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Exploring the use of Contemporary Methods of Construction in the Ghanaian Construction Industry.

BY

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(Bsc. Construction Technology and Management)

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DECLARATION

I hereby declare that, this thesis submission is my own work towards the MSc. Project Management and that to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the university except where due acknowledgement has been made in the text.

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ABSTRACT

Contemporary construction involves the process of preparation, scheming, manufacturing, moving and assembling building elements for fast site assembly. Although the use of contemporary methods of construction provides several significant advantages and it can help solve problems associated with duration of work, quality and further reduce cost when compared to 'traditional construction' which is widely practiced in the Ghanaian construction industry. In an attempt to address this issues, a study was carried out to help simplify the Ghanaian construction industry's' perception on contemporary construction methods and establish how it would help improve real estate development industry. To achieve this aim, the objectives were; to identify the extent of awareness of contemporary methods of construction, identify the challenges associated with the implementation of these methods of construction and identify strategies needed to alleviate the challenges inhabiting the implementation of these methods to resolve social housing needs in Ghana. The study was positioned in the positivist paradigm which enabled the researcher to make an objective analysis by using the quantitative research strategy which involved a questionnaire survey. A sum total of One hundred and fifty (150) questionnaires were administered and One hundred and twenty (120) responses were retrieved from Project managers, Quantity surveyors, Architects, suppliers and manufacturers of off-site produced building components and Site Engineers all from construction related firms in Accra and Kumasi. The data was then statistically analysed and found that contemporary methods of construction reduce material waste, improves product quality, improves safety on site, increases profits and helps reduce construction duration. The challenges that were dominant were transportation restraints, the rigid nature inhibiting changes on site and restricted design options. Recommendations such as; forums and teachings about the changing and the use of construction methods should be held periodically for building practitioners in major firms. Comparative value analysis should be done for both traditional and contemporary methods of construction especially on cost for the clients' consideration.

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DEDICATION

This dissertation is dedicated to God Almighty, my entire family and my friends for their immense support throughout the period of this study.

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CHAPTER ONE

GENERAL INTRODUCTION

1.1 RESEARCH BACKGROUND

In numerous reports and studies of Habitat's UN, it was highlighted that rapid development is complemented by worse accommodation problems. Cities are unreasonably growing to the rates of economic improvement thus increasing the differences between the rich and the poor. Cities with population of over three (3) million are the symbols of our period, but, inappropriately, they ordinarily do not mean such perceptions as comfortable living environment, the same prospects for all populace and many more. These cities face problems as unplanned development, slums and urban sprawl. The Ghanaian statistics in 2005 stated that, most habitant of a city lived in hostile conditions. It is required to construct a total of about 35 million apartments a year to satisfy the world needs in housing (approximately ninety-five thousand apartments a day) (Gray, 2009).

The housing minister of the United Kingdom at 2004 was quoted saying contemporary method of construction is a key component in stepping up the housing and construction sector but, the construction industry was in a large extent very slow to make full use of the technology (Roskrow, 2004). Barker's Review (2003) proposed that offsite construction technologies could help improve the high quality of construction and help address skills shortage in the industry. Contemporary methods of construction (CMC) is a term used to describe a number of innovations in building construction, most of which are offsite technologies, thus moving the construction sites to the factories (Gibb, 1999). Although there are many issues that have been raised, many studies have neglected the issues and are rather promoting its application overlooking the supply chain and its relevant associations. (*Roy et al.,* 2003). There is a gap in the understanding of the whole nature of how contemporary methods of construction are set up to help the construction industry. (Pan *et al.,* 2004). This study aims at exploring the use of contemporary methods of construction in Ghanaian construction industry. The contemporary methods of construction, offers significantly high opportunity for increasing the delivery of housing and possibly reduce cost, thereby potentially slowing house price inflation. It again decrease construction time, reduce whole life cost, increase quality through minisation of onsite operations and duration, less congestion on site, improve health and safety along with increased sustainability are by documented as the most distinguished benefits of CMC (Engstrom *et al.,* 2009). With the increase in CMC, project participants are embracing the drive towards offsite production, which is the production of construction elements, components, modules and nearly complete buildings in the factory environments. The benefits of these automated formed components are that they also meet the building codes if not exceed them as compared to the traditional method of construction. Glass and Pepper (2006) mentioned in their publication that, the use of offsite construction technologies has often been a strategy to improve the overall performance of construction. Reduction of the negative impact was identified as another benefit if the contemporary method of construction is used (Venables *et al.,* 2004). Waste materials are reused in the factory premises or are further recycled for other use. Unlike in the traditional way of construction the waste is either buried. Also Hazardous waste are contained in factory premises whilst it is exposed on the traditional sites.

1.2 STATEMENT OF PROBLEM

The conventional methods of construction have failed to answer the current demand for construction due to low productivity, skilled labour shortage, unprofessional small developers, materials, defective management and many more. Numerous policies and strategies have been considered by the governments to confront this dilemma. The reports stated contemporary methods of construction as part of the solutions (Venables et al., 2004). The overall belief is that such methods can enhance the current situation and lead to a professional and dynamic construction industry.

A number of these have failed due to the lack of proper understanding of the Ghanaian situations, limitations and potentials. Edge et al. (2002) establish that construction practitioners are most strongly influenced by adverse perceptions of the post-war 'prefab' that, they will resist any innovations in building construction which affect what a 'traditional' building looks like. Human perception barriers, grounded in the historical disappointment of CMC practices, also exists among construction practitioners such as architects and other designers (Pan *et al.,* 2004). According to Gibbs et al. (2001) much research has been done in ways of incorporating CMC into the construction industry with the aim of improving the use of contemporary methods of construction in the Ghanaian construction.

1.3 RESEARCH AIM

The research aim was to explore the use of contemporary methods of construction in Ghanaian construction industry.

1.4 RESEARCH OBJECTIVES

To achieve the stated aim, the research focused on the following objectives:

1. To identify the extent of awareness of contemporary methods of construction in the real estate development industry of Ghana;
2. To identify the challenges associated with the implementation of contemporary method of construction in the real estate development industry in Ghana;
3. To identify the drivers for using contemporary methods of construction in the Ghanaian construction industry; and
4. To identify strategies needed to alleviate the challenges inhibiting the implementation of the contemporary methods of construction to resolve the social housing needs in Ghana.

1.5 SIGNIFICANCE OF STUDY

Even though when it comes to construction the reduction of waste and the ability to get quality materials is supposed to be the hallmark of all the construction practitioners', it is strange to find out most of them still rely on the tradition methods on construction. It is clear that any substantial increase in the rate of construction of new buildings by traditional methods would impose considerable tension on the real estate development industries which is having difficulty engaging sufficient skilled labour to meet present-day rates of construction. One means of increasing production without a corresponding increase in the demand for site labour is to move to contemporary construction (Barlow *et al.,* 2002). The contemporary method of construction in itself is designed to alleviate all these problems and help come out with the best quality of work. This study is concentrated on solving the factors which limits the use of contemporary methods in the construction industry, thus;

a. Construction Cost.

With offsite production materials wastage is reduced to its barest minimum especially during production because excess materials are reused for the next component unlike in traditional method of construction where it take days and time to move to the next stage.

b. Construction Time

Delivery of construction projects on time is one of the important factors every contractor looks at, as soon as the contract is awarded. Every time lost is a lot of money been wasted, which can never be gotten back.

Academia will also benefit since more knowledge will be brought to bear on the benefits of these contemporary methods and others will be motivated to investigate further into this field.

These findings and recommendations of the study would lead to initiatives aimed at solving the difficulties of using and implement contemporary methods of construction in the Ghanaian construction industry.

1.6 SCOPE OF THE STUDY

The scope of the research was limited to identified key stakeholders in the building industry of Ghana with precise mention to building practitioners'' consisting of Architects, general contractors (quantity surveyors, civil engineers and site engineers), Suppliers and Manufacturers of off-site produced building components and Real Estate developers. Geographically, this research was restricted to Greater Accra and Ashanti Regions in Ghana. This was due to proximity and rapid growth of real estate development in its environ to the researcher which made questionnaire retrieval easier.

1.7 RESEARCH METHODOLOGY

The preparatory nature of the study required the collecting of data with the purpose to explore the use of contemporary method of construction in the Ghanaian construction industry. The research therefore adopted the use of a questionnaire as a data collection instrument. This gave rise to the use quantitative research strategy, which employed the use of statistical techniques to identify facts and casual relationships. The selection of questionnaire as a data collection tool was influenced by the nature of the investigation and the type of study population (Kumar, 1999). The analysed results was presented in bar charts, pie charts or histogram form, with explanations in details regarding the data collected.

1.8 OUTLINE OF THE THESIS

The structure of this thesis has been divided into five separate chapters as follows:

Chapter one: Dealt with introduction, problem statement, research aims and objectives, research questions, scope of study, methodology, significant of the research, structure of the study.

Chapter two: This covered the literature review related to the subject matter, moreover the review would discover the relation between the related literature and the subject matter and attempt to link them.

Chapter three: This chapter has examined details of the methodology used in the research. Detailed discussions would be provided on the data collection tools that would be used.

Chapter four: This section covered analysis of data collected and answer all research questions and objectives.

Chapter five: This dealt with summary of findings of the study, conclusion and recommendation of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter analysed and discussed existing literature on various concepts and framework of contemporary methods of construction and to have a better understanding of the construction concept. It begun by highlighting the historical background of CMC and the industries perspective on the use of these contemporary methods. It also exhibited an exhaustive writing audit on the classification of CMC with its benefits and drivers to its adoptions. Furthermore, this section gave an accounts of a background investigation done by researchers on how CMC was applied in other European countries. The barriers, merits and demerits were not to be left out of this research because of the importance and relevance to this study. Insight and background knowledge obtained from the literature review assisted in understanding how contemporary methods of construction are been used in the Ghanaian construction industry.

2.2 BUILDING METHODS (FABRICATION ISSUES)

Generally, there have been three main building methods/approaches in terms of fabrication and the use of machinery and labour according to Riley and Howard (2002) and these include, traditional methods, post-traditional or conventional methods and rationalized and industrialized systems.

2.2.1 Traditional Methods

The traditional methods of construction are very slow and time-consuming. This is because building mechanisms are built from a few components to fit on site. Climate conditions and skilled labour accessibility that reduce the working ability continuously and to attain validity and precision are some factors that restrict the traditional approach. Such methods are so laboured exhaustive and demanding, however as a result of huge affiliated costs, now they are restricted to only a few exceptional building projects. In spite of the demerits mentioned, the traditional method, however, have some merits which may include the fact that they are greatly flexible to certify that all the components fit onsite. It is important to note that the demerits of traditional methods led to the conception of post-traditional or conventional methods of construction.

2.2.2 Post-Traditional Method

Post-traditional method is the combination of the traditionalistic approach with innovative skills, methods and equipment. One major difference of post-traditional methods from the traditional one is by the use of mechanical plants in such methods. In the post-traditional methods, the plants utilized are for mixing concrete, lifting the components, excavation, among others. These machinery forms a basic portion of the construction projects as a result of the scale of projects.

Moreover, in such methods in a traditional approach, prefabricated components are increasingly used in and thus the use of traditional workmanship like plastering and joinery for finishes.

2.2.3 Rationalised and Industrial Building Methods of Construction

These are other techniques used where producing companies are extremely engaged. This method does not essentially imply the use of application of factory-made building structures but rather the frequent use of existing techniques in an organized programmed way. The main use of this method is to reduce cost while attaining proper quality through the collaboration and engagement of designs and producing bodies in all the stages of construction. This, therefore, demands the continuation of the construction process by the organized utilization of the resources that can somewhat be attained by the proficient utilization of application of prefabricated elements and plant, that allow for a separate production from assembly thereby reducing the usage of labour on site.

According to Osburn (1997), choosing any of these methods of construction can be influenced by technology availability, building materials and expert designers. For instance, in a country like Iran, these factors are specifically salient as some of the mentioned necessities are hard to meet.

2.3 HISTORICAL REASONS FOR USING CONTEMPORARY METHODS OF CONSTRUCTION

Pertaining to world wars I and II, there was a post war shortage of materials accompanied by an inadequately skilled labour, which became essential to consider substitute construction methods to help solve the issues of housing. Subsequent regimes/governments provided generous funds to non-traditional system building techniques. Transformed drives to the utilization of system housing rose as a result of a combination of political and social pressures, to re-house the people who were displaced by the great slum clearances of the late 1950s and 1960s.

Over these periods, about over 4.5 million houses were constructed and manufactured, however, about 5% were developed using new schedules for development. The 1970s experienced a public response against pre-fabricated system buildings, predominantly due to eminent profile failures like the Ronan Point, East London gas explosion where a tower block collapsed completely due to an explosion in one floor (Burnett, 1978).

According to Palmer (2000), in 1982, timber frame was used to construct about 27% of all new houses in the UK. Nevertheless, a known investigative television programme 'World in Action' (1983), shattered the confidence of using timber frame in constructing houses. The greater part of houses were still customarily constructed as work and materials turned out to be less rare.

Moreover in Scotland, there was a demand to assemble new homes. Thus a demand that could not be accomplished using conventional building techniques fundamentally because of a deficiency of proper quality blocks, an absence of bricklayers and the increasing expenses of stone and slate. This constrained the need to assemble considerably more houses utilizing elective schedules for development contrasted with the south (Taylor, 2009). History appears to be recurring as the driving force following the application of CMC remain similar thus need for quicker construction, skilled labour shortage, extravagant demand, high costs of building and the need to curb them. Nonetheless, it now appears exceptionally hard for the UK regime to motivate the general public and developers to utilize CMC due to the memory of unsuccessful attempts formerly. Additionally, the high cost of CMC as likened with the traditional techniques stays a task facing architects and developers. These issues will be discussed in the following sections.

2.4 DEFINING CONTEMPORARY METHODS OF CONSTRUCTION (CMC)

CMC is a term that is used to identify a number of construction methods that differ from the ‘traditional’ method of construction. Other terms usually used include factory-built, off-site construction, prefabrication and industrialized or system building. Zurich, in a report, defined CMC as a constructional procedure that encompasses the usage of combined innovative and traditional materials and modules frequently with extended factory produced sub-assembly sections. Such may be an arrangement with induced on-site assembly techniques and often to the exception of a lot of the constructional industry traditional trades. The process consists of repair and extension of existing, new buildings and retrofitting. Chen (2010) argued that, CMC in the industry of construction has boosted productiveness and enhanced quality in addition to various benefits such as reduced construction time, enhanced quality, lower overall construction cost, better durability, improved architectural appearance, material conservation, improved occupational health and safety, a reduced amount of construction site waste, water consumption, less environmental emissions and reduction of energy. The National Audit Office reported that CMC are about improved products and processes. Thus they intend to enhance environmental performance, business effectiveness, quality customer satisfaction, sustainability and predictability of delivery timescales. CMC are, however, widely based to a greater extent than a specific focus on the product.

CMC involve people and process seeking out enhancement in the delivery and execution of construction. According to Burwood and Jess (2005), CMC provides an efficient product management process which delivers quality products within a short time. It can be classified in diverse ways which may require key services like plumbing, key items like foundations, internal shell like walls, outer walls, or any combination of the mentioned components. CMC can also be classified by materials like steel, timber, concrete and masonry. Warszawski (1999) also defined CMC as a set of elements or factors that are inter-related towards assisting the execution of construction works activities. He further explained that, CMC are an investment in equipment, facilities, and technology with the aim of maximizing production output, minimizing labour resource and enhancing quality.

Again, CMC may be identified as a method where concrete elements, prefabricated at the site or in the factory are gathered to build a structure with a minimal in situ construction (Trikha, 1999). Therefore, according to Barker (2006), CMC must be seen not as an end in itself, but as a means to attaining;

- Better business effectiveness;
- Improved design and quality;
- Enhanced customer satisfaction;
- Improved building performance;
- Better housing supply meeting the aspirations of the market wholly (open market, social and affordable);
- Sustainability and predictability of delivery timescales; and
- Improved environmental performance with reduced impact.

2.5 INDUSTRY PERSPECTIVES ON THE USE OF CONTEMPORARY METHOD OF CONSTRUCTION

A lot of studies have attempted to examine industry perspectives on the usage of offsite technologies conforming to the reports of Latham (1994) and Egan (1998). Edge *et al*., (2002) proposed that house purchasers are highly influenced by the negative perceptions of the post-war ‘prefab’ that, they will resist any construction in-house innovations which affect a replica of a ‘traditional’ house.

According to Pan *et al.,* (2004), the perception barrier of human beings, based in the historical failure of CMC (offsite practices), also is among architects and other designers. This is however linked with technical difficulties such as logistics, site specifics, interfacing issues; high costs (where there are no potential economies of scale) and the fragmentised system of the supply chain which curbs designers’ acceptance of contemporary methods of construction. In the social housing sector, Palmer *et al.,* (2003) proposed that there was a significant impact from architects, contractors/producers, developers, maintenance and implementers pertaining to the success of modern manufactured housing schemes as a result of their contribution towards the development procedure and their roles in the decision-making process. However, a recent study by Lusby-Taylor *et al.,* (2004) suggested that nothing proved a relationship between design quality and the utilization of CMC. Most of the schemes utilized CMC for reasons of speed although cost savings were required from using CMC. Others accounted on the fact that projects would cost more when built traditionally.

Additionally, in the financial market and insurance industry, a research by BRE Certification (2005), has identified increasing concerns over the usage of offsite technologies in housing. Various government-backed studies have discovered enablers and barriers of offsite innovation from a broader perspective of stakeholders'. The Housing Forum (2001) analysed the barriers to innovation that contractors, clients, developers and housebuilders, suppliers and consultants are facing on a daily basis in their organizations' working relationships and on site. The study provided commendations throughout aspects of culture, design and construction and the regulative environment and called for efforts from the whole supply chain. The Housing Forum (2002) investigated the utilization of off-site technologies and showed the related significance to a wide range of stakeholders including off-site fabricators, housebuilders and developers, lenders, suppliers, insurers, purchasers and surveyors. Even though these initiatives have provided the industry context of CCM applications, thorough investigations of housebuilders are however needed. Drawing on the results of interviews with 27 key players in both manufacturing and housing development, Venables *et al.,* (2004) proposed that, the intake of off-site manufacture is partially determined by the percept of developers regarding its merits and demerits; that are determined by their business models and procedures and partially by broader market and regulative factors.

Ross (2000), reviewed about 200 social housing organizations and about 100 builders/developers. He as well proposed that respective policies and drivers of the market were resulting an increment in CMC from dwellings. Entirely, these outcomes are mirrored in a recent cross-industry off-site market survey that states that the utilization of off-site technologies bring in benefits centered on increased quality and shorter on-site duration; but genuine or perceived additional cost comparing to traditional methods by clients and their advisors and long lead-in time act as the main barriers to utilize (Goodier and Gibb, 2004). The past study reviews into the utilization of off-site technologies in housing has disclosed a number of barriers to its take-up and various results. Such existing body of work has not discovered the percept of housebuilders. It is salient to give knowledge on the part of housebuilders regarding the utilization of CMC in that, the larger firms report on the vast majority of housing developments and thus are essential to the broader take-up of CMC in the future. This research has discovered how the benefits of such technologies and methods could be connected to bring about modification and enhancement in housing supply.

2.6 CLASSIFICATIONS OF CONTEMPORARY METHODS OF CONSTRUCTION

Studies of literature by respective authors (Waste and resource program, 2007), have been prepared following the classifications of CMC which are listed in table 2.1 below;

Table 2.1: Classification of CMC

	Systems	Components
Offsite Contemporary Methods of Construction	Volumetric Construction	Modular Construction
		Pod Construction
	Hybrid Construction	Semi-volumetric Construction
	Panelised Construction	Open Panels
		Closed Panels
		Structural Insulated Panels - SIPS
		Composite Non- structural Insulated Panels
		Prefabricated Parts
		Prefabricated Lightweight and Roof Panels
	Natural materials	Timber Frame construction
		Multi-layered Engineered Timber (Solid)
		Components from Renewable Materials
	Lightweight facades	Masonry block walls with timber frame
		Masonry block walls with metal frame
		The Ventilated Facade system
	Sub-Assemblies and Accessories Systems	Floor or Roof Cassettes
		Pre-cast concrete foundation assemblies
		Pre-assembled products
Onsite Contemporary Methods of Construction	Prefabricated auxiliary structures (site assembled)	Tunnel Form
		Stick Build Timber Frame
		Insulated Concrete Formwork (IFC)
		Thin Joint Blockwork / Clay Block
		Oak Framed Buildings
		Glulaminated Framed Building

2.6.1 Volumetric System

The factory produces three-dimensional units which are then conveyed to the site and attached together. The frames are usually timber, steel or concrete and can be supplied with all internal and external finishes (including services like electric and plumbing), or just the fundamental structure. Volumetric does not need a superstructure unlike pod construction. For instance student accommodation, fast food restaurants and hotels. According to Burwood *et al.,* (2005), volumetric construction (also called modular construction) consists of the off-site production of three-dimensional units. Quality controlled systems of production in the factory should be put in place and projected as part of any third party approval. Modules may be conveyed to site in different forms; ranging from a fundamental structural shell to one where all the internal and external finishes and services are already installed. In such system, about 85-90% of the procedure is completed in the factory (Burwood *et al.,* 2005).

According to Lender and Media (2010), one main merit of modular construction is, it is more cost effective than the traditional on-site building. Modular builders take advantage of economies of scale by building several similar pieces at once. They also get to work on smaller pieces of the building, decreasing the need to utilize ladders or scaffolding.

Finally, since the bulk of the construction and finishing work are done indoors, there's less risk of weather-related delays in construction which can cause labours' to sit idle waiting for the ability to work.

Volumetric construction consists of two components which include,

i. Modular Construction
ii. Pod Construction

2.6.1.1 Modular Construction

This is a term used to describe the utilization of factory-produced pre-engineered building units which are delivered to site and assembled as large volumetric components or as substantial elements of a building (Lawson *et. al.,* 2014). This can be seen in ***Appendix A, fig. 2.1 &2.2***

2.6.1.2 Pod Construction

Pods are normally non-structural and are usually used in a loadbearing structure. Pods were introduced into the construction market for hotels and student accommodation, even though their use in apartments and housing is increasing (Staib *et. al.,* 2013). The inclusion may be of steel frame, timber frame, concrete or composite constructions. The factory produced three-dimensional elements that are incorporated into the superstructure of a building. These are ready-made rooms that can be coerced together to make complete premises when setting within a light steel framework.

All the building services will typically be pre-installed with just the final link made on site. For instance, hotel bathrooms, kitchen units for accommodation blocks, among others. This can be seen in ***Appendix A, fig. 2.4***

2.6.2 Panelised System

Panelised systems include floors, walls, and roofs that are made from flat, pre-engineered panels and are assembled on site. Panelised systems may be structured into two main categories and thus open and closed systems. According to Burwood *et al.*, (2005); National Audit Office (2005); Ross (2005), in the open systems, structural components are sent to site where the rest of the work is done on site but in the closed systems which are more complicated and different, elements such as windows, doors, internal finishes, external cladding, insulation etc. can be fitted in factory.

2.6.2.1 Open Panels

Panels are transported to site where insulation, windows, services and linings are fitted. All structural components are visible. Panels may be structural (transmitting load to the foundations) or non-structural (utilized as non-loadbearing separating walls and partitions) (Ross, 2005). They are typically transported to the site mainly as a structural component with services, cladding, insulation and internal finishes installed in situ. This can be seen in ***Appendix A, fig. 2.5***

2.6.2.2 Closed Panels

These are panels based on a structural framing system (like the type used for open panel systems), that can have factory fitted windows, doors, services, internal wall finishes and external cladding. The inner structural elements can only be seen around the perimeter of the panel (Burwood *et al.*, 2005). Closed panels usually include more factory-based fabrication like lining materials and insulation and yet may include cladding, internal finishes, services, doors and windows. This can be seen in ***Appendix A, fig. 2.6***

2.6.2.3 Structural Insulated Panels (SIPS)

These are sandwich construction consisting of two layers of sheet material attached to a foam insulation core. They do not depend on internal studs for their structural performance. SIPS is utilized primarily as wall and roof panels. Structurally Insulated Panels (SIP‘s) consists of a structural core of insulation that is glue bonded along each face to a racking board. Materials for the board also differs directly with producers but are usually plywood, OSB or one of the new composite boards (Staib *et. al.,* 2013). This can be seen in ***Appendix A, fig. 2.7***

2.6.2.4 Composite panels:

These panels are made from the amalgamation of diverse materials that act together to provide structural support. Structural insulated panels are a specific form of a composite panel (Staib *et. al.,* 2013).

2.6.2.5 Concrete Panels:

Concrete panels are structural wall panels that may include cladding (usually bricks or brick slips), insulation materials, windows and doors.

2.6.3 Sub-Assemblies and Components

Sub-assemblies and components primarily include floor or roof cassettes and pre-cast foundations that are made in a factory (Burwood *et al.,* 2005; National Audit Office, 2005; Ross, 2005). Sub-assemblies and components in this category include;

- Pre-Fabricated Foundations: Series of pre-fabricated ground beams and other components assembled to form foundations quickly and accurately. This can be seen in ***Appendix A, fig. 2.9***
- Floor Cassettes: Pre-fabricated panels particularly designed for floor construction. Fewer man-hours on-site are required per square meter of the floor and decreased work at height has potential health and safety benefits. This can be seen in ***Appendix A, fig. 2.10***
- Roof Cassettes: Pre-fabricated panels particularly designed for pitched roofs. The panels are extremely stiff and are designed to leave the loft free of struts and props, permitting easy production of 'room in the roof' construction. Using roof cassettes permits the building to become watertight very quickly than with conventional trussed rafter or cut roof constructions. This can be seen in ***Appendix A, fig. 2.11***

- Pre-Assembled Roof Structure: Roofs gathered at ground level before constructing the shell of a dwelling. The roof can be craned into place as soon as the rest of the superstructure are in place, creating a weathertight structure very quickly than gathering the roof in situ. There are also health and safety benefits leading from the workforce not undertaking all the work at height. This can be seen in ***Appendix A, fig. 2.12***

2.7 BENEFITS OF CONTEMPORARY METHODS OF CONSTRUCTION

Many beneficial factors associated with CMC's, not only for the benefit of the client or country, but also for the main contractors, sub-contractors, local communities etc. Some of the main merits of using contemporary methods of construction include the following;

2.7.1 Reduced Waste and Better Waste Management

According to Jaillon (2009) waste stream can be managed easily as production is usually affected in a factory controlled environment. Particular quantities of materials can be bought, materials can be utilized more proficiently and however since the materials are properly stored, breakages and damage are less likely to occur. Again, un-used materials can be gathered easily, re-used or recycled leading to less waste. Waste reduction is a substantial merit, as waste from construction is one of the standard waste streams to landfills and it has been shown that a high percentage of materials transported to the site are never used and are sent straight into the waste cycle. Persistent monitoring also takes place in the production plants permitting new waste management strategies to be executed without difficulty, if necessary.

2.7.2 Increased Health & Safety:

Pan (2007) stated that, without doubt, construction works undertaken in a factory controlled environs is a safer working environment for all trades. Safety controls and policies are affected, examined and safe working conditions are easier to meet and maintain. On the use of contemporary methods of construction, there are substantial decreases in the number of trades working on site and this proves more manageable from a health and safety perspective. Construction works on the site can integrate some dangerous activities which can, in turn, result in a large number of causalities and/or fatal injuries. Amongst the largest number of fatal injuries between all the main industries in the world is construction.

2.7.3 Reduction in Defects and Increased Quality Control

Construction work opened to the components of wind and rain proves more difficult to supervise with regard to quality control. For instance, a building site, exposed entirely to a rainy and windy climate is not the exact perfect working environment for high-quality workmanship (Harris and McCaffer, 2013). Human-caused error is also another substantial factor that deters the attainment of high-quality construction as it can prove difficult to work in extreme weather conditions. Factory based constructions forms employ better and safer working conditions with no intrusion by climate and however, a tremendous standard of quality control can be attained that includes testing, trials, checks and re-checks (Harris and McCaffer, 2013). For more reasons than one, factory-based construction provides enhanced working conditions than a building site and in turn also produces improved quality.

2.7.4 Quicker On-Site Build Time/ Shorter Programmes/ Reduced Preliminaries:

It is possible to implement several activities of the project simultaneously or even before the project has begun on site as more of the work is removed from the site with CMC. This decreases the project's construction time since the building or components of the building can be manufactured off-site whereas the ground and site works are taking place. CMC results in the reduction of onsite trading and a shorter construction programmes that in turn results in decreased preliminaries, overheads and a quicker return on investment for the client (Jaillon, 2009).

2.7.5 Social Benefits and Reduced Local Impacts:

CMC's, specifically off-site construction, permits local communities to benefit from the process of producing away from the site. The key merit to communities is that, there are less traffic and smaller on-site workforces summing to traffic congestion in the area. Moreover, noise and pollution levels will reduce as a result of faster on-site programmes and the area surrounding the site will be disrupted for a far shorter period of time. Construction sites offer little or no amenities for the local communities as they are only temporary employment locations while manufacturing facilities usually provide long-term social services and economic benefits for the surrounding community (Morel *et. al.,* 2001). Also, manufacturing facilities are more likely to invest in education and training for their workforce and develop a highly trained local workforce in their facility.

2.7.6 Greater Efficiency in the Use of Resources and Transport:

For many years it has been noted that the use of labour, plant and materials on building sites is exceptionally ineffective as is not the case with factory based activities which are kept under extreme scrutiny, monitored and controlled. Recycling and re-using of materials are also very difficult to enforce on a building site but it is easily effected in a factory based environment. In another vein, monitoring of transport patterns and schedules can be extremely difficult on construction sites especially if the site is condensed and compact. The number of deliveries direct to the building site with off-site CMC is minimized and deliveries to factories may be prearranged and controlled in that full loads may be utilized and transport costs are kept to a minimum (Harris and McCaffer, 2013). Transport of prefabricated or modular buildings to the site on the other hand must be planned carefully and heavy plant and equipment necessary for off-loading and erection require careful site management and consideration.

2.8 DRIVERS FOR BUILDING WITH CONTEMPORARY METHODS OF CONSTRUCTION

2.8.1 Shortage in Housing Supply

The percentage of housing supply where substantial progression is forecast, which is lesser than a government would prefer, results in high demand of housing and increasing prices, making it extremely difficult for vital workers and those on low incomes to find suitable accommodation. The development of affordable private sector dwellings is outside the control of the government and thus the concentration has been on stimulating the development of CMC capacity as a means of increasing the rate of housing supply (Ross *et al.,* 2006). Most countries have proceeded towards this purpose by specifying that a proportion of dwellings procured utilizing public funds, or on government-owned land, will have to be constructed utilizing advanced techniques. In practice, this means that a proportion of dwellings built with Housing Corporation grants, or on land owned by partnerships, will be built using CMC.

2.8.2 Skills Shortage

In recent years, underinvestment of training in the building industry has resulted to an overall skill level minimizing with promising implications for quality. As opposed to direct labour, the situation has been made worse by the greater utilization of contract (Pickard, 2002). Procurement is normally based on lower tender/fixed price. This means there is little incentive for contractors to perform better than the minimum required. It is also difficult for main contractors to predict the calibre of operative used on a job. Current moves towards partnering and best value techniques may be improving the situation, but those techniques are far from universal. According to Building (2004), in surroundings of great construction activity, the insufficiency of skilled labour is more acute. Utmost CMC housing is built wholly or partly in factories. There is a greater incentive for the employer to invest in training, both for factory-based operatives and site erection teams provided by the manufacturer since the workforce in factories tends to be direct labour.

2.8.3 Concerns about Housing Quality

It is very difficult to draw firm conclusions as to whether construction quality is improving or not. There is the perception that, build quality is reducing, but that may probably be as a result of high profile media coverage of a few instances of poor practice and increasing customer expectations, than to an overall decline. In most cases, conventional construction can provide good quality housing but there is a common feeling that quality will be needed to enhance only if it can meet the high performing standards required to conform with the revised Building Regulations (see below) (Ross *et al.,* 2006). To what can be attained, there is a limit in a sense of predictable performance given the adverse working conditions on building sites and a largely contracted workforce. Nonetheless, CMC housing factory-made in controlled conditions with a dedicated workforce has a potential to provide more persistent quality.

2.8.4 Revisions to Building Regulations

According to Ross *et al.,* (2006) when the Building Regulations were presented, the health and safety of people in and around buildings were the main concern. Of late, the regulations have been expanded to cover the building performance, specifically their thermal and acoustic performance. House builders are not only concerned with meeting higher standards in cases like these, but with the view that performance might be tested after construction. This can result in costly remedial work if performance falls short of the standard required. Some house builders are looking at CMC as a potential way of providing more predictable performance in the completed dwelling.

2.8.5 Environmental Performance

Emphasis is increasingly being placed on the environmental performance of buildings, not only in utilization but also during construction, and the environmental credentials of the materials being utilized. One aspect of the construction process that is criticized on conventional sites is the level of wasted material, either through damage or profligacy. Materials are usually bought in bulk and contractors are hired to fit them on conventional sites. There is little incentive for the contractor (who is usually on a fixed-price contract) to economize on the usage of materials. With CMC, suppliers usually quote a price for manufacture or supply that includes the cost of the materials, so there is a much greater incentive for them to reduce wastage. There are other environmental benefits specifically for manufactured dwellings since much of the work is conducted in a factory; hence the impact on the local community in terms of noise, dust and traffic movements associated with conventional construction sites is reduced (Ross *et al.,* 2006).

2.9 HOW CONTEMPORARY METHODS OF CONSTRUCTION IS PRACTICED IN EUROPEAN COUNTRIES

Most European nations have used CMC as part of diverse structures for a long time, and each of them added to a framework that fits their own way of life and development innovation. For instance, in the Netherlands, most homes are fabricated by a half and half strategy for solid shells and a couple of special cases of timber casings. The basic use of offsite development methods in the Netherlands was for rooftop and divider boards. The system is called supported optimising lodging method. This method utilizes steel burrow formworks with the cast set up cement to finish a building with 50 units or more, because of the prudent scale (Gibb, 2002). In the Netherlands, the basic dividers of structures are pre-assembled and protected, using timber depression internal leaves fusing windows and entryways. The internal leaves of hole dividers are pre-assembled timber-encircled development, consisting of timber boards, a plasterboard inward skin, protection, vapour boundaries, soggy rooftop courses, windows, and door jambs((either PVC or timber surrounded). Smooth-confronted gypsum squares are utilized as a part of the building for non-burden bearing inward dividers that give format plan adaptability, and better solid and imperviousness to fire. Rooftops are pre-assembled with pivoted timber components fusing rooftop lights and vents. The pre-assembled timber pivoted rooftop components are intended to sit on divider plates on the overhang and peak dividers (Waskett, 2001). Contrasted with traditional development innovation in the Netherlands, offsite development methodologies diminish development duration from 21 months to 12 months, with 33% more usable floor territory. They likewise decrease the building expense by up to 17%. Most overwhelm contractual workers are exploiting these routines and materials. It has been effectively connected in the business for over 25 years (Waskett, 2001).

2.10 BARRIERS OF CONTEMPORARY METHODS OF CONSTRUCTION

A review of the literature indicates that common barriers/demerits/problematic issues of CMCs may be grouped under eight main headings related to cost, skills and experience, motivation and culture, tools and standards, the market of CMCs, industry, interface and flexibility, and projects. The barriers are discussed in the following subsections;

2.10.1 Cost-Related Issues

The factories that manufacture elements and modules for CMCs require high start-up costs to set up suitable machinery and a prefabrication yard for producing the components and modules (BRE, 2007; NAO 2005; Chiang *et al.,* 2006). They also need to buy all the appropriate materials at the beginning of the project, resulting in higher initial costs (Mtech, 2009). Moreover, the majority of factory overhead costs (like labour) are fixed, regardless of output. If precast components are of small quantities, the construction cost per unit becomes high (Pan *et al.,* 2011). On the other hand, many site-based overhead costs are only incurred if construction takes place. Hence, it is not easy to utilize CMCs to respond to unstable demand (POST, 2003). These results to CMCs with higher initial costs (Jaillon and Poon, 2010) and possibly higher overall costs than traditional methods (Chiang *et al.,* 2006; Pan *et al.,* 2011), which leads to difficulties in obtaining finance for projects (Homes and Communities Agency (HCA, 2010).

2.10.2 Skills and Experience

CMCs require highly skilled labour, both for producing parts and modules for CMCs in factories and for the precise on-site assembly of these parts (Jaillon and Poon, 2010). However, many of the diverse forms of CMCs are more recent innovations. Inadequate adoption of older forms has led to an inadequate skills and experience relating to CMCs, since a lot of people engaged in the construction industry have had little or no experience working with CMCs (BRE, 2007; Pan *et al.,* 2011). Again, the little market demand means a limited number of projects are utilizing CMCs, so few or zero new people are learning CMCs (HCA, 2010). Moreover, university level students are least exposed to the technology, organization, and design of CMCs. The academic curriculum rarely includes courses which incorporate a systematic and methodological manner and the potential and limitations associated with CMCs. In consequence, there is a natural tendency among practitioners to select conventional methods (Thanoon *et al.,* 2003).

2.10.3 Motivation and Culture

According to BRE (2001), a lot of people are suspicious of the performance and quality of CMCs because of high-profile failure in the past. A lot of elements and modules of CMCs are extremely lightweight, resulting in the belief that they are of low quality, less durable and might require frequent refurbishing (BURA, 2005; Yau unpublished data, 2006), and thus they may create overheating in the summer months (BRE, 2007). A lot of companies and people have a certain mind set and are not willing to try new methods according to Cooperative Research Centre for Construction Innovation thus CRC (2007). This results in a reluctance of producers to innovate and alter to CMCs (Innovate Offsite, 2010). There is also inadequate incentives for companies to create and alter (HCA, 2010). Clients are mostly interested in a well-built dwelling in the right location rather than in how it is created (BRE, 2007) since the property is seen as an investment, and CMCs are not considered as worthy investments (CRC, 2007).

2.10.4 Tools and Standards

A lot of the distinct forms of CMCs are relatively recent innovations. Some others have only recently become viable substitutes to more traditional construction methods. Hence, there is inadequate design standardization according to Pan et al. (2011) ; and a lot of substantial quality assessment tools and accreditations are yet to be established (Nadim and Goulding, 2011). Consequently, fewer codes and standards are available for CMCs and the regulatory authorities are yet to include a lot of them in planning regulations (HCA, 2010).

2.10.5 Market of Contemporary Methods of Construction

The small market demand controls the capacity of the existing producers. This in turn has an effect on the cost of products for CMCs, and eventually, on the whole project cost, since manufacturers require to charge higher prices to continue making profits (Mtech, 2009; HCA 2010; Pan *et al.,* 2011). Traditional suppliers moreover do not want companies to alter to CMCs since they fear a decrease in gains/profits from selling more traditional supplies. A lot of traditional suppliers protect the market from suppliers of CMCs by selling supplies at relatively lower prices than suppliers of CMCs can offer and thus creates a rivalry between diverse producers who cut their profit margins to remain in business (Pan *et al.,* 2005).

2.10.6 Industry Related Issues

According to Wong (2000), CMCs require continuous communication and effective coordination between parties involved, throughout the project period, to ensure that deliveries arrive on time when they are required. The fragmented nature of the construction industry however hinders such communication and coordination, making it difficult to standardize designs for CMCs (HCA, 2010). This means elements from diverse suppliers may not fit together, resulting in a lower quality structure and a higher number of defects (Mtech, 2009). However, the lack of supply of developable land in the planning system makes less land available for construction. This therefore decreases the supply of housing and eases the pressure on the builders to provide faster delivery, which slows the speed of change in the industry toward CMCs (BRE, 2007; CBRE, 2010).

2.10.7 Interface and Flexibility

A timely design freeze according to Wong (2000) is essential to permit a timely start of production for the required parts and modules. This however makes CMCs inflexible and unsuitable for late design alterations (BRE, 2007; Jaillon and Poon, 2010). The moment production begins, altering any design may have an effect on how these diverse parts will fit together. Traditional constructional methods do not follow the same standardized designs as CMCs and hence issues rise when joining CMCs with traditional methods (Innovate Offsite, 2010). Again, there is less tolerance between the factory-made elements and those made on-site assembly, meaning that there may be an issue with interfaces between the two when trying to join them (BRE, 2007).

2.10.8 Project-Specific Issues

According to Wong (2000), BRE (2007), Jaillon and Poon (2010), since parts and modules for CMCs tend to be large, some sites with limited access and/or limited on-site space may not be appropriate for CMCs. CMCs are also not suitable for smaller sized projects due to the expensive transportation of the larger assembled modules to sites (Jaillon and Poon, 2010; Pan *et al.,* 2011). The limited number of producers of CMCs implies that some project sites may be at large distances from the nearest producer. Consequently, the large and heavy loads need to be transported long distances, resulting in expensive transportation costs (Innovate Offsite, 2010).

2.10.9 Present Initiative

Both China and the U.K. are suffering from an inadequate housing supply. According to Liu (2007), housing demands in China are mostly located in major cities due to its fast urbanization that is related to high-rise apartment buildings (CBRE, 2010), then again the nature of the housing demand in the U.K. is not confined within urban areas (NHF, 2009). The utilization of CMCs in the U.K. is not as new (BRE, 2001) as in China; however, the market for CMCs in China is much larger than in the U.K (Cai, 2012). With such commonalities and differences, it is predictable that the planned comparison between the two countries will permit interesting results in identifying and documenting the actual barriers of CMCs in each country, and will assist policymakers of these countries and other countries in devising proper strategies to overcome the identified barriers.

2.11 MERITS THAT COMES WITH THE USE OF CONTEMPORARY METHODS OF CONSTRUCTION

According to Lovell (2010), a lot of the benefits of utilizing CMC for housing are remain unproven or contentious. On the other hand, the merits/advantages and demerits/disadvantages are closely related to the drivers and barriers of prefabrication use.

2.11.1 Planning of Project

Sparing in time is a standout amongst the most considerable advantages of the construction, preassembly, and modularization procedures utilized as a part of the development business. Lessening nearby generation time greatly affects shortening general undertaking timetables. The site work is generally defenceless against interruption from extremes of climate, which is one of the fundamental variables of the development plan. The utilization of pre-assembled segments nearby lessens the dangers of deferral and insurance necessities in a given undertaking.

At present planning issues bringing about countless development, organizations can bring about enormous efficiency issues. Construction innovation is one response to shortening the timetable and enhancing effectiveness (Venables *et al.,* 2004). Notwithstanding lodging, some significant retail customers are effectively included in construction routines in the persistent lessening of development time in the business division of the business. In general, construction, preassembly, and modularization have the dynamic impact of calendar funds.

2.11.2 Construction Cost

The utilization of construction strategies at an undertaking permits cost investment funds at each phase of the generation affix because of large-scale manufacturing, for example, material reserve funds at the obtainment stage and work reserve funds at the development stage. A CII investigation of modern ventures found that now and again expenses were diminished by as much as 10% of general undertaking expenses and 25% of on-location work costs (Tatum, 1987). Taken a toll diminishments were to a great extent ascribed to the lower expense of offsite work. Also, investment funds may be connected with site overhead lessening, establishment efficiencies, and the institutionalization of the outline (CII, 2002). Taken toll diminishments can likewise be clarified as far as art profitability expanding and work rates diminishing nearby.

2.11.3 Safety of Site

Construction can build the on location security record by reducing the introduction of labourers to harsh climate, stature, unsafe procedures, and on location working time. Labourers in a creation shop are not influenced by severe climate. Pre-assembled segments additionally give a lot of working space to lighten the potential plausibility of mishaps on location (Ball, 1998).

2.11.4 Quality of Offsite Production Components

Higher item quality through the use of pre-assembled segments can be attained by exact outline and close supervision on location, which lessens the sum and extent of progress. The more exact profiles and institutionalized measurements of parts result in improved quality control on the product. At present, Construction IT programming guarantees arrangement and accuracy of a given task are kept up both on location and in the industrial facility. PC helped to fabricate innovation permits every item in the line to shift from each other. Programming incorporates outline hone with assembling to give mass modified generation (Russell, 1981).

2.11.5 Labour Force

According to Blismas (2006), construction can offer opportunities to lighten the issue of talented work deficiencies. In plant situations, the nature of the completed item is much less demanding to guarantee than on location. Every one of those remaining parts is to guarantee that the on-location collection meets the obliged norms to permit the item to execute as outlined. Contrasted with the conventional development approach, construction has lower workmanship prerequisites on location attributable to streamlined work content.

2.11.6 Material Waste

Observant quality control of the assembling method allows development waste to be managed and decreased through the suitable outline and reuse opportunities. The negative natural effect can be lightened by lessened nearby development time, less clamour, and less waste delivered nearby. Similarly, industrialized development procedures can enormously build material inputs and minimize costs. One particular plan being produced with the European Community (EC) subsidizing has been cited as having the accompanying foreseen merits (Blismas, 2006). Thus half diminishment in the measure of water used for the development of an average house, half diminishment in the utilization of quarried materials in the development as well as the slightest half reduction in the vitality utilization.

2.12 DEMERITS OF USING OFFSITE METHOD OF CONSTRUCTION

2.12.1 Project Scope and Planning Stage

The greatest drawback of construction, preassembly, and modularization in development is the increment of pre-task arranging stage. There is a requirement for expanded building exertion forthright (CII, 2002). In this manner, configuration work and broad arranging must be absolutely directed before creation. Moreover, coordination of outline, transportation, and on location establishment are basic segments for effective execution.

2.12.2 Transportation Limitations

Transportation logistics assumes an extensive part in deciding offsite development practicality. The system and course of conveyance force size and weight confinements and additionally width and stature limitations amid travel (CII, 2002). Roadway transport, as the well-known technique used, normally limits the extent of a secluded building or preassembled fabricating segments to about twelve (12) to fourteen (14) feet in width, and 50-55 feet long. Likewise, and their weight additionally confined by the limit of lifting gear ordinarily between 10 to 30 tons. According to Pendlebury (2004), there exist the U.S. parkway limitations alongside lifting limit of the crane. Manufactured assembling parts must be excessively intended to ease conceivable harm amid travel, which prone to expand outline and development cost.

2.12.3 Client Perceptions

In light of the writing examined, the generally negative view of offsite development strategies was a standout amongst the difficulties in both the U.S. what's more, abroad with the exemptions of in Germany and Japan. In the U.S., pre-assembled structures have dependably been mistaken for production houses, "trailers", despite the fact that there is a major diverse between these two sorts of structures (Hass *et al.,* 2000).

2.12.4 The Ease to Roll out Improvements on Location

The utilization of contemporary construction methods may be diminished by the powerlessness to roll out progress on location amid development. CMC, particularly for specific structures, require a very much characterized scope early the task arranging stages (CII, 2002).

2.13 SUMMARY FOR MERITS AND DEMERITS OF CONTEMPORARY METHODS OF CONSTRUCTION

Table 2.2: Summaries of the merits and demerits of contemporary methods of construction.

Merits of Contemporary Methods of Construction	Demerits of Contemporary Methods of Construction
Smaller demands on facilities and equipment construction site	Requirements for size and site equipment for handling CMC components CMC
Safer working environment at the off-site production of building elements; faster construction over labour costs	Security risks when mounting CMC elements CMC at the construction site
The possibility of using state budget funds, special purpose funds, or foundations	Higher costs for construction products (prefabricated and higher costs for subcontracting)
Fewer design errors and better quality in the manufacturing of components	Initial costs of setting up a production line for manufacturing components
Easier quality control at the factory	Time-consuming proposals
Less waste on the construction site and less environmental pollution during construction	Compliance and quality control in the contact joints
Easier quality control at the factory	Multiple transport materials; into the factory and from factory to the construction site

Source: Lovell and Smith, 2010

According to Doherty (2010), there are mainly three specific aspects which are basic for an investor, thus time, cost and quality. According to the Eternal Triangle, one cannot change any aspect without openly affecting the other two. The MMHB (2003) distributed the merits of CMC according to three main pillars thus,

a) Economic – CMC houses usually have fewer imperfections and may be built more quickly, the elements are of better quality and of higher standards, the construction procedure may be sped up by the mass production of prefab elements in factories.

b) Social – There may be less accidents and fewer impact on local residents during construction. This reduces labour-intensive activities and provides a safer working area/environment. Designers from diverse disciplines may work thoroughly together in the initial design stage to aid decrease abortive work.

c) Environmental – The houses may be more energy-efficient. This may include fewer material transport and produce fewer waste.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 INTRODUCTION

Extensive studies conducted in the pursuit to explore the use of contemporary methods of construction to help resolve social housing deficits in Ghana, has led to diverse conclusions made based on the research methodology. It is therefore vital that the applicable methodology is used to present the work plan of the study. This chapter however discusses the research methodology adopted for this study to answer the research questions raised in order to achieve the research aim and objectives. The Chapter addresses the research design, strategy, population and data collection and analysis procedures. The purpose of the methodology and research design is to provide direction in the planning and implementation of the study in a way that is most likely to achieve the intended goal. The research is based on a quantitative analysis of collected data. Simple random sampling of knowledgeable and experienced persons as far as construction management is concerned were employed. Questionnaires were administered to these people to aid in collecting the necessary data.

3.2 RESEARCH APPROACH

A quantitative approach was adopted in exploring the use of contemporary methods of construction in Ghana construction industry. A survey in the form of questionnaires was conducted to collect information on critical factors pertaining to the use of this methods in Ghana. Various construction related firms were involved in the coming out with the various factors that influence the use of contemporary methods of construction. Their inputs were critically noted and helped in adapting tool for exploring the use of CMC.

3.3 RESEARCH STRATEGY.

It is necessary to adopt the most appropriate research strategy to collect data and subsequently analyse them (Bryman, 2004). A research strategy outlines a guide leading from a precise method, to a suitable way to collect and analyze data (Denzin and Lincolns 2005). As revealed by Naoum (1998), research strategy may be defined as the examination of research goals. Subsequently, Baiden (2006) affirmed that, the three main research strategies are qualitative, quantitative, and triangulation. However, the decision to select any of the strategies essentially is reliant on the aim the research, the nature, and the availability of information for the study (Naoum, 1998; Baiden, 2006). The research strategy therefore determines the method to be used for data collection, which is also reliant on on the necessary information required from the selected sample. Research strategy can be undertaken through two prime ways; qualitative and quantitative (Creswell, 1998; Saunders, *et al.,* 2000). Henceforth, this research employs a quantitative strategy.

3.4 RESEARCH METHOD

When the primary data of a survey is normally picked through surveys and interviews it is best to use the descriptive methods of survey (Zikmund, 1997). To get the best result for the survey, the descriptive method of survey was adopted. With the aim and the objectives of the study in mind, the literature review helped formulate the questionnaires used in the survey. Site visits were also done to get to know more about the materials and their properties comparing them with the traditional materials used in building.

3.5 RESEARCH DESIGN

This research intends to get information from a particular group of people to help establish the current opinions on the use of contemporary methods of construction in Ghana. The research is centered on research design stages to ensure the attainment of the above stated research aim and objectives. Hence, the research design will identify:

- Questionnaire design
- Pilot Questionnaire
- Population
- Sampling technique
- Sample size
- Data Analysis tools

3.5.1 The Questionnaire

Upon a critical review of the existing literature and research objectives, a well-structured questionnaire was prepared and self-administered to the various respondents. Practically all the questionnaires have closed-ended questions to certify consistency of respondent feedback. For the reason that it is not totally possible to design all questions as closed-ended, some of the questions were left open-ended, to acquire numerical data or to lobby some written comment.

The questions were grouped under five main subdivisions.

1. General Information
2. Identification of Contemporary Methods of Construction

3. Challenges for the implementation of Contemporary Methods of Construction
4. Measures to enhance the use of Contemporary Method of Construction

The first part, "General Information" dealt with the demographics, with respect to the respondents company's name, years of experience in construction / real estate development industries and professional background of respondents. This phase was considered necessary in order to determine the credibility and reliability of the data and as an end result, be used to link satisfaction and performance with the test system among diverse groups of users.

The second part, "Identification of Contemporary Methods of Construction" asked more precise questions pertaining to the first objectives listed in the research. This aspect deals with the awareness of Contemporary Methods associated with construction. It requires the respondents to score themselves according to their level of awareness to some listed contemporary methods of construction in the questionnaire. The five-point type Likert original scale was employed to measure this awareness. Thus from "Very Poor" to "Excellent".

The third part, "Challenges for the implementation of Contemporary Methods of Construction" asked respondents to score identified reasons hindering the adoption of these contemporary methods by developers in the construction industry. Based on the identified measures, the Likert rating scale was again adopted to extract the suitable ratings as per their influence as a reason/barrier hindering the adoption by real estate developers in Ghana. The five point Likert ordinal scale (1-5) was used where:

1= Very weak, 2= Weak, 3= Average, 4= Strong, 5= Very strong

Finally, "Measures to enhance the use of Contemporary Method of Construction" inquiries about the necessary measures to help enhance/improve the adoption of these contemporary methods into the construction/ real estate development industries. Open end questions were asked for the respondent to write the possible suggestions to improve on the adoption of these modern methods of construction.

3.5.2 Pilot Questionnaire

A sample of the draft questionnaire was deliberated with three highly decorated real estate developers to evaluate the content of the questionnaire. A purposive sampling was used based on availability, proximity and experiences in the construction industry. Amendments and changes were integrated into the questionnaires. A pilot study was conducted which added some very vital questions, clarify some questions and change the contents of others.

3.5.3 Population

Respondents were limited to architectural, constructional and real estate developers in Greater Accra and Ashanti region. The choice of this group was made on the basis that they are well established and they had done major works with contemporary methods of construction. The decision to focus on these two regions was based on the snowball method of sampling.

3.5.4 Sample Technique

The sampling method adopted for the study trailed a sequential process (Teddlie and Yu 2007), involving a snowballing sampling technique for administering survey questionnaires. The targeted group for the study were the real estate professionals in Ghana, specifically architects, general contractors (site engineers, structural engineers, and quantity surveyors), project managers, facilities managers and manufacturers in Ashanti and Greater Accra Regions. These locations were chosen because, they constitute most of the major real estate professionals and also handles major construction/ real estate development projects.

3.5.5 Sample Size

In line to difficulties faced in attaining correct and dependable data on the population of these professionals, the researcher through the snowball methods of sampling, identified a total of 13 Architects, 19 Quantity Surveyors, 32 Contractors, 8 Facilities Managers, 9 Civil Engineers, 8 Site Engineers, 4 Suppliers and Manufacturers, 12 Real Estate Developers and 8 Project Managers, totalling a sample size of 120 construction practitioners.

3.5.6 Data Analysis Tool

In analysing the data collected from the questionnaires by the researcher, the data was analysed using three methods. Thus; Important Index, Frequency Analysis and Mean Score. In order to generate the results, the researcher used Microsoft Excel and SPSS.

3.5.7 Relative Importance Index

The relative important index (RII) was adopted to help us analyse the questionnaires that are using the Likert scale. The computing was done using the following equation.

Important index (I.I) =

$$\frac{(5n5 \ + 4n4 \ + \ 3n3 \ + 2n2 \ + \ n1) x \, 100}{\left(5(n5 \ + n4 \ + n3 \ + n2 \ + n1)\right)}$$

Where: n1 = number of respondents who choose 'Very Weak'

n2 = number of respondents who choose 'Weak'

n3 = number of respondents who choose 'Average'

n4 = number of respondents who choose 'Strong'

n5 = number of respondents who choose 'Very Strong'

The results from the importance index calculation were ranked; 1st, 2nd, 3rd, 4th etc. in order to know their cardinality of importance.

3.5.8 Frequency Analysis

Here, descriptive statistical methods such as tables, bar charts and pie charts were used to analyse the responses from the questionnaire. The tables give a vivid description of the analysed data and the bar and pie chart gives a pictorial view of the analysed data as well.

Statistical testing such as descriptive statistics, factor analysis and mean score index would also be utilized to compare sample mean to the known population, and study relationships between facts and relationships in accordance with theory.

3.6 QUESTIONNAIRE ADMINISTRATION

The administration of the questionnaire commenced in June, 2018 and finished in August, 2018. A duration of three weeks was used for the administration of the questionnaires, though all the completed questionnaires were retrieved by the fifth week. Retrieving the answered questionnaires was a problem. This was because the researcher had to go to firms' offices a number of times before the questionnaires were returned. A total number of 120 out of the 150 questionnaires administered were retrieve.

CHAPTER FOUR

ANALYSIS AND DISCUSSION OF RESULTS

4.1 INTRODUCTION

The outcomes and the discussions of the field survey after the data collection are presented in this chapter. Analysed in this section is the primary data gathered from the various respondents, composed of construction professionals; Architects, Construction Managers, Suppliers and Manufacturers of off-site produced building components, Real Estate developers, Site Engineers, quantity surveyors and Project Managers. With respect to the analysis, the tools adopted for use took the form of the simple descriptive statistics, Relative Importance Index and Mean score. The analysis is pivoted around the objectives of the study, that is, to identify the extent of awareness of contemporary methods of construction practices in the real estate development industry, to identify the challenges or limitations associated with the implementation of contemporary method of construction in the real estate development industry in Ghana and to identify strategies needed to alleviate the challenges inhibiting the implementation of these contemporary methods to resolve the social housing needs in Ghana.

A total number of 150 questionnaires were administered, using the snowballing sampling technique. Out of which 120 questionnaires, representing 80% were completed and retrieved. The analyses of the results were based on this number of questionnaires retrieved and consequently formed the basis of the findings of this research.

4.2 DEMOGRAPHY OF THE RESPONDENT

This segment of the questionnaire encompassed questions in quest of obtaining basic information and some related issues from the respondents to determine the respondents' understanding about the study in order to provide comprehensive respondent characteristics. One key importance of this section is to establish the trustworthiness or otherwise, and generate confidence in the data collected.

4.2.1 Job Title

Table 4.1 represents the total number of respondents with respect to their various professions in their respective firms. This data was included to enable respondent specify their profession within the firms to establish that the right respondent filled the questionnaire. The results shown in the table indicates that the total number of respondents who completed this section were 120 professionals. Out of the 120 respondents, general contractors recorded the highest number with a percentage of 26.7%. Quantity surveyors recorded the second highest with a percentage of 15.8%. Facilities and Project Managers recorded the lowest of the response with just 6.7% respectively. The high representation of contractor and Quantity Surveyors was inevitable as these are the very key professionals usually engaged in the Ghanaian construction industries.

Table 4.1: Job title

Job Title	Frequency	Percent
Architect	13	10.8
Quantity Surveyors	19	15.8
General Contractors	32	26.7
Facilities Managers	8	6.7
Civil Engineers	9	7.5
Site Engineers	9	7.5
Suppliers and Manufacturers	10	8.3
Real Estate Developers	12	10.0
Project Manager	8	6.7
Total	120	100.0

Source: Field Survey, 2018

4.2.2 Job Category/ Classification

Seen in this section are respondents' assessments based on the category of their jobs they belong to. The results gathered shown below in Table 4.2, depicts that majority of the respondents were from the construction firms with a percentage of 44.4%, this was followed by consultancy firms with a percentage of 32.3%. The remaining two (2) which are manufacturing and facilities management firms recorded a percentage of 8.1% and 12.1% respectively.

Table 4.2: Firm Category

	Frequency	Percent %
Consultancy Firms	40	33.3
Manufacturing Firms	10	8.3
Facilities Management Firms	15	12.5
Construction Firms	55	45.8
Total	120	100

Source: Field Survey, 2018

4.2.3 Working Experience

Respondents were asked for how long they have been in the construction industry/ real estate development industry, thus to depict their level of experience so as to command their authority as far as contemporary method of construction is concerned. Table 4.3 depicts their working experience in the construction industry with 40.8% of the respondents having had 5 to 10 years' experience. 25.8% represented respondents with 10 to 15 years of experience. Respondents with less than 5 years and over 15 years of experience had a percentage of 18.3% and 15.0% respectively. This can be deduced that more respondents are exposed to the rapid changes or growth of in the construction industries.

Table 4.3: Working Experience

	Frequency	Percent %
< 5 years	22	18.3
5-10 years	49	40.8
10-15 years	31	25.8
Over 15 years	18	15.0
Total	120	100.0

Source: Field Survey, 2018

4.3 LEVEL OF AWARENESS OF CONTEMPORARY METHODS OF CONSTRUCTION.

As part of this research's objectives was to identify the extent of awareness of contemporary methods of construction in the real estate development industry of Ghana. It sought to assess the industries' understanding of the concept of contemporary methods of construction, whether they recognize offsite/ contemporary methods as a key resource, how they perceive contemporary methods of construction and whether they deem certain practices of CMC as relevant for the construction industry. Results of the findings of these questions in the section have been analysed below.

4.3.1 Satisfied Construction Methods

Respondents were asked of which of the construction methods they will be satisfied most to work with when the opportunity arises. A number of 73 representing 60.8% of the respondents choose the Traditional method of construction, leaving just 47 with a percentage of 39.2% as modern method of construction. This implies that construction professionals are mostly comfortable using the traditional ways of construction.

Table 4.4; Satisfied Construction Methods

	Frequency	Percent %
Traditional Method	73	60.8
Modern Method	47	39.2
Total	120	100.0

Source: Field Survey, 2018

4.3.2 Categories in Which Contemporary Methods of Construction are used

Figure 4.1 shows that out of the total number thus one hundred and twenty (120) which quantifies all the respondents, 41.7% which is the highest percentage representing fifty (50) respondents mostly use offsite/ contemporary methods for commercial construction. Followed was 35% of the respondents representing Forty-two (42) in number were found to have used contemporary methods in residential construction as the second highest. 21 respondents representing 17.5% used contemporary methods in industrial construction works whereas 5.8% which were seven (7) persons were with the usage of contemporary methods in heavy construction.

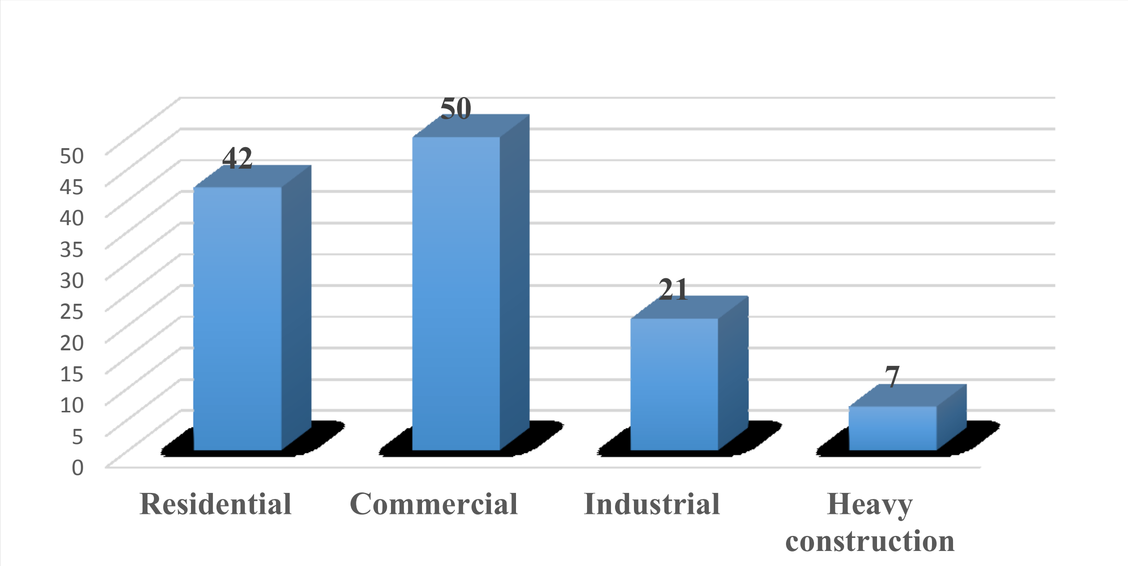

Figure 4.1: Categories in which CMC is mostly used.

Source: Field Survey, 2018

4.3.3 Components of CMC/ Offsite Prefabrication

In order to explore the offsite prefabrication practices embarked in the construction industry, different research works on the topic was studied to come up with the most prominent prefabrication components. In all nine (9) components were noted. Respondents were asked to rank the Nine (9) components according to their level of awareness and familiarity through a survey. This was done on a Likert scale 1-5; ***1=very poor; 5= Excellent***.

The purpose was to determine predominate offsite prefabrication components mostly used and that could be improved to enhance the construction industry should there be a widespread in its usage. The offsite prefabrication practices were subjected to Relative Importance Index for analysing the data collected from the field. The mean as well as RII scores of all the one hundred and twenty (120) respondents were calculated for each practice and have been indicated on the Table 4.7 below.

Table 4.5: Prefabrication Components

Prefabrication Components	Mean	Std. Deviation	RII	Ranking
Bathroom Pods	2.56	1.31	0.51	***9th***
Aircrete	2.85	1.39	0.57	***8th***
Timber Frame construction	3.08	1.41	0.62	***3rd***
Frame structure of the building	2.99	1.43	0.60	***7th***
Pre-cast concrete foundation	3.50	4.99	0.70	***1st***
Roof panels	3.04	1.39	0.61	***6th***
Wall panels	3.04	1.59	0.61	***5th***
Floor panels	3.33	3.08	0.67	***2nd***
Modular construction	3.06	1.37	0.61	***4th***

Source: Field Survey, 2018

After the analysis, the result showed that the most commonly known prefabrication components in the construction industry is Pre-cast concrete foundation. Pre-cast concrete foundation had the highest RII of 0.70 which signifies an extremely strong sense awareness of this particular component in the Ghana construction industry.

Followed suit was Floor panels which was ranked 2nd. Floor panels had an RII ranking of 0.67 with its mean value of 3.33. Respondents were of the view that floor panels were easy, fast and efficient to use because of its flexibility to work with. Timber frame construction was ranked 3rd with a mean of 3.08 and an RII ranking of 0.62. Timber frame construction uses timber studs and rails, together with a structural sheathing board, to form a structural frame that transits all vertical and horizontal loads to the foundation. Their floors are mostly made of floor panel components.

Modular construction, Wall panels, Roof panels, Frame structure of the building, Aircrete and Bathroom Pods were other prefabrication components all deemed useful and familiar with the respondents with RII rankings of 0.614, 0.612, 0.611, 0.60, 0.57, and 0.51 respectively.

4.4 CHALLENGES AFFECTING THE SUCCESSFUL IMPLEMENTATION OF CONTEMPORARY METHODS OF CONSTRUCTION IN THE GHANAIAN CONSTRUCTION INDUSTRY

In a bid to analyse the use of contemporary methods of construction in the construction industry, it is very important to explore the challenges affecting the successful implementation. It became very necessary to conduct a survey among construction professionals in their respective firms to ascertain their opinion on the reasons that impedes contemporary methods in the construction industry. This was conducted on them since they are the professionals who undertake construction and as such they will be in the best position to give reliable responses for meaningful analysis. These factors were categorised into four (Financial, Human, Technical and Environmental reasons) of which each category was further breakdown into at least two reasons. A total of 27 reasons was identified from literature and respondents were asked to rate them in other of importance on a five-point Likert scale rule i.e. (1-very weak; 2-weak; 3-Average; 4-strong; 5-very strong) was used.

Table 4.6: Challenges Affecting the Implementation of CMC

Reasons	Mean	Std. Deviation	RII	Ranking	Avg. Mean	Ranking
FINANCIAL FACTORS						
Higher initial (capital) cost to traditional approach	3.02	1.44	0.603	*5th*	3.061	*1st*
Potentially higher overall cost to traditional approach	3.04	1.38	0.608	*4th*		
Difficulty in obtaining financing, because it requires higher initial cost	3.00	1.41	0.600	*6th*		
Expensive long distance-distance transportation for large and heavy loads	3.31	1.31	0.662	*1st*		
Mortgages and insurances	2.98	1.47	0.595	*7th*		
Value for money	3.06	1.48	0.612	*3rd*		
Commercial risk	3.10	1.43	0.620	*2nd*		
Cost of maintenance	2.98	1.41	0.595	*8th*		
HUMAN FACTORS						
Lack of experience and skills	3.00	1.38	0.600	*4th*	2.987	*3rd*
Limited capacity of existing manufacturers	3.00	1.41	0.600	*3rd*		
Satisfaction with existing method of works	2.91	1.44	0.582	*6th*		
Inadequate coordination: procurement, supply chain, site management	2.98	1.45	0.597	*5th*		
Lack of incentives	3.02	1.46	0.603	*1st*		
High fragmentation in the industry	3.01	1.38	0.602	*2nd*		
ENVIRONMENTAL FACTORS						
Site-specific constraints, e.g., access limitations and space for large loads	3.08	1.47	0.617	*1st*	3.003	*2nd*
Poor public acceptability: suspicion about meeting customer expectations	3.08	1.48	0.615	*2nd*		
Mindset of the industry (cultural problems)	3.00	1.46	0.600	*3rd*		
Limited market demand	3.00	1.44	0.600	*4th*		
Market protection from traditional suppliers	2.93	1.37	0.587	*6th*		
High fragmentation in the industry	2.93	1.43	0.587	*5th*		
TECHNICAL FACTORS						
Fewer codes/standards available	2.29	1.37	0.592	*7th*	2.949	*4th*
Poor integration and interface performance with traditional method	2.93	1.42	0.587	*8th*		
Less tolerance between factory made components and on-site assembly	3.00	1.43	0.600	*6th*		
Lack of quality assessment tools and changes	3.00	1.44	0.600	*5th*		
Inflexible/not suitable for late design changes	3.18	1.46	0.635	*1st*		
Past failures with prefabrication	3.08	1.44	0.617	*3rd*		
Problems with lightweight construction, e.g., overheating	3.10	1.34	0.620	*2nd*		
Low IT integration in the industry	3.01	1.43	0.602	*4th*		

Source: Field Survey, 2018

4.4.1 Financial Reasons

From the general analysis financial reasons were the most important component. Expensive long-distance transportation for large and heavy loads was ranked the most significant financial reason that impedes construction professionals from using CMC. Higher initial (capital) cost to traditional approach was next ranked. This was an indication that it would require a lot more finances or start-up capital to procure key components to start up works under the CMC than that of the traditional approach. Value for money as the 3rd ranked RII was as a result of respondents not having fully assurance that the required standards and material would not be put in place as many be specified.

Potentially higher overall cost to traditional approach, Cost of maintenance, Difficulty in obtaining finance, because it requires higher initial cost, Mortgages, and insurances and Commercial risk were all ranked as factors which hinders the implementation of CMC fully into the Ghanaian construction industry.

4.4.2 Human Reasons

From the summary of results under human reasons, it can be seen that lack of incentives which recorded an RII of 0.603 with 3.02 mean respectively is the most ranked challenge in the Ghanaian construction industry, affecting the successful implementation of contemporary methods of construction. This means that most Ghanaian workers in the construction industry are not being motivated enough to improve their performances. This is followed by a high fragmentation in the industry which recorded an RII of 0.602 with 3.01 mean respectively, then limited capacity of existing manufacturers with an RII of 0.600, mean of 3.00 and hence this means that the required number of manufacturers needed to produce or attain the actual or immediate demand of customers in terms of the recommended tools and equipment machinery needed to increase their construction works are limited/ just a few and this however slows their work.

Lack of experience and skills, the fourth ranked human factor hindrance to construction also recorded an RII of 0. 600. This means that most people in the industry do not have the right skill set and experience needed, thereby reducing or slowing down the expansion of an ongoing or future project thus reducing competitiveness and productivity in the long run. Lack of experience and skills is followed by inadequate coordination in terms of procurement, supply chain, site management. From the table, inadequate coordination recorded an RII of 0.597. This depicts that, an inadequate coordination reduces developed relationships among key implementation parties, vision, trust and confidence and therefore reduces the value of project delivery and its total effectiveness and efficiencies and this is also followed by an overall satisfaction with existing method of works. From the table satisfaction with existing method of works, which is the least ranked under human factors or reasons recorded a mean of 2.91 and an RII of 0.582 respectively. This explains that most workers/contractors/managers in the construction industry are comfortable and confident with the present method used in construction and however do not want to improvise due to high costs of study. This causes their inner feelings that make them remain where they are even though certain measures might be put in place by other to entice them to other arears.

4.4.3 Environmental reasons

From the table, site-specific constraints, e.g., access limitations and space for large loads ranked the highest environmental factor/reason which hinders the use of contemporary methods of construction. This implies that, the specific area and space planned and designed to be used to for the storage of large quantities of loads are limited therefore making it difficult to import extra set of loads which causes intimidation and frustration of actors/contractors/managers slowing down projects.

The next ranked, poor public acceptability thus in terms of suspicion about meeting customer expectations (RII =0.615, mean =3.08). By implication, it means that respondents strongly agree that the public attitudes before and after a construction work is poor. For instance most construction works in certain areas of Ghana are done shoddily and with poor tools and equipment, thereby increasing accidents/injuries, economic costs and emergency services greatly which should not be so. This rank is followed by the mindset of the industry (cultural problems) which recorded an RII of 0.600. By implication, this means that, most people in the construction industry are either more interested in their personal benefits and gains in the long run rather than the general performance outlook of a firm/project. This however causes delays and deletion of important projects. Limited market demand also recorded 0.600 RII and 3.00 mean. The mean range of 3.00 here depicts the fact that respondents significantly agree to limited market demand. This may be due to the limited capacity /number of existing producers, most contractors/managers resort to the usage of archaic tools and equipment which slows projects thereby reducing effectiveness and efficiencies of actual works leading to low productivity while maximizing costs and hence reducing the market demand for these contractors.

High fragmentation in the industry also recorded mean of 2.93 with an RII of 0.587. The mean range of 2.93 depicts the fact that respondent significantly agree high fragmentation in the industry as a factor hindering and affecting the use of contemporary methods of construction.

Finally, the least ranked environmental reason was market protection from traditional suppliers. This implies that respondents significantly agree that market protection from traditional suppliers is a reason hindering the use of contemporary methods of construction.

4.4.4 Technical reasons

According to the survey conducted inflexible/not suitable for late design changes ranked the highest score under technical reasons that causes a hindrances to the use of contemporary methods of construction. By implication, inflexible designs (or resorting to old designs) can cause design errors leading to a cost overrun. This reason according to the survey is followed by problems with lightweight construction such as overheating which recorded a mean of 3.10 and an RII of 0.620 and which is also followed by past failures with prefabrication recording an RII value of 0.617 and a mean value of 3.08 respectively.

Low IT integration in the industry, which is the fourth ranked according to the survey recorded an RII of 0.602, mean 3.01of and standard deviation of 1.43.This explains that, respondents are of the view that the industry lacks the use of information technology and technical know-how needed to plan, implement and execute projects and however reduces the efficiencies in the industry thereby affecting productivity to reduce which also results in low competitiveness. This reason is followed by a lack of quality assessment tools and accreditation. From the survey, lack of quality assessment tools and accreditation which was ranked 5th also recorded an RII of 0.600 with 3.00 mean respectively. This depicts that the required methods/tools needed to evaluate and assess the workforce are not being used. This is because most contractors think it is difficult and time consuming and therefore this rather increases risks in the industry.

Lastly, poor integration and interface performance with traditional method is a technical reason which ranked least and recorded a mean of 2.29 and RII of 0.587. This implies that respondents are strongly of the view that poor integration and interface performance with traditional method affects the use of contemporary methods of construction. Thus poor integration and interface performance may cause issues like design errors, mismatched parts, systems performance failures, coordination difficulties and construction conflicts which to a large extent affects the use of contemporary methods of construction.

4.5 DRIVERS FOR USING CONTEMPORARY METHODS OF CONSTRUCTION

From the table according to the survey, addressing skills shortages ranked the 1st with an RII of 0.683, a mean of 2.0500. This implies that, addressing skills shortages is a factor that drives the use of contemporary methods of construction. This driver is followed by a reduction in site waste which ranked 2nd with a recorded RII of 0.675, mean of 2.0250 followed by restricted site specifics which recorded an RII of 0.675, mean of 2.0250 followed by the 4th ranked driver which is the reduction of environmental impacts during construct. This driver recorded an RII of 0.672 and 2.0167 mean respectively.

Maximizing lifecycle environmental performance was ranked 5th according to the survey. This driver recorded an RII of 0.669, mean of 2.0083 followed by a part of company strategy which also recorded a mean of 2.0000, with an RII of 0.667 which ranked 6th according to the survey. The 7th ranked driver which is reduction of health and safety risks recorded an RII of 0.667 and 2.0000 mean respectively. This ranked driver was followed by an increase in number of units built which also ranked 8th which recorded an RII of 0.664, mean of 1.9917 respectively.

Furthermore, according to the survey, the 9th ranked driver for using contemporary methods of construction thus revisions to the building regulations recorded an RII of 0.664, mean of 1.9917 which is followed by minimizing on-site duration ranked 10th according to the survey. This driver recorded an RII of 0.658 and 1.9750 mean respectively. The 11th ranked driver which is ensuring cost certainty recorded an RII, and mean of 0.656 and 1.9667 respectively.

Achieving high quality ranked 12th which recorded an RII of 0.653, mean of 1.9583 and lastly followed by the 13th ranked driver thus ensuring time certainty which recorded an RII of 0.639, mean of 1.9167.

Table 4.7: Drivers for using CMC

Drivers	Mean	Std. Deviation	RII	Ranking
Ensuring cost certainty	1.9667	0.80891	0.656	11th
Ensuring time certainty	1.9167	0.78412	0.639	13th
Minimizing on-site duration	1.9750	0.79349	0.658	10th
Achieving high quality	1.9583	0.82397	0.653	12th
Reducing health and safety risks	2.0000	0.80961	0.667	7th
Reducing environment impacts during construction	2.0167	0.77766	0.672	4th
Maximizing lifecycle environmental performance	2.0083	0.75030	0.669	5
Restricted site specifics	2.0250	0.78283	0.675	3rd
Addressing skills shortages	2.0500	0.78697	0.683	1st
Revisions to the Building Regulations	1.9917	0.78318	0.664	9th
As part of company strategy	2.0000	0.81992	0.667	6th
Reduce site waste	2.0250	0.82465	0.675	2nd
Increase number of units built	1.9917	0.82499	0.664	8th

Source: Field Survey, 2018

4.6 STRATEGIES FOR THE SUCCESSFUL IMPLEMENTATION OF CONTEMPORARY METHODS OF CONSTRUCTION TO RESOLVE THE SOCIAL HOUSING NEEDS IN GHANA

4.6.1 Contemporary Methods of Construction to Resolve Social Housing Deficit

Respondents were asked of their view whether the use of MMC can resolve the social housing crises in the country. Figure 4.5 depicts the responses the respondents gave. Out of the total 120 responses, 57 respondents representing 47.5% were in the view that contemporary methods of construction cannot resolve the housing problems. 54 respondents representing 45% were also in the view that CMC can help resolve the social housing needs. Responded “Not sure” were only 9 respondents representing 7.5%. This implies that respondents in the construction industry, think there are far more critical things to look at other than CMC to resolve these housing needs.

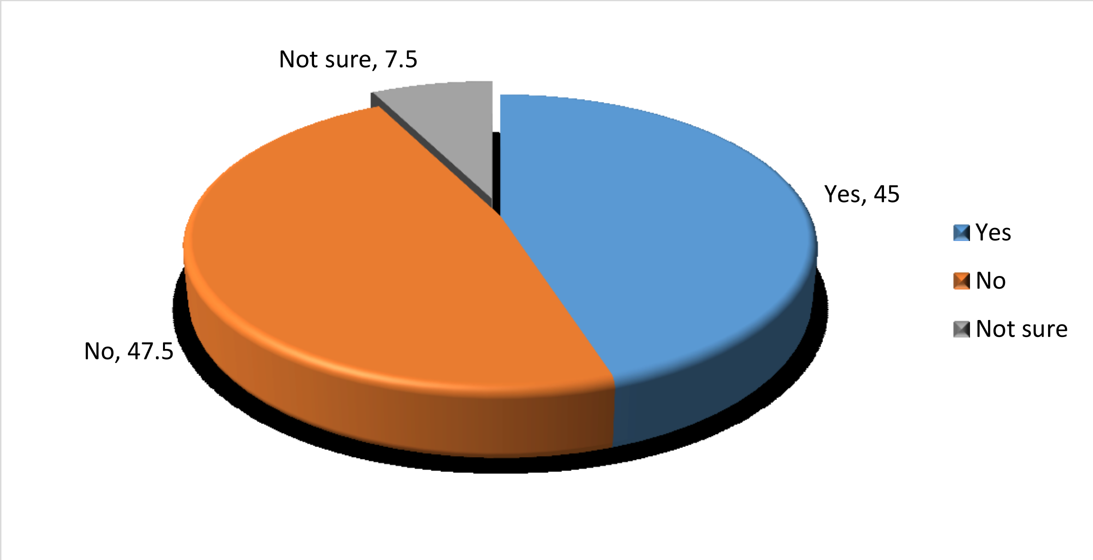

Figure 4.2: CMC to Resolve Housing Crises

Source: Field Survey, 2018

4.6.2 Need to Increase the Take-up of MMC

From the questionnaire collected, the data reveals that, 55.8% of the respondents in the firms want the increase take-up of modern methods of construction, with 35.8% of the respondents in the firms disagreeing. Only 8.3% of the respondents were not sure with the increase take-up of modern methods of construction. This reveals the fact that there is the high willingness of the firms to increase take-up of modern methods of construction.

Table 4.8: Need to Increase the Take-up of MMC

	Frequency	Percent
Yes	67	55.8
No	43	35.8
Not sure	10	8.3
Total	120	100.0

Source: Field Survey, 2018

4.6.3 Strategies Recommended for Increasing the Take-up of Offsite-CMC in the Industry

1) Change of peoples' perception

The respondents indicated that there are significantly high negative perceptions against the take-up of offsite-CMC among construction practitioners and institutions. Smaller classified housebuilders were even more reluctant to use CMC. It was felt that offsite-CMC practises need to be tested and proven as providing good or better performance than the traditional methods. Providing a central site with practical examples of using offsite-CMC techniques should be very helpful. Institutions were required to develop a consistent and objective approach to the use of offsite techniques.

2) Enhanced procurement to achieve long-term success

Many construction practitioners mentioned that partnering had not fully understood by the construction industry. Cooperation between construction practitioners and manufacturers/ suppliers was weak in so many cases. Many suggested forming Strategic Partnering Alliance (SPA). Manufactures and suppliers should be integrated into the decision-making process as early as possible and cooperation between them should be improved.

3) More competitive costing and better cost data should be available

Perceived higher capital cost was identified as the most significant limitation against the use of offsite-CMC. It was recommended that better cost data and more competitive costing should be obtained and an approach 'value for money', rather than 'cost focus', should be demonstrated. Many also recommended increasing design standardisation and addressing the issue of economies of scale.

4) Planning needs to be more flexible and changing building regulations must be acknowledged

The responses revealed that the slow process of obtaining planning permission and changing building regulations are inhibiting the use of CMC. It was recommended that the planning system needs to be more flexible to consider CMC techniques. Dialogues between construction practitioners and the related authorities must be established. Construction practitioners should ensure compliance with enhanced building regulations and designers should not sacrifice design flexibility when specifying the use of offsite techniques.

5) Political levers would encourage the use of Offsite-CMC

A significant number of respondents indicated that the government should support the use of CMC. Tax deductions should be awarded to permit the cost of the "learning curve" in housebuilding organisations to be recovered. Also, it was suggested that the supply of more traditional building choices should be reasonably restricted to provide a more favourable context for the use of CMC.

6) Guidance on the decision-making process and practical applications

Many construction practitioners pointed out that the use of offsite techniques appears more applicable for particular building types and / or house elements. Project circumstances should also be taken into consideration.

Concerns with skills shortages and mortgage ability were also indicated but no detailed information was provided. All these strategies required an input from the whole supply chain, covering the construction practitioners, designers, manufacturers and suppliers, institutions and the government.

It is important to note that the strategies both in use and recommended were based on housebuilders' specific experience and knowledge of CMC within the context of their companies and projects. They should be treated more like analytical strategies than quantitative formula for the use of CMC.

4.6.4 Materials used in Place of Traditional Materials

Table 4.9: Qualities of Materials used in Place of Traditional Materials

	Frequency	Percent
Fragile	47	39.2
Sustainable	24	20.0
Robust	29	24.2
Adequate	20	16.7
Total	120	100.0

Source: Field Survey, 2018

With the materials used in the contemporary methods of construction, 39.2% viewed them as fragile, 20% viewed them as sustainable, 24.2% also viewed them as robust and 16.7% viewed them as adequate. From this analyses, the respondents believe that most of the materials used in the offsite/ modern methods of construction are fragile, hence their refusal to use this method.

CHAPTER FIVE

RECOMMENDATIONS AND CONCLUSION

5.1 INTRODUCTION

This chapter summarizes the results from the research and draws deductions from the collated data. It commences by summing up all the core issues discussed earlier in the preceding chapters including a recap of the key research questions. Afterward, a review of how the key objectives were satisfied and a summary of the results are described. Finally, conclusions are drawn and recommendations for action are also included.

5.2 SUMMARY OF THE RESEARCH

This research so far has presented the aim, objectives and the background problems that induced the formation of the theoretical framework as well as the research questions. Following this, a research methodology was chronologically adopted to answer the key objectives of the study as presented in the research analysis and findings. In addressing this aim and the objectives of the research, the main approach used was to review and explore the current state of contemporary methods adoption in construction literature. This was then trailed by investigating the use and relevance of these findings in Ghana through survey questionnaire. At the end of the empirical study, the factors; identify the extent of awareness of contemporary methods of construction in the real estate development industry, challenges or limitations associated with the implementation of contemporary method of construction and strategies needed to alleviate the challenges inhibiting the implementation of the contemporary methods of construction were appropriately established. The research came out with key findings some of which addressed the main aim and objectives.

5.2.1 Identify the Extent of Awareness of Contemporary Methods of Construction in the Ghanaian Construction Industry.

To this effect, literature on the types and classification of contemporary methods of construction in the Ghanaian construction was reviewed covering a number of them. Seven classifications of CMC were categorized and was further broken down. Questionnaire was designed to assess the awareness of respondents on CMC's available in the construction industry. Some prefabrication components were listed in the questionnaire and respondents were asked to indicate the level of awareness. The findings show that, majority of the respondents in the survey are not aware of most of the prefabrication components pertaining to construction. The only type of the prefabrication components most of the respondents were able to identify most is pre-cast concrete foundation and floor panels. This was because most of their works involve the use of these components. Apart from these types, the other prefabrication components were all ranked poor because of their low usage and unavailability on the market. The study also revealed that, some of the prefabrication components identified; to the respondents are not necessary to use because they see no importance and relevance in them.

5.2.2 Identify the Challenges Associated with the Implementation of Contemporary Method of Construction in the Construction Industry of Ghana.

Subsequently, to explore the challenges affecting the successful implementation of Contemporary Methods of Construction practices in the Real Estate Development Industry, different research work on the topic was studied to come up with the most prominent barriers. In all twenty-eight (28) variables were noted. Respondents were asked to rank the eight (8) financial barriers, the six (6) human barriers, the six (6) environmental challenges and the eight (8) technical challenges that affect the successful implementation of CMC's practices according to the level of severity through a survey. A hundred percent response to this inquiry was achieved and the results indicates that, reasons such as expensive long-distance transportation for large and heavy loads, site-specific constraints, e.g., access limitations and space for large loads, lack of incentives and inflexible/not suitable for late design changes were some of the major reasons that limited the proper implementation of CMC in the Ghanaian construction industry. These stated barriers/ limitations when dealt with by the construction firms, will increase the implementation of CMC thereby increasing the productivity of works.

5.2.3 Identify Strategies Needed to Alleviate the Challenges Inhibiting the Implementation of the Contemporary Methods of Construction in the Ghanaian Construction Industry.

The third objective was set to prescribe measures to improve technology in the construction industry. Questionnaires were set for respondents to choose 'yes or no or not sure' whether they are ready to take-up contemporary methods of construction in their firms and industry. The results indicate that 55.8% of the respondents were ready to take-up CMC in their firms and the industry. Further questions were asked to seek their opinion on strategies recommended for increasing the take-up in the construction industry. Relevant points from their responds were as follows; peoples' perceptions should be challenged, improved procurement to achieve long-term success, better cost data and more competitive costing, planning needs to be more flexible and changing building regulations must be acknowledged, also Political levers will encourage the use of CMC and guidance on the decision-making process and practical applications.

5.3 CONCLUSIONS

This study has discovered that the current usage of contemporary methods of construction by construction practitioners in Ghana is relatively low. This situation is likely to improve, albeit that growth in CMC may be limited in the foreseeable future unless additional 'external' measures are taken. Considerable work in this sector is needed to achieve construction targets for growth of 100% in the coming years. A combination of financial, technical, human and environmental barriers is clearly inhibiting the use of CMC. The construction practitioners have accordingly provided a framework of strategies mainly on aspects of process, procurement, learning, benchmarking and training for encouraging the use of contemporary methods of construction.

All the strategies are interrelated and require commitments from government and the industry but changing peoples' perceptions is fundamental.

5.4 FUTURE RESEARCH

Though this study has proposed recommendations for promoting the use of contemporary methods of construction in the Ghanaian construction industry, future research should look at assess the risk and adaptability of the various methods of CMC described in this thesis.

Again, project case studies are also suggested for future research, in that the case studies would focus on the decision-making process in which contemporary methods of construction are integrated and the project performance on which the benefits of using CMC are measured using Key Performance Indicators (KPIs). This would complement the analytical strategies developed in this report in a more quantitative manner.

5.5 RECOMMENDATIONS

From the above conclusions, the study recommends the accompanying methodologies if received, may not just expand the attention to the utilization CMC systems for development, however in the long run will enhance the development business.

a) Construction practitioners ought to put in more innovative work. Detections from this study demonstrated that constrained configuration choices were a standout amongst the most critical hindrances to expand the utilization of CMC systems.
b) Develop and give mindfulness preparing to producers, general contractual workers and architects in the utilization of contemporary methods of construction. The discoveries from this study show that absence of information of CMC systems is a significant boundary. Hence, the development and configuration order ought to work with full grown produces and suppliers to create proceeding with training course to expand the consciousness of draftsmen and general contractual workers' information of the utilization of CMC development procedures.
c) The government should support the use of contemporary methods of construction. Tax deductions should be awarded to permit the cost of the "learning curve" in housebuilding organisations to be recovered. Also, it was

suggested that the supply of more traditional building choices should be reasonably restricted to provide a more favourable context for the use of CMC.

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APPENDIX A

Figure 2.1 Factory producing volumetric units

Figure 2.2 Completed block of flats in volumetric construction

Figure 2.4 Stages in the construction of bathroom pods

Figure 2.5 Open Panel Timber Frame

Figure 2.6 Closed Panel Timber Frame

Figure 2.7 Structural insulated panels (SIPS)

Figure 2.9 Prefabricated Foundation

Source: http://www.sbki-bg.com/steele_constructions_en.php

Figure 2.10 Floor cassettes

Source: http://www.acrooftrusses.co.uk/products/floor-cassettes

Figure 2.11 Roof Cassettes

Source: http://streif.co.uk/services/design/roof-cassettes/

Figure 2.12 Pre-assembled roof structure

Source: https://www.napier.ac.uk/about-us/news/royal-recognition-for-timber-research

APPENDIX 2

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY COLLEGE OF ART AND BUILT ENVIRONMENT
DEPARTMENT OF CONTRUCTION TECHNOLOGY AND MANAGEMENT
Research topic:

EXPLORING THE USE OF CONTEMPORARY METHODS OF CONSTRUCTION IN GHANAIAN CONSTRUCTION INDUSTRY.

Dear Sir/Madam,

This questionnaire is meant to assess the extent in use of contemporary methods of construction in the Ghana as well as its Challenges impeding its implementation in the Ghanaian Construction Industry.

Contemporary Method of Construction is a term used to describe a number of construction methods which differ from the 'traditional' method of construction. Other terms that are commonly used include off-site construction, factory-built, industrialized or system building, modern method of construction and pre-fabrication.

It would be much appreciated if you could spare some time to complete this questionnaire for me. This questionnaire is a tool for collecting data for a university study and will not be used for any other reason. Please be assured that your answers will be confidential and will only be used for conducting this study.

Thank you

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SECTION A-DEMOGRAPHIC DATA

1. What is your gender?

a. Male [ ]   b. Female [ ]

2. What is the category of your firm?

a. Consultancy Firm [ ]   b. Manufacturing Firm [ ]

c. Facilities Management Firm [ ] d. Construction Firm [ ]

Other (Please specify) …………………………………………………...

3. What is your current position in your organization?

a. Architect [ ]   b. Quantity Surveyors [ ]

c. General Contractors [ ]   d. Project Manager [ ]

e. Site Engineer [ ]

Other (Please specify) …………………………………………………...

4. How long have you been in the building construction industry?

a. Less than 5 years [ ]   b. 5 - 10 years [ ]

c. 10 - 15 years [ ]   d. Above 15 years [ ]

SECTION B

1. Which construction method will you be satisfied most to work with?
    - Traditional method of construction
    - Modern method of construction (Prefabricated Components)

2. Have you utilized modern methods of construction techniques in your previous project recently? In which of the following construction categories:
    - Residential
    - Commercial
    - Industrial
    - Heavy construction

3. As building developer, how will you grade yourself based on the use of the under listed prefabrication components below? Pls. tick

Prefabrication Components	Very Poor	Poor	Good	Very Good	Excellent
Bathroom Pods					
Aircrete					
Timber Frame construction					
Frame structure of the building					
Pre-cast concrete foundation					
Roof panels					
Wall panels					
Floor panels					
Modular construction					

4. Please tick the top 5 reasons that restrain/ hinder companies from using modern methods of construction in Ghana. Note: 1=very weak; 2=weak; 3=Average; 4=strong; 5=very strong

Reasons Hindering Modern Method of Construction	1	2	3	4	5
FINANCIAL REASONS					
Higher initial (capital) cost to traditional approach					
Potentially higher overall cost to traditional approach					
Difficulty in obtaining finance, because it requires higher initial cost					
Expensive long-distance transportation for large and heavy loads					
Mortgages and insurances					
Value for money					
Commercial risk					
Cost of maintenance					
HUMAN REASONS					
Lack of experience and skills					
Limited capacity of existing manufacturers					
Satisfaction with existing method of works					
Inadequate coordination: procurement, supply chain, site management					
Lack of incentives					
High fragmentation in the industry					
ENVIRONMENTAL REASONS					
Site-specific constraints, e.g., access limitations and space for large loads					
Poor public acceptability: suspicion about meeting customer expectations					

Mindset of the industry (cultural problems)					
Limited market demand					
Market protection from traditional suppliers					
High fragmentation in the industry					
TECHNICAL REASONS					
Fewer codes/standards available					
Poor integration and interface performance with traditional method					
Less tolerance between factory made components and on-site assembly					
Lack of quality assessment tools and accreditation					
Inflexible/not suitable for late design changes					
Past failures with prefabrication					
Problems with lightweight construction, e.g., overheating					
Low IT integration in the industry					

5. Which of the following statement in your opinion best describe the drivers for the use of Modern Methods of Construction in Ghana. (Pls. tick) (Note; 1- Very

Drivers for Using Modern Method of Construction	**1**	**2**	**3**
Ensuring cost certainty			
Ensuring time certainty			
Minimizing on-site duration			
Achieving high quality			
Reducing health and safety risks			
Reducing environment impacts during construction			
Maximizing lifecycle environmental performance			
Restricted site specifics			
Addressing skills shortages			
Revisions to the Building Regulations			
As part of company strategy			
Reduce site waste			
Increase number of units built			

important: 2- Moderately Important, 3 –low important).

6. Do you agree that the use of modern methods of construction can help resolve the social housing deficit in Ghana?

☐ Yes

☐ No

□ Not Sure

7. Does the construction industry need to increase the take-up of modern methods of construction?

   □ Yes

   □ No

   □ Not Sure

8. If **yes**, what measures will you suggest to improve the adoption of technology in your firm?

…………………………………………………………………………………………

…………………………………………………………………………………………

9. How would you describe materials used in place of the traditional materials used in offsite construction?

   □ Fragile

   □ Sustainable

   □ Robust

   □ Adequate