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The Potentials of Lean Construction For Optimized Construction Cost In The Nigerian Real Estate Industry

Master Thesis

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2nd Supervisor: Mr Eric Pollock

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Conceptual Formulation of the Master Thesis

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Topic:

POTENTIALS OF LEAN CONSTRUCTION FOR OPTIMIZED CONSTRUCTION COST IN NIGERIAN REAL ESTATE INDUSTRY

Background

The question is how affordable is a low-cost estate housing unit in Nigeria? Housing affordability is extremely limited given the level of unemployment in the country and the low incomes earned. As a developing country, Nigeria's real estate sector is evolving at a tremendous pace and governments at all levels are aware of the role of real estate development on the growth of her territories. This is because having roof over one's head is a very vital part of life. Various plans have been put in place to enable people own a home in Nigeria and these include the construction of low cost estates and residential areas to give low income earners a chance at owning or renting a home. However, despite the plans and strategies, this industry is still plagued with very high cost, unaffordable housing units. Some affordable housing estates are tagged "substandard" due to compromised level of quality in exchange for profit maximization.

It is not impossible to apply lean production concept to optimize real estate housing construction cost by systematically eliminating waste generation, simplify construction procedures and speed up housing unit construction. Lean construction provides a value seeking tactic that aims to maximise value and pursue perfection in a continuous approach.

Goal of Study

This research aims to study the potentials of lean construction concept in the Nigerian Real Estate Industry towards construction cost optimization without compromise to quality, safety and time of project delivery. The Nigerian real estate housing construction and management processes will be analysed, identify various cost indices and the effect of lean concept. An optimised construction process will imply an affordable housing unit as the total project cost is reduced.

Research Methodology

This research project wishes to employ a Design Science approach to address the research question. A Design Science Research (DSR) aims to produce scientific knowledge by developing solutions that links theory and practice while solving real world problems. Data would be collected using observation and documentary analysis, interviews, and questionnaires, case studies shall be carried out. Quantitative data will be analysed using the Ranking Indices of Importance (RII) while data presentation shall be with the use of Microsoft excel & words. Data shall be evaluated for Reliability, Validity, Representativeness, amongst others.

Research Questions

1. What is an affordable (low cost) housing units in the Nigerian context?
2. What is the conventional practice of real estate construction and management strategy in Nigeria?
3. What are major cost factors and determinants?
4. What is Lean Construction (LC) concept?
5. How could Lean Construction (LC) support affordable housing in Nigeria?
6. How can Lean Construction optimise construction cost?
7. What are the challenges of its implementation?

Bunte Eric Pollock

Abstract

Housing affordability is the bane of most Nigerians. Traditionally, Nigerians see shelter as the greatest achievement, even if it requires saving all earnings to achieve home-ownership. Housing affordability is extremely limited, given the country's level of un-employment and the low incomes earned. As a developing country, Nigeria's real estate sector is evolving at a tremendous pace, and it received supports from the government for territorial developments, including building housing units for the people.

However, this industry is still plagued with very high cost, unaffordable housing units despite the plans and strategies. Some affordable housing estates are tagged "sub-standard" due to a compromised level of quality in exchange for profit maximisation. The cost of a housing unit in Nigeria is the combined cost of land (fixed), construction cost (amount varies), and profit margin.

After the study of 'Lean-Thinking' Principles, the researcher feels it is not impossible to optimise the housing development process for a reduced cost of construction. The Lean production concept was applied to the real estate housing development projects by systematically eliminating waste in the processes, simplify construction procedures and speed up housing unit delivery. A case study estate project in Lekki, Lagos was worked on, to determine lean construction potential for optimised construction cost in the industry. While trying to determine the possibility for cost optimisation, the researcher uses qualitative tools to determine the potential challenges and barriers to implementing lean thinking principles in the Real Estate Industry.

The researcher used Vico Office for the Location-Based Scheduling of their conventional process, which revealed many potentials for improvement in terms of labour waste, activities clashes, and duration. The research outcome showed lean thinking portends a good cost-saving for the housing development process for the industry. It was observed that Sponsor Instalment Payment Rate has an enormous influence on Cash Flow Performance which is pivotal for timely project delivery. Cash Flow performance was improved from -73.9% to -52%. There were cost savings from labour waste and cost savings from gained duration. Optimisation revealed that the project could be completed earlier with 30days gain. Findings from the questionnaires' analysis showed that the Real Estate Industry lacks an adequate number of construction professionals in the sector. The employees are new to Lean principles and have no BIM tools or BIM

use experience. The barrier analysis for implementing lean construction is high, even though 100% of respondent companies indicated readiness for change adoption for an optimised process for cost savings.

Table of Contents

Table of Figures

List of Tabulations

List of Equations

List of Abbreviations

BIM	Building Information Modeling
LBMS	Location-Based Management System
LBS	Location-Based Scheduling
USD	United State Dollar
WBS	Work Breakdown Structure
YOY	Year-On-Year

1.0 Introduction

The cost of building a residential housing unit in Nigeria has recovered from the recession and continues to escalate, making it impossible to execute potential housing units' projects. The essential basic need of man is shelter, which means housing even to the illiterates on Nigeria's streets. According to Ozo (1990), the aspiration to own a house constitutes one of the most substantial incentives for savings and capital formation. The affordable housing challenge is increasingly becoming precarious following the level of unemployment in the country. Misilu et al. (2010) researched and attribute housing problems in Nigeria to the rapid urbanisation currently being experienced worldwide and Nigeria in particular. A recent study of Nigeria's housing situation put existing housing stock at 23 per 1000 inhabitants (Ezeigwe, 2015). The housing deficit is estimated to be at 15 million houses (Mabogunje 2004).

Housing affordability is extremely limited, given the country's level of unemployment and the low incomes earned. Nigeria's real estate sector is evolving with several ongoing housing construction projects, intending to support the government's effort for infrastructural developmental growths in the territories. To enable people to own a home in Nigeria, one of the government's strategies was the construction of low-cost estates and residential areas to give low-income earners a chance at owning or renting a home. However, this industry is still plagued with very high cost, unaffordable housing units despite the plans and strategies. Some affordable housing estates are tagged "substandard" due to a compromised level of quality in exchange for profit maximisation.

Several research works have analysed the cost factors of the housing unit in Nigeria. Babatunde (2017) identified land values, construction costs, development fees, permit and development timelines, materials and labour costs, and regulatory requirements as the major factors affecting housing cost. Oke et al. (2012) analysed the rising trends of the construction cost of a typical 3-bedroom residential bungalow unit in Lagos (Nigeria) between 2000 and 2009. The research revealed an increasing upward trend throughout the study period, with average annual inflation in construction costs between 11.27% and 268.88% for the years under review. Oke et al. (2012) concluded that the cost of housing construction is the primary cause of housing shortages leading to the high cost of urban accommodation, construction estimates losing usefulness

within short periods, difficulty in forecasting and planning, and frequent contract price variations, which often leads to projects abandonment. According to Abiodun (2013), the increase in the price of commodities is directly proportional to the value of the property. Upward review of the cost of building new houses and renting older housing units also increases. This is because a shortage of housing supply creates competition for the limited available older housing units.

1.1 Need For Optimisation

Construction cost is one major cost determinants of a housing unit. According to Anuja and Parag (2015), construction delay, time overrun is one of the significant causes of housing construction cost overrun, and it harms project success in terms of time, cost, and quality. Cost Overrun is unavoidable when a project continues with re-works stemming from poor site management and supervision, inadequate work experience, incorrect planning and scheduling, wrong estimation method. A lean project delivery system ensures organised, location-based monitoring and provides enhanced search of value maximisation for owners and workflows' efficiency on construction sites. The systematic efforts made towards improving profit margins and obtain the best results under given circumstances or a situation is called optimisation. The cost optimisation process is essential throughout the construction period. Apart from ensuring that adequate attention is given to project monitoring, it also ensures no cost overrun (Anuja and Praja, 2015). This is to maximise investment profit and with a satisfactory quality of work.

1.2 Research Questions

A research question is formulated when a problem is identified along a study path of interest to solve it (Lipowski, 2008). Consequently, the research question for this study is as follows:

'Can Alternative Planning Technique (Lean-BIM Principles) be successfully applied to optimise construction costs in the Nigeria Real Estate Industry'? To answer the question, the research hopes to answer the following sub-questions:

i. What is the Effect of Location-Based Schedule for Housing Development Process Optimisation?
ii. How does Lean Thinking impact the Cash Flow Performance of the Housing Development Project?
iii. Effect of Poor Sponsor's Instalmental Funding Agreement on Cost Optimisation

iv. What are the possible barriers to the Lean-BIM implementation for Cost Optimisation in Nigeria Real Estate's effectiveness?

1.3 Research Aims

This research aims to optimise the construction costs of housing units development in Nigeria using the Lean Thinking Principle (Lean-BIM Alternative Planning technique) while optimising the existing process for wastes identification and elimination. It aims to evaluate the potentials of the application of lean thinking in cost performance and improvements.

1.4 Research Objectives

The research objectives are:

i. To review the Real Estates Business in Nigeria
ii. To review workflow Scheduling and Variability in Nigerian Building Industry
iii. Review the conventional project management approach in Nigeria building industry
iv. Review Lean Construction practices and concepts
v. Perform Process Optimisation with Lean-Thinking concept while analysing conventional project for process wastes in terms of waiting time and duration.
vi. Implement alternative planning using Vico Schedule Planner for a typical project in Nigeria.
vii. Perform Cash Flow Analysis and Simulations using MS Excel
viii. Determine potential barriers to the effectiveness of lean thinking for cost optimisation.

1.5 Research Scope

The research is limited to:

i. Housing units construction in Nigeria with a case study in Lagos
ii. Housing projects currently in the execution (Construction) stage of the project development;
iii. Implementation of Location-Based Scheduling (Lean-Thinking Concept) using Vico Office and MS Excel.

1.6 Research Motivation

The rising difficulty of shelter in Nigeria is a significant concern. Life is rather hard for low-income earners, living on less than €2 per day. The increasing construction cost of developing units of apartments is posing significant challenges; even while this could be achieved, the quality of the apartment is compromised. Nigerians have resorted to endless savings strategy which will never meet the rising cost of housing due to inflation. The Nigerian government has set up different low-cost housing estates and particular interventions in a different part of the country, which after construction, the eventual cost of rental/ sales/ mortgage still not affordable by the average Nigerians. Different scholars have researched extensively into housing affordability in Nigeria, the determining factors for housing affordability, the optimisation of Cost-Time Project Management, but none had looked into optimising using the lean-BIM technique for LBMS.

The researcher's first knowledge of the lean project delivery system (Last Planner System) during practice while working for a European construction company (Bouygues Construction- Nigeria) on a mega project in Nigeria for five years. B-Lean (Bouygues Lean), as it is called, was introduced when all effort to bring back the project to schedule had failed. The full potential and principles of lean construction were studied during the Master Degree studies in Construction and Real Estate Management at the University of Applied Sciences Berlin and Helsinki Metropolia University of Applied Science, Finland. Nigeria, like other developing African countries, is new and fresh to the knowledge and concept of lean construction practices.

It is not impossible to optimise costs with lean construction schedule monitoring and control. The desire to optimise construction costs, potential construction delays, material inflations, loss of use of construction cost estimate over the period, contract price variations, and eventual project abandonment is prevented.

1.7 The Case Study

The thesis explores the cost optimisation potentials of lean construction principles and LBMS for estate development planning, scheduling, and on-site control of residential housing units in a real estate development company in Lagos city, Nigeria. The author made email contacts to companies in Lagos, Nigeria. The author has confirmed a

positive response from one of the Real Estate Companies who had agreed for a case study support. The author confirmed that the company is currently developing estate apartments in the Lekki area of Lagos, Nigeria. Further information from the company indicates that they have used activity-based scheduling for the project, set up in MS Project. The project sponsor is a bank with agreed instalment payment. It was not mentioned if there was already a project cash flow planning for the project. The author intends to explore the company activities schedule, determine waste in the processes, determine the cost of waste, optimise the process using the Lean-BIM tool (Vico Schedule Planner) and advise on the cost performance of the project.

1.8 Thesis Overview

The thesis is structured into six (6) chapters, including the Introduction section. Chapter two and three provides details of the Literature Reviews. **Chapter two** provides detailed information about **Study Context-Nigeria.**

Chapter three provides a detailed review of the literature about Lean Construction and Location-Based Planning. Also, it explained the benefit of LC in the construction industry and the application of its tools and there possible benefits on the performance of the construction projects.

Chapter four is the Research Methodology. It provides the details of the method for the actualisation of the research. It provides the overall concept of the research in detail, how the lean tool can be applied and how it can affect the performance of the construction projects.

Chapter five is the case study under consideration. This chapter is devoted to the description and analysis of the case studies and to find out the impact of lean optimisation process on the case studies, with a focus on cost performance. It also included data analysis for the questionnaires.

Chapter six presents the research conclusion and recommendation.

2.0 The Study Context- Nigeria

2.1 The Geographical Context Of Nigeria

Nigeria is among the 19 countries in the Western region of the African continent, officially called the Federal Republic, perhaps because it practices a Federal system of government after independence. Nigeria is located on the borders with the Cameroon and Chad in the East, Niger to the North, the Republic of Benin in the West, and

borders the Atlantic Ocean to the South and, (the Gulf of Guinea), as shown in Figure 2.1. Nigeria has a total area of 923,768 sq km, with an estimated population of over 206 million (Internet World Stats, 2020) and the most populous country in the entire African continent. Nigeria accounts for 48% of West Africa's population and ranks 5th amongst the highest population in the world (Internet World Stats, 2020).

Nigeria's capital is currently located in Abuja, the Federal Capital Territory, after moving from Lagos in 1991. It consists of 36 States plus a Federal Capital Territory. The country is known to have over 274 ethnic groups in the Federation, which is divided into three major regions and grouped under six geopolitical zones with a total of 774 Local Government Areas (LGAs) (Ograbe A. Ahiakwo, 2014).

Figure 2.1: Map showing Geographic Location of Nigeria
Source: Odusote (2010)

2.2 The Nigeria Real Estate Housing Units

Many laws are regulating and governing real estate in Nigeria. The real estate laws in Nigeria can be broadly divided into federal and state regulations. One crucial law which forms the basis for other laws is that, by the Section 43 of the 1999 Constitution, the federal law provides that every citizen of Nigeria have the freedom to buy, acquire and own immovable property anywhere in Nigeria. Under the provision, the right to real estate business either as an individual or corporate organisation is guaranteed. It, therefore, becomes legitimate for an investor to develops, renovates, buys, and re-sell

properties such as residential apartments, buildings, office spaces, lands, hotels in Nigeria. Nigeria, no doubt, is experiencing a rapid rate of urbanisation, the same as other developing countries. The world urbanisation prospect (2018) estimated that about 50% of the population of Nigeria would live in urban centres by the year 2018 – this figure being about 28% in 1980 and 16% in 1960 (see Figure 2.2 below). Ten (10) Nigerian urban cities have been estimated with a population of over one million people. Lagos occupies the top position with a current population estimated to be as high as 14 million people, making it one of the 10 most populous cities globally and projected by the United Nations to be the third most populous by 2050 (Oladimeji Odusote, 2010).

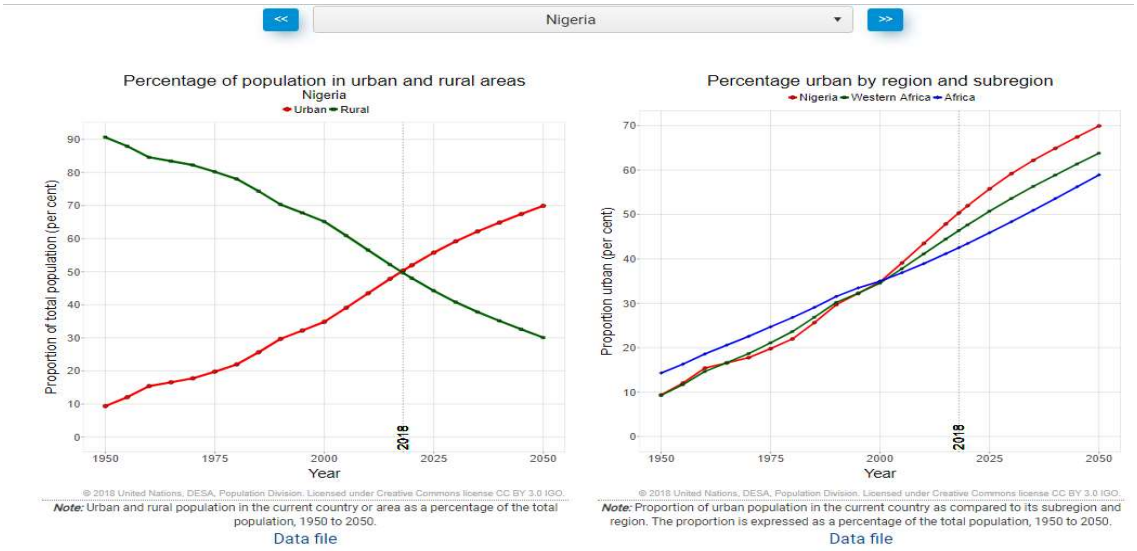


Figure 2. 2: Percentage Population in Nigeria in 2018
Source: World Urbanization Prospect (2018)

2.2.1 The Demand for Real Estate in Nigeria

It has been established that the demand for real estate products is linked to the formation of cities and urban centres, which in turn, is mostly influenced by the economic drivers in these cities in terms of jobs, employers, businesses, and revenue generation. Dashol et al. (2017) pointed out that Nigeria's real estate industry is still underdeveloped, with very limited and plagued with non-existent institutional-quality products. Real Estate Investors have continued to show interest in the regions, with excellent

investment in Lagos, Portharcourt, and Abuja, following positive macroeconomic outlook and this point to growth in the market. (Dashol et al., 2017).

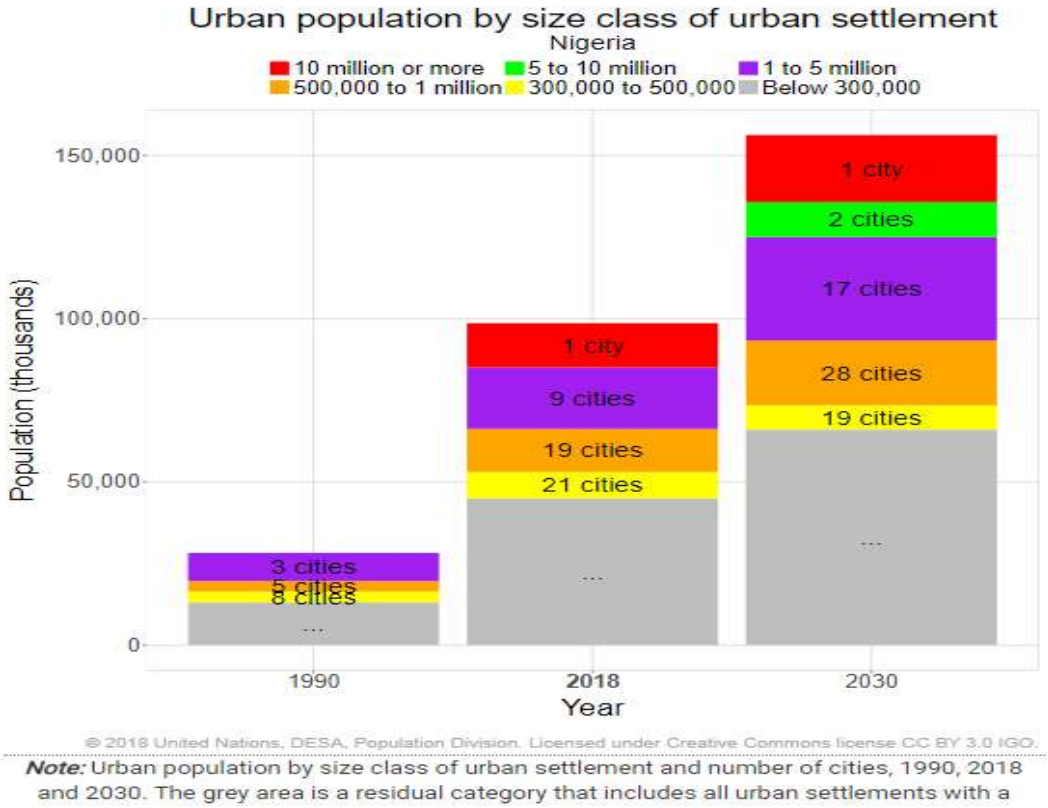


Figure 2. 3: Urbanization Population and Forcast by Nigerian Cities
Source: World Urbanization Prospect (2018)

According to the World Bank, the estimated housing deficit in Nigeria stood at 17.4million as of the year 2013. Reference to figure 2.2, which shows UN growth projections, Nigeria is set to rise as the 3rd next to the most populated country in the world by 2050. Lagos, by this time, is forecasted to double its population according to figure 2.3. The figure shows the urbanisation forecast and population growth in Nigerian cities. Based on this, the demand for housing roses by 800,000 units annually with the current pace of development in the city. According to the Residential Auction Company (RAC), a Lagos based real estate research company, the housing markets have since started showing signs of economic recovery.

2.2.2 Average Cost of Housing Units in Nigeria

Lagos city is the most expensive and populous city with the highest urban migration in Africa. Ikoyi is a neighbourhood in Lagos, most affluent, registered the highest y-o-y house price growth of 20% in May 2019, followed by Ibeju Lekki, with an annual price increase of 12%. House prices in Lekki, Ajah, Gbagada, Surulere, and Yaba were largely steady. In Ikoyi, the average price of three-bedroom apartments was NGN 140 million (US$388,906) in H2 2018, while five-bedroom apartments are sold for an average price of NGN 350 million (US$972,266) according to Nigeria Property Centre, Global Property Guide (2020).

On the other hand, Ikorodu saw the biggest decline in house prices of 25% during the year to May 2019, followed by Ikeja (-16.7%), Alimosho (-10.7%), Isolo (-9.1%), and Victoria Island (-8.7%). Table 2.1 gives the average asking price of a five-bedroom single-family unit on Lagos Island and Lagos Mainland between 2015 and 2017.

Areas in Lagos	**Years under Review**		
	2015 (₦)	2016(₦)	2017(₦)
Lagos Island			
Lekki, Ikoyi, Victoria Island	129.5m	172.2m	196.1m
USD	*$419,094*	*$557,000*	*$634,000*
Lagos Mainland			
Anthony Village, Gbagada, Ilupeju, and Omole Phase 1	17.2m	75.5m	75.9m
USD	*$56,209*	*$244,000*	*$245,000*

Table 2. 1: Average Price of 5-Bedroom Housing Unit
Adapted from https://globalpropertyguide.com/Africa/Nigeria/Price-History, 2020

In outside Lagos, table 2.3 gives the average sales prices of different housing units in other popular Nigerian cities in H2 2018.

City	3-Bedroom Apartment	4-Bedroom Apartment	5-bedroom Apartment
Abuja (Maitama)	-	₦ 213,000,000.00	₦ 350,000,000.00
		$ 972,266.00	$ 972,266.00
Rivers (Portharcourt)	₦ 40,000,000.00	-	₦ 75,000,000.00
	$ 111,116.00		$ 208,343.00
Oyo (Ibadan)	₦ 13,000,000.00	-	₦ 40,000,000.00
	$ 36,113.00		$ 111,116.00
Ogun (Abeokuta)	₦ 15,000,000.00	-	₦ 30,000,000.00
	$ 31,946.00		$ 83,337.00

Table 2. 2: Average Prices of Housing Apartments in other Nigerian Cities in 2018
Adapted from https://globalpropertyguide.com/Africa/Nigeria/Price-History, 2020

2.3 The Nigerian Building Construction Industry

The construction industry poses a significant challenge, as it is essential to generate wealth, improve life through social and economic infrastructure, and links the entire spectrum of the economy with a multiplier effect that allows other industries to thrive alongside others (Noushbad et al., 2006). According to Thomassen et al. (2003), construction is commonly viewed as having a range of organisational characteristics that tend to be general and shared by various local or national environments. There is never an equal or similar construction project; every project is unique. Construction activities involve temporary project organisations, labour-intensive, fragmentation resulting from the presence of many small and subcontracting firms, separation of design and coordination from production, not innovation or optimisation as regards consumer values, low rates of confidence, and high levels of conflict. The construction market is plagued by low quality, late project completion, and cost overrun. The traditional house-building process is not designed as a foundation with continuity, instead focuses on the uniqueness and singularity of the projects characterised by the unique choice of technical solutions, limited use of platforms, a unique combination of teams, and hardly developed logistics and procurement strategies (Thomessen et al., 2003).

Locations in Lagos, Nigeria	NGN	USD*	Y-O-Y CHANGE (%)
Ikoyi	240,000,000.00	666,697	20
Ibeju Lekki	28,000,000.00	77,781	12
Lekki	55,000,000.00	152,785	0
Ajah	45,000,000.00	125,006	0
Gbagada	50,000,000.00	138,895	0
Surulere	55,000,000.00	152,785	0
Yaba	65,000,000.00	180,564	0
Victoria Island	105,000,000.00	291,680	-8.7
Isolo	50,000,000.00	138,895	-9.1
Alimosho	25,000,000.00	69,448	-10.7
Ikeja	75,000,000.00	208,343	-16.7
Ikorodu	15,000,000.00	41,669	-25

Table 2. 3: Average Prices of 4-Bedroom Housing Units in Lagos, Nigeria
Sources: Nigeria Property Centre, Global Property Guide
*Exchange rate: NGN 360 = USD 1

According to Oladinrin et al. (2012), the Nigerian building construction industry is fundamental for the operation of every other sector because they depend on its product to operate. Infrastructural and housing developments are key drivers of economic developments. According to Oluwakiyesi (2011), the Nigerian construction industry is predominantly dominated by small and medium-sized contractors. Their operations are primarily local, involving private residential buildings and estate development. The Nigerian construction sector is responsible for 1.4% of the country's Gross Domestic Product (Olatunji 2008, Dantata 2008).

2.3.1 Operators in the Building Industry

In Nigeria, the construction industry is dominated by small and medium-sized local contractors who are mainly involved in private residential projects (Ograbe A. Ahiakwo, 2014). According to Dantata (2008), it is the usual practice to consider these kinds of contractors as an unorganised group in the sectors. Organisational structures are never standardised, characterised by the execution of simple residential building

projects through the effort of direct labour and with the project owner directly supervising the project in some cases.

However, the major contractors are referred to as the organised sector by Dantata (2008). The established contractors are legally registered to carry out construction projects, posses standard structures, with a highly skilled workforce, sometimes with expatriate.

2.3.2 The Performance of the Building Sector

The Nigerian building sector has been performing far below standards. Similar to other Sub Saharan African (SSA) countries, the Nigerian construction industry is faced with enormous challenges which are constantly mitigating the development of infrastructure and the growth of the sector (Ograbe A. Ahiakwo, 2014). The industry is plagued with delays, cost overrun, and poor quality deliverables (Oyewobi *et al.,* 2011). Olesegun and Michael (2011), and Oke and Ogunsemi (2011) identified poor project definitions during planning, scope variation, inadequate funds, wrong estimation, poor cost control, inflation, inadequate planning, political factors as the root causes. Dlakwa and Culpin (1990) also added waste generations due to bureaucracy, variations, delays in procurement, and poor site administration.

2.3.3 Work Flow Scheduling and Variability in Nigerian Building Industry

The fluctuating and unpredictable cost of housing units in the Nigerian real estate market is enormous as a result of a flawed management approach to construction deliverables. According to Gonzalez et al. (2010), the traditional management approach for activities schedules is ore commonly used by the Nigerian building industries. Companies tend to plan the activities and tasks without due consideration for the personnel and workers responsible for the execution of the works but a stem of activities from the masterwork plan. Ahiakwo et al. (2012) conclude that this workflow pattern is responsible for high records of project completion delays, project abandonment, quality issues, cost overruns, and ethical issues. Olusegun et al. (2011) classified the problems into two (2) broad groups, poor planning and workflow variability. Workflow variability happens when the project process fails to follow a precise pattern.

A project workflow process is a series of sequential tasks that are carried out to execute a building plan. It is a collection of tasks (activities) that are needed to be

completed to achieve the set goals of the project completion. According to Thomas et al. (2003), the workflow is the entire material, information, and equipment resources used within a project. The impact of workflow variability has been underestimated—Ahiakwo et al. (2012) shown that workflow variability is an essential factor in construction performance. The way the workers perform primarily affects the cost and schedule performance of the project. Aibiun et al. (2006) identified that Nigerian building construction projects perform negatively (poorly) in terms of workflow variability, and this affects work crews causing ineffective work, project completion delays, and cost overrun. Thomas et al. (2003) recommended improving labour flow reliability for optimum project performance while improving workflow and work plans. According to Alsehaimi et al. (2009), quite many researchers are looking into the suitability, and in recent times, lean construction concepts and LPS implementation has been found to improve workflow reliability on construction sites.

2.3.4 Conventional Project Management Approach in Nigeria

Building project management is essential towards ensuring clients' expectations are met in terms of cost, schedule, and quality of deliverables. Opara (1986) defines Construction Management as the overall planning, execution, monitoring, and control of a project from the start to completion, with the sole aim of meeting the client requirements. The management process ensures the project is functional and financially viable. Most Project managers in Nigerian building/ construction industries are graduates of civil or building engineering, with only a few having professional qualifications in management. According to the CMAA (Construction Management Association of America), a project manager is expected to possess expert skills in Construction Management Planning, Cost Management, Time Management, Quality Management, Safety Management, Contract Administration. Arnaboldi et al. (2004) noted that in addition, a project manager is also required to define the responsibilities and management structure of a project, lead and organise implementation controls, define roles and responsibilities, establish communication protocols and identify elements of projects construction and designs likely to generate claims and dispute.

The project management approach in Nigeria is strictly in line with the provisional principles of the Project Management Institute (PMI). Recent recruitments in the field of Project Management often comes with the qualification requirement of PMP Certificate (Project Management Professional Certificate). PMBOK (2008) identifies nine

knowledge areas that Construction Project Managers should be familiar with to be considered professionals. These are as follows:

2.3.4.1 Project Integration Management Skill

According to Muller et al. (2007), every activity is required to be well-coordinated and integrated in order to achieve the desired outcome. Integration management skills ensure the project is properly planned, executed, and controlled, including project change control and management.

2.3.4.2 Scope of Management Skill

According to Project Management: Financial Perspective (2013), Changes to project scope are often the factors that "kill" a project. Scope management is sub-dividing the job tasks into manageable work components to enhance deliverable follow-up, cost monitoring, and changes tracking.

2.3.4.3 Time Management Skill

Patel (2008) refers to time management in construction as schedule management. Time management is the act of developing a project schedule planning, then controlling to ensure compliance. Time is key; the schedule is important. The importance of schedule management cannot be overemphasised. Lack of adequate, effective, and efficient time management leads to project delays and construction cost overrun.

2.3.4.4 Cost Management Skill

This involves cost estimation, cost budgeting, and tracking to keep the project within a set margin (Project Management: Financial Perspective 2013)

2.3.4.5 Quality Management

Quality is one other important factor as Time and Cost. Project Managers often overlook or sacrifice quality at the expense of time. To what advantage is it to complete a project on time, only to discover that the project delivered does not work properly (James P. Lewis, 2007).

2.3.4.6 Human Resource Management

Managing human resources is often overlooked in construction projects. According to White & Fortune (2002), it involves setting up the project team, defining the job functions and duties, and the organisational structure.

2.3.4.7 Communications Management

Involves the planning, executing, and controlling of the acquisition and dissemination of all information relevant to the needs of the project and stakeholders.

2.3.4.8 Project Risk Management Skills

According to Project Management: Financial Perspective (2013), Risk Management is the systematic process of identifying, quantifying, analysing, and responding to project risk. It includes maximising the profitability and consequences of positive events and minimising the profitability and consequences of adverse events on the project objectives.

2.3.4.9 Procurement Management Skill

Procurement is pivotal to the timely delivery of projects, especially where long lead items are required. Deciding what must be procured, requesting bids, selecting vendors, and following up is a requisite skill in procurement management.

2.4 Scheduling in Traditional Planning Approach (Activity-Based Scheduling)

The traditional project management practice is characterised by the scheduling process in the traditional way. Traditional planning is established on the working principle of the WBS (Work Breakdown Structure), a tool used to breakdown project details in other to achieve the end product or deliverables. WBS is a deliverable-oriented decomposition of the project goal. It is a technique to break down the project into more manageable and deliverable components based on different criteria such as area, function, phase, and other respects. According to Kenley et al. (2014), WBS provides an adequate means to project definition, scope identification and provides resources and interdependent actions to manage a project from start to finish (Russel Kenley and Toby Harfield, 2014).

In the view of Stal-Le Cardinal and Marle (2006), the WBS process ensures the tiniest, little task is defined and is well managed within a complex project system. Decomposition is based on a hierarchy of the project execution tree, referred to as ‘parent and child’ segmentation of the total project. Each subdivision is required to be according to the project’s predefined scope and completion deliverables.

3.0 Lean Construction And Cost Management Concept

3.1 Lean Thinking- The Principles

Waste is never a friend with the cost. Waste is key to project cost overrun. In recent years, construction economists around the world have taken waste in the construction industry as the subject of several research projects. Different methods have been tested and investigated. Abbasian et al. (2012) affirmed that the lean approach is one effective method that can be implemented in the construction industry. The generic principle of lean, its technologies, and tools can easily be applied. Lean thinking is hinged on waste reduction for improved performance. The definition of lean construction is about applying lean principles to the building sector (Koskela L, 1992). Lean construction is about optimising the building project in terms of schedule, cost, and quality while ensuring it exceeds consumer or client expectations. Lean is as much a collection of concepts as theory and culture. Regardless of the environment which takes the developer, contractor, or manufacturer view, the end-to-end supply chain needs to be engaged. The contractor has a unique role in managing downstream activities within the supply chain. In Lean Construction, owners, designers, contractors, and suppliers of general and speciality work team-up together to create value-added, constructible, facilities, and maintainable (Ballard and Howell, 1998).

Koskela. L (1992) indicates that its implementation involves a fresh approach in thinking about the entire process from design to construction to reduce waste, create a continuous workflow, and dramatically improve value for the project owner. Lean main principles are: *specify a value from the perspective of the end customer*, *clearly identify the process which delivers customer values* and *eliminate all non-value adding steps, make the remaining value-adding steps flow without interruption, let the customer pull-do nothing until it is needed, then make it quickly, pursue continuous perfection improvements.* Lean is about creating and consistently applying values that are right for the company to achieve high output that continues to generate value for consumers and society. Lean drives competition and productivity (Mastroianni and Abdelhamid, 2003).

3.2 The Lean Philosophy

The Lean philosophy of production has been successful in the manufacturing industry. Lean construction is a derivative of the Lean Production Concept of Toyota. For years,

Lean manufacturing processes have been used and mastered in manufacturing facilities around the world. Many see Toyota's "Just-In-Time" development (providing the requisite parts for the car when it's needed instead of storing them) as the historic accomplishment of Lean Production (Malloy, 2002). This attracted the attention of the construction industry experts to the rising challenge of project delays, schedules, quality, and cost overrun. The lean process is achieved by shifting management's emphasis from optimising separate technologies, assets, and departments to maximising the flow and exchange of goods and services across the entire value stream that horizontally flows to the customer. There have been attempts to create and promote a −lean construction concept since the early 1990s, through institutes, government reports, construction management scholars, some professional organisations. Louri Koskela was the first to introduce the lean movement in manufacturing to the construction sector.

3.3 The benefit of Lean Construction

Lean construction provides a way to design production processes to reduce waste of resources, time, and energy to produce as much value as possible (Koskela et al. 2002). Lean is a theory and not a collection of strategies and methods (Koskela L, 1992). Lean provides companies with ideas and concepts to strengthen processes, using a range of standard and creative methods and techniques. Terminology and programs can be daunting, but it is a fundamental concept that can be clouded by methods and techniques. He further notes that Lean requires a straightforward concept of common sense, which can be applied in the enterprise from the most basic level of operations. Lean thinking can bring drastic changes, which are especially appealing for consumers. Shen et al. (2001) on Lean thinking, the reduction in costs is the aim of lean practice, not the income. Faith relationships (trust) between customers and suppliers are vital to achieving such dramatic savings. The focus should be on cost, time, and quality —these parameters are determinant of Lean performance.

Lean is a communication-rich, regulated manufacturing process based on the concepts of lean production and operational control found in manufacturing. Lean is about using products, people, and energy in a balanced manner. It helps in cost optimisation, reduces duplication, and executes projects on time. Abdelhamid (2004) describes Lean Construction as a holistic facility design and delivery strategy with the ultimate

objective of optimising value for all stakeholders through systemic, synergistic, and on-going changes in contractual agreements, product design, creation of the construction process, and selection of technologies, supply chain, and efficiency of site operations.

3.4 Construction Wastes via Lean Thinking

Lean construction creates a working environment among employees and departments whose goal is to eliminate all waste forms within the project. During the last decades, many research efforts have been made in order to classify construction waste according to different attributes such as kind, quantity, etc. In spite of different classifications, all of them follow the same basic concept (Abbasian et al., 2012). Excess materials, delays, re-work, and defects are those wastes commonly mentioned by researchers (Senaratne and Wijesiri, 2008). Although the term' construction and demolition waste' has been defined as any kinds of solid waste generated during construction processes, Formoso et al. (2002) recommended a more broad definition of waste to include not only material waste but also waste generated in a construction project such as waiting times, transportation times, and etc.

The non-physical waste within construction processes is the basis of the waste concept from the lean construction approach. Actually, these kinds of waste are those wastes that occurred during the construction processes. Koskela (1992) also states that a systematic attempt for identifying wastes in construction processes (flow wastes in lean thinking terms) has not been made by the construction management practitioners until the lean construction concept was introduced. Innovative waste categorisation, which is considered a lean thinking concept, is illustrated in Fig. 3.1, according to Abbasian et al. (2012).

3.5 Alternative Planning Technique -Location-Based Management System

According to Kenley and Seppänen (2010), location-based scheduling provides alternative methods based on tracking the continuity of crews working on production tasks. Location-based Management system (LBMS), the Lean-BIM technique, provides an effective method to eradicate barriers and challenges of wastes culminating in delays and cost overrun. The concept has been found to improve used resources in the project through the visualisation of locations for each activity on the site. Russell Kenley and Olli Seppänen (2010) defines *LBMS as an integrated network of management*

system component potentially involving all stages of construction, from design through to completion. The system components are unified through their knowledge of the location. In location-based scheduling, data components integration into a knowledge-base for a project is possible. It is not a building information model (BIM) but rather a methodology for interacting with BIM.

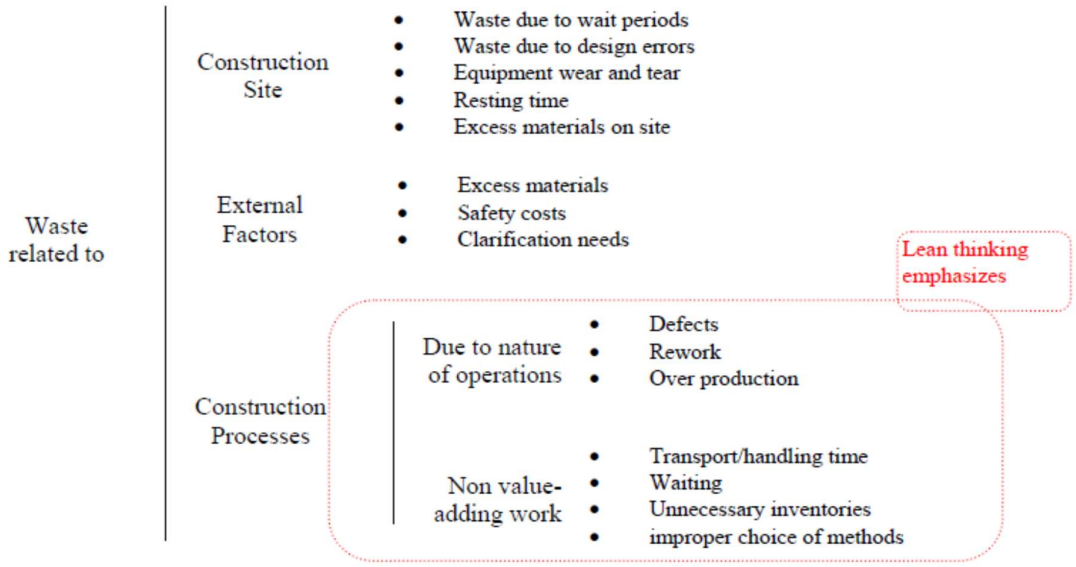


Figure 3. 1: Construction Wastes Categories in line with Lean Thinking
Source: Abbasian et al.,2012

3.5.1 History of LBMS

The origin of the LBMS concept is based on the graphical technique that was used in 1929 in some projects such as the Empire State Building in the USA. Since this time, significant researches have been undertaken in the 1960s and 1970s on this technique but was discovered that LBMS is not adequate for non-repetitive projects (Kolltveit et al., 2007). There are different names used for this technique during the last decades, such as LOB, linear scheduling, and matrix schedule. This family of methods involves repetitive activities, which Harris and Ioannou (1998) gave the generic term repetitively

Figure 3. 2 :Pictorial Representation of typical Wastes in Construction Processes
Source: Alsaleh (2020)

Scheduling method (RSM). Figure 3.3 shows a typical LBMS schedule. Russell Kenley (2004), considering the appropriateness and descriptive character of the method, decided to call it location-based scheduling. The proposed paradigm is more concerned with the movement of the workforce and other resources through project locations. It is more appropriate to describe the proposed method as multiple locations oriented with full traditional functionality (Battersby, 1964).

3.5.2 How LBMS Supports Lean Construction

The LBMS methodology harmonises with lean production strategies in many ways. The core concept of lean construction is the flowline, and the flowline principle is the continuous use of the work resources. It sets the daily works based on a chain of progress through locations instead of activities with random places or vague locations. Knowing the location of each activity by management can identify the location of the entire resource and correlates the needed resources in each place. LBMS planning method does not need an unprecise estimation for productivity, but it provides a realistic production rate target based on quantities, resource availability and tight estimation of productivity.

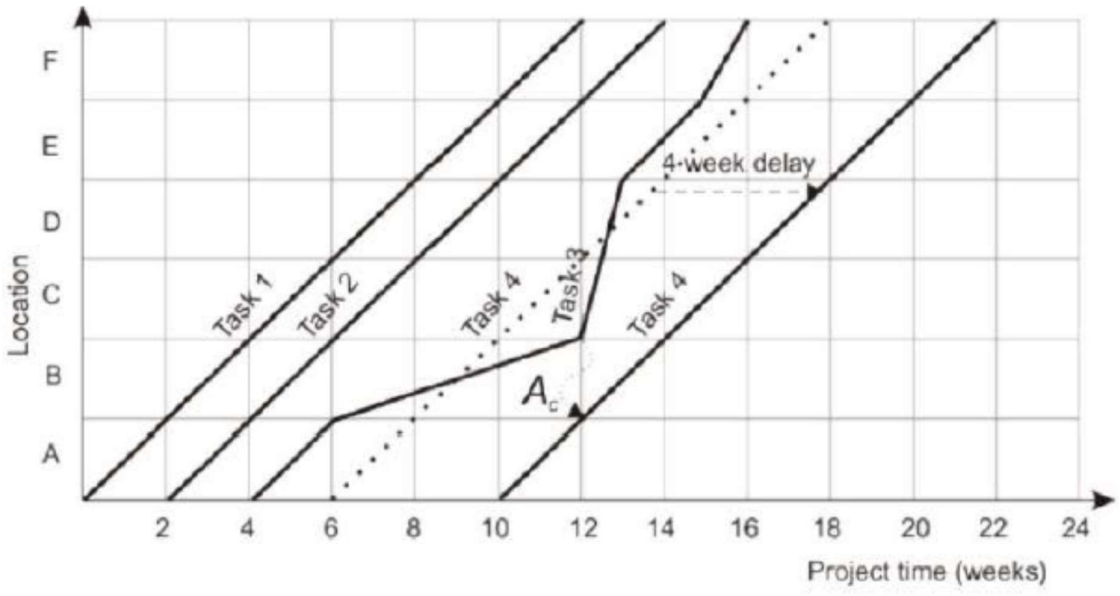


Figure 3. 3: Typical LBMS Schedule
Source: Alselah (2020)

3.5.3 Location Breakdown Structure (LBS)

Location Breakdown Structure (LBS) is an important tool for LBMS. According to Russel Kenley and Toby Harfield (2014), when LBS combined with suitable models and management strategies can production efficiency in a systematic way. It should not be confused that LBS is not a building information model (BIM), but rather a methodology for interacting with a BIM (Kenley et al.,2014). Ibrahim et al. (2009) found that the building elements, work sections, physical locations, and construction aids are the mostly used decomposition criteria for project WBS formulation. By this, it indicates that location is a key factor as it found its usefulness also in the WBS hierarchy. Ibrahim et al. proposed building projects also be decomposed in the hierarchy order based on the criteria of sections, building elements, and location. Location is at the key centre of a location-based management system.

The location serves as the storage device for the project information and is used as the primary work station through a location breakdown structure (LBS)—rather than the more familiar work breakdown structure (WBS). The LBS, the arrangement is such that the higher-level location logically incorporates all the lower level locations (Kenley et al.,2014). The hierarchies are defined by purpose. While highest level locations are useful for optimising construction sequence due to the inter-dependencies of sections, the middle level is essentially used to plan the production flow of the structure. With this arrangement, starting the sections in any sequence or simultaneously is possible. The lowest location levels are needed to plan the project details and finishes. The hierarchical order permits project data to be collected at different levels.

3.5.4 Planning Processes in LBMS

The planning process in LBMS is an important process towards the realisation of a Lean target process. LBMS requires firstly defining the Location Breakdown Structure (LBS). The project Work Breakdown Structure (WBS), if already existed for the project, needs to be replaced. The key to changing thinking perception of project management is to change the decomposition strategy of the project structure. WBS is known for its single hierarchy structure with the difficulty of meeting conflicting demands challenges. As a way forward, the breakdown structure uses the location from the hierarchy to create a matrix. It is breaking down a project in a way as this clarifies the advantages of location-based management (Ibrahim et al., 2009). The WBS once freed of location

- repetition is more efficient for use on the work being executed. The LBS creates a matrix that removes data redundancy in repetitive WBS.

3.5.4.1 Calculating Location-based Quantities

BOQ is an important tool for location-based quantities estimation. This task is initiated as soon as the Location Breakdown Structure of the project is formulated. The Project Management team gets clarification of the workload that must be executed in a specific location. BIM tools are employed in this case for a more accurate quantities measurement; otherwise, manual measurement is adequate. The BOQ shows when the work will be done before relocating to the next location.

3.5.4.2 Establishment of Tasks in Project Locations

Each location is the container of all data (Ibrahim et al., 2009). LBMS planning supports the ideology of produce a workflow in each location. Flowline planning can optimise production efficiency and backing lean theory (Kenley and Seppänen, 2010). Flowline can be defined as a simple line that represents the flow of work through the different locations on a single graph that contains the LBS on the Y-axis and project time on the X-axis. Its graph has a single line to represent the entire works in various locations, while traditional methods would have been represented by numerous lines. The sequences and the interrelationships among the tasks are similar to the principles of traditional planning. Buffer is the elementary attribute of LBMS, and it can be defined as a presumptive delay in time between the completion dates of two activities. It is classified as horizontal and vertical buffers.

3.5.4.3 Assigning Resources in LBMS

It is important to scrutinise the process for design specifications, special client requirements, and other circumstances before proceeding to resource allocation. Knowing the productivity of each crew increases cyclic activities. Specialised crew members are assigned to each task unit while adding crews gradually to the task as needs arise, not in a single batch.

3.5.4.4 Task Duration and Project Cost Estimate in LBMS

The productivity of each crew is calculated for 1metre of an item. The total quantity is obtained when the productivity is multiplied by the total quantity of the item. Project cost is the total cost of the entire activities in each location. This system is powerful

because it estimates the cost of the full location. This ideology is effective in allocating the due date for expenditures and revenues; it depends on the actual cost of needful resources in production. It does not depend on benchmarks or previous projects. LBMS maintains a constant cost plan and reduces variations during the project, taking adequate control of all risk factors in the project.

3.6 Project Monitoring and Control in LBMS

By implementing location-based control, the management can commit to the subcontractors, ensuring that the work will proceed in a foreseeable and continuous way (Kenley & Seppänen, 2010). Monitoring is conducted for each section based on its BOQ, and contractors are prevented from leaving their place unless work is completed 100%. The system uses the locations and visualisation to detect problems before they take place. The forecast is used to remind the management that there are problems yet to be solved. The location-based control model will detect changes in quantity, delays in starting up, changes in production rates, and also if trades are working out of sequence, changes in the production, and the production prerequisite (Hákon Jónas Ólafsson, 2018). This leads to improved efficiency in production. In accordance with Kenley & Seppänen, the control system has four stages of production information: “The location-based control model utilises four stages of production information. The stages are baseline, current, progress, and forecast.” (Kenley & Seppänen, 2010, p. 403) There are two types of task used to establish the control of the schedule in the four stages: scheduled (baseline) tasks, which are the tasks present in the baseline schedule, and detailed

3.7 LBMS Tool- Vico Office Application

Vico Office is a 5D BIM tool and considered a stellar solution in the construction market in recent times (see figure 3.2). It has a complete feature of full CPM, Bar Chart, and Location-based structure functionality in a single software. The level of the work process in the building industry has developed over the last two decades. Building Information Modeling (BIM) has been described as one of the most promising developments in the AEC industry (Hákon Jónas Ólafsson, 2018). With this technology, one

or more virtual models are constructed with the purpose of improving the work process from the design phase throughout the life of the building. BIM affects the whole life cycle of the building process, including the design, construction, and facility management (Eastman et al., 2011).

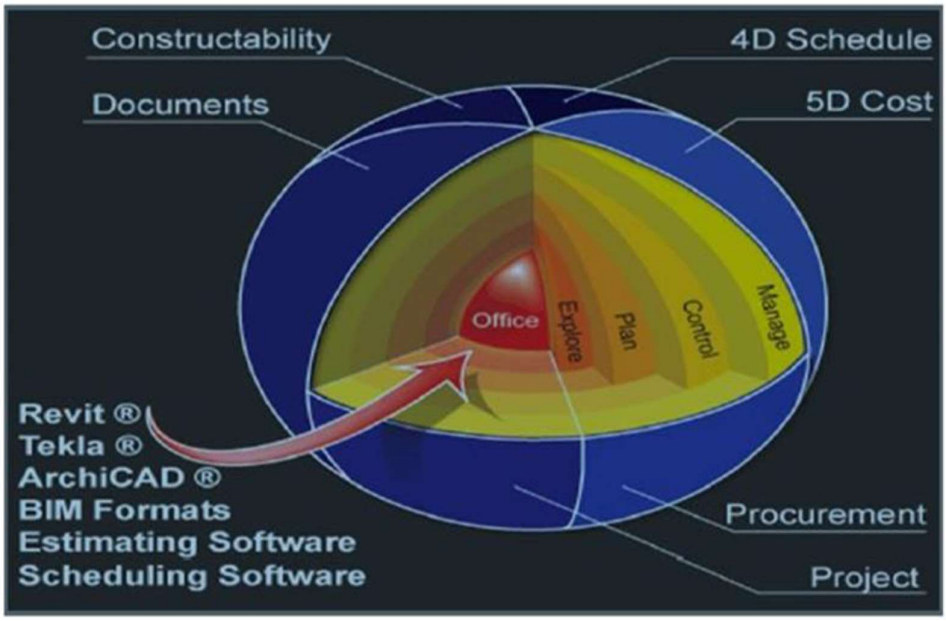


Figure 3. 4: Vico Office 5D BIM Tool
Source: Alselah (2020)

Vico Office is a planning, scheduling, and control tool, and initially, the application was called Dyna Project. The application was developed in Finland by Olli Seppänen. It was created to suit the Location-Based Management System, with its development based on Finnish research. Furthermore, the application was first presented internationally at Stanford and Berkeley in 2003 (Seppänen, 2009). Vico Office offers integrated solutions in coordination and clash detection. The objective is to resolve problems before the start of the project. Takeoff Manager in the Vico Office suite helps to extract quantities from the building model. This is called the Quantity Takeoff, which is the fourth item in the sequence above. Next comes one of the bases of the system, the Location Breakdown Structure (LBS). The location definition is performed in the LBS Manager. The creation of the schedule is performed using the Vico Schedule Planner. At this point, it is possible to connect the models and the BIM components to

the work crews, resources, and materials. Another part of the system is the cost estimating, which is based on Target Cost Planning.

4.0 Research Methodology

4.1 Introduction

The word “Research” has been defined by different scholars. The Oxford English Dictionary (2007) defined research as the investigation and study of materials so as to establish facts or reach a logical conclusion. The Longman Dictionary (1997) defined research as a serious study of a subject that is intended to discover new facts or test ideas. Payton (1979) defined it as the process of looking for a specific question in an organised, objective and reliable way. Kerlinger (1873) sees research as a systematic, controlled, empirical and critical investigation of hypothetical propositions about the presumed relations among natural phenomena. Research is not complete without the identification and definition of the process, techniques and tools to achieve it.

Easterby-Smith et al. (2002) defined Methodology as a set of techniques or procedure used to inquire into a problem. Crotty (1998) defined ‘Methods’ on a more elaborate form and in specific terms as the techniques or procedures used to gather and analyse data related to research questions or hypotheses. The research question of interest in this project is:

Can Alternative Planning Technique (Lean-BIM) be successfully applied to optimise construction costs in the Nigeria Real Estate Industry?

4.2 Research method

At this point in time, it is essential that the author gives clearer details of how the research work would be executed. While aiming to answer the research question, it is necessary to investigate the sector that the problem formulation covers. This is conducted using a pragmatism research philosophy by implementing mixed method research (Bryman, 2016) involving qualitative and quantitative methods. Qualitative methods are used to investigate the company’s internal factors, which will influence the integration of the Lean Construction Principles. In addition, the status of management, scheduling and control in the company’s projects will be assessed by conducting interviews, observations and data gathered during the investigation.

A quantitative method is used to explore the external barriers concerning the integration of the LBMS by sending out a questionnaire. In addition, information was collected about material quantities and the number of employees working in the company's projects. There was no possibility to collect quantitative information regarding the company's operation performance, so for that reason, qualitative methods were applied.

4.3 Design Science Research, DSR

This research aims to adopt the Design Science approach to address the problems of the research questions. According to Formoso *et al*. (2012), the ultimate goal of a Design Science Research is to produce scientific knowledge by developing scientifically grounded solutions that links theory and practices while solving real-world problems. This is a no better approach to finding the solution to the problems of cost uncertainties that characterise the real estate industry in the Nigerian market. Ahiakwo (2014) while reviewing the different processes of implementation of design science research method, identified that the process proposed by Lukka (2003) is the most suitable for ease of adaptability and quality of results. The process includes:

-Identify a problem; -access the problem; -understand the problem; -innovate a solution; -implement a solution; -identify and analyze theoretical contributions.

This research was conducted as applied research with a case study, with projects within the real estate property developments located in Lagos, Nigeria. The case study shall be a project which is currently in the execution phase. The research applied the design approach method, according to Herrington (2007), starting with the research hypothesis. In this case, due to current challenges of COVID-19 and limited time, research hypothesis will not be tested in the field. The research aims to investigate the 'cost gains' because of the optimisation process of Lean-BIM Location-Based Management System (LBMS). Further to this, the research hopes to evaluate the opportunities, advantages, and challenges in the implementation process of LBMS in Nigerian projects. Refer to Figure 4.1 and 4.2 for the research structure.

The research process is divided into six broad sections, as shown in figure 4.1, starting with the theoretical study. The first part includes the problem formulation, where the problem statement is developed, the definition of research questions, and the formulation of problem de-limitations. Then the history of lean and its principles were

explored, the author compares the traditional and lean approach to project management in relations to location and activity-based systems of management. The theoretical framework about Lean construction and Location-Based Management System was formulated from books and articles, the information which was essential for integration into the case studies.

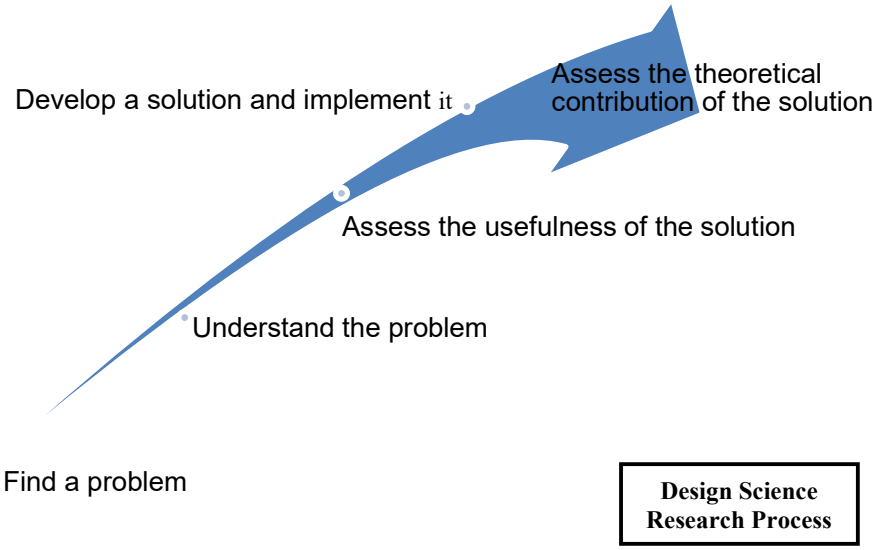


Figure 4. 1: Design Science Research Process

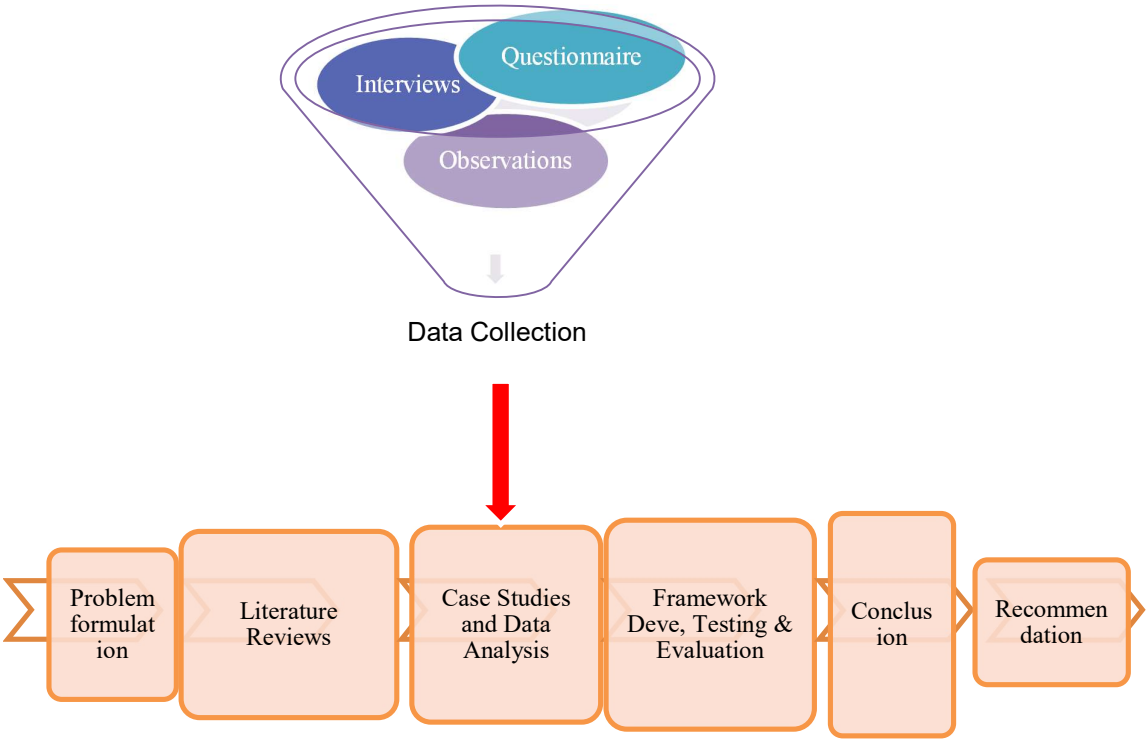


Figure 4. 2: Research Process

Data collection is divided into two, data collected internally and externally. Internal data refer to the data obtained from the company, while the external data refer to data from professionals within the construction field. The research obtained the current situation in the company's planning, scheduling and on-site production progress and compared these with the LBMS procedures. Issues involving integration are explored. Thereafter, the findings from the questionnaire are introduced. The thesis thereafter lists the advantages, opportunities and challenges of integrating the system into the company. Finally, a conclusion is presented, and suggestions for further research are outlined in the discussion.

4.4 Data Collection Method

The research explored the combination of three data collection methods for information sourcing. Interviews, observations and questionnaires were implemented. According to Bryman (2016), semi-structured explorative interviews were conducted with the companies' owners and production managers, respectively, via Microsoft teams. Questions were fielded with the target on obtaining vital information needed by the research starting with the information about the company history and its future direction, its operations, employees, the internal situation of the company, technical information, work procedures, planning methods, project controls and financing, cost, sales of property, past effects of uncontrolled cost of construction on the property, etc.

The objective was to acquire the necessary information about the procedures implemented in the company during planning, scheduling and on-site control to support the solution for the problem formulation and research questions. Refer to Appendix A, B and C for the interview questions. The researcher performed project observations through pictures as it is difficult to visit the construction site due to distance, time and COVID-19 challenge in the country.

Questionnaires were sent out to construction experts in Nigeria to investigate the external barriers to integrating Lean-BIM optimisation techniques of Location-Based Management System (LBMS) into real estate projects in the country. The questionnaire contained background questions. Thereafter, information about the work procedures was collected. Questions were asked regarding the respondents' use of Building Information Models (BIM) in their work and what kinds of software were used among the respondents when planning and scheduling. Additionally, the knowledge of theory and skills in the software applications used in construction management was investigated. The respondents were asked to evaluate their knowledge and skills on the scale from "Poor" to "Excellent". The respondents were also asked to respond to a list of statements which assessed their opinion on the possibilities of improvements by implementing the LBMS and the barriers to its integration. The questionnaire design is located in Appendix B.

5.0 Case Study (Residential Terrace Duplex Apartments)

5.1 Case Background

The case study is an on-going estate development projects in Lekki suburb of Lagos, Nigeria. It entails the construction of blocks of five (5) Terraced duplexes of 4 bedrooms with a ground floor plan shown in figure 5.1. Figure 5.2 is currently showing the status of work progress on the site. This chapter is dedicated to the analysis of a block of the 4-bedroom duplex which already has been conventionally (traditionally) planned by the company. The aim of the study is to examine the impact of lean principles and the use of LBMS using Vico Schedule for performance improvement of the project in terms of waste reduction and analysis of the cash flow.

Most projects in Nigeria have suffered a setback from the invisible effects of cash flow anomalies. Negative cash flow and labour cost waste have led most estate developers into taking loans with interest rates factored into the eventual cost of the project. The case study was chosen based on data availability, and the willingness to solve the menace of the rising cost of construction and create an affordable housing unit for the low income in the society.

5.1.1 Project Location

The project location is the most expensive and highly demanded residential area in Lagos city, Nigeria. The land is part of the reclaimed landmass in the city, and as a result, care is required in the choice of foundation. The project location is an open area, accessibility is not a problem, materials are easily delivered, and safety is assured. It is never a challenge sourcing competent tradesmen and artisans in the city, but sure there is competition for best hands due to other development projects in the area.

5.1.2 Company Organisation Structure

The real estate company is coded with the name LSR1. It is an indigenous company whose services includes sales, development (construction), leasing, and management of housing units, and other properties. It controls average 50 direct staffs and other indirect staffs that includes the Real Estate teams (responsible for sales, customer service, technical, etc.), construction development teams of engineers, architects, quantity surveyors, project managers, planners, builders, foreman, plumbers, and

bricklayers. The company was established in 2011 with head office in Lagos. The CEO is a Project Management Professional with a background in Civil Engineering. The company has successfully completed several residential buildings, including sales in different cities in Nigeria. Detailed information is as obtained in Appendix A (Research Interview).

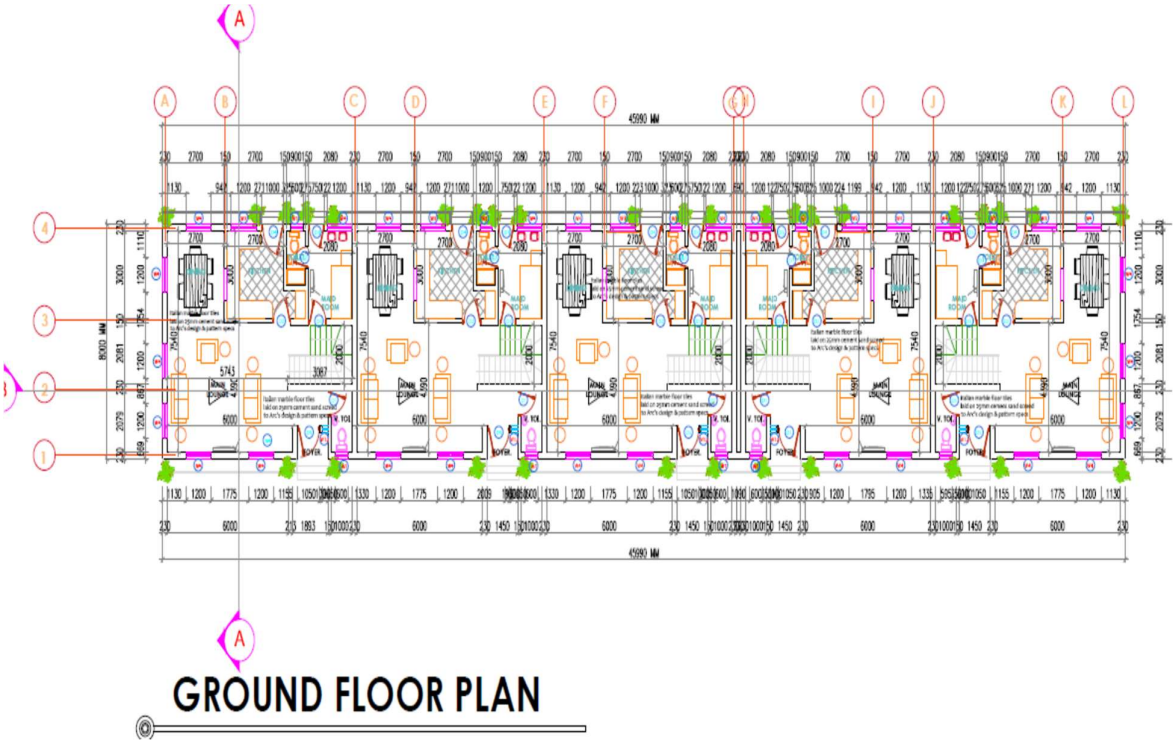


Figure 5. 1: Block One (1) of 5 Terrace Duplexes of 4 Bedrooms Flat

Figure 5. 2:Pictorial View of Work in Progress at the Site

The company organisation structure is like the structure described in figure 5.3 below. The Project development manager is responsible for construction works of the housing developments. He controls and oversees the activities of the project managers, engineers, architect, project quantity surveyors, and supervisors. He is responsible for the cost performance of the project.

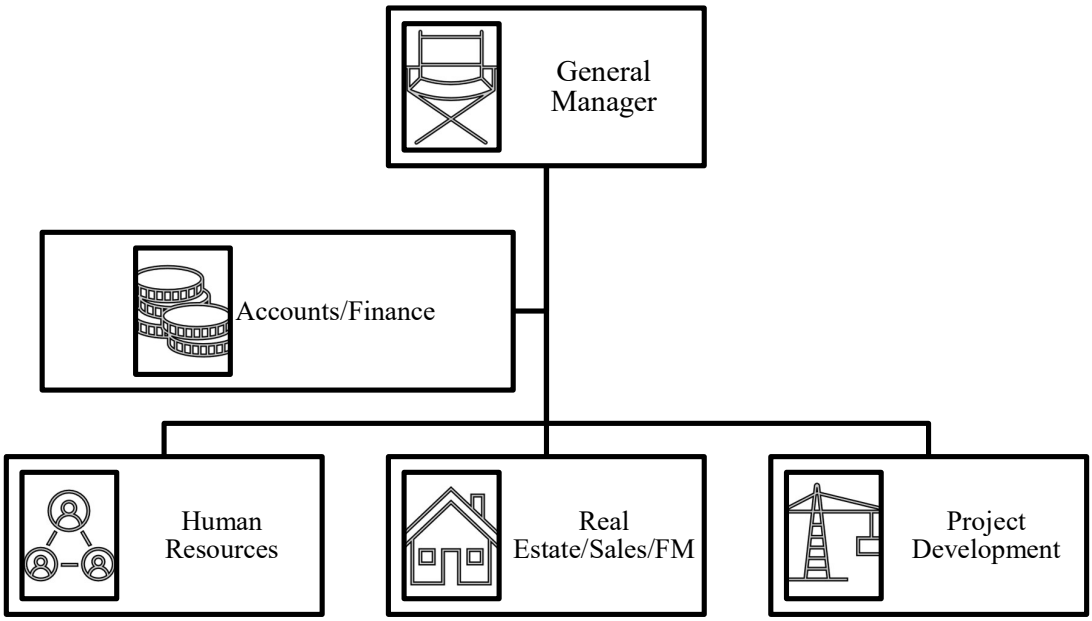


Figure 5. 3: Organisational Structure of company LSR. (Top level)

5.2 Case Study Analysis

To fully assess the potentials of Lean Construction for cost optimisation is equal to evaluating a live (real) project subjected to the lean construction principles. The project is investigated for costs performance in terms of cash expenditures, cash inflow (from project sponsors) and labour waste cost before optimisation. The same process is repeated after the optimisation process using lean support BIM tool (Vico Schedule Software). Wastes is essentially a key factor in project execution processes which affects the overall project optimisation process in terms of time and cost. The analysis process intends to keep the production rate of the project constant while reducing the project wastes by the application of the lean principle during the optimisation phase. The identification of all non-value adding activities, durations and resources will be made by invoking the value stream method and the effect on the cash flow performance investigated.

5.2.1 Data Collection

S/No	Description	Data
1	Type of Project	Block of 5 Duplexes (4-Bedrooms)
2	Project Category	Housing Development (Estate)
3	Project Location	Lekki, Lagos State, Nigeria
4	Project Start Date	February 2019
5	Project Completion Date	June 2020
6	Contract Duration	17 months
7	Project Cost	₦396,677,700

Table 5. 1: Data Summary of Case Study Project LSR1

5.2.2 The Planning and Schedule Method

Project planning was executed using MS Project in the traditional way, as seen in figure 5.4 below. It involves the breakdown of work activities into predefined unit tasks (Work Breakdown Structure). Since the project finance and sponsor is from the bank, the project time schedule and cash flow need to be prepared and agreed for funds to be disbursed accordingly. The planning and scheduling for the project was a joint exercise between the management team of a project manager, engineers, planner, supervisors, and architect. Evaluation of project tasks and activities were done based on different factors such as size, manpower, weather, and resources. After the time schedule is done, the expected projected cost is determined, and the cash flow analysis prepared. As illustrated in figure 5.4, the drawings were reviewed and approved before any construction, and administrative works proceeded out of it.

Quantities are extracted from the drawings using Microsoft excel, and BOQ prepared. The bill of quantities is organised using the seven (7) points building project Work Breakdown Structure (WBS) as stated below:

- Work Area
- Earthwork

- Structure
- Roof
- Façade (External finishes)
- Internal finishes
- Landscaping

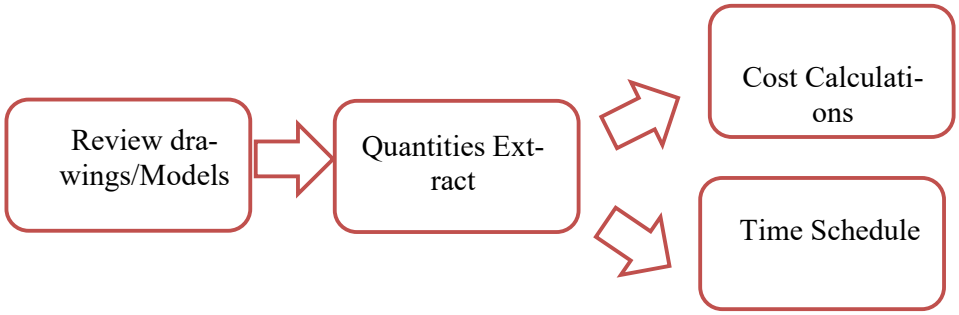


Figure 5. 4: Illustration of the Planning and Scheduling Process within the company

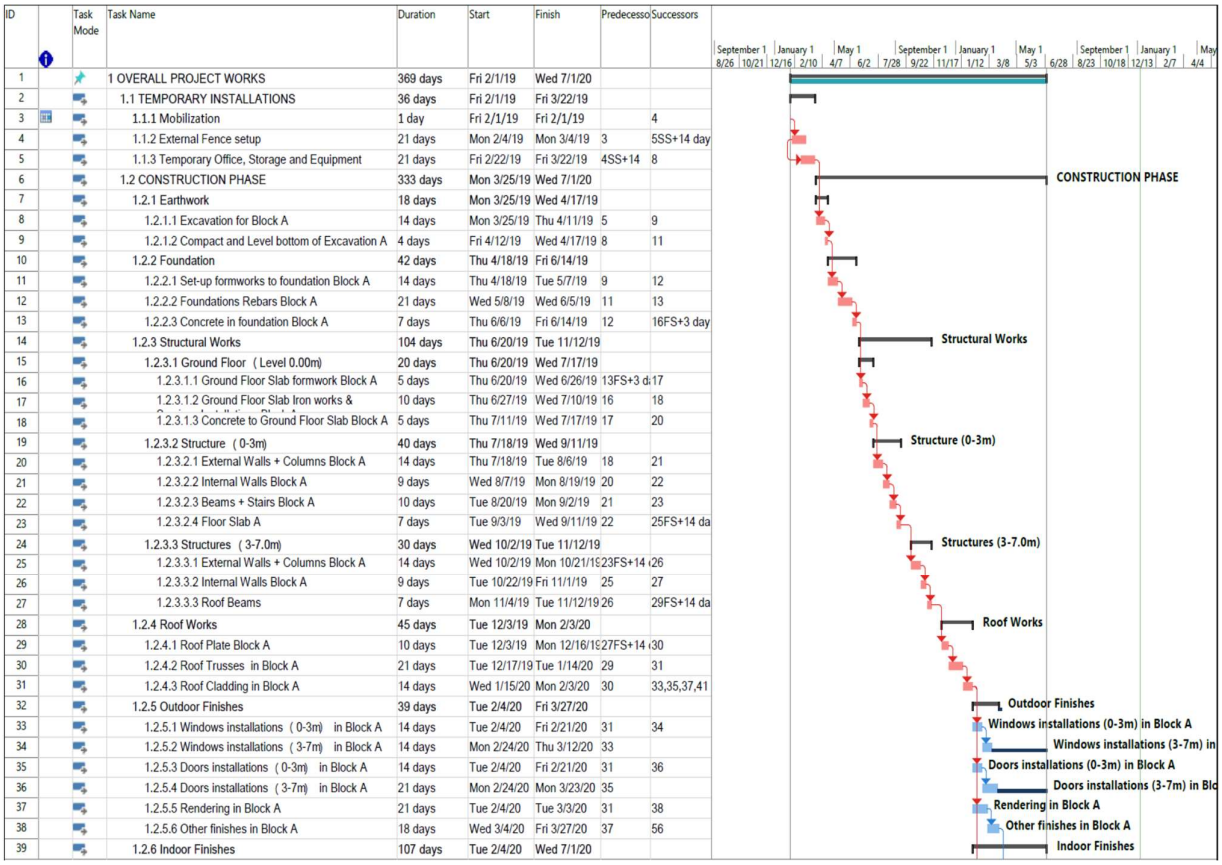
The WBS is further divided into activities (tasks) within these seven categories, such as roof, walls, floor, painting etc. After the quantities have been extracted, the cost calculations and schedules are performed, as shown by the process flow in figure 5.4. Project Cost is determined by equation 5.1 below.

$$\textbf{Total Cost}\ (€) = \mathbf{Q} * (\mathbf{M} + \mathbf{EM} + \mathbf{W} * \mathbf{L})$$

Equation 5. 1: Project Cost Calculation

Where Q: Total quantity of the item, M: Cost of material, EM is equipment cost, W labour cost/hour and L is the productivity hours/unit

The project planning and time schedule are setups in MS Project according to the project's Work Breakdown Structure (WBS), as previously stated. The schedule is formulated by using Finish to Start (FS) and Start to Start (SS) dependencies between activities (see figure 5.5 and Appendix E). The critical path is shown in red colour in the project's schedule.



ID	Task Mode	Task Name	Duration	Start	Finish	Predecesso	Successors
1		1 OVERALL PROJECT WORKS	369 days	Fri 2/1/19	Wed 7/1/20		
2		1.1 TEMPORARY INSTALLATIONS	36 days	Fri 2/1/19	Fri 3/22/19		
3		1.1.1 Mobilization	1 day	Fri 2/1/19	Fri 2/1/19		4
4		1.1.2 External Fence setup	21 days	Mon 2/4/19	Mon 3/4/19	3	5SS+14 day
5		1.1.3 Temporary Office, Storage and Equipment	21 days	Fri 2/22/19	Fri 3/22/19	4SS+14	8
6		1.2 CONSTRUCTION PHASE	333 days	Mon 3/25/19	Wed 7/1/20		
7		1.2.1 Earthwork	18 days	Mon 3/25/19	Wed 4/17/19		
8		1.2.1.1 Excavation for Block A	14 days	Mon 3/25/19	Thu 4/11/19	5	9
9		1.2.1.2 Compact and Level bottom of Excavation A	4 days	Fri 4/12/19	Wed 4/17/19	8	11
10		1.2.2 Foundation	42 days	Thu 4/18/19	Fri 6/14/19		
11		1.2.2.1 Set-up formworks to foundation Block A	14 days	Thu 4/18/19	Tue 5/7/19	9	12
12		1.2.2.2 Foundations Rebars Block A	21 days	Wed 5/8/19	Wed 6/5/19	11	13
13		1.2.2.3 Concrete in foundation Block A	7 days	Thu 6/6/19	Fri 6/14/19	12	16FS+3 day
14		1.2.3 Structural Works	104 days	Thu 6/20/19	Tue 11/12/19		
15		1.2.3.1 Ground Floor (Level 0.00m)	20 days	Thu 6/20/19	Wed 7/17/19		
16		1.2.3.1.1 Ground Floor Slab formwork Block A	5 days	Thu 6/20/19	Wed 6/26/19	13FS+3 d	17
17		1.2.3.1.2 Ground Floor Slab Iron works &	10 days	Thu 6/27/19	Wed 7/10/19	16	18
18		1.2.3.1.3 Concrete to Ground Floor Slab Block A	5 days	Thu 7/11/19	Wed 7/17/19	17	20
19		1.2.3.2 Structure (0-3m)	40 days	Thu 7/18/19	Wed 9/11/19		
20		1.2.3.2.1 External Walls + Columns Block A	14 days	Thu 7/18/19	Tue 8/6/19	18	21
21		1.2.3.2.2 Internal Walls Block A	9 days	Wed 8/7/19	Mon 8/19/19	20	22
22		1.2.3.2.3 Beams + Stairs Block A	10 days	Tue 8/20/19	Mon 9/2/19	21	23
23		1.2.3.2.4 Floor Slab A	7 days	Tue 9/3/19	Wed 9/11/19	22	25FS+14 da
24		1.2.3.3 Structures (3-7.0m)	30 days	Wed 10/2/19	Tue 11/12/19		
25		1.2.3.3.1 External Walls + Columns Block A	14 days	Wed 10/2/19	Mon 10/21/19	23FS+14	26
26		1.2.3.3.2 Internal Walls Block A	9 days	Tue 10/22/19	Fri 11/1/19	25	27
27		1.2.3.3.3 Roof Beams	7 days	Mon 11/4/19	Tue 11/12/19	26	29FS+14 da
28		1.2.4 Roof Works	45 days	Tue 12/3/19	Mon 2/3/20		
29		1.2.4.1 Roof Plate Block A	10 days	Tue 12/3/19	Mon 12/16/19	27FS+14	30
30		1.2.4.2 Roof Trusses in Block A	21 days	Tue 12/17/19	Tue 1/14/20	29	31
31		1.2.4.3 Roof Cladding in Block A	14 days	Wed 1/15/20	Mon 2/3/20	30	33,35,37,41
32		1.2.5 Outdoor Finishes	39 days	Tue 2/4/20	Fri 3/27/20		
33		1.2.5.1 Windows installations (0-3m) in Block A	14 days	Tue 2/4/20	Fri 2/21/20	31	34
34		1.2.5.2 Windows installations (3-7m) in Block A	14 days	Mon 2/24/20	Thu 3/12/20	33	
35		1.2.5.3 Doors installations (0-3m) in Block A	14 days	Tue 2/4/20	Fri 2/21/20	31	36
36		1.2.5.4 Doors installations (3-7m) in Block A	21 days	Mon 2/24/20	Mon 3/23/20	35	
37		1.2.5.5 Rendering in Block A	21 days	Tue 2/4/20	Tue 3/3/20	31	38
38		1.2.5.6 Other finishes in Block A	18 days	Wed 3/4/20	Fri 3/27/20	37	56
39		1.2.6 Indoor Finishes	107 days	Tue 2/4/20	Wed 7/1/20		

Figure 5. 5: Screenshot of the Case Study Schedule in MS Project

5.2.3 Project Cost, BOQ and Sponsor Instalment Rates

Refer to Appendix C for the Project Bill of Quantities and Unit Prices as obtained from the Real Estate Firm. The Total Project Cost is obtained using equation Equation 5.1 plus 10% overhead. The unit price of the quantities, as shown in Appendix C is inclusive of the cost of materials, equipment and labour. For the purpose of this analysis, the labour cost is 35% of the total construction cost, while materials and equipment are 35% and 20% respectively. From Appendix C, it is possible to see how the Total Project Cost is calculated in excel tables.

Traditionally, construction funds are released by instalment as progress is made with the construction works. The project sponsor agreed to instalments payment rates as the project progresses. Table 5.2 (Also, in Appendix D) below shows the agreed rates by Sponsor Banks. Based on this agreement, the estate developers received funds as each stage of the milestones is completed while ensuring quality delivery.

5.3 Before Optimisation Analysis

5.3.1 Flowline Representation of Planning

Since the problem formulation of the research is about investigating how lean-BIM principles can optimise the work process for housing unit developments in Nigeria while reducing cost, to be able to achieve this, the traditional schedule as received from the company in MS project is represented in Vico Schedule, as shown in figure 5.6. With this, the opportunities for optimisation can be clearly implemented while identifying the faults and challenges with the schedule. Figures 5.7 and 5.8 show the Flowline Representation and Resource Graph, respectively before the optimisation process.

Instalment Rate as per Sponsor Bank Agreement		
No	Item	Percentage of Const. Cost %
1	Received at the Beginning of Excavation and Foundation	30
2	Structural Works	35
3	Roof Works	6
4	MEP Works	11
5	Fixation of Windows, Glazing works, and Interior Plaster works and screed	5
6	Completion of all Interior works including Tiles, Plaster, and kitchen	5
7	Façade works	4
8	After Handing over	4

Table 5. 2: Funding Agreement for Construction Cost

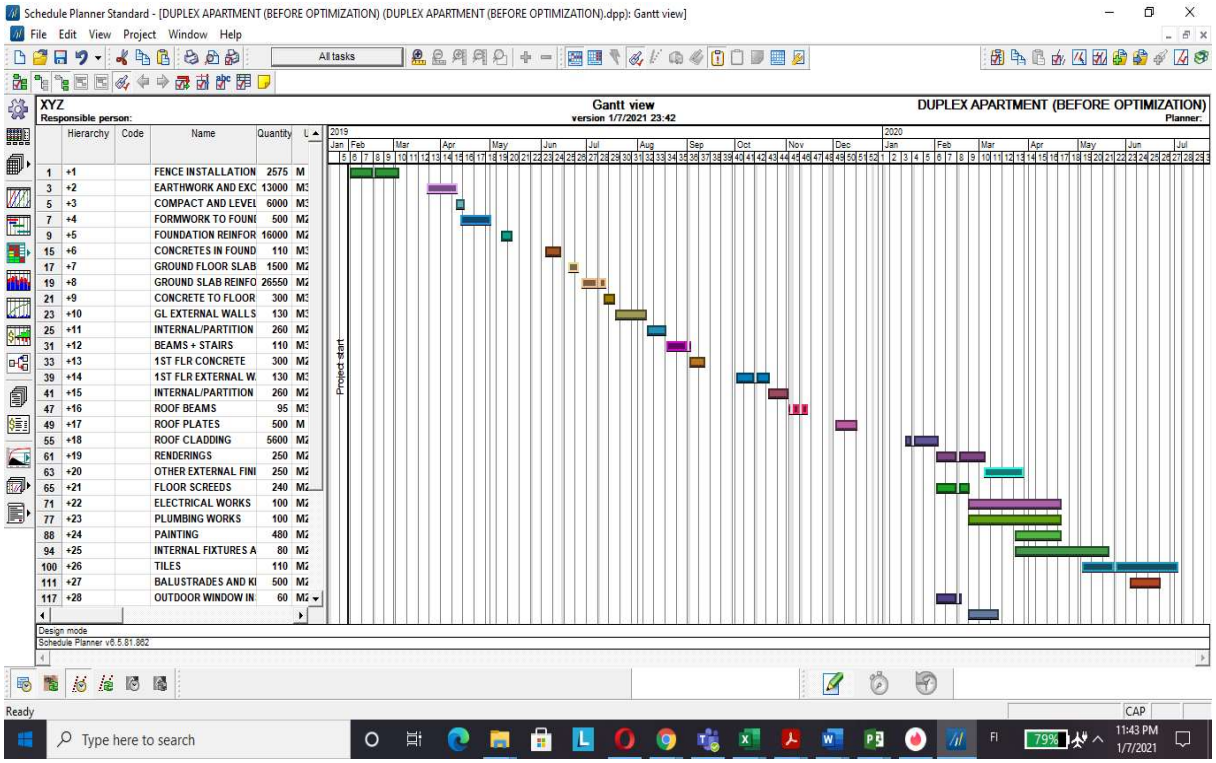


Figure 5. 6: Location-Based Scheduling in Vico Schedule (Before Optimisation)

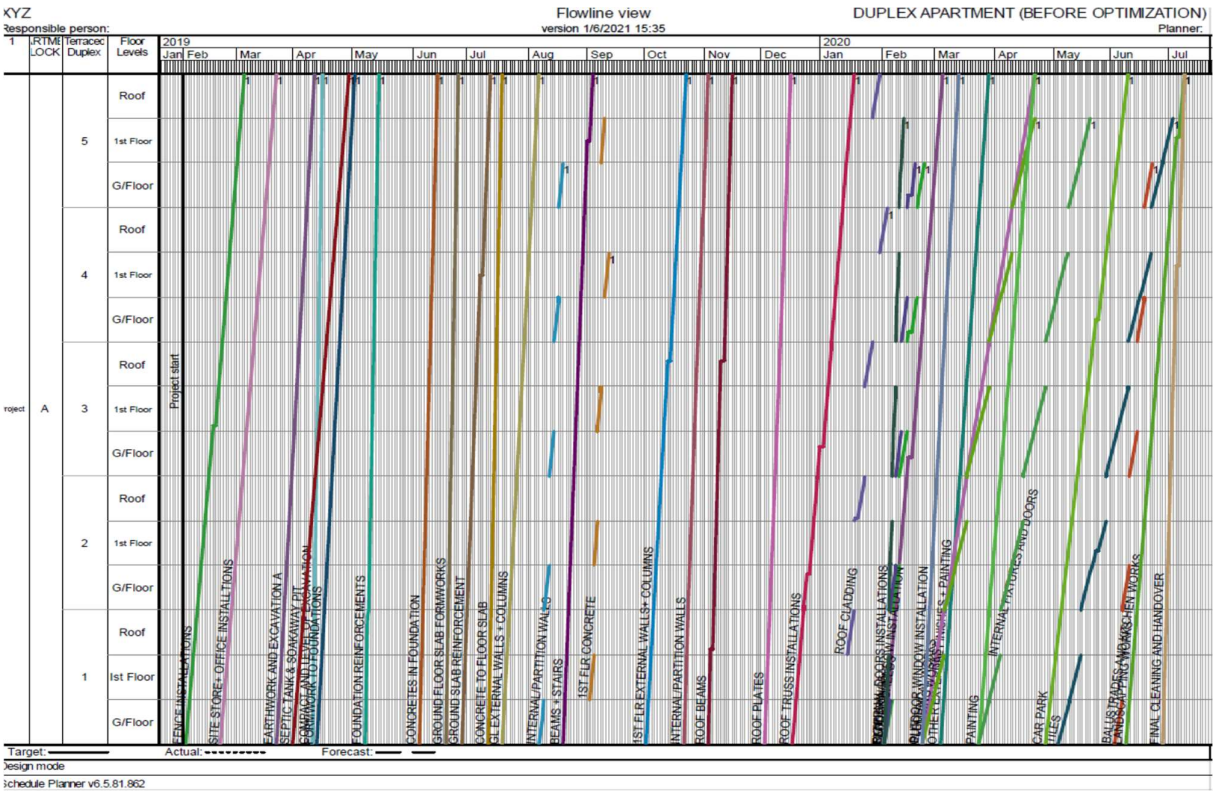


Figure 5. 7: Flowline Representation of the Schedule (Before Optimisation)

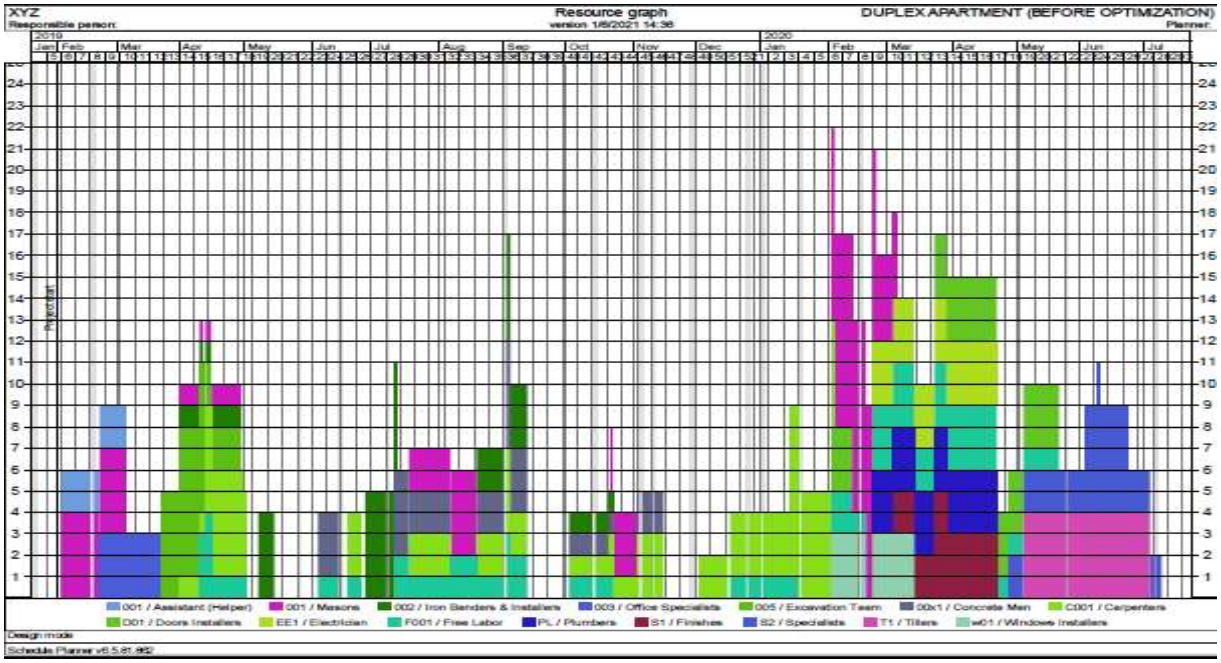


Figure 5. 8: Resource Graph (Before Optimisation)

5.3.2 Cost Performance Analysis

5.3.2.1 Labour Cost

The total labour cost for the project has been factored into the total construction cost. In Nigeria, it is generally taken between 30-50% of the Project Cost. For the purpose of this case study, the labour cost is taken as 35% of the Total Construction Cost. Hourly rates for labour varies in Nigeria, also depends on professionalism, availability and type of project. Table 5.3 shows the Labour Cost for the Case Study before optimisation.

NOTES:

Labor Cost= 35% of the Total Cost
Material Cost=35%
Equipment Cost=20%
Overhead Cost=10%

EXPECTED LABOUR COST CALCULATIONS

BEFORE OPTIMISATION

S/No	ITEMS	Total Cost (₦)	Labor Cost 35% (₦)
1	Total Construction Cost	**₦369,677,700**	**138,837,195**

Table 5. 3: Overall Labour Cost on the Project

5.3.2.2 Cash Flow Analysis

The Cashflow performance of the project was plotted in MS Excel, comprising of the project expenditures (from the developer part) and the income (from the sponsor) as the project progresses. The Cashflow analysis is essential to determine the health of the project as the absence of funds can stall the project progress or leads to bankruptcy and unnecessary loans to further push the project to completion.

The Project **Expenditure (Cash Outflow)** is calculated using the schedule as obtained from the company (before optimisation), assuming progress is as per schedule. Completion factors between 0 and 1 are assigned and distributed as per the scheduled completion dates in the planning. Refer to Appendix G for details of the progress Cash Performance Simulations. For every progress recorded, there is cash outflow (expenses) on the project. Appendix G shows the Detailed Calculation of the Cash Outflow (Expenditures) per Month on the project. Figure 5.9 shows the graphical distribution of the expenses based on the activities completion time in the schedule.

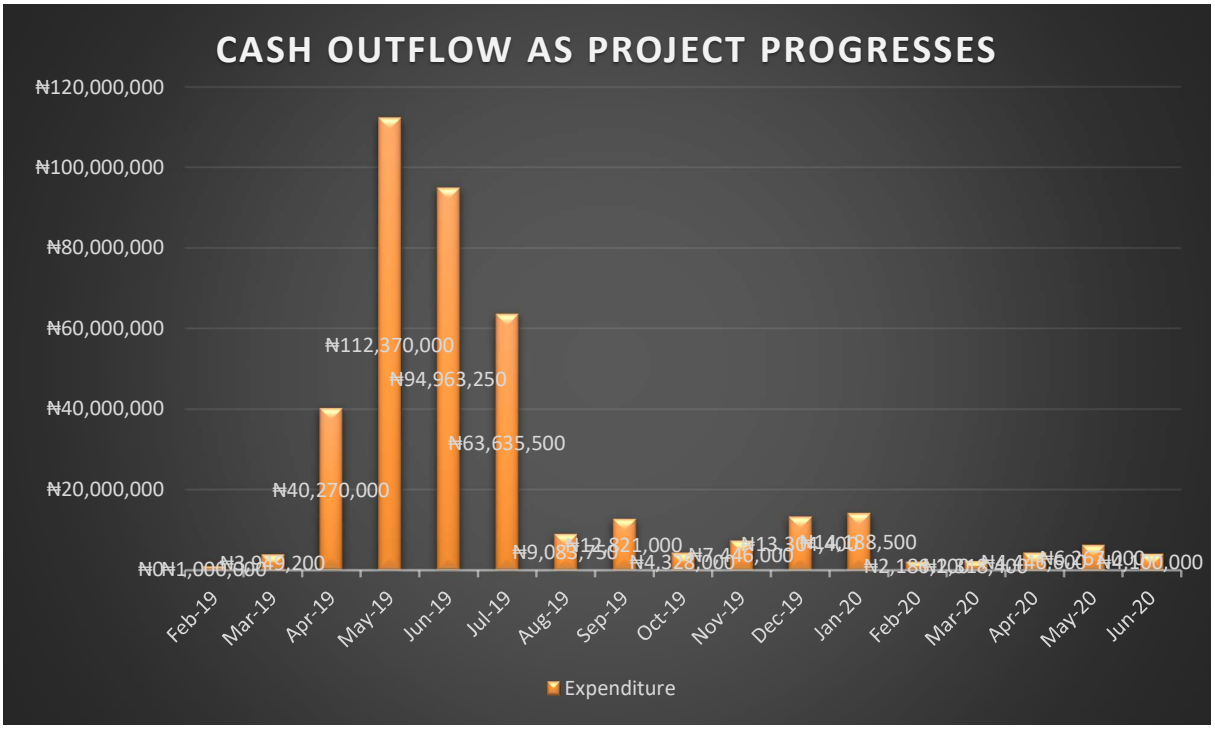


Figure 5. 9: Cash Outflow (Before Optimisation)

The Project **Income (Cash Inflow)** is calculated based on the instalment agreement as per the completion of the milestone stages on the project. Percentage payment is

calculated for tasks completed as scheduled. The graphical representation of Cash Inflow is shown in figure 5.10. The detailed calculation for the activities is shown in Appendix G.

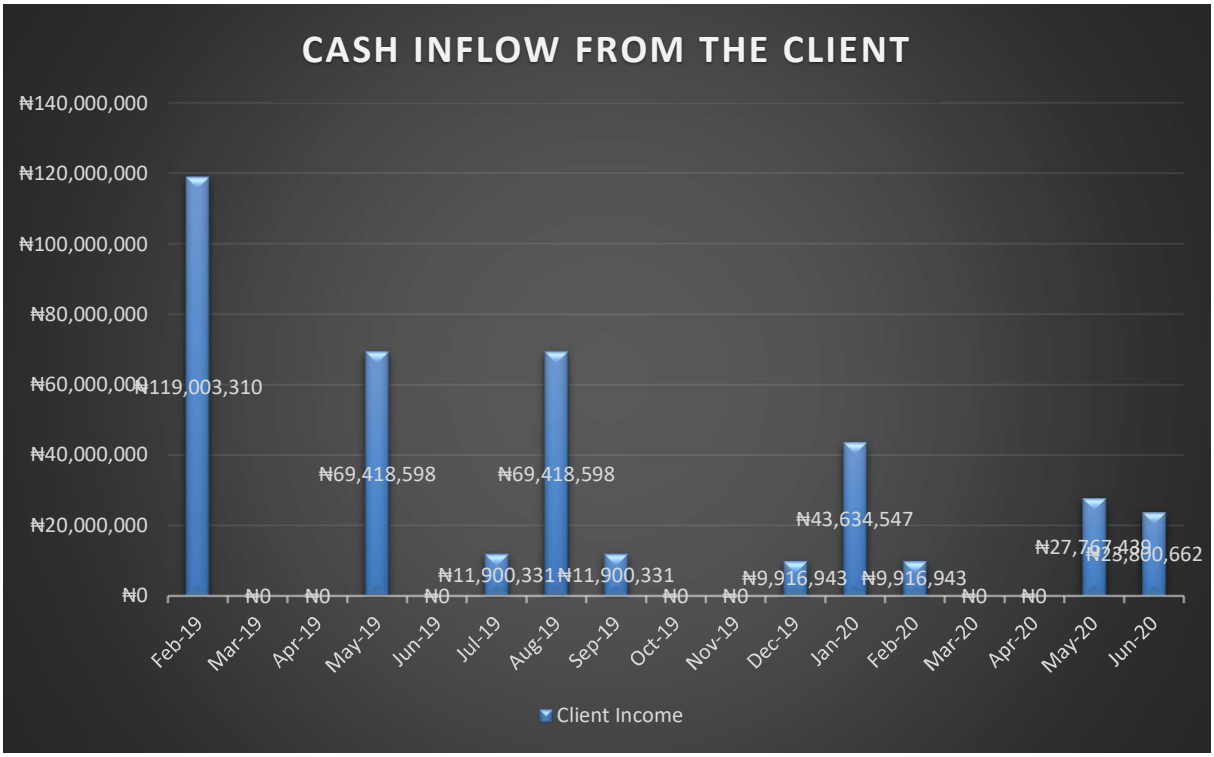


Figure 5. 10: Cash Inflow As per Payment Instalment Plan

The Cost Variance (Cash Flow Variance) is calculated by subtracting the Earned Value from the Expenditure. Figure 5.11 shown below is a curve of the cash flow performance. It indicates 73.9% of the total construction cost is on the negative (-ve). The Cumulative Cash Flow performance is shown in figure 5.12. The cumulative cash flow is a reflection of the cash at hand during the execution phase of the project.

5.3.3 Faults Analysis and Explanation of Observations

The “before Optimisation” analysis of the schedule revealed many faults, from the time schedule, resource graph and cash flow management. This helps to form the basis for the optimisation process. The **flowline schedule** revealed:

- There are many idle (unused time) in the schedule.
- Clashes between activities (work crews working at the same time)
- Activities are observed to only connected using Finish-to-Start relationships

Figure 5. 11: Cash Flow Curve (Before Optimisation)

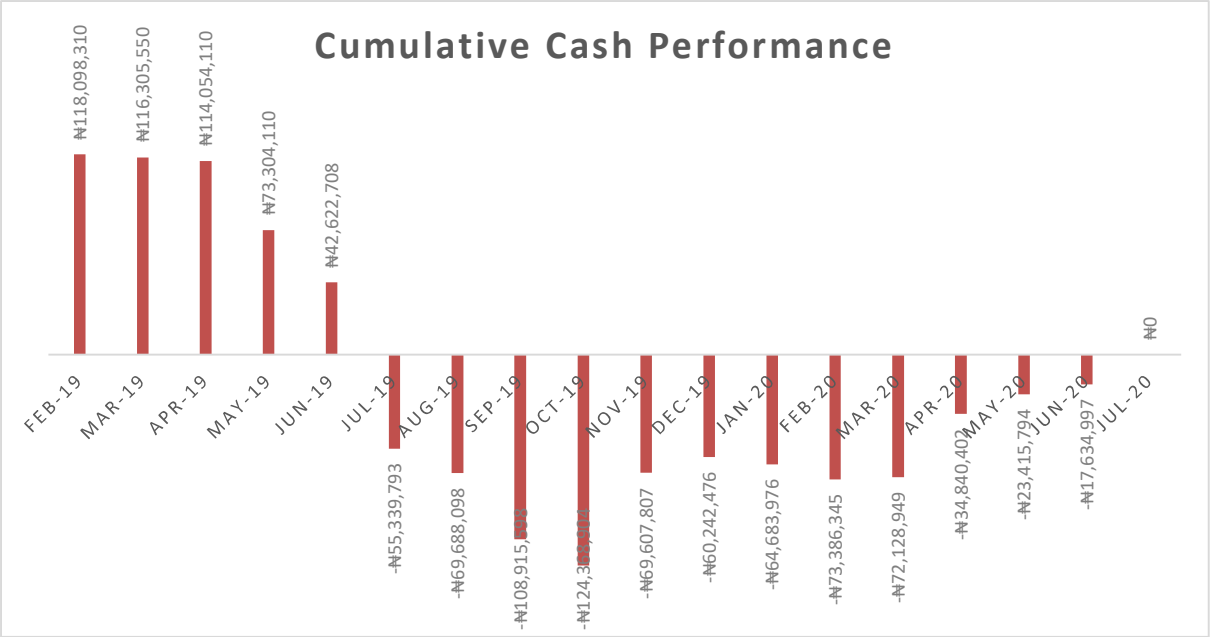


Figure 5. 12: Cumulative Cash Flow Performance (Before Optimisation)

- The execution priority of activities is faulty. It can be optimised.
- The construction process idealisation was based on the progressive execution process which required the setting of block walls (External and Internal walls) to provide support for beams and reduce the use of formworks and props/struts.

The **resource graph** revealed:

- Poor resource levelling.
- Considerable increase in the workforce on-site between February 2020 and April 2020.

Cost Analysis is the most critical part of the optimisation challenges. The cash flow performance reflects the suitability of the schedule. The **Cash Flow analysis** revealed:

- Project Expenditures far exceed the Cash Inflow from the Project Sponsor.
- Cost Variance is 64.1% negative (-ve) which is totally not healthy for the project.
- The Cumulative Cash runs negative till project completion. This is not good. This explains why projects are abandoned and excessively delayed in Nigeria. At this point, some developers engage in loans from other sources to push the projects to completion for the reasons of reputation. Loans come with percentages interest, the cost of which is transferred to the overall cost of construction of the project.

5.4 The Optimisation Analysis

5.4.1 The Lean Application Process

The main purpose of this process is to analyse the schedule and consider the possibilities of optimisation within the project's time schedule. The production rate is kept constant during the optimisation process. The Lean application process requires that the number of labour requirements for the tasks and the consumption rate (hours/unit) is determined. For the purpose of this case study, the labour requirements and consumption rates are calculated with Microsoft Excel using the equations as shown below.

$$\mathbf{No.\ of\ Labour\ Required} = \frac{\mathbf{Labour\ Cost\ of\ Task}}{\mathbf{Duration\ of\ Tasks} * \mathbf{Cost\ of\ Labour\ per\ Hour}}$$

Equation 5. 2: Number of Labor Required to Execute the task

$$\mathbf{Consumption\ Rate}\ \left(\frac{\mathbf{Hours}}{\mathbf{unit}}\right) = \frac{\mathbf{No.of\ Labours\ Required} * \mathbf{Duration\ of\ Task}}{\mathbf{Total\ Quantities\ of\ the\ Tasks}}$$

Equation 5. 3: Consumption Rate

The process required strict analysis of the construction process, with attention set at maximising the labour force and time without unnecessary lost in cash performance.

5.4.2 Optimised Flowline Schedule

With the mindset at reducing cash flow negativity, reducing labour and time wastes and improving overall project performance, the execution order of works was re-arranged. The execution of structural works was considered a priority. From the BoQ for the project, the cost of structural works is 80.1% of the Total Project Cost. Also, since all the structural works activities belong to the critical path. The idealisation was to try to push other avoidable costs forward during this period. In the optimisation schedule, as shown in figure 5.13:

- Waiting time between activities was removed
- The structural works were executed as framed structure
- The execution of block walls (Internal and External Walls) was pushed to start later in the year
- Project duration was reduced by 1month

5.4.3 Cost Performance Analysis

5.4.3.1 Labour Cost

NOTES:

Labor Cost= 35%
Material Cost=35%
Equipment Cost=20%
Overhead Cost=10%

LABOUR WASTE CALCULATIONS

S/No	ITEMS	BEFORE OPTIMIZATION	AFTER OPTIMIZATION
1	Labour Wastes	₦ 4,971,600.00	₦ 3,992,800.00

COST GAIN= **₦ 978,800.00**

Table 5. 4: Labour Waste Cost Calculations

Following the optimization process, the wastes in the idleness of labour are determined and factored into cost using the hourly rate of the workers. There is a Cost gain following the implementation process of the lean thinking principle.

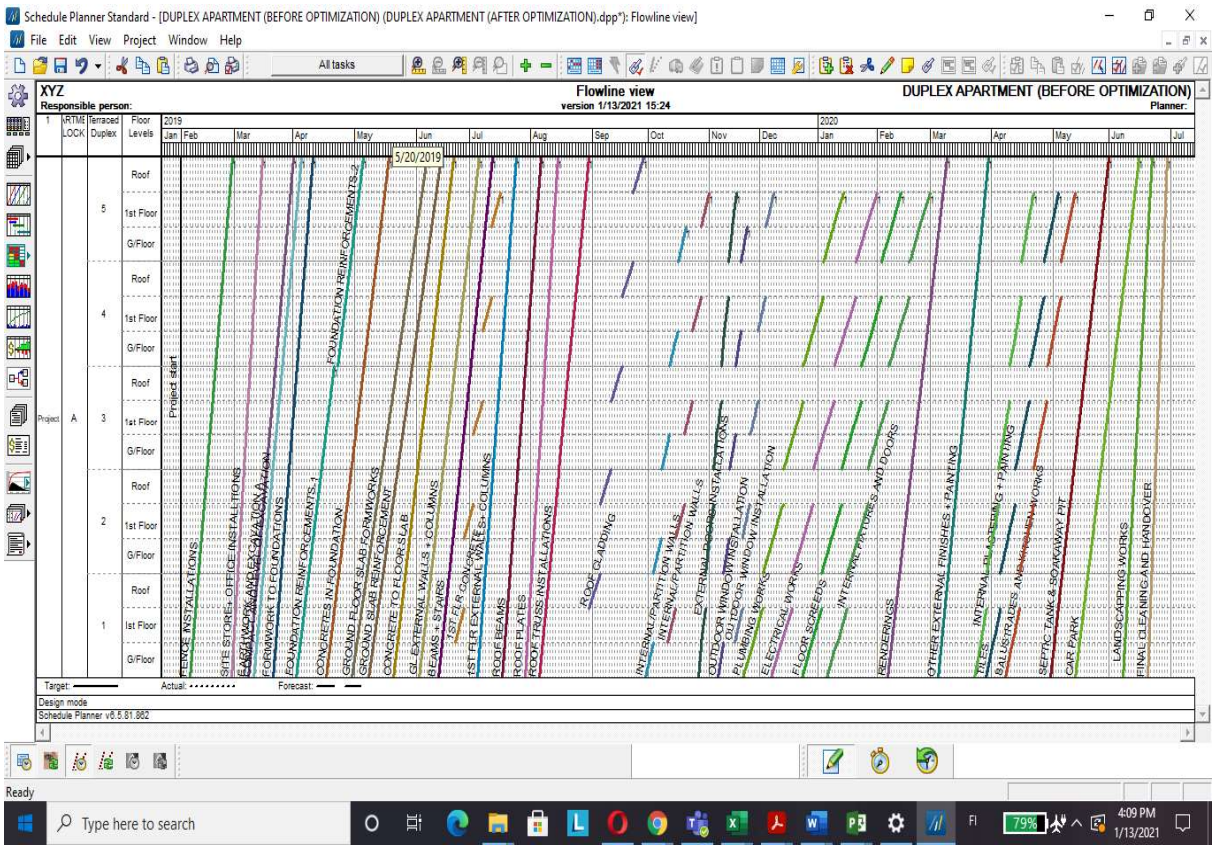


***Figure 5. 13**: Optimized Flowline Schedule (After Optimisation)*

5.4.3.2 Cash Flow Analysis (After Optimization)

Figures 5.14 and 5.15 show the Cash Flow Curve after the process optimization compared to the flow curve obtained before the application of lean thinking principles. An optimised cost reflects good cash flow performance. After the schedule was optimised in Vico, there was a cost gained from the recovered duration. The cash flow performance was improved from negative **73.9%** to **- 52%.** It was observed that the percentage (%) distribution of the instalment payment is poor with reference to the quantities of actual work to be executed.

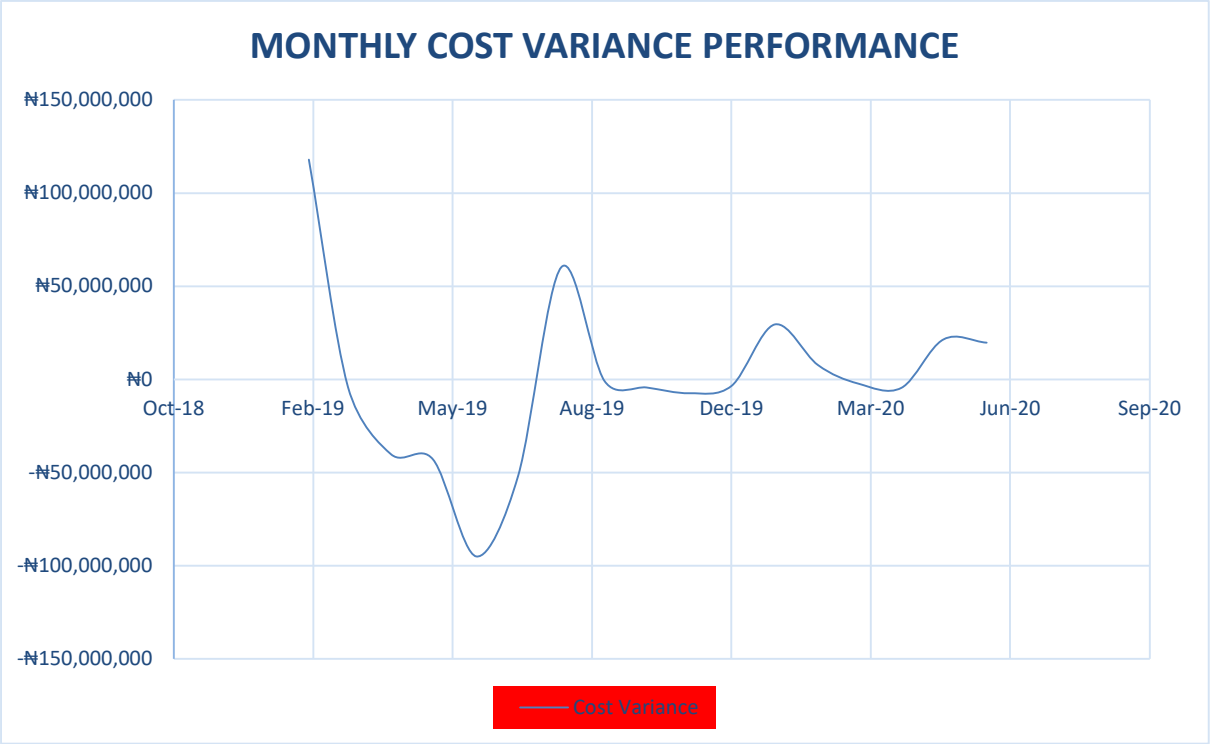


Figure 5. 14: Optimized Flowline Schedule (After Optimisation)

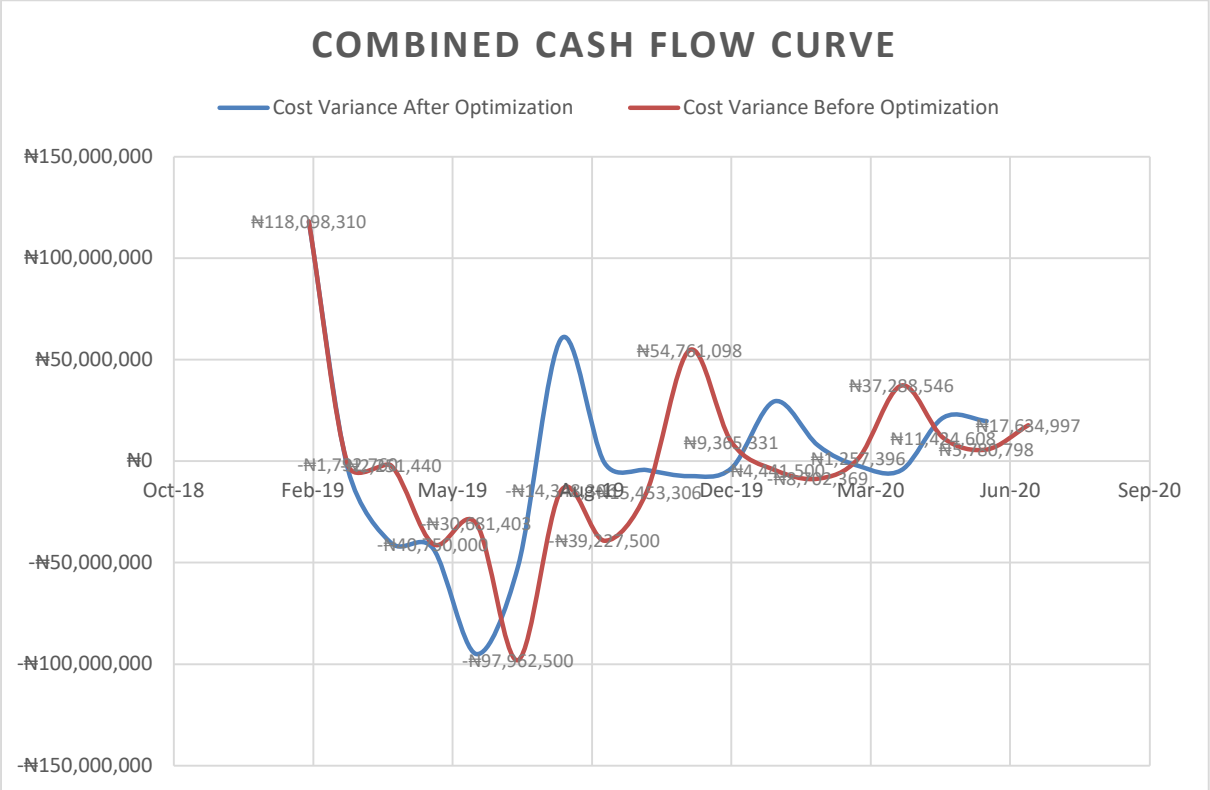


Figure 5. 15: Combined Optimize Cash Flow Curve

5.5 Analysis of Questionnaires

This section analyses the questionnaire which was distributed to fifteen (15) Real Estate Companies in Nigeria. The level of response gotten was affected by the current pandemic situation in the country. Ten (10) responses were received, and they were anonymous. The questionnaire was designed to assess the possible factors of which could portend challenges in the implementation of Lean-BIM Location-Based Scheduling for construction cost optimisation in the real estate industry.
The questionnaire was sent out from 18th to 30th of November. The sample questionnaire has been provided in Appendix B. While trying to achieve the overall aim of the questionnaire, it was divided four (4) basic sections. They are as discussed in the subsection below: 'The background of the respondent company', 'The employee level of Education', 'Level of Software Use, Application and Knowledge in the organisation', and finally 'the Scheduling and Planning Skills'.

5.5.1 Background of the Respondent Company

A total of 10 responses were received out of 15 requests, which indicated about a 67% response rate. The investigation focused on the company's years in the business of Real Estate Development (Housing Projects), assessed the business owners educational background and discipline. Researches have shown that the level of education and discipline of the management at the corporate level determines the growth and performance of an organisation.

Response analysis shown in figures 5.16 and 5.17 below revealed that about 30% of the Real Estate Companies have been in business for just a maximum of 9 years. 40% of the companies are just newbies in the business. This justifies the recent boom in the Real Estate Housing Development projects in Lagos, Nigeria. It is evidenced that the Real Estate market is harnessing the business opportunity created by rising urbanisation and population increase in the city of Lagos. The response also indicates that there are about 30% of companies had been in business for more than 10 years.
Assessing the educational background of the companies' business owners showed that the majority of the Estate Company Owners in Nigeria are not professionals with a construction background. From figure 5.17, 60% of the responses confirmed that their CEO has an educational background in Business/ Accounting or Legal training.

20% responses indicated the business owners have a background in Facility Management (Estate Management) and 10% in Civil Engineering. The response also indicates that 100% of the CEOs have Master Degree as the highest level of education.

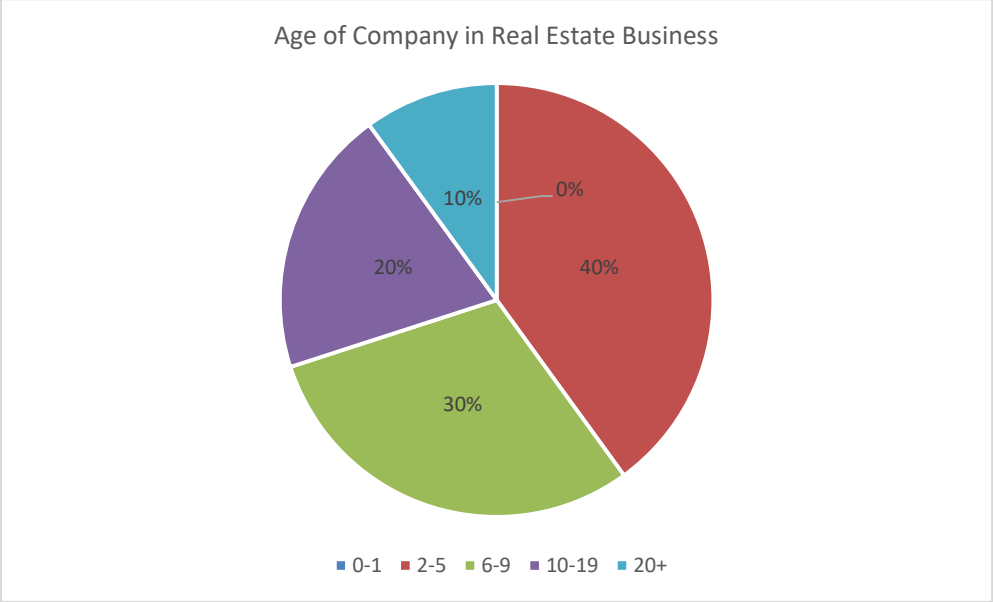


Figure 5. 16: Years of service for Real Estate Development

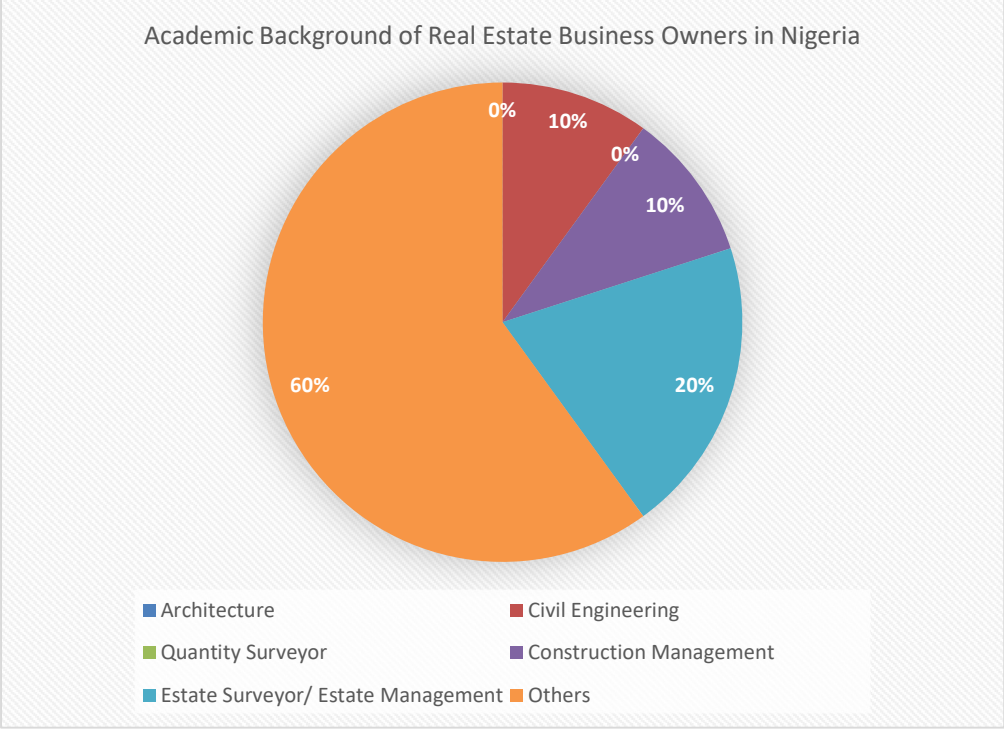


Figure 5. 17: Academic Background of the Real Estate Business Owners in Nigeria

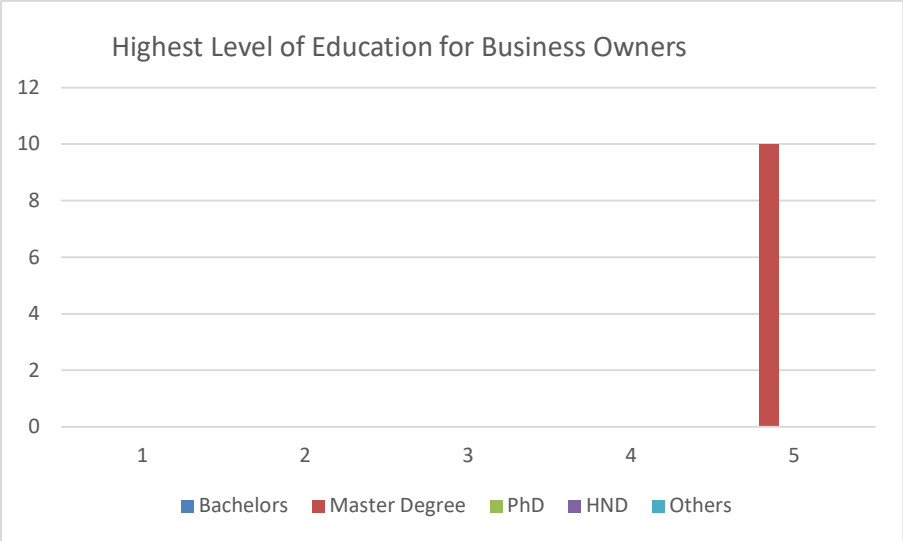


Figure 5. 18: Highest Level of Education for Real Estate Business Owners in Nigeria

5.5.2 Employee Distribution in the Real Estate Industry

The questionnaire tried to obtain data concerning the number, level of education and professionalism of the employees working in the real estate sector. Response analysis, as shown in figures 5.19, 5.20 and 5.21, reflects the distribution of employees in the Real Estate Business in Lagos, Nigeria. Companies responses showed that 70% of the companies have up to nine (9) professional employees in the company. While 30% indicate, they have about 10 to 14 professional staff in the company. None of the companies is big enough to accommodate more than 14 professional employees in the office, and also, none of the companies is too small to afford just only four (4) professional employees in the office.

Further breakdown of the analysis in figure 5.20 revealed that 60% of the Real Estate Companies employ a maximum of five (5) construction professionals in the estate development projects. 30% of the companies indicated that they have about the maximum of nine (9) construction professionals handling the project development phase of the estate business. While 10% of the respondent companies indicate, they only needed one (1) construction expert in the Real Estate business. Figure 5.21 showed that 60% of the companies prefer to employ construction professionals with Higher National Diploma Certificates (Graduate from the Polytechnics). Only about 30% strive to employ Bachelor Degree holders and 10% demands for Master Degree.

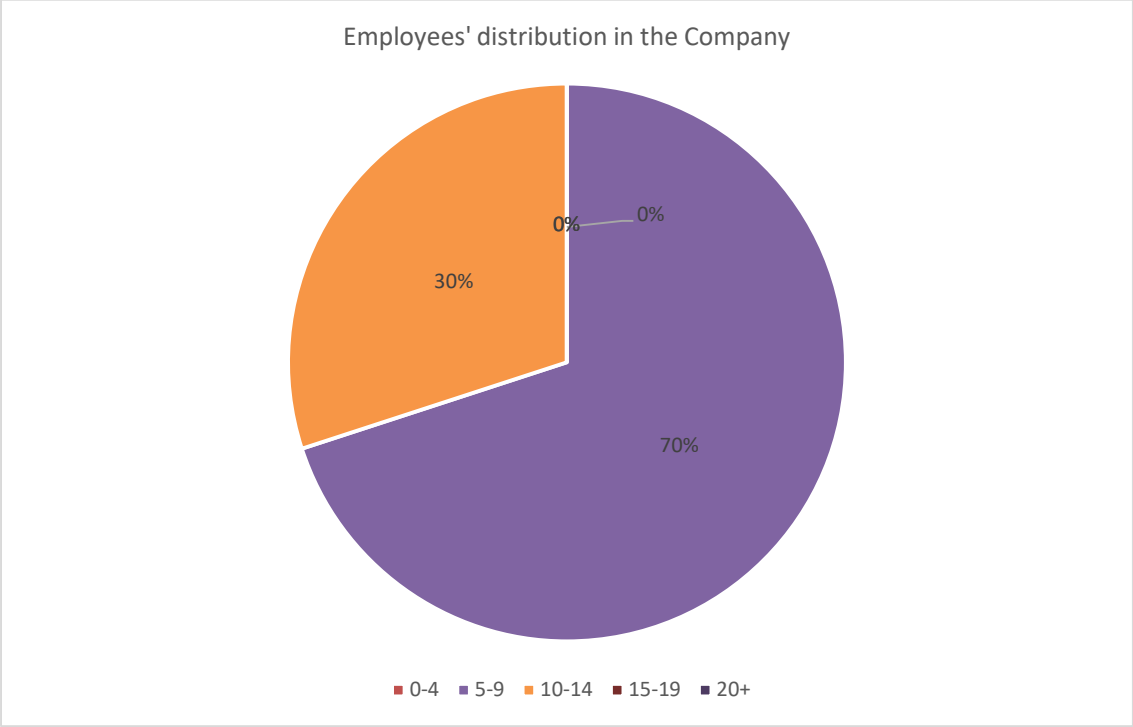


Figure 5. 19: Staff Distribution in the Real Estate Company

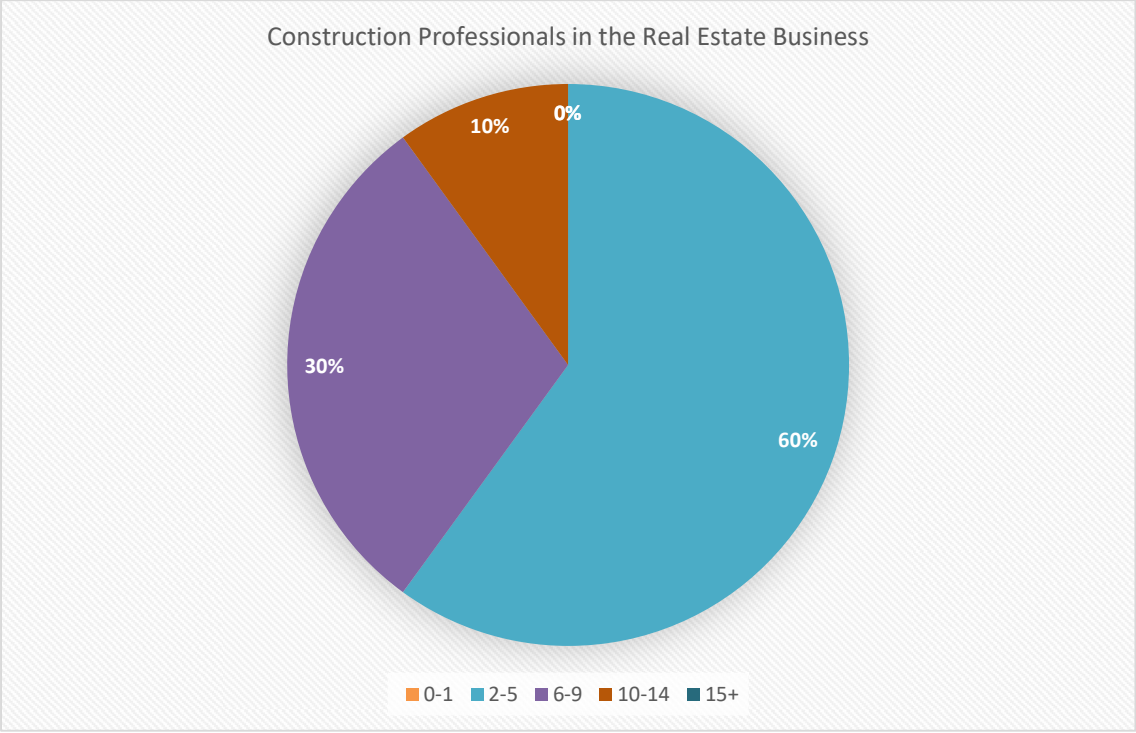


Figure 5. 20: Employment of Construction Professionals in the Real Estate Business

Figure 5. 21: Highest Level of Education for Construction Employees in the Real Estate Sector in Nigeria

5.5.3 Skills and Knowledge

This section of the questionnaire assessed the residual skills and knowledge which could enhance the implementation of lean-BIM processes (culture) for improved project performance in the industry. When asked about the familiarity with BIM Use in the construction industry, 70% of the companies answered Yes, and 30% replied No, as shown in figure 5.22. Further request to indicate what possible use have they applied BIM to, 100% of the companies indicated No use due to limited knowledge about the subject matter.

However, the questionnaire showed that certain software is deployed for use in the execution of housing projects in the real estate industry in Nigeria. When asked about the common software available for use in their respective companies, 100% of the companies indicated the use of AutoCAD and MS Project, as shown in figure 5.22. 50% of the companies still deploy Sketch up for their employees, 40% uses Revit Autodesk, 30% uses Primavera, while 20% still have ArchiCAD as shown in figure 5.22.

The analysis revealed that 100% of the companies provide the least software requirements for project development which are AutoCAD and MS Project.

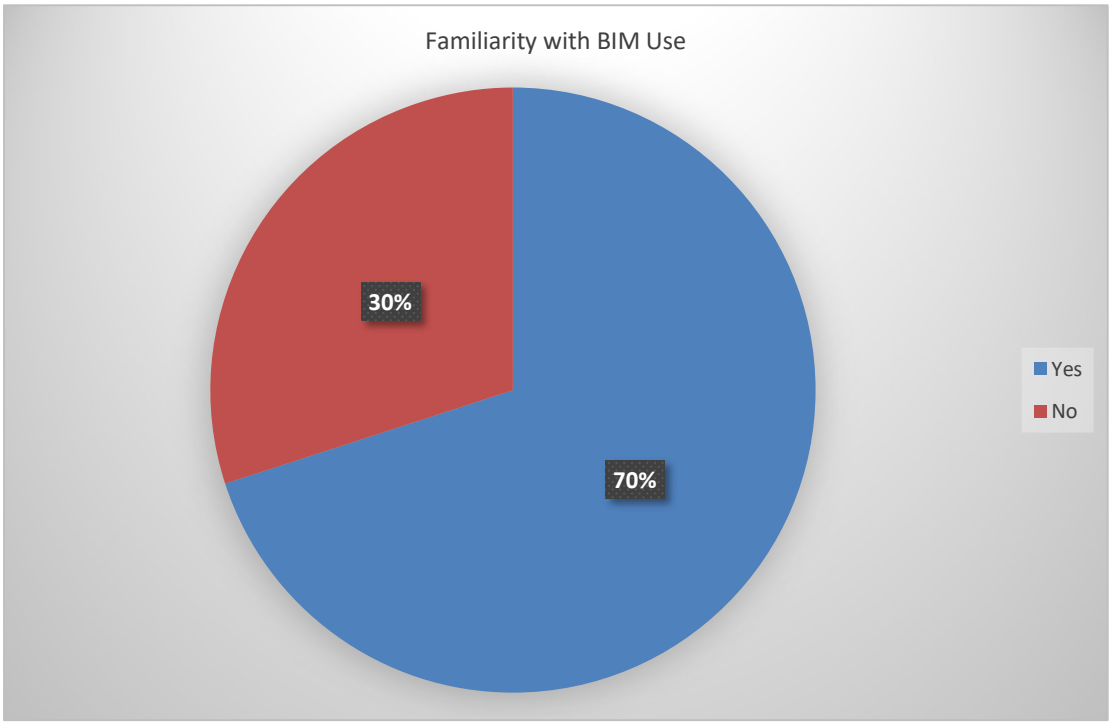


Figure 5. 22: Familiarity with BIM Use in Construction and Project Development

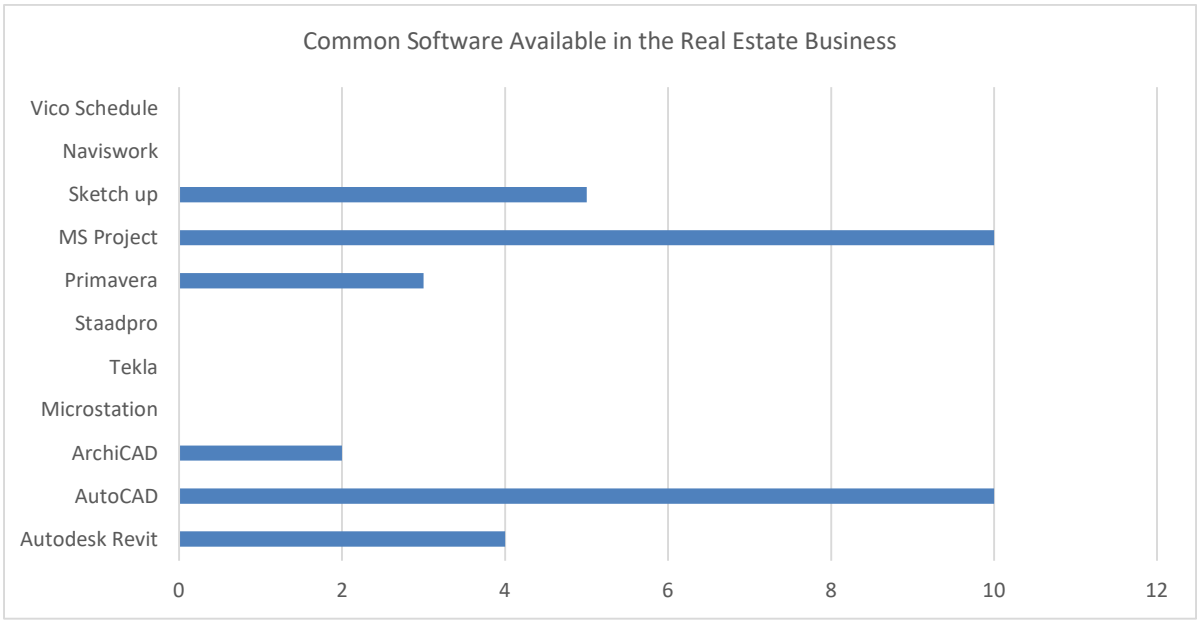


Figure 5. 23: Familiarity with BIM Use in Construction and Project Development

It is normal for companies to be able to assess the employees' ability to use software and deploy new innovations for project execution. Figure 5.23 shows companies responses to the rating request of the employees' ability to use software without any challenges or difficulties. The response showed that 40% of the companies are not too satisfied with the performance of the employees. 30% of the companies indicated poor rating for the professionals in software-use to drive innovations and optimise processes, while 20% and 10% indicate Good and Very Good respectively for their staff.

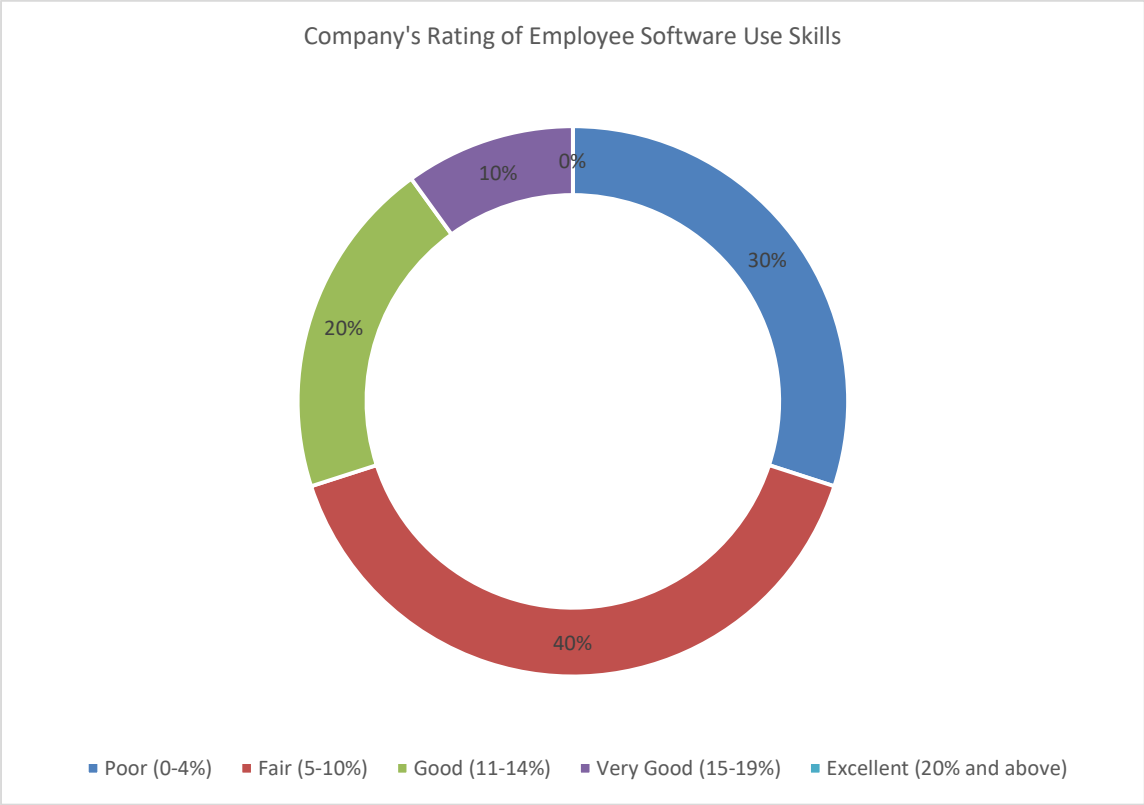


Figure 5. 24: Rating of Employee Software Skills

When asked about the possible cause of low or poor performance ratings, 100% of the companies indicated a lack of the University Education to integrate software-use into the training from the beginning as the reason. The questionnaire also assessed the level of technical know-how of the employees about some key elements (components) of Lean Construction and BIM. When asked about seeing the traces of the following knowledge as shown in figure 5.24 in their employees, 100% of the companies indicated zero (0) knowledge for their staff in Cash Flow Simulations, BIM Use Tools,

Location-Based Management System, Location-Based Scheduling, Line of Balance and Lean Construction. However, 100% of the companies revealed that their employees are very excellence with the use of Gantt Charts, 70% agreed to their employees being Good at Critical Path method and 30% just Good.

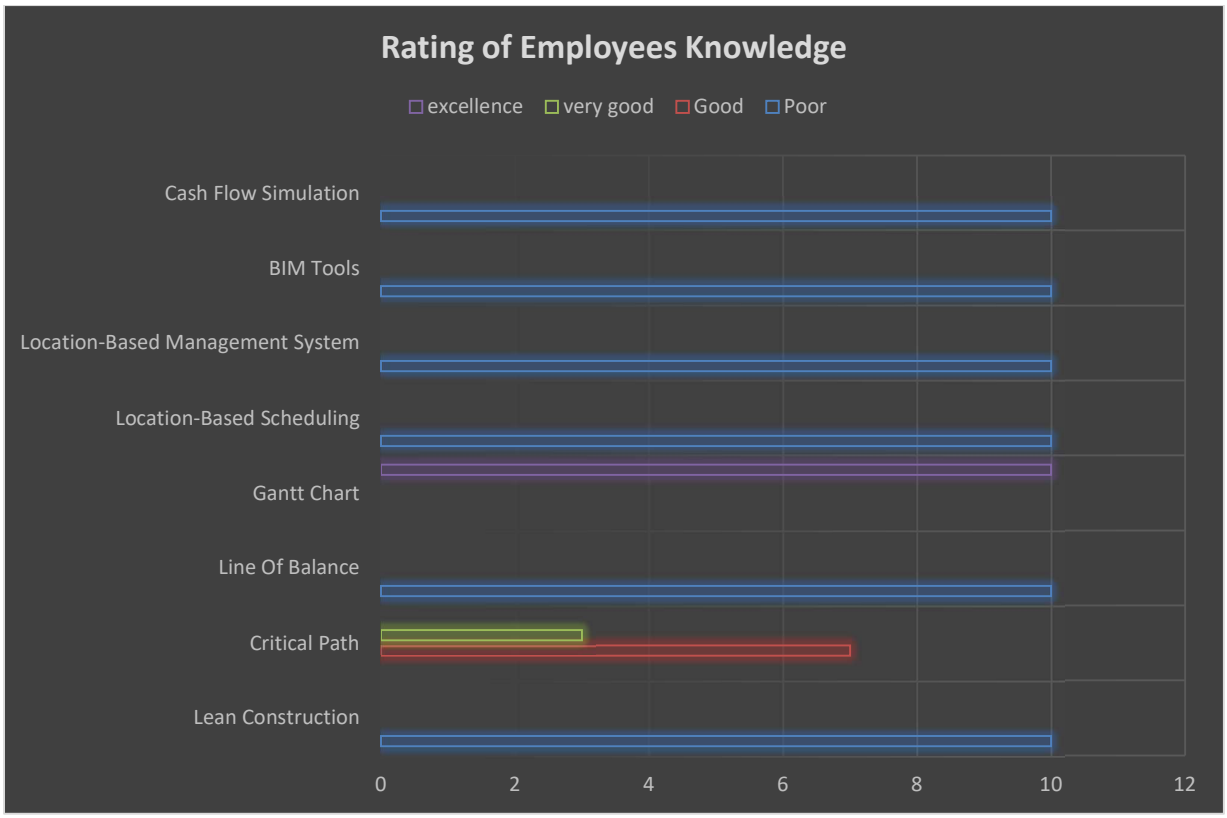


Figure 5. 25: Rating of Employees Knowledge

5.5.4 Attitudes Towards Planning and Scheduling

The objective of this section is to investigate the attitudes among the Nigerian Real Estate Companies towards current and new methods in scheduling and planning for process optimisation. The opinion poll of the companies is reflected in the questionnaires sent out for this purpose. Questions were asked about the support for innovation for optimisation of housing estate development processes through the implementation of a location-based schedule system using the principle of Lean Construction. Figures 5.25, 5.26 and 5.27 show the result of the responses obtained.

Figure 5.25 showed that 50% of the companies do not have dedicated planners on their project for progress tracking and follow-up. 20%, however, indicated a positive response which either showed that they have at least one (1) planner for all projects they have or per project. The remaining 30% of the companies feel it is not important to have project planners or to prepare schedules for housing estate development.

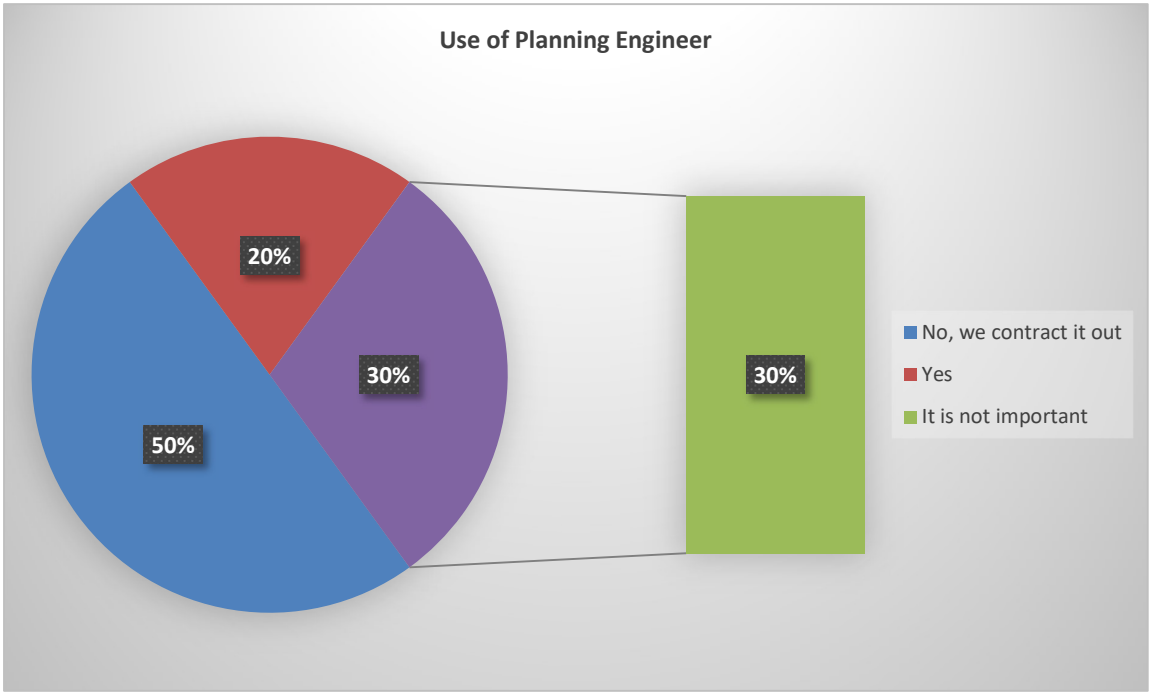


Figure 5.26: Companies Attitude to Use of Planners for Projects

Even though they may not have the dedicated planners for projects, when asked about the commonly available software for Planning and Scheduling in their companies, responses are as shown in figure 5.26. 100% of the companies indicated the use of MS Excel and MS Project for their project scheduling and progress tracking. Only 50% went further to provide a license for the use of Primavera for Scheduling in the company.

While assessing the industries perception for improvement in the scheduling process of activities, questions were asked as per the options in figure 5.27. 70% of the responses from the companies indicated that they are not satisfied with their current method for planning and scheduling.

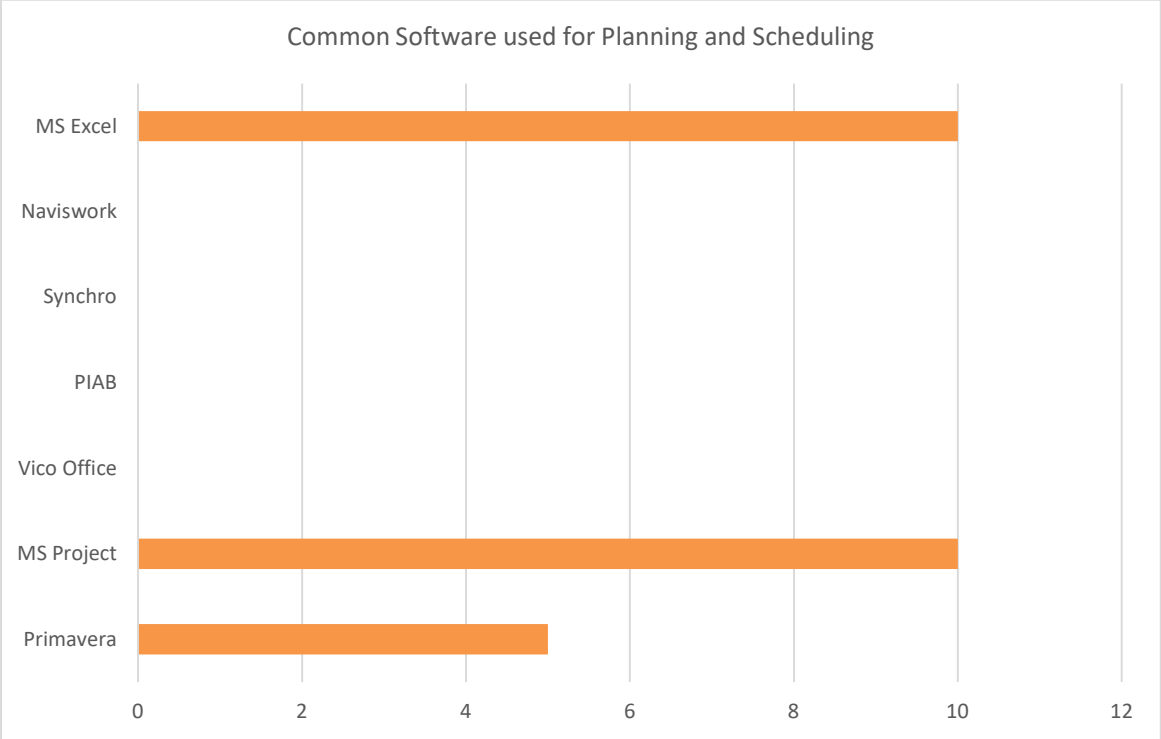


Figure 5.27: Common Software in the Companies for Planning and Scheduling

60% of the companies are also not satisfied with the Critical Path Method, and they feel it is not sufficient to adequately maximise the process. 40% and 30% respectively feel satisfied in this case. It is not surprising to see from figure 5.27 that 100% of the companies are open and interested in new methods for planning and scheduling that guarantees improved performance.

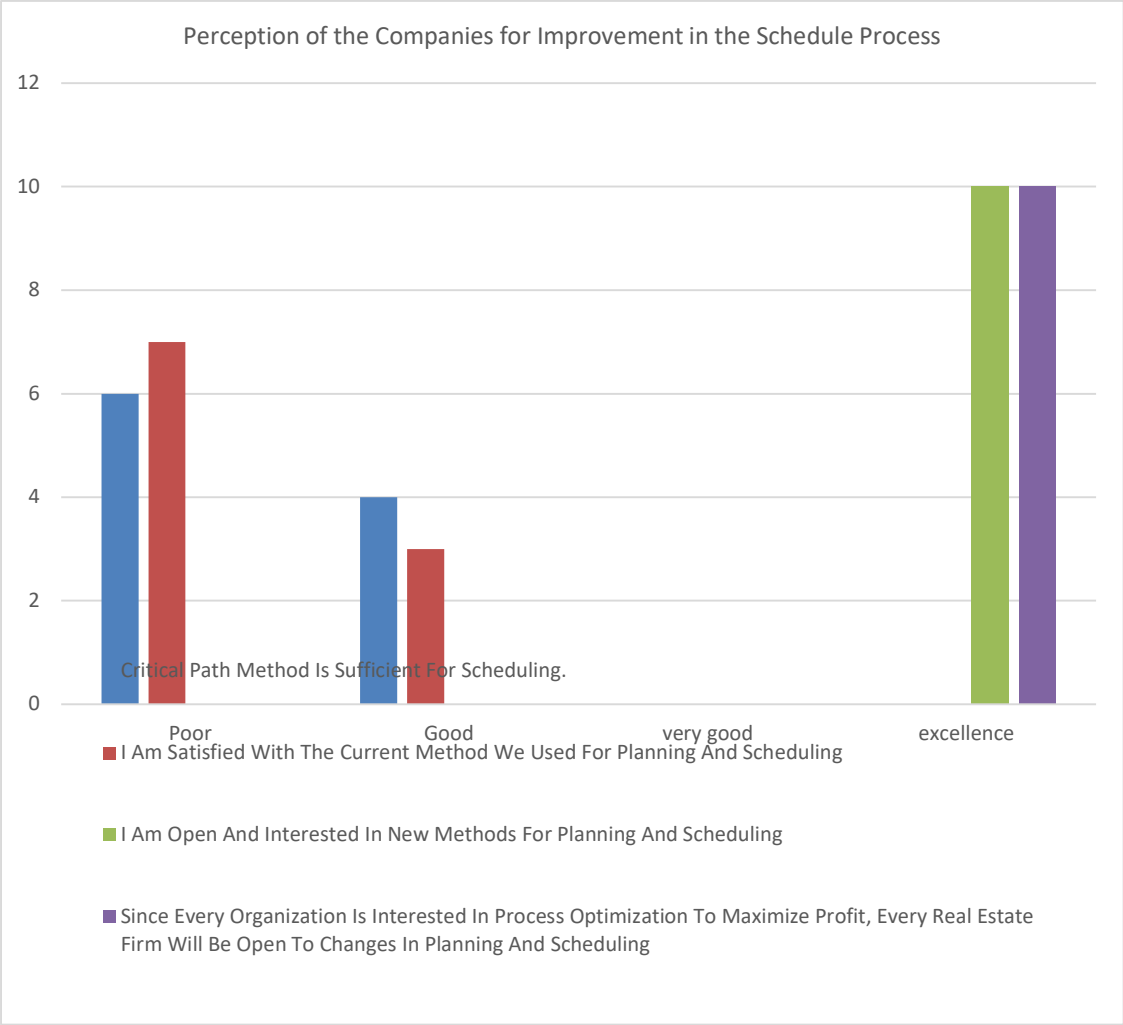


Figure 5. 28: Perception of the Companies for Innovative Improvement

6.0 Conclusion

The following chapter gives a conclusion to the report. Clause 6.1 explains the findings from the analysis. The question from the problem formulation is answered under this clause. Clause 6.2 gives a general conclusion to the thesis.

6.1 Findings

The preceding chapter gives a detailed analysis of the data collected on the case study and, compared it to the Location-Based Management System's (LBMS) involving only the location-based planning, not considering the control. The preceding clauses will attempt to answer the problem formulation and the research question. From the

analysis, Lean Construction through the implementation of LBMS using Vico Schedule Planner, portend certain risks in terms of advantages, challenges and opportunities.

While trying to answer the research question: ***Can Alternative Planning Technique (Lean-BIM) be successfully applied to optimise construction costs in the Nigeria Real Estate Industry?***

The housing development process in the Nigeria Real Estate Industry is not different from the normal practices in the construction market. The conventional procedures are the same, and differ in project owners and project type (which is housing units). The potentials for implementation of Lean-BIM Location-Based Planning for construction cost optimisation can be answered under the following subheadings:

- *The Effect of Location-Based Schedule for Process Optimisation*

From the analysis of the **Before** and **After** Process Optimization, the transferred company's schedule from the MS Project to the Vico Schedule flowline view revealed many inconsistencies in activities. The activities schedules are not aligned with quite a number of clashes. The location-based schedule provided by Vico Planner provides an effective method to eradicate these barriers and brings a better overview of the time schedule. The concept also allows for improved use of resources in the project through visualisation of locations for each activity on the site. The implementation of Location-Based Scheduling provides the opportunity to optimise the housing development process planning within the stipulated delivery time frame. The research revealed that lean-BIM alternate planning has the potential for project duration reduction to the tune of 13%. The project team can be redeployed to other projects without waste in resources available.

- *The Effect of Location-Based Schedule for Cost Optimisation*

Implementing the principle of lean construction requires that all non-value adding processes, activities, duration and resources be eliminated. All these wastes cost money and eventually adds to the project construction cost. Most importantly, the impacts of cash flow performance on the project stem also from the optimisation strategy of the schedule. An optimised construction cost is the cost obtained after the construction process is optimised and eliminated of wastes. An optimised cost reflects good cash flow performance. After the schedule was optimised in Vico, there was a cost gained from the recovered duration. The cash flow performance was improved from negative **73.9%** to negative 52%**.**

- *Effect of Poor Sponsor's Instalmental Funding Agreement on Cost Optimisation*

Further analysis revealed that the Sponsor's Instalment funding for the project had been poorly agreed. From the cost analysis based on the activities costs and unit rates, the structural works cost about 75% of the total project works. Executing the structural works to completion and being paid 30% will continually keep the cash flow performance in the negative. A poorly negotiated project instalment funding will continually affect the cost optimisation campaign, which will eventually cause project delays, time overrun and additional cost on the construction cost.

- *Possible barriers to the effectiveness of the Lean-BIM implementation for Cost Optimisation in Nigeria Real Estate?*

From the outcome of the investigations, the barrier potentials are high, which could impact the effectiveness of the optimisation process. It was encouraging to know that all responded companies showed the readiness to embrace new technology, innovations and principles to enhance process performance while reducing waste and improving profit. The research revealed that Real Estate companies in Nigeria (Lagos) lack a requisite adequate number of professionals with a background in Construction and Building Technology. Perhaps they believe they are rather too expensive to employ. In addition, findings revealed 60% of the employees with construction background are HND (Higher National Diploma) certificate holder, with educational curriculum poorly integrated with the use of software since Lean-BIM principles involve the use of software to have better views of the project while reducing clashes, wastes and delays. Findings revealed that companies are poorly familiar with BIM and BIM Use in construction and project development. This is a big challenge. Rating of the employees' knowledge in Cash flow simulations, Location-based Scheduling and Lean Construction revealed that employees lack the basis to enhance the implementation process for the Lean principles in the industry. The questionnaire indicated there is a knowledge gap when it comes to location-based planning theory within the Real Estate Industry. There is a low level of skills in Vico Office and software that it interacts with, such as Tekla. No responding companies use Vico Office. This could indicate that it will be a challenge to find professionals to help with the integration of the LBMS. Furthermore, there seems to be a trend to the common use of MS Project and MS Excel in planning and scheduling, and this too could become a barrier when finding qualified workers.

6.2 General conclusion

The thesis tried to apply the Lean-BIM optimisation principles to live housing project in Lagos, Nigeria. It investigated how activities planning and scheduling affect project cost performance which is believed to have a greater impact on the eventual housing unit cost. The company scheduling is activity-based, and the project is currently delayed due to issues with cost. A case study of a block of five (5) terrace duplex was analysed for the potentials for improved performance in terms of cost, time and resources. The opportunity for optimisation was explored after the case study schedule was transferred to Vico Office for Location-Based Lean scheduling. The transfer increased the overview of the project. The flowline view revealed many idle (unused time) in the schedule. The construction process idealisation was based on the progressive execution process which required the setting of block walls (External and Internal walls) to provide support for beams and reduce the use of formworks and props/struts. The execution priority of the activities is faulty, which has so much impact on the cash flow performance being in the negativity. There was an indication that certain work crews could clash on-site due to clashes in the activities.

During the optimisation process, the activities were set in a continuous manner and some minor changes made while keeping the production rate constant. The schedule alignment resulted in reduced duration by 30days. Because it is already very expensive (costly) to execute concrete structural works, it makes no sense to combine this activity with other activities like blockwork which are billed under Internal works in the Funding Agreement. Based on this, the optimisation strategy was to execute structural works using the frame pattern, pushing blockwork and other tasks to start after. With this approach, there was gain total duration, improved cash flow performance, even though not as good as expected. Reason already identified as stemming from poorly negotiated instalment agreement from the sponsor. There is an opportunity for the company to organise the flow of workers and the logistics within the work site by implementing the location-based control method. The company can make more reliable plans in production and better optimise manpower and resources.

From the research, it is not impossible for Lean-BIM principles to be applied for construction cost optimisation for housing projects for real estate development in Nigeria. However, the research also showed how much cost optimisation (in terms of cash flow

performance) could be affected by Sponsor Instalment Agreement. The implementation of the Lean-BIM principle requires that all parties to the construction process must work together with a common goal. Analysis of the questionnaires sent out to 15 Real Estate companies in Lagos, Nigeria revealed that 0% uses BIM tools for their processes. The companies rated high skills in the level of software applications such as AutoCAD, Revit, and MS Project. Question about the use of Vico Office for Scheduling showed none of the company uses Vico Office Schedule for planning.

6.3 Recommendations

Following the findings from the research, it will be worth advising the company whose case study was analysed in this research on the following recommendations for action:

1. Review the project quantities using another method of estimations. Since the overall project cost is developed from the unit rate of items per quantities, it would be eye-opening and profiting from carrying out a second check at the project quantities.
2. Review the Sponsor Instalment Agreement Rate. A 30% completion fund for structural works from the Sponsor Agreement does not support the timely project completion goal since only structural works in the BoQ is 75% of the Overall Project Cost.
3. While keeping the production rate constant, review the project execution strategy while observing the performance of the cash flow.
4. Ensure proper training and transfer f skills to site workers
5. Encourage and deploy new tools—the use of Lean-BIM support tools for the optimisation process in the industry.

Declaration of Authorship

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

Location, Date	Signature of the student

Appendices

Hochschule für Technik
und Wirtschaft Berlin
University of Applied Sciences

Treskowallee Campus
10313 Berlin
www.htw-berlin.de

Date: 2020-10-06

Dear Sir,

CONSTRUCTION COST OPTIMISATION-REQUEST FOR RESEARCH PARTICIPATION

Housing affordability has been a growing challenge to Nigerians and the government in general. In Nigeria, low-cost/real estate housing projects are by facts, not affordable because the eventual budgeted construction cost rises by 150% at the end of completion periods of the project. Most developers/ real estate companies have resorted to compromise on the quality level of deliverables for profit maximisation.

On this basis, the University of Applied Sciences Berlin, Germany and the Metropolia University of Applied Science, Helsinki, Finland is carrying out applied research on construction cost optimisation using Lean-BIM Location-based Management System (LBMS) and Earned Value Analysis. The research is hinged on lean principles, to optimise the building project processes, schedule, cost, and quality while ensuring it exceeds client or customer expectations.

I hereby request your participation in this research as industry experts. As a key player in the real estate business in Nigeria, access to your projects is fundamental to the success of the research. I like to request access to one of your on-going projects for **a case study** at no cost to your organisation. This would involve interviews with key project team (Zoom meetings), and project key data. Physical access to project sites might not be feasible due to current COVID-19 challenges.

In return for your participation, the research findings will be made available to you, and the outcome of the research could have the potential for project waste detections, improved construction processes and schedule, and profit maximisation. I am willing to comply with any requirements or negotiate terms that deem necessary in accordance with your company policy. No real identity shall be revealed; information shall be treated confidential.

The other members of the research team are Prof. Dr Ing. Dieter Bunte (HTW Berlin, Germany) and Prof. Eric Pollock (Metropolia, Helsinki, Finland). I can be reached anytime via my email *uchejulius.obaye@metropolia.fi* or my cell phone +2347020386977 or +358452730533

Thank you while hoping for your organisation's willingness to participate in this research.

Yours sincerely

OBAYE Uche Julius
(Researcher)
University of Applied Sciences, Berlin-Germany.
Metropolia University of Applied Sciences, Helsinki-Finland

Appendix A

Research Interview

This appendix contains an interview performed through Microsoft Teams with the Project Teams, including the Chief Executive Officer (CEO) of the Real Estate Company.

BACKGROUND INFORMATION:

Researcher: Can you confirm your position in the organisation to the researcher?

Project Manager: Yes, I double as a Project Director and Construction Manager on the Estate Projects in Lagos.

Researcher: What is the level of your education?

Project Manager: Master in Engineering (M.Eng)

Researcher: Do you have any other professional certifications?

Project Manager: Yes, Basic HSE Certifications, and ISO 9001:2008 QMS Internal Auditor

Researcher: How long have you been working in the building industry?

Project Manager: I have been working for 14 years.

Researcher: How would you describe your work in the company?

Project Manager: It is challenging. I oversee and control construction works and manages finances on the project. I am responsible for the cost performance of the project.

BACKGROUND OF THE COMPANY

Researcher: What is your project about?

Project Manager: Our project is about developing and constructing low cost, affordable housing projects in Lagos, Nigeria. Currently, we have about 40 blocks of 5 units Terrace Duplex in Ajah, and Lekki in Lagos, Nigeria.

Researcher: When was the company established?

Project Manager: The company was established in the year 2011

Researcher: How would you describe the history of the company? Operations

Project Manager: The company is basically into Real Estate Business. We buy landed property and develop low housing units, yet sophisticated designs to provide shelter for Nigerians. Years before now, we invested in hectares of landed property in the Lagos island region since areas seem not developed. Now, due to population explosion, urbanisation and business

opportunities in Lagos, there is housing scarcity. Since our operations started in 2011, we have executed 50 housing duplexes, all sold and still providing space management services. Companies whose staff are entitled to housing allowances approached us for deals where they fund part of the housing cost while executing the housing unit.

Researcher: How would you describe the company's structure? Departments, number of Employee, e.t.c.

Project Manager: The CEO is the boss. The Finance Manager Reports Directly to the CEO/MD. There are three(3) critical departments in the organisation, the HR, The Real Estate Sales, and Project Development Department. I belong to the Project Development section of the company. We have today around 40 employees that are mostly carpenters and masons, also some helpers. Then there are around 30 that work for subcontractor which are other trades involved in the projects, electricians, painter, plumbers and others.

Researcher: What is the prospect for the company?

Project Manager: The stake is high, the future is bright, generally for real estate business in Nigeria, especially in Lagos. The demand for housing units is continually rising due to increased population, urbanisation, and Lagos' job opportunities. We hope to continually optimise our processes, keep improving our services and make our customers happy. We hope to expand our services depending on our customers' request and provide world-class estate buildings with reduced cost.

SCHEDULES AND PLANNING

Researcher: How would you describe the work procedures when planning and scheduling?

Project Manager: We have a Planning Engineer who tries to schedule the activities and define the most suitable work pattern depending on the project's agreed completion time. To my understanding, we have been using the work breakdown structure in our scheduling process and procedures. The project is usually divided into sectional components, which are again divided into activities. The activities are divided into tasks which are then assigned some execution due dates and duration.

Researcher: What kind of software do you use to make time schedules and cost estimates; do you find this sufficient?

Project Manager: Our Quantity Survivors uses basic AutoCAD and manual estimate process. Other software is just to perform checks to be sure. I think they know better.

Researcher: How do you estimate the cost and quantities?

Project manager: I do not make the estimates myself; it is believed the professionals should be 95% accurate in their estimates. We treat every project differently under the unique property of a project. We tend to analyse every project separately depending on size, location, environment, customer/client requirements, and other outmost interest factors. The Costing part sometimes depends on past work done involving similar tasks or activities. Also, records of prices compiled in the city are consulted to fix an item's unit cost.

Researcher: Do you estimate at this stage how much workforce you need, to perform the task?

Project Manager: No, most time we try to fix the duration we desired to complete the job and plan based on that. During the execution process, we mobilise the workforce starting with the minimum number.

Researcher: How would you describe the work procedures when controlling onsite?

Project Manager: Combined with the site, quality engineers and the Planner, we make a weekly site visit. The Planner records daily progress to track delays or otherwise. The Site engineer is saddled with the responsibility of ensuring timely project execution. Usually, I don't interfere with how much work needs to be done, but all I am interested in is that the target date must be achieved without additional cost. The site visit is generally to identify issues and challenges with site progress and offer an instant solution.

Researcher: Do you make weekly plans

Project Manager: No, we don't prepare weekly extracts from the Master Schedule. We work directly with the Master Work Schedule. Well, sometimes this becomes confusing for young engineers due to the number of tasks and activities.

Researcher: In months, how long is the estimated project time for a Duplex Project in Lekki, Lagos?

Project Manager: Concrete work + Blockworks+ Finishes can take 6-8 months depending on funds.

Researcher: Your Duplex Estate Project has Started since 2018, is your progress according to the project schedule?

Project Manager: You are correct. The project started already since January 2019. The Projects are planned to be executed in phases such that there will be room to regain the funds. Well, we are not bold to say we have the progress as planned. We had challenges with funds, and the cash flow was not too interesting.

Researcher: How much work have been executed?

Project Manager: Right now, we are 49% of the project progress. Block walls to the Roof level is done with some of the first floor columns and lintels already in place. Roof Beams is

yet to be constructed. The basic challenge is the fund which drags and limit the number of the workforce on site.

Researcher: What is the implication of Project Delays in the overall contract?

Project Manager: Well, the more the project completion time is delayed, the more tendency for other unplanned costs to climb on the project. Timely completion of the housing projects enables quicks sales and handover to the end-users. Happy customer, happy client, more fund and projects

Researcher: Did you make a detailed time schedule for your Estate Projects?

Project Manager: We did yes, we have it.

Researcher: Have you been able to keep the schedule?

Project Manager: Yes, we work to keep to the schedule except now when we start having the issues of the fund.

Researcher: Have you had any delays on the project?

Project Manager: Yes. Sometimes the durations in the planning don't tally but we always finish within the worst-case durations. But right now, we have major delays causing us to reduce the workforce due to insufficient funding.

COST PLANNING AND MANAGEMENT

Researcher: Who has the overall responsibility for Project Construction Cost?

Project Manager: I do. The project cost performance is my strict responsibility. We don't want to delay the project and cause other unwanted costs to start accumulating.

Researcher: Where do the funding from the project come from?

Project Manager: The project funding comes from the Bank, who is the main sponsor for the construction works. It's a partnership deal where we own the land, and the execution funds come from the Bank.

Researcher: How is the total project Cost developed?

Project Manager: The overall project cost is developed from the Bill of Quantities (BoQ) and the unit rates of items. The labour cost was built up, allowing for 10% overhead, 20% equipment cost, 35% labour cost and 35% materials.

Researcher: How is the Instalment Payment Agreement negotiated?

Project Manager: Well, no specific rule was followed during the negotiation of the instalment funding from the sponsor. It was strictly on what we believed was ideal to do, making sure the fund is evenly spread.

Researcher: Was there Cash Flow Planning for the project? If yes, how was it prepared?

Project Manager: No. It was not easy to simulate data to observe the performance of cash flow when the project have not started.

Researcher: Has the Cash Flow been useful in the progress of the project?

Project Manager: Since we do not have it, we cannot say exactly if this would have been useful in making decisions.

Researcher: What do you think always make the eventual cost of the project expensive than planned?

Project Manager: Nothing increases project costs other than the cost of delays, wastes and time overrun. When a project is delayed, it incurred additional expenses, cost of materials rises, cost of equipment and labour increases.

Appendix B

Questionnaire

(Accessing the factors of Integrating Lean-BIM Alternative Planning in the Nigeria Real Estate Sector)

Part 1: General Questions

1. Age of company in service?
    a. 0-1
    b. 2-5
    c. 6-9
    d. 10-19
2. How many years have your organization been in estate development business?
    a. 0-1
    b. 2-5
    c. 6-9
    d. 10-19
    e. 20+
3. What is the Academic Background of the Business Owner(s)?
    a. Architecture
    b. Civil Engineering
    c. Quantity Surveyor
    d. Construction Management
    e. Estate Surveyor/ Estate Management
4. What is the MD/CEO's highest level of education?
    a. Bachelors
    b. Master Degree
    c. PhD
    d. HND
    e. Others

Part 2: Employees Background Education

5. How many employees does your company have?
    a. 0-4
    b. 5-9
    c. 10-14
    d. 15-19
    e. 20+
6. How many of the employees are construction professionals?
    a. 0-1

b. 2-5
c. 6-9
d. 10-14
e. 15+

7. What is the highest qualification of the employees?
    a. Bachelors
    b. Master Degree
    c. PhD
    d. HND
    e. Others

Part 3: Software Application and Knowledge

8. Have you heard about BIM (Building Information Modeling) before?
    a. Yes
    b. No
9. Do you use BIM for your processes? *Choose one option from below.*
    a. We do not use BIM for any of our processes
    b. For Cost Estimation
    c. Clash Detection
    d. Visualization of the project timeline
    e. For 2D/3D Design Coordinations
    f. Other use?_____
10. What is the commonly available software in your company? Tick as many.

Autodesk Revit ⬭
AutoCAD ⬭
ArchiCAD ⬭
Microstation ⬭
Tekla ⬭
Staadpro ⬭
Primavera ⬭
MS Project ⬭
Sketch up ⬭
Naviswork ⬭
Vico Schedule ⬭

Others_____

11. How can you rate your professionals' skills in software use?

a. Poor (0-4%)
b. Fair (5-10%)
c. Good (11-14%)
d. Very Good (15-19%)
e. Excellent (20% and above)

12. What do you think is responsible for your rating above?
    a. Lack of interest
    b. None availability of software for use
    c. University training does not integrate software applications from the beginning
    d. Other_____

13. How would you rate your employees' knowledge?

SKILLSET	POOR	GOOD	VERY GOOD	EXCELLENCE
LEAN CONSTRUCTION				
Critical Path				
LINE OF BALANCE				
Gantt Chart				
LOCATION-BASED SCHEDULING				
Location-Based Management System				
BIM TOOLS				
Cash Flow Simulation				

Part 4: Planning, Scheduling and Control

14. Do your company have specific planning engineer?
    a. No, we contract it out
    b. Yes
    c. It is not important
15. Does your estate development involve direct supervision of works on-site?
    a. Yes
    b. No
16. Do you have your own direct team responsible for the supervisory operations?
    a. Yes
    b. No
17. Which Softwares have you been using or used for your planning and scheduling?
    Primavera

MS Project ⬭
Vico Office ⬭
PIAB ⬭
Synchro ⬭
Naviswork ⬭
MS Excel ⬭
Others:_____

18. Which statement can better describe your company (organization)

STATEMENT	POOR	GOOD	VERY GOOD	EXCELLENCE
CRITICAL PATH METHOD IS SUFFICIENT FOR SCHEDULING.	⬭	⬭	⬭	⬭
I Am Satisfied With The Current Method We Used For Planning And Scheduling	⬭	⬭	⬭	⬭
I AM OPEN AND INTERESTED IN NEW METHODS FOR PLANNING AND SCHEDULING	⬭	⬭	⬭	⬭
Since Every Organization Is Interested In Process Optimization To Maximize Profit, Every Real Estate Firm Will Be Open To Changes In Planning And Scheduling	⬭	⬭	⬭	⬭

19. What do you consider the main barriers to the implementation of Lean-BIM alternative Planning for Cost Optimization in the Nigerian Real Estate Sector?
    a. Expensive implementation Cost
    b. Lack of Knowledge in the Scheduling
    c. Lack of knowledge in the use of the Scheduling Software
    d. Lack of Organization Interest
    e. Lack of expertise in the field of Lean-BIM implementation
    f. Other_____

Thank you.

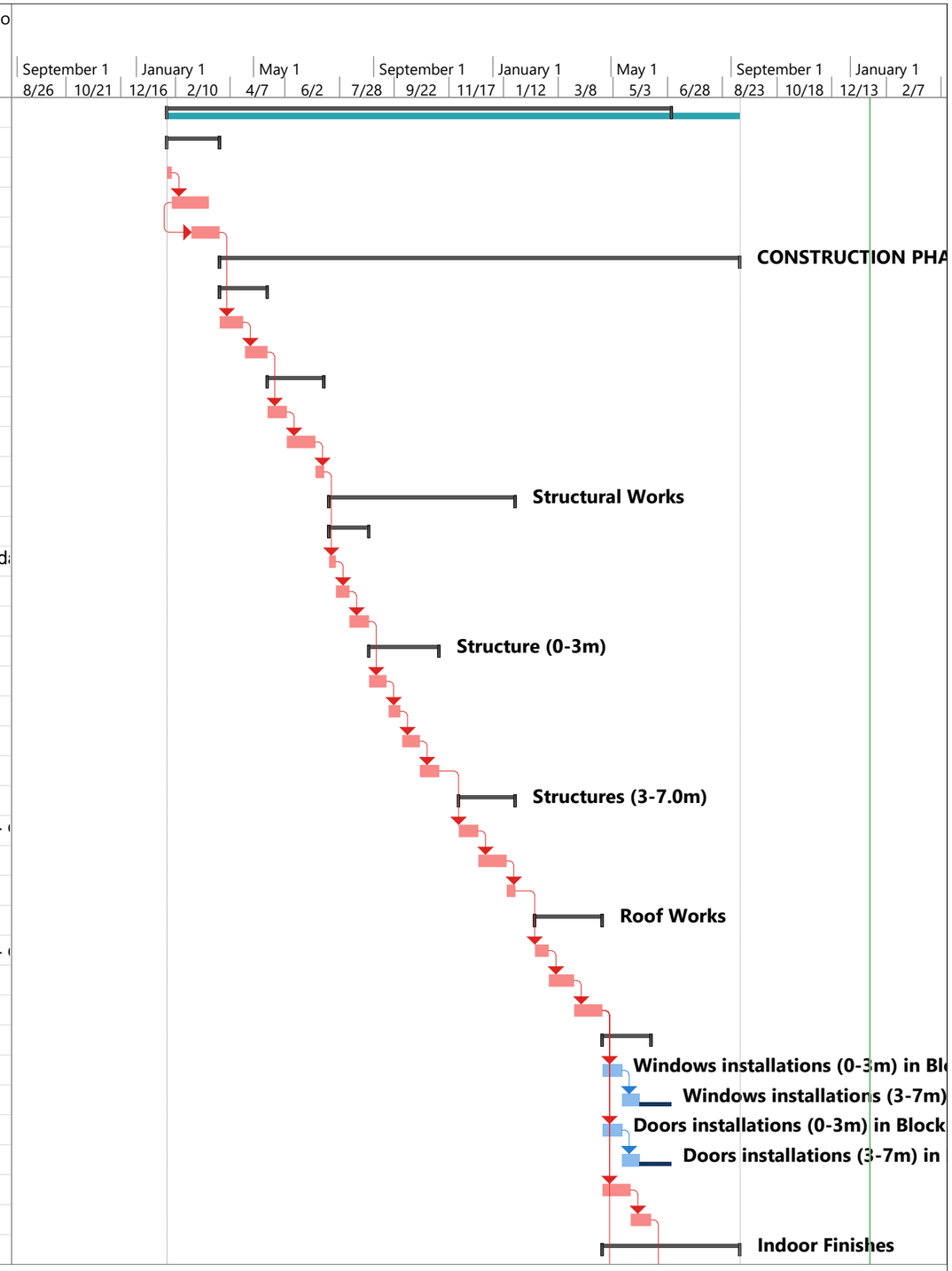
Bill of Quantities

S/No	ITEMS	Qty	Unit	Cost(₦)/Unit	Total Cost (₦)
1	External Fence setup	500	m	2,000.00	1,000,000
2	Temporary Office, Storage and Equipment Installations	3	no.	450,000.00	1,350,000
3	Excavation for Block A	276	m3	2,800.00	772,800
4	Compact and Level bottom of Excavation A	276	m3	3,900.00	1,076,400
5	Set-up formworks to foundation Block A	250	m2	6,000.00	1,500,000
6	Foundations Rebars Block A	10000	kg	8,000.00	80,000,000
7	Concrete in foundation Block A	110	m3	80,000.00	8,800,000
8	Ground Floor Slab formwork Block A	230	m2	6,000.00	1,380,000
9	Ground Floor Slab Iron works & Services Installations Block A	15600	kg	8,000.00	124,800,000
10	Concrete to Ground Floor Slab Block A	300	m3	53,000.00	15,900,000
11	External Walls + Columns Block A	130	m3	110,500.00	14,365,000
12	Internal Walls Block A	260	m2	8,000.00	2,080,000
13	Beams + Stairs Block A	110	m3	110,500.00	12,155,000
14	Floor Slab A	300	m3	110,500.00	33,150,000
15	External Walls + Columns Block A	130	m3	110,500.00	14,365,000
16	Internal Walls Block A	260	m3	8,000.00	2,080,000
17	Roof Beams	95	m3	110,500.00	10,497,500
18	Roof Plate Block A	250	m	6,500.00	1,625,000
19	Roof Trusses in Block A	650	m3	7,800.00	5,070,000
20	Roof Cladding in Block A	1500	m2	6,580.00	9,870,000
21	Windows installations (0-3m) in Block A	60	m2	23,000.00	1,380,000
22	Windows installations (3-7m) in Block A	60	m2	23,000.00	1,380,000
23	Doors installations (0-3m) in Block A	28.4	m2	25,000.00	710,000
24	Doors installations (3-7m) in Block A	30	m2	25,000.00	750,000
25	Rendering in Block A	250	m2	10,600.00	2,650,000
26	Other finishes in Block A	250	m2	9,400.00	2,350,000
27	Mortar Screeding in Block A	240	m3	10,400.00	2,496,000
28	Electricity in Block A	50	m2	120,000.00	6,000,000
29	Plumbing in Block A	50	m2	150,000.00	7,500,000
30	Painting in Block A	240	m2	8,000.00	1,920,000
31	Fixtures and Doors in Block A	40	m2	25,000.00	1,000,000
32	Tiling in Block A	55	m2	10,500.00	577,500
33	Balustrades and Kitchen Installations in Block A	80	m	15,000.00	1,200,000
34	Mortar Screeding in Block A	240	m2	5,700.00	1,368,000
35	Electricity in Block A	50	m2	120,000.00	6,000,000
36	Plumbing in Block A	50	m2	150,000.00	7,500,000
37	Painting in Block A	240	m2	8,000.00	1,920,000
38	Fixtures and Doors in Block A	65	m2	25,000.00	1,625,000
39	Tiling in Block A	55	m2	10,500.00	577,500
40	Septic and Soakaway Tanks Block A	9	m3	93,000.00	837,000
41	Car Park Block A	120	m2	25,000.00	3,000,000
42	Landscaping works for Block A	80	m2	25,000.00	2,000,000
43	Final Cleaning and Handover	10	day	10,000.00	100,000
					₦396,677,700

Appendix D: Instalment Funding Agreement from the Sponsor Bank

Instalment Rate as per Sponsor Bank Agreement		
No	Item	Percentage of Const. Cost %
1	Received at the Beginning of Excavation and Foundation	29.5
2	Structural Works	24.7
3	Roof Works	5.6
4	MEP Works	8.3
5	Fixation of Windows, Glazing works, and Interior and External Walls and screed	14.4
6	Completion of all Interior works including Tiles, Plaster, and kitchen	11
7	Façade works	2.5
8	After Handing over	4

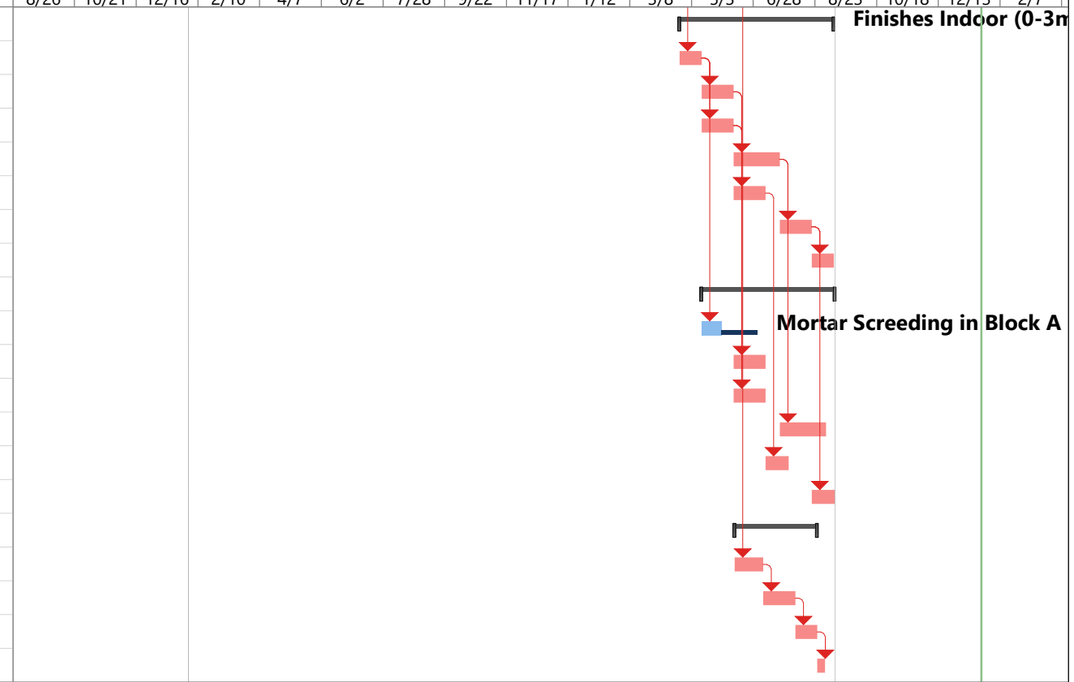
ID	Task Mode	Task Name	Duration	Start	Finish	Predecesso
1		**1 OVERALL PROJECT WORKS**	**369 days**	**Fri 2/1/19**	**Wed 7/1/20**	
2		**1.1 TEMPORARY INSTALLATIONS**	**38 days**	**Fri 2/1/19**	**Tue 3/26/19**	
3		1.1.1 Mobilization	3 days	Fri 2/1/19	Tue 2/5/19	
4		1.1.2 External Fence setup	28 days	Wed 2/6/19	Fri 3/15/19	3
5		1.1.3 Temporary Office, Storage and Equipment	21 days	Tue 2/26/19	Tue 3/26/19	4SS+14
6		**1.2 CONSTRUCTION PHASE**	**381 days**	**Wed 3/27/19**	**Wed 9/9/20**	
7		**1.2.1 Earthwork**	**35 days**	**Wed 3/27/19**	**Tue 5/14/19**	
8		1.2.1.1 Excavation for Block A	18 days	Wed 3/27/19	Fri 4/19/19	5
9		1.2.1.2 Compact and Level bottom of Excavation A	17 days	Mon 4/22/19	Tue 5/14/19	8
10		**1.2.2 Foundation**	**42 days**	**Wed 5/15/19**	**Thu 7/11/19**	
11		1.2.2.1 Set-up formworks to foundation Block A	14 days	Wed 5/15/19	Mon 6/3/19	9
12		1.2.2.2 Foundations Rebars Block A	21 days	Tue 6/4/19	Tue 7/2/19	11
13		1.2.2.3 Concrete in foundation Block A	7 days	Wed 7/3/19	Thu 7/11/19	12
14		**1.2.3 Structural Works**	**137 days**	**Wed 7/17/19**	**Thu 1/23/20**	
15		**1.2.3.1 Ground Floor (Level 0.00m)**	**29 days**	**Wed 7/17/19**	**Mon 8/26/19**	
16		1.2.3.1.1 Ground Floor Slab formwork Block A	5 days	Wed 7/17/19	Tue 7/23/19	13FS+3 d
17		1.2.3.1.2 Ground Floor Slab Iron works &	10 days	Wed 7/24/19	Tue 8/6/19	16
18		1.2.3.1.3 Concrete to Ground Floor Slab Block A	14 days	Wed 8/7/19	Mon 8/26/19	17
19		**1.2.3.2 Structure (0-3m)**	**52 days**	**Tue 8/27/19**	**Wed 11/6/19**	
20		1.2.3.2.1 External Walls + Columns Block A	14 days	Tue 8/27/19	Fri 9/13/19	18
21		1.2.3.2.2 Internal Walls Block A	10 days	Mon 9/16/19	Fri 9/27/19	20
22		1.2.3.2.3 Beams + Stairs Block A	14 days	Mon 9/30/19	Thu 10/17/19	21
23		1.2.3.2.4 Floor Slab A	14 days	Fri 10/18/19	Wed 11/6/19	22
24		**1.2.3.3 Structures (3-7.0m)**	**42 days**	**Wed 11/27/19**	**Thu 1/23/20**	
25		1.2.3.3.1 External Walls + Columns Block A	14 days	Wed 11/27/19	Mon 12/16/19	23FS+14
26		1.2.3.3.2 Internal Walls Block A	21 days	Tue 12/17/19	Tue 1/14/20	25
27		1.2.3.3.3 Roof Beams	7 days	Wed 1/15/20	Thu 1/23/20	26
28		**1.2.4 Roof Works**	**49 days**	**Thu 2/13/20**	**Tue 4/21/20**	
29		1.2.4.1 Roof Plate Block A	10 days	Thu 2/13/20	Wed 2/26/20	27FS+14
30		1.2.4.2 Roof Trusses in Block A	18 days	Thu 2/27/20	Mon 3/23/20	29
31		1.2.4.3 Roof Cladding in Block A	21 days	Tue 3/24/20	Tue 4/21/20	30
32		**1.2.5 Outdoor Finishes**	**36 days**	**Wed 4/22/20**	**Wed 6/10/20**	
33		1.2.5.1 Windows installations (0-3m) in Block A	14 days	Wed 4/22/20	Mon 5/11/20	31
34		1.2.5.2 Windows installations (3-7m) in Block A	14 days	Tue 5/12/20	Fri 5/29/20	33
35		1.2.5.3 Doors installations (0-3m) in Block A	14 days	Wed 4/22/20	Mon 5/11/20	31
36		1.2.5.4 Doors installations (3-7m) in Block A	14 days	Tue 5/12/20	Fri 5/29/20	35
37		1.2.5.5 Rendering in Block A	21 days	Wed 4/22/20	Wed 5/20/20	31
38		1.2.5.6 Other finishes in Block A	15 days	Thu 5/21/20	Wed 6/10/20	37
39		**1.2.6 Indoor Finishes**	**101 days**	**Wed 4/22/20**	**Wed 9/9/20**	



Project: Block A ONLY Planning
Date: Thu 1/21/21

Task	Inactive Task	Manual Summary Rollup	External Milestone	Baseline Milestone
Split	Inactive Milestone	Manual Summary	Deadline	Baseline Summary
Milestone	Inactive Summary	Start-only	Critical	Progress
Summary	Manual Task	Finish-only	Critical Split	Manual Progress
Project Summary	Duration-only	External Tasks	Baseline	Slack

ID		Task Mode	Task Name	Duration	Start	Finish	Predecesso
40			**1.2.6.1 Finishes Indoor (0-3m)**	**100 days**	**Wed 4/22/20**	**Tue 9/8/20**	
41			1.2.6.1.1 Mortar Screeding in Block A	14 days	Wed 4/22/20	Mon 5/11/20	31
42			1.2.6.1.2 Electricity in Block A	21 days	Tue 5/12/20	Tue 6/9/20	41
43			1.2.6.1.3 Plumbing in Block A	21 days	Tue 5/12/20	Tue 6/9/20	41
44			1.2.6.1.4 Painting in Block A	30 days	Wed 6/10/20	Tue 7/21/20	43
45			1.2.6.1.5 Fixtures and Doors in Block A	21 days	Wed 6/10/20	Wed 7/8/20	42
46			1.2.6.1.6 Tiling in Block A	21 days	Wed 7/22/20	Wed 8/19/20	44
47			1.2.6.1.7 Balustrades and Kitchen Installations in	14 days	Thu 8/20/20	Tue 9/8/20	46
48			**1.2.6.2 Finishes Indoor (3-7m)**	**87 days**	**Tue 5/12/20**	**Wed 9/9/20**	
49			1.2.6.2.1 Mortar Screeding in Block A	14 days	Tue 5/12/20	Fri 5/29/20	41
50			1.2.6.2.2 Electricity in Block A	21 days	Wed 6/10/20	Wed 7/8/20	42
51			1.2.6.2.3 Plumbing in Block A	21 days	Wed 6/10/20	Wed 7/8/20	43
52			1.2.6.2.4 Painting in Block A	30 days	Wed 7/22/20	Tue 9/1/20	44
53			1.2.6.2.5 Fixtures and Doors in Block A	15 days	Thu 7/9/20	Wed 7/29/20	45
54			1.2.6.2.6 Tiling in Block A	15 days	Thu 8/20/20	Wed 9/9/20	46
55			**1.2.7 External Works and Landscapping**	**53 days**	**Thu 6/11/20**	**Mon 8/24/20**	
56			1.2.7.1 Septic and Soakaway Tanks Block A	18 days	Thu 6/11/20	Mon 7/6/20	38
57			1.2.7.2 Car Park Block A	21 days	Tue 7/7/20	Tue 8/4/20	56
58			1.2.7.3 Landscaping works for Block A	14 days	Wed 8/5/20	Mon 8/24/20	57
59			1.2.8 Final Cleaning and Handover	5 days	Tue 8/25/20	Mon 8/31/20	58



Project: Block A ONLY Planning
Date: Thu 1/21/21

Task	Inactive Task	Manual Summary Rollup	External Milestone	Baseline Milestone
Split	Inactive Milestone	Manual Summary	Deadline	Baseline Summary
Milestone	Inactive Summary	Start-only	Critical	Progress
Summary	Manual Task	Finish-only	Critical Split	Manual Progress
Project Summary	Duration-only	External Tasks	Baseline	Slack

XYZ

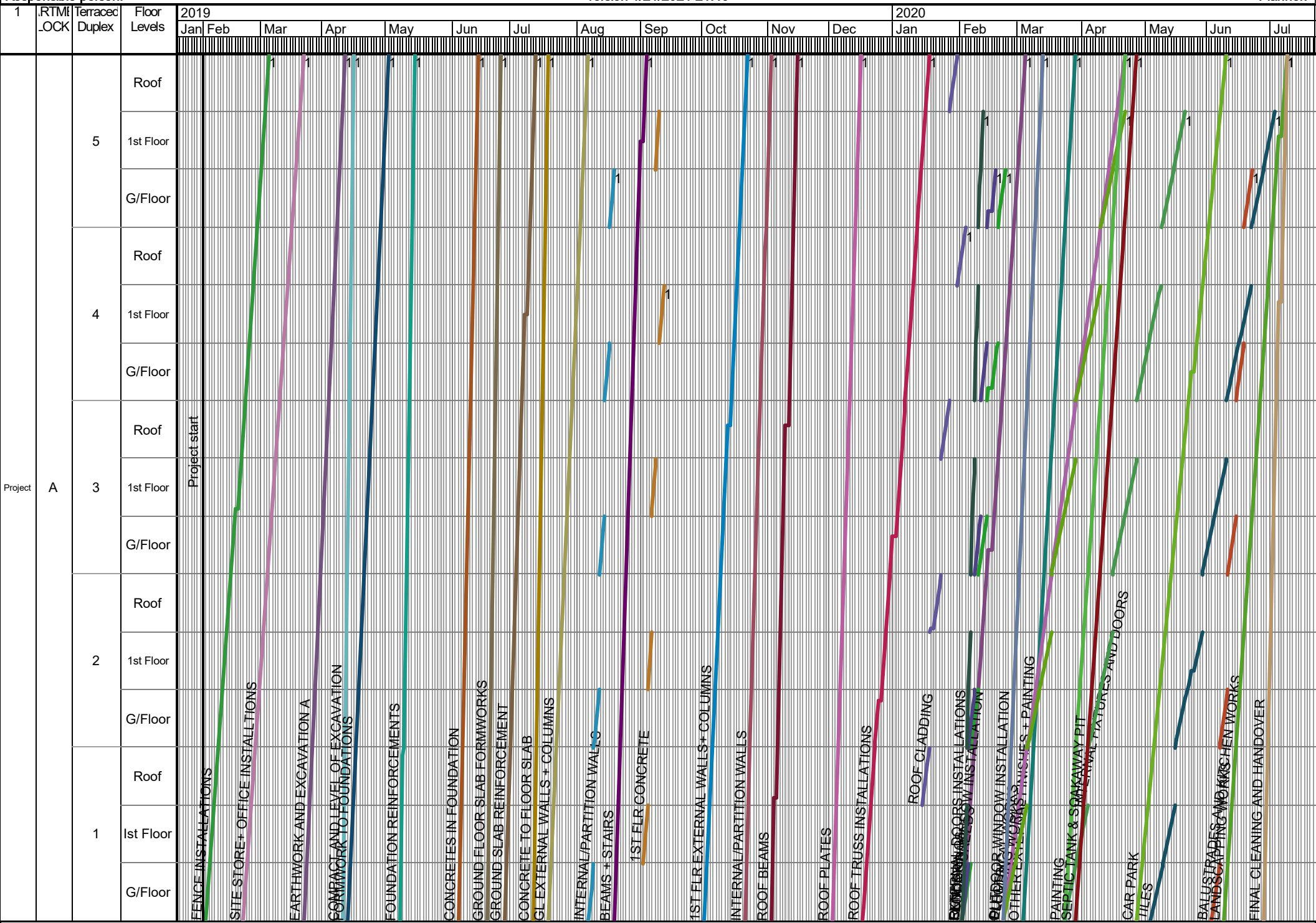
Flowline view

DUPLEX APARTMENT (BEFORE OPTIMIZATION)

Responsible person:

version 1/21/2021 21:40

Planner:



Target: ——— Actual: - - - - - - - - - Forecast: ——— ———

Design mode

Schedule Planner v6.5.81.862

XYZ

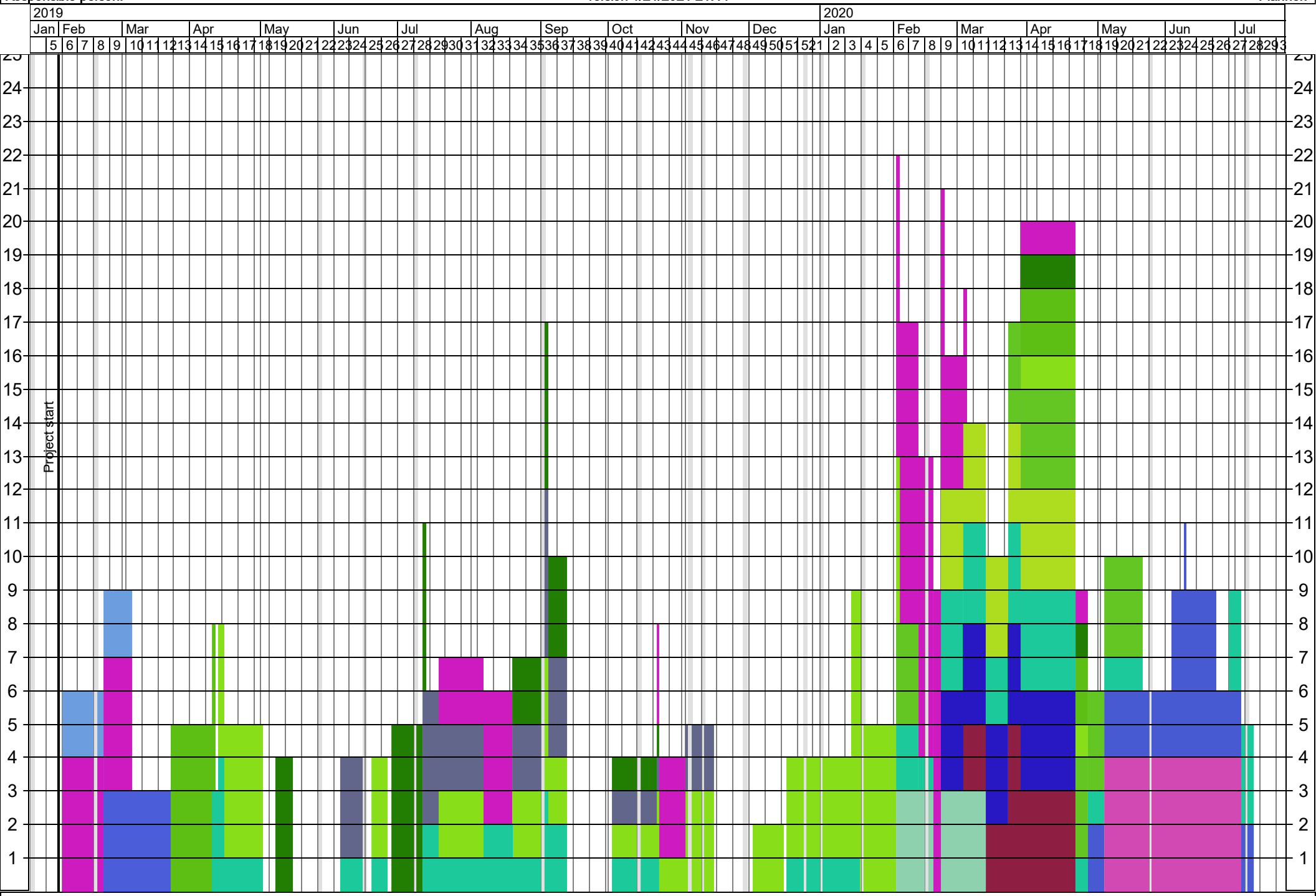
Resource graph

DUPLEX APARTMENT (BEFORE OPTIMIZATION)

Responsible person:

version 1/21/2021 21:44

Planner:



Design mode

Schedule Planner v6.5.81.862

NOTES:

BEFORE OPTIMIZATION

PROGRESS SIMULATIONS

S/No	ITEMS	Start	Finish	Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20
1	Mobilization	Fri 2/1/19	Fri 2/1/19	1																	
2	External Fence setup	Mon 2/4/19	Mon 3/4/19	0.5	0.5																
3	Temporary Office, Storage and Equipment Installations	Fri 2/22/19	Fri 3/22/19	0.3	0.7																
4	Excavation for Block A	Mon 3/25/19	Thu 4/11/19		0.45	0.55															
5	Compact and Level bottom of Excavation A	Fri 4/12/19	Wed 4/17/19			1															
6	Set-up formworks to foundation Block A	Thu 4/18/19	Tue 5/7/19			0.5	0.5														
7	Foundations Rebars Block A	Wed 5/8/19	Wed 6/5/19				0.5	0.5													
8	Concrete in foundation Block A	Thu 6/6/19	Fri 6/14/19					1													
9	Ground Floor Slab formwork Block A	Thu 6/20/19	Wed 6/26/19					1													
10	Ground Floor Slab Iron works & Services Installations Block A	Thu 6/27/19	Wed 7/10/19					0.4	0.6												
11	Concrete to Ground Floor Slab Block A	Thu 7/11/19	Wed 7/17/19						1												
12	External Walls + Columns Block A	Thu 7/18/19	Tue 8/6/19						0.5	0.5											
13	Internal Walls Block A	Wed 8/7/19	Mon 8/19/19							1											
14	Beams + Stairs Block A	Tue 8/20/19	Mon 9/2/19							0.5	0.5										
15	Floor Slab A	Tue 9/3/19	Wed 9/11/19								1										
16	External Walls + Columns Block A	Wed 10/2/19	Mon 10/21/19									1									
17	Internal Walls Block A	Tue 10/22/19	Fri 11/1/19									1									
18	Roof Beams	Mon 11/4/19	Tue 11/12/19										1								
19	Roof Plate Block A	Tue 12/3/19	Mon 12/16/19										1								
20	Roof Trusses in Block A	Tue 12/17/19	Tue 1/14/20										0.5	0.5							
21	Roof Cladding in Block A	Wed 1/15/20	Mon 2/3/20												0.45	0.55					
22	Windows installations (0-3m) in Block A	Tue 2/4/20	Fri 2/21/20													1					
23	Windows installations (3-7m) in Block A	Mon 2/24/20	Thu 3/12/20													0.6	0.4				
24	Doors installations (0-3m) in Block A	Tue 2/4/20	Fri 2/21/20													1					
25	Doors installations (3-7m) in Block A	Mon 2/24/20	Mon 3/23/20													0.4	0.6				
26	Rendering in Block A	Tue 2/4/20	Tue 3/3/20													0.3	0.7				
27	Other finishes in Block A	Wed 3/4/20	Fri 3/27/20														1				
28	Mortar Screeding in Block A	Tue 2/4/20	Fri 2/21/20													1					
29	Electricity in Block A	Mon 2/24/20	Mon 3/23/20													0.6	0.4				
30	Plumbing in Block A	Mon 2/24/20	Mon 3/23/20													0.5	0.5				
31	Painting in Block A	Tue 3/24/20	Mon 5/4/20													0.4	0.4	0.2			
32	Fixtures and Doors in Block A	Tue 3/24/20	Tue 4/21/20														0.3	0.7			
33	Tiling in Block A	Tue 5/5/20	Tue 6/2/20																0.8	0.2	
34	Balustrades and Kitchen Installations in Block A	Wed 6/3/20	Mon 6/22/20																1		
35	Mortar Screeding in Block A	Mon 2/24/20	Thu 3/12/20													0.4	0.6				
36	Electricity in Block A	Tue 3/24/20	Tue 4/21/20														0.5	0.5			
37	Plumbing in Block A	Tue 3/24/20	Tue 4/21/20														0.5	0.5			
38	Painting in Block A	Tue 5/5/20	Mon 6/15/20																0.4	0.6	
39	Fixtures and Doors in Block A	Wed 4/22/20	Wed 5/20/20															0.5	0.5		
40	Tiling in Block A	Wed 6/3/20	Wed 7/1/20																	0.8	0.2
41	Septic and Soakaway Tanks Block A	Mon 3/30/20	Mon 4/27/20														0.2	0.8			
42	Car Park Block A	Tue 4/28/20	Mon 6/8/20															0.2	0.4	0.4	
43	Landscaping works for Block A	Tue 6/9/20	Fri 6/26/20																	1	
44	Final Cleaning and Handover	Mon 6/29/20	Tue 7/7/20																		1

NOTES:

BEFORE OPTIMIZATION

CASH FLOW PERFORMANCE (EXPENDITURES)

S/No	ITEMS	Start	Finish		Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20
1	External Fence setup	Mon 2/4/19	Mon 3/4/19	₦ 1,000,000.00	500,000.0	500,000.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	Temporary Office, Storage and Equipment Installations	Fri 2/22/19	Fri 3/22/19	₦ 1,350,000.00	405,000.0	945,000.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	Excavation for Block A	Mon 3/25/19	Thu 4/11/19	₦ 772,800.00	-	347,760.0	425,040.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	Compact and Level bottom of Excavation A	Fri 4/12/19	Wed 4/17/19	₦ 1,076,400.00	-	-	1,076,400.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	Set-up formworks to foundation Block A	Thu 4/18/19	Tue 5/7/19	₦ 1,500,000.00	-	-	750,000.0	750,000.0	-	-	-											
6	Foundations Rebars Block A	Wed 5/8/19	Wed 6/5/19	₦ 80,000,000.00	-	-	-	40,000,000.0	40,000,000.0	-	-											
7	Concrete in foundation Block A	Thu 6/6/19	Fri 6/14/19	₦ 8,800,000.00	-	-	-	-	8,800,000.0	-												
8	Ground Floor Slab formwork Block A	Thu 6/20/19	Wed 6/26/19	₦ 1,380,000.00	-	-	-	-	1,380,000.0													
9	Ground Floor Slab Iron works & Services Installations Block A	Thu 6/27/19	Wed 7/10/19	₦ 124,800,000.00	-	-	-	-	49,920,000.0	74,880,000.0	-											
10	Concrete to Ground Floor Slab Block A	Thu 7/11/19	Wed 7/17/19	₦ 15,900,000.00	-	-	-	-	-	15,900,000.0												
11	External Walls + Columns Block A	Thu 7/18/19	Tue 8/6/19	₦ 14,365,000.00	-	-	-	-	-	7,182,500.0	7,182,500.0											
12	Internal Walls Block A	Wed 8/7/19	Mon 8/19/19	₦ 2,080,000.00	-	-	-	-	-	-	2,080,000.0											
13	Beams + Stairs Block A	Tue 8/20/19	Mon 9/2/19	₦ 12,155,000.00	-	-	-	-	-	-	6,077,500.0	6,077,500.0										
14	Floor Slab A	Tue 9/3/19	Wed 9/11/19	₦ 33,150,000.00	-	-	-	-	-	-		33,150,000.0	-	-								
15	External Walls + Columns Block A	Wed 10/2/19	Mon 10/21/19	₦ 14,365,000.00	-	-	-	-	-	-			14,365,000.0									
16	Internal Walls Block A	Tue 10/22/19	Fri 11/1/19	₦ 2,080,000.00	-	-	-	-	-	-			2,080,000.0	-	-							
17	Roof Beams	Mon 11/4/19	Tue 11/12/19	₦ 10,497,500.00	-	-	-	-	-	-	-	-	-	10,497,500.0								
18	Roof Plate Block A	Tue 12/3/19	Mon 12/16/19	₦ 1,625,000.00	-	-	-	-	-	-	-	-	-	1,625,000.0								
19	Roof Trusses in Block A	Tue 12/17/19	Tue 1/14/20	₦ 5,070,000.00	-	-	-	-	-	-	-	-	-	2,535,000.0	2,535,000.0	-	-					
20	Roof Cladding in Block A	Wed 1/15/20	Mon 2/3/20	₦ 9,870,000.00	-	-	-	-	-	-	-	-	-			4,441,500.0	5,428,500.0					
21	Windows installations (0-3m) in Block A	Tue 2/4/20	Fri 2/21/20	₦ 1,380,000.00	-	-	-	-	-	-	-	-	-				1,380,000.0					
22	Windows installations (3-7m) in Block A	Mon 2/24/20	Thu 3/12/20	₦ 1,380,000.00	-	-	-	-	-	-	-	-	-				828,000.0	552,000.0				
23	Doors installations (0-3m) in Block A	Tue 2/4/20	Fri 2/21/20	₦ 710,000.00	-	-	-	-	-	-	-	-	-				710,000.0					
24	Doors installations (3-7m) in Block A	Mon 2/24/20	Mon 3/23/20	₦ 750,000.00	-	-	-	-	-	-	-	-	-				300,000.0	450,000.0				
25	Rendering in Block A	Tue 2/4/20	Tue 3/3/20	₦ 2,650,000.00	-	-	-	-	-	-	-	-	-				795,000.0	1,855,000.0				
26	Other finishes in Block A	Wed 3/4/20	Fri 3/27/20	₦ 2,350,000.00	-	-	-	-	-	-	-	-	-				-	2,350,000.0				
27	Mortar Screeding in Block A	Tue 2/4/20	Fri 2/21/20	₦ 2,496,000.00	-	-	-	-	-	-	-	-	-				2,496,000.0					
28	Electricity in Block A	Mon 2/24/20	Mon 3/23/20	₦ 6,000,000.00	-	-	-	-	-	-	-	-	-				3,600,000.0	2,400,000.0				
29	Plumbing in Block A	Mon 2/24/20	Mon 3/23/20	₦ 7,500,000.00	-	-	-	-	-	-	-	-	-				3,750,000.0	3,750,000.0				
30	Painting in Block A	Tue 3/24/20	Mon 5/4/20	₦ 1,920,000.00	-	-	-	-	-	-	-	-	-				768,000.0	768,000.0	384,000.0			
31	Fixtures and Doors in Block A	Tue 3/24/20	Tue 4/21/20	₦ 1,000,000.00	-	-	-	-	-	-	-	-	-					300,000.0	700,000.0	-		
32	Tiling in Block A	Tue 5/5/20	Tue 6/2/20	₦ 577,500.00	-	-	-	-	-	-	-	-	-							462,000.0	115,500.0	
33	Balustrades and Kitchen Installations in Block A	Wed 6/3/20	Mon 6/22/20	₦ 1,200,000.00	-	-	-	-	-	-	-	-	-				-	-	-	1,200,000.0		
34	Mortar Screeding in Block A	Mon 2/24/20	Thu 3/12/20	₦ 1,368,000.00	-	-	-	-	-	-	-	-	-				547,200.0	820,800.0				
35	Electricity in Block A	Tue 3/24/20	Tue 4/21/20	₦ 6,000,000.00	-	-	-	-	-	-	-	-	-				-	3,000,000.0	3,000,000.0			
36	Plumbing in Block A	Tue 3/24/20	Tue 4/21/20	₦ 7,500,000.00	-	-	-	-	-	-	-	-	-				-	3,750,000.0	3,750,000.0	-	-	
37	Painting in Block A	Tue 5/5/20	Mon 6/15/20	₦ 1,920,000.00	-	-	-	-	-	-	-	-	-							768,000.0	1,152,000.0	
38	Fixtures and Doors in Block A	Wed 4/22/20	Wed 5/20/20	₦ 1,625,000.00	-	-	-	-	-	-	-	-	-						812,500.0	812,500.0		
39	Tiling in Block A	Wed 6/3/20	Wed 7/1/20	₦ 577,500.00	-	-	-	-	-	-	-	-	-						-	-	462,000.0	115,500.0
40	Septic and Soakaway Tanks Block A	Mon 3/30/20	Mon 4/27/20	₦ 837,000.00	-	-	-	-	-	-	-	-	-					167,400.0	669,600.0			
41	Car Park Block A	Tue 4/28/20	Mon 6/8/20	₦ 3,000,000.00	-	-	-	-	-	-	-	-	-						600,000.0	1,200,000.0	1,200,000.0	
42	Landscaping works for Block A	Tue 6/9/20	Fri 6/26/20	₦ 2,000,000.00	-	-	-	-	-	-	-	-	-								2,000,000.0	-
43	Final Cleaning and Handover	Mon 6/29/20	Tue 7/7/20	₦ 100,000.00	-	-	-	-	-	-	-	-	-								-	100,000.0
		Total Construction Cost		**396,677,700.00**																		
			EXPENDITURES:		905,000.0	1,792,760.0	2,251,440.0	40,750,000.0	100,100,000.0	97,962,500.0	15,340,000.0	39,227,500.0	16,445,000.0	14,657,500.0	2,535,000.0	4,441,500.0	20,602,700.0	20,163,200.0	9,916,100.0	4,442,500.0	4,929,500.0	215,500.0

NOTES:

BEFORE OPTIMIZATION

CASH FLOW PERFORMANCE (INCOME FROM CLIENT)

S/No	ITEMS	Start	Finish		Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20
1	Mobilization				119,003,310.00																	
2	External Fence setup	Mon 2/4/19	Mon 3/4/19	₦ 1,000,000.00																		
3	Temporary Office, Storage and Equipment Installations	Fri 2/22/19	Fri 3/22/19	₦ 1,350,000.00																		
4	Excavation for Block A	Mon 3/25/19	Thu 4/11/19	₦ 772,800.00																		
5	Compact and Level bottom of Excavation A	Fri 4/12/19	Wed 4/17/19	₦ 1,076,400.00																		
6	Set-up formworks to foundation Block A	Thu 4/18/19	Tue 5/7/19	₦ 1,500,000.00																		
7	Foundations Rebars Block A	Wed 5/8/19	Wed 6/5/19	₦ 80,000,000.00																		
8	Concrete in foundation Block A	Thu 6/6/19	Fri 6/14/19	₦ 8,800,000.00					69,418,597.50													
9	Ground Floor Slab formwork Block A	Thu 6/20/19	Wed 6/26/19	₦ 1,380,000.00																		
10	Ground Floor Slab Iron works & Services Installations Block A	Thu 6/27/19	Wed 7/10/19	₦ 124,800,000.00																		
11	Concrete to Ground Floor Slab Block A	Thu 7/11/19	Wed 7/17/19	₦ 15,900,000.00																		
12	External Walls + Columns Block A	Thu 7/18/19	Tue 8/6/19	₦ 14,365,000.00																		
13	Internal Walls Block A	Wed 8/7/19	Mon 8/19/19	₦ 2,080,000.00							991,694.25											
14	Beams + Stairs Block A	Tue 8/20/19	Mon 9/2/19	₦ 12,155,000.00																		
15	Floor Slab A	Tue 9/3/19	Wed 9/11/19	₦ 33,150,000.00																		
16	External Walls + Columns Block A	Wed 10/2/19	Mon 10/21/19	₦ 14,365,000.00																		
17	Internal Walls Block A	Tue 10/22/19	Fri 11/1/19	₦ 2,080,000.00									991,694.25									
18	Roof Beams	Mon 11/4/19	Tue 11/12/19	₦ 10,497,500.00										69,418,597.50								
19	Roof Plate Block A	Tue 12/3/19	Mon 12/16/19	₦ 1,625,000.00																		
20	Roof Trusses in Block A	Tue 12/17/19	Tue 1/14/20	₦ 5,070,000.00											11,900,331.00							
21	Roof Cladding in Block A	Wed 1/15/20	Mon 2/3/20	₦ 9,870,000.00													11,900,331.00					
22	Windows installations (0-3m) in Block A	Tue 2/4/20	Fri 2/21/20	₦ 1,380,000.00																		
23	Windows installations (3-7m) in Block A	Mon 2/24/20	Thu 3/12/20	₦ 1,380,000.00																		
24	Doors installations (0-3m) in Block A	Tue 2/4/20	Fri 2/21/20	₦ 710,000.00																		
25	Doors installations (3-7m) in Block A	Mon 2/24/20	Mon 3/23/20	₦ 750,000.00																		
26	Rendering in Block A	Tue 2/4/20	Tue 3/3/20	₦ 2,650,000.00																		
27	Other finishes in Block A	Wed 3/4/20	Fri 3/27/20	₦ 2,350,000.00														9,520,264.80				
28	Mortar Screeding in Block A	Tue 2/4/20	Fri 2/21/20	₦ 2,496,000.00																		
29	Electricity in Block A	Mon 2/24/20	Mon 3/23/20	₦ 6,000,000.00																		
30	Plumbing in Block A	Mon 2/24/20	Mon 3/23/20	₦ 7,500,000.00																		
31	Painting in Block A	Tue 3/24/20	Mon 5/4/20	₦ 1,920,000.00															1,983,388.50			
32	Fixtures and Doors in Block A	Tue 3/24/20	Tue 4/21/20	₦ 1,000,000.00																		
33	Tiling in Block A	Tue 5/5/20	Tue 6/2/20	₦ 577,500.00																		
34	Balustrades and Kitchen Installations in Block A	Wed 6/3/20	Mon 6/22/20	₦ 1,200,000.00																9,916,942.50		
35	Mortar Screeding in Block A	Mon 2/24/20	Thu 3/12/20	₦ 1,368,000.00														11,900,331.00				
36	Electricity in Block at 3-7m	Tue 3/24/20	Tue 4/21/20	₦ 6,000,000.00															21,817,273.50			
37	Plumbing in Block at 3-7m	Tue 3/24/20	Tue 4/21/20	₦ 7,500,000.00															21,817,273.50			
38	Painting in Block A	Tue 5/5/20	Mon 6/15/20	₦ 1,920,000.00																	5,950,165.50	
39	Fixtures and Doors in Block A	Wed 4/22/20	Wed 5/20/20	₦ 1,625,000.00																5,950,165.50		
40	Tiling in Block A	Wed 6/3/20	Wed 7/1/20	₦ 577,500.00																		1,983,388.50
41	Septic and Soakaway Tanks Block A	Mon 3/30/20	Mon 4/27/20	₦ 837,000.00															1,586,710.80			
42	Car Park Block A	Tue 4/28/20	Mon 6/8/20	₦ 3,000,000.00																		
43	Landscaping works for Block A	Tue 6/9/20	Fri 6/26/20	₦ 2,000,000.00																	4,760,132.40	
44	Final Cleaning and Handover	Mon 6/29/20	Tue 7/7/20	₦ 100,000.00																		15,867,108.00
		Construction Cost		396,677,700.00																		
		INCOME (CLIENT PAYMENT)			119,003,310.0	-	-	-	69,418,597.5	-	991,694.3	-	991,694.3	69,418,597.5	11,900,331.0	-	11,900,331.0	21,420,595.8	47,204,646.3	15,867,108.0	10,710,297.9	17,850,496.5

NOTES:

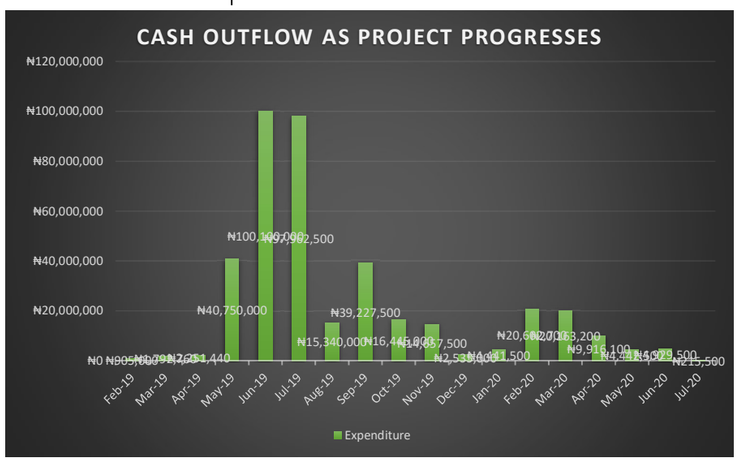
BEFORE OPTIMIZATION

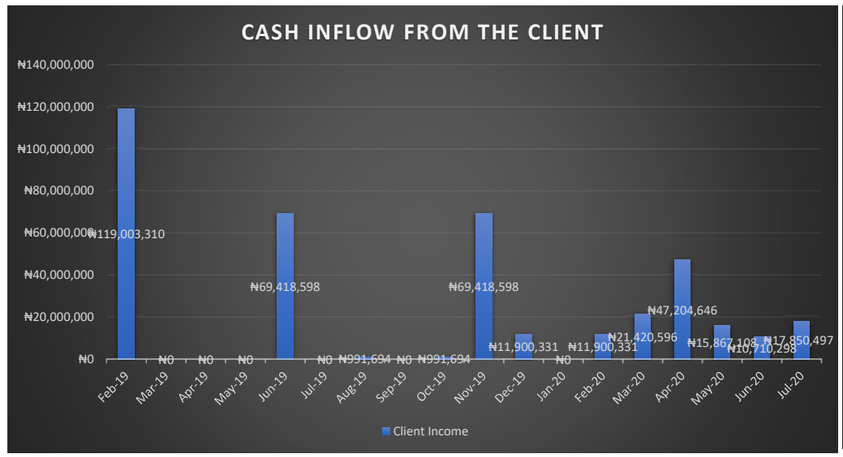
CASH FLOW PERFORMANCE (INCOME FROM CLIENT)

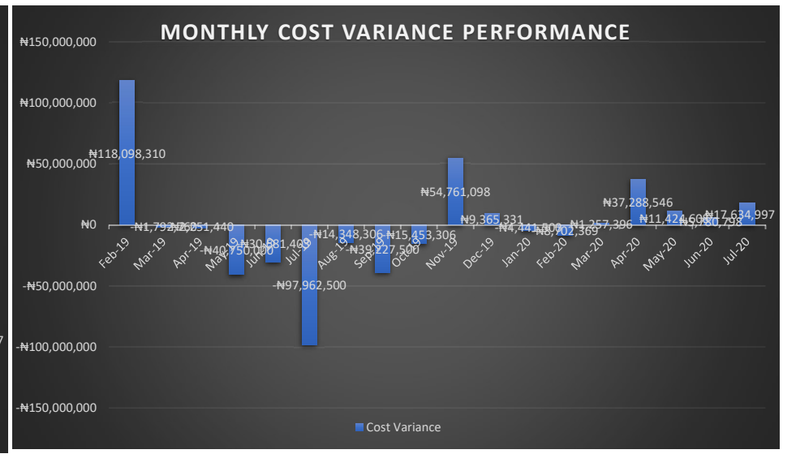
S/No	ITEMS	Start	Finish		Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20
1	**Agreed Instalmental Payment**	%																				
2	Received at the Beginning of Excavation and Foundation	0.3			0.3																	
3	Structural Works	0.35							0.175					0.175								
4	Roof Works	0.06													0.03		0.03					
5	Electrical and Plumbing Works	0.055																	0.055			
6	Plumbing works	0.055																	0.055			
7	Fixation of Windows, Glazing works, and Interior walls and screed	0.05									0.0025		0.0025					0.03		0.015		
8	Completion of all Interior works including Tiles, Plaster, Painting and kitchen	0.05																	0.005	0.025	0.015	0.005
9	Façade Works	0.04																0.024	0.004		0.012	
10	After Handing Over to Authorithies	0.04																				0.04

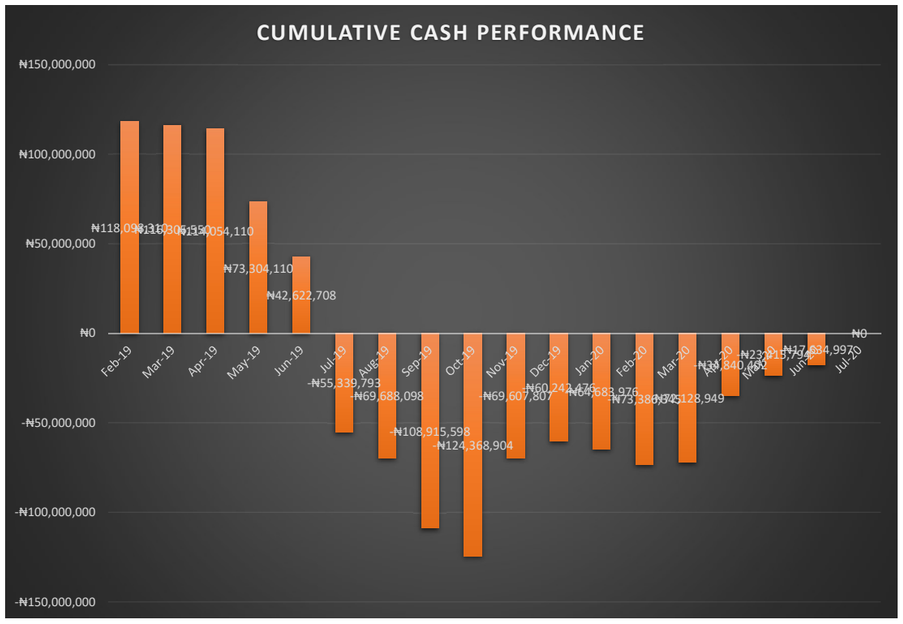
CASH FLOW PERFORMANCE (BEFORE OPTIMIZATION)

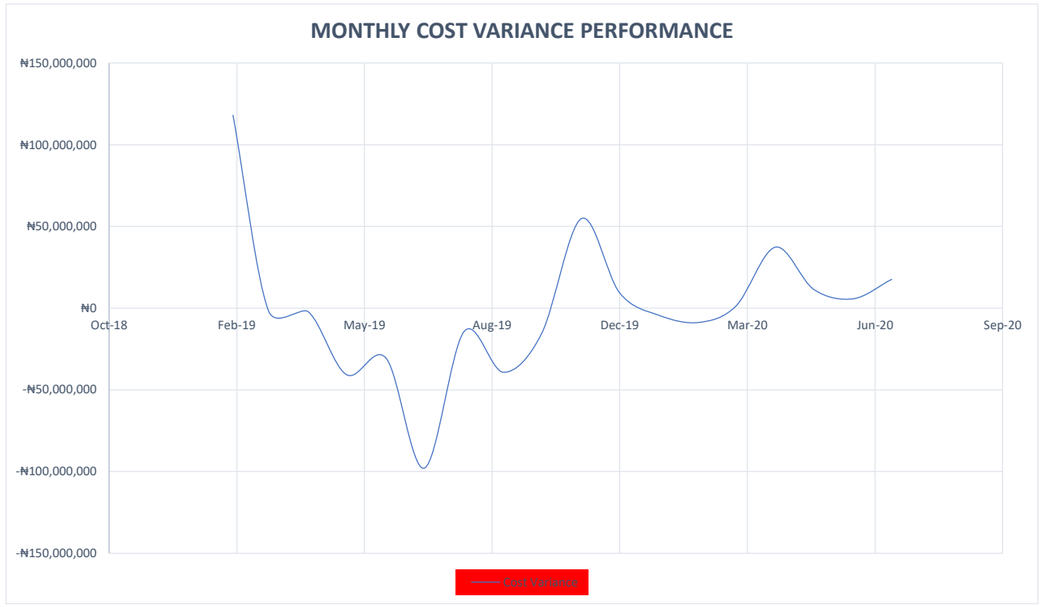
MONTHS	Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20
EXPENDITURE	₦905,000	₦1,792,760	₦2,251,440	₦40,750,000	₦100,100,000	₦97,962,500	₦15,340,000	₦39,227,500	₦16,445,000	₦14,657,500	₦2,535,000	₦4,441,500	₦20,602,700	₦20,163,200	₦9,916,100	₦4,442,500	₦4,929,500	₦215,500
INCOME FROM CLIENT	₦119,003,310	₦0	₦0	₦0	₦69,418,598	₦0	₦991,694	₦0	₦991,694	₦69,418,598	₦11,900,331	₦0	₦11,900,331	₦21,420,596	₦47,204,646	₦15,867,108	₦10,710,298	₦17,850,497
CASH FLOW	₦118,098,310	-₦1,792,760	-₦2,251,440	-₦40,750,000	-₦30,681,403	-₦97,962,500	-₦14,348,306	-₦39,227,500	-₦15,453,306	₦54,761,098	₦9,365,331	-₦4,441,500	-₦8,702,369	₦1,257,396	₦37,288,546	₦11,424,608	₦5,780,798	₦17,634,997
CUMMULATIVE	₦118,098,310	₦116,305,550	₦114,054,110	₦73,304,110	₦42,622,708	-₦55,339,793	-₦69,688,098	-₦108,915,598	-₦124,368,904	-₦69,607,807	-₦60,242,476	-₦64,683,976	-₦73,386,345	-₦72,128,949	-₦34,840,402	-₦23,415,794	-₦17,634,997	₦0











XYZ

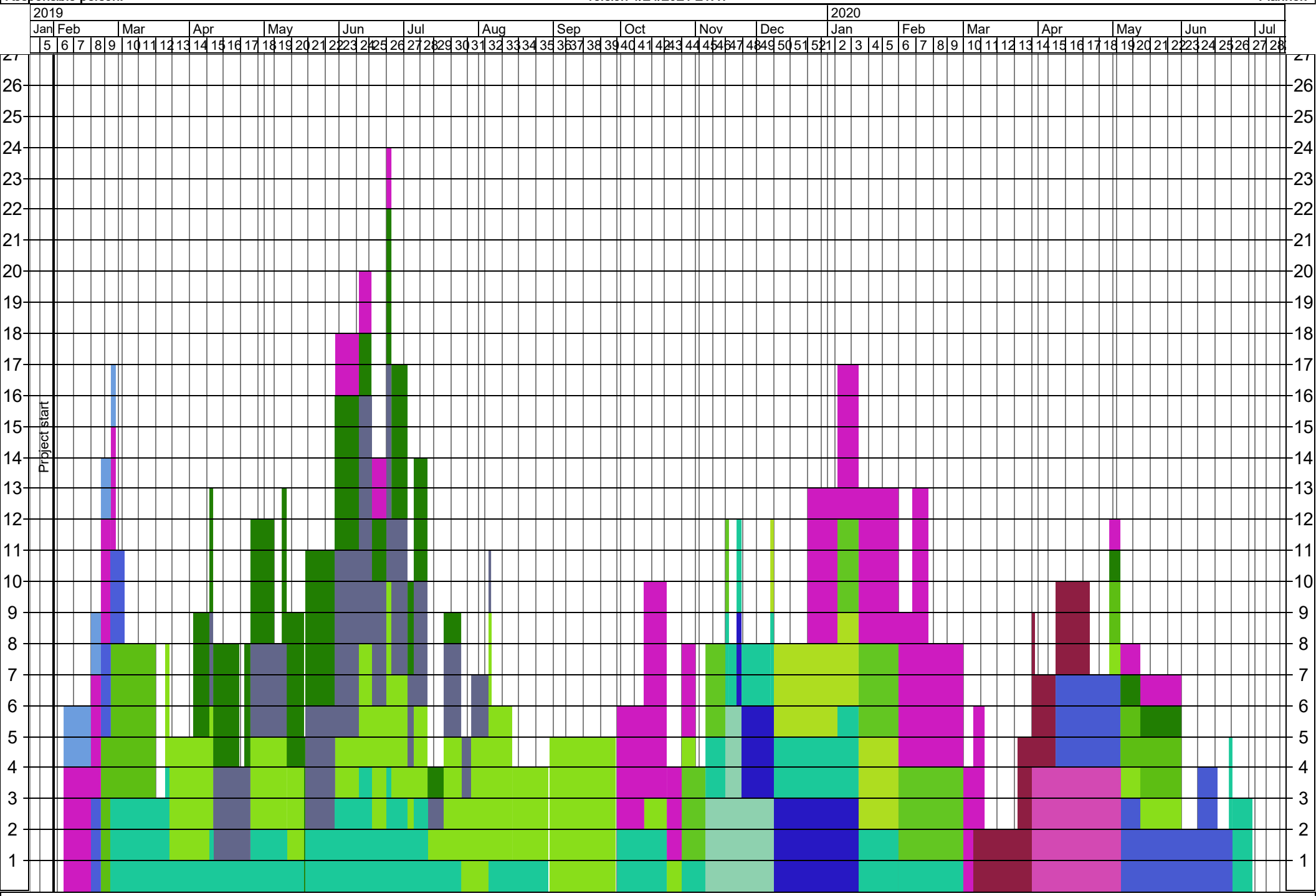
Resource graph

DUPLEX APARTMENT (BEFORE OPTIMIZATION)

Responsible person:

version 1/24/2021 21:47

Planner:



Design mode

Schedule Planner v6.5.81.862

XYZ

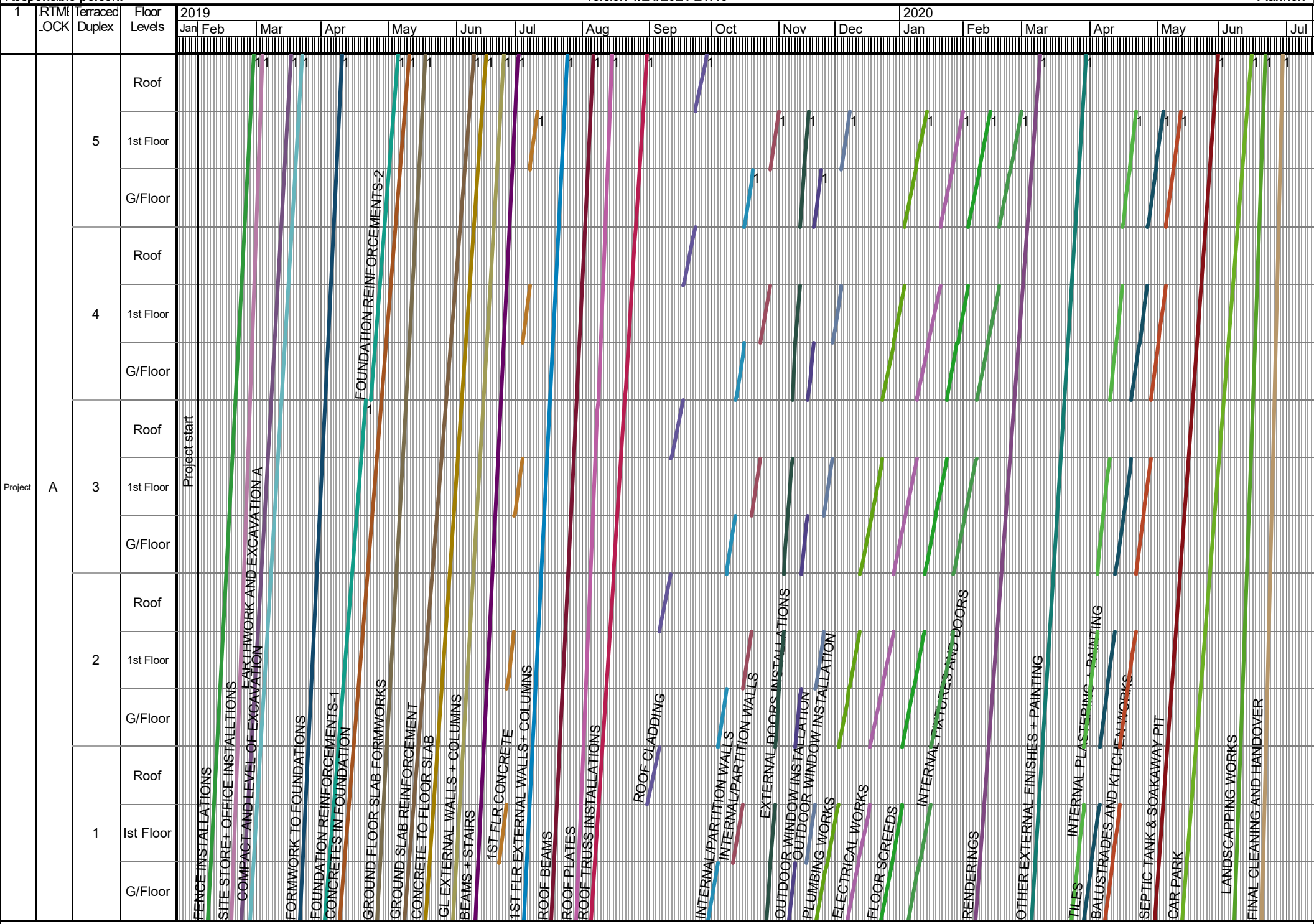
Flowline view

DUPLEX APARTMENT (BEFORE OPTIMIZATION)

Responsible person:

version 1/24/2021 21:45

Planner:



Target: ——— Actual: - - - - - - - - - Forecast: ——— ———

Design mode

NOTES:

AFTER OPTIMIZATION

OPTIMIZED PROGRESS SIMULATIONS

S/No	ITEMS	Start	Finish	Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20
1	Mobilization	Fri 2/1/19	Fri 2/1/19	1																	
2	External Fence setup	2/6/2019	2/28/2019	1																	
3	Temporary Office, Storage and Equipment Installations	2/28/2019	3/14/2019	0	1																
4	Excavation for Block A	3/8/2019	3/27/2019	0	1																
5	Compact and Level bottom of Excavation A	3/12/2019	3/28/2019	0	1																
6	Set-up formworks to foundation Block A	3/21/2019	4/9/2019		0.5	0.5															
7	Foundations Rebars Block A	4/2/2019	4/24/2019		0	0.45	0.55														
8	Concrete in foundation Block A	4/17/2019	4/30/2019			0.4	0.6														
9	Ground Floor Slab formwork Block A	4/25/2019	5/20/2019			0	0.5	0.5													
10	Ground Floor Slab Iron works & Services Installations Block A	5/15/2019	5/29/2019				0.5	0.5													
11	Concrete to Ground Floor Slab Block A	5/24/2019	6/6/2019					0.5	0.5												
12	External Walls + Columns Block A	5/31/2019	6/20/2019					0.55	0.45												
13	Internal Walls Block A	9/30/2019	10/21/2019								0.2	0.8									
14	Beams + Stairs Block A	6/11/2019	7/2/2019					0.5	0.5												
15	Floor Slab A	6/24/2019	7/11/2019					0.3	0.7												
16	External Walls + Columns Block A	7/4/2019	7/24/2019						1												
17	Internal Walls Block A	10/10/2019	10/31/2019									1									
18	Roof Beams	7/18/2019	8/6/2019						0.5	0.5											
19	Roof Plate Block A	7/30/2019	8/14/2019						0.2	0.8											
20	Roof Trusses in Block A	8/12/2019	9/15/2019							0.5	0.5										
21	Roof Cladding in Block A	9/6/2019	9/23/2019								1										
22	Windows installations (0-3m) in Block A	11/7/2019	11/22/2019										1								
23	Windows installations (3-7m) in Block A	11/18/2019	12/6/2019										0.5	0.5							
24	Doors installations (0-3m) in Block A	10/28/2019	11/18/2019									0.4	0.6								
25	Doors installations (3-7m) in Block A	10/28/2019	11/18/2019									0.4	0.6								
26	Rendering in Block A	2/7/2020	3/9/2020															0.3	0.7		
27	Other finishes in Block A	3/5/2020	3/30/2020																1		
28	Mortar Screeding in Block A	12/23/2019	2/13/2020											0.3	0.35	0.35					
29	Electricity in Block A	12/6/2019	1/31/2020											0.5	0.5						
30	Plumbing in Block A	11/21/2019	1/14/2020										0.3	0.35	0.35						
31	Painting in Block A	3/24/2020	4/21/2020														0.5	0.5			
32	Fixtures and Doors in Block A	1/7/2020	2/28/2020												0.5	0.5					
33	Tiling in Block A	3/30/2020	5/4/2020														0.2	0.4	0.4		
34	Balustrades and Kitchen Installations in Block A	4/8/2020	5/12/2020															0.5	0.5		
35	Mortar Screeding in Block A	12/23/2019	2/13/2020											0.45	0.55						
36	Electricity in Block A	12/6/2019	1/31/2020											0.5	0.5						
37	Plumbing in Block A	11/21/2019	1/14/2020										0.3	0.35	0.35						
38	Painting in Block A	3/24/2020	4/21/2020														0.5	0.5			
39	Fixtures and Doors in Block A	1/7/2020	2/28/2020												0.5	0.5					
40	Tiling in Block A	3/30/2020	5/4/2020														0.2	0.4	0.4		
41	Septic and Soakaway Tanks Block A	4/30/2020	5/29/2020														0.2	0.8			
42	Car Park Block A	6/8/2020	6/22/2020																	1	
43	Landscaping works for Block A	5/13/2020	6/15/2020																0.5	0.5	
44	Final Cleaning and Handover	6/19/2020	6/29/2020																	1	

NOTES:

AFTER OPTIMIZATION

CASH FLOW PERFORMANCE (EXPENDITURES)

S/No	ITEMS	Start	Finish		Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20
1	External Fence setup	2/6/2019	2/28/2019	₦ 1,000,000.00	1,000,000.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	Temporary Office, Storage and Equipment Installations	2/28/2019	3/14/2019	₦ 1,350,000.00	-	1,350,000.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	Excavation for Block A	3/8/2019	3/27/2019	₦ 772,800.00	-	772,800.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	Compact and Level bottom of Excavation A	3/12/2019	3/28/2019	₦ 1,076,400.00	-	1,076,400.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	Set-up formworks to foundation Block A	3/21/2019	4/9/2019	₦ 1,500,000.00	-	750,000.0	750,000.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	Foundations Rebars Block A	4/2/2019	4/24/2019	₦ 80,000,000.00	-	-	36,000,000.0	44,000,000.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	Concrete in foundation Block A	4/17/2019	4/30/2019	₦ 8,800,000.00	-	-	3,520,000.0	5,280,000.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	Ground Floor Slab formwork Block A	4/25/2019	5/20/2019	₦ 1,380,000.00	-	-	-	690,000.0	690,000.0	-	-	-	-	-	-	-	-	-	-	-	-	-
9	Ground Floor Slab Iron works & Services Installations Block A	5/15/2019	5/29/2019	₦ 124,800,000.00	-	-	-	62,400,000.0	62,400,000.0	-	-	-	-	-	-	-	-	-	-	-	-	-
10	Concrete to Ground Floor Slab Block A	5/24/2019	6/6/2019	₦ 15,900,000.00	-	-	-	-	7,950,000.0	7,950,000.0	-	-	-	-	-	-	-	-	-	-	-	-
11	External Walls + Columns Block A	5/31/2019	6/20/2019	₦ 14,365,000.00	-	-	-	-	7,900,750.0	6,464,250.0	-	-	-	-	-	-	-	-	-	-	-	-
12	Internal Walls Block A	9/30/2019	10/21/2019	₦ 2,080,000.00	-	-	-	-	-	-	-	416,000.0	1,664,000.0	-	-	-	-	-	-	-	-	-
13	Beams + Stairs Block A	6/11/2019	7/2/2019	₦ 12,155,000.00	-	-	-	-	6,077,500.0	6,077,500.0	-	-	-	-	-	-	-	-	-	-	-	-
14	Floor Slab A	6/24/2019	7/11/2019	₦ 33,150,000.00	-	-	-	-	9,945,000.0	23,205,000.0	-	-	-	-	-	-	-	-	-	-	-	-
15	External Walls + Columns Block A	7/4/2019	7/24/2019	₦ 14,365,000.00	-	-	-	-	-	14,365,000.0	-	-	-	-	-	-	-	-	-	-	-	-
16	Internal Walls Block A	10/10/2019	10/31/2019	₦ 2,080,000.00	-	-	-	-	-	-	-	-	2,080,000.0	-	-	-	-	-	-	-	-	-
17	Roof Beams	7/18/2019	8/6/2019	₦ 10,497,500.00	-	-	-	-	-	5,248,750.0	5,248,750.0	-	-	-	-	-	-	-	-	-	-	-
18	Roof Plate Block A	7/30/2019	8/14/2019	₦ 1,625,000.00	-	-	-	-	-	325,000.0	1,300,000.0	-	-	-	-	-	-	-	-	-	-	-
19	Roof Trusses in Block A	8/12/2019	9/15/2019	₦ 5,070,000.00	-	-	-	-	-	-	2,535,000.0	2,535,000.0	-	-	-	-	-	-	-	-	-	-
20	Roof Cladding in Block A	9/6/2019	9/23/2019	₦ 9,870,000.00	-	-	-	-	-	-	-	9,870,000.0	-	-	-	-	-	-	-	-	-	-
21	Windows installations (0-3m) in Block A	11/7/2019	11/22/2019	₦ 1,380,000.00	-	-	-	-	-	-	-	-	-	1,380,000.0	-	-	-	-	-	-	-	-
22	Windows installations (3-7m) in Block A	11/18/2019	12/6/2019	₦ 1,380,000.00	-	-	-	-	-	-	-	-	-	690,000.0	690,000.0	-	-	-	-	-	-	-
23	Doors installations (0-3m) in Block A	10/28/2019	11/18/2019	₦ 710,000.00	-	-	-	-	-	-	-	-	284,000.0	426,000.0	-	-	-	-	-	-	-	-
24	Doors installations (3-7m) in Block A	10/28/2019	11/18/2019	₦ 750,000.00	-	-	-	-	-	-	-	-	300,000.0	450,000.0	-	-	-	-	-	-	-	-
25	Rendering in Block A	2/7/2020	3/9/2020	₦ 2,650,000.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	795,000.0	1,855,000.0	-	-
26	Other finishes in Block A	3/5/2020	3/30/2020	₦ 2,350,000.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,350,000.0	-	-
27	Mortar Screeding in Block A	12/23/2019	2/13/2020	₦ 2,496,000.00	-	-	-	-	-	-	-	-	-	-	748,800.0	873,600.0	873,600.0	-	-	-	-	-
28	Electricity in Block A	12/6/2019	1/31/2020	₦ 6,000,000.00	-	-	-	-	-	-	-	-	-	-	3,000,000.0	3,000,000.0	-	-	-	-	-	-
29	Plumbing in Block A	11/21/2019	1/14/2020	₦ 7,500,000.00	-	-	-	-	-	-	-	-	-	2,250,000.0	2,625,000.0	2,625,000.0	-	-	-	-	-	-
30	Painting in Block A	3/24/2020	4/21/2020	₦ 1,920,000.00	-	-	-	-	-	-	-	-	-	-	-	-	-	960,000.0	960,000.0	-	-	-
31	Fixtures and Doors in Block A	1/7/2020	2/28/2020	₦ 1,000,000.00	-	-	-	-	-	-	-	-	-	-	-	500,000.0	500,000.0	-	-	-	-	-
32	Tiling in Block A	3/30/2020	5/4/2020	₦ 577,500.00	-	-	-	-	-	-	-	-	-	-	-	-	-	115,500.0	231,000.0	231,000.0	-	-
33	Balustrades and Kitchen Installations in Block A	4/8/2020	5/12/2020	₦ 1,200,000.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	600,000.0	600,000.0	-	-
34	Mortar Screeding in Block A	12/23/2019	2/13/2020	₦ 1,368,000.00	-	-	-	-	-	-	-	-	-	-	615,600.0	752,400.0	-	-	-	-	-	-
35	Electricity in Block A	12/6/2019	1/31/2020	₦ 6,000,000.00	-	-	-	-	-	-	-	-	-	-	3,000,000.0	3,000,000.0	-	-	-	-	-	-
36	Plumbing in Block A	11/21/2019	1/14/2020	₦ 7,500,000.00	-	-	-	-	-	-	-	-	-	2,250,000.0	2,625,000.0	2,625,000.0	-	-	-	-	-	-
37	Painting in Block A	3/24/2020	4/21/2020	₦ 1,920,000.00	-	-	-	-	-	-	-	-	-	-	-	-	-	960,000.0	960,000.0	-	-	-
38	Fixtures and Doors in Block A	1/7/2020	2/28/2020	₦ 1,625,000.00	-	-	-	-	-	-	-	-	-	-	-	812,500.0	812,500.0	-	-	-	-	-
39	Tiling in Block A	3/30/2020	5/4/2020	₦ 577,500.00	-	-	-	-	-	-	-	-	-	-	-	-	-	115,500.0	231,000.0	231,000.0	-	-
40	Septic and Soakaway Tanks Block A	4/30/2020	5/29/2020	₦ 837,000.00	-	-	-	-	-	-	-	-	-	-	-	-	-	167,400.0	669,600.0	-	-	-
41	Car Park Block A	6/8/2020	6/22/2020	₦ 3,000,000.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3,000,000.0	-	-
42	Landscaping works for Block A	5/13/2020	6/15/2020	₦ 2,000,000.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,000,000.0	1,000,000.0	-
43	Final Cleaning and Handover	6/19/2020	6/29/2020	₦ 100,000.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100,000.0	-
			Total Construction	396,677,700.00																		
			CASH OUTFLOW (EXPENSES)		1,000,000.0	3,949,200.0	40,270,000.0	112,370,000.0	94,963,250.0	63,635,500.0	9,083,750.0	12,821,000.0	4,328,000.0	7,446,000.0	13,304,400.0	14,188,500.0	2,186,100.0	2,318,400.0	4,446,600.0	6,267,000.0	4,100,000.0	-

NOTES:

AFTER OPTIMIZATION

CASH FLOW PERFORMANCE (INCOME FROM THE SPONSOR)

S/No	ITEMS	Start	Finish		Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20
1	Mobilization	Fri 2/1/19	Fri 2/1/19	-	119,003,310.00																	
2	External Fence setup	2/6/2019	2/28/2019	₦ 1,000,000.00																		
3	Temporary Office, Storage and Equipment Installations	2/28/2019	3/14/2019	₦ 1,350,000.00																		
4	Excavation for Block A	3/8/2019	3/27/2019	₦ 772,800.00																		
5	Compact and Level bottom of Excavation A	3/12/2019	3/28/2019	₦ 1,076,400.00																		
6	Set-up formworks to foundation Block A	3/21/2019	4/9/2019	₦ 1,500,000.00																		
7	Foundations Rebars Block A	4/2/2019	4/24/2019	₦ 80,000,000.00																		
8	Concrete in foundation Block A	4/17/2019	4/30/2019	₦ 8,800,000.00				69,418,597.50	-													
9	Ground Floor Slab formwork Block A	4/25/2019	5/20/2019	₦ 1,380,000.00																		
10	Ground Floor Slab Iron works & Services Installations Block A	5/15/2019	5/29/2019	₦ 124,800,000.00																		
11	Concrete to Ground Floor Slab Block A	5/24/2019	6/6/2019	₦ 15,900,000.00																		
12	External Walls + Columns Block A	5/31/2019	6/20/2019	₦ 14,365,000.00																		
13	Internal Walls Block A	9/30/2019	10/21/2019	₦ 2,080,000.00									-									
14	Beams + Stairs Block A	6/11/2019	7/2/2019	₦ 12,155,000.00																		
15	Floor Slab A	6/24/2019	7/11/2019	₦ 33,150,000.00																		
16	External Walls + Columns Block A	7/4/2019	7/24/2019	₦ 14,365,000.00																		
17	Internal Walls Block A	10/10/2019	10/31/2019	₦ 2,080,000.00																		
18	Roof Beams	7/18/2019	8/6/2019	₦ 10,497,500.00							69,418,597.50											
19	Roof Plate Block A	7/30/2019	8/14/2019	₦ 1,625,000.00						11,900,331.00												
20	Roof Trusses in Block A	8/12/2019	9/15/2019	₦ 5,070,000.00											-							
21	Roof Cladding in Block A	9/6/2019	9/23/2019	₦ 9,870,000.00								11,900,331.00					-					
22	Windows installations (0-3m) in Block A	11/7/2019	11/22/2019	₦ 1,380,000.00																		
23	Windows installations (3-7m) in Block A	11/18/2019	12/6/2019	₦ 1,380,000.00											9,916,942.50							
24	Doors installations (0-3m) in Block A	10/28/2019	11/18/2019	₦ 710,000.00																		
25	Doors installations (3-7m) in Block A	10/28/2019	11/18/2019	₦ 750,000.00																		
26	Rendering in Block A	2/7/2020	3/9/2020	₦ 2,650,000.00																		
27	Other finishes in Block A	3/5/2020	3/30/2020	₦ 2,350,000.00															-		7,933,554.00	
28	Mortar Screeding in Block A	12/23/2019	2/13/2020	₦ 2,496,000.00																		
29	Electricity in Block A	12/6/2019	1/31/2020	₦ 6,000,000.00																		
30	Plumbing in Block A	11/21/2019	1/14/2020	₦ 7,500,000.00																		
31	Painting in Block A	3/24/2020	4/21/2020	₦ 1,920,000.00																		
32	Fixtures and Doors in Block A	1/7/2020	2/28/2020	₦ 1,000,000.00																		
33	Tiling in Block A	3/30/2020	5/4/2020	₦ 577,500.00																		
34	Balustrades and Kitchen Installations in Block A	4/8/2020	5/12/2020	₦ 1,200,000.00																		
35	Mortar Screeding in Block A	12/23/2019	2/13/2020	₦ 1,368,000.00															-			
36	Electricity in Block at 3-7m	12/6/2019	1/31/2020	₦ 6,000,000.00												21,817,273.50						
37	Plumbing in Block at 3-7m	11/21/2019	1/14/2020	₦ 7,500,000.00												21,817,273.50			-			
38	Painting in Block A	3/24/2020	4/21/2020	₦ 1,920,000.00																	-	
39	Fixtures and Doors in Block A	1/7/2020	2/28/2020	₦ 1,625,000.00													9,916,942.50			-		
40	Tiling in Block A	3/30/2020	5/4/2020	₦ 577,500.00																19,833,885.00		-
41	Septic and Soakaway Tanks Block A	4/30/2020	5/29/2020	₦ 837,000.00															-			
42	Car Park Block A	6/8/2020	6/22/2020	₦ 3,000,000.00																		
43	Landscaping works for Block A	5/13/2020	6/15/2020	₦ 2,000,000.00																	7,933,554.00	
44	Final Cleaning and Handover	6/19/2020	6/29/2020	₦ 100,000.00																	15,867,108.00	
			Construction Cost	396,677,700.00																		
			CASH INFLOW (CLIENT PAYMENT)		119,003,310.0	-	-	69,418,597.5	-	11,900,331.0	69,418,597.5	11,900,331.0	-	-	9,916,942.5	43,634,547.0	9,916,942.5	-	-	27,767,439.0	23,800,662.0	-

NOTES:

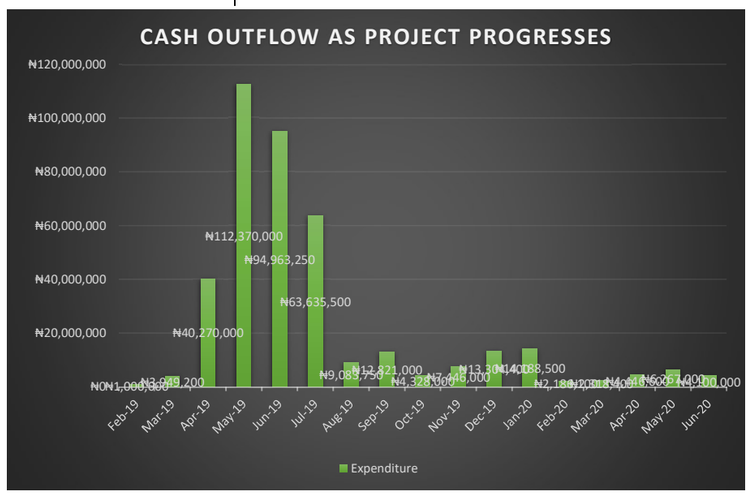
AFTER OPTIMIZATION

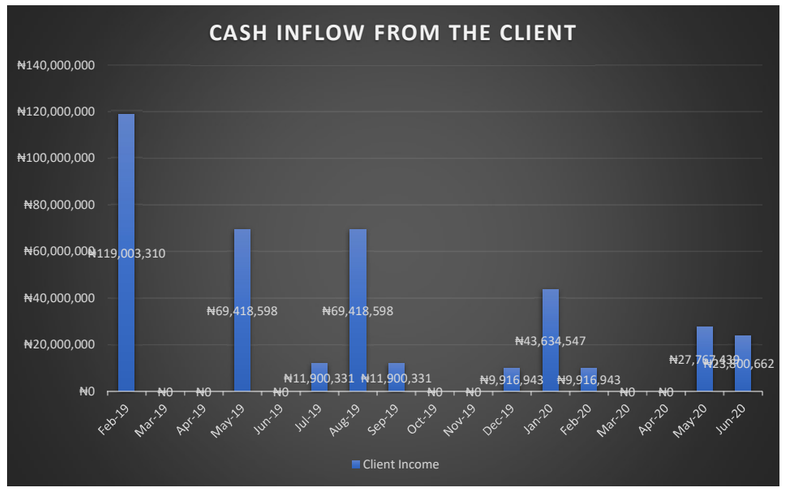
CASH FLOW PERFORMANCE (INCOME FROM THE SPONSOR)

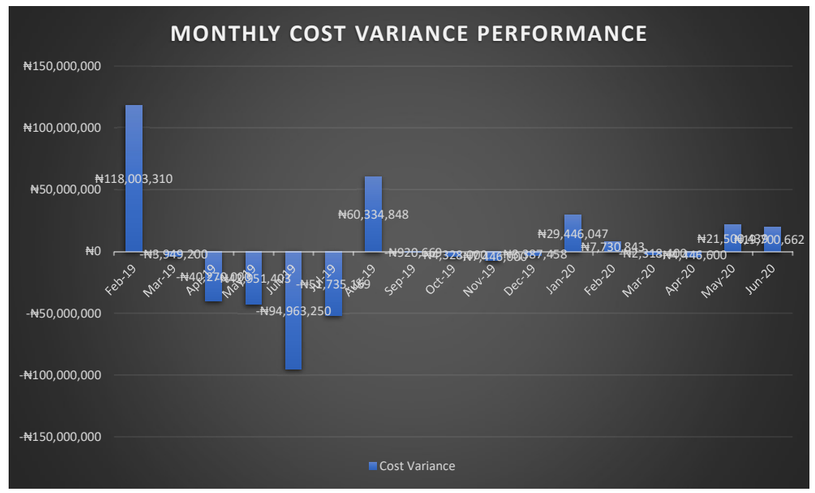
S/No	ITEMS	Start	Finish		Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20
S/No	**Agreed Instalmental Payment**	%																				
1	Received at the Beginning of Excavation and Foundation	0.3			0.3																	
2	Structural Works	0.35						0.175			0.175											
3	Roof Works	0.06								0.03		0.03										
4	Electrical and Plumbing Works	0.055														0.055						
5	Plumbing works	0.055														0.055						
6	Fixation of Windows, Glazing works, and Interior walls and screed	0.05													0.025		0.025					
7	Completion of all Interior works including Tiles, Plaster, Painting and kitchen	0.05																		0.05		
8	Façade Works	0.04																		0.02	0.02	
9	After Handing Over to Authorithies	0.04																			0.04	

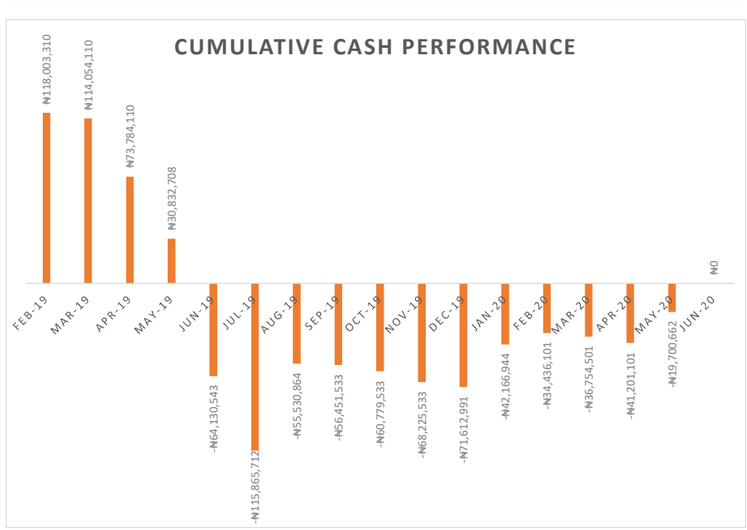
CASH FLOW PERFORMANCE (AFTER OPTIMIZATION)

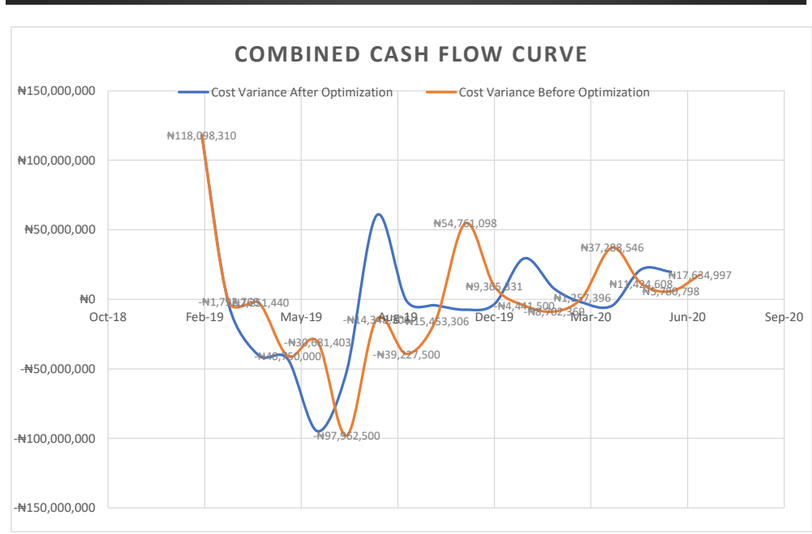
MONTHS	Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20
EXPENDITURE	₦1,000,000	₦3,949,200	₦40,270,000	₦112,370,000	₦94,963,250	₦63,635,500	₦9,083,750	₦12,821,000	₦4,328,000	₦7,446,000	₦13,304,400	₦14,188,500	₦2,186,100	₦2,318,400	₦4,446,600	₦6,267,000	₦4,100,000
INCOME FROM CLIENT	₦119,003,310	₦0	₦0	₦69,418,598	₦0	₦11,900,331	₦69,418,598	₦11,900,331	₦0	₦0	₦9,916,943	₦43,634,547	₦9,916,943	₦0	₦0	₦27,767,439	₦23,800,662
CASH FLOW	₦118,003,310	-₦3,949,200	-₦40,270,000	-₦42,951,403	-₦94,963,250	-₦51,735,169	₦60,334,848	-₦920,669	-₦4,328,000	-₦7,446,000	-₦3,387,458	₦29,446,047	₦7,730,843	-₦2,318,400	-₦4,446,600	₦21,500,439	₦19,700,662
CUMMULATIVE	₦118,003,310	₦114,054,110	₦73,784,110	₦30,832,708	-₦64,130,543	-₦115,865,712	-₦55,530,864	-₦56,451,533	-₦60,779,533	-₦68,225,533	-₦71,612,991	-₦42,166,944	-₦34,436,101	-₦36,754,501	-₦41,201,101	-₦19,700,662	₦0











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