ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL

KNOWLEDGE MANAGEMENT TOOL PROPOSAL FOR EFFECTIVE CLAIM MANAGEMENT IN THE CONSTRUCTION INDUSTRY: A LESSON LEARNED APPROACH

M.Sc. THESIS

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Department of Civil Engineering

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İNŞAAT SEKTÖRÜNDE ETKİN HAK TALEBİ YÖNETİMİ İÇİN BİLGİ YÖNETİMİ ARACI ÖNERİSİ: ÖĞRENİLMİŞ DERSLER YAKLAŞIMI

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FOREWORD

I wish to convey my profound gratitude to Assoc. Prof. Dr. Deniz Artan for providing invaluable guidance and feedback during the preparation of my thesis. I deeply appreciate her significant contributions.

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Bartu Kologlu
(Civil Engineer)

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ABBREVIATIONS

AI	: Artificial Intelligence
BIM	: Building Information Modeling
CIOB	: Chartered Institute of Buildings
EOT	: Extension of Time
FDC	: Full Detailed Claim
FIDIC	: Fédération Internationale Des Ingénieurs-Conseils
HSEQ	: Health and Safety, Environment and Quality
IoT	: Internet of Things
IT	: Information Technologies
KAT	: Knowledge Archive Toolkit
KET	: Knowledge Enhancing Toolkit
KM	: Knowledge Management
KPI	: Key Performance Indicator
KST	: Knowledge Sharing Toolkit
KUT	: Knowledge Utilization Toolkit
NOC	: Notice of Claim
OM	: Organizational Memory
OL	: Organizational Learning

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KNOWLEDGE MANAGEMENT TOOL PROPOSAL FOR EFFECTIVE CLAIM MANAGEMENT IN THE CONSTRUCTION INDUSTRY: A LESSON LEARNED APPROACH

SUMMARY

This thesis aims to address the critical role of knowledge management (KM) in the construction sector, focusing on improving claim management practices. The study is driven by two primary objectives: first, to understand the current practices of KM in the construction industry through interviews with sector leaders, and second, to propose KM toolkits tailored for claim management to reveal how such tools can contribute to process enhancements.

The methodology unfolds across distinct phases, starting with reviewing existing literature on KM benefits and organizational practices and identifying challenges in the construction sector. Sector interviews were then conducted with leading construction firms to gauge their understanding and usage of KM, followed by similar interviews with consulting companies to compare practices. These interviews highlighted the need for improvements in KM within the construction industry, especially given the challenges and complexities of claim management. Furthermore, a review of the existing literature reveals a notable scarcity of research on applying KM theories to claim management. This thesis aims to address this gap by exploring and contributing to this under-researched area.

The literature review on claim management analyzed the processes that must be followed according to the type of contract. The challenges and key aspects are highlighted for a successful claim management and dispute procedure from the contractor's side. Based on these insights, a KM toolbox that consists of four KM toolkits was developed to facilitate more effective knowledge sharing and organizational learning (OL) in claim management. Their applicability was tested using the lesson-learned approach across five real-life case studies. Additionally, expert claim managers provided validation by ranking the proposed toolkits according to their potential benefits.

The research findings demonstrate that a strategic approach to KM in the construction sector can significantly improve claim management outcomes. The proposed KM toolbox, which consists of four KM toolkits, offers a structured framework to harness organizational knowledge, reduce claim resolution times, and foster a more proactive, collaborative culture. The toolbox aims to increase the efficiency of construction companies by exploiting OM and thus influence the sector in effective KM. Overall, this thesis contributes valuable insights and practical tools for construction firms aiming to transform their claim management processes through enhanced knowledge sharing and organizational learning practices. As per future studies, the KM toolbox that the thesis suggests could be digitalized, and real-life implementations could be tested.

İNŞAAT SEKTÖRÜNDE ETKİN HAK TALEBİ YÖNETİMİ İÇİN BİLGİ YÖNETİMİ ARACI ÖNERİSİ: ÖĞRENİLMİŞ DERSLER YAKLAŞIMI

ÖZET

Bu tez, hak talebi yönetimi uygulamalarının iyileştirilmesine odaklanarak Bilgi Yönetiminin (BY) inşaat sektöründeki kritik rolünü ele almayı amaçlamaktadır. Çalışmanın iki temel amacı bulunmaktadır: birincisi, sektör temsilcileriyle yapılan görüşmelere dayanarak inşaat sektöründeki mevcut bilgi yönetimi uygulamalarını anlamak; ikincisi ise, hak talebi süreçlerini iyileştirmeye katkıda bulunabilecek bilgi yönetim uygulama setleri önermektir.

Metodoloji, BY'nin organizasyonlara getirdiği faydaların literatürden incelenmesiyle ve inşaat sektöründeki uygulamalarda karşılaşılan zorlukların belirlenmesi ile başlamaktadır. Literatür taramasında kurumsal hafızanın oluşturulması, organizasyonel öğrenme yöntemleri ve BY araçlarıyla ilgili araştırmalara yer verilmiştir. BY'nin inşaat sektöründe kullanılmasıyla ilgili araştırmalar da incelenmiş ancak güncel uygulamalarla ilgili çalışmaların yetersiz görülmesi nedeniyle sektörden uzmanlarla röportajlar yapılarak bu eksikliğin giderilmesi hedeflenmiştir. Sektörde ileri gelen inşaat ve danışmanlık firmalarıyla röportajlar gerçekleştirilmiş ve BY konusunda sektörün yaklaşımı ve mevcut uygulamaları incelenmiştir.

Üç inşaat sektöründen ve üç danışmanlık sektöründen olmak üzere yönetici pozisyonunda altı katılımcı ile röportaj gerçekleştirilmiştir. Röportajda, yetkililere çalıştıkları firmalarla ilgili veri depolama yöntemleri, verilere veya depolanmış bilgilere ulaşım mekanizmaları, ne kadar sıklıkla kurumsal hafızadan yararlanıldığı ve firmaların bilgi paylaşım yöntemleri hakkında sorular sorulmuştur. Gerçekleştirilen görüşmelere dayanarak, literatür çalışmalarında da belirtildiği gibi, inşaat sektöründeki BY uygulamalarındaki eksiklikler tespit edilmiştir. Daha sonra, sektörün önemi ve süreç yönetimindeki zorlukları göz önüne bulundurularak, anlaşmazlıklardan doğan hak taleplerine mercek tutulmuş ve BY uygulamalarının süreci nasıl iyileştirebileceği araştırılmıştır.

Hak talepleriyle ilgili süreçteki zorlukları anlamak adına literatür araştırması yapılmıştır ve bu süreçteki sözleşmesel zorunluluklar ve sonucu etkileyen faktörler araştırılmıştır. Literatür çalışması sırasında BY'nin hak talepleri süreçlerinde kullanılmasını araştıran çalışma sayısının çok az olduğu görülmüştür. Bu tez çalışmasının bir diğer amacı ise literatürdeki bu eksiğin giderilmesine katkıda bulunmaktır.

Gerçekleştirilen röportajlardan ve literatür taramasından yola çıkarak, hak talebi yönetiminde daha etkin bilgi paylaşımını ve kurumsal öğrenmeyi kolaylaştırmak adına dört BY araç setinden oluşan bir BY araç kutusu geliştirilmiştir. BY araç setleri, içinde benzer amaçlara hizmet eden BY araçlarını barındırmaktadır. Dört adet BY araç seti oluşturulmuştur. Bunlardan ilki bilgi paylaşım araç setidir ve amacı firma içerisindeki çalışanların sahip oldukları bilgiyi birbirleriyle paylaşmak için gerekli şartları yaratmaktır. İkincisi bilgi kullanım araç setidir ve bu set çalışanların firma içerisinde var olan bilgileri günlük işlemlerinde kullanmayı teşvik etmeyi amaçlar. Üçüncü araç seti bilgi geliştirme araç setidir ve çalışanların uzmanlık alanlarında sahip oldukları bilgiyi artırmayı amaçlar. Sonuncusu ise bilgi arşiv araç setidir ve bir bilgisayar destekli program yardımıyla, firmaya dijital bir kurumsal hafıza oluşturmayı hedefler.

BY araç setlerinin uygulanabilirliğini ölçmek için, beş vaka çalışmasında "öğrenilen ders" yaklaşımı kullanılarak 21 adet senaryo test edilmiştir. Bu beş vaka çalışması farklı müteahhitlerin maruz kaldığı anlaşmazlık durumundan doğan hak taleplerini incelemektedir. Birinci vaka çalışması, müteahhidin öngörmediği hava koşullarından kaynaklanan verimlilik düşüklüğü yaşamasıdır ve bu sebepten ötürü idareye karşı bir hak talebinde bulunmasıdır. Anlaşmazlık çözüm kurulu, müteahhidi haksız bulur ve talebi kabul etmez. İkinci vaka çalışması aynı müteahhidin karşılaştığı iki farklı anlaşmazlık konusunu ele alır. Yaşanan anlaşmazlık konuları benzer olduğundan iki numaralı vaka çalışması altında iki durum da incelenmiştir. Müteahhidin hak talebinde bulunduğu konu, deprem çirozlarının parasının idare tarafından ödenmiyor olmasıdır. Müteahhit aynı anlaşmazlığı farklı iki idareyle yaşamıştır. İki durumda da, anlaşmazlık çözüm kurulu müteahhidi haklı bulmuştur. Üçüncü vaka çalışması, idare tarafından şantiyede güvenlik önlemlerinin fazla sıkı olmasından kaynaklanan verimlilik düşüşüyle ilgilidir. Anlaşmazlık çözüm kurulu müteahhidi haksız bulmuştur. Dördüncü vaka çalışması, müteahhidin saha teslimini vaktinde almamasından kaynaklı hak talepleridir. Müteahhit, idare tarafından geç teslim edilmesinden kaynaklı süre uzatımı talep ederken aynı zamanda yaşadığı verimlilik kaybından ötürü maruz kaldığı mali kayıpların da telafisini talep etmiştir. Bu durumda anlaşmazlık çözüm kurulu müteahhidin süre uzatım talebini haklı bulmuş, ancak diğer taleplerini reddetmiştir. Son vaka çalışması ise proje süreci boyunca müteahhide verilen dokümanlar arasındaki farklılığı ele alır. İhale zamanındaki gerekliliklerle, proje esnasındaki isteklerin farklılığını fark eden müteahhit, aradaki farkların doğan finansal değişikliklerine ve süreye etkilerine binaen idareye karşı hak talebinde bulunur. Anlaşmazlık çözüm kurulu, müteahhidin talebini haklı bulur.

Tezde önerilen BY aracının doğrulanması ise dört adet BY araç setinin detaylı bir biçimde anlatılan beş vaka çalışmalarına uygulanarak, hak talebi yönetim sürecinin ne şekilde değişebileceği gözlemlenerek gerçekleştirilmiştir. Bu amaçla beş adet uzman hak talebi yöneticisiyle önerilen BY araç setlerinin vakalar üzerindeki potansiyel faydalarını inceleyen bir röportaj çalışması yapılarak teyit işlemi gerçekleştirilmiştir. Hak talebi uzmanları 21 adet senaryoda BY araç setlerinin uygulanabilirliği konusunda görüşlerini bir ile beş arasında verdikleri puanla derecelendirmiş ve BY araç kutusuyla ilgili görüşlerini beyan eden iki adet açık uçlu soruya cevap vermiştir.

Araştırma sonuçları, inşaat sektöründe BY'ye yönelik stratejik bir yaklaşımın, hak talebi yönetimini veya sonuçlarını önemli ölçüde iyileştirebileceğini göstermektedir. Uzmanlar, BY araç setlerini %71 ile %89 arasında değişen oranlarda uygulanabilir olarak görmüştür. Açık uçlu sorulara verilen cevaplar da önerinin kullanılabilir olduğunu teyit etmektedir. Önerilen BY araç setleri, kurumsal hafızadan yararlanmak ve daha proaktif ve işbirlikçi bir kültürü teşvik etmek için yapılandırılmış bir strateji sunmaktadır. Bu da inşaat firmalarındaki hak talebi çözüm süreçlerine pozitif bir etmen olarak yansımaktadır.

Sonuç olarak bu tez çalışması, bilgi paylaşımı ve kurumsal öğrenme uygulamalarıyla hak talebi yönetim süreçlerini iyileştirmeyi amaçlayan inşaat firmaları için öngörüler ve pratik araçlar sunmaktadır. Gelecekte araştırmalarda bu tezde önerilen BY aracı dijitalleştirilerek tezin çıktılarının teoriden çıkıp pratikte kurulumu ve gerçek projelerde kullanımı gerçekleştirilebilir. Geliştirilecek ürün, sektördeki inşaat firmaları tarafından deneme amaçlı kullanılıp, geri dönüşlere göre iyileştirmelerle hak talebi sürecinin daha etkin hale gelmesine önemli katkılar sağlayabilir.

1. INTRODUCTION

1.1 Problem Statement

Effective knowledge management (KM) has become crucial in today's rapidly evolving industries, as it plays a key role in sustaining a competitive edge and improving operational effectiveness. The construction sector remains significantly behind other knowledge-intensive industries in adopting modern KM strategies. This gap is especially noteworthy considering the complex characteristics of construction projects, which may involve large amounts of data, diversified expertise, and broad collaboration across various disciplines and sites.

The construction sector is commonly perceived as being resistant to adopting new technologies and advances, particularly KM. This issue is further exacerbated by the sector's reliance on project-based work, which often results in knowledge being secluded within specific projects. This leads to a pattern of recurring errors and inefficiencies. The absence of a methodical approach to KM leads to the failure to capture and utilize key lessons and best practices throughout the company's operations, which in turn results in missing opportunities for learning and improvement.

Furthermore, due to the mounting demands on construction companies to expedite project completion and reduce costs while improving quality, the need to leverage OM to guide decision-making processes cannot be emphasized enough. The construction sector's organizational memory (OM), which includes project databases, lessons learned, and past performance data, has the capacity to improve operational efficiency significantly. Nevertheless, this capacity is frequently not fully exploited due to insufficient knowledge management systems, which are unable to capture, store, and distribute knowledge efficiently. One of the areas most impacted by the mismanagement of KM and OM in construction companies is the claims management process. Effective lessons-learned practices are crucial in managing claims efficiently.

In order to succeed in a highly competitive and resource-limited environment, construction companies must prioritize the creation and execution of strong KM strategies. This requires not only using technology to support the sharing of knowledge but also cultivating a culture that places importance on continuous learning and the transfer of knowledge. Construction companies may optimize their intellectual assets, streamline operations, eliminate redundancies, and ultimately achieve much greater project success and organizational growth by enhancing their KM methods.

1.2 Purpose of Thesis

This thesis aims to enhance the understanding and application of KM within the construction sector in the context of claim management. It aims to fill the existing gaps in modern applications and provide actionable strategies for the industry.

The first objective is to understand current KM practices in the construction sector. The initial objective is to thoroughly investigate and document current KM practices in the construction sector. This involves conducting detailed interviews with leaders from multinational construction firms to gather insights into how KM is currently integrated and utilized within their operations. The aim is to identify existing practices, pinpoint areas of strength, and uncover gaps where improvements are necessary. This assessment will provide a solid empirical foundation for the thesis, reflecting the real-world application of KM within the sector.

The second objective is to develop and propose specific KM toolkits that are not just theoretical concepts but practical solutions designed to enhance the efficiency and effectiveness of claim management processes. These toolkits, based on the lessons learned from current KM practices, will be tailored to address the unique challenges of claim management in construction. Each toolkit aims to facilitate better management of claims through structured knowledge sharing, improved documentation practices, and enhanced collaborative environments. The efficiency of these toolkits will be evaluated through a series of case studies, which will apply the lesson-learned approach in applicable scenarios to illustrate the potential improvements KM can bring to claim management.

The objectives aim to narrow the gap between current approaches and potential improvements in KM and showcase the true benefits of a structured KM strategy.

These benefits include managing risks, increasing efficiency, and easing institutionalization by creating a company culture. This thesis aims to contribute to the area by providing practical solutions that can be applied in the construction sector to harness OM and learning to gain a competitive edge.

1.3 Research Methodology

The methodology of this thesis is organized under six distinct headings: initial studies, literature review, sector interviews, solution proposal, case studies, and validation via expert reviews. Initially, the research identifies prevalent issues within the construction sector, delineating the problems arising from existing deficiencies in KM. A comprehensive literature review follows, exploring the potential benefits of KM alongside related organizational practices, such as organizational learning (OL) and memory. Subsequently, the application of KM in the construction sector is scrutinized, with a specific focus on claim management due to its inherent challenges and procedural complexities.

To gain a deeper understanding of current KM practices, representatives from three multinational construction firms are interviewed, thereby capturing the insights of industry leaders. Similar interviews are conducted with leaders from the consulting sector to benchmark these findings against a sector renowned for its proficient use of KM. This comparative analysis validates the weaknesses identified in the literature review and highlights potential areas for improvement based on advanced KM practices observed in other sectors.

Following the interviews, a solution proposal is crafted, advocating for the implementation of KM toolkits to enhance efficiency in claim management. This proposal is informed by insights garnered from the literature and interview outcomes, leading to the development of four distinct KM Toolkits, each designed to improve different facets of KM within claim management. Five case studies are analyzed in a lessons-learned study to evaluate the efficacy and applicability of these toolkits. The dispute cases presented are chosen among real-life cases to better evaluate the applicability and usability of the proposed tools. However, the cases are anonymized, and certain elements in the cases have been changed to respect the confidentiality of the dispute resolution processes.

The applicability of these toolkits involves creating validation questions that detail the application of each KM Toolkit across the case studies. The final stage of the methodology involves expert reviews, where eight claim managers assess the interview question items and rank them based on the perceived benefits of the toolkits in effectively managing claims or achieving superior outcomes.

This structured approach ensures a comprehensive understanding of KM in the construction sector and facilitates the development of practical solutions tailored to the unique challenges of claim management. Thus, it contributes to the broader field of KM and its application in construction industry-specific contexts.

Table 1.1 : Research Methodology.

Method	Explanation	Thesis Section
Initial Studies	1) Identifying the construction sector problem, 2) Understanding the benefits of KM, 3) Determining study goal.	Thesis Section 1
Literature Review	1) Examining OM, OL, and KM, 2) Searching the implementations of KM in the construction sector, 3) Analyzing various KM tools, 4) Examining claim management procedures and analyzing the value of construction projects,	Thesis Sections 2 & 3
Sector Interviews	1) Understanding the need to conduct sector interviews to understand today's practices of KM, 2) To have a fair analysis of the position of the construction sector in the practices of KM compared to other sectors, the consulting sector is chosen as a counter-comparative reference, 3) Determining the questions to understand and compare the construction and consulting sectors' approaches to KM,	Thesis Section 4.1
Sector Interviews	1) Understanding the need to conduct sector interviews to understand today's practices of KM, 2) To have a fair analysis of the position of the construction sector in the practices of KM compared to other sectors, the consulting sector is chosen as a counter-comparative reference, 3) Determining the questions to understand and compare the construction and consulting sectors' approaches to KM.	Thesis Section 4.1
Solution Proposal	1) Determining the need for implementations of KM to claim management in the construction sector, 2) Grouping the KM tools in terms of their addition of value to KM sub-categories, 3) Proposing KM Toolbox, which consists of KM toolkits, that aim to improve the outcome of dispute claims or prevent them before occurring,	Thesis Section 4.2

Table 2.1 (continued) : Research Methodology.

Method	Explanation	Thesis Section
Case Studies	1) Finding five case studies of dispute claims caused by various reasons and have various outcomes, 2) Propose the usage of KM Toolbox.	Thesis Section4.3.1
Validation via Expert Interviews	1) Preparing application-based interview questions on the implementations of each KM Toolkit for every case study in a lesson-learned proposal 2) Collecting applicability ratings for the claim experts 3) Validating the usage of KM Toolbox in claim management procedures	Thesis Section 4.3.2

2. KNOWLEDGE MANAGEMENT IN CONSTRUCTION SECTOR

Intellectual assets are the main capital in industries that rely heavily on knowledge. For companies aiming to succeed in such environments, it is essential to develop internal procedures to gather, explore, and utilize both corporate and individual knowledge. The concept of "KM" first appeared in books, academic research, consulting, and organizational practices in Western countries during the late 20th century. However, KM's practical application didn't take off until the mid-1990s. Despite this, elements of KM, like knowledge-sharing activities, were present in companies long before the term was coined. For instance, in the early 1990s, leading companies such as BP, Shell, and Chevron already implemented KM initiatives before any academic literature on the subject was published (Quintas, 2005). This indicates that KM practices were naturally integrated into cooperative efforts to gain a competitive edge and enhance business performance. Today, KM is central to any modern business, driven by rapid advancements in information and communication technologies, leading to a significant shift from tangible to intangible assets, emphasizing the importance of people and knowledge.

OL is a dynamic KM system focused on identifying, maintaining, distributing, and leveraging knowledge. It allows for continually revising OM for each project, helping organizations build on what they've learned. Organizations are viewed as cognitive entities that reflect on their actions, experiment with alternative solutions, and optimize their approaches to enhance performance (Robey et al., 2000). Successful outcomes are closely tied to these OM revisions. This learning culture promotes individual and collective capacity for higher performance among employees (Kululanga et al., 2001).

The construction sector, a knowledge-intensive environment, depends significantly on knowledge from various project participants (Ferrada et al., 2016). Unlike other industries that can thrive with a single successful business model, each construction project is unique, especially infrastructure projects, and faces distinct challenges requiring unique solutions. Therefore, past experiences are invaluable, as they can help generate new solutions if they relate to similar past incidents. Consequently, construction firms gain a competitive edge by effectively transferring knowledge from previous projects to new ones, making capturing, sharing, and using corporate knowledge crucial to prevent its loss (Ferrada et al., 2016).

Although many sectors have developed methods to manage their specific types of knowledge, companies in the construction sector have only begun to embrace the concept of KM in the past decade (Rezgui and Miles, 2011).

The construction sector is a multilayer knowledge-based environment that relies heavily on knowledge input from different project parties (Ferrada et al, 2016). It differentiates itself from other industries that can thrive using a single successful business model; every project differs immensely from its predecessor, especially for infrastructure projects. Every project faces different challenges that require unique solutions for the contractor to implement. Thus, the experience becomes marginally significant as new solutions can be derived more easily if they can be related to a similar incident from the past. For this reason, construction firms can distinguish themselves from their competitors if they can convey their know-how from previous projects to the upcoming ones. For this reason, capturing, sharing, and utilizing the combined knowledge of a company is essential to prevent the loss of corporate knowledge (Ferrada et al., 2016).

Even though many sectors have adapted ways of managing the types of knowledge they encounter, it has only been in the last ten years that companies in the construction sector have started familiarizing themselves with the KM concept (Rezgui and Miles, 2011).

Construction firms must use KM to establish OM and consequently improve their performance by learning from past mistakes and best practices. Construction firms should aim to implement OL in every meaningful knowledge acquisition possible to be successful. Knowledge is the input to innovation; thus, the industry must adopt better ways of managing knowledge to advance the construction processes. KM consists of locating, modifying, and sharing knowledge to meet the needs of the current fast-paced sector. Various efforts have been made to support KM and OM in construction companies. However, addressing the sector's needs adequately for successful implementations is very important.

2.1 Organizational Memory

OM is an organization's collective memory. It was originally introduced to show how past experiences influence current behaviors (Stein and Zwass, 1995). OM relies on the continuous sharing of knowledge among individuals and organizational processes, distinguishing it from individual memory, similar to how OL differs from individual learning (Argyris and Schon, 1978). OM should not be limited to the memories of current participants, as employee changes should not impact the accumulated knowledge.

OM helps reduce transaction costs, aids decision-making, and serves as an organization's power base (Stein and Zwass, 1995). This is crucial for OL, as it connects past knowledge to present problems, improving strategic decisions and integrating new experiences. OM is defined as using past knowledge for present activities, allowing diverse information to enhance current operations (Ozorhon et al., 2005a).

The challenge for organizations is identifying useful past data for current situations, recognizing that solutions may vary by context. Organizations must refine their responses and understanding (Argote, 2013). Even if past experiences don't always apply, they may solve future problems.

Establishing OM is a key knowledge management activity that supports OL by collecting, sharing, and reusing employee knowledge, treating it as a valuable asset (Ozorhon et al., 2005a).

2.1.1 Components of OM

The idea of OM is a cornerstone in the ever-changing world of modern business, deeply ingrained in how companies maintain their inventiveness and competitiveness. The diverse elements of OM reveal a notion that goes beyond simple data collection; rather, it is a sophisticated combination of shared knowledge, life experiences, and educational procedures embedded in an organization's culture. Perhaps the most pivotal role comes in documentation, from meticulously archived records to digitally stored data, serving as a tangible reservoir of organizational history and processes. As this component is also one of the key research areas of this thesis study, it is extensively explained in the Knowledge Management Tools Section of the thesis. Another key factor to consider is individual employee knowledge, which lies at the core of OM. Simultaneously, routines and practices become vital to integrating previous lessons into present-day operations and guaranteeing that historical experiences are translated into effective, modern action. Moreover, an organization's hierarchy and networked relationships substantially affect the flow and accessibility of knowledge, which in turn affects memory retrieval and retention. Furthermore, external archives offer a wider perspective by connecting the internal knowledge base of an organization with the abundance of external intelligence. This section aims to cover the importance of the aforementioned aspects of OM. The true understanding and implementation of OM in real-life activities rely highly on the concept's components.

OM is mostly composed of the information retained by individual employees. Individual employee knowledge becomes a crucial thread in the complex fabric of OM, bound into the foundation of how an organization views, processes, and holds onto information. This idea goes beyond the simple collecting of data to include the complex, varied, and frequently implicit experiences, abilities, and insights that workers build up over time. Individual knowledge is a dynamic and vital resource that provides a special perspective for understanding the past and planning the future. Significant efficiency in the dissemination of information in memory can be achieved at the group level because several factors are more favorable than at the company level: - a group is smaller in number, which means that the links of individuals can be closer, freer and more open (Bencsik et al, 2009). Combining these individual cognitive environments creates an organization's collective memory, which affects creativity, strategic direction, and decision-making. Knowledge and information are usually found in different individuals. It is common for knowledge and information to be available to different people. This is why companies aim to increase the capacity of individuals and organizational knowledge enhancers. This will require the development of strategic people management (Theriou and Chatzoglou, 2009). In this field, the relationship between individual thought processes and organizational frameworks reveals a complex interaction in which individual experiences both affect and are impacted by the organization's collective memory.

The significant influence of individual employee knowledge on the formation of OM is not only a theoretical concept but is supported by several empirical research and practical applications. The study undertaken by Argote and Miron-Spektor (2011) in their groundbreaking work, "Organizational Learning: From Experience to Knowledge," emphasizes the potential for individual experiences and insights to enhance organizational processes and decision-making when properly utilized greatly. They show that the sharing and integration of individuals' own expertise into the corporate knowledge base improves collective problem-solving capabilities and promotes creativity. Moreover, an analysis of Toyota's manufacturing system, as studied by Spear and Bowen (1999) in the Harvard Business Review, highlights the significance of human expertise in OM. The study demonstrates how Toyota's focus on ongoing growth and education, guided by the knowledge and experiences of its employees at every level, has played a crucial role in cultivating a strong and adaptable OM. This approach not only acquires the implicit information possessed by individual workers but also establishes it as a part of conventional work procedures, converting individual learning into a valuable organizational resource. Furthermore, Nonaka's (1994) theory of knowledge creation offers a structure for comprehending how personal tacit information is converted into explicit knowledge within an organization. The model demonstrates the constantly changing relationship between tacit and explicit knowledge, highlighting how individual, internalized information is transformed into articulated and disseminated knowledge across the organization, enhancing collective memory. Thus, individual employee knowledge is not separate; instead, it is an important factor in creating and maintaining OM. It plays a very important role in determining the ability of the organization to adapt and innovate.

Organizational knowledge embedded in routines and practices enhances efficiency through standardization of activities, reduced unpredictability, and reduced time and resources needed for decision-making. These routines are established, repeating behavior patterns or activities inside an organization used to accomplish certain objectives or tasks. An example of organizational routines in the construction sector can be seen by implementing safety rules and site induction procedures for new personnel. Safety is crucial in the construction industry, which is infamous for its hazardous operations. Many construction businesses have a standard practice of providing thorough safety orientations for all new on-site personnel.

These procedures are essential for businesses as they establish a structure for uniformity and effectiveness in operations, acting as a form of ingrained memory for the entire unit. They include many practices, from routine processes and standard operating protocols to the customs and traditions that characterize the organization's work methods. It is proposed that routines in organizations serve as the equivalent of individual abilities, providing stability and predictability. (Nelson and Winter, 1982). These procedures allow businesses to reach high operational efficiency by formalizing effective behavior patterns that can be easily duplicated. Feldman and Pentland (2003) distinguish between the demonstrative (the operational aspect of the routine) and the performative aspect (the actual adoption of the routine), stating that continuous improvements and efficiency in organizational procedures are achieved as a result of the interplay between both aspects.

Yet, the characteristics that enhance efficiency in routines and procedures can also result in organizational rigidity. The dual nature of routines highlights that although they enhance learning and efficiency, they may also inhibit adaptability by constraining organizations inside rigid behavioral patterns (Levitt and March, 1988). Established routines may continue even when they are no longer the best option, resulting in path dependency, where previous decisions overly limit present and future possibilities. Rigidities can impede creativity and adaptability, especially in fast-paced situations. Becker (2004) explores the 'capability rigidity paradox,' which refers to how formerly advantageous qualities might later hinder organizational adaptability. However, it can still be argued that if the organizational structure values and enforces OL activities, these routines will be subject to change over time.

External archives enhance OM by serving as an extension of an organization's internal knowledge repository. They offer a library of information that may be used to bridge gaps in internal knowledge, verify internal data, or provide historical context. This is crucial in the construction industry as regulations, technology, and market dynamics shift quickly. According to Huizing and Bouman (2002) documents and archives contribute to OM by acting as a barrier against the ever-changing character of internal memory, which can be affected by staff turnover or over the course of time.

Organizations use external archives to compare their performance with industry standards, understand new trends, and discover best practices. Organizations may enhance flexibility and competitiveness by combining external knowledge with their internal data and experiences to create a more dynamic learning environment. Interacting with other information sources in collaborative governance is highly significant as these archives may help in reciprocal learning and innovation (Ansell and Gash, 2008). Cohen and Levinthal (1990) introduced the idea of 'absorptive capacity,' which is an organization's capability to understand the value of fresh external information, integrate it, and apply it for business purposes. This capability is essential for properly utilizing external archives since it allows companies to enrich their OM with useful external information.

External archives play a crucial role in enhancing OM by providing access to a broader range of knowledge and information beyond the internal confines of the organization. In the construction sector, these archives can include industry reports, academic research, case studies, regulatory documents, benchmarking, and tender results that can inform decision-making, strategic planning, and innovation.

External archives contribute to OM by acting as an extension of an organization's internal knowledge base. They provide a repository of information that can be accessed to fill gaps in internal knowledge, validate internal data, or provide historical context. This is particularly important in the construction sector, where regulations, technologies, and market dynamics change rapidly. Huizing and Bouman (2002) discuss the role of documents and archives in OM, noting that external documents can counterbalance the potentially ephemeral nature of internal memory, which may be lost through employee turnover or the passage of time.

2.1.2 Organizational structure, culture, and OM

Organizational culture significantly impacts OM by affecting how information is generated, distributed, and preserved. Schein (1992) defines organizational culture as a set of common fundamental ideas that a group acquires while overcoming challenges related to external adjustment and internal harmony. A common set of ideas and values affects how responsive and open an organization is to new knowledge and its integration into the OM. A culture that prioritizes learning and sharing information creates an environment that encourages employees to participate in and interact with the OM actively.

The norms and values within an organization's culture may greatly influence how well knowledge is conveyed and integrated into the collective OM. A culture that promotes open communication and cooperation can enhance information sharing throughout the business, capturing vital knowledge for future reference. The culture of openness and shared learning transforms the OM into a dynamic asset rather than a stagnant information storage.

The organizational structure is a crucial aspect that might improve OM. The organizational structure directly impacts the organization's capacity to manage knowledge by processing, storing, and retrieving it. A flexible and decentralized organizational structure can promote freedom and leadership at lower levels, fostering innovation and the generation of new information (Tsoukas,1996). A decentralized organizational structure involves distributing decision-making authority across different levels and divisions within the organization instead of concentrating it at the top (centralized). Individuals and teams in various departments of the business have the freedom to make decisions related to their respective duties and responsibilities. In centralized systems, important decisions are made by a limited number of top-level managers, and instructions are sent down through the organizational structure. A decentralized structure facilitates the creation of a dispersed OM by integrating information and knowledge generation into the practices and routines of different teams and units within the company.

Based on Tsoukas' (1996) statement, a decentralized structure may encourage a culture of sharing knowledge by minimizing obstacles across various organizational divisions. It facilitates direct communication and collaboration, which are crucial for efficiently sharing and storing knowledge in the OM. Moreover, when the organizational structure is in harmony with a culture that prioritizes learning and sharing information, it generates a strong synergy that boosts the organization's capacity to innovate and adjust. This collaboration ensures that the OM is maintained and consistently enhanced by the experiences and insights of each employee, creating a dynamic asset for maintaining competitive advantage.

The relationship between the culture of the organization and the structure of the organization is very important for the creation and preservation of a strong corporate memory. A climate that encourages learning and sharing information and a supportive structure transforms OM from an elementary archive function into a strategic asset that fuels learning and creativity.

2.1.3 Decision-making and OM

OM is crucial for enhancing decision-making in companies through the integration of significant knowledge gained from previous experiences into current and future strategic plans. Companies can utilize OM to prevent duplicating previous errors, navigate evolving circumstances more rapidly, and make smart choices based on historical knowledge and expertise.

OM assists managers in making better decisions by providing data on earlier successes and failures. An organization's repositories, structures, and cultures hold valuable information that may influence decision-making. Organizations can benefit from accessing and understanding stored information to prevent previous mistakes and repeat successful techniques (Walsh and Ungson, 1991).

Efficient use of OM necessitates systems for collecting, preserving, and accessing pertinent information. With these systems created, decision-makers may easily access historical data, lessons learned, and case studies from past strategic operations. This access allows them to review previous achievements and failures to prevent repeating mistakes and utilize successful techniques.

The strategic application of OM in decision-making is further supported by the connection between OM and OL (Moorman and Miner, 1998). An organization's capability to innovate and adapt to changes in the competitive environment is greatly influenced by its ability to learn from prior experiences.

Companies with powerful OM systems may better handle uncertainties and complexity while making strategic decisions. For example, a construction company that has carefully documented and evaluated the results of its past market entry strategies can use this information to guide its approach to entering new markets. The company can make informed decisions by avoiding strategies that lead to poor performance and adopting those that lead to successful growth.

Leveraging OM in strategic decision-making allows businesses to become learning organizations that consistently develop and adjust using collected knowledge. This capacity not only prevents the occurrence of previous errors but also promotes a culture of intelligent decision-making. Success depends on collecting knowledge and establishing systems and cultures that support the practical use of this knowledge in shaping future actions and decisions.

2.2 Organizational Learning

OL is defined as a dynamic KM system that focuses on identifying, maintaining, and sharing knowledge and involves reviewing OM for each project in order to benefit from what has been learned. Organizations are seen as cognitive entities that can reflect on their actions, experiment with different solutions, and optimize their approaches to improve performance (Robey et al., 2000). For this approach to work effectively, it is very important to update the OM. This systematic approach to learning is effective for employees at all levels in organizations to improve their performance both individually and collectively (Kululanga et al., 2001).

2.2.1 Theoretical frameworks in OL: key concepts and models

Examining theoretical frameworks in OL is essential for comprehending the cultivation, sharing, and utilization of knowledge in business environments, especially in sectors such as construction management, where procedures and technology are constantly evolving. The focal point of this discussion revolves around many fundamental models and concepts that elucidate the intricacies of learning inside an organization.

The groundbreaking research conducted by Argyris and Schön on single-loop and double-loop learning serves as a crucial foundation. Single-loop learning is a technique in which faults are identified and rectified without necessarily questioning the system's fundamental values. This approach is prevalent in organizations that value conformity to established standards and processes. Double-loop learning, in contrast, entails the reassessment and modification of fundamental beliefs, policies, and objectives that underpin decision-making. Organizations operating in dynamic industries such as construction management must prioritize this profound level of learning. They must possess adaptability and engage in strategic reevaluation to successfully navigate complex projects and market swings (Argyris and Schon, 1978).

The model of knowledge generation proposed by Nonaka and Takeuchi is a major component of OL theory. It highlights the interplay between information that is unacknowledged and knowledge that is clearly spoken. Tacit knowledge, often specific to individuals and situations, is gained by direct experience and is challenging to articulate properly. In contrast, explicit knowledge is distinguished by its structured and methodical quality, which allows for easy communication and sharing. The subsequent sections will provide a more comprehensive exploration of the two categories of knowledge. Nonaka and Takeuchi argue that the dynamic interchange of these two types of knowledge, supported by processes like socialization, externalization, combination, and internalization, drives the creation of knowledge inside an organization. This paradigm is particularly relevant in the domain of construction management, where the imperative to transform practical, hands-on experience (tacit knowledge) into formal protocols and optimal methods (explicit knowledge) for the sake of OL and enhancement is of utmost significance (Nonaka and Takeuchi, 1995).

A learning organization is distinguished by its capacity to facilitate the acquisition of knowledge by its members and engage in ongoing transformation. An influential book on this topic is "The Fifth Discipline" by the renowned author Peter M. Senge. In his work, Senge (1990) proposes five disciplines that are essential for creating a learning organization: systemic thinking, shared vision, team learning, mental models, and personal mastery. Implementing this approach in construction management can lead to improved teamwork, creativity, and flexibility in addressing complex project requirements and changing industry conditions.

These theoretical frameworks not only shed light on the learning process inside companies but also provide practical consequences for construction management. They emphasize the need to foster a culture that encourages ongoing learning, analytical thinking, and flexibility, which allows firms to stay competitive and inventive in a quickly changing industry. Comprehending and implementing these ideas is crucial for construction managers who want to improve organizational performance using effective KM and OL methodologies.

2.2.2 Factors affecting OL

Three contextual aspects are closely interconnected with the prevalence and improvement of OL. The aspects include business culture, strategic flexibility, and the environmental setting. (Fiol and Lyles, 1985). Each of these components facilitates and enhances learning within an organization and is also influenced and redefined by the learning process itself.

The initial component, organizational culture, is demonstrated by the dominant ideas and established behavioral patterns that exist inside an organization. Closely related to the culture required to institutionalize an OM, a similar understanding must be established as an environment to be suitable for OL. An organization's culture is formed by the collective beliefs, ideologies, and conventions that substantially impact the activities taken by the organization. Miles et al. (1978), claim demonstrating the strong connection between an organization's strategic position and cultural values. They argue that overarching belief systems partially determine strategy and organizational transformation trajectory. These norms significantly impact the possibility of organizational behavioral and cognitive growth. Hence, organizational transformation and learning often require a reassessment and reorganization of these overarching norms and belief systems (Argyris and Schon, 1978).

The second aspect, strategy, plays a crucial role in determining an organization's ability to acquire knowledge. Strategy defines the desired outcomes, targets, and the various options for executing a strategy. The text establishes the criteria for making decisions and offers a framework for understanding and analyzing the surroundings. The recognized strategic possibilities indicate the organization's ability to acquire knowledge and adapt (Burgelman, 1983). The company's strategic orientation creates a force that is difficult to shift with little adjustments and requires significant, transformative changes for repositioning.

The contextual context, encompassing internal and external factors, ultimately has a pivotal impact. An excessively intricate or ever-changing environment might result in cognitive overload, impeding learning. Hedberg (1981) argues that learning requires finding a harmonious equilibrium between alteration and constancy. An excessive level of stability might decrease motivation to learn, while an excessive amount of change can make it challenging to understand and navigate the environment (March and Olsen, 1975). Learning entails effectively balancing the conflict between stability and transformation, where a certain degree of pressure is essential for learning to occur. The efficacy of the learning conditions and the perception and understanding of the environment are impacted by the degree of stress and uncertainty regarding previous achievements (Daft and Weick, 1984).

2.2.3 Measuring the impact of OL by metrics and evaluation techniques

Evaluating the effects of OL is a complex yet crucial component of KM in a corporation, especially in industries such as construction, where the learning results directly impact project success and the organization's growth. This entails developing suitable measurements and evaluation procedures that may precisely reflect the scope and efficacy of learning within the company. The difficulty lies in measuring a frequently subjective process that is firmly ingrained in the organization's everyday operations and culture.

An effective strategy involves creating a collection of Key Performance Indicators (KPIs) that are in line with the organization's strategic goals. Research has shown a positive association between learning organization practices and firms' financial performance (Elinger et al, 2002). Within the realm of construction, KPIs may encompass measurements pertaining to project delivery timelines, adherence to budgetary constraints, safety records, and the caliber of completed projects. By monitoring fluctuations in these metrics over time, firms can assess if their learning are resulting in enhanced operational efficiency.

Another crucial measure is the pace of innovation within the organization. The quantification of this can be achieved by the assessment of the number of novel procedures or methodologies devised, the integration of innovative technologies, or enhancements in the utilization of designs and materials. The elements of intellectual capital are argued to influence organizational capabilities for incremental and radical innovation (Subramaniam and Youndt, 2005). Similarly, it is argued that the institutionalized knowledge that an organization acquires, accumulates and utilizes through its patents, databases, structures, systems and processes strengthens its existing knowledge and enhances its incremental innovative capabilities. Within the construction field, an organization's ability to learn and adapt can be shown through the rate at which it innovates. This can be the on-site or the off-site innovations. This is particularly important because differentiating projects and operating efficiently can provide a company with a strong competitive edge.

Employee feedback and engagement levels offer valuable information into the efficacy of learning initiatives. Conducting regular surveys, interviews, and focus groups can assist in evaluating employees' perceptions of learning opportunities and determining if they believe these possibilities are positively impacting their professional growth and job contentment. Effective OL can be inferred from high levels of involvement and positive feedback.

Furthermore, the capacity to effectively adjust to modifications and unexpected obstacles, particularly significant in the ever-changing domain of construction, can serve as a crucial indicator of learning. This may involve evaluating the organization's ability to promptly and efficiently adapt to shifts in market conditions, laws, or technical progress.

To summarize, assessing the influence of OL in construction management necessitates a comprehensive and diverse methodology. An organization's effectiveness in learning and growing can be assessed by a complete evaluation that incorporates both quantitative and qualitative indicators. These metrics encompass several aspects, such as project performance, innovation rates, employee involvement, and adaptability. These measurements not only enable ongoing improvement but also aid in aligning learning programs with strategic objectives.

2.2.4 The role of leadership in fostering OL: a management perspective

The task of leadership in promoting OL, specifically from a managerial standpoint, is a complex and crucial factor in the development and flexibility of any organization. Within OL, leaders serve as more than mere administrators or decision-makers. They play a crucial role as the creators of a culture that promotes learning and as the driving forces behind sharing information and generating creativity. The function is particularly important in dynamic industries such as construction management, as the capacity to acquire new knowledge and adjust accordingly can directly influence project outcomes and the company's long-term viability.

Successful leadership in promoting OL encompasses various crucial elements. Leaders must exemplify and advocate for a vision of perpetual learning and enhancement. This entails advocating for learning programs and actively engaging in them. Through this action, leaders establish a benchmark and foster a culture that appreciates and promotes the pursuit of knowledge and questioning established norms. This can have a significant effect on construction management, as changing technologies and processes require continuous learning.

Additionally, leaders should actively promote the establishment and upkeep of systems that foster the exchange of knowledge and encourage collaboration. This involves the implementation of technological platforms for KM, as well as the establishment of organizational structures and processes that foster open communication and collaboration. Building projects could entail using cross-functional teams and frequent knowledge-sharing sessions to ensure that key insights and lessons learned are efficiently recorded and distributed. In a research published by the Chartered Institute of Building (CIOB), Green (2016) notes that leaders who prioritize training and development in areas like Building Information Modeling (BIM) and green construction techniques have led their organizations to gain competitive advantages.

Furthermore, leadership in OL also involves recognizing and fostering potential within the business. This entails not only acknowledging and cultivating the abilities and proficiencies required for present positions but also anticipating future requirements and equipping personnel for forthcoming difficulties and prospects. An environment that fosters experimentation and creativity is essential for learning, particularly in the dynamic field of construction management. Research has consistently shown that leadership styles significantly impact OL. Transformational leadership is defined by García-Morales et al. (2012) as a leadership style that raises awareness of collective interests among members of the organization and helps them achieve their collective goals. This leadership style is used to analyze, change and direct systems, share knowledge through OL and transfer it to future projects.

Furthermore, leaders must possess the skill of change management, as developing a learning organization generally necessitates substantial alterations in culture, procedures, and conduct. It necessitates both strategic foresight and the capacity to communicate proficiently, handle opposition, and synchronize different stakeholders' many interests and objectives (García-Morales et al, 2012).

To summarize, leadership plays a complicated and multidimensional function in promoting OL from a management standpoint. It necessitates the integration of vision-setting, culture-building, talent development, and change management, which are crucial for establishing an atmosphere where continual learning and enhancement are ingrained.

2.3 Knowledge Management

An essential capability in the developing knowledge economy is KM. The ability to use knowledge efficiently gives it a competitive edge for any organization. However, organizations have a valuable resource in the unstructured knowledge that serves as the daily currency for their knowledge workers, and this resource is typically only maintained and managed as part of collective human memory that has the possibility of being lost (Conklin, 2001). Knowledge depreciation has a significant negative impact on companies' strategic behavior. Up-to-date knowledge better indicates present productivity than cumulative output if knowledge depreciates (Argote, 2013). Therefore, the advantages of possessing a large stock of accumulated information are diminished by knowledge depreciation. A newcomer to the industry would not be disadvantaged compared to companies with a significant cumulative knowledge pool under knowledge depreciation conditions (Argote, 2013). When we mirror the situation in the construction sector, it is clear that KM is a must for big firms to maintain their legacy.

Resources and competencies are critical factors for construction companies to survive in an evolving and fiercely competitive atmosphere in the knowledge-based economy

(Subramaniam and Youndt, 2005). Thus, one of the biggest challenges is to be able to distinguish characteristics of knowledge from information. There is a popular attempt to categorize types of knowledge in order to ease comprehending, storing, and sharing it. Each categorization considers different aspects of knowledge that guide the analysis in the specific field. The most applicable and renowned categorization for the KM field belongs to Polanyi (Polanyi, 1966), which divides knowledge into tacit and explicit knowledge. Understanding the distinguishing ways of tacit and explicit knowledge is essential to comprehend the notion of organizational knowledge. In order to benefit from KM as a pursuit of enriching OM and achieving productivity, the types of knowledge encountered must be analyzed.

Explicit knowledge is founded on widely recognized and objective standards. It is archived in the form of written procedures or documents. Therefore, it can be codified and communicated with relative ease. It encompasses the majority of knowledge exchange inside companies. Since explicit knowledge can be easily documented, formalized, and expressed, processes of sharing knowledge tend to be more widely used in the workplace. Several management tools are used to increase the willingness of employees to share their explicit knowledge, such as handbooks and information technology systems (Coakes, 2006). Since this knowledge can be codified, it may be reused repeatedly and is, hence, simpler to convey. Design codes of practice, performance requirements, paper-based or electronic drawings, and building methods are a few examples of explicit knowledge in the construction industry (Egbu and Robinson, 2011). Other instances of explicit information include design sketches and photographs, 3-D models, and textbooks. Explicit knowledge is the data that can be interpreted by others once it has been codified. People with supplementary knowledge who are able to understand the "codes" and derive meaning from them may be able to understand the presented knowledge. Even this process of comprehending or deriving meaning from knowledge requires the application of implicit interpretational, evaluative, and generalizing skills.

The foundation of tacit knowledge sharing is human experience (Nonaka and Takeuchi, 1995). Polanyi (1966) described tacit knowledge as instinctive knowledge that cannot be expressed coherently by means of words; it is acquired via collective involvement and can be challenging to describe, systematize, and transmit. The informal adoption of taught behavior and methods obtains the uncodified and disembodied know-how. Furthermore, tacit knowledge cannot be directly conveyed to someone since knowledge and task performance have distinctive personal qualities, requiring the acquirer to adjust their mindset. Hence, the degree to which it is conveyed varies. Tacit knowledge can be maintained by individuals or as a team in the form of collective experiences and assessments of events. Employee objectives, capabilities, routines, and intangible information are sources of individual tacit knowledge. On the other hand, collective tacit knowledge may arise from various notions, including top management strategies, organizational agreement on previous shared experiences, company procedures, company culture, and professional customs (Lyles and Schwenk, 1992). Tacit knowledge can also be described as knowledge that has been converted into a habit and possesses a personal quality, as well as being very context-specific. The reality of tacit knowledge is that the less clear and codified the tacit know-how, the more difficult it is for individuals and businesses to internalize. Academics and managers have overlooked the notion of tacit knowledge until recently, although it now plays a major role in corporate growth and economic competitiveness (Howells, 1996). Transmitting tacit knowledge is frequently done primarily through direct conversation. Some tacit knowledge transfers are official as a result of training programs or seminars, while others are more informal as a consequence of interdepartmental work teams, unofficial social networks, and personnel interactions. The desire and ability of individuals to share their knowledge and apply it in practice are crucial to the formal and informal transmission of tacit knowledge (Holste and Fields, 2010). On the other hand, explicit knowledge is able to be formalized and communicated through structured and methodical means, such as in the form of rules and procedures (Nonaka and Takeuchi, 1995).

The difference between individual and collective explicit knowledge is that individual explicit knowledge consists of expertise and abilities that are easily teachable or writable, whereas collective explicit knowledge lies in standard operating procedures, record keeping, IT systems, and policies (Brown and Duguid, 1991). Regarding innovation speed and financial success, tacit knowledge sharing is more influential than explicit knowledge sharing, whereas innovation quality and operational efficiency are influenced more by explicit knowledge sharing (Wang and Wang, 2012). Thus, companies must learn to share and store both knowledge practices to unlock their potential benefits fully. The following statement explains the criticality of harmonizing explicit knowledge with tacit knowledge; “If NASA wanted to go to the moon again, it would have to start from scratch, having lost not the data, but the human expertise that took it there last time” (Brown and Duguid, 2000).

In a knowledge economy, conducting business has opportunities as well as drawbacks. The opportunities include the potential for expanding market share, enhancing productivity, and increasing profitability through innovation and efficient knowledge asset management. The key difficulties are dealing with rising global competitiveness, shifting levels and patterns of client, customer, and societal demands, and the speed as well as effects of change in information and communication technologies (Egbu and Robinson, 2011). In order to gain a competitive edge, one must be able to use knowledge efficiently. A common question is whether organizations store knowledge in memory similarly to how people do. The answer is that there is a rising notion that organizations do have frameworks, practices, structures, and other tangible artifacts that demonstrate the existence of knowledge encoded in the organizational culture.

The formation of an OM within an organization is a critical KM activity that promotes the OL processes (Ozorhon et al, 2005a). OM can be defined as the means by which knowledge from the past is brought to bear on present activities; thus, it helps to learn from previous experiences (Stein and Zwass, 1995). OM becomes a corporate asset by sharing, organizing, storing, and reusing the knowledge created previously. The KM activities within organizations should aim to enhance the OM.

OM requires continuous improvement and growth of organizational knowledge, which means that both the organizations and the individuals within them must be constant learners. One important aspect of KM is its need to reinvent your organization through learning constantly. Experience-based knowledge is incorporated into procedures and is embedded in technologies and systems. Organizational routines and a culture that encourages the creation, assimilation, and abandonment of outdated information and practices must be developed in order to promote continuous change. Organizations must accomplish two goals that may be in conflict with one another: first, they must build their knowledge bases over time and draw lessons from their past experiences; second, they must make sure that they are learning outside of their core competencies and develop the capacity to assimilate new knowledge in order to be able to respond to change (Quintas, 2005). The generation of knowledge is frequently seen as somehow more significant than knowledge reuse, more challenging to manage, and less dependent on information technology support. However, perhaps a more common organizational concern—and one that is unmistakably tied to organizational effectiveness—is the efficient reuse of knowledge (Markus, 2001). The reuse of knowledge in various decision-making mechanisms and circumstances is expected to result in the generation of new remarks that automatically update the OM when stored back into the system. A cycle should be made where OM is referred to on knowledge transactions, and outcomes are reflected back to enhance the OM.

Construction companies must implement KM mechanisms in their daily routines to improve effectiveness and thrive in an overly competitive sector. In order to meet this objective, first, the sources of knowledge generation need to be analyzed, as well as the type of knowledge they generate. As explained in the previous section, the possible tools for regulating and sharing tacit and explicit knowledge differ due to the nature of the knowledge.

2.4 Knowledge Management Tools

Various tools are available for KM; thus, choosing the right one that aligns with the organization's objectives is crucial. These tools can be categorized into IT and non-IT categories that support key elements such as knowledge sharing, reuse, and access. Experts suggest calling IT tools KM technologies and non-IT tools KM techniques (Al-Ghassani et al., 2005).

KM techniques do not rely on IT tools for activities such as knowledge sharing, recognizing that human knowledge is beyond what can be captured digitally. Examples of these techniques include seminars, post-project evaluations, communities of practice, project feedback systems, mentoring programs, and training initiatives. Social knowledge benefits from these interactions and enables employees from different backgrounds to share knowledge. For example, post-project evaluations, feedback mechanisms, and mentoring programs increase knowledge transfer by mimicking the master-apprentice model. Although simpler to implement than IT-based tools, these techniques are valuable for sharing tacit knowledge that is often unrecognized, such as problem-solving skills or business resources. Tacit knowledge is personal, derived from experience, and not easily documented. Therefore, its sharing relies heavily on communication within the organization and promoting common understanding and practices (Brown and Duguid, 1998).

The IT-based KM tools mainly focus on capturing codifiable knowledge. These tools act as a great OM archive that eases how organizations create an OL and KM culture. The data stored in software and hardware systems can be referred to and reused whenever necessary, making monitoring the data much simpler. Today, a variety of software-based programs on the market offer diversified approaches to KM.

Using Artificial Intelligence (AI) and machine learning-based software for KM is one of the leading trends in the knowledge industry. The classification, labeling, and retrieval of data are only a few examples of KM tasks that can be automated with AI's help. These technologies may analyze large volumes of unstructured data, making finding insightful patterns and trends in a company's knowledge base simpler. According to Forrester Consulting's principal analyst, Gualtieri (2016), between 60% and 73% of all the collected data within an enterprise goes unused for analytics. With the help of AI-driven KM tools, advanced data structuring could be done for an insight-driven data presentation for the knowledge seeker. The result is similar to a personal intelligence assistant that can revolutionize how knowledge workers consume meaningful information and increase their cognitive capacity by providing more efficient tools for processing, filtering, sorting, and navigating information sources (Jarrahi et al., 2022). Thus, by applying AI-powered algorithms, organizations can improve their search capabilities, use time more efficiently for KM operations, and provide employees with more personalized content recommendations. An ontology-based KM system is an IT tool that can enhance knowledge integration and retrieval by organizing knowledge data into a structured format. It extracts metadata from various sources and uses ontology and metadata standards to convert semi-structured and unstructured knowledge into structured knowledge for storage (Zhang et al., 2015).

Whether it is a more futuristic approach to KM, such as AI-based tools or more simple cloud-based archive programs, these IT tools share distinct key functions to cover the majority of the needs of KM. Firstly, a “Document Management” function must be present to act as an archive with a correct taxonomy for material and track document changes when they occur. The second one is a “Knowledge Archive”. Knowledge bases store structured and unstructured information in the system. These could be not only documents but also tutorials, videos, etc. The third key functionality is the “Security System.” This feature limits accessibility for predetermined employees, which determines which data is available to obtain. The fourth feature is a strong “Search Function.” This function aims to save time when searching for past documents. The final feature should be “Communication Tools”. Communication channels can make the systems much more efficient, especially when one has further questions on the uploaded material and can directly reach the author.

Information systems can play an essential role in storing and distributing knowledge. Today, construction firms benefit from various IT services, such as cloud services and data storage modules. Still, this KM is mostly managed by happenstance and systems lacking the abovementioned necessities. Additionally, due to the incompatibilities faced while using these systems, most data accounts for a single project storage, lacking the motivation to be stored for future needs.

One of the most important factors to consider while implementing KM tools in an organization is that they are inseparable. The methodologies and approaches work harmoniously to achieve KM's main objectives: Knowledge Sharing, Knowledge Usage, Knowledge Acquisition, and Knowledge Preservation. A study made by Peter Massigham (2014) evaluates the reflections of 23 KM tools in private cooperation, categorizing them into four objectives according to their purposes and benefits. The participating cooperation in the study is selected for being a knowledge-intensive organization with an aging workforce. During a five-year period from 2008 to 2013, a total of four KM toolkits and 23 KM tools were evaluated as part of a significant long-term transformation initiative. Each tool is evaluated using a methodology specifically created to address strategy, implementation, and performance. The results are given in Table 2.1 below.

Table 2.1 : Knowledge management tools and practical outcomes (Massighman, 2014).

KM Toolkit	Driver	Measure	Organizational Challenges
Knowledge Sharing	Connectivity	If search cycle efficiency is increased	Reduced the task completion time and customer. Satisfaction increased from 5.1% in 2009 to 38.3% by 2011.
Knowledge Usage	Experience	If sharing of experience is increased	Value-creating work performance declined. The activity score dropped by 45% between 2009 and 2011.
Knowledge Acquisition	Learning	If time to competence accelerates	Capability growth for learning and development increased from 3.4% in 2009 to 36% by 2011.
Knowledge Preservation	Risk management	If work outputs confidence increases	Decreases the risk of inconsistent interpretations: feedback from discussions with customers played an important role.

The findings of this study by Massigham (2014) show many valuable lessons for researchers in this field. One important outcome that can be noticed within the framework of this study is the validation of the performance increase of KM tools when applied together as a group.

2.5 Construction Sector & KM

Construction companies are project-based organizations that limit their knowledge generation to the site while executing the work or in the tender stage while preparing for the project. Projects are a valuable source of organizational know-how and expert knowledge. Still, because lessons learned from them are not consistently applied to new projects, there needs to be a culture of KM and active learning. This makes it difficult to capture and store knowledge. Construction companies have adopted a way of gathering and storing information on-site that is necessary to track the progress of their work. Still, they often need to improve when it comes to using that information on other projects or making strategic decisions. Due to obstacles specific to construction companies, the natural resiliency of the sector, and the lack of institutionalization of individual knowledge, construction firms cannot improve their OL competence compared to other industries (Ozorhon et al. 2005b).

Diverse risks involved in construction projects require a comprehensive and precise decision-making process throughout the project life cycle. Construction firms must use their know-how effectively to make strategic decisions and gain a competitive advantage in the sector. In pursuance of this, experience gained from previous projects and lessons learned from success and failure are valuable resources. In this context, OM can be used to improve the quality of strategic decisions in construction firms. OM can be established by utilizing KM mechanisms that stay dynamic throughout a construction project's life cycle.

The activities of today's construction industry demand an increased level of knowledge, skills, and learning, as the sector is a multilayered knowledge-based environment that has knowledge input from different project parties (Ferrada et al, 2016). Explicit and tacit knowledge come together to form organizational knowledge. In every individual's thought lies an accumulation of tacit knowledge. It is a collection of experiences, observations, and intuition that can be either cognitive or technical. Examples of tacit knowledge in the context of construction may include estimating and tendering prices that have been prepared over time through practical experience in preparing bids, encountering the construction processes, interaction with clients/customers and project team members in the construction supply chain, as well as an understanding of markets. Experience-based, judgmental, and context-specific knowledge makes it challenging to codify and share this type of knowledge.

Explicit knowledge in construction is generally the data obtained from site activities. This could be man-hours, machine hours, periodical reports, unit prices, and anything generated from real-life implementations. As a result, better KM methods should be the primary target for comprehending the overflow of data in the construction sector. However, this might be unfavorable initially for some managers due to the lack of human resources or timely pressure on on-site activities. Thus, the general outcome and long-term benefits of adopting such an ideology must be made clear to decision-makers for the right resource allocation. Every employee in a construction organization must embrace a culture that values knowledge capture and sharing of knowledge.

However, a set of socio-technical barriers defined by Rezgui and Miles (2011) limit the progress of KM in the construction industry. Firstly, employees do not perceive any immediate benefits from sharing knowledge and experiences. In fact, this is seen as a possible threat to their status as "experts" since there is usually no encouragement for a supportive knowledge-sharing culture focused on all employees. (e.g., by implementing creative ways for rewards and recognition). Next, shelf solutions do not work, and there is a weak culture of software adoption. In order to perform their duties and access software, employees are frequently limited to a specific place, which is usually their office. However, access to information from construction sites is frequently constrained by network availability. Another obstacle is that the industry is divided and organized into numerous disciplines, each with its own rules and specialized terminology. No particular language captures a shared comprehension of construction principles utilized across disciplines. All these aforementioned challenges limit effective communication and the sharing of experiences.

By actively participating in projects over an extended length of time, one can gain valuable construction knowledge. However, this is usually not the case, as employee turnover is radically high. The specific needs of the employees who will use the project data may not always be understood by those in charge of gathering and archiving it. Furthermore, data is gathered and archived at the end of the construction phase rather than being handled while it is being created. By now, it is likely that those who were aware of the project have moved on to other projects. Again, due to high turnover, many businesses keep archives projects; however, it is challenging to get in touch with the original report authors. These projects should be available for use with little (or no) consultation; this past data should represent the data context. Lastly, decision-making objectives are frequently not noted or documented. The millions of spontaneous messages, phone calls, emails, and discussions that comprise much project-related information require complex methods to track and document.

While witnessing an age where data engineering is adulated in many industries such as software, finance, and others, it is inevitable to wonder how far construction companies could enhance their effectiveness with the correct KM approaches. Every construction project requires decision-making at different levels of criticality, ranging from simple ones made every day to sophisticated and chaotic ones depending on the project's complexity. These decisions rely on having access to the right knowledge in the right place at the right time (McKenzie et al., 2011). Thus, decision-makers should be able to access the required knowledge conveniently since every mistake could impact the budget and other success factors. Building a construction firm's knowledge base and managing it sustainably depends on the ability of both individuals and organizations to implement the correct solutions for OL. Strategic decision-making is naturally improved with every valuable knowledge put back into the system. This way, every construction site a construction company operates contributes to a more accurate prediction of a future project that would result in sustainable success if KM is implemented correctly.

In the following section of this thesis, claim management is chosen as a pilot subcategory in construction for the purpose of implementing KM due to its importance to project management and its complex nature. The natural procedures significantly depend on past data and practical knowledge from previous projects, making it an ideal choice for an integrated KM application. Construction companies may enhance their competitive advantage by utilizing KM principles such as organized data sharing and collaborative learning in claim management. This allows them to gain insight into their OM to predict possible claims, develop more effective arguments, and enhance the outcomes of claims

3. CLAIM MANAGEMENT

Today's construction projects carried out under Fédération Internationale Des Ingénieurs-Conseils (FIDIC) contract terms present challenges of both a technical and managerial nature. In this context, the claims management process plays a key role, defined as a comprehensive set of activities aimed at identifying, analyzing, formulating, and asserting its claims.

FIDIC is an organization that develops standard terms and conditions for construction contracts used worldwide. One of FIDIC's most important contributions is developing these terms and conditions, which cover issues related to the rights, duties, and responsibilities of the parties to the contract. These terms and conditions are commonly known as the "FIDIC Conditions of Contract" (hereinafter: FIDIC).

In the context of the FIDIC regulations, it is important to note the three main actors crucial to the investment implementation process:

a) The Ordering Party (hereinafter: the Investor or Employer):

- is the party that commissions a specific construction or engineering project.
- is the project's owner or a person/company representing the owner's interests.
- uses its role to provide the Contractor with the contract terms and conditions, technical specifications, and financing for the project.
- is responsible for, among other things, providing the land, properly preparing the site, and obtaining the necessary permits and approvals.

b) The Contractor:

- is the party that accepts the order from the Employer and performs the work in accordance with the terms of the contract.
- uses its role to ensure that the work is carried out according to the schedule, technical specifications, and quality standards.

- is responsible for providing materials, equipment, labor, and supervision of workers.

c) Contract Engineer (hereinafter: Engineer):

- is an independent expert appointed by the Employer to oversee the progress of the work, resolve disputes, and adopt various decisions related to the project's implementation in accordance with the terms of the contract.
- is a neutral party that ensures the work is performed in accordance with the terms of the contract and the technical specifications.
- is represented by a specialized engineering firm.

These three roles, Principal, Contractor, and Contract Engineer, are crucial to the efficient and effective execution of construction projects under a FIDIC contract. Each party has specific duties, rights, and responsibilities under the contract, ensuring transparency, clarity, and balance between them.

The claim process, which is the subject of this section, proceeds through numerous stages and requires interdisciplinary knowledge. It requires the participation of all the entities indicated. This process is an absolutely key element in ensuring the success of construction investments in terms of timely completion and profits.

The claims management process for construction projects requires in-depth knowledge of the law and contractual regulations, negotiation skills, risk analysis, and an excellent understanding of the project's specifics. This multidimensional nature makes it one of construction project management's most complex and demanding elements.

This section presents various aspects and challenges in managing claims implemented under FIDIC contract terms. In addition, an analysis of the claims procedure will be conducted, detailing the challenges associated with filing and formulating claims and the opportunities to use modern technology to streamline the process.

3.1 Type of Claims

The definition of a claim varies depending on what is stipulated in the terms of each contract. In the literature, the definition in question can be found: "a written demand made by one of the parties to a contract that, by virtue of its rights, seeks the payment of an additional payment, a change in the interpretation of the terms of the contract, an extension of the contract term, or other compensation arising out of or related to the contract in question" (Bramble and Cipollini, 1995). Bramble and Cipollini (1995), also define the following phases of the evolution of a construction claim in claim management:

- Problem: an element of the ordinary construction process, subject to solution on an ongoing basis;
- Incompatibility: an issue that can only be resolved through hard and concrete negotiations;
- Controversy: occurs when the project team is unable to agree on disagreements, resulting in the involvement of people outside the field offices;
- Conflict: occurs when it is necessary to consult an outside expert to resolve the resulting dispute in a timely manner;
- Dispute: a process that takes legal form in the form of a court case or motion and requires resolution by a court or other legal forum.

In addition, Bramble (1995) developed a process for the evolution of a construction claim, taking into account the above-mentioned phases illustrating the differences, including semantic differences between. According to Bramble (1995), a claim evolves through five phases of the relationship between the claimant (contractor) and the owner, with the first three phases allowing for resolution within the project and the remaining phases requiring outside assistance.

This section thoroughly outlines the range of claims that may arise under the FIDIC conditions of the contract, focusing specifically on infrastructure projects. The significance of infrastructure projects in supporting economic growth and improving public welfare makes it crucial to understand the nuances of potential claims within these projects. This examination focuses on a thorough analysis of the various claims arising from specific divisions, specifically those outlined in the "Contract Conditions for Construction for Engineering and Construction Works with Design by the Employer," commonly referred to as the "Red Book," and the "Contract Conditions for Equipment, Design, and Construction," commonly known as the "Yellow Book."

The emphasis on focusing on these particular FIDIC publications is due to their extensive acceptance and acknowledgment as official standards for global engineering construction projects. The "Red Book" is mainly employed in construction projects where the Employer provides the design. This leads to specific claim situations generally associated with design obligations, changes, schedule extensions, etc. In contrast, the "Yellow Book" was created for projects in which the contractor is accountable for both the design and construction of the works. This introduces many types of claims, including those related to design advancements, effectiveness, and the incorporation of intricate systems, etc.

This section seeks to analyze the types of claims included in these contractual frameworks to gain a detailed knowledge of the potential issues and conflicts that parties may face during the lifespan of infrastructure projects. This investigation provides insight into the contractual processes that may be used to resolve claims. It emphasizes the significance of proactive claim management in reducing risks and promoting collaboration between contracting authorities and contractors. Understanding the types of claims is essential to improving the existing knowledge of efficient contract management techniques in the construction and engineering sectors and improving the effectiveness and prosperity of infrastructure investments. In the Contract Terms described before, namely the Red Book and Yellow Book, there are variations in the settlement of the contract, which in turn result in varying levels of risk. Table 3.1 summarizes the similarities and differences between the red and yellow books.

Table 3.1 : Description of FIDIC Red and Yellow Book

Contract	Payment Form	Employer Involvement	Contractor Risk
Red	Quantitative Lump Sum	High High	Small Medium
Yellow	Lump Sum	Medium	Medium

A new claim management system was introduced into the FIDIC Conditions of Contract Claus 20 in their 2017 edition. This system is based on two different procedures. A press release from the FIDIC indicated that the changes intended to distinguish between claims for extension of the contract's duration and financial claims for which a more formalized procedure was introduced compared to other claims, as indicated in Sub-Clause 20.2 (FIDIC 2017). As indicated by Clas (2018), despite FIDIC's stated intent, the language used in Subclause 20.1 suggests that a more formal procedure should not be used for all monetary claims.

The referred “Conditions of Contract” - 2017 update introduced by Subclause 20.1 explains three types of claims due entitled party:

a) if the Employer believes that it is entitled to any additional payment from the Contractor (or a reduction in the contract price) and/or an extension of the defect notification period and/or damage to the work, section, or part,

b) if the contractor believes that it is entitled to any additional payment from the Employer and/or an Extension of the Time (EOT),

c) if either Party believes it has any other right or demand against the other Party. Such other entitlement or demand may be of any kind (including in connection with any certificate, determination, order, notice, opinion, or valuation of the Engineer), except for entitlements to the extent described in subsections (a) and/or (b) above.

   Under the FIDIC “Model Terms and Conditions,” in the event of a claim under Subclause (a) or (b) indicated above, the provisions of Subclause 20.2 [Claims for Payment and/or Extension of Completion Time] shall apply.

   In the case of a claim under subclause (c) above, where the other party or the Engineer has not agreed with the claimed right or demand (or should be deemed to have disagreed in the absence of their response within a reasonable time), no dispute shall be deemed to have arisen, but the party making a claim, by filing a “Notice,” may submit the claim to the Engineer. In such case, the provisions of Subclause 3.7 [Agreement or Determination] shall apply. Such notification shall be made as soon as practicable after the claiming party becomes aware of such disagreement (or alleged disagreement) and shall contain details relating to the subject matter of the claim and the issue of the other party's or the Engineer's disagreement (or alleged disagreement).

The third type of claim, however, includes any other entitlements not mentioned in (a) and (b), which may be asserted by either party. Two separate procedures are associated with these types of claims.

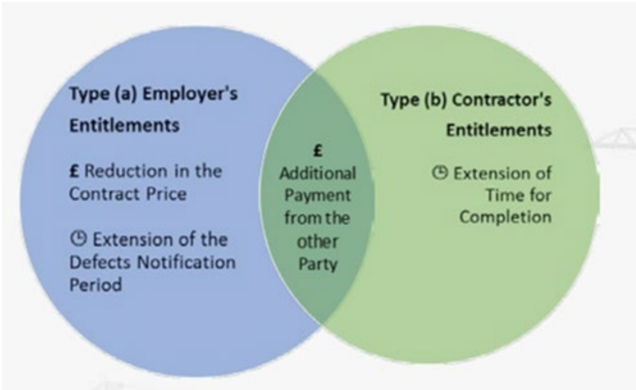

Figure 3.1: Employer's and Contractor's Entitlements (Class, 2018).

The type of claim indicated in letter (c) includes any entitlement within its scope except those specified in types (a) and (b).

Much research has been done on categorizing common dispute cases and their causes. According to Kumaraswamy (1997), dispute cases in the construction industry can be categorized as being "Owner-Related," "Contractor-Related," "Design-Related," "Contract-Related," "Human Behavior-Related," "Project-Related," or due to "External Factors." As per the subject of this research, the owner-related are elaborated.

Common causes of owner-related claims can also be classified based on the source of the disputes causing them (Cakmak and Cakmak, 2013). Claims considered under the contract terms, disputes can be identified as arising from one of the following main groups of disputes:

1) Change of Scope (Differing conditions). For example, if execution conditions were not specified in the contract documents and were identifiable based on the contract documents up to the date of the bid for the work. This type of claim may include, among others, different ground conditions, unidentified collisions, or in the case of contracts executed in Europe, different environmental conditions (e.g., the presence of protected or invasive species);
2) Variation Orders. Variation is an aspect that alters the character of the contract. This might involve an increase or decrease in the quantity of work,

a modification in the specifications for certain aspects of the work, or, in some instances, a revision to the contractual terms of the project, such as the contract price or duration. Typically, construction contracts grant the Employer the right to implement such modifications. The majority of typical contract types assign the Engineer the responsibility of offering guidance for variations in the works (Hewitt, 2016). For example, the work that the contractual documentation did not provide falls into this category.

3) Delays. This type of claim refers to claims beyond the Contractor's control, arising in executing the work caused by the Employer or due to circumstances at the Employer's risk. A flagship example of this type of claim is the Employer's delay in handing over the right of access to the Construction Site, failure to hand over construction materials or equipment attributable to the Employer, or the forfeiture of claims based on the "Contract Conditions Red Book" also delay in handing over design documentation.

   Payment delay by the Employer could also be included in the occurrence of the type of claim.

4) Acceleration Request. This type of claim relates to disputes related to the duration of the contract resulting from, among other things, the aforementioned circumstances (different conditions, additional work, customer delays) and the associated need to extend the contract completion date and the costs incurred by this change. This claim, in addition, may relate to instructions issued by the engineer to accelerate the work in both the time and financial aspects of such actions (Suryawanshi, 2010).

5) Global Claims. This type of claim is characterized by the Contractor invoking all the delaying events that have occurred and seeking to claim an extension of the completion date it has achieved and occurs when the Contractor has not made specific claims for each delay separately during the course of the contract, and a situation arises in which it is aware that it will not complete the contract on time (Hewitt, 2016)

3.2 Claim Management Process

When analyzing the course of the procedure for formulating claims based on FIDIC, special attention should be paid to the basic concepts that the conditions of the contract provide in this regard. Particular attention should be paid to:

1) Notice of Claim (hereinafter also: NOC) - is strictly informational in nature. The Employer informs of circumstances giving rise to a claim within its framework. The notification should indicate the occurrence of such circumstances and describe the "event or circumstance giving rise to the claim." Still, there is no need to specify the Contractor's detailed demand or its contractual basis at this stage. In doing so, the contractor should notify the Engineer of the situation as early as possible but no later than 28 days from the date the contractor became aware of the circumstance giving rise to the claim or should have become aware of such circumstances. Notification of a claim is to be distinguished from the next step of the contractor's claim procedure, which consists of submitting a Full Detailed Claim (FDC) containing detailed justification and the contractor's demand

2) Full Detailed Claim (FDC) - a letter containing a detailed description of the event or circumstance giving rise to the claim, a description of the grounds for the claim, and information justifying the amount of the claimed financial claim or the claimed extension of the contract completion dates. It should be submitted within 84 days from the date of occurrence of the event or circumstance causing the claim.

3) Interim full detailed claim (hereinafter: Interim Claim) - is submitted when the event or circumstance giving rise to the claim has a continuing effect and the effect of these circumstances on the performance of the contract has not ended.

4) Final full detailed Claim (hereinafter: Final Claim) - is submitted within 28 days from the cessation of the effects of the event or circumstance giving rise to the claim. In its content, the party must indicate the total amount of the financial claim or the claimed extension of contractual terms.

The new 2017 edition of FIDIC significantly expands the claims procedure and divides it into two separate modes. The creators have also expanded Clause 20 to include claims available to the Employer rather than the 1999 version exclusively to the Contractor. The most significant differences also include the expanded responsibilities of the Engineer, on whom the Conditions of Contract impose more requirements in evaluating submitted claims.

Subclause 20.1 in FIDIC 2017 divides claims by their subject matter (Hewitt, 2016).

a) Financial - when a Party considers itself entitled to an additional payment (Contractor) or a reduction in the Contract Price (Employer).

b) Time-Based - when the Contractor considers itself entitled to a change in contractual deadlines (Completion Time or Milestones) or when the Employer considers itself entitled to an extension of the Notification of Defects Period.

c) Other types that are others not covered by (a) and (b).

3.2.1 Procedures for filing time-based and financial claims

The claims procedure under FIDIC 2017 presupposes a certain sequence of actions to be taken by the parties to exercise their rights, as indicated by Clause (2018):

a) STAGE I - submission of the Notice of Claim

According to Subclause 20.2.1, a party is clearly obligated to submit NOC when it believes that a claim may give rise to a timely or financial claim.

Particularly importantly, Clause 20.1 clearly spells out the deadline for such notification and the consequences of failure to do so. This deadline is 28 days after the party learns or should have learned of the event or circumstance giving rise to the financial or timing claim.

Violation of the indicated 28-day deadline by a party is sanctioned by forfeiture of the right to make an effective demand for changes in contractual deadlines and financial demands, as well as release of the other party from liability for such a claim.

What is particularly important is that a completely different situation applies to claims relating to non-contractual performance (additional work). The provisions of Subclause 20.2.1 reserving a 28-day deadline for submitting notifications are regulations that should be treated as strictly contractual restrictions, regulating the manner of performance of obligations between the parties within the framework of the concluded agreement (contract). However, these regulations cannot be applied to elements beyond the contractual relationship's framework, such as additional works.

This is because such elements are subject to the regulations provided for by generally applicable laws.

Therefore, the termination of the right to claim as a result of a breach of the aforementioned contractual obligations (the 28-day time limit in clause 20.1) can find no justification, for example, in the case of the Contractor's demands involving issues beyond the scope of the contract's subject matter.

b) STAGE II - verification of the Notice of Claim - Preliminary Response by the Engineer.

If the Engineer believes a Party has exceeded the 28-day deadline for submitting an NOC, it may issue its own Notice indicating the violation described within 14 days of receipt of the NOC.

Particularly important in this regard is the fact that the Engineer's failure to submit such a notice within the above 14-day period results in the NOC being considered timely filed, which is a fundamental difference from the regulations of the 1999 edition of FIDIC. Thus, the Engineer's timely failure may provide an opportunity for the claiming party to preserve its rights.

Suppose the party making the claim does not agree with the content of the Engineer's notice or believes that the untimely submission of the NOC was justified. In that case, it has the right to submit a FDC, with arguments defending its position.

If the other party against whom the claim has been filed objects to the NOC due to time constraints, it has the right to submit its own notice to the engineer with related reasons. The Engineer will consider such objection by issuing a determination under Subclause 3.5, where they will indicate whether the NOC was filed effectively or why any violation of the deadline for filing the NOC was justified, considering the circumstances indicated in Subclause 20.2.5.

c) STAGE III - FDC

As a general rule, within 84 days from the date the party learned or should have learned of the event or circumstance giving rise to the claim, the party submitting the claim shall submit a FDC.

The FDC's role is to present its claims' scope in detail, with appropriate justification. In this regard, the party shall primarily provide a description of the event giving rise to the claim, indicate to the engineer the contractual and legal basis for the claim, and justify the scope of its financial and time claims.

If the claiming party fails to provide a description of the basis for its claim within the above 84-day period, the claim shall be deemed to have lapsed, and the Engineer shall issue a corresponding notice to this effect within 14 days after the expiration of the claiming party's deadline.

Similarly, as in Stage II described above, the NOC will still be considered timely filed if the Engineer does not file such a notice. In this regard, the parties also have analogous remedies against the Engineer's action - as in Stage II.

In a situation where the circumstances giving rise to the claim have not ceased and are ongoing, the Contractor shall submit FDCs to the Engineer at monthly intervals. With respect to the first interim claim, the Engineer is obliged to submit his response in the form of a notice within 42 days of its receipt.

Within 28 days from the date of cessation of the circumstances giving rise to the claim, the claimant shall file a final claim.

d) STAGE IV - Settlement of the Claim

The Engineer's contractual duty is to consult with the contract parties, in which he encourages discussions to reach an agreement.

Depending on the course of these consultations, there is an obligation on the part of the Engineer to issue a notice:

On Agreement of the parties - if the parties reach an agreement on the claim within 42 days from the date of the claiming party's issuance of either a FDC or a Final Claim (in the case of claims based on continuing effects);

On the determination of the Engineer - within 42 days after the deadline for the Parties to reach an agreement. The Engineer's determination will be a fair determination of the claim in question, taking into account all the case circumstances and including detailed justification.

If the engineer does not timely issue a notice, the Engineer shall be deemed to have issued a determination rejecting the claim.

The effect of settling a given claim within the framework of the parties' settlement or the Engineer's determination shall be a clear determination of the scope of the financial or time claim.

The issuance of an arbitrary determination by the Engineer is not a final action that forecloses the parties from asserting their rights. Suppose either party is not satisfied with the content of the Engineer's determination. In that case, it has the right to submit a “Notice of Dissatisfaction” with the Engineer's determination within 28 days from the date of receipt of the Engineer's notice of determination. Thereafter, each Party will have the right to proceed by Sub-Clause 21.4 and bring the dispute before the “Dispute Avoidance and Settlement Committee.”

However, if neither Party submits a notice of dissatisfaction within the designated 28-day period, the Engineer's determination will be binding on the Parties and final.

3.2.2 Filing claims that extend beyond financial or time-based

In the case of claims in which a party believes it has a right separate from a financial or EOT request, the procedure is much less formalized (Mellors, 2019). The subject of such claims is often the Engineer's actions (determinations, orders, or opinions).

When the other party or the Engineer does not agree with the submitted claim, the party shall have the right to submit a notice, which shall contain all case details and refer to the disagreement expressed by the other party or the Engineer.

As in the case of Time-Based or Financial Claims, the Parties shall have time to reach an agreement within 42 days of receipt of such notice.

If the parties fail to reach an agreement (consensus), the Engineer shall decide, issuing a position on the Claim's merits. However, as in the case of financial and time claims, the Parties have the right to object to the Engineer's assessment (Mellors, 2019).

3.3 Challenges in Claim Management

This chapter provides practical information on claims management, including preparation and negotiation. It also discusses changes related to the implementation of construction projects, ways to detect them early to avoid costly and time-consuming disputes, and the challenges involved.

Contract claims are an integral part of contracts based on the FIDIC Conditions of Contract. Construction claims management is a procedure that consumes more and more time, money, and human resources. Construction contracts are based on an obligation relationship between the Employer and the Contractor and, like any obligation, involve risks associated with the inability to perform as specified in the bid. Many times, filing a claim is the only way to obtain reimbursement of additional costs incurred or changes in contract completion dates in the event of circumstances unforeseeable at the bid stage that, for objective reasons, were not included in the bid (Pellicer et al, 2014). Possible obstacles, along with a breakdown of the claims associated with them, are discussed in the previous chapter. The obstacles in question involve claims for additional payment or extension of time. Cooke and Williams (1998) point out that even successful projects sometimes involve claims, and good claims management and administration are as important as good engineering, safety, or business principles. Proper claim management requires the implementation of five different stages - some of which overlap, as illustrated in the figure below. There are different challenges associated with each stage that need to be addressed in order to fulfill the requirements of the process appropriately.

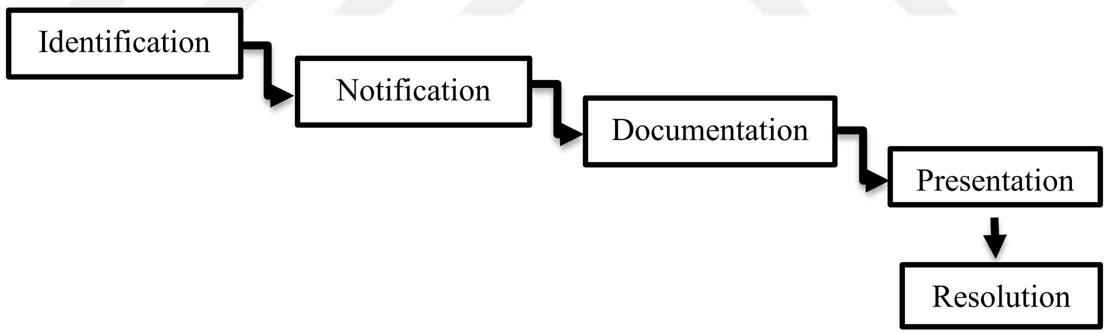

Figure 3.2 : Stages of Claim Management (Pellicer et al, 2008).

3.3.1 Identification of claim

The first stage involves the proper identification and precise determination of the possibility of a claim, as well as timely notification by the personnel of each party regarding claims and risk management within the organization. This stage occurs either after the occurrence of a specific event or as a result of the analysis of contractual documentation (Pellicer et al, 2008). There are a number of challenges associated with this phase. For example, staff awareness is one of the aspects that must be taken into consideration for the identification of the claim. Most often, construction claim incidents occur at the construction site and are handled by site staff, who may not have the appropriate qualifications and experience to identify claims. Therefore, it is important to implement training among staff and provide adequate management personnel to support site teams. The next challenge is the management of information flow. This is a necessary element after the proper identification of a claim. Even if a correctly identified claim is made, the information about the occurrence of an event must be passed on to claims managers who are able to assess the situation. This interdepartmental exchange is also affected by communication within the teams at various levels.

This stage should be considered one of the most important since identifying a claim allows for the evaluation, analysis of risks, estimation of possible losses and profits, and, thus, the initiation of further actions applicable to the type of claim.

3.3.2 Notification of claim

The second step is to submit a notice of claim as required by Sub-Clause 20.1, within 28 days (Glover and Elliott, 2015). Notification is an extremely important element, as it involves informing the other party of the problem that occurred and the potential consequences. It is to inform the other party for the initiation of work to resolve it, to enable the other party to prepare for the impact of the claim in question by securing financing - budgeting the costs, appropriate reporting, and considering its impact on the parties' project planning (Hewitt, 2016). Thus, the claim must be notified as soon as possible. One of the key challenges associated with the need for timely filing of the notice of claim in order to preserve the rights. The component people in charge of preparing and presenting the notice must act quickly as it requires a significant amount of work. The right communication with the other party to which the notice is made is also important, as the lack of response may delay the resolving the problem.

3.3.3 Documentation of claim

The third stage in claim management is the collection of relevant documentation due to the need to prove the validity of the claim. This stage involves rearranging the relevant elements of contractual documentation, accounting documents, photographic documentation, reports, protocols, test results, expert opinions of analysis, etc., to substantiate the facts on which the claim is based and to demonstrate the costs incurred and the impact on the duration of the contract. As part of the documentation of the claim, the party entitled to submit the claim must submit claims in full detail, containing a description of the facts, the aforementioned documentation, the contractual and legal basis for the claim, and correspondence related to the circumstances giving rise to the claim.

According to Skorupski (2017), the biggest challenge in claims management is time disputes. He states that claims for time extensions for completion require sound claims management and solid evidence - other than letters, i.e., schedules, time reports, invoices, and bills. In turn, proving the costs associated with these claims depends on properly identifying them and attributing them to the circumstances causing the delay, as well as presenting receipts, facts, and proof of payment for these costs. Claims for extension of time for completion are subject to time analysis, so it is necessary for the claimant's personnel to have specific abilities in analyzing and evaluating them.

Associated with this stage are the challenges already identified in the previous stages in terms of the proper flow of information, the proper selection of claims management personnel, and the proper cooperation and instruction of other team members. In addition, this stage involves the need to provide staff with the appropriate work tools, including project management software and modern technology used for claim management.

3.3.4 Presentation of final claim

The fourth stage is the repercussion of the previous stages and thus urges the outcome of solving all the challenges of claims management. However, at this stage, the biggest challenge is the subsumption of facts, evidence, and effects, which requires a suitably experienced and competent team and the support of specialists. This stage of claim management involves drafting a full-detail claim or a final claim, which will be subject to review by the Engineer. The FIDIC Conditions of Contract set specific requirements for the drafting of these claims, which can be summarized in the following four points:

1) A detailed description of the event or circumstance giving rise to this claim,

2) Indicate the contractual and/or other legal basis for the claim,

3) Submission of comprehensive correspondence related to claims,

4) Submission of details of expected payment/contract price reduction/extension of time for completion/extension of other guarantees/securities.

3.3.5 Resolution of the claim

The fifth and final stage of claims management involves taking steps to resolve the claim, which in turn involves challenges different from those indicated so far in contract management. These are varied, as there are several ways to resolve claims. This subsection discusses the main claim resolution methods occurring under the FIDIC "Conditions of Contract." This may consist of negotiations between the parties - included in Subclause 3.7 [Agreement or determination]. If no consensus position is reached - the Engineer's Determination - also included in Subclause 3.7 [Agreement or Determination]; the dissatisfied party with the determination obtained has the right to file an application with the "Dispute Adjudication Board."

The first option of negotiations is the least costly, as it involves negotiating between the parties to reach a satisfactory solution for both sides. During negotiations, the parties must present their positions and demonstrate their negotiating skills, which creates a challenge for the party representatives to prepare in advance, define the limits of flexibility, and avoid conflict (Pellicer et. al, 2008)

The FIDIC "Conditions of Contract" provides for the Engineer to issue a determination in the absence of agreement between the parties. In this case, the Engineer should act as an independent mediator, making an impartial and fair settlement of the dispute between the parties. The FIDIC "Conditions of Contract" applied.

The last way to resolve claims is to submit the dispute to the "Adjudication Board." This way, depending on the equal edition of the FIDIC "Conditions of Contract", results in either a binding (superseding the decision of a common court) settlement or a non-binding settlement, which, if not further accepted by either party, will require the dispute to be resolved by a common court.

3.4 Technology and Innovation in Claim Management

The emergence of modern technology and innovation has significantly revolutionized the field of claim management, signifying a crucial transition towards more effective, precise, and user-friendly procedures. Central to this shift are advanced software tools developed for KM, which have fundamentally changed the manner in which information is stored, retrieved, and utilized in the claim management industry. These tools have not only made operations more efficient but also greatly improved decision-making abilities, resulting in a major enhancement in the overall efficiency of claim processing. The potential of artificial intelligence (AI), combining predictive analytics and automated decision-making, can significantly enhance the accuracy and efficiency of claims management. This section analyzes the current state of technology used in claim management, particularly software tools, and explores the possible uses of AI, highlighting how these improvements can potentially transform the future of claim management.

3.4.1 Software tools in claim management

Software tools enable collaboration by offering a centralized platform that allows all team members to view and share information. Companies may get a more streamlined, open, and protected claim management process by utilizing these solutions. This digital transformation enhances the efficiency of activities and the speed and quality of service provided to customers. This eliminates barriers that commonly restrict the transfer of information across departments or teams. Stakeholders can encourage alignment by establishing a common communication platform that encompasses information exchange, minimizes misinterpretations, and expedites decision-making procedures. The possibility of generating and allocating tasks within these programs cultivates a culture of responsibility and openness, as every team member can identify the individuals responsible for fulfilling certain tasks and the designated deadlines for their completion.

Organizing claims of various projects within these software programs greatly improves project effectiveness. It facilitates a systematic approach to managing claims, enabling the tracking of progress on specific tasks and the more efficient allocation of resources. By establishing timelines and prioritizing activities, one may effectively address crucial elements of the filing a claim procedure in a timely manner, hence minimizing the time. This methodical technique not only simplifies the sequence of tasks but also enhances a well-organized and effective procedure for handling claims, thus improving the organization's operational efficiency.

Using professional software solutions for claim management has the dual advantage of ensuring data confidentiality and providing convenient access. These platforms are equipped with strong security protocols to safeguard sensitive information against unwanted access and data breaches. Moreover, the tools' cloud-based nature guarantees that documents and data may be accessed from any location and at any given moment, as long as there is an internet connection available. This kind of accessibility is especially advantageous in modern, high-speed work environments that frequently involve remote or hybrid work arrangements.

3.4.2 IoT in claim management

Gubbi et al. (2013) define the Internet of Things (IoT) as the connectivity of objects that can sense and activate, enabling the sharing of information across platforms through a single framework, resulting in a shared operating system. These physical objects are embedded with sensors, software, and other technologies. They are specifically engineered to communicate with other devices and systems over the Internet to exchange data. IoT devices are essential for monitoring project progress, ambient conditions, and equipment status in construction.

IoT enables real-time monitoring, which would be helpful in building up necessary data for claims. These sensors have the capability to continuously monitor and track many aspects of construction progress, including the efficient use of resources, the condition of equipment, and the presence of employees at the construction site. This data may facilitate the management of project deadlines, mitigate delays, and optimize the allocation of resources. Similarly, environmental monitoring involves using sensors to track and measure various environmental factors, which include temperature, humidity, and vibration levels. This data is essential in building up claims over construction defects or delays resulting from adverse environmental conditions.

The implementation of IoT technology also enables the monitoring and tracking of the locations and operation of construction equipment, which helps with equipment and asset management. This ensures optimal resource utilization and compliance with contractual obligations related to equipment usage. It may also help resolve conflicts pertaining to disruption claims and productivity.

3.4.3 AI and claim management

AI has experienced a significant increase in significance in the past decade. In earlier times, AI research was mostly conducted by academia and specialized institutes. Nevertheless, the industry has experienced a significant transformation since AI has become widespread on an unparalleled level. The shift from a major emphasis on research to substantial market integration highlights a fundamental transformation in technology paradigms. Artificial intelligence, amid constant enhancements, is transforming into an integral component of contemporary technology, offering an expanding array of capabilities.

The implications of AI on the claims management process within the construction industry merit particular attention. The integration of AI could potentially revolutionize claims operations, enhancing efficiency and control. Specifically, AI's application in assisting construction personnel with the preparation of claim notifications, interim claims, or final claims poses intriguing possibilities. The question, thus, shifts from "if" AI will influence these processes to "when" its impact will be realized, indicating an inevitable paradigm shift toward AI-driven operations in claims management. There are a number of stages in which AI could have a major impact on the claims process itself.

A possible improvement AI can present to claim management is the analysis of needs, requirements, and errors in investment documentation. AI can be widely used to analyze investors' needs and identify possible errors or inaccuracies in documents on which the contractor is to implement the investment. Furthermore, based on historical data and past investments, artificial intelligence could draw appropriate conclusions and predict the Employer's needs for a given type of procurement. The use of AI in this area, in the case of more advanced algorithms, could boil down to performing risk analysis on various solutions and recommending a specific strategy of action. At the same time, in the case of access to appropriate data sources, AI could assist contractors in analyzing various cost scenarios, identifying the most cost-effective and efficient solutions, and searching for environmentally friendly solutions.

The sophistication of AI tools can make it possible to create key documents in the claim process automatically generate claim documents, and suggest specific solutions. Based on properly entered data - including, among other things, the relevant regulations of the investor contract or FIDIC provisions – AI-based tools are able to generate a letter that will meet the requirements of the investor contract. Based on existing letter templates and contractor input, AI can create standard claim documents such as claim notices, interim claims, or even final claims. AI is able to analyze the contents of FIDIC, identify the relevant contractual grounds, relate them to the facts, and generate the contents of the contractor's request in this regard. Moreover, AI itself is able to suggest to the contractor the need to inform the Employer of a circumstance that may cause a claim. This is because the tools have direct access to databases and analyze current events.

The combination of AI, IoT, and advanced software tools is bringing forward a significant change in claim management in the construction industry. AI, with its unique ability to analyze data, automate processes, and forecast results, can lead to groundbreaking results in this transformation as it has the potential to enhance decision-making significantly. Meanwhile, IoT devices provide the ability to monitor and gather data in real time, allowing for useful insights into project development and enabling proactive management of claims. Software technologies provide smooth integration of data, communication, and workflow management, producing a unified environment that aids in complicated claim management. Collectively, these technologies provide a complete structure for enhancing transparency, effectiveness, and precision in claim management procedures, eventually resulting in more successful management of claims.

4. DEVELOPMENT OF KM TOOLBOX FOR CLAIM MANAGEMENT

The current literature clearly demonstrates the need for creative solutions in the construction sector to address issues and improve KM efficiency. Despite the widespread academic support for KM implementations, critics argue, notably the view that KM is overly conceptual and laden with "managerial rhetoric" (Andreeva and Kianto, 2012). Communicating directly with sector leaders is a practical approach to understanding the industry's practices for managing knowledge and addressing criticism. Academic literature may lag in incorporating the latest understanding of management strategies due to delays in publication and feedback mechanisms. To assess how constructing companies are currently applying KM strategies and to draw comparisons across other sectors, interviews with representatives of industry leaders must be conducted.

To ensure an accurate and enlightening comparison in order to understand the position of the construction industry among the others in terms of advancements in KM, the research takes a closer look at management consulting companies. The consulting industry is highly advanced in the field of KM. They prioritize and invest substantially in KM since knowledge is their most valuable asset. They were pioneers in actively investigating the utilization of information technology to acquire and distribute knowledge (Hansen et al, 1999). In the mid-1990s, the concept of KM emerged and became a topic of study to examine organizational knowledge. Ever since the major consulting firms have taken advantage of the immense potential of information technology, they have been the driving force in the business world. Their concept is relatively straightforward and combines well-known IT tools like databases and electronic conferencing to make it easier to gather, share, store, retrieve, and use knowledge (Easterby-Smith and Lyles, 2015). It can be seen that the consulting sector started KM implementations way before the construction sector and would be an ideal reference to compare the positive and negative implementations of KM in today's construction world.

This section reports the results of the interviews done with the senior managers of multinational firms operating in the construction and consulting sectors. Three pioneer companies from the two sectors are chosen to get an all-rounded view, and interviews are conducted with their representatives about their KM policies. The experts were asked the same set of 12 questions under three main categories: Data Collection, Data Accessibility and Usage, and Knowledge Management (See Appendix 1 for the Interview Form). The interviews with the company representatives took approximately one and a half hours each, during which the experts were guided by the questions and expressed their views on the topics driven from, but not limited to, the interview questions. Individuals and companies' names are kept discrete to preserve disclosure. The key figures of the companies and professions of the representatives with whom the interviews are summarized in Table 4.1 below

Table 4.1 : Key figures of the companies and their representatives participating in the interview.

	Construction		Consulting
Company A	• Operates in 50 countries • Has more than 80.000 employees • Among the top 5 European contractors (ENR) Representative Role: Country Manager	Company D	• In the sector for more than 60 years • Has 100 offices worldwide • Among the top consultant firms Representative Role: Senior Consultant
Company B	• In the sector for 80 years • Has more than 15.000 employees • Among the top 15 engineering-contractor firms globally (ENR) • Representative Role: Senior Manager	Company E	• In the sector for more than 40 years • Has 30 offices worldwide • Among the top European consultant firms • Representative Role: Senior Manager
Company C	• In the sector for more than 60 years • Operates in 80 countries • Has more than 10.000 employees • Representative Role: Business Development Manager	Company F	• Has more than 100.000 employees • Operates in 150 countries • Among the top consultant firms • Representative Role: Senior Consultant

4.1 Motivation of Study: Sector Interviews

4.1.1 Construction sector

Three interviews were conducted with management-level personnel of three construction firms to understand the current implementations of KM in today's sector. The three firms are among the sector leaders who are pioneers in innovation and technology.

The first construction firm (hereinafter " Company A") has its headquarters in Europe and operates in 50 countries. The company has over 100 years of experience in the construction sector and over 80,000 employees. According to the construction sector benchmark magazine ENR (Engineering News Records), it is among the top five European contractors in terms of global revenue in 2023. The representative of the company that participated in the interview is one of the country managers who has been an employee for more than 15 years. The second construction firm (hereinafter "Company B") is based in the USA and was founded around 80 years ago. They have more than 15,000 employees across 25 countries. ENR ranks them among the top 15 engineer-contractor firms in terms of global revenue. The participant that the interview was conducted with is the senior manager of one of the domestic projects. The final company operating in the construction sector (hereinafter "Company C"), has more than 60 years of experience in the sector and has specialized in mass transit and rail. They are among the 25 largest engineering firms in the world, operating in 80 countries and having more than 10.000 employees. The representative who participated in the interview was responsible for the strategy and business development of one of the leading markets in which the company operates.

The initial phase of the interview involves a detailed inquiry to evaluate the policies and methodologies the companies employ for data storage and knowledge archiving. Data storage is the foundational element in initiating KM; thus, the policies and practices in this area significantly influence the methodologies that will be applied in KM. The first question under this headline asked the participants if they had any departments or processes that collect and store data acquired from projects, and the follow-up question asked the participants what kind of data is collected. All companies showcase robust data management systems, albeit structured differently. Company A uses a centralized system where data collection is department-specific, leading to a structured yet possibly siloed data environment. It was stated that every department has predetermined data that they are responsible for collecting. The participant gave examples such as the HSEQ (Health and Safety, Environment and Quality) department collecting man-hours and machine hours, the accounting department collecting financial information, and the technical department collecting progress reports. Whereas in Company B, the participant stated that, even though it is the responsibility of the project managers to upload significant data to a common cloud system, there is no clear description of the context other than the financial reports and working hours. Company C employs a decentralized method where individual employees are responsible for uploading their data. The representative clarifies that all the drawings, significant mail, employee working hours, and reports are archived for each project. In the next set of questions, participants were asked if there was a predetermined taxonomy when storing the project data and what kind of environment this data is stored in. Company A's representative responded that they have a taxonomy on the documentation of a small number of departments, such as finance and cost control, where the rest can be ununiform. It is stated that the company has a cloud system in the headquarters where the data is uploaded. For Company B, no predetermined taxonomy is mandatory when uploading any documents. However, the documents do naturally resemble the initial worksheets supplied by the Company. Company B also has a cloud system to upload the data. Company C utilizes a software-based tool, where for each project, there is a departmental division of predetermined taxonomy that guides the user on what to upload.

In the following section, the representatives are presented with questions on the accessibility and usage procedures of the archived data. The initial question examined the ease of accessibility of the stored data and any employee restrictions. Company A uses a centralized data management system, which can only be accessed in headquarters. Furthermore, departmental permit systems allow certain employees to access certain information. In Company B, the data uploaded into the cloud system can only be accessed through approved and secured network connections in offices. The data is only accessible to management-level employees. A more accessible system is seen in Company C, where the data is accessible to everyone with company-verified devices. However, permission accessibility is limited in terms of positions and departments. Next, the details of the platform where the data is stored and accessed are asked of the representatives. It is found that Company A has software that headquarters and site use to conduct the knowledge transfer. The sites are obliged to upload it to the system on a regular basis or when asked by headquarters. The platform is used for one-way knowledge transfer. In Company B, the system is much simpler as there is a cloud system and a folder for each construction site where the managers upload the relevant documentation when necessary. In Company C, there are two main platforms. In the first one, the predetermined taxonomy and descriptions are embedded for each project with a unique identification number. With this identification number, the second program is used to access larger files with project drawings, files, and additional data. In the following interview question, the usability of the stored data is examined. The participants are asked if the ongoing projects benefit from the stored data and how often they use it. The representative of Company A answered that the site rarely uses the data stored. The only occasions when they refer to headquarters are references to subcontractor information from previous cooperation experiences. In Company B, it is stated that the stored data is accessed by management only when there is a problem and background information is required. The referral to stored data is only done within the data stored within the project. In Company C, the motivation for the need to access previous data is similar to that of Company B, but the process is very different. It is stated that previous data is usually accessed when there is a unique problem that the project team faces. In such cases, the software where this data is stored is referred to in order to find if this problem had been faced previously. The final question for this section was on representatives' thoughts on their current practice of the software that is used and the improvements they wished to have. The representative of Company A stated that the biggest difficulty they faced was not accessing the data directly. For the challenge in Company B, the representative stated that the system is not effective as only a very limited amount of people have the opportunity to access it. As for Company C, the biggest challenge stated by the representative was towards the search engine in the software, as the preference is for the filtering system to be improved in order to reach the desired data with less effort.

In the final section of the interview, the representatives were asked about the KM applications and company culture on the topic of concern. The first question asked the representatives about their company's methods to share explicit knowledge. Representatives of Company A answered that the only explicit knowledge-sharing mechanism they have is the software they have described previously. In Company B, it is stated that there are monthly "newsletters" with updates concerning the sector and company. The representative explained that the context is about the tenders they have won, the milestone achievements of the projects, accomplishments, and sector updates. In Company C, the representative stated that similar to Company B, the only source of explicit knowledge sharing is within their software program. The next question to the representatives followed, asking them this time about the tacit knowledge-sharing practices that were utilized. It is seen that Company A uses two main KM tools to share the tacit knowledge employees possess. The first one is holding seminars or webinars on various topics of construction once every month. These seminars and webinars are non-compulsory for the employees to attend, and the speakers are usually experts within the sector, talking about new technologies and new construction methodologies, etc. The second method they use is the master-apprentice method, where young site engineers are teamed up with senior site engineers, and a natural knowledge transfer occurs between them. Company B also benefits from webinars and seminars and enables the employees to attend online lessons that are uploaded to software where they can improve their profession-related skills. Company C also utilizes a master-apprentices model in their offices, where they form project teams with senior and junior engineers. Additionally, Company C also conducts post-project seminars where, after finishing each project, the project team explains the challenges and unique aspects of the construction to other employees. As the final question, the participants are asked if their company uses any KM tools in case of a dispute claim. All the participants answered that even if there were any, they were not aware of it since their law department has a different management system. However, a representative for Company A stated that in case of such an occurrence, the law department in their headquarters would ask for some background information about the ongoing dispute. The key factors that influenced the outcome of the interviews are summarized in Table 4.2 below.

Table 4.2 : Construction sector interviews summary.

Company	Data Collection	Data Accessibility & Usage	Knowledge Management
Company A	Centralized System: Data collection is department-specific, with each department responsible for its own data Limited Taxonomy: Only certain departments have a predefined taxonomy for documentation, such as finance and cost control. Cloud Storage: Data is uploaded to a cloud system located at the headquarters.	Centralized Access: Data can only be accessed at headquarters, with departmental permissions restricting access to certain employees. Software for Knowledge Transfer: Sites must upload data regularly, and the platform facilitates one-way knowledge transfer from site to headquarters. Limited Use: Data is rarely used, mainly for subcontractor references.	Explicit Knowledge Sharing: Limited to the described software system. Tacit Knowledge Sharing: Uses monthly seminars/webinars and a master-apprentice method where young engineers are paired with senior engineers. Policy for Dispute Claims: KM tools in dispute claims are not known; specific information is requested by the law department as needed.
Company B	Manager Responsibility: Project managers are tasked with uploading significant data to a common cloud system, though the context beyond financial reports and working hours is not clearly described. Natural Resemblance: Documents often resemble initial worksheets supplied by the company, indicating an informal taxonomy. Cloud Storage: Uses a cloud system for data upload	Restricted Access: Data is only accessible through approved network connections at offices and is limited to management-level employees. Software System: Uses a cloud system with folders for each construction site where managers upload relevant documents as needed. Problem-Driven Access: Data is accessed by management only when specific problems require background information.	Explicit Knowledge Sharing: Monthly newsletters with updates on sector and company achievements. Tacit Knowledge Sharing: Webinars, seminars, and online lessons for professional skill improvement. Policy for Dispute Claims: Similar to Company A, there is no clear awareness of knowledge management tools in dispute claims.
Company C	Decentralized Method: Individual employees are responsible for uploading data Software-Based Tool: Utilizes a software tool with a departmental division and predetermined taxonomy guiding users on what to upload.	Broad Accessibility: Data is accessible to all employees with company-verified devices, though permissions vary by position and department. Two Platforms: It uses two main platforms: one with a predetermined taxonomy for each project and another for accessing larger files. Problem-Driven Use: Data is accessed primarily when unique problems arise, seeking solutions from past project data.	Explicit Knowledge Sharing: Similar to Company A, it uses its software program to share explicit knowledge. Tacit Knowledge Sharing: Master-apprentice model in project teams and post-project seminars to discuss challenges and unique aspects of projects. Policy for Dispute Claims: No specific knowledge management tools are mentioned for dispute claims

4.1.2 Consulting sector

After finalizing the construction sector interviews, three interviews were conducted with management-level personnel of three consulting firms to compare the current practices with the construction sector. Similar questions were asked to compare and contrast the ideologies and approaches for the concept of KM. The aim is to understand the position of the construction sector in terms of KM when compared with a leading sector in the field. The three consulting firms are among the top-tier management consulting companies that operate at the international level.

The first consulting firm (hereinafter “Company D”) is an American-based company that is considered to be among the top leagues in management consulting, with more than 60 years of experience in the sector and more than 100 offices worldwide. The interview is made with a senior consultant who has expertise in KM. The second company (hereinafter “Company E”) is also a global strategy consultant headquartered in Europe. They have offices in 30 countries and 40 years of experience in the sector. The representative has been working in the company for 10 years and is one of the senior managers. The final company (hereinafter “Company F”) is again a multinational firm based in Europe that is among the top firms in the sector. They have more than 100.000 employees worldwide and operate in 150 countries. The participant from the company is a senior consultant specializing in KM within the company.

The first stage of the interview was again initiated with a comprehensive examination focused on assessing the companies' strategies and techniques for data storage and knowledge archiving. In the first question, the companies were asked if any departments or processes collect and store data from projects. Company D reports that they have a global knowledge management team divided into sectors, with knowledge experts dedicated to specific fields. This team is actively involved at the start of each project to identify and utilize relevant data from past projects. In Company E, it is stated that it operates with a dual approach. A global department manages an online library accessible to all, though not every project is available globally. Local offices maintain their own databases where project teams create project one-pagers and store comprehensive project data. In Company F, each consultant is responsible for uploading the relevant project data to the system at the beginning and end of the projects. As a follow-up question, the type of data stored is asked of the companies. In Company D, they collect end-project analyses, which are anonymized and stored in the database. This system uses various identifiers for easy retrieval, such as summary pages, keywords, dates, locations, and project teams. Company E collects a variety of data, including detailed presentations, newsletters, and data analyses. Sensitive data like financials are sometimes restricted or hidden depending on their confidentiality level. In company F, project-related data such as the summary, client-related data, specific challenges, and financials are uploaded. Next, the methods of how this data is stored are asked of the companies. Company D utilizes a digital database that functions like a search engine with a predetermined taxonomy for storing data using specific identifiers. Company E also uses a digital database with a commonly used folder taxonomy, ensuring that most project files follow the same structural format for consistency across the organization. Company F has a data library where the data is regularly updated by consultants and verified by managers.

For the next section, the representatives are asked about the accessibility and usage of the data. Company D affirms that its data is accessible at any time by anyone within the company, ensuring continuous availability for all project phases. In Company E, all project data is accessible unless it is explicitly hidden or marked confidential. Similarly, in Company F, the data is easily accessible to employees with confidentiality levels according to the position. Next, the representatives are asked if the ongoing projects use this data and what type of data is used most frequently. Company D mentions that past project data is frequently used to frame and understand current challenges during the initial project phase. They add that their IT system's search engine is pivotal for efficient operation. Company E also notes that similar project documents are examined at the start of a new project, especially those within the same business field or practice. The most checked files include detailed project closing presentations and analytical Excel files. For Company F, the data library is often used during the tender preparation for a new project. The consultants refer to past projects to calculate their bids with reference to previous projects.

The final section examines companies' approaches to KM practices. The initial question asked about methods for sharing explicit knowledge. All companies pointed out their software system as a great way of sharing explicit knowledge within their organization, which is their main source of sharing this type of knowledge. Then, they were asked about methods of tacit knowledge sharing. One other thing common for all the companies is that all consultant companies have post-project reviews and regular performance evaluations. Furthermore, Company D utilizes seminars tailored to specific expertise and distributes short news reports about practice areas. Participation is encouraged with incentives like certificates and conference invitations. Additionally, Company D adopts a master-apprentice model where senior and junior members collaborate, facilitating direct knowledge transfer through hands-on project involvement. Company E has monthly knowledge-sharing sessions and sector-based seminars globally, where consultants share project summaries, main challenges, and solutions devised for clients. Also, they discuss their personal experiences and provide actionable advice for similar future situations. Company F publishes expert reports who work in the company on project insights, market potential, and accomplishments. These reports are shared in their data library and explained in seminars and company talks. External reports, such as sector overviews and the latest updates, are also shared with relevant project groups. The key factors that summarize the outcome of the interviews are summarized in Table 4.3 below.

Table 4.3 : Consulting sector interviews summary.

Company	Data Collection	Data Accessibility & Usage	Knowledge Management
Company D	Global Knowledge Management Team: A dedicated team divided by sectors with knowledge experts involved at the start of each project to leverage past data. Type of Data Collected: End-project analyses, anonymized and stored using identifiers like summary pages, keywords, dates, locations, and project teams. Storage Method: A digital database functions like a search engine with a predetermined taxonomy for easy retrieval.	Accessibility: Data is accessible at any time by anyone within the company, ensuring continuous availability. Usage: Past project data is frequently used to frame and understand current challenges during the initial project phase. The IT system's search engine is critical for efficient operation.	Explicit Knowledge Sharing: Software system. Tacit Knowledge Sharing: Post-Project Reviews and Performance Evaluations Seminars tailored to specific expertise, short news reports about practice areas, a master-apprentice model for hands-on collaboration and direct knowledge transfer
Company E	Dual Approach: A global department manages an online library accessible to all, supplemented by local offices maintaining their own databases with comprehensive project data. Type of Data Collected: Detailed presentations, newsletters, data analyses, and sometimes restricted or hidden sensitive data. Storage Method: Digital database with a common folder taxonomy, ensuring consistency in file structure across the organization.	Accessibility: All project data is accessible unless explicitly hidden or marked confidential. Usage: Similar project documents are examined at the start of new projects, especially those within the same business field or practice. Frequently checked files include project closing presentations and analytical Excel files.	Explicit Knowledge Sharing: Software system. Tacit Knowledge Sharing: Post-Project Reviews and Performance Evaluations Monthly knowledge-sharing sessions, sector-based seminars, project summaries, main challenges, solutions, and personal experiences are shared globally.

Table 4.3 (continued) : Consulting sector interviews summary.

Company	Data Collection	Data Accessibility & usage	Knowledge management
Company F	Consultant Responsibility: Each consultant uploads relevant project data at the beginning and end of projects, with data verified by managers. Type of Data Collected: Project summaries, client-related data, specific challenges, and financials. Storage Method: The data library is regularly updated by consultants and verified by managers.	Accessibility: Data is easily accessible to employees with confidentiality levels based on position. Usage: The data library is often used during tender preparation for new projects. Consultants refer to past projects to calculate bids based on previous project data.	Explicit Knowledge Sharing: Software system. Tacit Knowledge Sharing: Post-Project Reviews and Performance Evaluations Expert reports on project insights, market potential, and accomplishments are shared in the data library and explained in seminars and company talks. External reports relevant to project groups are also shared.

4.1.3 Discussion on sector interviews

When the interview answers are analyzed, a similar level of understanding of KM applications within companies in the same sector is noticeable. KM has a similar level of understanding of the consulting sector. In construction, it is seen that even though the overall understanding is similar, some companies are more capable of some applications than others. Thus, companies within the same sector will first be analyzed, and then a sector comparison will be done. Table 4.4 shows the comparison in terms of answers in the two sectors.

Table 4.4 : Comparison of the answers of construction and consulting representatives.

Interview Section	Consulting	Construction
Data Collection	Structured and consistent data collection systems Well-defined taxonomies and digital databases ensure consistent data storage and easy retrieval.	Decentralized and inconsistent data collection practices Predetermined taxonomies are either limited to specific departments or non-existent
Data Accessibility & Usage	Data accessibility in consulting firms is designed to be broad and efficient. Consulting firms frequently use historical data to frame and understand current project challenges.	Data accessibility in the construction sector is more restricted and harder to access The construction sector rarely uses historical data for ongoing projects.
Knowledge Management	Consulting firms have robust systems for sharing explicit knowledge, and all companies use their software systems extensively. Tacit knowledge sharing is well-supported through post-project reviews, regular performance evaluations, and additional methods.	Explicit knowledge sharing is less developed and limited. Tacit knowledge-sharing practices are present but less formalized.

In the construction sector, each company has some level of understanding of the importance of KM tools. This is not surprising as all the firms are multinational successful companies that have been doing business for a long time. It is also noticeable that certain companies are stronger in certain aspects while it is very difficult to differentiate a single one for being much ahead. For example, in terms of data collection, we see that Company A has a more centralized system with a slight implementation of homogeneous uploading of data, whereas Company B has one type of profession group (managers) with no taxonomy, and Company C has assigned individuals to upload the data in predetermined taxonomy. For data accessibility and usage, Company A has centralized access that can only be accessed from headquarters. In Company B, the data is only accessible to top management, and Company C has broader access with a ranking-based permission system. In general, one-way knowledge transfer is seen in all companies for this section, with OM rarely used. For KM implementations, explicit knowledge sharing is more structured in Company B with newsletters, whereas Companies A and C rely on software systems. Tacit knowledge sharing is facilitated through all companies' seminars, webinars, and master-apprentice models. Awareness of KM tools in dispute claims is generally low across every company.

There is a more comprehensive understanding of KM implementations among consulting companies. For data collection, Company E Utilizes a global knowledge management team and a digital database with a structured taxonomy for efficient data retrieval. Company E and F data collection rely on individual consultants to upload data, verified by managers, and store it in a regularly updated data library. On data accessibility, Company D ensures continuous data availability, focusing on using past data to address current project challenges. Company E Provides broad accessibility with some data confidentiality, frequently using detailed project documents for new projects. Company F offers easy access based on confidentiality levels, often using past project data for tender preparations. All the companies have a wide range of accessibility and are regularly used. In terms of KM, all companies primarily use their software systems to share explicit knowledge. As for tacit knowledge sharing, All companies conduct post-project reviews and performance evaluations. Company D also uses seminars, news reports, and a master-apprentice model. Company E holds monthly knowledge-sharing sessions and sector-based seminars. Company F publishes expert reports, conducts seminars and company talks, and shares external reports relevant to projects.

Following the analysis of interview results derived from the company-based data, it is now feasible to proceed with sector-dependent comparisons to better highlight variances and similarities across different approaches to KM. In terms of data collection, a more structured and consistent system is seen for the consulting sector. Companies D, E, and F in the consulting sector utilize highly structured data collection systems. Company D has a global knowledge management team divided by sectors, actively involved at the start of each project. Company E employs a dual approach with both global and local databases, ensuring comprehensive project data collection. Company F relies on individual consultants to upload data at key project stages, with managerial verification ensuring consistency. In contrast, the construction sector displays more decentralized and inconsistent data collection practices. Company A collects data through department-specific methods, leading to potential silos. Company B relies on project managers to upload data without clear guidelines beyond financial reports and work hours. Company C uses a decentralized method where individual employees are responsible for data upload, leading to potential inconsistencies. The difference is also noticeable in the uniformity of the data collected. In the consulting sector, all companies have well-defined taxonomies and digital databases, ensuring consistent data storage and easy retrieval. For example, Company D uses identifiers like summary pages, keywords, and project teams, while Company E maintains a common folder taxonomy across the organization. Meanwhile, in construction, predetermined taxonomies are either limited to specific departments (Company A) or non-existent (Company B). Company C has a more structured software tool with departmental divisions, but the sector lacks uniformity overall.

When sector implementations of data accessibility and usage are analyzed, broad and efficient accessibility with high use of historical data is seen in consulting firms. Data accessibility in consulting firms is designed to be broad and efficient. Company D allows data access at any time by anyone within the company. Company E makes all project data accessible unless marked confidential. Company F ensures data accessibility with confidentiality levels based on employee positions. Consulting firms frequently use historical data to frame and understand current project challenges. For instance, Company D uses past project data during the initial phases of new projects, and Company F uses past data for tender preparation. On the other hand, the results show that construction firms have restricted and limited accessibility to data with infrequent referral to memory. Data accessibility in the construction sector is more restricted. Company A's data is centralized and accessible only at headquarters with departmental permissions. Company B's data can be accessed only through approved network connections and is limited to management-level employees. Company C offers broader accessibility but with position-based permissions. The construction sector rarely uses historical data for ongoing projects. Company A and B use stored data mainly for references when specific issues arise, while Company C accesses past data primarily for unique problems.

Finally, an effective and progressive attitude is seen when the consulting sector's approach to knowledge-sharing mechanisms is analyzed. Consulting firms have robust systems for sharing explicit knowledge. All companies use their software systems extensively for this purpose. Their software system is highly liable and is overly capable of solving any needs. Tacit knowledge sharing is well-supported through post-project reviews, regular performance evaluations, and additional methods. For example, Company D uses seminars, short news reports, and a master-apprentice model. Company F publishes expert reports and conducts company talks and seminars. When construction sector tools are analyzed, very limited explicit knowledge-sharing mechanisms are seen with unregulated tacit knowledge-sharing mechanisms. Explicit knowledge sharing is less developed due to one-way knowledge transfer. Tacit knowledge-sharing practices are present but less formalized. Company A holds monthly seminars/webinars and uses a master-apprentice method. Company B conducts webinars and online lessons. Company C has a master-apprentice model and post-project seminars.

The construction sector, as highlighted in the comparative analysis with the consulting sector, shows significant room for improvement in its KM practices. The first key area requiring enhancement is structured data collection. The construction sector needs to adopt comprehensive and consistent data collection systems. Implementing detailed taxonomies and centralized data management teams will ensure data integrity and facilitate seamless data retrieval across projects and departments. Secondly, broader data accessibility is another aspect that needs improvement. Enhancing data accessibility is crucial. Construction firms should develop systems that allow broader access to historical data, enabling all relevant personnel to benefit from past project experiences. Efficient search engines and reduced restrictions on data access will empower employees to make informed decisions. Lastly, a robust knowledge-sharing culture is needed. Explicit and tacit knowledge-sharing practices must be formalized and expanded. Regular knowledge-sharing sessions, sector-based seminars, and structured programs for tacit knowledge transfer, such as the master-apprentice model, will promote continuous learning and innovation within the organization.

Implementing a comprehensive software system is the most critical aspect of achieving these improvements. This system should be adopted company-wide to ensure consistent data management and knowledge sharing. This software must support the detailed taxonomy for data collection, offer efficient search capabilities for data accessibility, and facilitate various knowledge-sharing initiatives across the organization.

To address the needs of the construction sector and incorporate good practices from other industries, this study proposes the development of KM toolkits. These toolkits are designed to integrate best practices and tailored solutions to enhance KM in construction, which forms the core motivation of this study.

4.2 Proposed KM Toolbox for Claim Management

The essence of this study is to bridge the gap between the theoretical underpinnings of KM and the practical exigencies of claim management within the construction sector. This investigation pivots towards a focused application of KM on claim management by foregrounding Massingham's (2014) KM toolkits, which have demonstrated significant value in managing knowledge flows and facilitating OL in a broad context. This research seeks to adapt Massingham's KM toolkits to claim management and test the applicability and impact of these KM toolkits when specifically tailored and applied to claim management procedures. The proposed model is named "KM Toolbox for Claim Management". By methodically evaluating the effectiveness of these KM interventions in the claim management process, the research aims to ascertain the extent to which these toolkits can enhance operational efficiency, decision-making quality, and overall OL within the context of managing claims.

To this end, our study meticulously assesses the transferability of Massingham's KM toolkits to the claim management domain, exploring how these strategies can be tailored to meet the unique challenges that managers and stakeholders face in construction projects. This entails a detailed modification and reiteration of each toolkit's components while assessing their relevancy for effective claim management or dispute prevention. The key objective of developing the Toolbox is to improve the efficiency of claim assessment processes within construction companies. It is essential to highlight that the target users for the proposed KM Toolbox should extend beyond lawyers and claim managers, and involve the whole project team and the company. This thesis argues that the advantages provided by KM can only be utterly achieved when adopted throughout the company rather than being limited to a certain set of personnel. The toolkits comprise various KM tools, grouped according to their reinforcement to different KM components, such as knowledge sharing, acquisition, application, etc. Noticeably, some of the KM tools can influence more than one KM component when interpreted differently. For example, an IT software tool, when composed of correct elements that seek the needs of KM, can be used for knowledge sharing, acquisition, and storage. The ambition is to innovate the toolkits from Massingham's proposal to ensure they address the critical aspects of claims and improve a construction firm's ability to manage them when using these toolkits.

It is noticeable that some of the KM tools can influence more than one KM component when interpreted differently. For example, an IT software tool, when composed of correct elements that seek the needs of KM, can be used for knowledge sharing, knowledge acquisition, and knowledge storage. The ambition is to innovate the toolkits from Massingham's proposal to ensure they address the critical aspects of claims and improve a construction firm's ability to manage them when using these toolkits. After establishing the KM Toolkits, their applicability is tested in five dispute case studies using a lesson-learned approach. The Figure 4.1 below shows the schematic layout of the KM Toolkits and KM Tools.

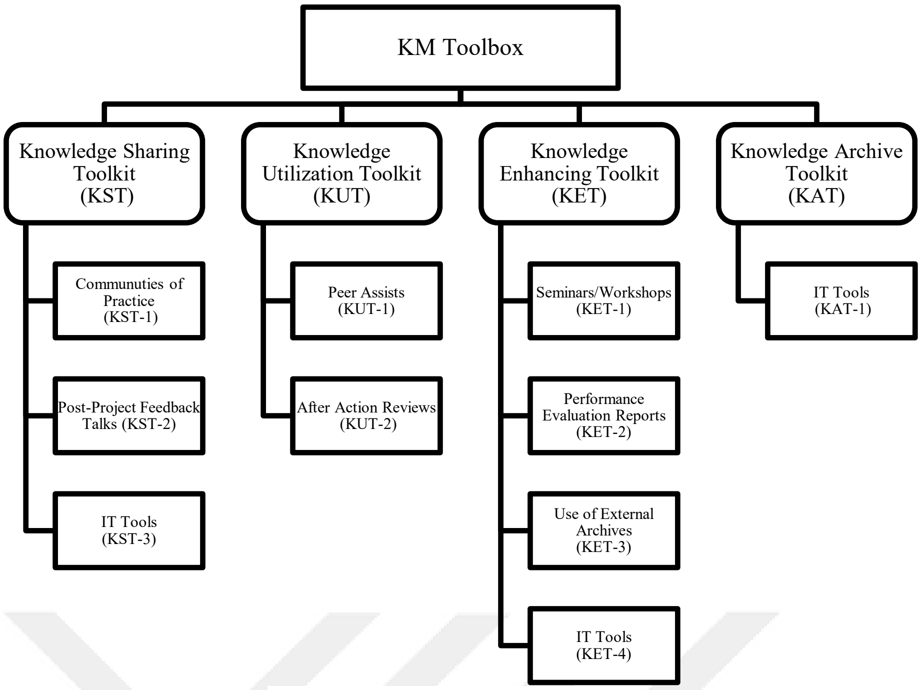

Figure 4.1 : KM Toolbox.

4.2.1 Tool Kit 1: Knowledge Sharing Toolkit (KST)

KM Tools in KST Toolkit: Communities of Practice, Post-Project Feedback Talks, and IT Tools.

KST toolkit aims to increase knowledge transfer between employees. The KM tools in this toolkit focus on creating value through increased connectivity. The tools encourage employees to interact with one another to discuss positive or negative lessons learned. The three KM tools included in this toolkit are Communes of Practice, Post-Project Feedback Talks, and IT Software Tools.

a) KST-1 (Communities of practice): Communities of practice are groups of employees who share a common set of problems or an interest in a topic and come together to fulfill individual and group goals. In the field of claim management, these could be all the lawyers and claim managers of a construction company working in different sites and offices but under the same roof. The concerned employees could share their practices and create new knowledge in regular face-to-face and online meetings. The employees can meet their colleagues from different locations, which, without this practice, they wouldn't have (especially if the company is multinational) to share similar experiences.

b) KST-2 (Post-project feedback talks): In the interest of claim management, post-project feedback talks could be conducted to increase the awareness and capabilities of concerned junior personnel with senior ones. After the decision of each claim from authorities, the responsible team that conducted the analysis could have an internal assessment of each individual's performance. Similar to the master-apprentice model, the junior employees could get feedback from the senior ones, and the whole team could look back and reflect on aspects that could be improved.

c) KST-3 (IT Tools): There are many benefits of using IT software tools to enhance KM. The concept of KST can be used as a platform to share project updates or end-project reports where relevant personnel can benefit from being aware of the updates.

4.2.2 Tool Kit 2: Knowledge Utilization Toolkit (KUT)

KM Tools in KUT Toolkit: Peer Assists, After Action Reviews

KUT aims to increase the company's usage of existing knowledge for everyday applications. In this way, the KUT aims to create value through increased utilization of experience. The tools intend to guide the employees at the beginning, during, and at the end of each project. The KM tools supporting this goal are peer assists, after-action reviews, and IT tools.

a) KUT-1 (Peer Assists): The peer assist tool aims to form project groups consisting of experienced and junior employees for each task or project. Each senior is assigned to a junior as their “mentor,” and the project challenge would be tackled with this group. Throughout the duration, the junior employees are assisted and guided by their mentor, and this enables the juniors to not only learn the optimal methods but also provide a chance to utilize what they have learned in real-life implementations. For example, in preparing a claim for EOT, the responsible team could be formed by one senior and one junior claim manager and, similarly, one senior and one junior planning engineer. Assigning the seniors as mentors would provide more confidence to the inexperienced employees to ask more questions and be more integrated with one another, which would speed up the learning processes.

b) KUT-2 (After-action reviews): After-action reviews are a tool that acts at the midpoint of the learning cycle. Through engaging in reflection and analysis of the ongoing progress of a significant work or project, employees have the opportunity to identify any issues and correct their performance, maybe by adopting an alternative approach. This prevents the continuation of inefficient processes or unfavorable performance and encourages the use of measures to bring about change.

4.2.3 Tool Kit 3: Knowledge Enhancing Toolkit (KET)

KM Tools in KET Toolkit: Seminars/Workshops, Performance Evaluation Reports, Usage of External Archives, IT Tools

KET aims to increase employees' knowledge acquisition. The KM tools in this toolkit aim to motivate the organization's learning culture and improve employees' knowledge in the field of their expertise. These tools are seminars and workshops, performance evaluation reports, usage of external archives, and IT software tools.

a) KET-1 (Seminars/Workshops): The seminars and workshops are a great opportunity for the employees to attend in order to boost their current knowledge. They consist of a speaker who is an expert in their field and provides talks to the concerned personnel about their experience or informs them about the latest updates in the field.

b) KET-2 (Performance evaluation reports): The performance evaluation reports are extremely valuable for employees to reflect on their performance. They are reports from managers or seniors that explain a person's strengths and weaknesses, which opens up a space for learning.

c) KET-3 (External archives): The use of external archives is a tool that may consist of sector reports, magazines, competitor information, etc., which would diversify the sources of knowledge from depending on only in-house material. Finally, IT tools are a great source for employees to look back at OM to strengthen their position in any decision-making situation.

4.2.4 Tool Kit 4: Knowledge Archive Toolkit (KAT)

KM Tool in KST Toolkit: IT Tools

a) KAT-1 (IT Tools): KAT aims to serve as an OM tool that would act as a database for any important information for any department within the company. In the view of claim management, the IT software tool may be a company-wide database where each claim and the outcomes are detailly embedded. In case of new disputes, claim managers can look back at archives to understand the company approach and benefit from lessons learned. The up-to-date project data would also be included in the database in a predetermined taxonomy where the companies can track their efficiencies.

4.3 Validation via Case Studies

The applicability of the KM Toolkits will be tested using the lesson-learned method on case studies. Thus, five different dispute claims and their outcomes are analyzed. Analyzing real-life cases can provide insights into existing problems and procedures, which allows us to determine how effectively the toolkits can enhance the claim management process.

4.3.1 Case Studies

4.3.1.1 Case Study A: Weather conditions

Claim Topic: Dispute on the effect of weather conditions on productivity at industrial plant construction

The claim report by the contractor evaluates potential productivity losses at the construction site caused by unfavorable weather conditions such as temperature, humidity, and wind. It is supported by climatic models described in existing literature. The measured mile method, which uses project data regarding productivity rates during impacted and unimpacted periods, is considered a more reliable approach to estimating productivity factors in a project. However, due to a lack of data, the contractor uses generic models from the literature to estimate the approximate productivity loss. Productivity coefficients are derived based on scientific research that is widely referenced in literature to compensate for production losses caused by adverse weather conditions.

In the report, when hot weather conditions and high humidity are concerned, the productivity coefficients that can be multiplied by original man-hours of construction tasks that require “medium-level effort (equipment-intensive)” during May, June, July, and August are calculated as 1.00,1.10,1.16 and 1.20. On the other hand, the productivity coefficients that can be multiplied with original man-hours of construction tasks that require “high-level effort (labor-intensive)” during May, June, July, and August are given as 1.10,1.18, 1.24, and 1.24. Tasks such as concreting works, rebar installation, and manual excavation can be classified as tasks requiring high effort.

Due to high wind conditions, productivity losses can occur in activities requiring crane lifting processes such as formworks. A productivity coefficient of 1.15 can be applied for all tasks/operations that necessitate a crane for lifting during the months of November to February.

Productivity coefficients regarding high wind are considered for the months of January and December; productivity coefficients regarding high temperature-high humidity are considered for the months of June, July, August, and September. For the rest of the months, productivity coefficients are taken as 1 (assuming no loss of productivity during March, April, May, and October due to climatic conditions). When adding and dividing these coefficients by 12, the average productivity coefficient is calculated as 1.10.

Table 4.5 below states the average productivity coefficient to be applied to all construction tasks during the year to account for adverse climatic conditions (taking the average of monthly productivity coefficients for tasks that require medium and high levels of effort).

Table 4.5 : Productivity coefficient according to months.

Month	Productivity coefficient
January	1.15
February	1.15
March	1.00
April	1.00
May	(1.00+1.10)/2=1.05
June	(1.10+1.18)/2=1.14
July	(1.16+1.24)/2=1.20
August	(1.22+1.24)/2=1.23
September	1.00
October	1.00
November	1.15
December	1.15
Yearly Average	1.10

It is stated that the coefficients calculated to compensate for loss of productivity due to adverse weather conditions are approximate values calculated by using monthly average values for temperature, humidity, and wind. They add that during some extreme weather events, work at construction sites may stop, leading to idle time and extensive delays. The claim report concludes that the client must compensate for the overall loss of productivity due to climatic conditions.

Decision:

The contractor should have been aware of the risks related to the location of the site facilities and thus should have taken necessary measures accordingly. Therefore, the Dispute Resolution Board has unanimously concluded that the contractor does not have the right to claim compensation for the weather conditions.

4.3.1.2 Case Study B: Unpaid earthquake cross-ties

Claim Topic: The contractor faced two disputes on unpaid earthquake cross-tie in two subsequent projects with different employers. Thus, the benefits of utilizing KM tools are evaluated for "Case Study B.1" and "Case Study B.2." together.

Case Study B.1: Dispute on unpaid "earthquake cross tie" reinforcement rates in residential buildings

The Contractor is engaged in residential building construction and requests the prices of unpaid earthquake cross-ties within the context of this claim. The Engineer did not include the rates of earthquake cross-ties in the progress payments, and thus, the rates of these reinforcements were not paid.

However, the earthquake cross ties, which are not used for fixing but as a structural element, were not included in any unit price. The Contractor contends that their rates should be paid separately. The contractual documentation states that materials such as losses, supports, saddles, spacers, spacer bars, tie bars, distance pieces, and steel binding wire, when used for purposes other than fixing, will be considered in the bill of quantities and paid separately, not included in the unit prices.

The Employer states that whether the materials of any work items are structural or not, their function's actual use amounts were not considered in the progress payments due to the contract documentation, but the Contractor states that it was not possible to agree on this opinion, likewise according to 2007 Regulation on Buildings to be Built on Seismic Zones, special earthquake cross ties are statically required to be used in reinforced concrete buildings, were not fixing elements, they were structural elements;

thus “Special Earthquake Cross Ties”, with the name in the Regulation, were needed to be produced and used according to the requirements of the relevant Regulation,

The Contractor submitted his proposal based on the information that Special Earthquake Cross Ties would be paid separately and not be included in unit prices. Likewise, the Contractor indicated Special Earthquake Cross Ties in shop drawings, and the Engineer approved them; this situation showed that the parties agreed that cross-ties would be paid based on their own unit prices. “Earthquake Cross Ties” reinforcements, the matter of dispute, were referred to as “Cross Ties”, and the expression “Tie Bars” was avoided being used; by doing this, it was requested that these reinforcements were not the “Tie Bar” which is a simple installation element to be used for fixing, specified in contract documentation, the reinforcement referred as “Cross Ties” had a structural task. The tie bars for fixing were elements to be used when needed and not included in the projects, but the claimed “Earthquake Cross Ties” reinforcements were structural parts in the projects; their shapes, bending diameters, and reinforcement diameters were determined in the project in detail, they were included in the bill of quantities by giving item number, they were named as “cross ties,” and therefore the Contractor claims that their rates should be paid.

In reply statement of Employer, for setting an example, Employer stated that the structural elements under Pumice Block Wall Works Unit Price Definition manufacturing work were included in unit prices; they would not be taken into consideration for measurements and no separate payments would be made; in Pumice Block Wall unit price definitions specified by Employer it is stated that “Flitch and lintels (formwork, concrete, iron) shall be made in accordance with the Specifications; and they shall not be paid separately since they are included in Pumice block wall price. Clamping wedges, dovetail, wire lath, etc., used in walling are included in the price.” as it is understood from here, no fixing and structural separation was made in the price definition of Pumice Block Wall. Instead, it was stated that separate payments for all iron items would not be made. In addition, payments of many items in steelworks, which was shown as an example by Employer, upon a single unit price was derived from the fact that some items of the bill of quantities regarding steelworks are defined as a lump sum in the contract, iron works were not defined as a lump sum.

As a result, the Contractor stated that applied “Special Earthquake Cross Ties” were not used for clamping/connecting (for fixing) columns and walls as stated in the specification annexed to the contract; their quantities and shapes were determined according to static projects prepared in compliance with Earthquake Regulation, cross ties were compulsory in terms of static, they were applied as they were "Special Earthquake Cross Ties", with the name in regulation; thus these cross ties were not installation tie bars, they were produced as "Special Earthquake Cross Ties" statically needed; for this reason, Contractor requested the unpaid remuneration since 11th progress payment, together with the commercial advance interest to be accrued till the payment date.

Decision:

Cross ties shown on the drawings are manufactured as a requirement of the Earthquake Code and thus should be included in the measurement. Therefore, the Dispute Resolution Board reached a conclusion and opinion unanimously that the Contractor has the right to claim the prices of installed cross ties. The manufactured earthquake cross ties with structural function should be included in the rebar bill of quantities and should be paid on the "reinforced rebar works" item number.

Case Study B.2: Dispute on unpaid "earthquake cross tie" reinforcement rates in governmental complex

The same Contractor is responsible for the construction of a governmental complex in a seismic zone where the earthquake cross ties are used in the reinforced concrete design.

Drawing from their previous experience, the Contractor claims that the earthquake cross-ties are not merely for fixing but serve as a crucial structural element, thereby requiring separate payment outside the unit price. The contractor points out that, again, the detailed shop drawings submitted and approved included these special earthquake cross-ties, indicating an understanding that these elements would be paid for separately based on their unique unit prices.

The core of the disagreement centers around the understanding of contractual clauses related to the understanding of particular structural components such as earthquake cross-ties. The contractor demands separate payment for the ties linking to their specialized nature and crucial function in seismic protection, which is not paid in the progress payments. On the other hand, the Employer believes that all components required for the building, regardless of their particular use, should be encompassed in the unit pricing stated in the contract.

Decision:

The Dispute Resolution Board has reached a conclusion and opinion unanimously that the Contractor has the right to claim the prices of installed cross ties. The manufactured earthquake cross ties with structural function should be included in the rebar bill of quantities and should be paid on the “reinforced rebar works” item number.

4.3.1.3 Case Study C: Unaccounted security measures

Claim Topic: Dispute on the decrease in labor productivity associated with the security measures of the construction site.

The construction project is intended for the defense industry and holds a special security classification. This status forces additional security measures to address any unfavorable circumstance that might pose a risk. The contractor claims that the security status causes interruptions, leading to delays for employees and machinery due to security checks and restrictions on accommodation and other service facilities on site. Thus, they have prepared a claim on the impact of "special security status" on productivity, focusing on time lost by workers commuting between accommodation and construction sites and time lost due to restricted catering services and the distance to the work site.

The effect of high-security measures on productivity is measured by the time workers lose between entry and exit from the construction site for security checks. It may also indirectly affect productivity beyond time lost, where productivity may be closely linked to employees' commuting habits. It is stated that the stress from commuting might decrease job satisfaction and lead to a decline in labor productivity.

The effect of security checks on productivity is highly related to the project size, including factors like the quantity of personnel and equipment being transported to and within the construction. As the numbers' values increase, the lines at security checkpoints get longer. Thus, the contractor states they are forced to wake workers up early to compensate for the time lost during these checks. Since the maximum number of personnel, machinery, and equipment are expected to reach considerable values during the peak, the contractor claims the project may experience inevitable delays due to poor accessibility to and inside the construction site.

The contractor's analysis, which was conducted for one week, revealed that around 3 hours per worker are wasted in a standard workday, resulting in a minimum productivity loss of about 12%. This would not have occurred if the site did not have special security status and constraints. However, they note that the estimated loss of production value is cautious since it does not consider the negative effects of damaging morale due to lengthy waiting times in lines and extended travel times for workers.

In conclusion, the contractor requested compensation for the reduced productivity and proposes applying a coefficient of 1.14 to man-hours and equipment hours to offset a reduction in labor productivity due to the project's security status.

Decision:

Dispute Resolution Board has concluded unanimously that the contractor does not have the right to claim compensation for the sensitive security measures as the contractor should have been aware of the risks allocated with the security category of the project and should have taken necessary measures accordingly

4.3.1.4 Case Study D: Delay in site handover

Claim Topic: Dispute on the decrease in labor productivity associated with the delay in handing over the worksite in the tram construction project.

The contractor has filed a claim against the Employer for the delayed handing over of the work site from the municipality. The contractor must submit a work schedule to the Employer within 28 days of receiving the construction permit. The work schedule takes into account all tasks that must be conducted on-site to complete the work. This also includes the responsibilities of third parties that directly or indirectly influence the commencement of the contractor's works.

Within the borderlines of the construction site, there are forests that are under the municipality's responsibility to deforest after the site's handover. With this knowledge in mind, the contractor provided a work schedule to the Employer after receiving the construction permit for the site. It should be noted that even though the construction permit allows the contractor to start the construction works on site, this does not necessarily mean the granted access to the whole site. There are sections on the project where the third parties' tasks must be completed for the complete site handover to the contractor. One of these tasks, which is the subject matter of the claim, is the deforestation of the municipality forest, which is under the municipality's responsibility.

The contractor submitted the work schedule in time and got approval from the Employer. The work schedule considers the tasks that must be accomplished by third parties and sees a completion time for the maximum allowable duration the contract allows. For the deforestation of third parties, the maximum allowable time stated in the contract is 6 months, which is the duration the contractor has implemented in the work schedule. Deforestation is highly influential on the rest of the construction works since it is located midway through the project and limits access to the other sections as it covers the whole construction area from one side of the borderline to the other.

Even though the contract states that the responsible authority has a maximum deforestation time of 6 months, the authority completed the deforestation and handed over the section in 8 months and 12 days.

This delay caused the prolongation of all construction activities within the section and caused major disruption in the work schedule beyond the 73-day delay. The contractor had planned the section to be handed over on the 8th of October when the weather conditions are eligible to progress the works in high productivity. However, since the section was handed over to the contractor on the 20th of December, the weather conditions have limited the contractor in this critical section to progress at the desired pace. The contractor claims that this limitation in productivity has caused a disturbance in the overall harmony of the projects, and the effects could not be compensated in the upcoming months.

Thus, the contractor not only claims an extension of time for the prolongation in handing over the section but also requests compensation for the loss of productivity due to this delay.

Decision:

The contract clearly defines the maximum time that should be considered for the deforestation works; since the responsible authority to conduct this work has breached this duration, the Dispute Resolution Board has reached the conclusion and opinion unanimously that the Contractor has the right to claim an extension of 73 days.

Regarding the contractor's compensation claim, the Dispute Resolution Board has concluded that the Contractor misjudged not having been prepared to adjust the necessary manpower and machinery for the desired productivity and, thus, has no right to claim extra compensation.

4.3.1.5 Case Study E: Errors in investor requirements

Claim Topic: Dispute on the errors in investor requirements

The Contractor has filed a claim for circumstances in which they suffer damage or are unable to meet the contract terms due to specific errors and discrepancies in the requirements submitted by the Employee. These errors and discrepancies are the differences in requirements for the determined contractual documents (design, legal permits, etc.). The claim consists of the Contractor's requests for compensation for the losses incurred or demand for a change in the terms and conditions of the contract to bring them into line with the actual requirements that were ill-defined or imprecisely described by the Employee.

The Contractor has filed the claim regarding the Employee's submission of new guidelines for developing the Emergency Action Program for the expressway construction project. These new circumstances, under which the development of the construction document in question requires additional design work, new guidelines for the implementation of experimental road signage, and horizontal and vertical signage on the existing sections of the expressway.

Outcomes related to errors in requirements include:

- additional costs incurred by the contractor to comply with new or changed requirements,
- the need to carry out additional work that was not included in the original requirements,
- loss of profits that could have been achieved if the requirements had been correctly defined and understood.

Thus, the contractor claims compensation for additional costs and extension of time for the described circumstances.

Decision:

The claim related to errors in the Employer's Requirements allows the Contractor to request compensation or changes to the contract terms when the errors affect its ability to perform the contract or incur additional costs. Therefore, the Dispute Resolution Board has reached a unanimous conclusion that the Contractor has the right to claim compensation for the discrepancies in the Employment Requirements.

4.3.2 Claim Expert Interviews for Case Studies

The applicability of KM toolkits is analyzed in terms of how influential they can be in claim management. Four main steps explained previously in Fig 3.2 lead to the resolution of the claim management processes: identification of the claim, notification of the claim, documentation of the claim, and presentation of the claim. The KM Toolkits are analyzed in terms of how they can be applied to these processes, and the results are given in Table 4.6.

Table 4.6: Most applicable KM tools on claim management processes.

KM Toolkit	Identification of Claim	Notification of Claim	Documentation of Claim	Presentation of Claim
KST		X		X
KUT	X			X
KET			X	X
KAT	X		X	

KST would be most beneficial when applied in “Notification of Claim” and “Presentation of Claim.” During the notification of a claim, it is crucial to ensure that all relevant stakeholders are promptly and accurately informed. KST can facilitate this through established communication channels and collaborative platforms where the employees can share relevant data. For the presentation of a claim, the toolkit’s focus on workshops and feedback sessions can help prepare and refine the claim presentation, ensuring it is comprehensive and persuasive.

KUT can be used to ease the “Identification of Claim” and “Presentation of Claim” processes. KUT focuses on guiding employees with senior colleagues' assistance, often involving mentorship and monitoring. During claim identification, senior experts can help junior employees recognize potential claims through their experience and insights. When it comes to presenting the claim, guidance from senior colleagues can help ensure that the claim is presented effectively, leveraging their expertise to anticipate and address counterarguments.

Using KET can be most advantageous in “Documentation of Claim” and “Presentation of Claim.” Access to external archives and performance reports can provide additional context and supporting information for the documentation of claims, making the documentation more robust. During the claim presentation, knowledge gained from seminars and continuous learning initiatives can enhance the quality and delivery of the claim presentation, ensuring it is well-informed and compelling.

KAT would be most advantageous in “Identification of Claim” and “Documentation of Claim.” Employees can identify potential claims early by accessing previous claims, past project data, and historical documentation. The previous records stored in the OM can also ensure that all necessary documentation is readily available and accurately reflects the issues at hand, making the documentation process more effective.

The applications of KM toolkits on claim management case studies are given in Table 4.7 below. The proposed KM Toolbox for Claim Management consists of four KM Toolkits. Five dispute cases are presented below to analyze the usability of each Toolkit in various dispute scenarios. Since each toolkit comprises multiple tools, the most applicable tools are presented below, and the explanation of how they can be implemented in each dispute scenario is given below. Driven form this table interview questions in Appendix 2 are formed. The participants are asked to enter their ratings, measuring the usability of each tool in enhancing the effectiveness of the claim and dispute management process through KM for the five dispute scenarios presented. In the “Rating” column, “5” means “Very useful,” and “1” means “Not useful at all.” At the end of the application list, there are two open-ended questions where the participants are requested to write their thoughts on the overall usability of the proposed “KM Toolbox for Claim Management” in construction projects.

Table 4.7 : Applications of KM tools on claim management case studies.

Case Study	KM Toolkit	Description
Case Study A	KST-1	Establishing communities of practice could have enhanced the project team's comprehension of the situational dynamics at the site, enabling them to exercise caution.
Case Study A	KST-3	Empirical data collected directly from the site and integrated into an information technology tool with proper data management principles would have provided a stronger foundation for constructing the claim report than reliance on empirical formulations.
Case Study A	KUT-1	Guidance from experienced personnel would have expedited the project team's and site engineers' understanding of the challenges posed by weather conditions and encouraged the contractor to adopt a more cautious approach.
Case Study A	KET-3	Benefiting from external archives of completed projects in the region during the tender preparation period would have benefited the Contractor in preparing claims or increasing the night shifts to compensate for productivity loss.
Case Study A	KAT-1	The contractor, an experienced entity in the industry with over three decades of experience, has a record of undertaking projects within the same region for similar clients. An examination of its previous projects reveals this pattern of regional and client consistency. Had the contractor maintained a comprehensive project archive, embedding essential project knowledge, it could have leveraged this repository better to understand the site conditions and the client's approach.
Case Study B	KST-1	Implementing post-project feedback mechanisms to address disputes encountered in the contractor's initial project could have served as a valuable reminder and prepared the relevant team for the potential occurrence of earthquake cross-ties.
Case Study B	KST-2	Establishing communities of practice during the initial dispute could have provided the project team with a simulated conflict scenario, benefiting a subsequent team facing a similar issue. This proactive approach would have enabled the second project team to implement necessary measures preemptively, potentially preventing the situation from escalating into a dispute.
Case Study B	KUT-1	Guidance from experienced personnel for the project team and site engineers could have facilitated a quicker comprehension of disputes when encountered a second time, enabling a swifter response. This strategic foresight would have better positioned the contractor to exercise caution effectively.
Case Study B	KET-2	The implementation of performance evaluation reports upon completion of the initial project would have been instrumental in preparing employees for subsequent projects. Those involved in the initial claims could have utilized this period for reflection, thereby enabling them to transfer their acquired insights more comprehensively and effectively to the next project.
Case Study B	KAT-1	Even in the absence of employees participating in both projects, the availability of a robust IT tool designed to archive previous claims could have significantly benefited the second project team. By accessing this system, they could have recognized the potential for a dispute based on historical data and responded to initial signs of trouble with greater seriousness and efficacy.

Table 4.7 (continued) : Application of KM tools on claim management case studies.

Case Study	KM Toolkit	Description
Case Study C	KST-2	The report indicates that the analysis spanned one week to build the case. If progressive, real-time data recorded on-site had been systematically captured and integrated into an IT tool adhering to proper data management principles from the onset of construction through to the preparation of the report, it would have constituted a more reliable and effective foundation for constructing the claim report.
Case Study C	KUT-1	Providing guidance to the project team and site engineers through experienced personnel would have expedited their understanding of site security conditions. This enhanced awareness could have enabled the contractor to exercise appropriate caution, thereby mitigating risks associated with productivity loss.
Case Study C	KET-3	The contractor could have derived significant advantages from using external archives prior to the commencement of the project to gain insights into the client's approach toward security measures. Such preemptive research would have facilitated the development of a project schedule that proactively incorporates potential delays associated with stringent security protocols, thereby optimizing time management and operational efficiency.
Case Study C	KAT-1	The contractor, an experienced company in the market where the project is situated, would have significantly benefited from maintaining an archive of previous claims and decisions from past projects. Access to such a repository would have enabled responsible employees to draw on lessons learned, thereby enhancing their ability to construct a more compelling and persuasive report.
Case Study D	KST-1 & KST-3	Given that this project represents the contractor's second project in this foreign market, a more thorough analysis of the problems and challenges encountered during the first project could have been beneficial. Implementing a post-project feedback mechanism would have facilitated reflection on the lessons learned, thereby equipping the team with enhanced preparedness for navigating the complexities of the second project.
Case Study D	KUT-1 & KUT-2	If the project planning team had been composed of senior engineers who had experience from the contractor's previous projects, in collaboration with new employees, the construction schedule could have been significantly optimized. For instance, it is a contractual obligation for the contractor to conduct a sapper check prior to deforestation at any site location. A senior planning engineer familiar with such protocols could have strategically advised initiating the sapper control specifically in the forest area that was targeted for early development. This proactive approach would have likely expedited the overall project timeline, leading to an earlier completion date.

Table 4.7 (continued) : Applications of KM tools on claim management case studies.

Case Study	KM Toolkit	Description
Case Study D	KET-3	External archives could be referred to assess the municipality's typical deforestation timelines accurately. With this information, the planning team could more effectively prepare the contractual documentation while also developing a contingency plan (Plan B) in the event that the deforestation process extends beyond the anticipated timeframe. This approach would ensure greater preparedness and adaptability in project scheduling and execution.
Case Study D	KAT-1	The implementation of an archival tool containing valuable and pertinent data from the contractor's previous project in this country could have significantly enhanced understanding of local weather conditions. This deeper insight would enable the project team to strategically rearrange productivity schedules to accommodate weather-related disruptions, thereby optimizing operational efficiency and minimizing downtime.
Case Study E	KST-3	An IT tool designed to record contracting necessities, documentation, key requirements, designs, and drawings would have offered significant advantages for document management and comparison. With such a system in place, the contractor could efficiently compile and cross-reference new documents against existing records. This streamlined approach would facilitate a quicker case build-up, ensuring that no discrepancies are overlooked and enhancing the overall case preparation process.
Case Study E	KUT-2 & KUT-3	Forming the project team by pairing experienced personnel with junior members could have expedited the identification of discrepancies in the original documentation during comparison processes. This structured team approach would enhance the contractor's ability to quickly recognize and address discrepancies, enabling swifter reactions to emerging issues and potentially averting complications in project execution.
Case Study E	KET	-
Case Study E	KAT-1	An IT tool designed to meticulously record contracting necessities, documentation, essential requirements, designs, and drawings would have offered significant advantages for document management and comparison. The contractor could efficiently compile and cross-reference new documents against existing records with such a system. This streamlined approach would facilitate a quicker case build-up, ensuring no discrepancies are overlooked and enhancing the overall case preparation process.

The interview was conducted with eight participants. One of the participants is academic personnel who has spent many years teaching claim management to university students as well as participating in juries on dispute adjudication boards. Three of the participants work in the construction sector as claim managers, and the remaining five participants work in a corporate law firm that gives consultation on claims to contractors. The overview of the participant's background is given in Table 4.8, and their numerical responses to the interview questions are given in Table 4.9 below.

Table 4.8 : Background information of interview participants.

Participant Number	Profession	Title	Years of Experience
Participant 1	Academic personnel	Professor	30
Participant 2	Civil Engineer	Claim Manager	25
Participant 3	Civil Engineer	Claim Manager	20
Participant 4	Civil Engineer	Claim Manager	15
Participant 5	Lawyer	Senior Claim Manager	18
Participant 6	Lawyer	Claim Manager	10
Participant 7	Lawyer	Claim Manager	9
Participant 8	Lawyer	Claim Manager	8
Participant 9	Lawyer	Claim Manager	8

Table 4.9 : Ratings given by participants.

Case Name	Tool	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Participant 7	Participant 8
Case Study A	KST-1	4	4	4	4	5	4	4	4
Case Study A	KST-3	4	4	5	4	4	5	3	4
Case Study A	KUT-1	5	5	4	5	4	5	3	3
Case Study A	KET-3	3	4	3	4	4	4	4	4
Case Study A	KAT-1	3	5	4	5	3	4	5	5
Case Study B	KST-1	3	5	4	4	4	4	4	4
Case Study B	KST-2	4	5	3	4	4	4	4	4
Case Study B	KUT-1	4	4	4	3	3	4	4	5
Case Study B	KET-2	3	4	3	4	4	5	3	5
Case Study B	KAT-1	4	4	5	5	4	5	4	5
Case Study C	KST-2	5	5	4	4	5	5	4	4
Case Study C	KUT-1	3	4	4	5	4	5	4	3
Case Study C	KET-3	2	3	3	3	3	4	3	3
Case Study C	KAT-1	4	4	5	5	4	4	5	4
Case Study D	KST-1 & KST-3	3	4	4	4	4	4	4	4
Case Study D	KUT-1 & KUT-2	3	4	3	5	4	4	4	4
Case Study D	KET-3	4	5	4	4	4	4	5	3
Case Study D	KAT-1	4	5	5	4	5	5	5	5
Case Study E	KST-3	4	5	5	5	5	5	4	5
Case Study E	KUT-2 & KUT-3	3	3	4	3	4	3	4	4
Case Study E	KAT-1	4	5	4	5	4	5	5	3

Next, the results are averaged for each KM Toolkit to see the applicability from the perspective of interviewed experts. Results are given in Table 4.10. The results and the final two written questions are discussed in the next section

Table 4.10 : Average applicability results of KM Toolkits.

KM Toolkit	Rating Score
KST	86 %
KUT	78 %
KET	74 %
KAT	89 %

4.4 Discussion

The methodology of validating the applicability and usability of the KM Toolbox proposal consisted of implementing the proposed benefits to five case studies in a lesson-learned manner. The case studies are dispute claims that different contractors faced in different site environments with varying outcomes. The implementation of the four KM Toolkits with their most appropriate tools in each case-study scenario aims to ease the claim management process, improve the outcome, or increase efficiency. This applicability of the KM Toolkits is verified by interviewing eight claim management experts and asking them to rate the 21 scenarios to which the toolkit is applied. The rating is done by scoring the scenario from 1 to 5 regarding usefulness. Additionally, the participants are asked two open-ended questions about their views on the KM Toolbox and its real-life applicability.

The highest-ranked Toolkit among the participants is KAT. The basis of the toolkit is having a comprehensive software tool that is easy to navigate. Employees can refer to this tool as an OM archive during or before claim management procedures. The participants ranked the usability of the tool in the five case studies as 4.46 out of 5, which shows possible effectiveness. Having an organizational archive is important for companies so that they do not repeat the same mistake twice and take precautions in similar unfavorable scenarios. In most case studies, participants agreed that referral to an OM archive would have prevented the claim from happening or improved the final outcome.

The results from Table 4.4 suggest that the participants viewed KST as the second most beneficial to apply to cases. KST consists of tools that encourage employees to share the knowledge they possess. Knowledge sharing is a key part of KM, and the tool aims to enhance collaborative work by forming the necessary grounds for sharing tacit or explicit knowledge. The participants ranked this tool as 4.29 out of 5 in terms of usability, which suggests the implementation of this tool would have resulted in a better outcome during the claim management processes. The suggestions were especially ranked high on case studies where communes of practices are applied to keep the OM up-to-date and on cases where sharing of construction data would have concluded in an more effective claim argument.

The next toolkit ranked third by the participants is the KUT. The toolkit aims to create value by guiding the employees with an assigned senior colleague. The juniors are monitored, and their seniors review their actions and decision-making. The participants ranked this tool 3.91 out of 5 on the possible effects for claim management scenarios. The tool is proposed to be used in cases where the senior engineers can share their tacit knowledge with younger team members to assess the dispute situation and strengthen the team's decision-making skills. This tool might have been rated slightly lower than the other because it might be harder to spot the benefits and implications quickly. This tool encourages to guide and develop the junior members of the team and allows for a knowledge-sharing environment. When this environment is set, and younger employees become more self-aware and educated, this will eventually benefit the company in the long run. A similar comment could also be made for the KET, ranked 2.97 out of 5. KET is a tool that aims to increase the knowledge intake by employees. These are aimed to be done by seminars, using external archives and performance evaluation reports, etc. Improving the engineers and claim managers to become more capable and competent in the field of claim management would shorten the processes and improve outcomes. However, it is difficult to evaluate the direct impacts applied to a case study compared to other toolkits.

The answers to the two verification questions at the end of the interview enlighten and solidify the application of the KM Toolbox. The first question sought the experts' suggestions for enhancing the effectiveness of the KM Toolbox, and five participants answered this question, while the others stated that they had no further suggestions. The first participant pointed out the importance of employee engagement to the KM

Toolbox for the desired outcomes and thus suggested adding a “knowledge sharing incentive program” to the IT tool. This program would reward the employees for valuable knowledge-sharing contributions and incentivize the employees to contribute, which would create a comprehensive knowledge base. The second participant suggested including a “knowledge validation and certification” process, which would act as an internal audit and enhance the reliability of the toolbox. This process would involve regular audits of all knowledge-sharing mechanisms to ensure the system operates accurately. Next, the participant suggested that a lesson-learned repository specific to claim management could be beneficial. She added that while the KAT focuses on archiving data, a dedicated repository for lessons learned from past claims would allow for more targeted knowledge sharing. The fourth participant suggested a scenario planning and simulation tool as an innovative addition. He said this tool could be used for claim managers to model different scenarios based on historical data. The final suggestion was an integrated knowledge retrieval and discovery system powered by AI. He suggested that this system could retrieve relevant past claims and project data stored in an organizational archive that could be used for current needs. This way, insights that might have been overlooked could be useful.

The second question asks the participants about the toolbox's applicability in construction projects and ways to increase its usability. While all the participants found the KM Toolbox and many of the toolkits easy to apply, they also pointed out some challenges. Three of the participants pointed out that employees would resist change to new organizational applications. Overcoming this challenge would require a comprehensive management strategy and determination, training, and clear communication with employees of all concerned positions should be made. Two other participants also had similar concerns and suggestions, such as possible difficulties with the existing system a company might have. The solution for this, which would increase usability, is to start pilot projects and gradually scale up as integration problems become more scarce. Two participants also pointed out that the time and resource investment required for such implementation can be discouraging. In order to overcome this and increase usability, a demonstration of the long-term return on investment of such implementation should be projected into workflows, and there should be metrics to evaluate the effectiveness and successes the KM Toolbox brings.

Overall, the open-ended answers and statistical data suggest that industry professionals support the KM Toolbox for claim management scenarios. The rating suggests a minimum usability score of 74% and an average rating of 81.9% for the KM Tools. This data highlights the acceptability and validation of the toolkits within the field.

5. CONCLUSION AND RECOMMENDATIONS

KM has become vital for sustaining competitive advantage in today's fast-paced business environment. KM is formed by storing, capturing, sharing, and utilizing knowledge to enhance the organization's collective memory. Effective KM practices can lead to better decision-making, innovation, and enhanced performance. Despite its significance, the construction sector has been slow to adopt comprehensive KM methodologies compared to other industries, such as consulting. In this thesis, sector interviews are conducted with representatives from construction and consulting companies to understand the construction sector's current practices on KM and its position concerning an advanced sector in the field.

Significant differences emerge when comparing the current KM practices in the construction and consulting sectors. Companies like D, E, and F in the consulting sector employ highly structured data collection systems, with global and local databases ensuring comprehensive data storage. They consistently use predetermined taxonomies and digital databases, facilitating easy data retrieval and storage. Conversely, construction companies A, B, and C exhibit decentralized and inconsistent data collection practices, often resulting in data silos. Limited or non-existent taxonomies lead to inconsistent data storage practices across the sector.

Data accessibility and usage also vary significantly between the sectors. Consulting firms demonstrate broad and efficient data accessibility, allowing frequent use of historical data to inform current projects. Data is broadly accessible, enabling regular use of past project data for framing and solving current challenges. In contrast, construction firms display restricted and limited data accessibility, often centralized at headquarters with restricted access based on employee positions. Historical data is rarely used for ongoing projects, limiting the benefits of OM.

Knowledge-sharing practices further highlight the disparity between the sectors. Consulting firms have robust systems for sharing explicit knowledge, extensively using software systems and supplemented by post-project reviews, seminars, and expert reports for tacit knowledge transfer. The construction sector shows less developed explicit knowledge-sharing mechanisms, often limited to one-way transfers, while tacit knowledge-sharing practices exist but are less formalized.

To bridge the gap between current practices and potential enhancements, the construction sector must focus on structured data collection, broader data accessibility, and fostering a robust knowledge-sharing culture. Adopting comprehensive and consistent data collection systems with detailed taxonomies and centralized data management teams will ensure data integrity and seamless retrieval. Developing systems that allow broader access to historical data will enable relevant personnel to benefit from past experiences. Efficient search engines and reduced access restrictions will empower employees to make informed decisions. Formalizing and expanding explicit and tacit knowledge-sharing practices through regular sessions, sector-based seminars, and structured programs like the master-apprentice model will promote continuous learning and innovation.

Implementing a comprehensive software system is critical to achieving these improvements. This system should be adopted company-wide to ensure consistent data management and knowledge sharing. It must support detailed taxonomies for data collection, offer efficient search capabilities for data accessibility, and facilitate various knowledge-sharing initiatives across the organization.

To address the construction sector's needs, this study proposes the development of KM toolkits, collectively referred to as the KM Toolbox. These toolkits are designed to integrate best practices and tailored solutions to enhance KM in construction. The applicability and usability of the KM Toolbox were validated through real-life case studies in claim management, where different contractors faced various dispute claims in diverse site environments.

Claim management in the construction sector is particularly complex and high-stakes, involving detailed documentation, negotiation, and resolution of contractual disputes, unforeseen changes, and delays. These processes require meticulous data management and extensive use of historical and experiential knowledge, making claim management an ideal candidate for applying KM principles. Implementing robust KM practices in claim management can streamline information retrieval, improve risk assessment, and foster collaboration, ultimately leading to faster resolutions and reduced legal disputes.

The KM Toolkits were applied to five case studies, and their effectiveness was verified by eight claim management experts who rated 21 scenarios. The results showed strong support for the KM Toolkits, particularly the Knowledge Archive Toolkit (KAT) and Knowledge Sharing Toolkit (KST), which received high usability ratings to enhance the claim management procedures and improve the outcomes.

In conclusion, effective KM is essential for the construction sector to thrive in today's competitive environment. Construction firms can significantly enhance their claim management practices by addressing the identified areas for improvement and implementing comprehensive KM toolkits. This study underscores the importance of structured data collection, broad data accessibility, and a robust knowledge-sharing culture. The proposed KM toolbox, validated by industry professionals, offers a practical solution for leveraging organizational knowledge, reducing errors, and improving project outcomes.

The contributions of this thesis are as follows:

1. Contribution to KM Literature,
2. Development of tailored KM Toolkits,
3. Comparative analysis of KM practices,
4. Empirical validation of KM Tools through case studies,
5. Expert insights and practical recommendations in claim management Processes.

Despite the significant findings, this study has several limitations that should be acknowledged to provide a comprehensive understanding of the results. The primary obstacle is the limited number of construction companies participating in the sector interviews. The study interviewed a limited number of international organizations, which may not comprehensively represent the various KM approaches seen in the worldwide construction sector. By incorporating a larger group of multinational corporations, the research might have examined the demographic factors impacting

KM strategies more comprehensively. This expanded scope could have benefitted from the insights of renowned researcher Geert Hofstede (1991), who noted that "culture is more often a source of conflict than synergy. Cultural differences are a nuisance at best and often a disaster." Understanding these cultural dimensions could have provided more profound insights into how national culture impacts KM implementation. Analyzing the demographic influences on KM can be considered for future studies to be conducted on the topic, offering a pathway to explore how cultural differences impact the adoption and success of KM strategies across diverse organizational settings.

REFERENCES

Al-Ghassani, A. M., Anumba, C. J., Carrillo, P. M., & Robinson, H. S. (2005). Tools and techniques for knowledge management. In C. J. Anumba, C. Egbu, & P. Carrillo (Eds.), *Knowledge management in construction* (pp. 10–30). London, UK: Blackwell Publishing.

Andreeva, T., and Kianto, A. (2012). Does knowledge management really matter? Linking knowledge management practices, competitiveness, and economic performance. *Journal of Knowledge Management, 16(4)*, 617-636.

Ansell, C., and Gash, A. (2008). Collaborative governance in theory and practice. *Journal of Public Administration Research and Theory, 18(4)*, 543-571. https://doi.org/10.1093/jopart/mum032

Argote, L., and Miron-Spektor, E. (2011). Organizational Learning: From Experience to Knowledge. *Organization Science, 22(5)*, 1123-1137. https://doi.org/10.1287/orsc.1100.0621

Argote, L. (2013). Organizational learning: Creating, retaining, and transferring knowledge. Heidelberg: Springer.

Argyris, C., and Schon, D. A. (1978). Organizational learning: A theory of action perspective. Reading, MA: Addison-Wesley.

Becker, M. C. (2004). Organizational routines: A review of the literature. *Industrial and Corporate Change, 13(4)*, 643-677. https://doi.org/10.1093/icc/dth026

Bencsik, A., Lore, V., & Maros, I. (2009). From individual memory to organizational memory (Intelligence of organizations). *International Journal of Economics and Management Engineering, 3(8).*

Bramble, B. B., and Cipollini, M. D. (1995). Resolution from disputes to avoid construction claims. Washington, D.C.: National Academy Press.

Brown, J. S., and Duguid, P. (1991). Organizational learning and communities-of-practice: Toward a unified view of working, learning, and innovation. *Organization Science, 2(1)*, 40–57. https://doi.org/10.1287/orsc.2.1.40"

Brown, J. S., and Duguid, P. (1998). Organizing Knowledge. *California Management Review, 40(3)*, 90–111. https://doi.org/10.2307/41165945"

Brown, J. S., and Duguid, P. (2000). The social life of information. Boston, MA: Harvard Business School Press.

Burgelman, R. A. (1983). A model of the interaction of strategic behavior, corporate context, and the concept of strategy. *Academy of Management Review, 8(1)*, 61-70. https://doi.org/10.5465/amr.1983.4287661

Cakmak, P.I., and Cakmak, E. (2013). An analysis of causes of disputes in the construction industry using analytical hierarchy process (AHP). AEI

Clas, G. M. (2018). Unintended consequences of the FIDIC 2017 clause 20.1 claims classification system. Retrieved from https://corbett.co.uk/wp-content/uploads/Unintended-Consequences-of-Claim-Classification.pdf

Coakes, E. (2006). Storing and sharing knowledge: Supporting the management of knowledge made explicit in transnational organisations. *The Learning Organization, 13(6)*, 579–593."

Cohen, W. M., and Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly, 35(1)*, 128-152. https://doi.org/10.2307/2393553

Conklin, J. (2001). Designing organizational memory: Preserving intellectual assets in a knowledge economy.

Cooke, B., and Williams, P. (1998). Planning during construction. In *Construction planning, programming and control* (pp. 193-206). https://doi.org/10.1007/978-1-349-14293-4_6

Daft, R. L., and Weick, K. E. (1984). Toward a model of organizations as interpretation systems. *Academy of Management Review, 9(2)*, 284–295. doi:10.5465/amr.1984.4277657

Easterby-Smith, M., and Lyles, M. (2015). The evolving field of organizational learning and knowledge management (2nd ed.). Chichester: John Wiley.

Egbu, O. C., and Robinson, S. H. (2005). Construction as a Knowledge-Based Industry. In C. J. Anumba, C. Egbu, & P. Carrillo (Eds.), *Knowledge Management in Construction* (pp. 31–49). London, UK: Blackwell Publishing."

Ellinger, A. D., Ellinger, A. E., Yang, B., & Howton, S. W. (2002). The relationship between the learning organization concept and firms' financial performance: An empirical assessment. *Human Resource Development Quarterly, 13(1)*, 5-21.

Feldman, M. S., and Pentland, B. T. (2003). Reconceptualizing Organizational Routines as a Source of Flexibility and Change. *Administrative Science Quarterly, 48(1)*, 94-118. https://doi.org/10.2307/3556620

Ferrada, X., Núñez, D., Neyem, A., Serpell, A., & Sepúlveda, M. (2016) A lessons-learned system for construction project management: A preliminary application. *Procedia - Social and Behavioral Sciences*, 226, 302–309.

FIDIC Communiqué (2017). FIDIC rainbow suite (2nd ed.). Retrieved from https://fidic.org/sites/default/files/press%20release_rainbow%20suite_2018_03.pdf

Fiol, C.M. and Lyles, M. (1985) Organizational Learning. *Academy of Management Review, 10*, 803-813.

García-Morales, V. J., Jiménez-Barrionuevo, M. M., & Gutiérrez-Gutiérrez, L. (2012). Transformational leadership influence on organizational performance through Organizational Learning and Innovation. *Journal of Business Research, 65(7)*, 1040–1050. doi:10.1016/j.jbusres.2011.03.005

Glover, J., and Elliott, F. (2015). Sub-clause 20.1 – the FIDIC time bar under common and civil law. Retrieved from https://www.fenwickelliott.com/research-insight/articles-papers/contract-issues/sub-clause-fidic-time-bar

Green, B. (2016). Productivity in construction: Creating a framework for the industry to thrive. Retrieved from https://www.ciob.org/industry/research/Productivity-Construction-Creating-framework-industry-thrive

Gualtieri, M. (2016). Hadoop is data's darling for a reason. Forrester. Available at https://go.forrester.com/blogs/hadoop-is-datas-darling-for-a-reason/

Gubbi, J., Buyya, R., Marusic, S., & Palaniswami, M. (2013). Internet of things (IoT): A vision, architectural elements, and future directions. *Future*

Generation Computer Systems, 29(7), 1645-1660. https://doi.org/10.1016/j.future.2013.01.010

Hansen, M.T., Nohria, N., & Tierney, T.J. (1999). What's your strategy for managing knowledge? *Harvard Business Review.* Retrieved from https://hbr.org/1999/03/whats-your-strategy-for-managing-knowledge

Hedberg, B. (1981). How organizations learn and unlearn. In P. Nystrom & W. Starbuck (Eds.), *Handbook of organizational design: Adapting organisations to their environment* (pp. 1-27). Oxford: Oxford University Press.

Hofstede, G. (1991). Cultures and Organizations: Software of the Mind. McGraw-Hill.

Holste, J.S., and Fields, D. (2010). Trust and tacit knowledge sharing and use. *Journal of Knowledge Management, 14(1)*, 128–140. doi: 10.1108/13673271011015615"

Howells, J. (1996). Tacit knowledge, innovation and technology transfer. Technology Analysis and Strategic Management, 8(2), 91-106.

Huizing, A., and Bouman, W. (2002). Knowledge and Learning, Markets, and Organizations: Managing the Information Transaction Space. *Organization Science, 13(3)*, 278-291. https://doi.org/10.1287/orsc.13.3.278.287

Hewitt, A. (2016). Construction claims and responses: Effective writing & presentation (2nd ed.). John Wiley & Sons.

Jarrahi, M. H., Askay, D., Eshraghi, A., & Smith, P. (2022). Artificial Intelligence and Knowledge Management: A partnership between human and ai. *Business Horizons, 66(1)*, 87–99. doi:10.1016/j.bushor.2022.03.002

Kululanga, G., Edum-Fotwe, F., & Mccaffer, R. (2001). Measuring construction contractors' organizational learning. *Building Research and Information, 29(1)*, 21-29.

Kumaraswamy, M.M. (1997). Conflicts, claims and disputes in construction. Engineering, *Construction and Architectural Management, 4(2)*, 95-111.

Levitt, B., and March, J. G. (1988). Organizational learning. *Annual Review of Sociology, 14*, 319-340. https://doi.org/10.1146/annurev.so.14.080188.001535

Lyles, M. A., and Schwenk, C. (1992). Top management, strategy, and organizational knowledge structure. *Journal of Management Studies, 29(2)*, 155-174.

March, J. G., and Olsen, J. P. (1975). The uncertainty of the past: Organizational learning under ambiguity. *European Journal of Political Research, 3(2)*, 147-171. https://doi.org/10.1111/j.1475-6765.1975.tb00521.x

Markus, L. M. (2001). Toward a theory of knowledge reuse: Types of knowledge reuse situations and factors in reuse success. *Journal of Management Information Systems, 18(1)*, 57-93. https://doi.org/10.1080/07421222.2001.11045671

McKenzie, J., van Winkelen, C., & Grewal, S. (2011). Developing organisational decision-making capability: A knowledge manager's guide. *Journal of Knowledge Management*, *15(3)*, 403-421.

Mellors, B. (2019). FIDIC 2017's enhanced contract management provisions. Retrieved from http://constructionblog.practicallaw.com/fidic-2017s-enhanced-contract-management-provisions

Miles, R. E., Snow, C. C., Meyer, A. D., & Coleman, H. J. (1978). Organizational strategy, structure, and process. *Academy of Management Review*, *3(3)*, 546-562. https://doi.org/10.5465/amr.1978.4305755

Moorman, C., and Miner, A. S. (1998). The convergence of planning and execution: Improvisation in new product development. *Journal of Marketing, 62(3)*, 1-20.

Nelson, R. R., and Winter, S. G. (1982). An evolutionary theory of economic change. Belknap Press of Harvard University Press.

Nonaka, I., and Takeuchi, H. (1995). The knowledge-creating company: How Japanese companies create the dynamics of innovation. Oxford University Press.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5(1)*, 14-37. https://doi.org/10.1287/orsc.5.1.14

Ozorhon, B., Toker, I., & Birgonul, M. T. (2005). A case-based reasoning model as an organizational learning tool. Retrieved from https://hdl.handle.net/11511/83112

Ozorhon, B., Toker, I., & Birgonul, M. T. (2005b). Organizational memory formation and its use in construction. Building Research and Information, 33, 67-79.

Pellicer, E., Yepes, V., Teixeira, J. C., Moura, H. P., & Catalá, J. (2014). Construction management. Chichester, West Sussex, United Kingdom: Wiley Blackwell.

Massingham, P. (2014). An evaluation of knowledge management tools: Part 2 – managing knowledge flows and enablers. *Journal of Knowledge Management, 18(6)*, 1101-1126. https://doi.org/10.1108/jkm-03-2014-0084

Polanyi, M. (1966). Human knowledge. Chicago, IL: The University of Chicago Press.

Quintas, P. (2005). The nature and dimensions of knowledge management. In C. J. Anumba, C. Egbu, & P. Carrillo (Eds*.), Knowledge management in construction* (pp. 10–30). London, UK: Blackwell Publishing.

Rezgui, Y., and Miles, J. (2011). Harvesting and managing knowledge in construction. New York, NY: Spon Press.

Robey, D., Boudreau, M.C., & Rose, G.M. (2000). Information technology and organizational learning: A review and assessment of research. Accounting, *Management and Information Technologies*, *10*, 125–155.

Schein, E. H. (1992). Organizational culture and leadership. San Francisco, CA: Jossey-Bass.

Senge, P. M. (1990). The fifth discipline: The art and practice of the learning organization. New York, NY: Currency Doubleday.

Skorupski, M. (2017). New act amending certain acts to facilitate debt recovery. Available at: https://kpmg.com/pl/pl/home/insights/2017/05/artykul-nowa-ustawa-o-zmianie-niektorych-ustaw-w-celu-ulatwienia-dochodzenia-wierzytelnosci.html (Accessed: 09 May 2024).

Spear, S., and Bowen, H. K. (1999). Decoding the DNA of the Toyota production system. *Harvard Business Review, 77(5)*, 96-106. Retrieved from https://hbr.org/1999/09/decoding-the-dna-of-the-toyota-production-system

Stein, E. W., and Zwass, V. (1995). Actualizing organizational memory with information systems. *Information Systems Research, 6(2)*, 85–117. Retrieved from http://www.jstor.org/stable/23011005

Subramaniam, M., and Youndt, M. A. (2005). The influence of intellectual capital on the types of innovative capabilities. *The Academy of Management Journal, 48(3)*, 450–463.

Suryawanshi, D. C. (2010). Analysis of claims based on provisions in 4th edition of FIDIC contracts. Retrieved 10 March 2024 from https://www.nbmcw.com/article-report/infrastructure-construction/project-management-arbitration/claims-and-counter-claims-in-all-construction-contracts.html

Theriou, G. N., and Chatzoglou, P. D. (2009). Exploring the best HRM practices–performance relationship: An empirical approach. *Journal of Workplace Learning, 21(8)*, 614–646.

Tsoukas, H. (1996). The firm as a distributed knowledge system: A constructionist approach. *Strategic Management Journal, 17(Winter Special Issue)*, 11-25.

Walsh, J. P., and Ungson, G. R. (1991). Organizational memory. *Academy of Management Review, 16(1)*, 57-91.

Wang, Z., and Wang, N. (2012). Knowledge sharing, innovation and firm performance. *Expert Systems with Applications, 39(10)*, 8899–8908.

Zhang, J., Zhao, W., Xie, G., & Chen, H. (2011). Ontology-based knowledge management system and application. *Procedia Engineering*, 1021–1029.

APPENDICES

APPENDIX A: Interview Questions (Construction and Consulting)
APPENDIX B: Claim management experts interview questions

APPENDIX A

Interview Questions (Construction and Consulting)

This survey is part of the MSc thesis study of Bartu Kologlu at Istanbul Technical University Construction Management Program. The aim of the thesis is to understand the current knowledge management practices and the tools that construction companies use to maintain and enhance their organizational memory. The answers will only be used for academic purposes, and the answers will be evaluated anonymously without the identity of the participant/organization.

Participant Name:
Participant E-mail:
Participant Organization:

1) **DATA COLLECTION:** One of the main capital of knowledge-intensive sectors such as construction consulting is intellectual assets. Most of the processes are generated toward exploration, accumulation, and exploitation of individual and firm knowledge. Your company has been in the construction sector for many years and has completed many projects.?

1.1) Is there a department/process in your company that collects and stores the knowledge data acquired from the projects?
1.2) What kind of data is collected/stored from the previous projects (financials, man-hours, machine hours, financials, reports, etc.)?
1.3) How often is this data collected?
1.4) How is this data stored? Is there a digital database for this purpose? If yes, is there a predetermined taxonomy or a uniform filing system that is used to store the data?

2) **DATA ACCESSIBILITY AND USAGE**

2.1) Is the stored data from the previous projects accessible when needed?
2.2) If yes, do the ongoing projects use this data? How often is the previous data used for ongoing projects?
2.3) What type of data is used? Please list the specific information/data items used most frequently.
2.4) Is there an IT program to access this data? If yes, what is the most critical aspect of this program to operate correctly?

3) **KNOWLEDGE MANAGEMENT**

3.1) What are the explicit knowledge-sharing methods in your company?
3.2) What are the methods in your company that convey tacit knowledge?
3.3) The sector operates in a project-based environment. How can you ensure that individual knowledge becomes a company asset and does not disappear when that person is no longer part of the company?
3.4) Are there any applications of KM tools incase of dispute claims?

APPENDIX B

Table B.1 : Claim management experts interview questions.

Case Study	KM Toolkit	Description	Rating (1-5)
Case Study A	KST-1	Establishing communities of practice could have enhanced the project team's comprehension of the situational dynamics at the site, enabling them to exercise caution.	
Case Study A	KST-3	Empirical data collected directly from the site and integrated into an information technology tool with proper data management principles would have provided a stronger foundation for constructing the claim report than reliance on empirical formulations.	
Case Study A	KUT-1	Guidance from experienced personnel would have expedited the project team's and site engineers' understanding of the challenges posed by weather conditions and encouraged the contractor to adopt a more cautious approach.	
Case Study A	KET-3	Benefiting from external archives of completed projects in the region during the tender preparation period would have benefited the Contractor in preparing claims or increasing the night shifts to compensate for productivity loss.	
Case Study A	KAT-1	The contractor, an experienced entity in the industry with over three decades of experience, has a record of undertaking projects within the same region for similar clients. An examination of its previous projects reveals this pattern of regional and client consistency. Had the contractor maintained a comprehensive project archive, embedding essential project knowledge, it could have leveraged this repository better to understand the site conditions and the client's approach.	
Case Study B	KST-1	Implementing post-project feedback mechanisms to address disputes encountered in the contractor's initial project could have served as a valuable reminder and prepared the relevant team for the potential occurrence of earthquake cross-ties.	
Case Study B	KST-2	Establishing communities of practice during the initial dispute could have provided the project team with a simulated conflict scenario, benefiting a subsequent team facing a similar issue. This proactive approach would have enabled the second project team to implement necessary measures preemptively, potentially preventing the situation from escalating into a dispute.	
Case Study B	KUT-1	Guidance from experienced personnel for the project team and site engineers could have facilitated a quicker comprehension of disputes when encountered a second time, enabling a swifter response. This strategic foresight would have better positioned the contractor to exercise caution effectively.	
Case Study B	KET-2	The implementation of performance evaluation reports upon completion of the initial project would have been instrumental in preparing employees for subsequent projects. Those involved in the initial claims could have utilized this period for reflection, thereby enabling them to transfer their acquired insights more comprehensively and effectively to the next project.	
Case Study B	KAT-1	Even in the absence of employees participating in both projects, the availability of a robust IT tool designed to archive previous claims could have significantly benefited the second project team. By accessing this system, they could have recognized the potential for a dispute based on historical data and responded to initial signs of trouble with greater seriousness and efficacy.	

Table B.1 (continued) : Claim management experts interview questions.

Case Study	KM Toolkit	Description	Rating (1-5)
Case Study C	KST-2	The report indicates that the analysis spanned one week to build the case. If progressive, real-time data recorded on-site had been systematically captured and integrated into an IT tool adhering to proper data management principles from the onset of construction through to the preparation of the report, it would have constituted a more reliable and effective foundation for constructing the claim report.	
Case Study C	KUT-1	Providing guidance to the project team and site engineers through experienced personnel would have expedited their understanding of site security conditions. This enhanced awareness could have enabled the contractor to exercise appropriate caution, thereby mitigating risks associated with productivity loss.	
Case Study C	KET-3	The contractor could have derived significant advantages from using external archives prior to the commencement of the project to gain insights into the client's approach toward security measures. Such preemptive research would have facilitated the development of a project schedule that proactively incorporates potential delays associated with stringent security protocols, thereby optimizing time management and operational efficiency.	
Case Study C	KAT-1	The contractor, an experienced company in the market where the project is situated, would have significantly benefited from maintaining an archive of previous claims and decisions from past projects. Access to such a repository would have enabled responsible employees to draw on lessons learned, thereby enhancing their ability to construct a more compelling and persuasive report.	
Case Study D	KST-1 & KST-3	Given that this project represents the contractor's second project in this foreign market, a more thorough analysis of the problems and challenges encountered during the first project could have been beneficial. Implementing a post-project feedback mechanism would have facilitated reflection on the lessons learned, thereby equipping the team with enhanced preparedness for navigating the complexities of the second project.	
Case Study D	KUT-1 & KUT-2	If the project planning team had been composed of senior engineers who had experience from the contractor's previous projects, in collaboration with new employees, the construction schedule could have been significantly optimized. For instance, it is a contractual obligation for the contractor to conduct a sapper check prior to deforestation at any site location. A senior planning engineer familiar with such protocols could have strategically advised initiating the sapper control specifically in the forest area that was targeted for early development. This proactive approach would have likely expedited the overall project timeline, leading to an earlier completion date.	
Case Study D	KET-3	External archives could be referred to assess the municipality's typical deforestation timelines accurately. With this information, the planning team could more effectively prepare the contractual documentation while also developing a contingency plan (Plan B) in the event that the deforestation process extends beyond the anticipated timeframe. This approach would ensure greater preparedness and adaptability in project scheduling and execution	

Table B.1 (continued) : Claim management experts interview questions.

Case Study	KM Toolkit	Description	Rating (1-5)
Case Study D	KAT-1	The implementation of an archival tool containing valuable and pertinent data from the contractor's previous project in this country could have significantly enhanced understanding of local weather conditions. This deeper insight would enable the project team to strategically rearrange productivity schedules to accommodate weather-related disruptions, thereby optimizing operational efficiency and minimizing downtime.	
Case Study E	KST-3	An IT tool designed to record contracting necessities, documentation, key requirements, designs, and drawings would have offered significant advantages for document management and comparison. With such a system in place, the contractor could efficiently compile and cross-reference new documents against existing records. This streamlined approach would facilitate a quicker case build-up, ensuring that no discrepancies are overlooked and enhancing the overall case preparation process.	
Case Study E	KUT-2 & KUT-3	Forming the project team by pairing experienced personnel with junior members could have expedited the identification of discrepancies in the original documentation during comparison processes. This structured team approach would enhance the contractor's ability to quickly recognize and address discrepancies, enabling swifter reactions to emerging issues and potentially averting complications in project execution.	
Case Study E	KET	-	
Case Study E	KAT-1	An IT tool designed to meticulously record contracting necessities, documentation, essential requirements, designs, and drawings would have offered significant advantages for document management and comparison. The contractor could efficiently compile and cross-reference new documents against existing records with such a system. This streamlined approach would facilitate a quicker case build-up, ensuring no discrepancies are overlooked and enhancing the overall case preparation process.	

Question 1:
In your opinion, is there any other KM mechanism that would be beneficial to use within the proposed KM Toolbox to enhance the effectiveness of the claim management process?

Question 2:
What are your comments on the applicability of this Toolbox (or the Toolkits) in construction projects? How do you think the usability of the Toolbox can be increased?

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