ITB managers will improve the coordination between the various technical disciplines when they are employed.***

6.1.2 Proposition 1(ii) – Reduction of energy consumption

Proposition 3 (ii) was established in section 3.1.3 - *Energy consumption,* to confirm the claims of authors (Johansen and Hoel, 2016, Studer, 2012, Integra, 2011) who discuss the use of ITB role to reduce the energy consumption in buildings.

From the empirical data, there were not enough findings to confirm this proposition. Besides, there were no factual or quantitative data (figures) to confirm the historical performance of using ITB role to reduce the energy consumptions of buildings. However, one of the informants mentioned that the ITB roles can be used to ensure that the right amount of electric current flows through the electric panels, but this information is not detailed enough to confirm the proposition in question. This affects the generalisation of my empirical findings based on number and quality. Therefore, the proposition cannot be either confirmed or dismissed. Hence, it is considered as ***inconclusive***. Confirmation of this proposition might be subject to further research, as it is more appropriate to explain using historical analysis research design (Yin, 2018). Further description of how this research can be conducted is presented in Chapter 7.5 – *Further Research.*

6.1.3 Proposition 1(iii) – Delivery of functional buildings

This theoretical proposition was introduced based on the literature review in section 3.1.4 - *Delivery of fully functional building,* to confirm the claims of authors (NS3935, 2019, Studer, 2012, Integra, 2011, Milosevic et al., 2007, Wheelwright and Clark, 1992) who describe the use of ITB roles to increase the likelihood of achieving optimal technical systems administration, and the delivery of functional buildings.

The empirical findings in Chapter 5.2 – *ITB Benefits,* provide information which either supports or dismisses the propositions. Overall, most findings recommended the use of ITB role to increase the likelihood of delivering the functional building to builders. In this context, a building is classified as a "functional building" when it is error-free, sustainable, environmentally friendly, and effective at achieving the desired objectives. In discussing proposition 1(i) in section 6.1.1, it was mentioned how the ITB role can improve multidisciplinary coordination. Based on this information, some findings indicated that effective integrated technical solutions are developed when the various teams work together effectively, and these solutions become the means of delivering effective and functional buildings. They highlighted that several technical delivery failures occur when the activities of the various systems are not coordinated properly. For example, the heating and cooling systems negatively affect each other when there is no integration, which results in rooms becoming too hot or cold.

Besides, in Chapter 5.2.2 – *Technical benefits,* the informants emphasised that the ITB manager collaboratively work with the other disciplines to perform several testing operations (such individual system testing, and full-scale testing, etc.) and trial operations of the integrated systems to ensure that there are fewer or no technical errors before the project is handed over to the builders. Besides, the ITB manager approves and documents the functional operation of the integrated systems after all the functional units have completed their work. According to the findings, the production of effective, sustainable and error-free buildings championed by ITB manager increases the chance of gaining customer satisfaction, and a higher rating when certifying the building (such as achieving BREEAM certifications).

Considering the positive effects of coordinating activities, and testing and trial operations organised by the ITB manager to ensure the desired buildings specifications are met***, the analysis supports the proposition of using ITB managers to increase the likelihood of ensuring the delivery of functional buildings.***

6.1.4 Proposition 2- Reduction of building's Life cycle cost

In Chapter 3.1.2 – *cost reduction and* Chapter 3.2.2 *cost related to ITB role*, proposition 5 was introduced to verify the arguments of authors (OSW, 2019, Studer, 2012, Integra, 2011) who consider the ITB role as an asset because of its likelihood to improve the value of the project by reducing the overall cost of the building.

According to the findings in section 5.2.3 – *Economic benefits*, many informants acknowledged that it is expensive to employ ITB roles in projects. However, they argued strongly that in big investment projects, the cost related to the ITB role is smaller than the cost of failures in technical deliveries. According to these interviewees, the building's cost considerably increases when there are failures in the technical deliveries, which makes up almost 40-50% of the overall cost of the building. The informants related the cause of technical failures to lack of holistic thinking and inadequate system testing and trial operations, which result in numerous technical faults such as malfunctioning of the lighting, ventilation, heating systems, etc. According to the informants, additional cost or resources are needed to correct these errors or make significant changes, which often increases the overall cost of the building. They highlighted that the ideal solutions to correct errors or make changes sometimes take a longer time to develop or they are not even developed, rendering the ineffective building useless.

In making recommendations, the interviewees mentioned that the presence of an ITB manager will improve cost reduction by ensuring effective planning, designing, installation, testing and trial operations of the buildings before they are given out to the builders. These activities assure that the buildings functions properly and they have no technical errors or faults. Therefore, no extra costs are used to resolve errors or make significant changes. Some informants recommended that the earlier involvement of the ITB manager can also help to reduce cost since it costs much less to make changes as the project evolves, compared to making changes when the project is finally completed. Per the findings, ITB managers can also improve buildings' cost by using of system centralisation to prevent functional duplications or redundancies.

Considering the increasing complexity of building projects, and the need to control cost based on the significant value (40-50%) that the technical systems contribute the overall cost of the building, ***the empirical findings support the proposition that the involvement of ITB roles in projects assists in improving the overall project cost.***

6.1.5 Summary of discussions on ITB benefits and theoretical implications

The table below shows the summary of the results of the propositions as discussed in the previous sections.

The following sections will describe the theoretical implications of the analysis of the proposition.

Table 6. 2 Summary of results regarding propositions on ITB benefits.

No.	Proposition	Results
1	***The application of ITB roles in building projects will increase the likelihood of improving the:***	
	i. coordination between the various disciplines involved in the project.	Confirmed
	ii. reduction of energy consumptions	Inconclusive
	iii. delivery of fully functional buildings.	Confirmed
2	The application of ITB role increases the likelihood of improving the overall cost of a building	Confirmed

!) the confirmations of these proposition in Table 6.2 are based on empirical data analysis and discussion relating to information received from interviewing some employees of Rambøl. Therefore, the results are limited to Rambøl. However, the results can be applied to other building projects or companies where the ITB role is implemented.

i. Theoretical implications of Proposition 1(i) - Multidisciplinary Coordination

In Chapter 6.1.1, the analysis concluded that ITB role can be used to improve the multi-discipline coordination in projects. In the analysis, theoretical implications of the system's complexity, silo thinking, accountability were analysed and confirmed, thereby supporting the authors of such theoretical assumptions. These theoretical implications are described in the paragraphs below:

In terms of *systems' complexity*, the analysis showed that building projects are becoming more complex in terms of the increasing number of systems, relationships and their characteristics (Schoderbek et al., 1990). The term "systems" in this context refer to the technical components and the disciplines. The findings showed that these systems are related to the extent that their activities and objectives need to be coordinated by a dedicated function (thus, the ITB manager) to ensure that they have no adverse effects on each other when they are operating simultaneously. For example, the lack of integration or coordinating between the heating and cooling systems can result in rooms becoming hot or cold when they operating together (Mazzucchelli and Lucchini, 2012, Integra, 2011). The deployment of a dedicated ITB manager confirms the theoretical implication of *requisite variety* where additional resources are needed to manage the complexity of the system (Schoderbek et al., 1990).

The analysis also confirmed how the improvement of multidisciplinary coordination can be used to manage the theoretical implications of *tunnel vision or silo thinking* of functional units. Silo thinking or tunnel vision refers to the extent at which the functional teams put much focus on achieving their objectives at the expense of the main or overall project's objectives (Hellriegel and Slocum, 1996, Hitt et al., 1989). Per the findings, the ITB manager prevents silo thinking by serving as a focal point that aligns the objectives of the functions teams to support the achievement of the builder's business objectives (Milosevic et al., 2007).

Finally, the analysis confirmed the theoretical implications of achieving accountability in projects. The findings indicate that in organisations where dedicated ITB managers are used, there is a challenge of who owns personal

accountability when there are integration problems. This is because there no dedicated ITB roles, and the integration roles are shared between the functional teams. Per the analysis, it was discovered that with the employment of a dedicated ITB manager, he/she assumes full accountability of the integration roles throughout the project development life cycle. So, there is no debated of or subjectivity about who owns and is accountable for the success or failure of planning, designing, installed, testing and trying the integrated systems (Milosevic et al., 2007). He/she ensures that functional and cost-effective products (in this context, buildings) are developed and delivered to the builder. This analysis supports the theoretical assumptions of the author (Milosevic et al., 2007), who discusses the theoretical implications of using program manager to achieve accountability in projects.

ii. Theoretical implications of Proposition 1(iii) - Delivery of functional buildings

In the discussion above, section 6.1.3, the analysis confirmed that the use of ITB manager improves the likelihood of delivering functional buildings. During the analysis, two relevant theoretical concepts were confirmed: thus, the importance of (1) Benefits of multidisciplinary coordination and (2) testing operations.

Concerning the importance of multidisciplinary coordination, it was confirmed that use of ITB managers to improve multidisciplinary coordination results in the delivery of effective integrated solutions which provides the means to deliver functional buildings. This analysis supports the theories of authors (Milosevic et al., 2007, Wheelwright and Clark, 1992, Mazzucchelli and Lucchini, 2012) who claims that outstanding teams or project's performance are achieved when the various teams work together to achieve a common goal.

Secondly, empirical findings showed that functional and effective buildings are delivered when ITB managers conduct and document testing and trial operations before handing over the building. He/she managers ensure that integration systems are operating properly before he gives a certificate of occupancy to the builders or end-users According to analysis, it is possible to discover earlier warning signs (such errors, faults and missing) when the building is tested, and these problems can be resolved early enough to avoid having adverse effects in the future. Therefore, there is a great need to perform testing and trial operations. These findings support the theoretical assumptions of authors (NS3935, 2019, Studer, 2012, Integra, 2011) that discuss the importance of performing testing and trial operations of products (in this context, buildings) before handing over to the end-user.

iii. Theoretical implications - Proposition 2- Reduction of building's Life cycle cost

In the analysis of proposition 2, there were confirmations of theoretical assumptions regarding the use of ITB role to achieve cost reduction in projects. The analysis showed that system/functional centralisation, effective business processes and earlier involvement of the ITB role might assist in reducing the project cost.

The findings confirmed the approach of using a system or functional centralisation to control cost by preventing system duplications or redundancy. Per the findings, the ITB manager prevents system duplications or redundancy by ensuring that technical systems that have similar and related functions are properly integrated on a single platform or location. For example, the use of Building Automation Systems (BAS) connects the heating, venting and air conditioning (HVAC) systems, lighting, security, and other systems to communicate on a single platform

(OSW, 2019). Therefore, there are no resource redundancies or duplications in these systems, which are likely to increase both the installation and operation cost of the building. However, due to the effects that the failure of these central systems/platforms can present, the findings indicated that the ITB manager ensures that these systems are properly installed, configured and tested before they are set into operation. This analysis of how to achieve cost reduction supports the notions of authors (OSW, 2019, Studer, 2012, Integra, 2011) who describe the use of system centralisation to reduce cost and energy consumptions in buildings.

With regards to the early ITB role involvement, the findings showed that it is very cheap for ITB managers to makes changes or correct technical faults when they are involved early in the project, compared to when the comes late in the projects. Besides, they can have a general overview and understanding of the project's objectives and scope. This analysis supports the assumptions of (NS3935, 2019, Hussein, 2018, Samset, 2010) who discusses the socio-economic benefits of involving key stakeholders in the project in the early stages or phases of the project.

Finally, another approach that contributes to cost reduction in projects is the application of effective business processes that contribute to the effective installations of the integrated systems. From the findings, it was discovered that the use of ITB managers improve multidisciplinary coordination, which results in the development of effective integrated technical solutions which serves a means to deliver cost-effective functional buildings (Milosevic et al., 2007, Wheelwright and Clark, 1992). Per the analysis, the overall cost of buildings is expected to considerably increase when extra cost are resources are needed to correct errors relating to the failures in the technical deliveries. It appears that the cause of these failures is due to a lack of holistic thinking and integrated solutions (NS3935, 2019, Studer, 2012, Integra, 2011). Therefore, there is a need to achieve coordinate efforts to assure the production of functional and cost-effective buildings.

6.2 Discussions of propositions on ITB Challenges

This chapter presents discussions of propositions on ITB challenges. The evaluations will involve comparing the theoretical propositions on ITB challenges to the empirical findings in subsections of chapter 5.3. The process for discussing these propositions will be similar to the discussion process described in the previous chapter, Chapter 6.1.

The table below shows the propositions that were established base on ITB challenges:

Table 6. 3 Propositions on ITB challenges

No.	Proposition
3	ITB managers need to have charismatic, positional and contractual authority to be effective in making and implementing decisions.
4	The competence of an ITB manager does not extensively depends on his expertise and knowledge in technology solutions and integration

5	The NS 3935 and 6450 are mostly ineffective because they are not defined in NS 8407
6	Late involvement of ITB managers in building projects makes it difficult and expensive to make changes and provide ideal solutions.

6.2.1 Proposition 3 – ITB manager's Authority

To confirm the implications of the types of authority that the ITB manager needs to be effective in building projects, theoretical proposition 3 was established in section 2.4 – *structure of an ITB organisation*, and section 3.2.1 – *lack of authority*. This proposition is built on theoretical assumptions of authors (Paul and Jean, 2007, Nelson, 1993, Weber and Parsons, 1964) who describe the implications of the different forms of authorities such as positions, charismatic authority, etc. that exist in organisations.

The empirical findings in section 5.3.1.2 - *Lack of Contractual Authority*, describe the extents to which different forms of ITB manager's authorities are applied in building projects. Per the findings, ITB managers are able to use their charismatic and positional authority to influence projects based on their expertise and experience. However, other findings show that even though some ITB managers have positional and charismatic authority, they cannot extensively influence projects because they lack contractual or legal authority. This issue is due to the invisibility of ITB role and mandate in tenders or the most commonly used general contract (NS 8407). According to the findings, this challenge makes it difficult for ITB managers to instruct other entrepreneurs to implement their decisions. The ITB managers' decisions or instructions are either resisted or perceived as advice.

Per the findings in Chapter 5.3.1.1 and Chapter 5.4.1, the informants recommended the amendment of NS 8407 to include the roles and mandates of the ITB manager. Based on the relationship that exists between the described forms of authority, many of the interviewees argued that ITB managers need charismatic, positional and contractual authority to be very effective in their role. They explained their views by saying that ITB managers who possess only contractual authority but lacks charismatic or positional authority might be viewed as less competent to perform his role. Likewise, ITB manager who possess positional and charismatic authority but lacks contractual authority might be perceived as less powerful with regards to the contract. Based on these analyses, the empirical findings ***support the proposition that ITB managers need to have charismatic, positional and contractual authority to be effective in making and implementing decisions.***

6.2.2 Proposition 4 – Technical competence of an ITB manager

The findings in section 5.3.3 - *ITB manager's competency*, contradict the assumption of the authors (Integra, 2011) which states that the ITB managers are not responsible for understanding the technicalities that lie between various technical teams since he is not expected to be an expert in providing technology solutions.

The data in Chapter 5.3.4 – *ITB manager's competency*, suggest that the ITB manager needs to include technical competence to his managerial competencies in order to be effective in his role. According to these empirical findings, the ITB manager needs to be multi-disciplined in terms of technically understanding how the individual technical systems operate when they are integrated. From the data, it is assumed that possessing technical

competence is very important as it might inform the ITB manager's decisions to influence the project effectively. Per the findings, ITB manager's role should be handled by people with technical minds.

Considering the extent to which the use of technical competence influences the activities and decision-making of the ITB manager, the empirical findings ***dismissed the notion that ITB managers should not have the technical competence to perform his/her role.***

6.2.3 Proposition 5 Ineffectiveness of ITB standard (NS 3935) and testing operation(NS 6450)

This proposition was introduced to confirm the effectiveness of standards relating to the ITB role. The data showed that the NS 3935 and NS 6450 are needed by the ITB manager to be effective in the project.

This proposition is built on pieces of literature that describe the relationships between the NS 3935, 6450 and 8407 (NS3935, 2019, NS6450:2016, 2016, NS8407, 2011). This analysis will be used to provide answers RQ2 in the concluding section of Chapter 7.1.2.

The empirical findings in section 5.3.1.1, supported the proposition that NS 3935 and NS 6450 are less effective because they are excluded or scantly described in the general contract – NS 8407. The experienced informants argued that the NS 8407 defines testing operations, but does not define it in detail compared to the description made by NS 6450. These informants described how the situation has impacted the roles of ITB managers in projects. According to these informants, the ITB manager does not only become less effective in exercising his positional or charismatic authority, but he is not able to perform his roles and testing operations that are required to ensure the delivery of functional buildings. The interviewees highlighted that the lack of specification or scanty description of NS 3935 and NS 6450 in the NS 8407 increases the probability of producing malfunctional buildings which generate numerous complaints from builder or end-users. They recommended that the NS 8407 should refer to the new NS 3935:2019 and NS 6450 standards, which respectively describe in detail the roles of the ITB manger and the comprehensive testing operations that need to be carried out before providing a certificate of occupancy to the builder or end-users.

From the empirical data, there were only findings that showed how the informants exhibited negative impressions about the incomplete definition of the general contract standard – NS 8407. Overall, the many interviewees strongly emphasized that the NS 6450 and NS 3935 should be mentioned in the contract and tenders to improve their effectiveness. Based on the negative implications that come with the scanty or exclusion of NS 3935 and 6450 in the NS 8407, the findings ***support the proposition that the effectiveness of NS 6450 and NS 3935 depends on their detailed description in the NS 8407.***

6.2.4 Proposition 6 – Late involvement of the ITB manager

To confirm the implications of the late involvement of ITB managers in projects, this proposition was introduced. This proposition is developed based on the claim of authors (Hussein, 2018, Samset, 2010) that describes the implications of the late involvement of key stakeholders in projects.

The empirical findings in section 5.3.3 - *Late Involvement*, supports the assumption that ITB managers face challenges in influencing projects when they are later involved in projects. By elaborating on these findings, some informants mentioned that ITB managers are only invited when builders or contractors experience integration failures in the technical deliveries. Per the findings, the late involvement of the ITB manager presents challenges in performing his core function (i.e. multi-disciplinary coordination) because he lacks a complete understanding of the whole project's objectives and its definitions, which have already been defined in the early stages of the project. Other findings showed that the late involvement of the ITB manager makes it difficult to make cost-effective changes to technical solutions or products that have already been implemented. Besides, he is not able to build a good rapport with existing disciplines who were involved in the early phase of the project. This is because he does not have the complete overview or same level of project's understanding compared to other entrepreneurs who were involved in the project's early phase. Therefore, it becomes difficult to instruct them. Some other findings indicated that the ITB manager's uncertainties about the projects are high because he/she does not have the opportunity to present and ask the right questions to the right group regarding his expectations and what he might require them to do. Another informant pointed out that the ITB manager is not able to make sure that the roles and mandates are defined in the tenders or other specifications when he/she is not involved early in the project.

Even though it can be assumed to be very expensive to involve the ITB manger throughout the lifecycle the project, it appears that the cost related to the ITB role is smaller compared to cost that the project will be incurred when the ITB managers are later invited resolves failures in the technical deliveries. Per the findings, it is assumed that the extensive use of dedicated ITB role assures one of reaping the investment he/she invested in building's technical systems. Overall, the findings showed the ITB manager will be effective and efficient when he is involved early in the project.

Based on the several negative impressions presented by all of the interviewees regarding the late involvement of ITB managers, it can be assumed that the early involvement of the ITB manager in projects will increase the likelihood of the project's success by the delivery of cost-effective and functional buildings. Based on the empirical findings, ***the analysis supports the proposition that ITB managers face challenges in doing their tasks when they are later involved in the project.***

6.2.5 Summary of proposition discussions on ITB Challenges

The table below shows the results of the propositions after making comparisons between the empirical and theoretical findings that relate to ITB challenges. The next sections will involve discussions of the theoretical implications of the analysis of the propositions.

Table 6. 4 Summary of results regarding propositions on ITB benefits.

No.	Proposition	Results
3	ITB managers need charismatic, positional and contractual authority to be effective in influencing the project.	Confirmed
4	The competence of an ITB manager does not extensively depend on his expertise and knowledge in technology solutions and integration	Dismissed
5	The NS 3935 and 6450 are mostly ineffective because they are not defined in NS 8407	Confirmed
6	Late involvement of ITB managers in building projects makes it difficult and expensive to make changes and provide ideal solutions.	confirmed

!) the confirmation of these proposition in Table 6.4 are based on empirical data analysis and discussion relating to the information received from interviewing some employees of Rambøl. Therefore, the results are limited to Rambøl. However, the results can be applied to other building projects or companies where the ITB role is implemented.

i. Theoretical implications of Proposition 3 - ITB manager's Authority:

In section 6.2.1, the empirical findings confirmed that ITB managers need contractual, positional and charismatic authority to be effective in influencing the project. In the analyses, the theoretical implications of the legitimate source of authorities were confirmed, thereby supporting the views of authors (Studer, 2012, Nelson, 1993, Weber and Parsons, 1964).

From the empirical findings, it was discovered that the ITB manager needs authority (contractual, charismatic, or positional authority) to be able to coordinate varying views and activities of the various technical disciplines. This finding supports the theoretical assumptions of Studer (2012), which states that there is a need for authority having jurisdiction (AHJ) to determine the acceptable system configuration and operation of the coordinated system. In the author's definition, he did not specify clearly which form of authority is needed by the ITB manager, so it can be assumed that either charismatic, positional or contractual authority may be needed by the ITB manager to perform his for coordinating role.

Other findings showed that the ITB manager is not able to extensively influence the projects because he lacks the legal or contractual right even though he has positional or charismatic authority. These findings confirm the claims of (Nelson, 1993) that argue that many pieces of literature have explicitly and implicitly considered rational-contractual authority as the principal form of authority for most organisations. Based on this assumption, it appears that the other forms of authorities are less regarded as far as legal or contractual authority is concerned.

Further empirical findings showed that the different forms of authorities must be treated fairly since they are related and have an impact on each other. These findings showed that the ITB manager might be viewed as less competence when he has only contractual authority but lacks charismatic or position authority, which are derived from expert knowledge or experience. Likewise, the ITB manger might be viewed as less effective or powerful if his decisions are based on only his experience or experience, but not a contractual mandate. Human theorists suggest that there should be a focus on forms of influence that promotes mutuality and collaboration in decision

making; thus, managers and workers should be able to make decisions to meet the needs of the involved parties and to derive the desired organisational objectives (Nelson, 1993, Hitt et al., 1989, Bolman and Deal, 1984)

ii. Theoretical implications of Proposition 4 - Technical competence of an ITB manager:

The assumptions that ITB managers do not need technical competence in order to be effective in their role was dismissed in Section 6.2.2 by the empirical findings. The data contributes to a clear understanding of the implications of managerial competencies, as described by different authors.

Managerial competence is defined as the skills, knowledge and attitudes that managers demonstrate in action to assist in the achievement of business objectives (Arditi et al., 2013, Watson, 2006). With this theoretical definition of managerial competence, it implies that in order for an ITB manager to be effective at performing his roles and making informed decisions regarding technical integrations, he needs technical competence. The ITB manager might be perceived as less competent to perform his role when he lacks technical competency (Knowledge@Wharton, 2016, Lester, 2006, Brill et al., 2006). In the definition of managerial competence, these authors included technical competencies in their list of managerial competencies. The implications of these theories were supported by the findings in Chapter 5.3.4, where the informants strongly argue that the ITB manager needs technical competence.

However, other authors (Crawford and Nahmias, 2010, Dulewicz and Higgs, 2004) provide a list of managerial competence which excludes technical competency. They made mention of managerial competencies such as resource management, communication skills, emotional and intellectual competencies, etc. These managerial competencies place significant emphasis on behavioural competencies than technical or engineering competency. These opinions are supported by the claims of the author (Integra, 2011) who states that ITB managers are not responsible for the technicalities that lie between the various technical disciplines since they are not expected to be experts in providing technology solutions. Besides, these theories support the notions of some managers who have the perception that they don't need technical competence to understand the business, but that technical competence should be demanded from employees within the technical departments (Knowledge@Wharton, 2016). These assumptions of managerial competency were dismissed by the empirical findings in Chapter 5.3.4.

On the other hand, it can also be assumed that authors (Crawford and Nahmias, 2010, Dulewicz and Higgs, 2004) definition of managerial competence does not relate to the technical field, but relates to the field of organisational development; since it places significant emphasis on behavioural competencies than technical or engineering competency. Hence the definition cannot be applied in a technical context. It appears that these authors definition of managerial competence might be needed by the ITB manager to manage the behavioural aspects of multidisciplinary coordination functions.

iii. Theoretical implications of Proposition 5 – Ineffectiveness of NS 3935 and NS 6450:

Based on the empirical findings, it was concluded in Chapter 6.2.3 that the NS 3935 and 6450 are less effective or scarcely used in projects because of their invisibility in the commonly used contract agreement standard, NS 8407.

In the analysis, the implications of not defining roles and mandates in legal documents such as contracts or other documents such as tenders, project charters were confirmed. These findings indicated that the ITB manager faces challenges in carrying out his/her ITB related roles and testing operations, and his decisions or instructions are often resisted by other technical disciplines. In effect, he is not able to ensure the delivery of buildings that are functional and environmentally friendly. Per the analysis, it appears that the NS 3935 and NS 8407 will be effective and frequently used in projects when they are defined in the NS 8407. These empirical findings support the theoretical notions of the authors who states the contracts are seen the most powerful legal document that serves as the principal foundation for most organisation, especially in areas where it is mostly recognised (Gonzales, 2004, Nelson, 1993). According to these authors, the contract binds the involved actors to its terms and conditions. Hence, it becomes difficult to breach them.

iv. Theoretical implications of Proposition 6 - Late involvement of the ITB manager:

In Sections 6.2.4, the proposition describing the challenges that the ITB manager faces when he is invited late in the project was confirmed based on the empirical findings.

In the analysis, the theoretical implication of the late involvement of the ITB manager was confirmed, thereby supporting the theories of authors (Hussein, 2018, Samset, 2010, Dvir and Lechler, 2004) that describe the implications of early and late involvement of key stakeholders in projects. These authors argued that the early planning and involvement of key stakeholders (in this context, ITB managers) in the design and planning phases are critical success factors if the project's goal is to deliver within budget, time and specifications. This implies that with the early involvement of ITB managers, they can have a complete overview and good understanding of the project's definitions and objectives, which helps in becoming committed to the project and building a good rapport with other technical disciplines. Besides, he becomes effective and efficient at coordinating the objectives of individual technical teams to align with the strategic business objectives (Hussein, 2018, Samset, 2010, Milosevic et al., 2007). Also, ITB manager's uncertainties regarding the project are reduced because he is able to inquire and present the right information to the right group. It is assumed that the level of uncertainties is high in the early phases of the project, and it reduces as the project evolves by using available and relevant information (Hussein, 2018, Samset, 2010). Moreover, ITB managers can make easier and cost-effective changes when invited early in the project (Hussein, 2018, Integra, 2011, Samset, 2010). According to these proponents of early involvement of ITB managers, the opposite effects are realised when ITB role are invited later in the project.

In contrast, some opponents of the early involvement of ITB argued it is expensive to involve the ITB managers throughout the development life cycle of the project lifecycle (Hussein, 2018, Integra, 2011, Samset, 2010). According to these proponents, the ITB role should only be invited when they are needed to correct technical integration errors. Nonetheless, the proponents dismissed this opinion and emphasised that the cost related to the

early deployment of ITB manager is less than the cost of failures in technical deliveries (Hussein, 2018, Integra, 2011, Samset, 2010).

6.3 Summary of the Empirical data

From the interviews, the informants recommended the application of ITB role in building projects considering the numerous benefits it presents. They argued that there needs to a dedicated ITB manager to oversee the integration roles since these roles are often neglected by the functional disciplines in the project. According to the informants, these technical disciplines have project constraints which compel them to focus on individual objectives at the expense of the main project objectives.

The informants mentioned that deployment of ITB managers increases the likelihood of producing an effective and functional building by coordinating the views and activities of various disciplines, and conducting testing and trial operations to correct errors. The argued that these duties of the ITB managers guarantee that the complete cost of the building is reduced since extras cost will not be needed to resolve technical failures that might surface when the building is completed. Even though the employment of ITB is sometimes considered as an expense, some informants said the cost is smaller compared to the cost that is incurred when there is a failure in the technical deliveries of larger investment projects. They argued that builders are assured of good quality buildings and they make lots of investment benefits when they consider ITB roles in their projects.

However, the informants mentioned that the ITB manager faces several challenges in carrying out his activities. These include lacks contractual authority to make changes and to influence the project because his roles and mandate are not clearly specified in the general contract agreement standard (NS 8407). Therefore, his instructions are either taken as advice or often resisted by other entrepreneurs. Also, the informants mentioned that the ITB manager is often involved later in the projects when everything has been completed with several technical failures such as malfunction of the door, lighting, cooling and heating systems, etc. Another challenge that was mentioned was the lack of builders and contractor awareness and experience with ITB role which results in the lack of understanding regarding the implications (cost and benefits) of ITB role. The interviewees highlighted that the lack of understanding results in builders and contractors not considering ITB roles in projects.

In dealing with these challenges, the informants mentioned some success factors or ground rules that must be adhered to increase the likelihood of successfully implementing ITB roles in projects. They strongly recommended that the general standard contract agreement should be amended and updated to include NS 3935 and 6450 which respectively define the roles, mandates and testing operations that need to be performed by the ITB manager. According to interviewees, this will ensure that the ITB managers have the contractual mandate to influence the projects. In addition, they point out that ITB managers should be involved early in the design and engineering process to understand the definition of project's scope and objectives and be able to present and ask the right information to the right group. Moreover, the interviewees proposed that ITB managers and contractors who have good experience with ITB should inform and educate builders and contractors who are not aware of the

ITB role and its implications (thus, challenges and benefits). They concluded that ITB role is the future of the building industry considering the ever-increasing complexity of building projects and the need for building companies to gain competitive advantages. Based on these factors, they expect a sharp increase in the interest to use ITB roles shortly to deal with the increasing demands of the builders and end-users for functional buildings.

7 CONCLUSIONS, IMPLICATIONS AND FURTHER RESEARCH

After completing the analyses of the findings and discussions, the research discoveries are ready to be concretised and presented. By conducting this research, there has been an achievement of gaining an in-depth understanding of how building companies like Rambøl perceive the application of ITB role in the project. The benefits and challenges relating to the ITB role have been understood from a practical and theoretical perspective. Besides, some recommendations have been discovered which can be used to address the found ITB challenges. These recommendations are assumed will help increase the awareness and the use of ITB roles in building projects. These recommendations are presented in chapter 7.2 – *Practical Implications*. These discoveries are in line with the research objective, as presented in Chapter 1.1 – *Research objectives*.

7.1 Conclusion of the thesis

In this section, the thesis provides answers to subordinate research questions (RQ1, RQ2 and RQ3) based on the conclusion of propositions in Chapter 6 – *Discussion.* These research questions are interdependent, and they relate to the overall research question. Therefore, the summary of the answers to these research questions will be used to provide answers to the main research question, *"How does a construction company like Rambøl perceive the ITB concept?"*

The answers to both sub and main research questions are based on the empirical data received after interviewing the employees of Rambøl. The table below shows the results of all the proposition concerning their research question.

Table 7. 1 Summary of propositional results in relating to their research question

No.	Proposition	RQ	Results
1	***The application of ITB roles in building projects will increase the likelihood of improving the**:*		
	i. coordination among the various disciplines involved in the project.	RQ1	Confirmed
	ii. reduction of energy consumptions,	RQ1	Inconclusive
	iii. delivery of functional buildings	RQ1	Confirmed
2	The application of ITB role increases the likelihood of improving the overall cost of a building	RQ1, RQ3	Confirmed
3	ITB managers need charismatic, positional and contractual authority to be effective in influencing the project.	RQ3	confirmed
4	The competence of an ITB manager does not extensively depend on his expertise and knowledge in technology solutions and integration	RQ3	Dismissed
5	The NS 3935 and 6450 are mostly ineffective because they are not defined in NS 8407	RQ2, RQ3	Confirmed

6	Late involvement of ITB managers in building projects makes it difficult and expensive to make changes and provide ideal solutions.	RQ3	Confirmed

!)the confirmations of these propositions in Table 7.1 are based on empirical data analysis and discussion relating to information received from interviewing some employees of Rambøl. Therefore, the results are limited to Rambøl. However, the results can be applied to other building projects or companies where the ITB role is implemented.

7.1.1 RQ1: To what extent is ITB role beneficial to building projects?

This research question was developed to discover the extent to which ITB role is beneficial to building projects. The answers to this question depend on the findings and discussion of proposition 1 and 2 in Chapter 6.1 - *Discussions on ITB benefits*.

The benefits of using technical program managers (such as ITB managers) have extensively been researched based on literature study, so the findings did not come as a surprise to me. However, it was surprising to discover that the role is not commonly used in building projects considering the projects' increasing complexity and the need to improve the overall building's cost. Therefore, the question that naturally came to mind was why are building projects not making extensive use of ITB role, and to what extent will the role be important/beneficial to the building projects? From the discussions in Chapter 6.1, some factors that describe the benefits of ITB role were discovered, which it is assumed that the knowledge of these factors might improve the extent to which the importance of the ITB role will be perceived in projects. The factors include:

i. **Multidisciplinary coordination:** Based on my analysis, it was concluded that the use of a dedicated ITB manager might improve multidisciplinary coordination between the various technical disciplines. Considering the increasing technical complexities of building projects in terms of the increasing number of technical systems and their interdependencies, there needs to be a coordinator to align the objectives of the functional units to support the builder's business objectives. This is where a dedicated ITB manager is employed to assume complete ownership and accountability of the integration role throughout the project development life cycle. It is believed that the presence of ITB managers might improve the interdisciplinary coordination, since their primary role/focus is to serve as a technical program manager. Thus, they serve as a focal point between the functional objectives and business objectives. Besides, they are considered to be effective in performing the integration role because they are cross-project and multi-disciplined.

   Some perfect projects have been conceived, planned and executed successfully without the need of dedicated ITB managers, and the integration role is managed by functional teams. In such projects, it becomes a challenge when problems begin to surface and personal accountability is needed on the part of one or more technical disciplines (Milosevic et al., 2007). With the presence of an ITB manager, there is no debate or subjectivity of who is supposed to be liable for the success or failure of the integrated system; thus, the ITB manager assumes full accountability throughout the life cycle of the project (Milosevic et al., 2007).

ii. **Delivery of functional building:** As described above, the benefits of improving multidisciplinary coordination results in the development of integrated technology solutions, which become the means of achieving the builder's strategic objectives (thus, the delivery of functional buildings). Besides, it is assumed that the ITB manager ensures the delivery of functional building by performing and documenting testing and trial operations before giving a certificate of occupancy to builder or end-users. These operations assure that buildings are delivered with no technical errors/faults, and these buildings provide acceptable environmental conditions to end-users.

iii. **Cost reduction**: In terms of cost reduction, the delivery of functional buildings assures that no extra cost is spent on correcting errors or making significant changes after the project is handed over to the builder. Besides, with the ITB managers having a complete overview of the project, there is an increase in the likelihood of cost reduction by ensuring that there are no system duplications and redundancy. Also, they are able to achieve the prevention of system duplications and redundancy by using systems or functional centralisation (an example is seen in the use of BAS which coordinates the HVAC systems). System duplications and redundancy are often considered to increase the overall building's cost when the technical systems are not properly integrated.

Due to the increasing technical complexities of modern buildings, the huge value (40-50%) that technical systems contribute to the overall cost of buildings, and the increasing builders and end-users demand for functional buildings, it is recommended that if builders and contractors want to make the most out of their investment into building's technical systems, they are urged to make extensive use of ITB role to increase the likelihood of (1) promoting effective multidisciplinary coordination, (2) delivering functional buildings (3) reducing the overall cost of the building.

7.1.2 RQ2 What relationships exist between the various ITB standards used in building projects?

From the literature review, there was a need to understand which standards are needed to increase the application of ITB role in projects. Therefore, the second research question was established to discover different ITB related standards used in projects, and understand the relationships that exist between them. The analysis of the proposition 5 in Chapter 6.2.3 provides answers to this research question.

From the empirical findings and discussions, it was discovered that the building industry (i.e. Rambøl) frequently make use of three standards concerning the ITB role. These standards include:

i. ITB standard – NS 3935

ii. General contract terms for general contracts - NS 8407

iii. Commissioning and Test operation of technical building installations – NS 6450

In answering RQ2, it was found that these standards are related in terms of their functions, and their impacts. From the analysis, it was noticed that there is currently no established relationship between these standards, so they are treated independently in projects. By classifying their interdependencies in terms of their functions, it was

noticed that the ITB manager needs the NS 6450 to perform testing and trial operations after the installation of the technical integrated systems based on his role specified in the NS 3935. The NS 6450 specifies which technical systems need to be tested and tried. The ITB manager ensures testing operations such as functional, integrated, full-scale and trial operations are performed and documented before finally giving the building to the builder or end-users. However, the ITB roles and testing operations which are respectively defined in the NS 3935 and NS 6450 are often not performed in projects because they are scantly or not specified in legal documents such the general contracts -NS 8407, tenders or project charters. Therefore, NS 3935 and 6450 appears to be scarce and ineffective even though they are classified as standards. In Norway, companies are not compelled to use standards in their business processes. Based on this information, it is presumed that Norwegian building and construction companies are not encouraged to use these standards.

To increase the effectiveness and application of NS 3935 and 6450, the interview subjects recommended the establishment of a direct relationship between these three standards. Thus, the NS 8407 should be amended and updated to include the specifications of NS 3935 and 6450, which provides a detailed definition of ITB roles, testing, and trial operations.

7.1.3 RQ3 what are some of the challenges hindering the application of ITB role in building projects?

To gain insights into some of the challenges facing the ITB role, the third research question (RQ3) was introduced. By providing answers to this research question, this chapter describes some of the ITB related challenges based on my findings and analyses.

Per the analysis in Chapter 6.2, it was discovered that the ITB role (manager) faces the following challenges when carrying out his role in projects.

i. Lack of authority

According to the findings, one of the pressing challenges facing the ITB manager's role is the lack of contractual authority to make and implement bold decisions. Even though the ITB manager can use his charismatic or positional authorities to influence the project, it appears that his views or opinions are often not given much necessary consideration because he lacks the legal mandate. In finding the root cause of the problem, it was discovered that the general standard contract – NS 8407 does not make provision for the ITB roles and mandates. Therefore, the instructions given by the ITB manager are often resisted. This challenge results in the ineffectiveness of the ITB manager, which affects the extent to which he/she can ensure the delivery of functional buildings.

By partially dealing with this challenge, the ITB managers ensure that roles and demands are included in every specification they prepare, which becomes a tedious work to do. Secondly, main contractors sometimes instruct subcontractors to cooperate with the ITB manager in performing his role. The challenge with these partial solutions is that they are still not regarded as legal sources of authority, so decisions of the ITB manager are not regarded. He/she cannot demand the other disciplines to adhere to his instructions.

By resolving this challenge, the findings suggest the amendment and update of the NS 8407 to include the ITB role as defined in the NS 3935. By doing this, the ITB manager will be effective in using contractual, positional and charismatic authority to influence the projects which might increase the likelihood of delivering a functional building. Human theorists suggest that there should be a focus on forms of influence that promotes mutuality and collaboration in decision making (Bolman and Deal, 1984).

ii. Late involvement of ITB manager

Another crucial challenge that affects the ITB role is the late involvement of ITB managers, especially when everything has been planned, designed and executed. Based on the findings, it was discovered that ITB managers are often invited when the project is experiencing technical faults such as malfunctioning of the lighting, doors, heating and cooling, ventilation systems, etc. With the late involvement of the ITB manager, he/she finds it difficult to: (1) have a good overview and understanding of the project's scope and objectives; (2) make cost-effective changes in the project, especially after the technical solutions have already been implemented; (3) establish a good rapport with existing technical disciplines because they have a different level of understanding of the project's definition and scope; (4) ideals solutions are sometimes not generated to correct the errors, which sometimes takes a longer time. It is assumed that these resulting challenges increase the overall cost of the building since additional resources will be needed to resolve the issues.

By handling this challenge, the analysis suggests that the ITB manager should be involved throughout the project's development cycle to gain deep insight into the project definitions and objectives, make cost-effective changes, etc.

iii. High cost attributed to ITB role

Based on the discussions in section 6.1.4, it was discovered that the high cost attributed to the ITB role is another reason why the ITB role is not frequently used in the projects. Some project organisations see the ITB role as an additional expense that might increase the overall cost of the projects. By applying cost reduction strategies, they sometimes exclude the ITB role and allows their functional units to manage the integration role. This approach works perfectly in a well-planned and executed projects. In failed projects, it is assumed that the technical teams operate with silo thinking which negatively affects the achievements of the overall business objectives. The lack of coordination among these technical units results in the production of malfunction buildings which generates complaints from the end-users. For example, the lack of coordination between the cooling, ventilation and heating systems (HVAC systems) results in buildings becoming too hot or too cold. To resolve these technical errors, additional resources (budget, times, etc.) are needed to correct these technical faults or make significant changes, which often might extensively impact the cost increment. From the data analysis, it was discovered that the problem resolution process takes a longer time to develop ideal solutions, or sometimes, ideal solutions are not often developed to correct the errors, which renders the buildings ineffective or useless. From these analyses, it appears that the cost related to the ITB role is minor compared to the cost that has to be incurred when there are failures in the technical deliveries.

It is therefore natural to think that the deployment of ITB role comes with a cost. However, builders and contractors must critically think about the economic gains they want to achieve after investing a larger sum of resources (time, money, etc.) into the building's technical systems. Besides, if they want to meet increasing builders and end-users demands of providing error-free, functional and sustainable buildings, it is recommended that they make extensive use of ITB role. Per the findings, it is assumed that the delivery of functional buildings brings economic gains and satisfactory to builders since there is no need to spend extra budget in correcting errors or making significant changes. Hence the overall cost is improved.

iv. Lack of ITB manager's technical competence

Another challenge that affects the effectiveness of performing the ITB role is the lack of the ITB manager's technical competencies required to perform his/her role. Based on the literature review, some managers have the perception that they don't need technical competence to be effective in their managerial role (Integra, 2011, Dulewicz and Higgs, 2004). Within the context of ITB role, Integra (2011) argued that ITB managers are not responsible for the technicalities that lie between the various technical teams, and that such requirement should be attributed to the technical department. Per my research findings and analysis, it was noticed the ITB manager needs to have a good multidisciplinary understanding of the technical systems to be effective at giving advice or instructions. Thus, he needs technical competence to perform multidisciplinary technical functions. With the lack of technical competence, it can be assumed that that the ITB manager will face challenges of using the BIM and VDC models which are some of the very important digital tools for cost-effective data management and improving collaborative work. Based on the analysis, the thesis supports the notion that ITB managers need to develop their technical competence.

v. Lack of experience and awareness

From the research findings, it was discovered that some builders and contractors are not aware of the application of the ITB role in projects. Therefore, they do not understand the implications (benefits and challenges) of using the ITB role. This appears to contribute to minimal use of ITB role in projects. Since the builders or project owners are those who set the business objectives and approves the project executions (Hussein, 2018, Samset, 2010), it was found to be very important to make them understand the implications of the ITB role. The findings recommended that experienced ITB managers should use their expertise to educate builders and contractors about the implications of using ITB role. It appears that this approach would increase the awareness and application of ITB role in projects.

7.1.4 Overall Research question: How does a construction company like Rambøl perceive the ITB role?

As mentioned earlier on in Chapter 7.1 – Conclusion of the thesis, the answers to the main research question will be based on confirmation of the propositions presented in Chapter 6 – *Discussion*. The answers to these research questions will specifically describe how Rambøl perceive ITB role in projects. However, the answers can be related to other companies as well.

The informants defined the ITB role as a position that is responsible for coordinating the activities of the other technical disciplines to ensure that functional integrated systems are developed. From the analysis, it was discovered that building projects are becoming more complex compared to projects that were completed some decades ago. These modern buildings possess numerous technical systems that need to be coordinated and integrated to ensure their smooth operation when the buildings are in use. Per the data analysis, it was noticed that this coordinating function is effectively managed by dedicated ITB manager who assumes full responsibility for the success or failure of the integrated systems.

Many employees perceive the ITB role to be very important because it serves a focal point which aligns the objectives of the functional teams to support the achievement of the specifications/objectives set by the builders. The ITB manager uses multidisciplinary coordination as a tool to develop integrated solutions which provide a means to achieve the business objectives. Therefore, the employees of Rambøl consider the ITB role as a multi-disciplined position that required one to have a good technical understanding of the integrated system. They assume that the use of dedicated ITB managers results in the achievement of outstanding performance of the integrated systems. Many interview subjects believe that the use of ITB manager increases the likelihood of reducing the overall cost of the building by ensuring that extra budgets or resources are not used to correct technical faults or make significant changes after the building is completed.

However, Rambøl assumes that the ITB role is not frequently used in projects due to some challenges that need to be attended to. Some of the challenges include: the invisibility of the NS 3935 in the general contract – NS 8407, which results in the ITB manager lacking the contractual mandate to influence the project; ineffective testing operations because the NS 6450 is not specified in the general contract; late involvement of the ITB role which makes it difficult and expensive to make changes or completely understand the project objectives; high cost related to the ITB role; lack of ITB awareness and experience of builders and contractors, etc. Based on the analysis, it was noticed that these challenges are affecting the ITB role and making it difficult to achieve the objective of delivering buildings which are fully functional and environmentally friendly.

In an attempt to increase the likelihood of applying ITB role in projects, the findings recommend the amendment of the general contract – NS 8407 to include NS 3935 and 6450 to improve the effectiveness of the ITB role. Besides, it recommends that the ITB manager should be invited early in the project to gain an overview of the project, present and ask the right information and make cost-effective changes.

7.1.5 Summary of answers to research questions

Overall, the interviewee subjects supported the notion that the ITB role is a relevant position in building projects which needs to be extensively used to gain the desired benefits presented in Chapter 7.1.1. They recommended that the challenges stated in Chapter 7.1.3 need to be addressed by using the success factors presented in Chapter 5. 4 – *Success factors*, and Chapter 7.2 – *Practical implications*. The addressing of these challenges is assumed to improve the effectiveness and efficiency of the role.

The table below provides a summary of the answers to the research questions developed in this thesis.

Table 7. 2 Summary of answers to research questions

No.	Research Question (RQ)	Answers
1	To what extent is ITB role beneficial to building projects	i. Multidisciplinary coordination – the need to align the objectives of the various technical teams to support the achievement of the builder's objectives ii. Improve overall cost reduction iii. Increase the likelihood of delivering buildings that are functional and environmentally friendly
2	What relationships exist between the various ITB standards used in building projects?	The standards (NS 3935, 6450 and 8407) are closely related based on their impacts and functions. However, there is currently no established direct relationships between these standards which results in their ineffectiveness and minimal application of the ITB role. NS 8407 is the most frequently used contract standard in the building industry. It is assumed that the definition of NS 3935 and 6450 in the NS 8407 might improve the effectiveness and awareness of these standards.
3	what are some of the challenges hindering the application of ITB role in building projects?	• Lack of ITB manager's authority to influence the project' • Cost related to the ITB role • Late involvement of ITB manager • Lack of ITB manager's technical competence • Lack of ITB experience and awareness

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7.2 Practical implications

The main objective for conducting this research is to gain an insight into the application of ITB role in projects. The roles appear to be scarcely used in projects, so I intended to find out the extent to which ITB role can be made relevant or beneficial to the building industry. Also, I intend to find out some challenges that are behind the minimal utilisation of the position, as presented in Chapter 1.1 – *Research objectives*. In additions, I planned to find out which success factors or recommendations can be applied to increase the awareness and application of ITB role in projects.

From the semi-structured interviews performed with Rambøl, the thesis identified some suggestions that are relevant to improving the application of ITB role, which fits the scope of my research. The list of suggestions is based on direct recommendations from my interview informants, combined with impressions of how the process was described.

7.2.1 Recommendations for regulators

- The general contract standard, NS 8407 is one of the most commonly used contracts in the building industry. However, this standard appears to be incomplete because some vital specifications such as ITB roles, mandates and testing operations have not been defined in the contract. Per the findings, the

informants strongly recommend Standards Norway (SN) to amend and update the contract to clearly define the ITB roles and authority, and testing operations as defined by NS 3935 and NS 6450. It is assumed that this initiative might increase the effectiveness of ITB role in projects.

7.2.2 Recommendations for builders and contractors

- Builders and contractors who want to the make the most out of the investment in terms of economic gains, and achieve higher BREEAM rating (such as very good, excellent and outstanding) must extensively make use of ITB managers. Since ITB roles increase the likelihood of delivering buildings that are functional, sustainable and environmentally friendly, and they meet the criteria for higher credit rating.
- Also, builders and contractors are recommended to involve ITB managers throughout the project's development life cycle for effective planning and execution of the project. In this way, ITB managers will have the opportunity to ensure that: their roles and mandates are defines in the contract or tender; be able to present and ask the right questions to the group to reduce their uncertainties about the project; gain complete understanding and overview of the project's definition and objectives; to make cost-effective changes, etc.
- Builders are recommended to have to dedicated client ITB manager who will ensure that (1) ITB tasks and mandates are defined in tenders and other relevant documents that improves the effectiveness of the ITB manager, (2) will have overall responsibility for coordination and quality assurance of the entire ITB process, (3) collaboratively with other ITB managers and technical teams to ensure the specified objectives are met.

7.2.3 Recommendations for ITB managers or responsible

- ITB managers and contractors with good knowledge and experience with ITB role should inform inexperienced builders and contractors about the implications of using ITB role in projects. This is believed might increase the awareness and application of the role in projects.
- Besides, ITB managers should extensively make use of BIM and VDC models to cost-effectively design and plan projects, and manage data with other disciplines. ITB managers can use the ICE (Integrated Concurrent Engineering) platform of the VDC model to engage in a single and cost-effective meeting with technical teams to discusses issues relating to the installation of the integrated technology systems.

7.2.4 Recommendations for ITB related institutions

- Educational institutions and technical training schools should train students who have technical minds and are interested in building technologies, the concept of ITB and the implications of the ITB role.
- Establishment of social organisations to discuss and find means to address the challenges affecting the application of ITB role in projects. This is believed to improve the awareness and application of ITB role.
- By contributing to creating ITB awareness and increasing its applications, big building companies (such as Statsbygg company) with a substantial financial background can frequently deploy ITB roles in their projects. In this way, small and medium-sized companies will be encouraged to do likewise when they witness the benefits of the ITB role in huge investment projects managed by big building companies.

7.3 Limitation

As described earlier on in Chapter 4 – *Personal reflection*, the outbreak of coronavirus disease was one of the main limiting factors I encountered when I was conducting my research. My initial intention was to perform face-to-face interviews in order to do away with the issues related to online interviews such as loss of internet connectivity. However, in the course of the interview process, I was compelled to switch to online interview because of the coronavirus disease, and we were advised to maintain "social distancing". This challenge did not only affect my interview meetings, but also affected my meetings with my supervisor. In using the online computer-mediated interviews, I experienced discontinuities with internet connections and software applications (such as Skype) that were used as communication platforms. These challenges impacted my ability to receive some vital information that were presented by the interview subjects and my supervisor. In dealing with these challenges, I made use of different software application (such as Microsoft teams) which was much better compared to skype for business. After the corona outbreak had improved, my meetings with my supervisor were changed back to face-to-face meetings. By then, I have completed all my research interviews. The use of face-to-face meetings helped to clearly understand and grasp very important statements made by my supervisor, which assisted in writing a good thesis.

Another challenge that limited my research was the lack of academic publications that describe the ITB role. There were minimal theoretical assumptions that disputed or opposed the positive views that were expressed by authors of technical and conference reports which describes technical integrating roles (ITB roles). The effects of this limitation can be seen in the results of the propositions present in Table 7.1 were several propositions have been confirmed. It is assumed that the availability of considerable academic publications which present varying perspectives of ITB concept/roles might introduce some changes in the results. Therefore, the thesis recommends that ITB concept should be given the necessary consideration in academic publications to improve the number of academic pieces of literature in this research area.

7.4 Further Research

In this research, it was established that the use of ITB role increases the likelihood of delivering functional building, promoting multidisciplinary coordination and assisting to reduce the overall cost of the building. However, the use of ITB role to improves the reduction of buildings' energy consumption was neither confirmed nor dismissed. This was due to the insufficient amount of data acquired during the studies. Confirmation of this proposition might be subject to further research, as it is more appropriate to explain using historical analysis research design (Yin, 2018). This approach will involve trend analysis of quantitative data which describes how ITB role has been able to improve the performance of energy consumption in buildings.

Secondly, even though the qualitative data was used to confirm the extent which ITB role can increase the likelihood of improving the overall cost of buildings, there is another research opportunity where quantitative research can be used to investigate how ITB role has impacted the economic/financial aspect of a building

company or the industry as a whole. It is assumed that the presentation of information in quantitative forms are sometimes more preferred than qualitative because they provide hard facts, statistical data, and they provide objective analyses of a situation (Bryman, 2012). The use of historical analysis research design might be the more appropriate design for this research (Yin, 2018). It will also involve a trend analysis of the financial or economic performance of the ITB role.

From my research findings, it was discovered that the use of ITB role adds value to the business process and present socio-economic benefits. With this concept, researchers can investigate the extent to which ITB role can be used to provide a source of competitive advantages to both private and public building companies. Besides, these pieces of information can be used by builders and contractors to know the implication of using ITB role, and decide whether to involve the role in their projects or not. Besides, it will increase the awareness and application of ITB role.

Finally, the findings showed that the BIM and VDC models are two relevant digital tools that can be used to improve the roles of the ITB manager. With these tools, the ITB manager can collaboratively work with other disciplines to cost-effectively use data to plan, design and execute the project. Besides, the VDC model provides a meeting platform (ICE- Integrated Concurrent Engineering) which cost-effectively allows the ITB manager to engage in a single meeting with all the relevant stakeholders to discuss about the progress of the project. At the meeting, he can present and ask the right information to reduce his uncertainties about the project. The empirical findings showed that these tools are not frequently used by the ITB managers even though they provide cost-effective means of using data and improving collaboration between the technical disciplines. The thesis suggests that research should be conducted to discover implications (thus, opportunities and threats) of using the VDC and BIM Model to improve the performance of the ITB role.

7.5 Concluding Remarks

Based on the research findings, Rambøl perceives the ITB managerial role to be a very vital role in building projects because of the tendency to ensure the delivery of functional, cost-effective and sustainable buildings. Based on these benefits, and the ever-increasing complexity of modern building projects, Rambøl expects to see a significant growth in the interest of using ITB roles building projects. The company considers **ITB role as the future** for the building and construction industry, especially for building companies who want to meet the changing demands of their builders and want to maintain their competitive position the real estate market.

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APPENDIX A – INTERVIEW GUIDE

RESEARCH TOPIC: Application of ITB (Integration Technical Building installation) in construction projects.

1. BACKGROUND INFORMATION

a) Brief description about yourself, education and working experience

b) Brief description about Rambøl

I. Your position within the company

II. Numbers of years worked in Rambøl and construction projects

2. ITB CONCEPT

a) In your own words, how will you describe Integration Technical Building installation **(ITB)**

b) What are the roles and skills required of an ITB manager?

c) Have you ever been involved in construction projects where integration or coordination of technical installations (ITB) was implemented?

- How was ITB role important to the project
- What will happen if ITB is not used in projects?
- To what extent does the success of a project depend on ITB?

d) To what extent do construction projects need a dedicated ITB manager.

- Can ITB functions be added to the duties of a subcontractor? Explain your answer

e) At which stage of the construction project should an ITB manager or function be employed? Explain your answer.

f) What are some of the challenges with ITB?

- How is ITB seen as a cost in project

g) When is one referred to as an ITB manager, and what skills does he need to be one?

h) How do ITB managers get their authority to operate? Positional or contractual

i) In your opinion, do you think ITB managers have the needed authority to carry out coordinating functions and to effect changes?

- How do ITB managers get their authority to operate? Positional or contractual

3. ITB CONTEXT

A. Contract Agreement

i. How will you describe a turnkey or general contract agreement (NS 8407)?

ii. Have you ever been involved in construction projects which were carried out as a general contract and ITB was used?

a) Yes, how did it influence the project?

b) No, did you feel or think there was a need for it?

B. Clients (builder)

i. How is ITB important to clients?

ii. To what extent do clients need personal ITB manager?

C. Norwegian standards

i. How will you describe the ITB standard **NS 3935:2019?**

a) what is its relevance?

ii. How will you describe the commission and Testing operation of technical installations standard **NS 6450: 2016?**

a) what is its relevance?

D. Building Information Model (BIM) tool

i. Are you familiar with the BIM tool?

ii. How will you describe the BIM in your own words?

iii. How relevant is the BIM tool to the ITB function or manager?

iv. How can the coordination between the BIM and ITB manager be enforced?

E. Virtual and Design Construction (VDC) model

i. Briefly describe the VDC model in your own words?

ii. What is the difference between the VDC and BIM model?

iii. How does the VDC model related to the ITB role?

F. Building Research Establishment Environmental Assessment Method (BREEAM)

i. How will you briefly describe BREEAM in your words?

ii. To what extent is the ITB role relevant to the BREEAM?

4. RECOMMENDATION

i. Since ITB or ITB manager is not mostly used in building projects,

What are your recommendations for promoting ITB or increasing awareness of the concept?

a) Should it be taught in school or it should be left in the hands of construction companies to train its personnel.

ii. How can the ITB standard NS 3935 be enforced in construction projects and be made possible for construction companies to make use of it?

APPENDIX B – PARTICIPANT AGREEMENT LETTER

DO YOU WANT TO PARTICIPATE IN THE RESEARCH PROJECT?

" A case study investigation of the importance and barriers connected to the Integrated Technical Building installations (ITB) managerial role in building company"

This letter requests if you would like to participate in a research project whose purpose is to gain more knowledge regarding the application of ITB in construction projects. In this letter, we will provide you with information about the objectives of the project and what the participation will entail for you.

Purpose

This research work is being carried out in support of a student's master's thesis. Its purpose is to determine the need for ITB in construction projects. It will explore test theoretical propositions about the concept of ITB and the implications of using such function in construction projects, both negative and positive. Other research objectives include:

- Gain deeper insight and understanding of ITB concept
- Increase the focus on ITB function and its standard NS3935:2019
- Investigate the importance of ITB function by highlighting the benefits and opportunities associated with ITB in commercial buildings.
- Get to know some of the challenges surrounding the concept and how it can be resolved

The research design is a case study involving a construction company (Rambøl) in Norway.

Who is responsible for the research project?

The *Norwegian University of Science and Technology (NTNU)* is responsible for the project. The master's thesis is being prepared by Prince Shadrack Okoe Adjequaye with supervision from Ola Edvin Vie (of NTNU).

Why are you asked to participate?

You are being asked to participate because you are either a manager or an employee in the building and construction industry. Your selection was primarily based on Prince Shadrack Okoe Adjequaye's familiarity with the local industry. An effort was made to select participants that could provide diverse perspectives.

What does it mean for you to participate?

Managers and employees in the building industry will be interviewed in two rounds. Each interview will last one hour and will be semi-structured (i.e. guiding questions will be asked). The second round will occur about 2-3 weeks after the first and is for explanation of purposes and to cover any gaps. Concerning the current situation regarding the spread of the coronavirus, most of the interview will be conducted via "skype for business". There will be audio recordings and notes taking from the interview. The recordings and notes are transcribed,

anonymized, and deleted immediately after. What you will be asked depends on whether you are a manager or an employee. Below are examples of types of guiding questions that might be asked.

Manager Participation:

You will be asked about the application of ITB in the construction projects, its impacts (both negative and positive) and how can the ITB function be enforced in construction projects. You will also be asked about the perception of employees regarding this function.

Employee Participation:

You will be asked about the application of ITB function in general and how they are employed in your construction building projects.

It is voluntary

It is entirely voluntary to participate in this project. If you choose to participate, you can withdraw your consent at any time without giving any reason. All information about you will then be anonymized. It will have no negative consequences for you if you do not want to participate or later choose to resign. However, your maximum participation will assist in producing quality research since I will have a comprehensive overview of the ITB concept.

Your privacy – how we store your information

We will only use the information about you for the purposes we have told you about in this letter. We process the information confidentially and in accordance with the Privacy Policy. Your information will only be accessible by the master's thesis student (Prince Shadrack Okoe Adjequaye) and his supervisor (Ola Edvin Vie).

Audio recordings are transcribed as soon as possible (maximum one month) and deleted thereafter. Audio recordings are stored on a USB key that is locked in a drawer only accessible to Prince Shadrack Okoe Adjequaye. This recording will be kept until the transcription is completed, then later destroyed. Transcribed versions of the audio recordings are anonymized by replacing personal data with a code (e.g. Bjørn = Employee 1). The code meanings are recorded on a physical sheet that is locked separately from other data. No participants will be directly identifiable in the master's thesis.

What happens to your information when we end the research project?

The project is expected to be completed on June 26th, 2020. All data shall be anonymized by the end of the project, and any remnants of personal data (e.g. code sheet) will be destroyed.

What gives us the right to process personal data about you?

We process information about you based on your consent. On behalf of the *Norwegian University of Science and Technology (NTNU)*, the Norwegian Center for Research Data (NSD) has considered that the processing of personal data in this project complies with the privacy regulations.

Where can I find out more?

If you have any questions for the study, or would like to take advantage of your rights, please contact:

- Norwegian University of Science and Technology by contacting either Prince Shadrack Okoe Adjequaye or Ola Edvin whose contact information is provided below.
- Our Data Protection Officer: Ola Edvin Vie at the Norwegian University of Science and Technology.
- NSD – Norwegian Centre for Research Data AS, by email (personverntjenester@nsd.no) or phone: 55 58 21 17.

Sincerely

Prince Shadrack Okoe Adjequaye
Shadrack.adjequaye@gmail.com
+47 93 99 48 70

Ola Edvin Vie
ola.edvin.vie@iot.ntnu.no
+47 735 96 340

(Researcher/student) (Supervisor)

Consent Statement

I have received and understood information about the project "*The application of Integrated Technical Building installations - ITB in construction projects"* and have been given the opportunity to ask questions. I agree to:

- participate in all semi-structured interviews mentioned

I agree that my information is processed until the project is terminated, approximately on July 2nd, 2020.

(Signed by project participant, date)

APPENDIX C – NSD CONFIRMATION LETTER

NSD NORSK SENTER FOR FORSKNINGSDATA

NSD's assessment

Project title

Digital competence of construction project manager

Reference number

139699

Registered

05.02.2020 av Prince Shadrack Okoe Adjequaye - psadjequ@stud.ntnu.no

Data controller (institution responsible for the project)

Norwegian University of Science and Technology / Faculty of Economics (EAC) / Department of Industrial Economics and Technology Management

Project leader (academic employee/supervisor or PhD candidate)

Ola Edvin Vie, ola.edvin.vie@ntnu.no, tel: 4773596340

Type of project

Student project, Master's thesis

Contact information, student

Prince Shadrack Okoe Adjequaye, Shadrack.adjequaye@gmail.com, doi: 93994870

Project period

09.03.2020 - 11.06.2020

Status

10.02.2020 - Assessed

Assessment (1)

10.02.2020 - Assessed

Our assessment is that the processing of personal data in this project will comply with data protection legislation, so long as it is carried out in accordance with what is documented in the Notification Form and attachments, dated 10 February 2020. Everything is in place for the processing to begin.

NOTIFY CHANGES
If you intend to make changes to the processing of personal data in this project it may be necessary to notify NSD. This is done by updating the information registered in the Notification Form. On our website we explain which changes must be notified. Wait until you receive an answer from us before you carry out the changes.

TYPE OF DATA AND DURATION
The project will be processing general categories of personal data until 11 June 2020.

LEGAL BASIS
The project will gain consent from data subjects to process their personal data. We find that consent will meet the necessary requirements under art. 4 (11) and 7, in that it will be a freely given, specific, informed and unambiguous statement or action, which will be documented and can be withdrawn. The legal basis for processing personal data is therefore consent given by the data subject, cf. the General Data Protection Regulation art. 6.1 a).

PRINCIPLES RELATING TO PROCESSING PERSONAL DATA
NSD finds that the planned processing of personal data will be in accordance with the principles under the General Data Protection Regulation regarding:

- lawfulness, fairness and transparency (art. 5.1 a), in that data subjects will receive sufficient information about the processing and will give their consent
- purpose limitation (art. 5.1 b), in that personal data will be collected for specified, explicit and legitimate purposes, and will not be processed for new, incompatible purposes
- data minimisation (art. 5.1 c), in that only personal data which are adequate, relevant and necessary for the purpose of the project will be processed
- storage limitation (art. 5.1 e), in that personal data will not be stored for longer than is necessary to fulfil the project's purpose

THE RIGHTS OF DATA SUBJECTS
Data subjects will have the following rights in this project: transparency (art. 12), information (art. 13), access (art. 15), rectification (art. 16), erasure (art. 17), restriction of processing (art. 18), notification (art. 19), data portability (art. 20). These rights apply so long as the data subject can be identified in the collected data.

NSD finds that the information that will be given to data subjects about the processing of their personal data will meet the legal requirements for form and content, cf. art. 12.1 and art. 13.

We remind you that if a data subject contacts you about their rights, the data controller has a duty to reply within a month.

FOLLOW YOUR INSTITUTION'S GUIDELINES
NSD presupposes that the project will meet the requirements of accuracy (art. 5.1 d), integrity and confidentiality (art. 5.1 f) and security (art. 32) when processing personal data.

To ensure that these requirements are met you must follow your institution's internal guidelines and/or consult with your institution (i.e. the institution responsible for the project).

FOLLOW-UP OF THE PROJECT
NSD will follow up the progress of the project at the planned end date in order to determine whether the processing of personal data has been concluded.

Good luck with the project!

Data Protection Services for Research: +47 55 58 21 17 (press 1)

APPENDIX D – CODES

Main themes	Categories	Mentioned	
ITB Description	7	59	
ITB Benefits	5	65	
ITB challenges	7	89	
Recommendation or Success factors	8	94	
		307	
ITB Description	**ITB Benefits**	**ITB challenges**	**Recommendation or Success factors**
History of ITB	Multidisciplinary coordination	Lack of contractual Authority	Amendment of NS 8407
coordination and Integration functions	Technical benefits	Lack of Budget and working hours	Early involvement of ITB managers
Quality assurance tool	Economic benefits	ITB invisibility	Coordination between BIM and ITB managers
Training tool	Stakeholder satisfaction	Lack of ITB manager's competence	Creating ITB awareness
Importance of Dedicated ITB manager	Achievement of BREEAM certifications	lack of ITB experience	Education and informing
Similar concept of ITB in other industries		Hight cost attributed to ITB role	Use of VDC model by ITB managers
ITB standards (NS 3935, NS6450, NS8407)		late involvement of ITB managers or role	Enforcement of ITB role by builders and contractors
		Silo thinking / Tunnel vision	Further Research

Prince Shadrack Okoe Adjequaye

ITB IS THE FUTURE

NTNU
Norwegian University of
Science and Technology