Assessment of change management practices to adopt Modern Methods of Construction (MMCs) in Egypt

Master Thesis

Construction and Real Estate Management

HTW Berlin

By

Mina Sadeek

Berlin, 04.07.2022

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Acknowledgement

First of all, I would like to thank Metropolia University of Applied Sciences and HTW Berlin for giving me the chance to study abroad and experience the European market in a broader view. I have learnt a lot during these two years, not only in the curriculum, but also being exposed to international setups and communicating with different cultures, which added a lot to my experience.

I would also like to thank my supervisors, Mr. Hannu Hakkarainen and Mr. Tashfeen Ahmad for their ultimate support when needed. Furthermore, I would like to extend my gratitude to all the professionals I have interviewed for their time. They were part of this research, and their insights indeed added value.

Moreover, I would like to thank my family, especially my mother; Seham Mounir. She has always been looking up to me, trusting whatsoever steps I am taking, pushing me forward, and believing in me. At the end, I would like to express my deepest gratitude to my friends that without them, this research would not have come to reality. They have always been here, supporting, guiding, trusting me, structuring my thoughts, and lifting me up when things seemed to be quite hard. Particularly mentioning; Michel Adel, Mina Harby, Marco Refaat, Bishoy Gamal, and David Indrawes: you guys are the best. I am grateful having you in my life.

Yours,

Mina Sadeek

For the
Chairperson of the Examination Board

of the **Programme** Construction and Real Estate Management
at the Hochschule für Technik und Wirtschaft Berlin

30. JUNI 2022
Received by faculty

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Assessment of change management practices in construction project-based organizations in Egypt

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International Master of Science in Construction and Real Estate Management

Joint Study Programme of Metropolia Helsinki and HTW Berlin

Conceptual Formulation **Date 04.05.2022**
Master Thesis for Mr. Mina Sadeek
Student number: 576663

Topic: Assessment of change management practices in construction project-based organizations in Egypt.

1. Background

Project-based organizations are characterized by unique features, which result in particular organizational and managerial issues. Aspects like high level of decentralization, independent teams, and loose connection between projects. Furthermore, their projects tend to be unique, uncertain, and often have short life cycles. The construction industry is a prime example of a project-based industry. Yet, it differs that it is well known as an outdated industry in terms of technology adoption or any attempt to impose a change. Recently, the construction industry in Egypt is going through a process of adapting to different clients requirements, competitive markets, less access to building materials, and currency fluctuation.

While the success and continuity for most companies in today's fast-paced world depends on how well they respond to change or how well they stay with it, it's still, for any business enterprise, the term change is a hard task to swallow. Therefore, the ability to cope with the pressing demands and developing technologies becomes inevitable. In Egypt, the construction sector is no exception to this fight for business existence. The aim of this research is to spot the light on how companies can adopt Modern Methods of Construction (MMC) and to formulate specific strategies to project-based organizations with similar characteristics to construction companies on how to manage change, with the end purpose to help them stand a better chance of surviving and evolving.

2. Methodology

A qualitative research with an exploratory and explanatory approach will be adopted here

- Literature study: Books, journals, academic research papers and articles related.
- Case studies: in which specific strategies and particular lessons are extracted from companies survived transition periods.
- Questionnaire or interviews: which will be designed and distributed, aiming to achieve answers to the research questions on a practical manner.

3. Research questions

1. What is change management?
2. What drives change in the construction industry?
3. What are the barriers of implementing modern methods of construction (MMC) in the Egyptian market industry?
4. What are the critical factors contributing to an efficient implementation of change management process in the construction market in Egypt?
5. What could be the possible risks of adopting modern methods of construction (MMC) in the Egyptian market industry?
6. What could be the possible opportunities/returns of adopting modern methods of construction (MMC) in the Egyptian market industry?
7. What are the criteria of a living company? Or what is so special about long-lived companies?
8. Are the change management models applicable to be implemented in the construction project-based organizations in Egypt?

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International Master of Science in Construction and Real Estate Management

Joint Study Programme of Metropolia Helsinki and HTW Berlin

Conceptual Formulation **Date 16.06.2022**
Master Thesis for Mr. Mina Sadeek
Student number: 576663

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While the success and continuity for most companies in today's fast-paced world depends on how well they respond to change or how well they stay with it, it's still, for any business enterprise, the term change is a hard task to swallow. Therefore, the ability to cope with the pressing demands and developing technologies becomes inevitable. In Egypt, the construction sector is no exception to this fight for business existence. The aim of this research is to spot the light on how companies can adopt Modern Methods of Construction (MMCs) and to formulate specific strategies to construction companies on how to manage change and lead the transition phase, with the end purpose to help them stand a better chance of surviving and evolving.

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Abstract

Modern Methods of Construction (MMCs) is a wide term used to describe a number of agile construction approaches to replace traditional methods. Basically, moving the work from construction site to factory-based environment. Offsite technologies are not particularly new to the construction industry. Yet, current trending factors have caused professionals to reconsider their appeal. Factors such as improving productivity, the rising usage of BIM technologies, the growing interest in green construction, and the increasing demand for agile projects and lean construction. The research has shed the light on the issue of poor productivity of the industry, and accordingly proposed adopting MMCs as a solution.

The objective of this research is to assess the viability of implementing MMCs in Egypt, where it is safer, faster, predictable, more productive, and more environmentally efficient. Furthermore, to formulate change management practices addressing industry players interests and motivations for successful adoption. In this regard, an in-depth literature review has been made, an intensive qualitative analysis through interviews with professionals from the industry, and a comprehensive case study has been conducted. The results show that while MMCs proved to bring positive returns in terms of time, quality, safety, and greener construction, yet in the meantime, their implementation in Egypt continues to be a challenge due to factors instilled in culture that slow down innovation. Most of which are the poor infrastructure road networks, transportation and logistics issues, dominance of the public sector, lack of experience and skills, and limited market demands.

On the other hand, few action steps are proposed to accelerate the adoption towards MMCs, such as financial payback orientation, simple and intuitive solutions, risk sharing among industry players, enhancing the academic curriculum, industry authority bodies support, and developing change management narratives. In addition, recommendations have been made to address each industry player motives and interests in an attempt to draw a roadmap for successful future adoption.

Key words: MMCs, change management, offsite construction, productivity.

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List of Abbreviations

Fig	Figure
Tab.	Table
CII	Construction Industry Institute
FIATECH	Fully Integrated and Automated Technologies for Construction
LSD	Least Significant Difference
PCT	Prosci Change Triangle
MMCs	Modern Methods of Construction
AEC	Architecture, Engineering, and Construction
PBOs	Project-based Organizations
IT	Information Technology
PMP	Project Management Professional
PMI	Project Management Institution
MBA	Master of Business Administration
IPMA	International Project Management Association
SWOT	Strengths, Weaknesses, Opportunities, and Threats
BIM	Building Information Modeling
MENA	Middle East and North Africa
NHBC	National House Building Council
ROI	Return on Investment
MBI	Modular Building Institute
UNEP	United Nations Environment Program
IEA	International Energy Agency
LEED	Leadership in Energy and Environmental Design
USGBC	United States Green Building Council
USEPA	United States Environmental Protection Agency

LGS	Light Gauge Steel
ICC	International Code Council
IBC	International Building Code
ISO	International Organization for Standardization
ANSI	American National Standards Institute
UL	Underwriters' Laboratories
CSA	Canadian Standards Association
US	United States
NDCs	Nationally Determined Contributions
UNFCCC	United Nations Framework Convention on Climate Change

1. Introduction

1.1 Background

In an industry that is driven by many competitive pressures to adapt to the present demands of the developing markets, it is no surprise that “change management” is a recognizable skill in the long-living companies (De Geus, 1997). Everyone is aware of the fact that the world is in a constant state of change, and the construction industry is no exception to this. Increased global competition, technological innovation, and growing scarcity of resources, they all impose a significant pressure on everyone to survive and adapt.

Modern Methods of Construction (MMCs) is a wide term used to describe a number of agile construction approaches to replace traditional methods of construction. MMCs include a range of offsite manufacturing and a few onsite techniques that provide an alternative to conventional house building (NHBC, 2018). Primarily, offsite technologies; moving the work from site assembly to factory-based environment, prefabrication, pre-assembly, and industrialized construction. Furthermore, the term MMCs may include modular building, paperless system, mobile technology, machine learning, laser scanning, digitalized inventory, agile procurement and materials tracking system (Rahman, 2014).

Offsite technologies, which are the main focus of this research, are not particularly new to the construction industry. Yet, current influencing factors trending up have caused many professionals to reconsider their appeal. Factors such as improving productivity, the rising usage of BIM technologies, the growing interest in green construction, the increasing demand for agile projects and lean construction. McGraw Hill Construction (2011) argued that what is worth noting about MMCs is their ability to bring all the agile trends together in an attempt to enhance productivity and adopt green practices adding an alternative value to construction projects.

1.2 Problem statement

For any business entity, the term change is always a hard task to swallow, and yet the ability to cope with the pressing demands of the market evolution and the developing technologies becomes a fundamental job for survival. As per (Al-Sedairy, 2001), the very existence of most companies in today's fast-paced environment depends on how well they respond to change or how well they actually cope with it.

The construction industry has been widely recognized with lower productivity rates compared to other industry sectors, which represents a major element for the need to change. To elaborate, most of construction projects run behind schedule and over budget. Also, quality and safety issues remain to be a challenge. According to McKinsey Global Institute (2017), the global labor productivity growth in construction industry has averaged only 1% a year over the past two decades, compared to a growth rate of 2.8% of the total world economy and 3.6% for the manufacturing sector.

Poor productivity can be a result of numerous reasons, but one significant factor causing the poor productivity in the construction sector is the relatively slow pace in adopting new technologies compared to other industries. Moreover, the construction industry has been well known by being an outdated industry due to the low integration of IT in the field. However, if organizations are to remain competitive in today's market, they have to adapt to the demanding needs of change. MMCs offer various advantages to the industry, but their application is relatively low, and therefore, their contribution to the field is also low.

1.3 Objective

Poor productivity of the construction industry compared to other sectors continues to be a challenge. One significant reason behind it is the relatively slow pace in adopting new technologies and the reluctance towards digital transformation. The objective of this research is to assess and evaluate the viability of implementing MMCs in Egypt by addressing issues such as change drivers, limitations, success factors, threats, and opportunities. Furthermore, to formulate change management practices to different industry players for successful adoption of offsite construction technologies where it is safer, faster, more productive, and more environmentally efficient, with an end purpose to make construction a predictable manageable process.

1.4 Methodology

Qualitative research includes the collection and analysis of nonnumerical data such as text, shapes, audios, or videos in order to fully understand ideas, concepts, views, or experiences. It can be utilized to get in-depth understanding of an issue or generate new insights about a given subject (Bhandari, 2022). Furthermore, Corbin and Strauss (2014) suggest that when a researcher wants to further investigate about an existing topic or learn about a new subject, a qualitative research approach is advised. The most common qualitative research forms are observations and interviews. In the former, the researchers record what they see, hear, or experience in detailed notes. In the latter, the researchers personally ask questions to people in one-to-one setups in order to get in-depth information about a given subject, have a chance to discuss the arguments, and build their analysis upon (Bhandari, 2022).

The proposed solution to the poor productivity issues in the industry from the author's side was MMCs in Egypt. And since the topic of MMCs is new to the construction market in Egypt, the author has decided to adopt a qualitative research methodology with an exploratory and explanatory approach in an attempt to get in-depth insights about the viability of their implementation. At the end, the author forms out a conclusion based on the analysis. In order to achieve the objective of the research, the author counts on five main phases, as per (Fig 1).

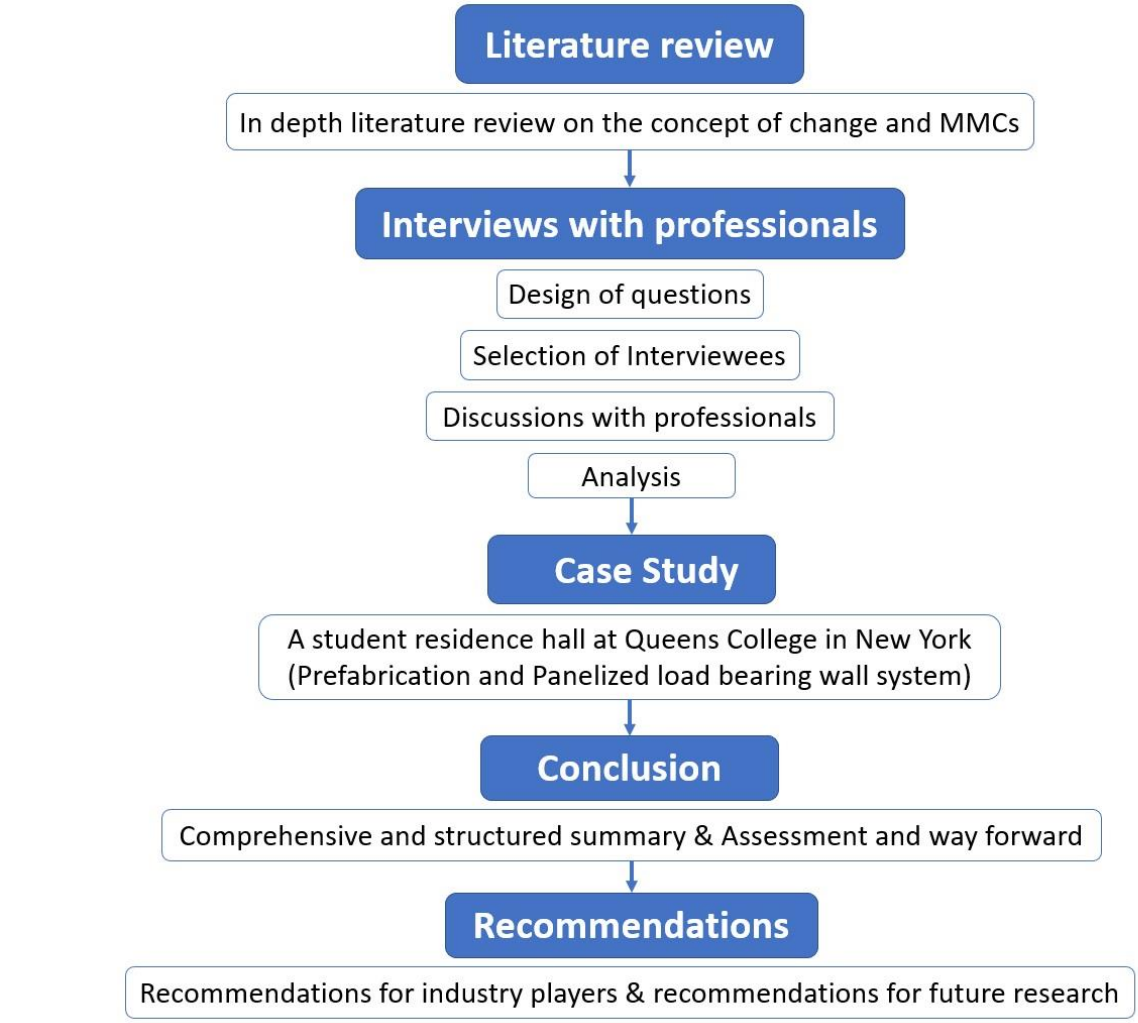


Fig 1: Research framework
Source: by author.

- **Phase 01:** In-depth literature review on two parts. The first part, a broad overview covering basically the concept of change, types, and the driving force leading to a transition. The second part, an introduction about MMCs, the concepts of prefabrication, modularization, and briefing about offsite construction categories and area of concerns.
- **Phase 02:** Intensive qualitative analysis through an informative one-to-one video call interviews with 5 professionals from the industry residing in Egypt with recognizable experience in the field of construction management. In this regard, the author developed a proper understanding of challenges and opportunities of adopting them and built his analysis upon.

- **Phase 03:** Comprehensive case study about a student residence hall at Queens College in New York City. In which, the author developed a broader understanding on practical manner on the decision to innovate, construction timeline challenges and prefabrication gains.
- **Phase 04:** The author built a conclusion based on the above-mentioned three phases, in which he relied on a structured, comprehensive, and wide industry analysis.
- **Phase 05:** Recommendations for industry players and recommendations for future research.

1.5 Scope

Referring to the literature in chapter (2.1 Types of change), the scope of this research has been limited to MMCs, which is categorized under “chosen change” being driven by a workforce for innovation, with particular focus on offsite construction technologies. A movement towards shifting work from the construction site to factory-based environment, prefabrication, modularization, pre-assembly, and industrialized construction. And offsite construction technologies were basically divided into volumetric modular systems, panelized systems, and hybrid system. A critical assessment has been to evaluate the viability of adoption in the Egyptian market addressing barriers, driving forces, challenges and opportunities.

1.6 Research structure

The structure of the study has been based on introduction, literature review, findings, conclusion, and recommendations. Those heading are distributed on seven chapters as follows:

- Chapter 01: Includes short overview on the research background, problem statement, objectives, methodology, and scope.
- Chapter 02: First part of the literature includes a broad overview covering basically the concept and types of change, the driving forces in the construction industry leading to a transition, followed by an introduction about the most common change management models proposed worldwide, and their limitations.

- Chapter 03: Second part of literature includes introduction about MMCs, the concepts of prefabrication, modularization, preassembly, and offsite fabrication, the development of guidelines, standards, and codes for modular industry. At the end, briefing about offsite construction categories and their benefits.
- Chapter 04: Includes the findings of this research. The findings are based primarily on in-depth one to one interviews with 5 professionals from the industry. The interviews provide informative and valuable insights about MMCs challenges and opportunities of adoption from different perspectives such as time, cost, quality, safety, and sustainability. The secondary part is a comprehensive case study about a student residence hall at Queens College in New York City. The case study involves construction timeline challenges, prefabrication gains, the variety of innovative options and optimum decision to make.
- Chapter 05: Summarizes the previous chapters and builds an opinion for the viability of adoption of MMCs in Egypt in the meantime.
- Chapter 06: Gives recommendations from two aspects. The first is recommendations formulated to industry players for accelerating the adoption towards MMCs. The second is recommendations for future research.

2. Change management concept

Reviewing the literature, it shows that the concept of change management has been broadly defined by many experts. A list of definitions sourced in previous studies are summarized in (table 01) and categorized into 3 contexts: general business, organization level and project level. It is important to note that the list of definitions mentioned here is not inclusive due to the high number of existing definitions of change management.

	Author	Area	Context	Definition
1	Abbs, 2012	Pakistan	General business	"A whole organized procedure of planning, initiating, realizing, controlling, stabilizing and sustaining new and altered work activities at the corporate, group and individual level."
2	Filicetti, 2007	Global	Project level	"A structured approach to shifting/transitioning individuals, teams, and organizations from a current state to a desired future state."
3	Yarberry, 2005	USA	General business	"A control system that ensures programs, systems, and infrastructure modifications are authorized, tested, documented, and monitored on its most basic level."
4	Mitchell et al., 2006	Australia	Organizational level	"A strategic activity which aims to get the best outcomes from the change process. It is about managing the changes that are part of or a consequence of that strategy in such a way to suit the particular organization's context and the type of change required. It is a sub-set of strategy making"
5	Moran and Brightman, 2001	USA	Organizational level	"The process of continually renewing an organization's direction, structure, and capabilities to serve the everchanging needs of external and internal customers."

6	Voropajev, 1998	Global	Project level	“An integral process related to: all project internal and external factors, influencing project changes; possible change forecast, to identification of already occurred changes; planning preventive impacts; and to coordination of changes across the entire project.”
7	Kudray and Kleiner, 1997	USA	Organizational level	“Continuous process of aligning an organization with its marketplace and doing so more responsively and effectively than competitors.”
8	Whelehan, 1995	Global	Organizational level	“A holistic approach to implementing large-scale change that integrates an organization’s strategy and processes with its people and culture.”

Tab. 1: Summary of change management definitions.
Source: Wang et al. (2013)

In their research, (Wang et al., 2013) noticed that there are some common keywords among all the definitions. And that may lead us to the conclusion that an integrative and systematic process based on proper planning and adequate control is the key factor driving effective change management. Therefore, they developed their own definition of change management as follows:

“An integrative and systematic process that involves continuously managing and aligning the needs of an organization and its employees for effective transition and hence better performance.”

2.1 Types of change

Many organizations have gone through fundamental changes over the past years and that made the rate of change to significantly increase. Therefore, if the change managers are to develop effective strategies to implement change, they need to understand the various types of change. The literature divided the change into two aspects; chosen change and crisis change.

2.1.1 Chosen change

In this regard, Price and Chahal (2006) defined the chosen change as “a proactive approach driven by a workforce that is committed to the organization success. It is a conscious change that entirely happens as a result of internal factors and fully supported by top management”. Furthermore, they divided it into three types that are shown in (Fig 2) and clarified below.

Fig 2: Types of Organizational Change
Source: designed by author.

- Development change

Improving the current state by doing more of, or better than, what currently exists, in order to slightly improve established processes.

- Transitional change

Shifting to a new desired state by implementing minor to intermediate ways to disassemble current ones, in order to solve occurring problems that often happen or in an attempt to enhance the procedures and optimize the operations.

- Transformational change

Transforming to an entire new state. Most of the time require major shifts in organizational structure, strategies, policies, and vision.

2.1.2 Crisis change

Later in (2006), Price and Chahal defined a more broadly approach to change that happens in organizations. They claimed that there is another type of change a company does not intentionally go through it. Therefore, they simply divided the change into unconscious and conscious approaches. The conscious refers to the chosen change and the unconscious refers to the crisis change, which is defined as “a reactive approach driven by external factors that happen to take place in times of emergencies. It is an unconscious change that tend to happen out of hand. The change happens here is based on a fear of failure”.

2.2 The need for change

2.2.1 What drives change in construction companies?

If organizations are to remain competitive in today’s market, they have to adapt to the demanding needs of change, which is usually driven by external factors such as increased competition, emerging markets or new legislation, or by internal factors such as shifting industry direction or applying new technologies. In any way, the implementation of change is a complex process that needs to be well delivered and highly communicated to the change agents. Further, although the new processes of change can be introduced over relatively short time, the adaptation to the new procedures may significantly take longer time than expected (Price and Chahal, 2006).

In developing a processual approach, which seeks to study the process of change over time, it is highly recommended that studying the timeframe before, during, and after change can be helpful in breaking down the complex process of change. This framework mirrors what (Kanter et al., 1992) claimed in their research, which stated that “In assessing the need to change, an organization should first review what it is changing from, before concentrating on what it is changing to”. They clarified later “The path of progress is not determined simply by the destination, a fact often overlooked by those who too glibly accept benchmarking results as a fixed road map for change”.

There are many factors that drive change, but (AlSalti, 2020) argued that change happens in response of internal or external factors. Furthermore, what (Dawson, 1994) highlighted on was an attempt to conceptualize the need to change. He claimed that “the initial awareness of a need to change may either be in response to external or internal pressures for change (reactive), or through a belief in the need for change to meet future competitive demands (proactive)”. From another standpoint, the increased complexity of the change process and the uncertainty of international business markets has led organizations to build change on imitation. They tend to follow former success factors of organizations which managed to introduce successful change strategies, rather than the belief of a need to adopt new techniques and try different approaches.

McKinsey Global Institute (2017) highlighted on the view that the construction industry has been widely recognized with lower productivity rates compared to other industry sectors, which represents a major element for the need to change. According to (McKinsey Global Institute, 2017), the global labor productivity growth in construction industry has averaged only 1% a year over the past two decades, compared to a growth rate of 2.8% of the total world economy and 3.6% for the manufacturing sector, as shown in (Fig 3). Over the past ten years, and in the sample of studied countries, less than one quarter of construction companies achieved their targeted productivity compared to other business fields in which they work. Many construction projects suffer from cost overruns and time delays.

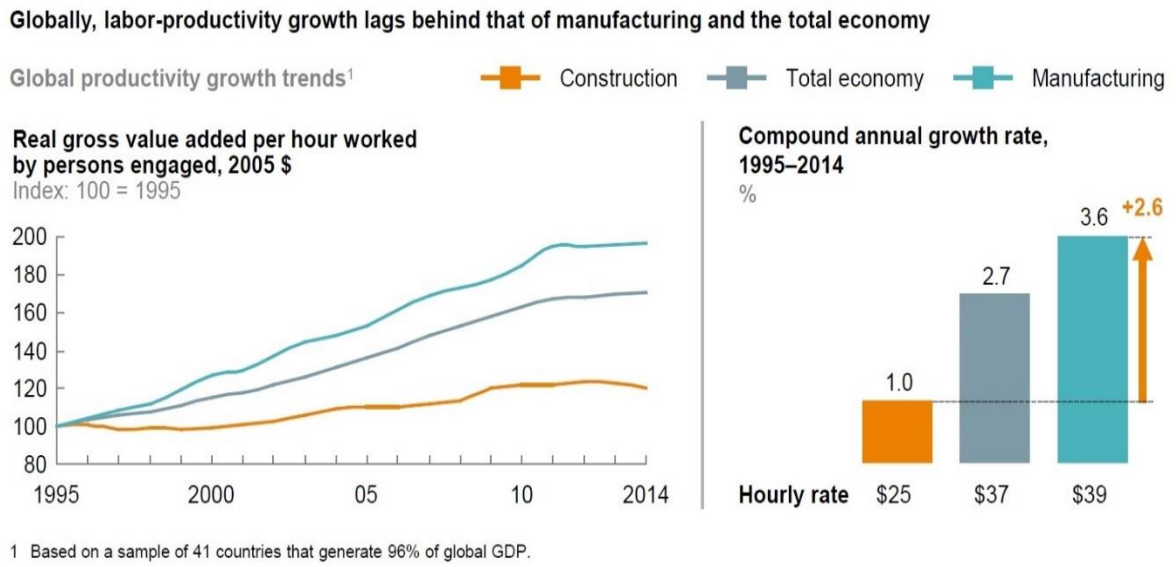


Fig 3: Global productivity growth trends
Source: McKinsey Global Institute (2017)

Poor productivity can be a result of numerous reasons, but one significant factor is the relatively slow pace in adopting a new technology compared to other industries. The fact that each construction project is unique in specification, method of execution, schedule, budget, and stakeholders can make the task of adopting a new technology harder. However, recently, more construction firms started to introduce new methodologies to apply in their projects (Radzi et al., 2019). And since most efforts to apply change in construction corporates are met with high resistance, it is crucial for organizations to recruit change agents that are responsible for leading the efforts to successfully adopt new methodologies in construction projects (Rahman, 2014).

There are many definitions of change agents, but what (Akesson and Conte, 2021) identified in their research about the role of change agent in accelerating the adoption of new systems, innovative technologies, and sustainable practices is that “change agents are individuals who initiate, facilitate, implement, and support the change efforts”. They know the organization very well and fully aware of the change risks and opportunities.

Recruiting and select the right individuals that are capable of not only initiating change, but also managing it efficiently is essential for companies seeking development (Lines et al., 2015). Those individuals who are supposed to design and execute the change process successfully are often referred to in literature as “change agents”. Their main

task is to implement change and facilitate any barriers towards it. While prior studies have proposed some critical competencies of how change agents should be in general context, there is still a need to identify the major competencies specified for construction industry. Therefore, there is a need for construction companies to hire dedicated individuals and formally identify them to lead the transition phase as part of their responsibilities and part of the organization structure (Radzi et al., 2019).

Key attributes of change agents in construction

In (2019) Radzi et al. aimed to discover what key attributes of change agents that contribute the most in adopting new technologies or introducing new systems in construction industry. To achieve this objective, they collected information through a questionnaire survey given to attendees of the Construction Industry Institute (CII) FIATECH conference in the United States. FIATECH stands for Fully Integrated and Automated Technologies for Construction, and it is a digital innovation conference where industry professionals collaborate to develop new technologies and introduce new systems for adoption. The authors of the survey used open-ended questions in an attempt to encourage members to share as much detailed information as they want. The survey was based on two questions:

1. Consider a period of time when a new technology or a system were successfully implemented and sustained in your organization. Now think of those who led and managed the transformation process. What would you say about their key characteristics that made the change possible?
2. Consider a period of time when a new technology or a system were about to be implemented in your organization, but due to a reason or another they were not successful or did not sustain. Now think of those who led and managed the transformation process. What would you say about their key characteristics that hindered the occurrence of change?

The authors counted on qualitative and quantitative data analysis. They performed a thematic analysis to identify the key attributes needed for an effective change agent. Therefore, after receiving the responses from industry professionals, they reviewed the data and grouped the responses they received into themes. They categorized the key attributes mainly in three groups.

- Human theme, which was concerned with personality traits, leadership, communication, and the ability to solve problems.
- Organizational theme, which was concerned with organizational change process from a business perspective.
- Technical theme, which was concerned with the technical expertise.

The results show that “Good personality” was placed at highest rank among all other attributes with a significant difference. Further, the “human” aspect scored 85% frequency of the responses received. According to the results, industry professionals claimed that change agents with good personality traits are more likely to contribute to the success of technology adoption or introducing new systems in the company.

While the study achieved the objective of grouping key attributes into few aspects and rated them accordingly, it has some limitations. First, grouping the data into the mentioned criteria is subject to the authors' interpretation of the responses since the questions were open-ended. Also, the study only considered the participants of a certain event and may not fully express the opinions of key industry professionals. Nevertheless, considering these limitations, the results highly emphasize on the importance of non-technical attributes of change agents compared to the technical and organizational ones. Further, it meant to spot some light on how the non-technical attributes can contribute much to the success of change according to industry professionals, yet it did not mean to discredit other attributes.

On the other hand, one of the downsides of having a change agent to facilitate and lead and change process, as per discussed by (Gichuhi, 2017), is that individuals may become passive and reliant on that change agent to achieve the proposed outputs, neglecting the fact that they have to be responsible by active participation. At the end, the practical outcome of (Radzi. et al., 2019) work can be that construction companies should carefully assess the personality traits of their chosen change agent. The fact that an individual has the technical knowledge, does not necessarily mean they are able to lead or manage a change adoption.

2.2.2 Improving construction productivity

The construction industry has much to do (McKinsey & Company, 2017) and the fragmented nature of it makes it a ripe for disruption. More than 20% of construction

projects run behind schedule, and 80% run over budget. Therefore, budget overruns and schedule delays are becoming the new norms in the construction sector (McKinsey & Company, 2016). Furthermore, the construction industry is among the least digitized as clarified in (Fig 4), and that is due to the lack of IT integration in the industry and the relatively slow pace in adopting new technologies. McKinsey & Company (2017) proposed few steps to enhance the productivity issue in construction arguing that construction can learn from success stories of other industries.

Fig 4: Where construction stands in digitization
Source: McKinsey & Company (2016).

1. Aligning stakeholders interests

Many professionals agree that when objectives are aligned and directed towards the same goals, projects are more likely to be accomplished on time and on budget. For that to happen, the industry should leave away the competitive contractual agreements that define many construction projects and adopt a structure based on systems thinking where collaboration and problem solving are the core values.

2. Design and engineering standard solutions

A significant value can be achieved by standardizing engineering processes and design solutions. Construction firms must have a standard design library. Almost everyone in the field of digital innovation agrees that change is feasible only if clients and contractors alike are able to adjust their views from customized project specifications to more standardized solutions. Having design libraries contributes a lot in achieving so and will accordingly lower the error margin.

3. Digitally enabled procurement and supply chain processes

The fragmented nature of construction makes it harder to adopt agile supply chain and procurement procedures and leaves room for improvement. In this regard, digitally enabled and innovative solutions increase reliability and enhance predictability. The digitization of procurement, inventory and supply chain processes will allow for agile logistics management and real-time updates about project deliveries and shortcomings. Furthermore, it helps to establish long term partnerships with suppliers, manufacturers, and subcontractors.

4. Agile onsite practices

One of the major reasons for poor productivity in site is the inconsistency of execution practices. In this regard, McKinsey & Company (2017) argued that for a real transformation of onsite practices, three aspects have to be considered: systems thinking, technical issues, and a blending mindset. It is important to note here that while “systems thinking” is a common term in construction to deliver sustainability better outcomes (Peter and Hanbin, 2018), its core value is to think in whole, and consider all the complex, interrelated variables of the project.

In this regard, four key approaches are suggested. First, developing smart forecasting lookaheads. Second, setting key performance indicators (KPIs) and crucially linking them to forecasting plans. Third, ensuring that all the preliminary works, such as permits and approvals from authorities and legalities, are done before the commencement date of the projects. Furthermore, identify the long lead items and make sure their delivery time is as requested. Fourth, the adoption of lean concepts with careful planning among site trades can significantly reduce waste and make the building process more predictable (McKinsey & Company, 2017).

5. Adoption of digital technologies and industrialized construction

The construction industry is substantially behind other industries in its adoption of digital technologies and innovative tools. Digital technologies such as offsite construction, modularization, 3D printing, and the growing expansion of BIM technologies are more likely to contribute to making construction a predictable manageable process. On the other hand, stakeholders raised the issue that there is a considerable difference between modular plans and as-built, which makes the transformation towards digital technologies, supply chain and procurement hard to gain (Serdar and Syuhaida, 2019)

Due to the limited investment in research and development, industry professionals are not utilizing pilot projects to test innovative ideas while mitigating their risk. In a few prominent examples, clients and contractors come together and share resources to overcome capital issues. At the end, technology alone cannot solve the problem of low productivity. A fundamental culture change is required alongside systems thinking, project lifecycle influence, processes, and clients buy-in, in order to implement these innovative solutions and gain their benefits.

2.2.3 The living company

In an attempt to understand “why do so many companies die young?”, a group at Shell has set out to analyze companies that lived more than 100 years. Therefore, they surveyed 30 companies to see if they share common characteristics that enabled them to long live. Most of the companies studied were with well documented histories and aged from 100 to 700 years at that time. De Geus (1997), in his analysis to the case made by Shell Group, asked “what is so special about long-lived companies? Do they share certain criteria that enabled them to survive longer?”. The study came out with four interesting findings, but one main finding remained on top of the four; the living companies are found to be very good at “change management”.

- Financial orientation

The first observation the group noted is that long-lived companies were paying careful attention to their investments, which allowed them to grab opportunities when their competitors could not. They did not have to convince an investor about how profitable or attractive the big project they are thinking of, their money in hand allowed them to pursue their plans and govern their growth (De Geus, 1997).

- Adaptability

The second observation the group noted is that the long-lived companies were able to adapt themselves to whatsoever changes around them. No matter whether these changes are wars, diseases, technologies, fluctuations in the economy, or political conflict of interests. They always seemed to step out and excel during hardships. They sometimes relied on improvision during uncertainties, yet that was based on knowledge and experience. Therefore, they were able to react in a timely manner to whatsoever showed up (De Geus, 1997).

- Unity

The third observation the group noted is that the employees of the long-lived companies felt like one unit, a part of whole. For many decades, the feeling of belonging to a company has always been identified as a soft speech, but repeatedly, the cases show that a sense of community was crucial for evolving and survival (De Geus, 1997).

- Tolerance of new ideas

The fourth observation the group noted is that the long-living companies tolerated new ideas in the margin of experience, which expanded their horizons and stretched their understanding of the market. In a world where so many cultures are stretched over and blended together, a company has to adapt to the constant fact of change (De Geus, 1997).

2.3 The most common change management models for organizations

Here is a range of the most common change management models developed by remarkable leaders in the field of managing a change. The aim of this section is to expand the knowledge about the process of organizational change. Furthermore, to identify the underlying theory behind each model, how to implement it, and finally understand its benefits and limitations.

2.3.1 Lewin – The 3 steps model

In (1951), Kurt Lewin developed his model, which was the first change management model developed in the whole history, however, still holds true until today. The model is considered one of the key models for understanding the term “organizational change”. The underlying theory behind Lewin’s model is that there are two opposing

forces: the driving force and the resisting force. And at any situation, for the change to happen, the driving force must outweigh the resisting force.

In his model, Lewin looked at the change process that happens to an organization as changing the shape of a block of ice. (Fig 5) clarifies the key steps for Lewin's model in detail.

- Unfreeze: The first step includes unfreezing the current state. That refers to analyzing the current situation, defining the driving and resisting forces and visualizing an end desired state.
- Move: The second step is about the transformation to a new phase through engagement.
- Refreeze: The third step focuses on reinforcing the new state by setting policy, establishing new standards, emphasising on the developed strategies and coping with change.

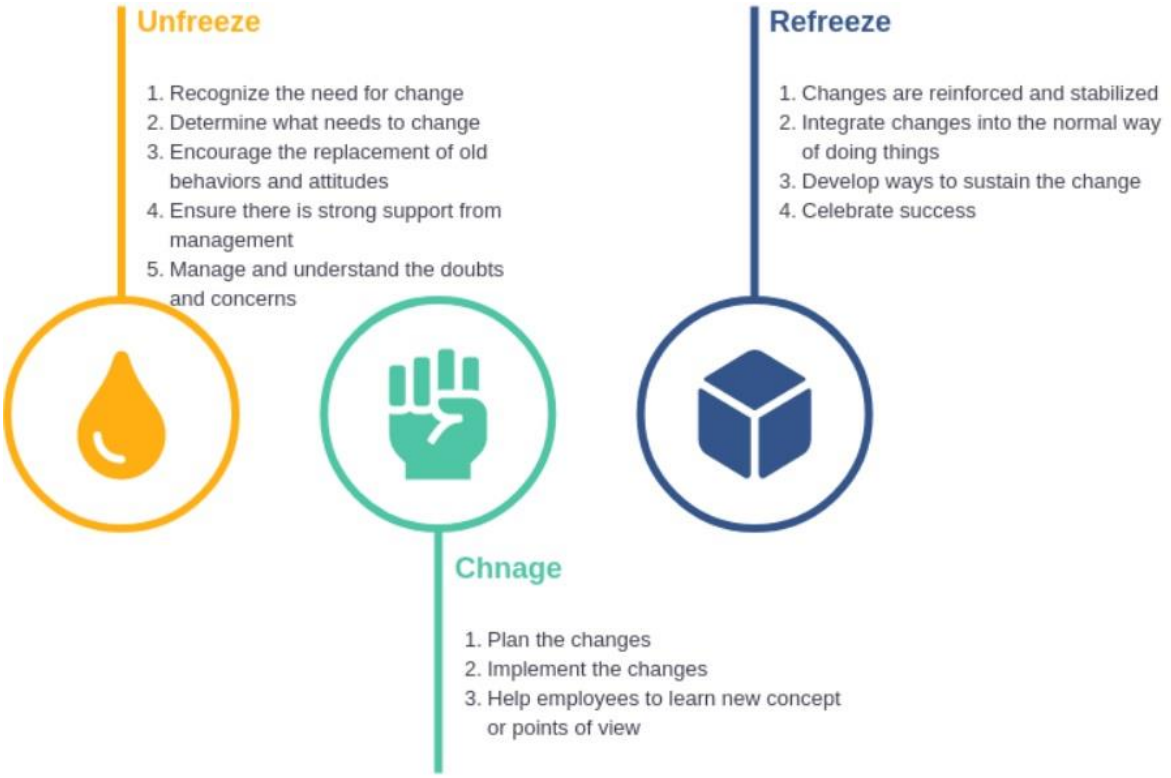


Fig 5: Lewin 3-steps model

Critical review:

The force field analysis that Lewin introduced is an excellent way of addressing the driving and resisting forces influencing the change. Along with defining the current state against the desired end state, a change agents team can be formed to:

- Communicate the gaps between the current state and the desired end state.
- Minimize the resisting forces.
- Develop and maximize the driving forces.
- Set a timeline for a change plan to achieve the end state.

Furthermore, (Cameron and Green, 2009; Gichuhi, 2017) argued that the model can be used as a planning tool, rather than a change management model. The unfreeze step represents the planning phase. The move step represents the implementation. The refreeze represents a post-implementation or a practical review for the end state. On the other hand, (Kanter et al., 1992) criticized the model intensively, declaring that organizations are never frozen; they are fluid entities with many characteristics that overlap and interconnect one another in a dynamic way.

2.3.2 Kotter – 8 steps flow

In (1995), John Kotter developed his organizational transformation 8-steps model highlighting eights keys lessons derived from his consultation practice with more than 100 different organizations went through change (Kotter, 1995a). He, later on, converted these insights into a change management model (Kotter, 1995b). The model addresses some of the powerful factors about making change happen, highlighting on the importance of creating a sense of urgency, and emphasizing on the need to communicate the vision throughout the organization and making sure that everyone perceived it the way it is planned (Cameron and Green, 2009).

The efforts of (Kotter, 1995a) in assessing more than 100 companies have gone under many sectors. However, all the companies had one goal in common: making fundamental changes in how the business operates in order to cope with the challenging demands of the market environment. (Fig 6) summarizes Kotter's 8-steps model and clarification of each phase is incorporated below.

Fig 6: Kotter 8-steps model

1. Create a sense of urgency

Most of the change efforts succeed according to (Kotter, 1995a) when some individuals or groups manage to look hard at their companies and address issues like: financial performance, poor market position, technology trends limitation, the revenue drop in the past years, or the declining margins of profit. Then, they find ways to communicate these gaps widely and dramatically, while looking at future potential scenarios. That will increase the felt-need to change.

2. Build a guiding coalition

In both small and large organizations, assembling a powerful group of people who are capable to lead a change will make an enormous difference in results. It can start with two or three persons, yet it has to expand while the change is taking place. And while the change has to be supported from the top management, forming a guiding coalition to extend that support is inevitable. They have to develop together a shared commitment to a unique performance throughout the change. Kotter (1995a) shares: It is not mandatory that all members of the guiding group to be from the senior management. However, for the change to take place, they have to be powerful; in terms of, titles, expertise, business knowledge, relationships and reputation.

3. Form a strategic vision

In order for the transformation to be implemented successfully, the guiding coalition must create an appealing and reasonably simple-to-communicate vision for the future that will resonate with employees, customers, and stakeholders. That far picture for the future is the vision. And a strategy has to be developed to achieve that vision. Kotter (1995a) interviewed many midsized European companies seeking to have a transformation, and there was one central idea among them all to reach their vision: getting out of low value-added activities.

Without a sound vision, change efforts can easily disappear under a list of daily repeatable tasks. In failed transformation, there are plenty of plans, directives and programs, but no solid vision. In some other cases, management tends to have a sense of direction, but it is too complicated to explain or buried under loads of procedures. As a rule of thumb (Kotter, 1995a) claims: “If you cannot communicate the vision to someone in five minutes or less and get a reaction that signifies both understanding and interest, you are not yet done with this phase of transformation”.

4. Enlist a volunteer army

Transformation is nearly impossible to occur unless it is supported by hundreds or thousands of people, frequently to the point of making temporary sacrifices. And for that to happen, they need to believe the change is bringing positive returns. Communication facilitates explaining the benefits, and it comes in two ways; words and actions, and the latter are often more impactful. Nothing weakens change more than a behavior by a significant individual, most likely executives, that is inconsistent with their actions (Kotter, 1995a).

5. Enable action by removing barriers

At the beginning, no company has the power, the capacity, or the time to overcome all barriers, but major ones have to be encountered and removed. The role of the change agents is to facilitate these barriers. The blocking force can be in the context of narrow job responsibilities, a flawed performance appraisal system, or a person from the top management that their behaviors are not in line with their speech (Kotter, 1995a).

6. Generate short-term wins

In this regard, the emphasis was on setting benchmarks and celebrating the short-term goals when met. Most people will not go further unless they experience solid evidence

on the way that the change is leading somewhere. Without short term wins, some people may give up or join the resisting camp (Kotter, 1995a).

7. Sustain acceleration

In most of transformation cases (Kotter, 1995a) claims, managers tend to declare victory too soon in an attempt to celebrate the results of transformation. While celebrating a win is acceptable on a short term, declaring that the war is over can be disastrous. Until change concepts are deeply implanted in the company's culture, a process that can take reasonably long time, the new alternatives are fragile and can easily return back to its former or less developed state.

8. Anchor change

At the end, change sticks when it becomes the norm things are being done, when it is deeply rooted in the company's culture and values, and when it is linked with a need of a company for development and standing a better chance of evolving. Until the new actions are implanted in the company's vision, they are subject to regression as soon as the pressure for change is not there. Continuously showing the positive returns of the new technology or system implemented and how it enhanced the performance is crucial for deeply implanting change (Kotter, 1995a).

2.3.3 Beckhard and Harris – The changed formula

In (1987), Beckhard and Harris developed their change formula and identified the factors that must be there in order for the change to occur. The formula is one of the simplest that has ever been developed, yet extremely useful, and can always be brought into the process of change at any point to check how feasible or likely the change to happen.

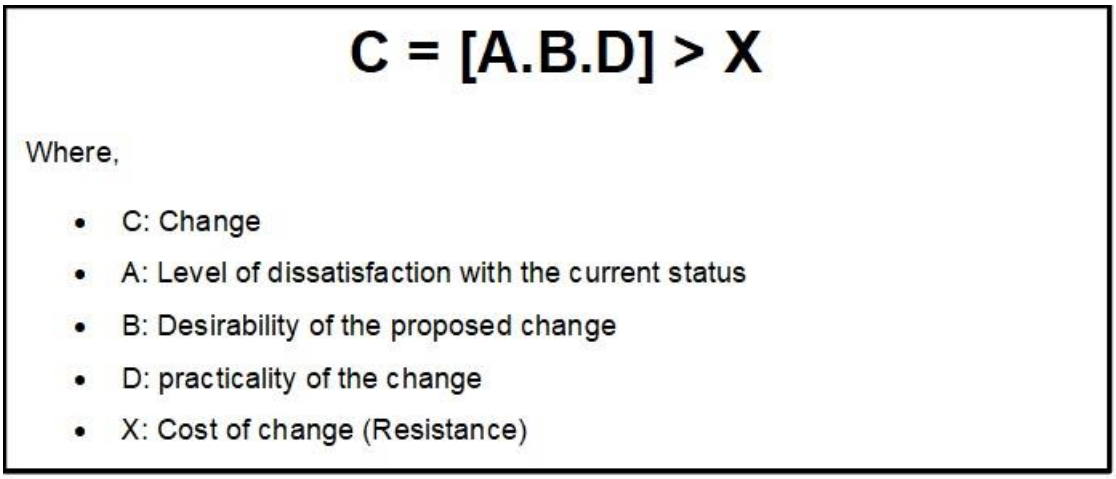


Fig 7: Beckhard and Harris change formula
Source: designed by Author

Beckhard and Harris (1987) simply claimed that in order for the change to happen, elements A, B, and D must overweigh the term X, as shown in (Fig 7), which here represents the cost of change as well as the efforts needed to be exerted to overcome the resistance resulted in change.

What is interesting about the formula is using the multiplication to link the 3 factors A, B and D together, which here means that if any factor is equal to zero or near zero, the output tends to fail. The resistance to change will overweight. And by then, the change won't happen. That means if the level of dissatisfaction within the current situation is not high enough, or the vision behind implementing change is not clearly seen, or the plan is not feasible or less likely to bring better results than the current situation, the change will not happen. The elements (A,B,D) do not compensate or replace each other. Each one has to score a proper weight so that the final value of them combined overweigh the resistance to change (Element X).

Critical review:

When the formula was shared with 100 companies from multiple industries based in the UK, some gaps in the theory were found (Cameron and Green, 2009):

- Employees dissatisfaction was not of a major significance to implement a change.
- The tasks given to those change implementers were found to be complicated or poorly defined.

Furthermore, (Chapman, 2018) discussed that the simplicity of the formula represents a weakness itself, as there are countless factors affecting the change to happen rather than the level of dissatisfaction of employees, the desirability of the plan and its practicality. Moreover, the assumption that the 3 elements (Dissatisfaction, desirability and practicality) are equal in weight, with regard to their importance, is somehow flawed. Each case is different. And sometimes, according to the type of organization, some elements may weigh more than others.

2.3.4 Nadler and Tushman – Congruence model

In (1980), Nadler and Tushman developed their model, which focused on the factors affecting the success of the change process. The model aimed to analyze what happens to the organization when change takes place. Thus, the model was built on the concept that an organization can be presented as a set of interconnected units that sense and filter changes in external environments. Therefore, and in order to achieve that, the model sees the organization as an input and output system. The inputs are represented in terms like (strategy, resources, and environment). While the outputs are represented in (individual, team, and organizational performance). They later commented, “It is important to view the congruence model as a tool for organizing your thinking, rather than a rigid template to dissect, classify and compartmentalize what you observe.” (Cameron and Green, 2009).

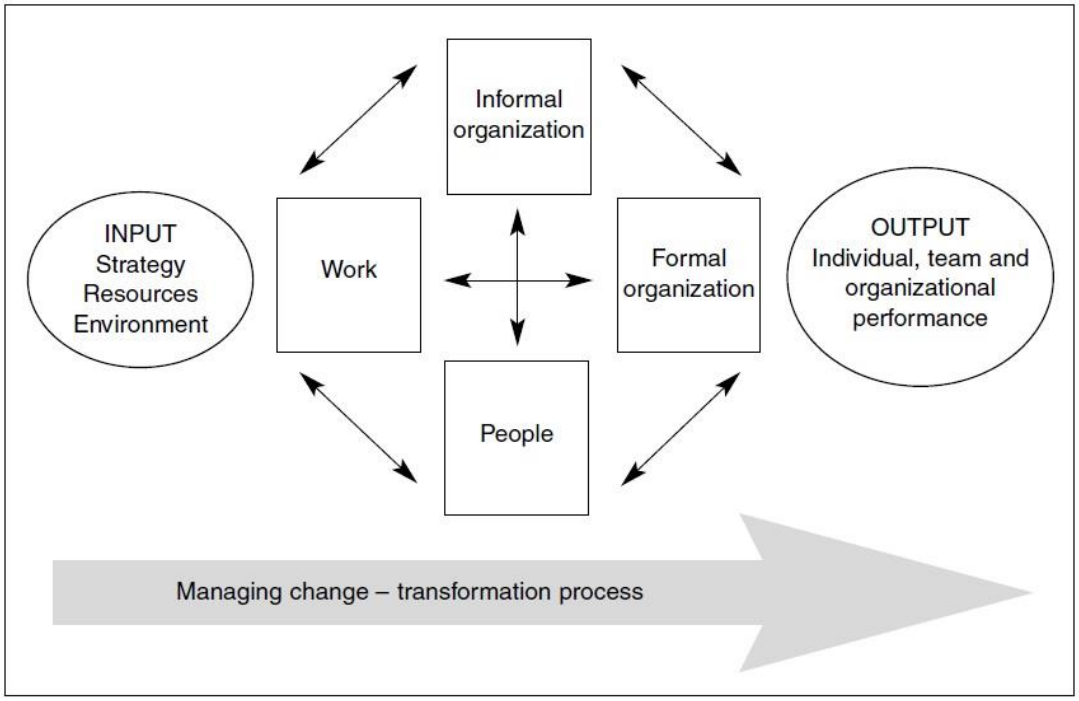


Fig 8: Nadler and Tushman's congruence model
Source: Nadler and Tushman (1980).

As shown in (Fig 8), the model counted on four key elements: work, people, formal organization, and informal organization for a successful transformation process. The model also assumed that the challenge is how to align these four components together so that the organization can transform its inputs of strategy, resources, and environment into the required outputs. Cameron and Green (2009) explain the four elements as follows.

- **Work:** This refers to the operations, process design, and day-to-day activities assigned to individuals. The level of satisfaction of individuals with their own tasks should be considered here, and a system of reward must be incorporated under this element.
- **People:** It is crucial to identify the major criteria of the people who are delegated to do the work in the organization. What are their skills, their backgrounds, their preferences, their needs, and their expectations? How do they perceive the tasks assigned to them and their relationship with work?

- **The formal organization:** This refers to the system, the structure, and the policy announced to achieve strategic goals. In brief, how are things formally going on?
- **The informal organization:** Running alongside the formal regulations are the informal. This refers to all the unwritten plans and practices that emerge over time such as culture, beliefs, value, power, and influence.

Critical review:

It is worth mentioning that the model Nadler and Tushman have developed is a problem-oriented rather than a solution-oriented. It does not provide a concrete guideline for a strategy, and it lacks any significant reference for a vision. However, from their perspective, the model was intended to be a tool rather than a rigid template to follow. On the other hand, the model provides an integrated checklist for those concerned of making change happen. Furthermore, it explains the transformation process in a sequential way that can easily be followed to monitor change. If the integration is not done properly among the four elements, the change is more likely to fail, and the organization may come back to its old norms (Cameron and Green, 2009).

2.3.5 Prosci – The triangle model

In (2002) Prosci developed his structured, adaptable and actionable change management model. The focus of his model is to enable the people side of change. His methodology was based on putting people at the center of any transformation wave. And therefore, his model consists of three key components, as per illustrated in (Fig 9).

- Prosci Change Triangle Model (PCT): A framework representing the four key aspects of successful organizational change (will be explained further).
- Prosci 3-Phase Process: A link connecting individuals and organizational change management.
- ADKAR Model: A model addressing the term individual change.

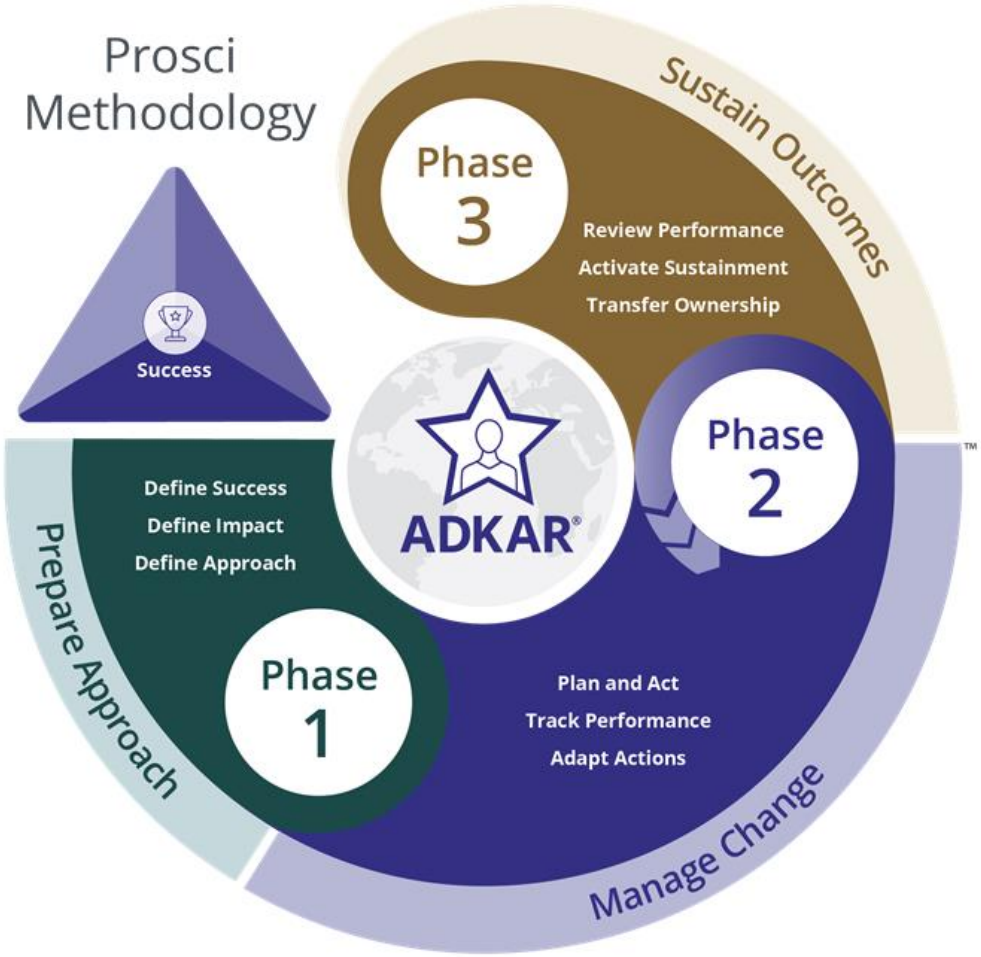


Fig 9: Prosci Methodology
Source: Prosci (2002)

Prosci Change Triangle Model (PCT)

Prosci claimed that “we change for a reason”. The purpose of the model is to clarify that reason by establishing the key factors of success and providing a way to assess the change process throughout the project lifecycle. Prosci change model is a powerful framework that shows the key elements for any successful change approach. The key aspects are represented in (Fig 10).

- Success: represents the objective of the change process.
- Leadership/sponsorship: represents the strategy and direction of the change process.
- Project management: represents the technical side of the change process.
- Change management: represents the people side of the change process.

Fig 10: Prosci Change Triangle
Source: Prosci (2006)

The corners of the triangle are interrelated together to achieve the required outputs of the change initiative (Prosci, 2006). As shown in (Fig 10), project management works with the leadership/sponsorship on the leaderships decisions that have to be made by integrating time, scope, and resources. Change management works with the leadership/sponsorship on the leadership actions that must be taken, integrating communication, vision and supporting agents. And change management works with project management to create an integrated approach focusing on people, process, and tools.

Critical review:

The Prosci change triangle model provides a powerful framework that was able to link the four key aspects of organizational change. It provides change managers with beneficial diagnostic tools to evaluate the health of their change process, identifying risks, determining any shortcomings, and enabling actions. However, Prosci's model works

as a three-legged chair. An organization that has any shortcoming in any of the key aspects of the change tends to fail in their attempts to change. If one leg is too short, the change process will sway, causing the benefits to slide off the seat. Therefore, it is crucial to pay attention to the integration between the key elements.

2.4 Limitations

The literature reviewed above shows that there are some limitations in the research conducted before in the field of change management. Prior studies have suggested linear sequential strategies to follow, disregarding the various conditions of each environment. Wang et al. (2013) discussed some limitation points below.

2.4.1 Regional limitation

From Table. 01 (Summary of change management definitions), it can be noted that only one out of 10 definitions listed is from a developing country; from Pakistan. In addition to that, the literature shows that most of the studies conducted in the field of change management are from western countries, which in turns reflects the fact that the quality of implementing change management properly in the developing countries is falling behind the US and Europe. Therefore, further research is needed in the developing countries.

2.4.2 Industrial limitation

It seems that most of the change management definitions are released in the general business contexts. Nothing specified to each industry highlighting the different characteristics. Instead, studies made on organizational change management focused on developing a generic view which could be used in various industries. And until now, it appears that little to nothing has been done in the field of organizational change management in construction.

2.4.3 The gap between project/organizational change management

The literature reveals that there is a knowledge gap between project and organizational concepts of change management. There are different perspectives from the researchers of the two fields and accordingly various research outputs.

- Those who focused on project change management were targeting terms like optimizing workflow, developing forecasting techniques and applying project strategies according to standards.
- On the other side, those who focused on the organizational context attempted to find the appropriate resource-based factors leading to instilling the innovative technology or the new system as part of the culture.

2.4.4 Lack of flexibility

In a constant era of change, the overflow of information and technologies developed every day keeps introducing new strategies and frameworks for industries to implement change. Consequently, there will be no “best way” to impose a change except a more flexible method. And thus, the existing change management models mentioned above can just work as guidelines for organizations to develop their own framework that has to be flexible and needs to be structured in a way to align with the organizational culture and facilitate the change processes.

3. Modern Methods of Construction (MMCs)

Modern Methods of Construction (MMCs) is a wide term used to describe a number of agile construction approaches to replace traditional methods of construction. MMCs include a range of offsite manufacturing and a few onsite techniques that provide an alternative to conventional house building (NHBC, 2018). Most of which are offsite technologies; moving work from the construction site to the factory, prefabrication, pre-assembly, and industrialized construction. Furthermore, the modular building, paper-less system, mobile technology, machine learning, laser scanning, digitalized inventory, agile procurement and materials tracking system (Rahman, 2014).

Offsite technologies are not particularly new to the construction industry. Yet, current influencing factors trending up have caused many professionals to reconsider their appeal. Factors such as improving productivity, the rising usage of BIM technologies, the growing interest in green construction, the increasing demand for agile projects and lean construction. (Fig 11) shows the adoption percent of UK developers of housing with MMCs in their operations, which reveals that currently, 69% are delivering buildings using MMCs, and 31% are considering implementing them in the future (NHBC, 2018). Furthermore, McGraw Hill Construction (2011) argued that what is notable about modularization/prefabrication is their ability to bring all the agile trends together in an attempt to enhance productivity and adopt green construction.

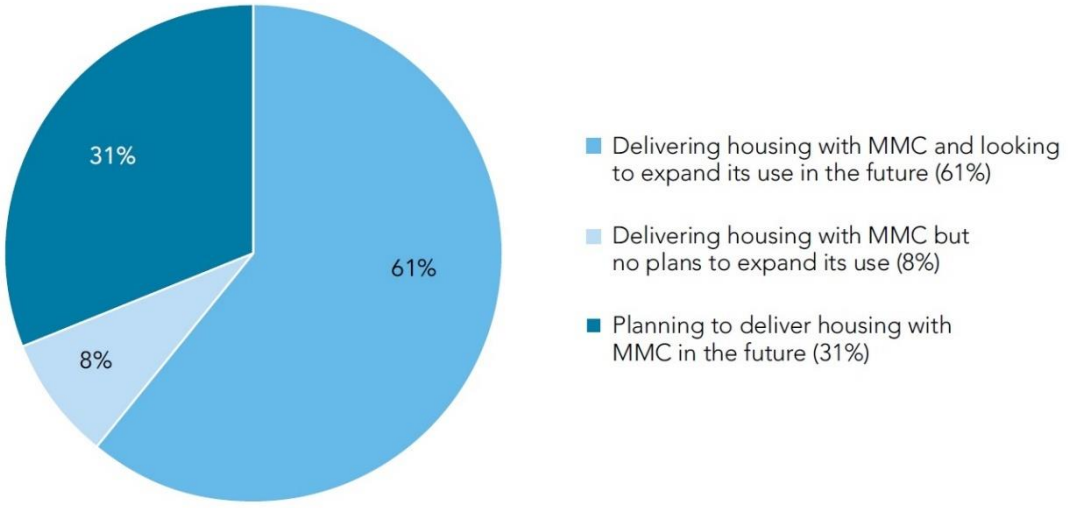


Fig 11: Developers activity using MMCs in the UK
Source: NHBC (2018).

3.1 Offsite construction concept

The term “modular” refers to an object “designed with standardized units or dimension, for easy assembly and repair or flexible arrangement and use” (MBI, 2015). Modular Building Institute (MBI) reports focus particularly on aspects involving market share, market size capacity, growth forecast, and manufacturing standards. The aim of MBI is to direct the efforts, talents and resources towards a higher market share of the modular building industry by showing its benefits in practical manners (Salama, 2018).

The modularization process is being used in several sectors, such as industrial plants, manufacturing, submarines and ships field, and also in nuclear power plants. However, their application in construction is relatively low. Salama (2018) argues that the literature presents various definitions and terminologies to describe offsite construction and here they are presented as follows:

Modularization

Haas et al. (2000) define modularization as “the preconstruction of a complete system away from the job site that is then transported to the site. Modules are large in size and may frequently need to be broken down into several smaller pieces for transport”. In addition, Tatum et al. (1987) define the module as “a major section of a plant resulting from a series of remote assembly operations and includes portions of many systems; usually the largest transportable unit or component of a facility”.

Prefabrication

Tatum et al. (1987) define prefabrication as “manufacturing processes, generally taking place at a specialized facility, in which various materials are joined to form a component part of a final installation”.

Preassembly

Tatum et al. (1987) also define preassembly as “a process by which various material, prefabricated components and/or equipment are joined together at a remote location for subsequent installation as a unit. It is generally focused on a system”.

Offsite fabrication

CII (2002) further defines the offsite fabrication as “the practice of preassembly or fabrication of components both offsite and onsite at a location other than the final installation location”.

To conclude, PPMOF “Prefabrication, Preassembly, Modularization, and Offsite fabrication” are several manufacturing approaches that tend to shift the work activities from the construction site into factory-based conditions, where it is safer, faster, more productive, and more environmentally efficient (Salama, 2018).

3.1.1 Offsite construction characteristics

In (2020), Razkenari et al. made the analysis to rank the usages of offsite construction methods by project types in the United States. Their analysis was based on current practices and future potential to use offsite technologies, as per (Fig 12). The results show that single family houses and multi-family houses were cited by more than 60% of the participants as the highest function of buildings. Healthcare facilities, educational premises, and multi-family houses were placed as future potential functions.

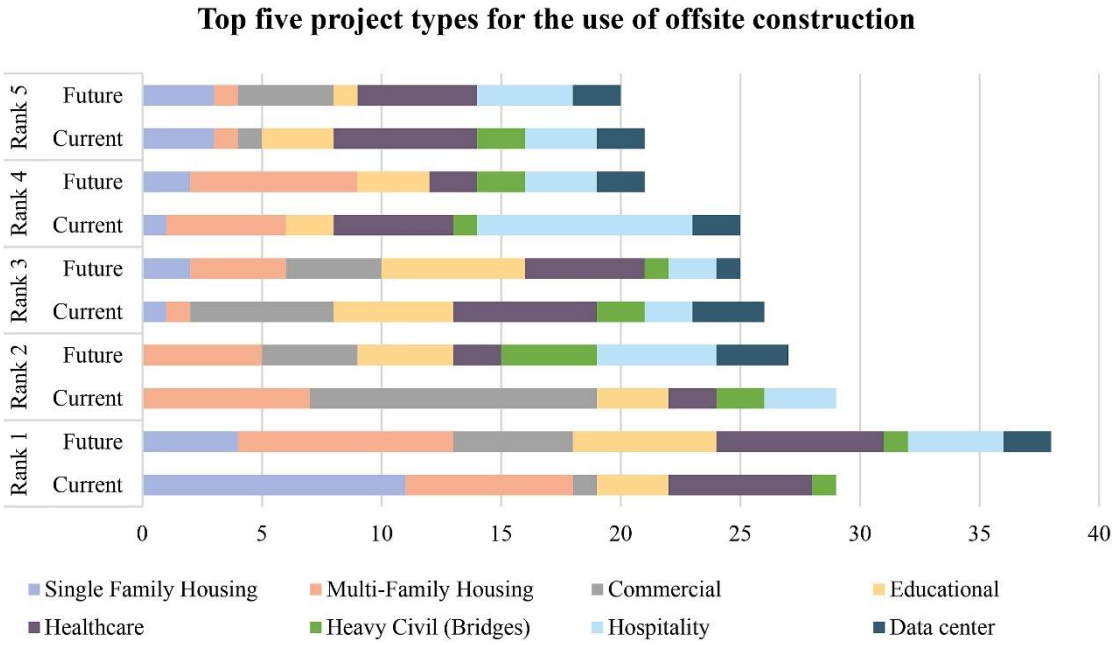


Fig 12: Usages of offsite construction technologies based on project type
Source: Razkenari et al. (2020).

Furthermore, when asked about the necessity of making the choice of using offsite construction as a primary method among various industry players (Fig 13), 35% voted for the client, being the upper hand in the project. 31% cited the architect, being the first contact with the client and has the ability to convince them, having proposed smart designs. 26% placed the general contractors on the third rank. The remaining percent was assigned for other stakeholders such as subcontractors, manufacturers, supplier, investors, and authorities. In addition, 90% of stakeholders believed that offsite construction technologies would remarkably gain interest in the future (Razkenari et al., 2020).

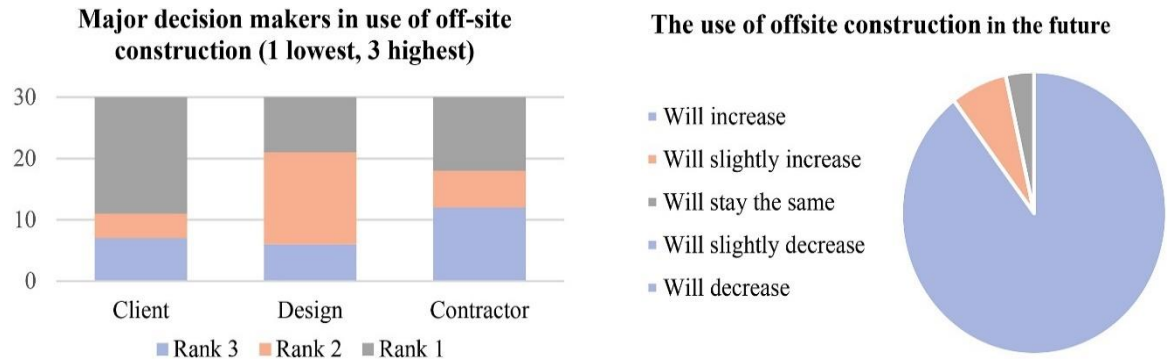


Fig 13: The key decision makers for offsite construction usage
Source: Razkenari et al. (2020).

3.1.2 SWOT Analysis

In an attempt to understand the offsite construction opportunities, challenges, strengths, and area of development, Razkenari et al. (2020) performed SWOT analysis based on the responses they received in “Symposium on the State-of-the-Art of Modular Construction” in the United States (US). The SWOT analysis addressed the whole production pipeline of offsite construction components starting with the planning, design phase, issuance to manufacturing, shipping, and assembly at site. (Fig 14 and Fig 15) summarize the SWOT analysis and can be sued as a roadmap for industry players to enhance their decision-making process and assist them to effectively adopt offsite technologies.

INTERNAL FACTORS	
STRENGTHS (+)	**WEAKNESSES (-)**
Better time and cost performance - Time saving and faster project delivery by performing component manufacturing and site preparation simultaneously. - Reducing the total cost of project including the overhead costs, material supply, and labor. - Higher level of design development and more precise planning which reduce uncertainties in cost and time predictions. **Controlled environment production** - Workforce productivity and well-being - Improved control and monitoring of quality, safety, and progress. - Improved waste management - Room for innovation and benefiting from industrialization technology **Integrated project processes** - Offsite strategies are facilitated by integrated project delivery by requiring involvement of the parties early in the process.	**Design limitations** - Low diversity of products, limitations in their size, and types of connections. - Lack of innovation in design - Design is fixed at early stages - Resistance to change orders **Lack of expertise** - Under-informed management **Complex logistics** - Transportation and shipping difficulties - Assembly limitations **Need for initial capital** - The manufacturing facility is expensive to build and maintain

Fig 15: Internal factors of SWOT Analysis for offsite construction

Source: Razkenari et al. (2020).

EXTERNAL FACTORS	
OPPORTUNITIES (+)	**THREATS (-)**
Shortage of skilled labor - Less labor needed in offsite operations **Branding and Marketing advantage** - Offsite has significant marketing potential and increases demand from developers by promoting sustainability and quality **Lack of affordable housing** - Higher cost of land and economic conditions are forcing reducing cost and faster deliveries **Urban density** - Cities are booming in size and population and filling the small and restricted lands is more feasible offsite strategies because of reduced site work and flexibility in production	**Uncertain market demand** - Offsite factories have fixed production rate and demand uncertainty have higher impact on them **Codes and regulations** - Most guidelines and codes are designed specific to onsite. - Quality control and inspection is varied among states. This have higher impact for modular projects, in which components are usually shipped to multistate locations **Negative perception of public and industry** - Conservative construction culture - Complex contractual process **Economies of scale** - Offsite has much low market share compared to onsite. Therefore, there are more experts, contractors, and suppliers for onsite

Fig 14: External factors of SWOT analysis for offsite construction

Source: Razkenari et al. (2020).

Most of the studies made on offsite construction found that the greatest strength of it is the ability to reduce time while performing work simultaneously. Furthermore, the improved quality control and safety procedures in the factory (Razkenari et al., 2020). For the weaknesses, number one cited barrier is the design limitation and the inflexibility for change orders. In addition, the lack of expertise and the complex logistics system in terms of site delivery (Rahman, 2014; Razkenari et al., 2020). As most of the offsite modules are relatively large, shipping continues to be a challenge. As for the opportunities, the lack of affordable housing and the urban density of the big cities are placed at highest rank. For the threats, the uncertainty of market demand and the lack of codes and regulations development in the modular industry are cited among the highest risks (Rahman, 2014; Razkenari et al., 2020).

At the end, The SWOT analysis demonstrates that while the modular building industry confronts various obstacles in expanding its position in the construction sector, the benefits associated with it outweigh the shortcomings. Many of the highlighted issues can be addressed by utilizing technologies more effectively and expanding beyond traditional building practices. One significant solution can be in adopting a manufacturing-like culture. Furthermore, taking into account the opportunities of offsite technologies such as the need for affordable housing and the promotion for the green building industry outweigh the listed risks, and this can accelerate the route for adoption. In reality, most of the highlighted elements can have both positive and negative consequences, and it is vital to employ the appropriate management approaches and be aware of these vulnerabilities and risks in order to maintain them on the positive side (Razkenari et al., 2020).

3.2 Regulating modular building

Modular construction has become an increasingly prominent issue in the recent years. This growing popularity, however, is accompanied by a significant lot of misunderstanding and even falsehoods. People frequently ask MBI, "What is the modular building code?". So MBI answered that question out loud “there is no modular building code in the sense of a national standard, which defines the building requirements for all manufactured homes. Instead, modular homes are built to comply with all applicable state and local building codes required by the location where the home will be placed” (MBI, 2022).

Despite the absence of a modular code, the industry is governed by a number of administrative rules and regulations, as well as, in some instances, guidelines and standards. As for the structure itself, however, the modular industry adheres to the same relevant building codes as in the onsite built components. The code can be silent about a specific topic (the term "modular" is not in the IBC), yet it continues to apply, as silence in the code does not claim an exemption from it (MBI, 2022). As the term “modular” is not in the international codes and the subject is dynamically growing and gaining interest, MBI has signed an agreement with the International Code Council (ICC) to work on guidelines and standards for the modular construction. In the next subchapters are the difference between guidelines, standards, and codes.

3.2.1 Guidelines

Guidelines are not codes nor standards, and their language is not obligatory. A guideline is a statement that educates and directs a code official or the end user on a given subject. For instance, MBI has recently finalized work with the ICC on the “G5-2019 Guideline” related to safe shipping of modular components. While a guideline is not binding, it provides jurisdictions with a lot of information regarding area of concerns and offers end users a safe route forward. As a result of the reactive nature of the codes, guidelines are frequently employed to address new trends and technology, until a building code comes in practice (MBI, 2022).

3.2.2 Standards

Standards are developed when it is recognized that there are insufficient administrative regulations to govern a certain issue. Numerous standard-writing organizations, including “International Organization for Standardization (ISO), American National Standards Institute (ANSI), Underwriters' Laboratories (UL), and Canadian Standards Association (CSA)”, develop standards for almost everything. The objective of a standard is to bring together stakeholders, such as customers, manufacturers, professional bodies, and concerned authorities on a given matter in order to determine "how things should be done". As the name suggests, they establish an agreed-upon standard method of performing the work. In other words, they develop a practice. There are a few Canadian-

developed modular construction standards that have a significant impact on the industry (MBI, 2022).

- CSA A227

The “CSA A227” covers the certification procedures for prefabricated buildings, as well as volumetric modules and panelized systems for buildings of any function type. In addition. the standard defines regulations for quality assessment in the built factory. Furthermore, it extends to prefabricated buildings, volumetric modules, and panels made of any material, including modular homes, portable workplace facilities, and any other factory-built components that are manufactured and being shipped to the construction site (MBI, 2022).

- UL-2600

The “UL-2600” standard outlines the specifications for modularly constructed portable structures. Portable structures are a type of modular construction that is manufactured offsite, and meant to be shipped to another location, assembled, and used. While “CSA A277” is adopted and in practice in the majority of the modular industry in Canada, “UL 2600” is a newly developed standard that has not yet been in force. Important to know regarding standards is that; unless they are adopted by a local authority or cited in the building codes, they are not themselves binding regulations (MBI, 2022).

3.2.3 Building codes

According to the ICC, “The regulation of the built environment is a unique experience within the United States. Even those within the industry may understand only a part of the process pertaining to their location or discipline. Codes and adoption process can vary significantly from state to state, and in some cases even county to county”. The building codes define how structures should be constructed. And while there is no reference of special treatment or cited exemptions for modularized buildings in the codes, the constructed modular projects must comply with all applicable requirements of the building code (MBI, 2022).

When people frequently inquire about the “modular code”, they are actually asking, “what laws and regulations do I need to know to construct a modular project in a specific region?”. In contrary to the Housing and Urban Development (HUD) code, the

modular housing industry is typically governed at a regional level. The majority of states in the US (35 at latest count) have an authorized legal body that establishes and evaluates the standards for modular construction operations. While these standards may vary from state to another, they often address topics such as the factory inspection process, quality control difficulties, and the submission, review, and approval of building designs. MBI maintains regular communication with these bodies in order to maintain a balance that allows the industry to provide safe manufactured modular products without excessive regulatory constraints (MBI, 2022).

Due to the diverse number of programs in the US, the ICC and MBI are now developing a new standard, “ANSI 1205” for the review, evaluation and approval of modular projects. This new standard is being developed alongside another ANSI Standard, “ANSI 1200”, that addresses design and logistics issues. Moreover, MBI is also collaborating with the CSA to establish an additional modular construction standard, yet it is still unnumbered or named.

3.3 Offsite construction categories

Another broader approach classifies the offsite construction technologies into three main sections based on the scale, size of construction, and complexity of manufactured components. This approach counts on the amount of manufacturing done in an offsite delivery mode with consideration of onsite work labor for assembly (Salama, 2018).

3.3.1 Volumetric modular systems

Volumetric modules are composed of three-dimensional units that are fully manufactured in a factory and fully fitted out to be fixed before transportation to the site. Once modules arrive to the plant site, they are stacked on prepared foundations to form the homes (NHBC, 2018). Volumetric systems are usually divided into modular construction and pod construction as per (Fig 16). The first is the typical factory-produced pre-engineered components that are delivered to the construction site and fixed on a foundation system. The latter are non-structural elements but load-bearing structures.

Fig 16: Volumetric modular construction

3.3.2 Panelized systems

Panelized systems are consisted of two-dimensional units that are typically manufactured offsite and assembled onsite. Their elements are basically flat panel units that can be made out of timber, light gauge steel, concrete, or cross laminated fiber structural element (NHBC, 2018). The panelized system can be used in the forms of walls, roof parts, floors, windows sections, and timber frames to create a structural shell as per (Fig 17), which requires more finishing work to assemble onsite than the volumetric modular systems (Salama, 2018).

Fig 17: Panelized construction

3.3.3 Hybrid systems

A mixture between volumetric modular and panelized systems where bathrooms and kitchens, for example, are manufactured as separate modules, and panels are used to form the rest of the building (Salama, 2018). Hybrid systems combines between modular and panelized systems in order to optimize the space provision by integrating 3D and 2D components. Hybrid systems mostly utilize light gauge steel (LGS) that is lightweight, not heavy as concrete, not bulky as structural steel, and does not deteriorate like timber. From another perspective, hybrid construction is defined as an approach that integrates precast and cast-in-situ concrete to make advantage of their inherent qualities and site-specific conditions, as per (Fig 18).

Fig 18: Hybrid construction

LGS is considered a cost-effective solution to use in hybrid systems because it provides rigidity during lifting and transportation, good resistance in horizontal and vertical loading and unloading, and also durability against fire. LGS hybrid structure is basically assembling panels of steel frames throughout various operations in the manufacturing units using computerized numerical control machines and manufacturing-related tables. The panels are then delivered to the site, stacked to each other, and connected to the 3D modules, such as kitchen or bathroom units, as well as floor shells that are built on site (Lawson et al., 2005).

3.3.4 Configuration summary of systems

Fabrication is basically a concept of “mass customization of products” in order to standardize the process, enhance the quality in a more dynamic way, and satisfy client needs. However, each offsite construction system has their own benefits and limitations based on constraints such as transportation, accessibility, manufacturing capacity, and craning limitation. Choosing which system to use shall depend on the project

needs in terms of delivery time, budget tightness, and required level of quality. Furthermore, the capability of overcoming site-specific constraints mentioned above (Salama, 2018).

Lawson et al. (2005) studied the limitation of modular designs in family house building and the results were focused on transportation barriers because of the nature of the modular box in the three dimensions. Site assembly, craning, factory capacity, manufacturer and material selection were also placed as important factors that concern users of MMCs. Lawson et al. (2005) further reviewed the modular construction opportunities and constraints considering market conditions, design standards and codes for factory-manufactured components and site-assembled ones.

In their analysis (Lawson et al., 2005) gathered data on timber, steel, and concrete modules and discussed the fundamental design features of each. The Concrete Centre, Steel Construction Institute, and UK Buildoffsite organizations provided this information, which refers to international codes and design standards. These studies, on the other hand, do not give a systematic technique for optimizing modular building designs or for determining the degree of modularity amongst various modular units. And that is the reason why many manufacturers have started to adopt hybrid construction to overcome some of the dimensions limits and the degree of modularity.

Due to the composite nature of hybrid construction, for example, traditional codes such as “The American Iron and Steel Institute (AISI) code”, “The Canadian Institute of Steel Construction (CISC) code”, “Eurocode 3: Design of steel structures,” and “The British Standards Institute Steel code” that govern the structural design of cold formed steel do not apply. As a result, further studies have examined the durability, serviceability, and deflection by testing full-size module units to demonstrate how module arrangement affects their properties. Transportation constraints also affect the layout of modules and panels, which may constitute some variances in the layout and size (Lawson et al., 2005). And that is the reason the literature emphasizes on the necessity of developing a framework that takes into account the identified limitations, strengths, and points of development to determine the optimum use of offsite construction systems.

3.4 Productivity Analysis

In (2011), McGraw Hill Construction conducted a study about the use of Modern Methods of Construction (MMCs) in order to assess the level and scope of use of prefabrication, modularization and offsite technologies in construction. The aim was to analyze how adopting digital transformation practices can influence the productivity of construction. The research has been on two parts. The first and primary one was through an online internet survey to industry professionals, which received 809 complete responses. About the respondents, (64%) of them came from a contractor's background, (24%) came from an engineer's background, and (12%) came from an architect's background. (Fig 19) shows the exact percent of respondents in terms of their professional background and their organization size.

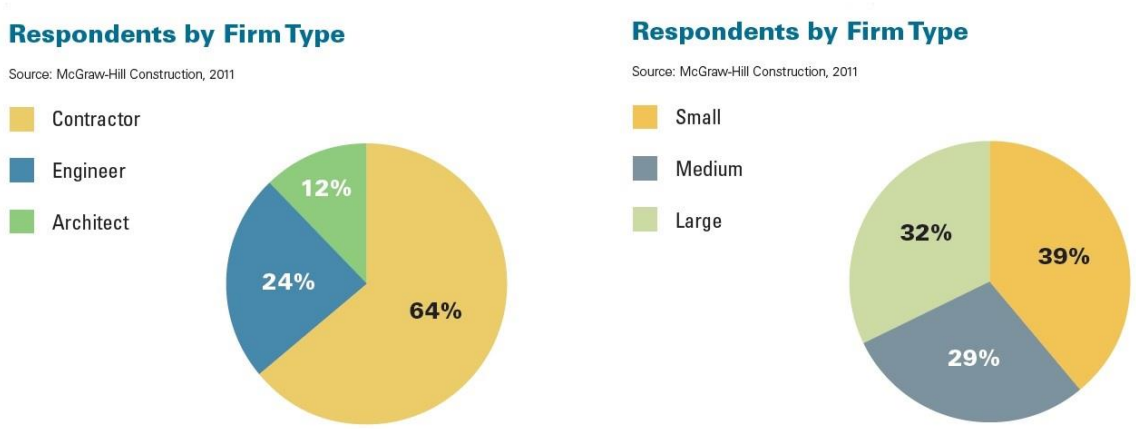


Fig 19: Respondents from McGraw Hill study
Source: McGraw Hill Construction (2011)

In addition to that, fifteen in-depth interviews were made to owners and developers to gather detailed information about their perception of adopting prefabrication and modularization in their operations and how they see the impacts on productivity. Therefore, the internet survey covered the contractor and consultant professionals, while the interviews tended to cover the client's perspective.

3.4.1 Project schedule

Time saving was one of the most commonly reported productivity benefits of using MMCs, and that is according to its large financial payback. As per shown in (Fig 20), more than two-thirds of organizations using prefabrication/modularization experienced time saving in their project schedule with a range between one to four weeks. And 35% of them experienced a time saving of four weeks or more (McGraw Hill Construction, 2011). The major reason behind the time saving is the ability to perform work simultaneously on-site and off-site as well. Moreover, enhanced coordination amongst different project units, and less onsite staging, such as scaffolding, is frequently occurring, which their assembly freezes time.

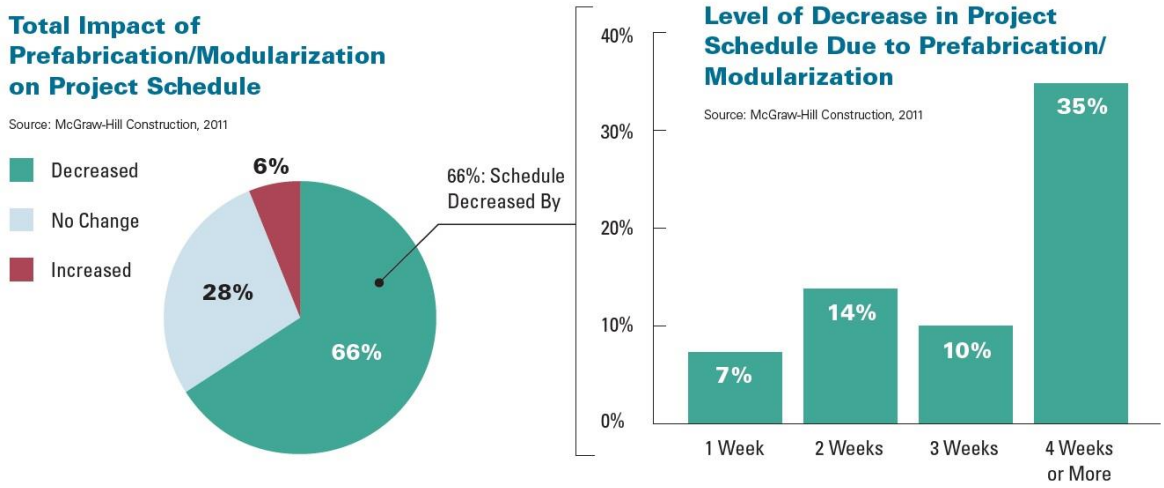


Fig 20: Impact on project schedule
Source: McGraw Hill Construction (2011)

Additional time might be spent at the beginning in the conceptual design phase due to the extensive planning and the design freeze while coordinating the use of prefabrication and offsite made components. However, the time saved on site covers the design freeze at the beginning and reduces the overall project duration. And interestingly, that is the reason why slightly larger percent of contractors show interest than consultants. Because of the intensive coordination in the conceptual design phase, particularly in mega projects, consultants seem to be reluctant to adopt MMCs. On the other hand, contractors are more likely to experience the gains of project time saving since their involvement comes later in the project lifecycle (McGraw Hill Construction, 2011).

3.4.2 Project budget

Since there is a time saving, there must be a cost saving as well because of the reduction in indirect cost finishing the project earlier than planned. In (McGraw Hill Construction, 2011) study, 65% of organizations reported a decrease in project budget by implementing prefabrication and offsite construction methods. In which, 42% of the respondents experience 6% or more of saving in budget as per (Fig 21). For a sector like construction, where it is recognized by very tight profit margins, a relatively small saving can make a remarkable impact on the total project budget.

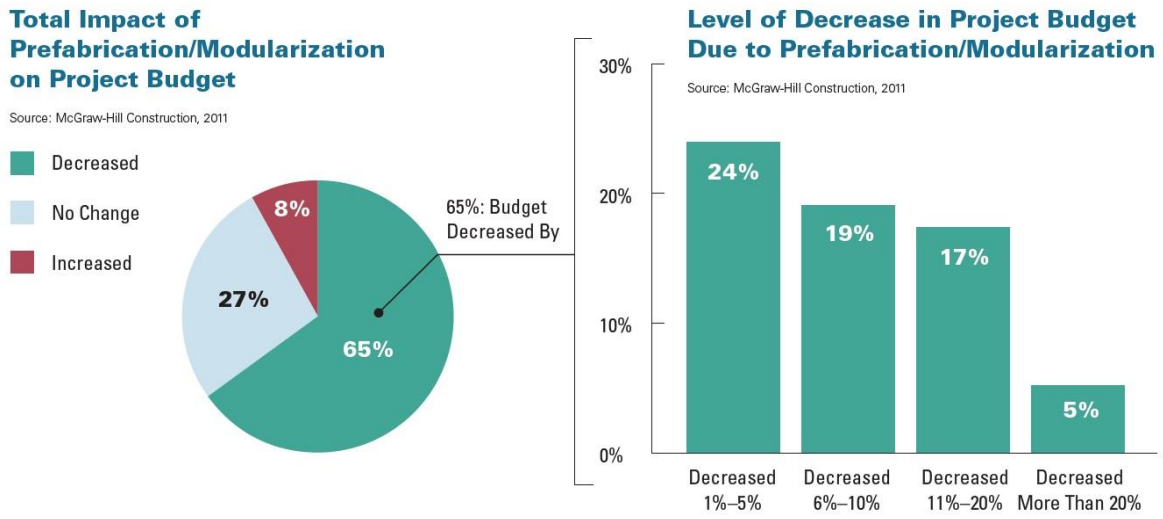


Fig 21: Impact on project budget
Source: McGraw Hill Construction (2011)

The reasons behind cost saving is the ability to reduce onsite resources and facilities like caravans, portable offices and toilets. Furthermore, decreasing the reliance on onsite labors and avoiding the unnecessary overtime pay. Switching everything to factory-based components controls the process, enhances the operations, and reduces the error margin. Several clients showed their interest in adopting MMCs because of their guaranteed budget. They argued that conventional construction projects are most of the time well-known by their budget increase due to change orders. So even if the prefabrication option seems to be slightly more expensive at the outer frame, avoiding sudden costs during the operations is of a great value, particularly for clients with tight budgets like the public sector (McGraw Hill Construction, 2011).

3.4.3 Site safety

For the construction sector and industrywide, improving safety continues to be a challenge. Offsite technologies address some benefits to solve that issue. In (McGraw Hill Construction, 2011) study, over one-third of respondents (Fig 22) reported seeing an improvement in their projects safety. The reasons behind this can be the reduced need for workers on heights, such as ladders or scaffolding. Also, avoiding working in less accessible areas and tight spaces. On the other side, almost 10% reported safety level decreases. Their argument was that prefabricated modules are often large, and their installation must be addressed carefully to avoid negative consequences.

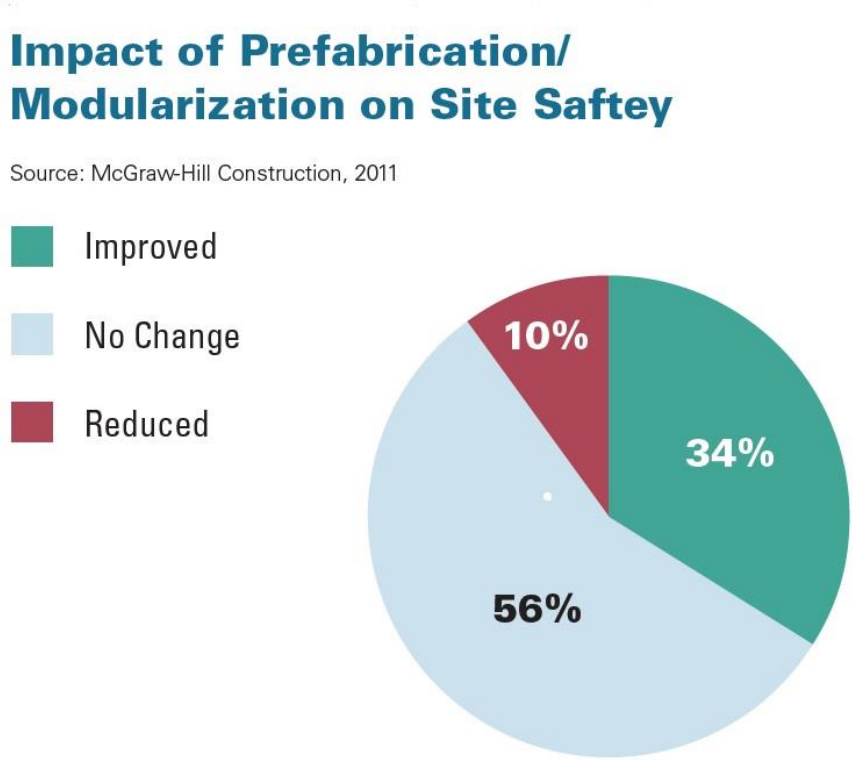


Fig 22: Impact on site safety
Source: McGraw Hill Construction (2011).

3.4.4 Greener building

McGraw Hill Construction (2011) defines a green building as “a building constructed to LEED or any other building standards, or one that involves numerous green building strategies across several categories, including energy, water efficiency, resource

optimization, and improved indoor air quality". LEED certification stands for "Leadership in Energy and Environmental Design", and it is the most commonly used green building rating system in the world. LEED is a framework designed to provide a healthier, highly efficient, and cost-effective green building. To achieve a LEED certification, a project is evaluated by earning points that address carbon emissions, energy saving, water efficiency, waste amount, transportation, resource optimization, health and safety, and indoor air quality (UNGBC, 2021).

Prefabrication and modularization contribute a lot to greener building practices, most significantly in terms of the reduction of construction waste, but also minimizing site disturbance and protecting materials from severe onsite conditions, such as rains and storms. The construction sector has a remarkable influence on the environment (UNEP, 2021). The United States Environmental Protection Agency (USEPA) estimates an annual average of 135 million tons of waste from construction sites that end up in landfills in the US. This amount can be reduced through the adoption of offsite technologies (McGraw Hill Construction, 2011).

Furthermore, Mackres (2020) argued that for industries to contribute to zero-carbon energy emissions, there are three steps. First, optimize, by reducing energy demand through improving operations. Second, electrify, by shifting energy demand away from fossil fuel sources of energy to renewable sources of energy. Third, decarbonize, by entirely shifting to zero-carbon operations in all aspects. This mirrors what the triple strategy for decarbonizing the built environment stated for (UNEP, 2021).

- First, reducing energy demand.
- Second, decarbonizing the power supply (for example, through electrification), which is shifting the operations demands from the use of fossil fuels such as oil, coal, and natural gas to operations that depend on electricity as a renewable source of energy.
- Third, addressing embodied carbon stored in building materials.

Taking this into practice, MMCs contribute a lot to greener building objectives, most significantly in terms of waste reduction and energy efficiency, which addresses the first two phases of the triple strategy. In (Fig 23), 76% of offsite construction technology users in (McGraw Hill Construction, 2011) study reported a significant enhancement in the materials consumption because of less waste produced. In which, 41% reported a

decrease of 5% or more in waste. These gains are not only environmentally beneficial, but also their financial payback is beneficial. Less waste is translated into cost saving in ordered quantities of materials and accordingly higher profit margin. In this regard, architects and engineers from consultancy firms experience the most positive returns from a greener construction site because of their inputs in materials selection and application.

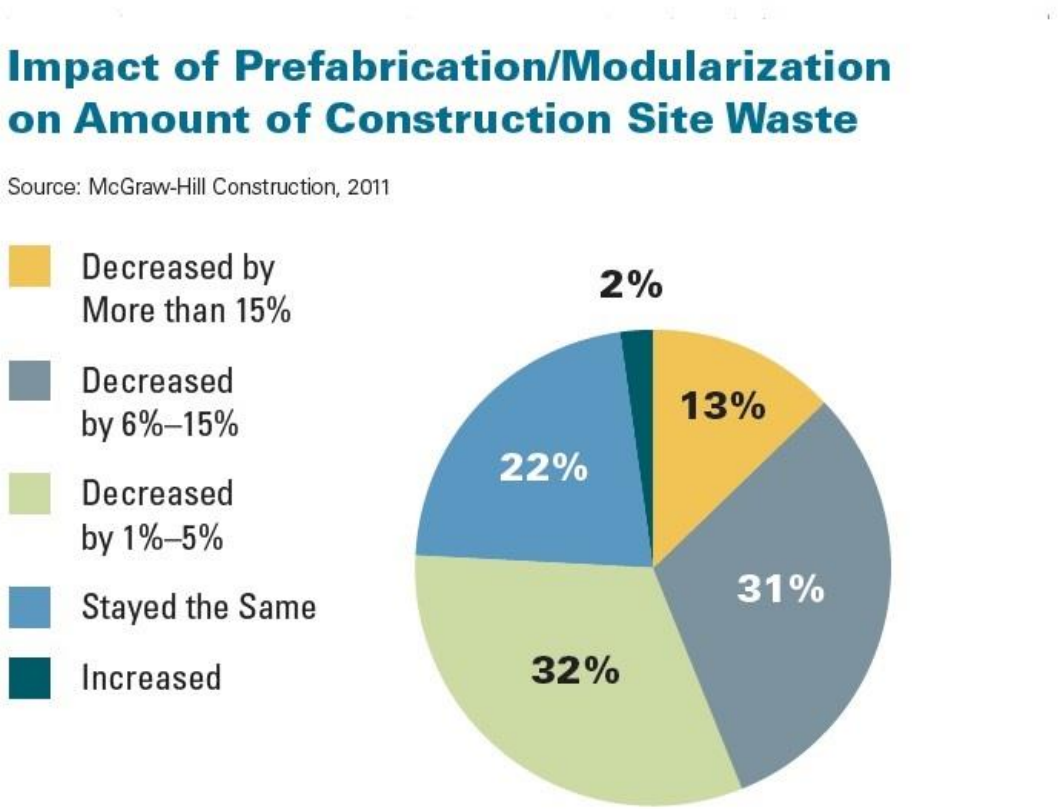


Fig 23: Construction waste impact on green building
Source: McGraw Hill Construction (2011).

From another perspective, The Paris Agreement is “a legally binding international treaty on climate change, to limit the harmful impacts of global warming and achieve decarbonization in the building environment by 2050” (UNFCCC, 2022a). The agreement was adopted by 196 countries in December 2015 and came into force in November 2016. The Paris Agreement works on a 5-year cycle plan of dynamically ambitious climate action solutions made by countries. In 2020, countries were requested to outline and communicate their action plans towards climate change, known as “Nationally

Determined Contributions (NDCs)". In this regard, countries outline actions they will take to reduce greenhouse gas emissions to meet Paris Agreement goals. Furthermore, countries communicate actions they take to build resilience against the rising temperature and its impacts. In 2025, countries will be requested to transparently report and evaluate the actions taken, and this will be assessed by a global committee. This will formulate recommendations for countries to set more ambitious plans in the next rounds (UNFCCC, 2022b).

The Paris Agreement is considered a landmark in the global climate change action plan, as for the first time, a legally binding agreement unites all nations in a joint effort to tackle climate change. In 2020, a total of 192 countries submitted their first NDCs. In which, enhancement in the energy efficiency was the most frequently cited after the use of clean sources of energy in the power supply. In terms of energy efficiency, the building energy codes dominate attention. Building energy codes are basically a set of regulatory guidelines that specify minimum energy efficiency requirements to assure a reduction in energy consumption and emissions during the lifecycle of the building (UNEP, 2021). However, the current coverage of these codes is not widely implemented.

4. Findings

As mentioned in the research methodology (Chapter 1.4), the author has decided to adopt a qualitative research method with exploratory and explanatory approaches. And in order to achieve the research objective, the author conducted in-depth interviews with professionals from the industry with recognizable experience in construction management. Furthermore, it is followed by a case study about a student residence hall at Queens College in New York.

4.1 Interviews with professionals

In the interviews section, the author has decided to follow a top-down approach starting with the generic questions about the topic definition, followed by the driving forces of change in the construction industry. Afterwards, started questioning about the barriers of implementing MMCs, the critical factors contributing to an efficient implementation of change management processes to MMCs in the construction market in Egypt, the possible risks of adopting these methods, and at the same time, the possible opportunities or returns in applying them. In the end, the author asked the interviewees freely about their opinion about the most common change management models mentioned in the literature, and how they see their validity in the construction market in Egypt.

4.1.1 Design of questions

It is worth mentioning that the questions given to professionals in the field were not just questions ended with a question mark. One of the limitations the author thought of is the variety of angels the professionals may approach the questions with. Therefore, all the questions were followed by a short description about the focus area the author intended to further investigate. That is meant to guide the interviewees and help them not to travel far away with their thoughts and also help the author to find answers that serve the research objective.

The professionals first received the author’s proposal to participate in the interviewing panel. Later, when they confirmed their availability, they received the questions by email and were given from 7 to 14 days to further discuss the questions to make sure they approach them from the same angle view as the author. Therefore, some of them

returned back inquiring about few points shortly and some of them asked for further clarification. After the given analysis time and when all of them confirmed they are ready, the author started to schedule video call interviews with them taking into consideration a time lapse of an average 2 days between each interview. The 2 days were recommended in order for the author to be able to record down each interview outputs separately, and not to interfere the results of each.

Following the top-down approach, which simply states that questions should start from the generic view going deeper to further investigate the topic, the questions were listed as follows:

1. How do you define the term “change management”?
2. What drives change in construction industry?
3. What are the limitations of implementing modern methods of construction (MMCs) in the Egyptian market industry?
4. What are the critical factors contributing to an efficient implementation of change management processes to (MMCs) in Egypt?
5. What could be the possible risks of adopting modern methods of construction (MMCs) in the Egyptian market industry?
6. What could be the possible opportunities/returns of adopting modern methods of construction (MMCs) in the Egyptian market industry?
7. How do you see change management models for adopting MMCs? Are they applicable to be implemented in Egypt?

4.1.2 Selection of Interviewees

While the literature has proven that change management insights are entirely valuable for the organization to survive and evolve in a constant era of change, the author has decided to link the change management insights with practical aspects that tend to acquire the majority of project and corporate managers attention. Therefore, the author has decided to focus on those 5 particular aspects: cost, time, quality, technical, and scope. Why? Simply, because they are specific and measurable. And when it comes to those aspects, managers are more likely to listen and adopt the recommended change management practices.

In addition to that, the author intended to interview professionals that match four criteria. First, all professionals have an engineering degree. Second, they are all with more than 10 years of experience and in a managerial level. Third, to a remarkable extent, all the professionals compiled between various backgrounds; client or developer, contractor, project manager, and consultant during their careers, which added some sort of a variety to the information they shared. Fourth, all the professionals have been exposed before to MMCs, either by directly working with it outside Egypt, or their current companies branches in Egypt are implementing it outside and soon planning to expand in Egypt. Having these criteria allowed the author to establish a reliable database, on which he later built his analysis upon.

For the scope aspect; Mohammad Yousry was chosen. It is worth mentioning that Yousry is currently a Project Manager in ASGC Egypt, one of the leading construction companies in the Middle East and North Africa (MENA) region. Furthermore, Yousry has more than 17 years of international experience, having worked before in Algeria, Saudi Arabia and Egypt in various project types. In addition to that, Yousry is a Project Management Professional (PMP) certified since 2016, and he recently had his Master of Business Administration (MBA) degree in 2021.

For the cost aspect; Ahmed Mohey was chosen. It is also worth mentioning that Mohey is currently the Budget and Cost Control Manager of ASGC Egypt branch. Mohey has more than 12 years of professional experience working in multinational firms in several construction areas ranged from residential, commercial and infrastructure. Further, Mohey started his career as a site engineer for quite long time, so he compiled the site experience with the managerial aspects. In addition to that, Mohey is a learning and technology passionate; he had his master’s degree in construction management in 2016, he is a certified PMP since 2016, International Project Manager Associate (IPMA) since 2020, and he recently had his MBA degree in 2022.

For the time aspect; Abdelrahman Afify was chosen. Afify is currently the Senior Projects Control Manager in Marakez Group, the leading mixed-use developer in Egypt, and spanning across the Middle East, North Africa, Europe and USA. It is worth knowing that Afify has an ever-growing portfolio of working in commercial and residential projects for more than 14 years in different backgrounds. His experience varies between working as a contractor, consultant, project manager, and recently in a real estate development company. Moreover, Afify had his master’s degree in construction

management in 2014. In addition to that, Afify is a professional planner that always has valuable insights when it comes to complex schedules for mixed-use projects.

For the quality aspect; Mohammad Abdelaziz was chosen. It is worth mentioning that Abdelaziz now is the Co-Founder and General Manager of NCGC, a dynamically growing construction company in Egypt, which he cofounded with his partners recently in 2019. Abdelaziz has previously held the position of Quality Control Manager in multiple international corporates and has worked in several project types ranging between residential, commercial, infrastructure, and industrial projects, which are well-known by being complex ones. Abdelaziz is currently planning to expand his business to take projects in the MENA region.

For the technical aspect, Michel Saad was chosen. Saad is currently a Technical Office Manager in ASGC Egypt, and he compiles more than 18 years of experience working on a wide spectrum of complex projects ranging from residential, commercial, administrative and Infrastructure. Furthermore, during his career, Saad has worked in multinational reputable companies from different backgrounds; client, consultant and recently contractor. In addition to his technical skills as a BIM expert, he has strong project and team management skills.

4.1.3 Discussions

The interviews started by providing a short overview about the author, the scope of research, MMCs categories, and finally the purpose of the research. Then, the author gave the space back to interviewees to talk about themselves and wrap up their experiences in a few sentences. The interviewees started talking about their current job positions, shared their past experiences in a glance, and briefly mentioned their education level and background. Afterwards, the author took the lead in directing the questions and taking notes on them.

1. How do you define the term “change management”?

When Yousry was asked to define the term “change management”, he directly referred to five phases that need to be defined beforehand in order to reach a proper definition of change management. First, identify where the company is now. Second, identify where the company wants to be. Third, develop a game plan. Fourth, assign the appropriate resources accordingly. Fifth, track and monitor. Afterwards, he defined the

change management by “the transition that happens to organizations to move from a current state (A) to a future state (B) with intended business needs”.

As for Mohey, he had his own definition ready in his mind about change management. He referred to it as “an organized, integrated, structured procedure of strategic planning for transformation of individual, groups, and organizations, to achieve a certain target needed for evolving and standing a better chance in the market”. He further continued that the change has to be aligned with the company’s vision and its mission to achieve so. Otherwise, these terms have to be redefined before.

For Afify, he answered that question by referring to the reason behind change, which he claimed it is either by expansion of business, implementing new ideas, technologies or a change in management. Afterwards, he defined the change management that happens to organizations as “the strategic plan you develop in order to pass through a transition phase”. Further, he argued that for the strategic plan to be successfully implemented, it has to be well planned, clearly communicated and achieving a business benefit for individuals, groups and organization.

Abdelaziz defined change management as “a strategic, planned, structured approach that organizations adopt in order to intentionally pass through a transformation phase”. Abdelaziz further explained that within the process of change, some terms have to be redefined and oftentimes adjusted. Terms like; strategy, vision, mission, culture and organizational chart. And that is in an attempt to give a meaning to the future state the company is moving towards.

For Saad, he defined the change management as “the strategic approaches an organization decides to adopt in order to manage a transition phase, which expected to serve its business needs”. Saad emphasized on the point that communication is highly efficient for any transformation to take place. And further he mentioned, the benefits have also to be communicated on individual and organizational level.

2. What drives change in construction industry?

The concept of the need to change in the construction industry is usually driven by factors residing within the construction company itself and factors emerging from outside (McKinsey Global Institute, 2017). That is what has been said to professionals

explaining the question. Then, the author asked them to think of the driving factors that could spark a change in the construction market in Egypt.

When Yousry was asked about the factors that drive change in the construction industry, he argued that we first need to do a SWOT analysis (Fig 24) in order to identify our strengths and weaknesses, which represent “the internal factors” and to get a figure about our opportunities and threats which represent “the external factor”. By scaling the events and placing them into the 4 pillars of the SWOT analysis, it helps us take advantage of our strengths, develop our weaknesses, carefully benefit from our opportunities, and mitigate our threats as much as we can.

Fig 24: SWOT Analysis quarters

Yousry continued; for the internal factors, primarily, they are laid in productivity losses, operational inefficiencies, and the gap between planning and reality, which often leads to time delays and cost overruns. For the external factors, Yousry claimed that the major driving force is the very competitive market and the unstable circumstances in Egypt leading to market and currency devaluation. Afterwards, he mentioned about Porter's 5 forces, which is a business analysis tool that seeks to know your position in the market and accordingly gives a figure about the industry trends and where you are. Porter's 5 forces explained in (Fig 25) states that by identifying the power of suppliers, power of customers, threats of new entrants, substitutes or services provides a foundation for a strategic agenda of action. Along with the SWOT analysis, they spot the light on areas where strategic changes may have the greatest return, and highlight on industry trends which are promised to acquire the major significance either as opportunities or threats (Porter, 1979).

Fig 25: Porter's 5 Forces Framework

Source: Porter (1979) in Harvard Business Review.

Mohey also referred first to the SWOT analysis, claiming that it will map out the four major aspects you need to build your analysis upon. He further argued that you have to perform TOWS analysis, which is the extension of the SWOT analysis but attempts to link strengths with opportunities, strengths with threats, weaknesses with opportunities, and weaknesses with threats, as per (Fig 26). Afterwards, you build your analysis with a goal in mind to link your strengths and weaknesses, which you can control, to work in your favor of taking advantage of opportunities and mitigating the threats.

Fig 26: TOWS Analysis

Mohey further continued; in his point of view, the major factor driving a change in the construction in market in Egypt was the poor cash flow and low productivity rates. For the first, he claimed it is the reason of publicizing the investment to public authorities, which are well known by their payment delays. For the latter, he approached it as a global issue that face construction all over the world, which was supported by (McKinsey Global Institute, 2017).

For the external factors he referred to PESTEL analysis (Fig 27), which seeks to study the key external factors that influence an organization. It can be used in a wide range

of scenarios, when a strategic decision is needed. In this context, Mohey reflected on the construction market in Egypt and shared his concern about the economic and political aspects; the decisions made recently to decrease the imports, which will drive innovative insights in the manufacturing sector. Further, and for the social aspect, if that is fitting the level of education and awareness of people. From a technology standpoint, there is a shortage, which may drive a change, but first the infrastructure problem has to be solved. At the end, he also emphasized on the increasing global competition in general and in MENA region in particular, which must drive contractors and investors to add value.

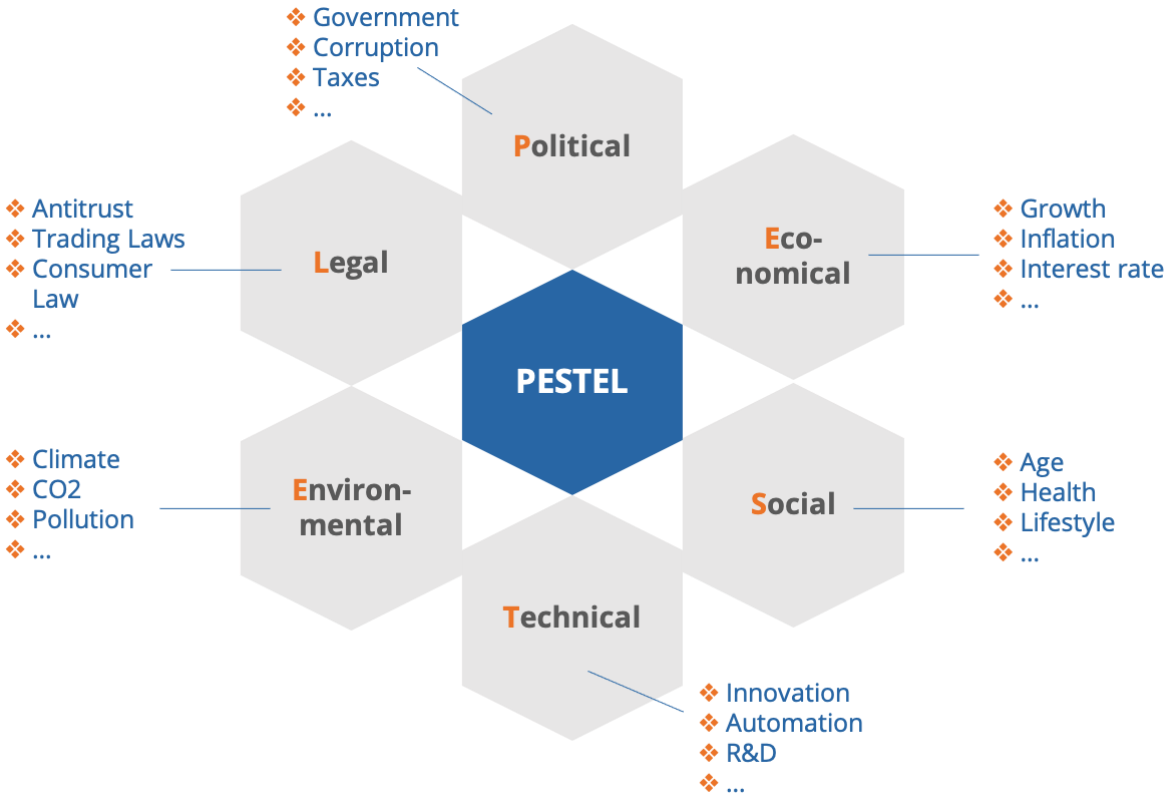


Fig 27: PESTEL Analysis

Afify approached that question quite differently and more in a dynamic way. When he was asked about the factors driving change in the construction market in Egypt, he claimed that there are two types of change in the Egyptian market; confined change and market change. For the confined change, he argued that it is evident, from state A to state B, most likely everyone knows what they are going through or what is required with the facilitation of change agents. Further, he gave the example of that few years ago, many companies in the real estate industry were focusing only on one type

of building; residential, commercial, or offices. When the need for mixed-used buildings started to grow, they realized that they needed to change, and the change was, to an extent, definite. They needed to train and educate engineers on how to integrate and adopt the mixed-use design and implementation in order to cope with the demanding need for mixed-used direction and to satisfy clients' requirements.

Afify continued; for the market change, it is not totally clear. More of like trial and error. At that point, he referred to the common executive module of management in Egypt and worldwide adopted. We have a client for a development project. The client brings a project manager for taking care of the managerial scope of work and a consultant for supervising the construction works that the contractor is performing. Later on, there was a growing need to handle the PM works by the client and deal only with a consultant and a contractor, which represented a change in the developers and stakeholders interests. At the end, he summarized "there are many capable contractors and investors to take up the work, but the global competition is forcing everyone to add a value to their works. The value could be in adopting MMCs".

As for Abdelaziz, he instantly referred to the external factors mentioning some very interesting points. First, he argued about the variant market demands which force construction companies in Egypt to change their directions to cope with the growing new demands. He mentioned the example of the growing direction to the agricultural reclamation in Egypt, which is currently forcing construction firms to further investigate this field and expected to shift part of their business from residential, commercial, administrative and industrial to the infrastructure of agricultural reclamation. Second, he referred to the newly issued laws and regulations which would also affect the industry. At the end, he expressed his concern about the less access to building materials and products, which remarkably affects the project delivery time and cost.

Abdelaziz further continued; for the internal factors, he also mentioned some very practical and interesting points that reflect the current construction market in Egypt. Primarily, he referred to the poor financial cash flow that happens to most of the contractors. And that is due to the delay of invoices payments from the client side, particularly the public ones, which are currently dominating the market and expanding in building new cities. Second, he mentioned about the relatively low production rates. He expressed his opinion about this point, holding the comparison between self-performing and subcontracting, mentioning the advantages and disadvantages of each. And that you may

need to go for subcontracting for resource optimization and relatively guaranteed production rates. Third, he argued about the extension in business direction to expand in a new scope.

For Saad, he argued that the primarily the major driving forces are external. Yet few of the internal forces can spark a change. For the internal forces, he referred to the low productivity rates, the excessive waste of materials in construction sites, the poor cash flow and the small profit margin. For the external forces, he instantly referred to the competitive markets which drive clients and contractors to adopt MMCs for their survival. Further, he mentioned about the new laws and regulations which contribute to fluctuation of the market. At the end, he also mentioned that one of the major driving forces is the change of developers and/or stakeholders interests and their attempts to invest in the proposed plans.

3. What are the limitations of implementing modern methods of construction (MMCs) in the Egyptian market industry?

When Yousry was asked about the barriers of implementing MMCs in the construction market in Egypt, he referred to many factors that could counter the adoption of such methods, but they primarily relate to the culture and the industry mindset. He argued that construction projects are unique, specific and non-repeatable, so it is hard to standardize. Further, he mentioned the potential higher initial cost compared to traditional methods. In addition, according to the industry mindset and considering the Egyptian market, which involves a lot of changes from stakeholders, people tend to prefer paper system to save their rights, assuming that they can claim on whatsoever recorded and signed on papers. Moreover, the less tolerance for late design changes after issuance for manufacturing.

In this regard, Mohey referred to some points majorly instilled in the culture. First, he referred to the relatively slow pace in adopting new technology in the construction sector in general and in Egypt in particular. He further explained that the reason behind this is the poor infrastructure networks in Egypt in terms of fiber optical cables and security, which affects the internet connection in distant areas. Second, he referred to the current direction of publicizing the majority of work, which represents a challenge convincing the public authorities about MMCs. The fact that the public authorities are

often cautious and less encouraged to innovate. At the end, he expressed his concern about the suspicion of meeting stakeholders expectations when newly deploying MMCs.

For Afify, he referred to few points in different directions. First, he also referred to the poor infrastructure, particularly in internet connection, which leads to a reluctance from investors about proposed MMCs implementation plans. Second, the end-user heritage, which treats the building as a lifelong asset. And since the life cycle time for most of MMCs are relatively less than conventional methods and requires regular maintenance, they do not lean towards them. It is worth mentioning here that the maintenance culture is not quite common. Third, he emphasized on the point that the industry is dynamically changing in all of its lifecycles. As for the MMCs, he argued that they limit the late design changes and are less flexible. At the end, while he believed in the impact of these methods for a greener construction, he said that “there is no bonus/encouragement from the government to adopt MMCs, which can also second the lack of investment in proposed MMCs plans”.

As for Abdelaziz, he answered that question by remarkably referring to the mindset of the industry in general and cultural problems in particular. He justified his point by mentioning the low IT integration in the industry in a general context. And further in particular, the limitation of heights in Egypt in flying drones, for example. And the paper system, which is deeply rooted in the culture, making people adopt the belief that signed papers in hand save their rights. Second, he argued about the inflexibility of MMCs for late design changes compared to on site assembling. At the end, he referred to the relatively fewer codes and standards available for such methods, which clarify the reason behind the limited capacity of existing MMCs manufacturers.

For Saad, when he was asked about the barriers of implementing such methods, he highlighted on the inflexibility of prefabricated, pre-assembled and factory-based components for late design changes. He further explained the nature of construction industry that it is dynamically evolving and fragmented, so it is quite hard to change the mindset to premade elements. Moreover, he referred to the unwillingness of the manufacturers and/or suppliers to innovate or change to MMCs. At the end, he argued about the lack of experience and the shortage of skilled labors in MMCs.

4. What are the critical factors contributing to an efficient implementation of change management processes to (MMCs) in Egypt?

When Yousry was asked about the critical factors contributing to an efficient implementation of change management processes in Egypt, he argued that there must be a link between the change and the business need of the company, and this has to be translated in a practical manner. Furthermore, people will not buy in unless they realize that change is beneficial, so a lot of training and communication is needed in such case to blend the mindset and convince them. Moreover, Yousry emphasized on the point that you cannot implement drastic changes at one time. It has to be planned to occur in particular timeframes and sequential.

Mohey found this question interesting saying “the majority of clients in Egypt are looking for instant results as much as they can, and here lays the problem”. He further explained one of the most efficient strategies to implement MMCs in Egypt is to assign a proper budget for Research and Development (R&D), which would allow the company to invest time and money without waiting for an instant return, and that shall influence efficient implementation for MMCs. Second, he referred to the planning aspect in terms of time and cost. The transition phase to adopt MMCs has to be well studied, and the benefits have to be represented in a time frame. Third, he referred to the necessity of establishing proper communication channels between individuals, teams and stakeholders, in which the objective of the desired change is communicated clearly to everyone. At that point, he emphasized on linking the change objective to the organization’s vision. If not, change the vision first and redraw the plan.

For Afify, based on his background on planning, he instantly referred to the time factor. He argued that the change has to be reasonably planned in an appropriate timeframe. In that regard, he mentioned that you first need to state your case. Second, list the steps you need to take in a timely manner. Third, set and clarify your change project goals. Fourth, which he emphasized on it, test your argument with those who are concerned with change and make sure to establish transparent communication channels. Fifth, identify critical milestones which will soon become benchmarks. At the end, develop an action plan that brings the change to life.

Abdelaziz responded to that question mentioning some practical aspects about the subject. Initially, he referred to the necessity of communicating the benefits of change

to individuals, groups, and stakeholders. Further, he mentioned about planning the change. And in that point, he referred to two aspects; First, choosing the right time of change. Second, setting benchmarks to measure the change periodically. He claimed, in a data-driven world, people tend to measure success by numbers, and while that may sound hard to be implemented in a transition phase, you have to invest as much effort as you can trying to quantify the outputs. Most commonly; in terms of time and cost. At the end, he emphasized on the senior leadership commitment to support the change and move it forward.

For Saad, he had four interesting insights in mind. First, he also referred to the top management support in guiding the change movement, which he claimed the most critical factor. Second, he mentioned about the necessity of recruiting change agents that their roles are to lead, guide, and facilitate any barriers to an efficient implementation of change processes. At this point, Saad emphasized that those change agents have to be powerful; in terms of, titles, expertise, relationships, business knowledge, and reputation, which was supported by (Kotter, 1995a). Third, the need of establishing proper communication channels between stakeholders, individuals and departments within the organization. Doing so facilitates the updates, expertise and information exchange being delivered in a timely manner across everyone involved. Fourth, training and development to overcome the lack of experience and the shortage of skilled labors in MMCs.

5. What could be the possible risks of adopting modern methods of construction (MMCs) in the Egyptian market industry?

When Yousry was asked the possible risks of adopting MMCs in the construction market in Egypt, he first referred to communication and data transfer difficulty, and that may lead to project delays due to the fact that people are not entirely familiar with these methods. Second, he referred to the expected higher cost compared to the traditional methods, if not implemented properly. Third, he mentioned about the challenge of convincing all the stakeholders and meeting client’s expectations. At the end, he also emphasized on the point of considering the risk of not making a change and how does that appeal to you in terms of business survival.

For Mohey, again he referred to factors mainly instilled in the culture. First, he referred to the culture mindset of people that when a new technology is implemented, that would replace the human element. And that is why manufacturers are quite resistant to digital transformation. Second, he argued about the evaluation of MMCs claiming that there is a lack of quality assessment manuals and standards. At the end, he expressed his concern about the poor infrastructure networks in Egypt in terms of security and fire-walls, which represent a significant fear of integrating larger percent of IT in the construction sector, particularly in the distant areas and the new cities built.

In this regard, Afify had some interesting thoughts in mind. He claimed that MMCs are imported from abroad, so there is a possibility of failure according to environmental conditions. He clarified his claim by mentioning that “we have a problem in after sales services in Egypt. That is why we always try to minimize the maintenance and lean more towards long lead lasting products”. Further, he explained that MMCs generally require frequent maintenance, renovation or refurbishment. Moreover, the fact that Egypt is quite behind in cyber security and IT systems makes people quite reluctant to digital transformation. At the end, he expressed his concern about two points. First, the possible license permit approvals and how challenging could be, considering relatively fewer codes and standards available for such methods. Second, the little potential of longer time at the beginning due to the design freeze.

As for Abdelaziz, he responded to that question be simply saying “any of the barriers mentioned above can turn into a threat if not properly taken care of”. Afterwards, he also expressed his concern about the lack of quality assessment tools and accreditation for MMCs. He further explained that often components of MMCs are relatively light in weight, which might lead to the classic assumption that they are less durable, lower in quality, and may require regular renovation. Therefore, considering the mindset of the industry and the fluctuated market conditions in Egypt, many manufacturers and suppliers become reluctant to innovate or change to MMCs. Furthermore, he expressed his concern about the lack of experience and skills which may result in negative outputs.

For Saad, he focused on two main points he argued they are critical. First, the suspicion of meeting client’s expectations, the fact that these methods are quite new to the construction industry. Second, the potential higher overall cost compared to conventional methods. He justified this point by saying; at the beginning, you need to establish

the factory, buy or rent the machinery, purchase all the relevant materials, build the system and train skilled labors on these methods. Furthermore, due to a fluctuating market demand, manufacturers tend to raise the prices to cover their overheads and pay their labors. On the other hand, in traditional methods, overheads occur only when construction takes place.

6. What could be the possible opportunities/returns of adopting modern methods of construction (MMCs) in the Egyptian market industry?

When Yousry was asked the possible opportunities/returns of adopting MMCs in the construction market in Egypt, he instantly referred to the potential time saving due to the short cycle of operations. The movement to industrialize all construction components and switch them to factory-based would save a lot of time. The traditional methods of cast in place are not only time consuming, but leave a lot of waste and defects which badly affect the environment. On the other hand, the modular building allowed us to see additional details which in turns enhanced our decision making. Moreover, the paperless system and industrialized constriction contribute a lot to turning the construction industry into a sustainable sector and making it environment friendly. Further, the digital transformation in inventory, procurement and materials tracking system helps in optimizing the resources required. At the end, Yousry argued that digitalizing the process would significantly influence the outcome, which would allow the adoption of green building operations.

Mohey answered that question by pointing out few interesting points. First, he referred to significant waste reduction from implementing MMCs. The fact that they are factory-assembled contributes a lot to having a sustainable industry. He further explained it from the waste management hierarchy triangle, which is fundamental to businesses to understand, as it explains the procedure of waste management from the most desirable to the least significant. As per (Fig 28), the hierarchy shows that (prevent and reduce) are the first two most desirable phases to waste management. His argument was controlling the process from the beginning. From the first line production, the process is clean. Further, he shared his opinion that the rest of the phases are actually not too practical when it comes to construction. If we could not control the process from

the beginning, we would jump to the disposal phase, which is safely dumping the waste to landfill. And that is the least desirable end of pipe solution.

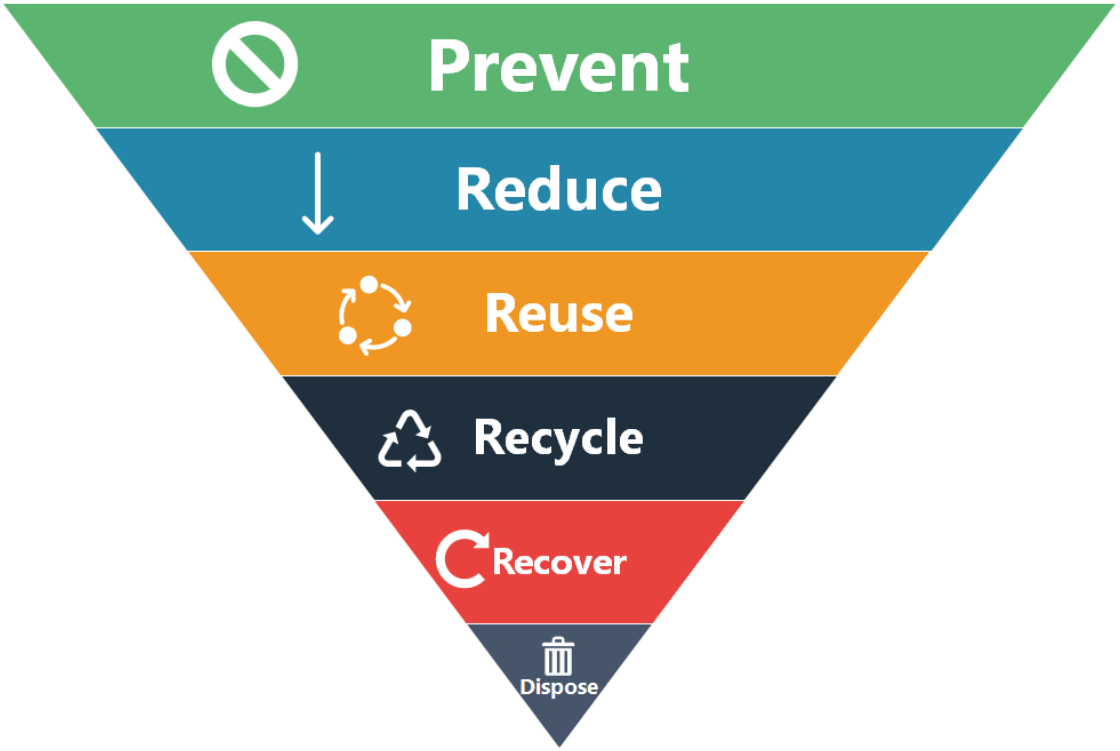


Fig 28: Waste Management Hierarchy
Source: Axil (2018)

Mohey continued answering the question, by also referring to the potential time saving from efficient implementation of MMCs. He further explained that MMCs components can be simultaneously manufactured while assembling on site elements. At that point, he mentioned the example of casting the foundation at site while preparing the super-structure components in factory. In addition to the time saving, real-time updates are provided about construction status between stakeholders. Moreover, he pointed out that the construction market in Egypt is not saturated yet in terms of technology, so there is a room for innovation. And due to the global competition, clients and contractors have to consider other aspects rather than the financial payback. One of them could be the environment, which can also run a profitable business, but differently.

In this regard, Afify instantly referred to the significant reduction in waste because of less human interaction, and most of the elements are factory-assembled. And in factory, there is proper monitoring and control. Furthermore, he referred to the insulation benefits of MMCs. He argued that the conventional methods of construction brought

poorly heat-isolated buildings, which consume a lot of energy during summer times to cool them. And for these two points, the reduction in waste and energy saving solutions must have a remarkable influence on the adoption of sustainable construction in general and a green building in particular.

Afify continued talking about the potential market opportunities from a construction standpoint; he referred to the significant growing need of awarding recent projects to design and built contractors, which leave the room to contractors to innovate and make the choice of MMCs, as they are not dependent on an external designer. Further, he referred to the increasing competition between contractors and market inflation, which opens the door for contractors to look for alternatives to save time, cost and achieve better quality. And in this regard, the MMCs appeal the most to them. At the end, he expressed his opinion about that the construction market in Egypt is not saturated yet, and that leaves the room for investors to think of digital transformation from different points of view.

For Abdelaziz, when he was asked about the possible opportunities/returns of adopting MMCs in the construction market in Egypt, he instantly referred to the significant reduction in waste. He argued that conventional methods of construction leave a lot of waste behind, yet having a digitalized system for inventory tracking the materials consumption and monitoring their assignment helps us work better towards optimizing our resources. Further, he mentioned that MMCs contribute a lot towards adopting sustainable construction. The fact that everything is monitored and censored in the building makes the energy consumption relatively lower than the traditional methods. Moreover, he saw the factory-based components being lightweight as an advantage to the construction building. At the end, he shared an interesting point of view “I see that the survival and success of any company in today’s data-driven world, is by how much data a company can gather about an issue. The data can be in various forms; could be numbers, figures, shapes, or drawings. And that remarkably enhances the quality of decision making”. It is worth mentioning that one of the MMCs advantages is providing extra details, which contribute much to enlarging the image and accordingly influence the decision making.

For Saad, he referred to some interesting points about the possible opportunities/returns to adopt MMCs. First, mitigating the risks in health and safety from a human standpoint, since the MMCs are primarily factory-based, and in factory a lot of safety

regulations are considered. Second, in case of a stable demand, the running cost of MMCs would be relatively low compared to traditional methods, so he argued about the advantages of MMCs in large enterprises. Third, significant waste reduction by having a proper monitoring and control over materials through a digitalized system. Fourth, he claimed that adopting MMC would lead to an energy-efficient building by optimizing the needed resources, which have a major environmental impact.

7. How do you see change management models for adopting MMCs? Are they applicable to be implemented in Egypt?

In this regard, professionals were introduced briefly to change management models in the literature and the idea of having a structured framework to guide through the adoption of a new technology, introducing an innovation plan, or implementing a new system. It is worth mentioning that most of them were familiar with Kotter (1995b) 8-steps change management model.

When Yousry was asked about the change management models and how they are applicable to be implemented in Egypt, he answered, “the attempts to implement sequential steps in a construction company in Egypt is quite hard. It is, however possible, but you have to be prepared for loads of resistance, and that is culture-related”. He further argued that the change needs to be highly supported from the top management or executives within the company. For the models, they could work as guidelines, but you have to tailor them according to what is suitable to your organization.

As for Mohey, he saw the change management models valid. He argued that even if the points mentioned are from a global spectrum, they spot the light on real issues that face organizations. He also expressed his concern about the sequential flow of them to be implemented in the construction industry. But again, he argued that having guidelines would facilitate the process of measuring progress and setting realistic milestones to achieve. Moreover, he clarified that you could use several models during your analysis and even customize one for yourself. At the end, he mentioned that the application of these models can expose the company to some deeply rooted issues that they are not aware of. At that point, test your assumptions again, and redefine the models inputs and area of concerns.

In this matter, Afify could not strictly say if they are beneficial and could be implemented in Egypt. Yet, he argued that “whether you decide to use them or not, they need to be customized upon your analysis”. Meaning that, their terms have to be redefined and shaped according to your company’s position in the market and its business need. Further, he expressed his concern about the market statistics problem in Egypt. Sometimes, when you want to find some data about certain topics, you might face some issues about the reliability of the sources, as you hardly can find official references. Therefore, his recommendation was to take these models and do your market research properly to find benchmarks for the terms defined.

Abdelaziz saw the change management models as beneficial frameworks that could be implemented in Egypt. Yet, you have to redefine their inputs and outputs according to your type of change. Abdelaziz argued that, considering the market conditions in Egypt, the most practical change management model would be the one based on simulations; trial and error model. By assuming scenarios, identify critical points of action, set a time frame, measure progress periodically, and see how far you are from your desired future point.

For Saad, he also saw the change management models as beneficial guidelines and strategic frameworks that could be implemented in Egypt, yet the variables have to change according to each company’s conditions and business strategy. Therefore, his point was to develop a particular framework for the feasibility of implementing any of these models. You may need to adjust it according to your business interests and the organization culture.

4.1.4 Analysis (concluding thoughts)

In this chapter, the author attempted to analyze what has been discussed before with professionals in order to assess the viability of implementing MMCs in Egypt. The author listened to professionals arguments and took notes of them. He elaborated points that were not fully clear to professionals, and here is the final output combining the opinions of five professionals residing in the Egyptian market from different backgrounds that stand for reputable organizations, strong project management skills and high level of academic achievements. The questions will be listed in order, and analysis will follow.

1. How do you define the term “change management”?

In this regard, the author noticed that there are some common keywords among all the professionals in their shared definitions. Terms like “strategy”, “planning”, “integration, “control”, and “system” are most commonly used to define change management. Therefore, the author developed his own definition as “An integrative, structured, planned, and comprehensible approach for transforming individuals, groups and organizations from a current state to a future desired state, with the goal of achieving better business benefits”. It is worth mentioning that in this regard, five important phases have to be well defined for a successful implementation of change.

- Identification of the current state of the company.
- Defining where the company wants to be in the future.
- Developing a game plan.
- Assigning the appropriate resources accordingly.
- Tracking and monitoring.

The first two phases involve investigating the current situation and verifying the need to change with a proper assessment of the challenge. In the third phase, goals and objectives are now clear. It is time to involve the technical experts with the change implementers and stakeholders to develop the plan, which must be signed off and agreed upon by the top management before moving into the action phase. In the fourth phase, the need for the change is defined, and the plan is agreed on. Now is the time for action, which involves assigning the appropriate resources based on the plan developed. In the fifth and final phase, it is very important to establish a feedback system which allows replanning if something goes off. Further, engaging everyone in the change and instilling it in the normal operations.

2. What drives change in construction industry?

In this regard, the author intended to divide the need for change into internal and external factors.

For the internal factors, primarily, they are laid in low productivity rates which has been communicated by all professionals in the industry and supported by (McKinsey Global Institute, 2017) study about productivity rates globally with classification of the

countries leading, countries lacking behind, accelerators, and laggards. From (Fig 29), we see that while Egypt's construction sector is lacking behind, it is accelerating, and the sector productivity growth exceeds the total economy. One significant factor causing the poor productivity in the construction sector is the relatively slow pace in adopting new technologies compared to other industries. The fact that each construction project is unique in specification, method of delivery, schedule, budget, and stakeholders can make the task of adopting a new technology harder.

Other factors has been mentioned such as, operational inefficiencies, small profit margin of construction projects so there is less room for risks, and poor cash flow, which results from publicizing the biggest share of investments to public authorities who are dominating the market, expanding in building new cities, and well known by their payments delay. Also, the less access to building materials and products recently, which is expected to drive the need for manufacturing everything in-house.

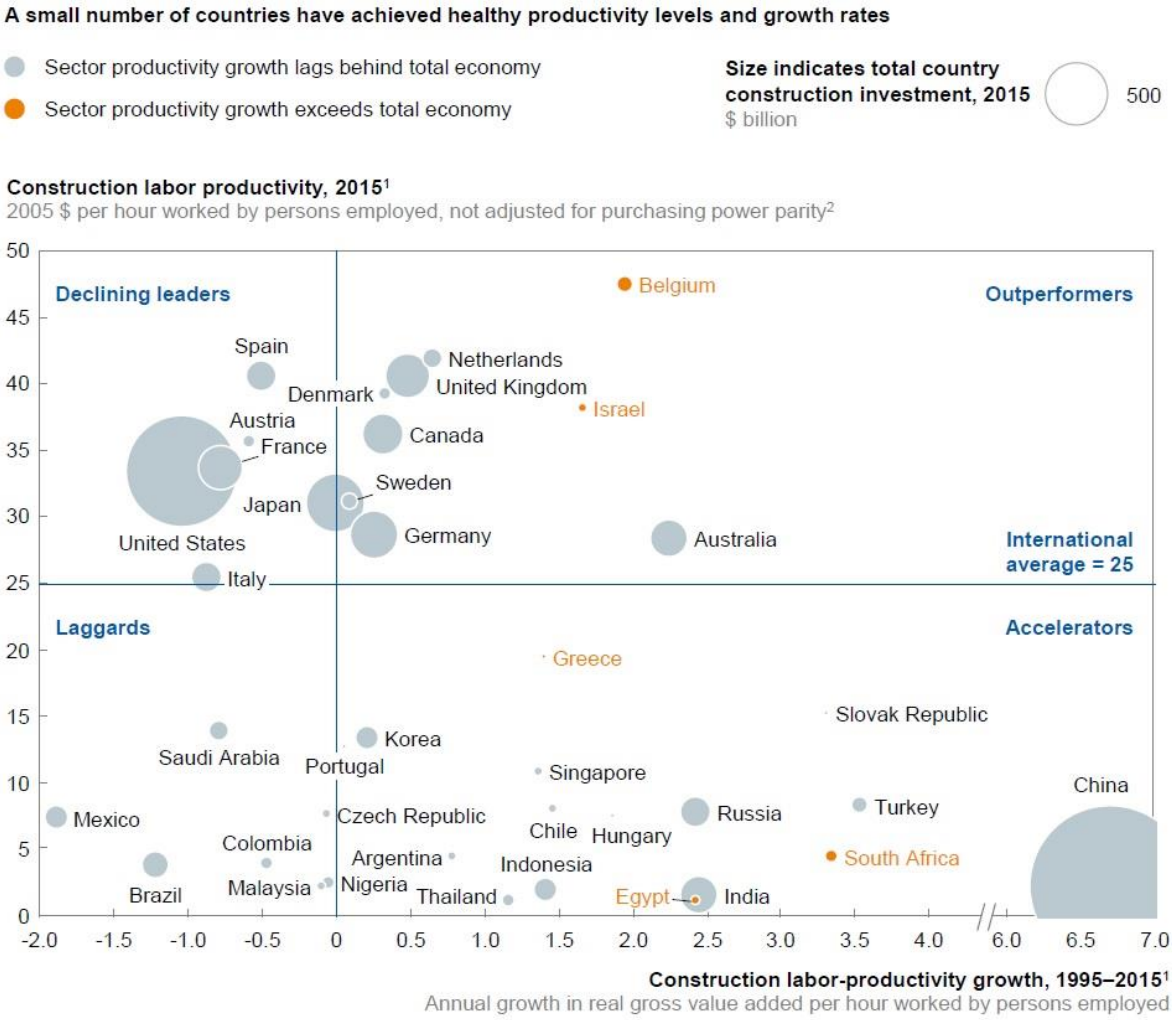


Fig 29: Construction labour productivity growth rates
Source: McKinsey Global Institute (2017).

For the external factors, there are many drivers that have been communicated by professionals. First and most importantly, the increased competitive markets that force developers to innovate and contractors to adopt modern methods of construction. Second, the change of stakeholders and/or developers interests upon the variant market demands, which require construction companies in Egypt to change their directions and business plans to cope with the growing new trends. Third, the media reports on success factors of other fellow organizations which promote for different management operation styles. Fourth, newly issued laws and regulations which may impose instructions that drift the current direction. Fifth, unexpected economic crises that result in currency fluctuation and market instability.

3. What are the limitations of implementing modern methods of construction (MMCs) in the Egyptian market industry?

In this regard, most of the professionals agreed on a few factors that limit the adoption of MMCs in Egypt and seconded it with specific market-related examples. The author has grouped them under five major elements.

- Mindset of the industry referring to cultural problems

The majority of MMCs forms are basically imported and new to the Egyptian market, and they have recently been considered as alternatives to conventional methods of construction, which clarifies the reason behind the lack of innovation incentives from companies to MMCs. Furthermore, offsite construction frequently requires effective communication and collaboration between all parties involved throughout the whole project to guarantee that deliverables are manufactured on time and as requested. Nevertheless, the fragmented nature of construction sector makes it more difficult for collaborating effectively and standardizing MMCs designs

- The less tolerance between factory-based components and on-site assembled

In traditional methods of construction there is a chance to step back in the design phase and make modifications. However, in the MMCs once the components are issued for manufacturing, there is no chance for modifications, and any design changes occur afterwards may influence how these different modules will fit in together on site. Therefore, the MMCs appear to be not suitable for late design changes due to their inflexibility.

- Transportation and logistics issues

Most of the modules and components of MMCs are large in size, which requires special treatment in shipping, loading and unloading, storage, and assembly. In addition to that, transportation to distant areas may still be a challenge and an expensive option due to the poor infrastructure road networks. Furthermore, craning limitations in terms of height and weight, which may slow down the assembly process. Therefore, the emphasis on this point was on site-specific constraints, like access, transportation, and space limitations.

- Relatively fewer codes and standards available

Since MMCs are still considered recent innovations worldwide, there are relatively lesser codes and standards available for them. And accordingly, there is a lack in their quality assessment tools and evaluation, and a standardized code is yet to be developed, which continues to be a challenge for industry authority bodies to include them in their future planning regulation. Furthermore, these reasons clarify the limited market demand, and the unwillingness of manufacturers and suppliers to innovate or change to MMCs.

- Lack of experience and shortage of skilled labors

The manufacturing of MMCs modules at the factory and precisely assembling them on site requires high level of skilled labor. And the fact that MMCs are recent innovations to the Egyptian market represents a challenge in adopting them. Moreover, since industry professionals and skilled labors have not been exposed to MMCs before, they have little to no experience in working with them.

4. What are the critical factors contributing to an efficient implementation of change management processes to (MMCs) in Egypt?

First and foremost, all professionals in this context agreed on the necessity of establishing appropriate communication channels between individuals, teams and stakeholders, in which the objective of the desired change is clearly communicated to everyone and linked to the organization's vision of innovation and business plan. Further in this regard, the question of "what is it for me?" has to be answered. Second, planning the change with measurable milestones and benchmarks, which has been broken down by Abdelrahman Afify during his interview into 5 steps (refer to chapter 4.1.3 Discussions). Third, assigning a proper budget for training and development, which would allow the company to invest time and money without waiting for an instant returns, to overcome the shortage of skilled labors in the MMCs field. Fourth, recruiting change agents to lead, guide and facilitate the transition phase barriers. Those change agents have to powerful in terms of; titles, expertise, relationships, business knowledge, and reputation, as per emphasized by professionals and supported by (Kotter, 1995a).

5. What could be the possible risks (threats) of adopting modern methods of construction (MMCs) in the Egyptian market industry?

In this regard, the risks in terms of threats have been analyzed, with all market-related views from the industry. The risks are listed below in solid points with further explanation:

- The lack of quality assessment tools and evaluation

The relatively fewer codes and standards existing for modularized components makes the quality assessment and accreditation for such elements a hard task, which may result in some challenges in convincing the authorities to implement. Furthermore, the suspicion of meeting clients' expectations. However, this is recently getting better after MBI's agreement with the ICC in 2017 to work on guidelines and standards for the modular industry. But a code is yet to be developed.

- The potential higher overall cost compared to traditional methods of construction

There is still a debate about the potential advantages of MMCs in terms of cost. And the argument is that at the beginning, a factory needs to be established, buy or rent the machinery, purchase all the relevant materials, build the system and train skilled labors on these methods. And considering a fluctuating market demand in Egypt, manufacturers tend to raise the prices to cover their overheads and pay their labors. On the other hand, in traditional methods, overheads occur only when construction takes place.

- The perception of quality standards

While many modules and components of MMCs are relatively light in weight, this might lead to the classic assumption that they are less durable, lower in quality, and may require regular repair or renovation.

- The poor infrastructure networks in Egypt

The poor infrastructure networks in Egypt in terms of cyber security, firewalls, and data transfer continues to be a challenge, which represents a remarkable amount of fear integrating bigger percent of IT in the construction sector, particularly in the distant areas and the new cities built. After all, considering the mindset of the industry in Egypt, many manufacturers and suppliers become reluctant to digital transformation, modular construction and offsite technologies.

6. What could be the possible opportunities/returns of adopting modern methods of construction (MMCs) in the Egyptian market industry?

There are many practical benefits that have been analyzed in this regard, with all market-related examples from the industry. The opportunities are listed below in solid points with further explanation:

- Time saving

Time saving was one of the most frequently mentioned benefits among professionals of applying MMCs, and that is because of its considerable financial payback. However, the main reason behind the time saving is the ability to perform work simultaneously for manufactured offsite components and onsite cast-in-situ as well. For example, casting the foundation onsite while preparing for the superstructure elements at the factory. Furthermore, enhancing the coordination amongst different site departments, and less setup onsite, such as scaffolding, is barely occurring, which their assembly freezes time.

It is worth mentioning at that point that due to the extensive planning and design freeze at the beginning while coordinating the use of prefabricated and modular elements, that contractors showed more interest than consultants, since they are more likely to experience schedule benefits as their involvement comes later in the project lifecycle. On the other side, consultants showed some concerns about the time freeze as their involvement occurs early in the conceptual design phase. To conclude, the time saved on site covers that freeze and reduces the overall project duration, which was supported by (McGraw Hill Construction, 2011).

- Cost benefits

Time saving will evidently bring cost benefits in terms of saving in the indirect cost finishing the project earlier than planned. But there are few other reasons for making cost saving than the one in indirect. First, the ability to optimize resources and facilities in the construction site. Second, switching the construction to factory-based controls the process, reduces the reliance on site labors, and lowers the error margin, which in turns has a significant impact on waste reduction and reduces the amount of rework on site. Third, modular and prefabricated components are well-known by their guaranteed budget. The fact that change orders are more likely to happen with traditional

methods in construction than factory-based components. As once they are issued for manufacturing after the design phase, there is no chance to modify.

While there is still a debate about the MMCs if they are bringing cost benefits or not, because of their high initial cost from establishing the factory, buy or rent the machinery, purchase the relevant materials, build the system, and train skilled labors, the point of guaranteeing the budget appears to attract many clients particularly those with tight budgets like the public sector in Egypt, claiming that while it seems to be slightly more expensive from outside, avoiding sudden costs during the operations is entirely of great value.

- Quality and safety improvement

From a quality standpoint, even those who do not see a persuasive cost advantage to prefabrication/modularization frequently choose to employ it due to its consistent quality. In factory conditions, each manufactured component goes through extensive quality control checks and inspections. Prefabricated concrete, for instance, can prevent the flaws that are typically observed in cast-in-situ concrete, such as cracks and colour change. Furthermore, the ability to fabricate in factory-based environment rather than on ladders setup or scaffolding reduces the manufactured element exposure to the outside environmental conditions, which in turns enhances the quality.

From a safety standpoint, which continues to be a challenge in the construction field, offsite construction offers many advantages to the safety issue. First, the MMCs components are primarily factory-based manufactured, and in factory safety regulations are carefully monitored. Second, the less interaction from the human factor, the safer it is throughout the production pipeline. Third, the reduced need for workers on heights, such as ladders or scaffolding. Also, avoiding working in less accessible areas and tight spaces. On the other hand, another opposing argument about safety improvement while implementing MMCs is that prefabricated modules are usually of a size that require careful installation techniques to prevent negative impacts on overall site safety.

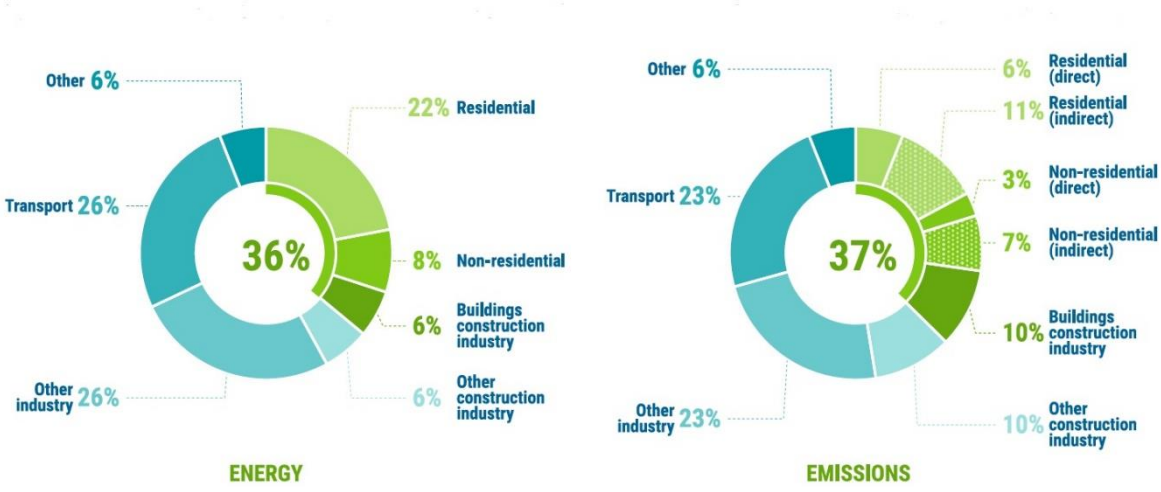
- Green objectives

The construction sector has a remarkable influence on the environment. As per (Fig 30), the construction industry contributed to 36% of the global energy demand and 37% of energy-related CO2 emissions in 2021. Those buildings emissions have to be reduced along the lifecycle of the project to achieve a complete decarbonized

environment by 2050, as per Paris Agreement (UNEP, 2021). One of the most common methodologies to achieve decarbonization in the building environment is named triple strategy, which basically states three stages of improvement towards a sustainable industry with zero carbon emissions:

- First, reducing energy demand.
- Second, decarbonizing the power supply (for example, through electrification), which is shifting the operations demands from the use of fossil fuels such as oil, coal, and natural gas to operations that depend on electricity as a renewable source of energy.
- Third, addressing embodied carbon stored in building materials.

Industry professionals in this regard claim that by addressing the first two stages, it could be possible to nearly achieve zero-carbon solutions in the building environment by 2050 (UNEP, 2021). Taking this into practice, MMCs contribute a lot to greener building objectives, most significantly in terms of waste reduction and energy efficiency, which addresses the first two phases of the triple strategy. First, factory conditions ensure the processes are clean from the first line production due to the extensive monitoring and control. Further, the digital transformation in inventory, procurement and materials tracking system helps in optimizing the resources required. Second, the insulation benefits. Conventional methods of construction in Egypt brought poorly heat-isolated buildings, which consume a lot of energy during summer times to cool them. Third, the ability to implement electrification. In site based conditions, the count is mostly on fossil fuel sources of energy such as oil, coal, or natural gas. However, in factory-based environment, there is a chance to shift to electricity as a renewable source of energy.

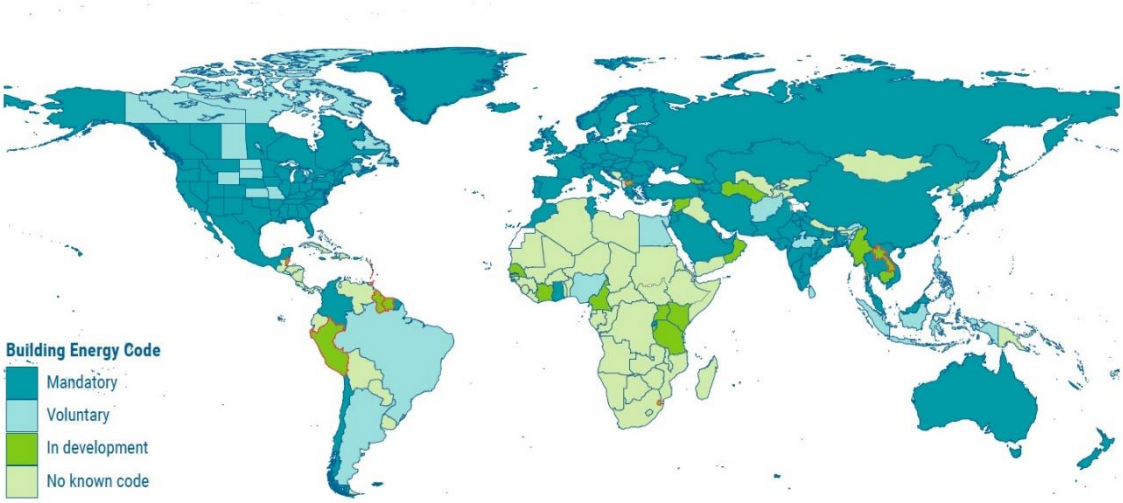


Note: "Buildings construction industry" is the portion (estimated) of overall industry devoted to manufacturing building construction materials such as steel, cement and glass. Indirect emissions are emissions from power generation for electricity and commercial heat.

Source: IEA 2021a. All rights reserved. Adapted from "Tracking Clean Energy Progress"

Fig 30: The construction sector share of global energy and emissions
Source: taken from UNEP (2021).

As per (Fig 31), which shows the coverage of building codes worldwide, 80 countries had mandatory or voluntary building energy codes, in which 43 countries had mandatory codes. Fig 31 also shows that there is a lack of implementation in South America and Africa, while Europe and US have the most coverage of mandatory codes. In this regard, it is worth mentioning that in 2018, Egypt with 4 other countries from Africa were the early implementers of the energy building codes between voluntary and mandatory application (UNEP, 2021).



Note: This map is without prejudice to the status of or the sovereignty over any territory, to the delimitation of international frontiers and boundaries, and to the name of any territory, city, or area. Recent updates are highlighted with a red border. Building energy codes relating to specific cities only are not shown.

Source: IEA 2021d. All rights reserved.

Fig 31: Building energy codes worldwide
Source: taken from UNEP (2021).

- Decision making enhancement

In today's data-driven world, the evolution and survival of a company is measured by how much informative data can they gather about a given subject. These data can be in various forms; could be numbers, figures, shapes, or dimensional modules. The modular building industry allows us to see extra details about the building in dimensional views, which in turns adds to our data wealth about visualizing the building before, and remarkably enhances our decision making. Furthermore, the digitalized inventory system included in the MMCs, which tracks the material consumption and monitors their assignment with real-time updates, helps us work better towards optimizing our resources and also enhances our decision making.

7. How do you see change management models for adopting MMCs? Are they applicable to be implemented in Egypt?

While most of the professionals in the industry were familiar with the change management models concept and agreed to a significant extent that they are beneficial, they all emphasized that the sequential implementation of them as they are is challenging. They have to be tailored according to what is suitable for each organization. In fact,

the real advantages of change management models can be achieved by customizing a framework upon the sensitivity of local environments. And in this regard, inputs have to be redefined. On the other hand, while these models were developed on a global spectrum, they spot the light on issues that deeply hinder change and could be taken as strategic framework guiding the change efforts. At the end, the models mentioned in the literature can be used as a tool rather than a rigid template to follow.

It is important in this regard to mention about the change performance curve (Fig 32), which addresses peoples' perceptions when they experience change. The curve mentions five major stages that people go through during the change process. The first stage is shock, which happens due to the lack of knowledge when change is first introduced. The second stage is denial which happens right after shock. When people cannot accept the fact that change is being introduced, they ignore it. The third stage is frustration which happens when people feel challenged with the introduced technology. At that stage, a lot of facilitation is needed to reduce the disruption time spent there. The fourth stage is experiment which occurs when people realize they are now part of the change and have to experience it themselves. The fifth stage is integration, when people feel the positive output of change, they start to integrate into it. Understanding these performance issues over time helps communicating the change objective and be ready to react upon.

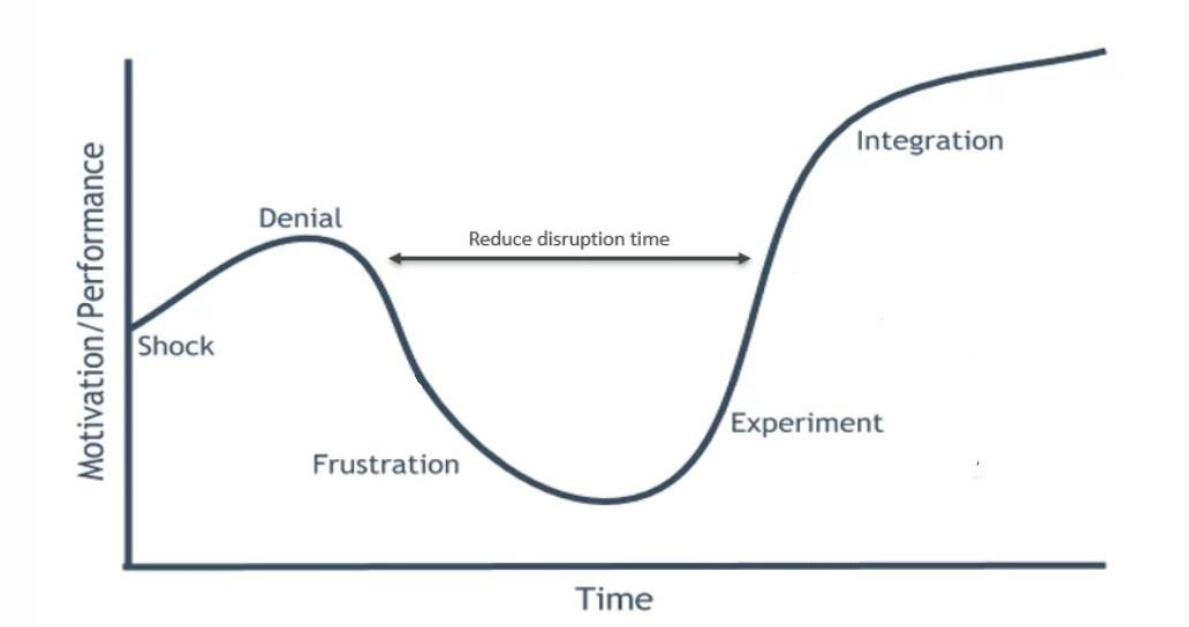


Fig 32: The change performance curve
Source: design by the author

4.2 Case Study: The Student Residence Hall at Queens College

The summit is a student residence hall located in the heart of Queens College Campus in New York City. The project is a 6-story height with 17,000 sqm construction area that is designed to accommodate 500 students. The project made substantial use of prefabrication, including innovative load-bearing external walls system to deliver a high quality student housing in the heart of New York on time and on budget achieving remarkable green objectives. Tab. 2 presents the project's key facts and figures.

Project Name	The Summit
Owner	QUNY Queens College
Developer	Capstone
Architects	Goshow Architects
Construction Manager	Nickel & Associates
Structural Engineer	WSP Cantor Seinuk
Load-bearing wall contractor	Island International Fabricators
Construction cost	58 Million USD
Size	17,000 sqm
Started	June 2008
Completed	August 2009

Tab. 2: Project key facts and figures

4.2.1 The decision to innovate

While the budget was a concern in the project, it was the 16-month tight building timeframe that promoted for the use of prefabrication. In addition to the tight schedule of the completion date, there were some challenges in the site logistics. The design team had to place a garage underneath the building. Therefore, the design and construction teams started to think of alternatives to speed up the construction on site. After analysis, they came up with prefabrication as a possible solution.

The prefabrication solution was basically implemented in two aspects. The first was the prefabricated concrete floor shells, which was quite common practice. The second was the lightweight, load-bearing external walls. The system contains wall sections

that approximately measure 10 meters. Each factory component included a metal stud, manufactured glazing sticked, exterior skin, insulation and air barriers. Construction progress and installation details are clarified in (Fig 33). For the system to work efficiently in a student residence multistorey hall, it had to be lightweight, so that it serves the site logistics and could be easily transported. This objective prompted the adoption of lightweight, high-strength metal studs in the panels. Moreover, the building's major exterior finish consisted of one-inch split tile bricks rather than the standard four-inch face brick, which remarkably decreased the overall weight of the walls (McGraw Hill Construction, 2011).

Fig 33: Construction progress on load-bearing wall section including glazing
Source: McGraw Hill Construction (2011) – Combined by the author.

4.2.2 Construction timeline

Everyone in the team credited the early research they did at the beginning. While the early research helped in establishing an efficient system and minimized the design modifications further in the construction phase, it also influenced the owner and developer to buy-in, for a critical tight schedule like this project (McGraw Hill Construction, 2011). The structural team considered different alternatives for systems that could speed up the construction in order to meet the tight schedule. In this regard, composite system of steel framed and cast in place concrete, metal studs and load bearing walls, and plank system of steel frames and panel boards were studied but none of them were able to fully satisfy the schedule and budget requirements.

At the end, the structural team decided on prefabrication and panelized load bearing wall system. One concern that faced the project team in the decision of prefabrication is the capacity of manufacturer or supplier; if the prefabricator is able to manufacture enough panels on time. The design team visited numerous prefabrication factories prior to committing to this methodology. They finally decided on “Island International Fabricators”, the load-bearing wall contractor, and began to collaborate with them on the manufacturing of the walls. Goshow Architects emphasized on the significance of involving the manufacturer early at the design stage, even before they are formally awarded. Fabricators were willing to collaborate (McGraw Hill Construction, 2011).

4.2.3 Prefabrication gains

Time saving

The project manager at the construction management firm (Nickel & Associates) reported the output of the innovative system of using prefabrication with load-bearing walls system that “we were able to establish the skeleton of 6-storey height building of 17,000 sqm in less than 4 months from January to April during winter”. The architects from Goshow estimate that this solution saved approximately six months of construction time (McGraw Hill Construction, 2011). Two reasons contributed to the time saving; first, finishing the skeleton as early as possible gave some room to interior works such as finishings and gypsum boards to start with much more efficiency. Second, the staging concept of prefabrication enabled working on several sections simultaneously, which contributed to significant time saving.

Resource optimization

One of the major advantages of the system was using fewer resources onsite. The main reason for this was that the system was designed and built that the bricks as well as the glazing are sticked to the prefabricated concrete wall in factory, instead of laid on site, as shown in (Fig 33), which led to the decision that less scaffolding is required (McGraw Hill Construction, 2011). In addition to that, only one crane was needed for the whole project, as per reported by the construction manager (Nickel & Associates). These two factors resulted in time, cost, and safety improvements.

Green objectives

The sustainability director at Goshow Architects reported some green objectives resulted in the use of prefabrication. First, minimizing waste, the fact that any metal studs or gypsum board panels that are left over can be used by the factory for another project. Second, less raw materials used. The choice of using the split tile brick, which is lighter, instead of the face brick, meant less utilization of raw materials. Furthermore, it served the dimensions needed. Third, energy efficiency, the fact that large manufactured prefabricated components have fewer joints that require sealing on site.

Quality

Many quality advantages were observed during the construction and after the final delivery of the project. First, the structural design team at WSP Cantor Seinuk reported that placing the load-bearing metal studs in the prefabricated panels minimized the deflection and accordingly served the structural system. Second, Capstone, the development firm, reported experiencing consistency across the entire structure, that they would not otherwise see with conventional methods of construction. And that is due to the extensive quality control checks at the factory. At the end, the owner (QUNY Queens College), further emphasized on the consistency of the building, referring to less imperfections were found in floor slabs and wall panels, which are typical in cast in place (McGraw Hill Construction, 2011).

5. Conclusion

Change is not an event. It is a project, that takes time. Therefore, the attempts to impose linear sequential steps of planned actions are not sufficiently valid in a dynamic industry like construction. Further, the hopes of ultimately being able to standardize a way or a practice to manage a transition phase may not achieve the change desirable results. In reality, transformation attempts are chaotic and full of unexpected outcomes. But in the same way that a relatively simple vision may guide individuals through a major change, it can also lower the error margin.

The calls to adopt “new methods of working” are somehow naive and relatively simplistic if they fail to acknowledge and account for adding value. The change towards MMCs proved to bring productivity benefits in key project aspects. First, the time saving, being able to perform the work simultaneously for manufactured offsite components and onsite cast-in-situ as well. Second, the budget gains, being able to optimize resources and facilities in the construction site. Also, reduce the reliance on site labors and lower the error margin, which has a significant impact on waste reduction and reducing the amount of rework on site. Third, enhancing quality, the fact that each manufactured component goes through extensive quality control checks and inspections. Fourth, improving safety operations, since MMCs components are primarily factory-based manufactured, in which safety regulations are carefully monitored. In addition to the reduced need for workers on heights, such as ladders or scaffolding. Finally, MMCs are found to contribute a lot to greener building objectives, most significantly in terms of waste reduction and energy efficiency, which address the first two phases of the triple strategy for decarbonizing the built environment.

At the end, while MMCs and particularly offsite construction technologies proved to bring positive returns in terms of time, quality, and safety. Further, its significant contribution to having greener building practices, yet in the meantime, their implementation in Egypt continues to be a challenge due to factors instilled in the culture that slow down innovation. Most of which are the poor infrastructure networks, logistics and transportation issues, the dominance of the public sector, the fragmented nature of construction, and the limited market demands, which justify the unwillingness of manufacturers and suppliers to innovate or change to MMCs, and also clarify the belief of perceiving MMCs as a more expensive solution. However, positive actions are being

taken in this regard recently, and few guidelines can accelerate the adoption of MMCs in Egypt.

- Financial payback orientation

Setting benchmarks and communicating how an innovative technology or a new system will enhance operations through positive returns on time, cost, and quality is the most efficient way to build a convincing case for implementation.

- Simple and intuitive solutions

To encourage utilization, user interfaces must be “foreman-friendly” at the front end to attract clients with old school practices such as those in the public sector. In this regard, the emphasis on training and development is essential.

- Risk sharing among industry players

Habits are hard to break, and one instilled habit in the construction contracts in Egypt is viewing them as competitive chances to transfer risk. Rather, contracts should be viewed as means that enable fair distribution of risks and returns among involved parties. This will occur if contracts adequately define responsibilities and fairly allow owners, consultants and contractors to share the advantages resulting from the use of an innovative technology.

- Enhance the academic curriculum

The majority of engineering graduates have not been exposed to offsite construction technologies in their academic curriculum. They have not had courses on innovative technologies such as modular construction and the ability to complete a structure fully off-site. Therefore, enhancing the academic curriculum to include innovative technologies such as MMCs, incorporate them in a practical manner, study their potential and associated limitations would be of great value.

- Industry authority bodies support

Industry professionals and authorized bodies shall invest in innovative incentives. They can collaborate with owners, contractors, consultants and all technology pioneers in the industry to create new frameworks for emerging technologies, and develop pilot projects with potential innovation leads in the market. They may also provide rewards, or even financial support to encourage several industry players to adopt digital solutions and assist them in educating and training the following generation.

- Change management

Construction industry firms need to adopt a change management narrative. Senior management must clearly communicate the change objectives to individuals, teams, and the group, and how these objectives serve the benefits of everyone. Companies that do not invest in the research and development of managing change will experience the same resistance encountered during earlier attempts of technology adoption. And they are more likely to fail.

6. Recommendations

6.1 Recommendations for industry professionals

The aim of this chapter is to formulate strategic recommendations and guidelines for different industry players to adopt MMCs. The recommendations address issues related to motivations and interests of each industry player.

Clients

While the owner demands are the fundamental driver for architects and engineers to innovate and include modular construction and offsite technologies into their designs, the main emphasis is placed on them to consider adopting prefabrication and modularization in their projects. Clients are more likely to gain the benefits from MMCs throughout the project life cycle. The accuracy and quality provided within the offsite technologies and manufactured components offer remarkable productivity gains. One thing that appeals of value to most of the clients is having a guaranteed budget for offsite manufactured components, which avoids the risk of unexpected costs during operations.

Consultants

For architects, understand the potential key advantages of prefabrication and modularization and educate the client on them. As the first point of contact with the owner, the architect has the most influence on choosing whether MMCs will be implemented or not during the conceptual design phase. It is important to mention here that architects have to communicate the benefits in a clients' language mentioning the productivity gains in terms of schedule, budget, quality, safety and energy efficiency. Moreover, once the clients buy in, make sure to incorporate offsite manufacturing into the early design phase. The earlier the decision made on using prefabricated components, the greater it is for maximizing benefits. The primary reason contractors raise for not utilizing MMCs is that the architects did not include it early in the design phase.

As for engineers, being the experts mainly accountable for systems efficiency during the design and construction, they should assess the validity of using manufactured components based on project type and conditions. A wide range of engineering firms prefer to implement prefabricated/modular parts in superstructure elements, external

walls, and roofs. And they view it as great alternatives from traditional methods of construction.

Contractors

While contractors are more likely to experience the MMCs gains, it is highly recommended to include prefabrication and modular construction in their tendering and bidding plans. The research shows that contractors are more likely to experience the project schedule and budget gains, since their involvement comes later in the project. So, they avoid the risk of time freeze at the beginning while making the decisions in the design phase. Furthermore, the promotion for the green factor. It is evident that modular building and prefabrication contribute a lot in waste reduction and lead to a greener construction site. The fact that offsite manufacturing can assist in achieving green targets and accelerate the way towards a sustainable industry should be emphasized in bids.

Manufacturers

With the increasing competitive markets around the world, there is an innovation call for survival and evolving. And in this regard, manufacturers can promote for the green benefits of MMCs and link it to the project lifecycle, offering alternative gains to schedule, budget and quality. Although the majority of contractors and consultants do not embrace the modular and prefabricated components as a key method for achieving green building targets, all industry professionals agree that these procedures are energy efficient and minimize waste. Manufacturers must raise the awareness of these eco-friendly advantages.

6.2 Recommendations for future research

Future research may investigate more on specific stakeholders interests from the construction project lifecycle. Meaning that focus on one industry player; client, contractor, consultant, or manufacturer, and understand their motivations and interests in adopting MMCs. Furthermore, dig deeper in project specific conditions such as project delivery system, types of contract awarding, procurement method, the integration between onsite and offsite operations, digital potential adoption, and barriers to limited market shares in order to understand how likely these factors can affect the adoption and implementation of MMCs.

Another recommendation for future research is the promotion for the green aspect of MMCs and its financial payback throughout the project lifecycle. While this research has shed some light on the green benefits of adopting MMCs in terms of waste reduction and energy efficiency, future research may focus more on the energy emissions sources and carbon footprint of shifting the industry from conventional methods of construction to MMCs, systems thinking, and how does implementing the triple strategy for decarbonizing contribute to a sustainable industry.

Declaration of Authorship

I, Mina Sadeek, hereby declare that the attached master's thesis was completed independently and without the prohibited assistance of third parties, and that no sources or assistance were used other than those listed. All passages whose content or wording originates from another publication have been marked as such. Neither this thesis nor any variant of it has previously been submitted to an examining authority or published.

Berlin, 04.07.2022

Location, Date

Signature of the student

Appendix

Appendix A

Interviewees details (with their consent to share).

	Name	Title	Personal Email
1	Mohammad Yousry	Project Manager	mohammad.youssry13@gmail.com
2	Ahmed Mohey	Budget and Cost Control Manager	eng_ahmed.mohey@hotmail.com
3	Abdelrahman Afify	Senior Projects Control Manager	eng.afify@yahoo.com
4	Mohammad Abdelaziz	Co-Founder of NCGC Contracting (Ex. Quality Control Manager)	muhammadeliwah@gmail.com
5	Michel Saad	Technical Office Manager	michel_adel@live.com

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