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A Study on Assessment of Carbon Footprints Reduction and Life-Cycle Cost of Buildings Using University Halls of Residence in Nigeria as a Case Study.

Ibitoye Olayinka Seun [a*], Ade-Ojo Comfort Olubunmi [b]

[a] *Quantity Surveying Department, Federal University of Technology Akure, Ondo State, PMB 704, 340223, Nigeria*
[b] *Quantity Surveying Department, Federal University of Technology Akure, Ondo State,PMB 704, 340223, Nigeria*
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A B S T R A C T

The costs of financing tertiary institution projects coupled with the dwindling economy in the country will make introducing concept like reduction of carbon footprints and constructing a low carbon building to clients a bit challenging as there is a wrong perception that estimating embodied carbon will be time consuming and add cost to the project. This made it imperative to study not only the initial cost of adopting low carbon materials on building projects but also the maintenance cost by carrying out life cycle costing. Relevant data were extracted from Bills of quantities of thirty halls of residence of a tertiary institution in Nigerian. The data collected were analyzed using Pearson correlation to rank the significance of the relationship between embodied carbon and life cycle cost. The findings suggested that there was significant relationship between embodied carbon and life cycle cost. The correlation was a positive value, this meant as embodied carbon increases, Life cycle cost will also increase. A reduction of up to 20.46% was seen in life cycle cost and 28.62% in embodied carbon. Based on the findings it was recommended that there is need for early design stage carbon estimation, and embracing low carbon alternative materials as these will go a long way to achieving carbon emission reduction in the industry.

Keywords: Carbon estimation, Cost and carbon relationship, Low carbon materials, life-cycle costing.

1. Introduction

Carbon estimation evolved within the past decade using similar techniques used for cost estimating. A carbon footprint is an estimate of the cumulative amount of carbon dioxide emitted within a given period that is knowingly or unknowingly generated by a company or product manufacture (Victoria et al, 2015). Reducing a building's carbon footprint will reduce its running costs, improves employee morale, raises property values, make buildings become environmentally responsible, profitable and healthier places to live and work in (Abolarin et al, 2013). With its inherent cost-benefits and earnings prospects, managing and reducing carbon footprints as part of a low carbon strategy is becoming more and more significant in the building industry. Buildings are constructed using materials that are produced by burning non-renewable energy sources, these materials includes cement and steel. Steel production emits roughly two tons of carbon dioxide for every ton of steel produced, compared to about half a metric ton for cement production. (Dixit & Singh, 2018). Nigerian tertiary institutions are built using a lot of cement and steel. Therefore, using academic buildings as a case study is necessary given the demand for more of these structures due to the expanding student population. As students tend to learn better through practical examples, constructing sustainable academic buildings will increase people' awareness of the necessity for such initiatives (Ibitoye & Ade-ojo, 2023). Cost and carbon are the primary currency for sustainable construction projects, embodied carbon measured in kilograms of carbon dioxide equivalents (KgCO2e) is the secondary currency.

Cost and carbon relationship is a perspective to seeking efficient and suitable alternative materials that will reduce carbon footprint of the building within the budget of the project (Victoria & Perera, 2017). Substituting conventional materials with low carbon alternatives like any other new innovations can be at an additional cost to a building project, it is important to evaluate the cost of using low carbon materials. The examples of low carbon materials are blended cements, bamboo, burnt clay bricks, stabilized mud blocks, compacted fly ash blocks, floor and roofing systems with low energy intensity. The type of building methods and materials employed have a major impact on embodied carbon in buildings. While the use of alternative low-carbon construction materials could result in reduction in embodied carbon, allowing for more effective use of energy resources, it could be expensive to the project budget (Giesekam et al, 2016). By comparing design or material alternatives, life cycle costing analysis is reliable to maximize the project budget as what is cheap at the initial stage might be expensive later due to high maintenance cost. Life cycle cost refers to all cost associated with construction, maintenance, operation and end of life of a project (Fuller, 2010).

Life cycle cost analysis can be used to calculate the financial benefits of energy use in a building. Victoria et al (2015) developed a decision support system to optimize the design in terms of cost and carbon during the early stages of design using sample data obtained from database of processed building data. The lump sum in the database made it difficult to analyze to the lowest level of specifications and details due to lack of sufficient information. It made the calculations not to be holistic as some items were missing in the measurement. Kale et al. (2016) calculated the life cycle cost of two educational buildings using the net present value method, based on existing conditions and the proposed energy efficient approach (EEA). The life cycle cost of an existing structure was compared to the cost of a proposed solar panel system, it was discovered that the cost of a minimum capacity solar panel was reduced by four percent. These research works were limited in the usage of historical online data, which created a gap for this research as real life and detailed data from existing building projects were used. Life cycle costing was beneficial in this study, it determined the cost effectiveness of low carbon materials and construction technologies, in order to make the idea attractive to clients who will be more interested in the project budget not being exceeded. In this study reinforcement bars were substituted with bamboo; cement blocks were substituted with burnt clay bricks to achieve maximum carbon reduction possible. These materials are readily available in Ogun state locality, as such local sourcing of construction materials is a way of reducing the project footprint by reducing transportation emission.

Life cycle cost analysis is crucial in this study to bring to the fore, the cost of adopting low carbon technologies and material so that the client can decide whether to build sustainable buildings or not. This study ranked the cost effectiveness of using low carbon materials in the project life cycle against traditional materials by carrying out life cycle costing. The relationship between life cycle cost and embodied carbon was established in order to determine the effects of carbon estimation on project's budget. As this would make it easier to sell the idea of carbon estimation to clients in order to manage project's carbon footprint and the building industry footprints at large. Thereby encouraging the construction of environmentally safe and sustainable buildings.

2. Methodology

2.1 Data collection

Data was collected from the bills of quantities of the projects understudy using Pro-forma. Initial cost of thirty projects were extracted from bills of quantities.

2.2 Overview of the method

Life cycle costing of building materials that are carbon intensive and their alternative low carbon materials were assessed in this research work to determine the cost implication of using low carbon materials in the building industry. The interest rate used was 18% which is the university's bank (name withheld) current lending rate on halls of residence development. Sixty (60) years was considered as the projects' average life span in this research because average life span of modern buildings built with concrete and steel is sixty years according to Marsh (2017). The initial cost was the cost of projects from the Bills of quantities, the annual running cost was discounted using the appropriate year purchase factor while the periodic cost was discounted using present value factor from Parry's valuation table. The recurring costs (annual and periodic) were real life costs of maintaining the halls of residence, the cost information was gotten from Babcock university Facilities management department. Detailed calculation of the cost information was presented in Table 2.0 (appendix A). After the lifecycle costing, Pearson correlation was used to analyse the data.

Pearson Correlation

$$r = \frac{[n(\Sigma xy) - \Sigma x \Sigma y]}{\sqrt{[n(\Sigma x2) - (\Sigma x)2][n(\Sigma y2) - (\Sigma y)2]}} \qquad \text{equation 2.1}$$

Where;

r = Pearson correlation coefficient

x = Values in the first set of data

y = Values in the second set of data

Σ = Summation of all values

n = Total number of values.

It's a parametric measure that indicates the strength and direction of linear relationships between pairs of continuous variables, it produces a sample correlation coefficient r, which evaluates the statistical evidence of linear relationship among the pairs of variables in the population. It was used to evaluate the relationship between embodied carbon and life cycle cost of building elements.

Test of Hypothesis.

Ho1: There is no relationship between embodied carbon and life cycle cost of building elements.

Ha1: There is relationship between embodied carbon and life cycle cost of building elements.

Hypothesis testing is a formal procedure for investigating ideas using statistics, often used by scientists to test specific predictions called hypothesis that arise from theories. This research hypothesis was tested at 0.05 (5%) significance level. The variables were total embodied carbon and lifecycle cost for each project. Pearson correlation was used to test the hypothesis at a two-tailed test of significance. Two tailed prediction means that the effect could be negative or positive. The criterion of testing the hypothesis was significance level, P< 0.05, that is a significance level less than 0.05 rejects the null hypothesis.

2.3. Embodied carbon and Life Cycle Cost of Building Projects

Table 2.1, presents the life cycle costing of conventional material option for the projects, the interest rate used was 18%, sixty (60) years was considered as the projects' average life span. The initial cost was the cost of projects from the Bills of quantities, the annual running cost was discounted using the appropriate year purchase factor while the periodic cost was discounted using present value factor from Parry's valuation table. Detailed calculation of the cost information was presented in Table 2.0 (APPENDIX A).

Table 2.1: Life Cycle Cost Analysis for Conventional Materials

HALLS	Initial capital cost (A)	Recuring cost (Bank rate 18%, life span = 60years) See Appendix A for Cost Details					
		Annual cost (discounted with Year's purchase factor)					Periodic cost(PVF)
		Electricity bills (Independent Power Plant)			Replacing door knobs&keys, wardrobe handles&keys		Evacuating septic tank every 2 years
		unit/year	bill @53.47 per unit	YPF @18% compound rate for 60 years=5.56 (B)	Cost per year (see backup)	YPF @18% compound rate for 60 years=5.56 (C)	Rate 80,000/septic tank @ 18% compound rate every 2 years=2.57 (D)
Adeleke	350,256,522.06	57,719	3,086,217	17,159,367.11	1,056,000.00	5,871,360.00	822,400
Ameyo A	372,950,106.10	63,479	3,394,204	18,871,775.95	1,161,600.00	6,458,496.00	822,400
Bethel Splendor	373,247,854.90	63,479	3,394,204	18,871,775.95	1,478,400.00	8,219,904.00	822,400
Courage court	208,825,757.10	43,319	2,316,249	12,878,345.03	1,008,000.00	5,604,480.00	616,800
Crystal	449,995,690.20	69,239	3,702,192	20,584,184.78	1,612,800.00	8,967,168.00	822,400
Endeavour	303,190,423.46	57,719	3,086,217	17,159,367.11	1,344,000.00	7,472,640.00	616,800
Endurance	285,860,878.00	43,319	2,316,249	12,878,345.03	1,008,000.00	5,604,480.00	616,800
Felicia Adebisi	796,883,668.00	76,439	4,087,176	22,724,695.82	1,780,800.00	9,901,248.00	1,233,600
Gamaliel	289,202,978.00	43,319	2,316,249	12,878,345.03	1,008,000.00	5,604,480.00	616,800
Gideon Troopers	797,203,217.60	76,439	4,087,176	22,724,695.82	1,780,800.00	9,901,248.00	1,233,600
Havillah Gold	799,301,868.00	76,439	4,087,176	22,724,695.82	1,780,800.00	9,901,248.00	1,233,600
Justice Jeborah	415,631,007.00	69,239	3,702,192	20,584,184.78	1,612,800.00	8,967,168.00	822,400
Neal Wilson	277,830,633.20	43,319	2,316,249	12,878,345.03	1,008,000.00	5,604,480.00	616,800
Kings Delight	798,891,468.00	76,439	4,087,176	22,724,695.82	1,780,800.00	9,901,248.00	1,233,600
Nelson Mandela	459,995,690.20	69,239	3,702,192	20,584,184.78	1,612,800.00	8,967,168.00	822,400
Patience	262,830,633.20	43,319	2,316,249	12,878,345.03	1,008,000.00	5,604,480.00	616,800
Royal	268,354,833.20	43,319	2,316,249	12,878,345.03	1,008,000.00	5,604,480.00	616,800
Peace court	287,105,384.00	43,319	2,316,249	12,878,345.03	1,008,000.00	5,604,480.00	616,800
Platinum	396,603,557.80	57,719	3,086,217	17,159,367.11	1,344,000.00	7,472,640.00	822,400
FSD block	225,688,050.00	28,919	1,546,281	8,597,322.95	672,000.00	3,736,320.00	616,800
BIG block	232,863,050.00	28,919	1,546,281	8,597,322.95	672,000.00	3,736,320.00	616,800
Queen Esther	357,097,554.90	57,719	3,086,217	17,159,367.11	1,344,000.00	7,472,640.00	822,400
Samuel Akande	461,300,490.20	69,239	3,702,192	20,584,184.78	1,612,800.00	8,967,168.00	822,400
Trust court	292,128,658.00	43,319	2,316,249	12,878,345.03	1,008,000.00	5,604,480.00	616,800
Rehoboth	696,265,778.00	76,439	4,087,176	22,724,695.82	1,780,800.00	9,901,248.00	1,233,600
Diamond	406,655,332.80	57,719	3,086,217	17,159,367.11	1,344,000.00	7,472,640.00	822,400
Marigold	914,162,979.00	80,759	4,318,166	24,009,002.44	1,881,600.00	10,461,696.00	1,233,600
Welch	361,154,554.90	57,719	3,086,217	17,159,367.11	1,344,000.00	7,472,640.00	822,400
White hall	307,064,929.45	57,719	3,086,217	17,159,367.11	1,344,000.00	7,472,640.00	822,400
Winslow	945,358,899.00	80,759	4,318,166	24,009,002.44	1,881,600.00	10,461,696.00	1,233,600

Table 2.1: Life Cycle Cost Analysis for Conventional Materials (Continued)

HALLS	Recuring cost (Bank rate 18%, life span = 60years)See Appendix A for Cost Details						Life Cycle Cost
	Periodic cost (discounted with Present Value Factor) Cont'd.						
	Replacing energy saving bulbs every 2 years	Repainting every 2 years		Finishings & services to be replaced every 5 years	Finishings &services to be replaced every 10 years	Finishings & services to be replaced every 20 years	LCC= A+B+C+D+E+F +G+H
	Present value @ 18% every 2 years =2.57 (E)	Wall Area	Present value 450/sqm. @ 18% every 2 years =2.57 (E)	Present value @ 18% evry 5 years =0.79 (F)	Present value @ 18% evry 10 years=0.24 (G)	Present value @ 18% evry 20 years =0.04 (H)	
Adeleke	2,467,200.00	19,348	22,375,962	6,952,000	2,412,000	2,996,000	411,312,811.17
Ameyo Adadevoh	2,713,920.00	22,618	26,157,717	7,647,200	2,653,200	3,295,600	441,570,415.05
Bethel Splendor	2,713,920.00	18,125	20,961,563	7,647,200	3,121,200	3,295,600	438,901,417.35
Courage court	1,850,400.00	16,044	18,554,886	5,214,000	3,096,000	2,247,000	258,887,668.13
Crystal	2,960,640.00	29,554	34,179,201	8,342,400	3,752,400	3,595,200	533,199,283.98
Endeavour	2,467,200.00	13,120	15,173,280	6,952,000	3,566,400	2,996,000	359,594,110.58
Endurance	1,850,400.00	12,259	14,177,534	5,214,000	2,971,200	2,247,000	331,420,636.53
Felicia Adebisi	3,269,040.00	56,694	65,566,611	9,211,400	4,268,400	3,969,700	917,028,362.82
Gamaliel	1,850,400.00	12,675	14,658,638	5,214,000	3,423,600	2,247,000	335,696,240.53
Gideon Troopers	3,269,040.00	61,326	70,923,519	9,211,400	3,410,400	3,969,700	921,846,820.42
Havillah Gold	3,269,040.00	56,449	65,283,269	9,211,400	3,332,400	3,969,700	918,227,220.32
Justice Jeborah	2,960,640.00	20,034	23,169,321	8,342,400	3,331,200	3,595,200	487,403,520.78
Neal Wilson	1,850,400.00	17,711	20,482,772	5,214,000	3,189,600	2,247,000	329,914,029.73
Kings Delight	3,269,040.00	49,669	57,442,199	9,211,400	4,003,200	3,969,700	910,646,550.32
Nelson Mandela	2,960,640.00	29,554	34,179,201	8,342,400	3,487,200	3,595,200	542,934,083.98
Patience	1,850,400.00	18,295	21,158,168	5,214,000	2,082,000	2,247,000	314,481,825.73
Royal	1,850,400.00	17,925	20,730,263	5,214,000	2,238,000	2,247,000	319,734,120.73
Peace court	1,850,400.00	12,960	14,988,240	5,214,000	2,550,000	2,247,000	333,054,649.03
Platinum	2,467,200.00	17,033	19,698,665	6,952,000	3,504,000	2,996,000	457,675,829.41
FSD block	1,233,600.00	9,630	11,137,095	3,476,000	1,596,000	1,498,000	257,579,187.95
BIG block	1,233,600.00	17,073	19,744,925	3,476,000	1,674,000	1,498,000	273,440,017.45
Queen Esther	2,467,200.00	27,492	31,794,498	6,952,000	2,973,600	2,996,000	429,735,260.01
Samuel Akande	2,960,640.00	12,340	14,271,210	8,342,400	4,142,400	3,595,200	524,986,092.98
Trust court	1,850,400.00	12,340	14,271,210	5,214,000	3,532,800	2,247,000	338,343,693.03
Rehoboth	3,269,040.00	12,340	14,271,210	9,211,400	4,580,400	3,969,700	765,427,071.82
Diamond	2,467,200.00	12,340	14,271,210	6,952,000	4,034,400	2,996,000	462,830,549.91
Marigold	3,454,080.00	18,125	20,961,563	9,732,800	4,812,000	4,194,400	993,022,119.94
Welch	2,467,200.00	12,311	14,237,672	6,952,000	3,504,000	2,996,000	416,765,833.51
White hall	2,467,200.00	12,856	14,867,964	6,952,000	3,738,000	2,996,000	363,540,500.56
Winslow	3,454,080.00	40,466	46,798,929	9,732,800	4,468,800	4,194,400	1,049,712,206.44

Table 2.2, presents the life cycle cost of usage of alternative low carbon materials such as burnt clay bricks (no plastering and painting required) in place of cement blocks. Bamboo in place of reinforcement, bio-digester septic tank in place of conventional septic tank. Bio-digester septic tank is where sewage will be treated and converted to liquid and gas, the liquid can be used for agriculture purposes as organic fertilizer while gas will be used for domestic purpose. The bills of quantities were adjusted accordingly to reflect the changes made on initial cost of the projects. The life cycle cost and embodied carbon for conventional and low carbon materials was calculated using equation 2.2;

LCC = Initial project cost + PV of all recurring costs equation 2.2

Where;

PV of all recurring costs are present value of the annual and periodic costs.

The results were listed in Table 2.3.

Table 2.2: Life Cycle Cost Analysis for Alternative Low Carbon Materials

HALLS	Initial capital cost (A)	Recuring cost (Bank rate 18%, life span = 60years) See Appendix A for Cost Details					
		Annual cost (discounted with Year's Purchase Factor)					Periodic cost (PVF)
		Electricity bills (Independent Power Plant)			Replacing door knobs&keys, wardrobe handles&keys		Sewage treatment (see Appendix A qty of septic tank)
		unit/year	bill @53.47 per unit	YPF @18% compound rate for 60 years=5.56 (B)	Cost per year (see backup)	YPF @18% compound rate for 60 years=5.56 (C)	Present value of 50,000 per septic tank @ 18% evry 2 years =2.57 (D)
Adeleke	291,770,177.06	57,719	3,086,217	17,159,367.11	1,056,000.00	5,871,360.00	514,000
Ameyo Adadevoh	312,743,156.10	63,479	3,394,204	18,871,775.95	1,161,600.00	6,458,496.00	514,000
Bethel Splendor	320,490,029.90	63,479	3,394,204	18,871,775.95	1,478,400.00	8,219,904.00	514,000
Courage court	162,532,387.10	43,319	2,316,249	12,878,345.03	1,008,000.00	5,604,480.00	385,500
Crystal	373,023,005.20	69,239	3,702,192	20,584,184.78	1,612,800.00	8,967,168.00	514,000
Endeavour	259,630,121.28	57,719	3,086,217	17,159,367.11	1,344,000.00	7,472,640.00	385,500
Endurance	232,197,168.00	43,319	2,316,249	12,878,345.03	1,008,000.00	5,604,480.00	385,500
Felicia Adebisi	640,963,858.00	76,439	4,087,176	22,724,695.82	1,780,800.00	9,901,248.00	771,000
Gamaliel	234,149,218.00	43,319	2,316,249	12,878,345.03	1,008,000.00	5,604,480.00	385,500
Gideon Troopers	650,034,415.10	76,439	4,087,176	22,724,695.82	1,780,800.00	9,901,248.00	771,000
Havillah Gold	642,338,293.00	76,439	4,087,176	22,724,695.82	1,780,800.00	9,901,248.00	771,000
Justice Jeborah	393,886,927.00	69,239	3,702,192	20,584,184.78	1,612,800.00	8,967,168.00	514,000
Neal Wilson	220,944,858.20	43,319	2,316,249	12,878,345.03	1,008,000.00	5,604,480.00	385,500
Kings Delight	641,822,438.00	76,439	4,087,176	22,724,695.82	1,780,800.00	9,901,248.00	771,000
Nelson Mandela	381,848,975.20	69,239	3,702,192	20,584,184.78	1,612,800.00	8,967,168.00	514,000
Patience	203,999,158.20	43,319	2,316,249	12,878,345.03	1,008,000.00	5,604,480.00	385,500
Royal	247,937,308.20	43,319	2,316,249	12,878,345.03	1,008,000.00	5,604,480.00	385,500
Peace court	232,737,124.00	43,319	2,316,249	12,878,345.03	1,008,000.00	5,604,480.00	385,500
Platinum	407,626,832.80	57,719	3,086,217	17,159,367.11	1,344,000.00	7,472,640.00	514,000
FSD block	185,694,200.00	28,919	1,546,281	8,597,322.95	672,000.00	3,736,320.00	385,500
BIG block	248,263,100.00	28,919	1,546,281	8,597,322.95	672,000.00	3,736,320.00	385,500
Queen Esther	399,412,996.90	57,719	3,086,217	17,159,367.11	1,344,000.00	7,472,640.00	514,000
Samuel Akande	386,539,685.20	69,239	3,702,192	20,584,184.78	1,612,800.00	8,967,168.00	514,000
Trust court	284,331,648.00	43,319	2,316,249	12,878,345.03	1,008,000.00	5,604,480.00	385,500
Rehoboth	571,512,918.00	76,439	4,087,176	22,724,695.82	1,780,800.00	9,901,248.00	771,000
Diamond	345,691,507.80	57,719	3,086,217	17,159,367.11	1,344,000.00	7,472,640.00	514,000
Marigold	812,567,499.00	80,759	4,318,166	24,009,002.44	1,881,600.00	10,461,696.00	771,000
Welch	343,638,139.40	57,719	3,086,217	17,159,367.11	1,344,000.00	7,472,640.00	514,000
White hall	300,724,003.25	57,719	3,086,217	17,159,367.11	1,344,000.00	7,472,640.00	514,000
Winslow	836,661,999.00	80,759	4,318,166	24,009,002.44	1,881,600.00	10,461,696.00	771,000

Table 2.2: Life Cycle Cost Analysis for Alternative Low Carbon Materials (Continued)

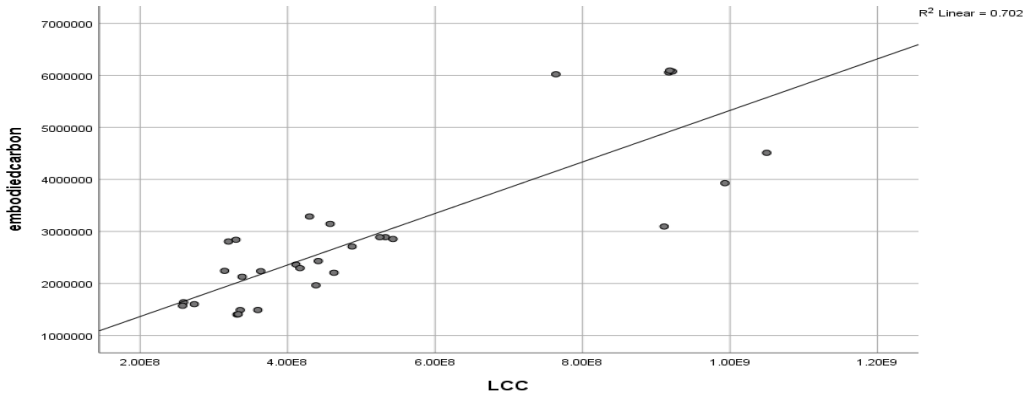
HALLS	Recuring cost (Bank rate 18%, life span = 60years) See Appendix A for Cost Details					Life Cycle Cost
	Periodic cost (discounted with Present Value Factor) Cont'd.					
	Replacing energy saving bulbs every 2 years	Polishing burnt clay brickwall every 2 years	Services to be replaced every 5 years	Services to be replaced every 10 years	Services to be replaced every 20 years	LCC= A+B+C+D+E+F+G +H+J
	Present value @ 18% every 2 years =2.57 (E)	PVF of @ 18% evry 2 years =2.57 (F)	PVF @ 18% evry 5 years =0.79 (G)	PVF @ 18% evry 10 years=0.24 (H)	PVF @ 18% evry 20 years =0.04 (J)	
Adeleke	2,467,200.00	15,863,582	4,865,000	5,040,000	2,160,000	345,710,686.17
Ameyo Adadevoh	2,713,920.00	17,705,758	4,865,000	5,040,000	2,160,000	371,072,106.05
Bethel Splendor	2,713,920.00	15,973,321	4,865,000	5,040,000	2,160,000	378,847,950.85
Courage court	1,850,400.00	11,522,595	4,865,000	5,040,000	2,160,000	206,838,707.13
Crystal	2,960,640.00	22,651,209	4,865,000	5,040,000	2,160,000	440,765,206.98
Endeavour	2,467,200.00	12,287,170	4,865,000	5,040,000	2,160,000	311,466,998.40
Endurance	1,850,400.00	10,509,758	4,865,000	5,040,000	2,160,000	275,490,651.03
Felicia Adebisi	3,269,040.00	40,873,280	4,865,000	5,040,000	2,160,000	730,568,121.82
Gamaliel	1,850,400.00	10,509,758	4,865,000	5,040,000	2,160,000	277,442,701.03
Gideon Troopers	3,269,040.00	44,645,783	4,865,000	5,040,000	2,160,000	743,411,181.92
Havillah Gold	3,269,040.00	43,622,152	4,865,000	5,040,000	2,160,000	734,691,428.82
Justice Jeborah	2,960,640.00	29,935,360	4,865,000	5,040,000	2,160,000	468,913,279.78
Neal Wilson	1,850,400.00	17,565,436	4,865,000	5,040,000	2,160,000	271,294,019.23
Kings Delight	3,269,040.00	43,918,987	4,865,000	5,040,000	2,160,000	734,472,408.82
Nelson Mandela	2,960,640.00	23,806,167	4,865,000	5,040,000	2,160,000	450,746,134.98
Patience	1,850,400.00	17,565,436	4,865,000	5,040,000	2,160,000	254,348,319.23
Royal	1,850,400.00	17,565,436	4,865,000	5,040,000	2,160,000	298,286,469.23
Peace court	1,850,400.00	9,844,128	4,865,000	5,040,000	2,160,000	275,364,977.03
Platinum	2,467,200.00	16,935,786	4,865,000	5,040,000	2,160,000	464,240,825.91
FSD block	1,233,600.00	5,037,200	4,865,000	5,040,000	2,160,000	216,749,142.95
BIG block	1,233,600.00	5,037,200	4,865,000	5,040,000	2,160,000	279,318,042.95
Queen Esther	2,467,200.00	16,935,786	4,865,000	5,040,000	2,160,000	456,026,990.01
Samuel Akande	2,960,640.00	24,360,259	4,865,000	5,040,000	2,160,000	455,990,936.98
Trust court	1,850,400.00	12,368,125	4,865,000	5,040,000	2,160,000	329,483,498.03
Rehoboth	3,269,040.00	23,588,488	4,865,000	5,040,000	2,160,000	643,832,389.82
Diamond	2,467,200.00	23,746,800	4,865,000	5,040,000	2,160,000	409,116,514.91
Marigold	3,454,080.00	20,299,916	4,865,000	5,040,000	2,160,000	883,628,193.44
Welch	2,467,200.00	17,729,145	4,865,000	5,040,000	2,160,000	401,045,491.51
White hall	2,467,200.00	13,089,524	4,865,000	5,040,000	2,160,000	353,491,734.36
Winslow	3,454,080.00	20,139,805	4,865,000	5,040,000	2,160,000	907,562,582.44

Table 2.3: Life Cycle Cost and Embodied Carbon of Building Projects

Project ID	Traditional materials		Low carbon alternative materials		% Reduction Embodied carbon	% Reduction LCC
	Embodied carbon (KgCO2)	LCC (₦)	Embodied carbon (KgCO2)	LCC (₦)		
1	2,364,260	411,312,811.17	1,875,614	348,867,611.17	20.67%	15.18%
2	2,430,479	441,570,415.05	1,873,165	374,036,006.05	22.93%	15.29%
3	1,964,417	438,429,817.35	1,544,522	381,023,350.85	21.38%	13.09%
4	1,637,936	258,887,668.13	1,230,787	210,713,107.13	24.86%	18.61%
5	2,889,674	532,633,363.98	2,264,268	444,304,856.98	21.64%	16.58%
6	1,489,657	359,594,110.58	1,142,720	311,466,998.40	23.29%	13.38%
7	1,401,986	331,420,636.53	1,070,141	275,490,651.03	23.67%	16.88%
8	6,057,115	917,028,362.82	4,881,054	729,408,121.82	19.42%	20.46%
9	1,488,543	335,696,240.53	1,123,120	277,442,701.03	24.55%	17.35%
10	6,075,557	921,846,820.42	4,915,437	744,341,181.92	19.09%	19.26%
11	6,092,133	918,227,220.32	4,884,319	734,691,428.82	19.83%	19.99%
12	2,710,578	487,403,520.78	2,304,224	468,913,279.78	14.99%	3.79%
13	2,840,448	329,914,029.73	2,477,878	271,294,019.23	12.76%	17.77%
14	3,095,004	910,646,550.32	2,457,450	734,472,408.82	20.60%	19.35%
15	2,854,350	542,934,083.98	2,272,956	452,633,144.98	20.37%	16.63%
16	2,242,908	314,481,825.73	1,784,535	254,348,319.23	20.44%	19.12%
17	2,806,091	319,734,120.73	2,258,803	280,193,469.23	19.50%	12.37%
18	1,408,934	333,054,649.03	1,076,283	275,364,977.03	23.61%	17.32%
19	3,144,880	457,675,829.41	2,479,319	398,609,175.91	21.16%	12.91%
20	1,571,391	257,579,187.95	1,172,123	216,749,142.95	25.41%	15.85%
21	1,602,337	273,440,017.45	1,200,226	219,985,592.95	25.10%	19.55%
22	3,287,275	429,735,260.01	2,525,548	361,500,980.01	23.17%	15.88%
23	2,889,674	524,986,092.98	2,264,268	455,990,936.98	21.64%	13.14%
24	2,127,732	338,343,693.03	1,518,737	271,491,488.03	28.62%	19.76%
25	6,020,930	763,802,971.82	4,871,912	642,162,139.82	19.08%	15.93%
26	2,206,182	462,830,549.91	1,651,737	409,116,514.91	25.13%	11.61%
27	3,928,351	993,022,119.94	3,094,134	831,251,993.44	21.24%	16.29%
28	2,294,611	416,765,833.51	1,877,718	365,656,441.51	18.17%	12.26%
29	2,237,072	363,540,500.56	1,843,602	316,507,639.15	17.59%	12.94%
30	4,511,402	1,049,712,206.44	3,645,759	885,097,532.44	19.19%	15.68%

From table 2.3, some reductions can be seen in embodied carbon of alternative materials that are low carbon compared with traditional materials. These data were further analyzed using Pearson correlation, before the analysis was carried out, scatter plot was done to check the linearity of the variables as Pearson correlation can only detect linear relationships between variables. Embodied carbon was plotted on the Y-axis while Life cycle cost was plotted on the X-axis.

Figure 2.1: Embodied Carbon and Life Cycle Cost Scatter Plot



From Figure 2.1, the scatter plot showed a positive correlation and R-square value is close to 1 at (0.702) which meant that there was linear relationship between the dependent and independent variables, hence, Pearson correlation was suitable to analyze the data.

The decision criteria for Pearson correlation results are; the strength and the direction of the linear relationship either positive (increasing) or negative (decreasing). Table 2.4 showed the results of the Pearson correlation.

Table 2.4: Correlation between Embodied Carbon and Life Cycle Cost for Traditional and Low Carbon Materials

Type	No of Observation	Pearson Correlation	Significance value
Traditional materials	30	(0.838)	(0.000)
Low carbon materials	30	(0.821)	(0.000)

The correlation, how close it is to -1 or +1 reflects the direction of the relationship, positive P-value showed increasing direction of the relationship. That is as Embodied carbon increases, Life cycle cost will also increase. The strength can be assessed as; $0.1<r<0.3$ indicates small or weak correlation, $0.3<r<0.5$ indicates medium or moderate correlation while $r>0.5$ indicates large or strong correlation. From table 2.4, the P-value of (0.838) and (0.821) indicate that there is strong correlation between embodied carbon and life cycle cost. The significance value of less than 0.050 meant that there is significant relationship between embodied carbon and life cycle cost.

Results and discussion of findings

From Table 2.4, the Pearson correlation results between embodied carbon and life cycle cost showed the direction was positive which meant that the dependent and independent variables tend to increase together that is an increase in embodied carbon will lead to an increase in life cycle cost. P-value of (0.838) and (0.821) which was close to 1, indicates that the strength of the relationship was strong. The correlation coefficient for the embodied carbon and life cycle cost was significant as the standard Significance value ($Sig<0.01$ for a two tailed test) was less than 0.01 at (0.000). This rejected the null hypothesis and accepted the alternate hypothesis that there is relationship between embodied carbon and life cycle cost. Table 2.3 showed significant reduction in cost of using alternative low carbon materials compared with traditional materials. Reduction up to 20.46% was seen in life cycle cost and 28.62% in embodied carbon.

Apart from the benefit of constructing safe, healthy and environmental-friendly buildings, there was reduction in the life cycle cost of low carbon buildings. This implied that the use of low carbon materials is cost effective and the maintenance cost of some of these are low compared to conventional materials. The cost of using materials such as burnt clay brick which when properly jointed require no plastering or painting can be quite low compared to cement blocks. Also, the cost of using dried mature bamboo in place of reinforcement can be quite low as seen in this study. Aside cost, the embodied carbon of bamboo and burnt clay bricks is lower than their traditional materials alternative. Also, construction of Bio-digester septic tank is a right step to keeping the environment safe by turning sewage to wealth (gas use for cooking). A biodigester is simply a tank that provides a means for aerobic digestion of organic materials such as human or animal waste. It's a water and air tight tank into which biodigester bacteria is introduced to digest solid waste to liquid and gas (Igoni et al, 2008). The liquid can be used as liquid manure for agricultural purpose or recycled to water for wetting plants or used in the toilet while the gas is connected to kitchen for cooking or cooling unit in the home.

Findings of other studies aligned with this study, such as Victoria et al (2015 & 2018) suggested that there is a close relationship between cost and embodied carbon. Perera et al (2021) findings established that there was significant relationship between cost and embodied carbon of building elements as reduction of embodied carbon of their case study projects led to reduction in cost. This will make estimating carbon to achieve reduction potential attractive to clients and investors as they will not only achieve value for money but also contribute towards sustainability. Langston et al (2018) findings suggested that there was a very strong relationship between embodied carbon and cost for both new-build and refurbish projects. They suggested that construction waste should be given consideration as well as embodied carbon with more emphasis on carbon reduction strategies such as recycling and adaptive re-use.

Imaowaji et al (2019) used regression analysis to analyze data sourced from world bank database and ministry of finance to investigate the impact of carbon emissions on firms' market value in Nigeria. The study found that there was no relationship between carbon emission and market value of firms, therefore firms can reduce their carbon emission without the concern of losing capital in the open market. Schmidt & Crawford (2017) identified financial implications as one of the main barriers to greenhouse gases emission reduction strategies. According to Ashworth & Perera (2015), cost was considered to be an impediment to zero carbon buildings as there is misconception about their construction leading to project budget being exceeded. However, this research work has proved that low carbon buildings can be cost effective. Therefore, the usage of low carbon materials in buildings is beneficial to the client and the environment at large.

Conclusion

The aim of the study was to evaluate the relationship between embodied carbon and life cycle cost of building elements with a perspective to seek efficient and suitable alternative materials that will reduce carbon footprint of the building within the budget of the project. Hypotheses were tested at 95% confidence interval based on the relationship between embodied carbon and life cycle cost, it was found that there was significance relationship between them. However, as client tends to be concerned about the project budget being exceeded, the use of alternative low materials was evaluated against traditional materials. It was found that the use of low carbon material will not add to the project budget if proper selection and estimation was carried out

at the early design stage. The initial cost may seem expensive but the maintenance cost will be cheaper and the benefits to sustainability of the environment in the long run will outweigh the cost.

Table 2.0: Details of Life Cycle Cost (Continued)

Projects	Recuring cost (All Cost details are Carried to Table 4.4 & 4.5)										
	Periodic cost										
	Replacing Energy saving bulbs every 2 years		Polishing of burnt clay brick wall		Finishes and Services to be replaced every 5 years						
					All Window nets		40 % of doors, 2 doors per room		Water & WHB taps		Total cost of finishes and services to be replaced every 5 years
	4 bulbs per room	Cost @ ₦600/bulb	Wall area multiplied by 2 sides of wall surface	Polishing @ ₦350 per square meter	No of windows	Cost @ ₦2500 per window	No of doors	Cost @ ₦15,000 per door	No of Taps	Cost @ ₦2,500 for both taps	
Adeleke	1,600	960,000	17,636	6,172,600	800	2,000,000	320	4,800,000	800	2,000,000	8,800,000
Ameyo Adadevoh	1,760	1,056,000	19,684	6,889,400	880	2,200,000	352	5,280,000	880	2,200,000	9,680,000
Bethel Splendor	1,760	1,056,000	17,758	6,215,300	880	2,200,000	352	5,280,000	880	2,200,000	9,680,000
Courage court	1,200	720,000	12,810	4,483,500	600	1,500,000	240	3,600,000	600	1,500,000	6,600,000
Crystal	1,920	1,152,000	25,182	8,813,700	960	2,400,000	384	5,760,000	960	2,400,000	10,560,000
Endeavour	1,600	960,000	13,660	4,781,000	800	2,000,000	320	4,800,000	800	2,000,000	8,800,000
Endurance	1,200	720,000	11,684	4,089,400	600	1,500,000	240	3,600,000	600	1,500,000	6,600,000
Felicia Adebisi	2,120	1,272,000	45,440	15,904,000	1,060	2,650,000	424	6,360,000	1,060	2,650,000	11,660,000
Gamaliel	1,200	720,000	11,684	4,089,400	600	1,500,000	240	3,600,000	600	1,500,000	6,600,000
Gideon Troopers	2,120	1,272,000	49,634	17,371,900	1,060	2,650,000	424	6,360,000	1,060	2,650,000	11,660,000
Havillah Gold	2,120	1,272,000	48,496	16,973,600	1,060	2,650,000	424	6,360,000	1,060	2,650,000	11,660,000
Justice Jeborah	1,920	1,152,000	33,280	11,648,000	960	2,400,000	384	5,760,000	960	2,400,000	10,560,000
Kings Delight	1,200	720,000	19,528	6,834,800	600	1,500,000	240	3,600,000	600	1,500,000	6,600,000
Neal Wilson	2,120	1,272,000	48,826	17,089,100	1,060	2,650,000	424	6,360,000	1,060	2,650,000	11,660,000
Nelson Mandela	1,920	1,152,000	26,466	9,263,100	960	2,400,000	384	5,760,000	960	2,400,000	10,560,000
Patience A	1,200	720,000	19,528	6,834,800	600	1,500,000	240	3,600,000	600	1,500,000	6,600,000
Patience B	1,200	720,000	19,528	6,834,800	600	1,500,000	240	3,600,000	600	1,500,000	6,600,000
Peace court	1,200	720,000	10,944	3,830,400	600	1,500,000	240	3,600,000	600	1,500,000	6,600,000
Platinum	1,600	960,000	18,828	6,589,800	800	2,000,000	320	4,800,000	800	2,000,000	8,800,000
FSD BLOCK	800	480,000	5,600	1,960,000	400	1,000,000	160	2,400,000	400	1,000,000	4,400,000
BIG BLOCK	800	480,000	5,600	1,960,000	400	1,000,000	160	2,400,000	400	1,000,000	4,400,000
Queen Esther	1,600	960,000	18,828	6,589,800	800	2,000,000	320	4,800,000	800	2,000,000	8,800,000
Samuel Akande	1,920	1,152,000	27,082	9,478,700	960	2,400,000	384	5,760,000	960	2,400,000	10,560,000
Trust court	1,200	720,000	13,750	4,812,500	600	1,500,000	240	3,600,000	600	1,500,000	6,600,000
Rehoboth	2,120	1,272,000	26,224	9,178,400	1,060	2,650,000	424	6,360,000	1,060	2,650,000	11,660,000
Diamond	1,600	960,000	26,400	9,240,000	800	2,000,000	320	4,800,000	800	2,000,000	8,800,000
Marigold	2,240	1,344,000	22,568	7,898,800	1,120	2,800,000	448	6,720,000	1,120	2,800,000	12,320,000
Welch	1,600	960,000	19,710	6,898,500	800	2,000,000	320	4,800,000	800	2,000,000	8,800,000
White hall	1,600	960,000	14,552	5,093,200	800	2,000,000	320	4,800,000	800	2,000,000	8,800,000
Winslow	2,240	1,344,000	22,390	7,836,500	1,120	2,800,000	448	6,720,000	1,120	2,800,000	12,320,000

Table 2.0: Details of Life Cycle Cost (Data from BU Facilities Management Department)

Projects	Recuring cost (All Cost details are Carried to Table 4.4 & 4.5)														
	Annual cost													Periodic cost	
	Electricity bills (Independent Power Plant)				Replacing door keys, wardrobe handles and keys									Evacuating septic tank every 2 years	
	Numbers of rooms (A)	Unit/ month (B)	Units of electricity used by central borehole/p er year C	Unit/year (AxB)+C	2 doors per room, on the average about 20% of rooms door key require replacement in a year	(d1) ₦1,800 per unit	2 doors per room, on the average about 50% of hall rooms door knobs require replacement in a year	(d2) ₦400 per unit	4 wardrobe doors per room, on the average 60% of hall rooms wardrobes handles require replacement	(d3) ₦300 per unit	4 wardrobe doors per room,on the average 25% of hall rooms wardrobe keys require replacement in a year	(d4) ₦800 per unit	D = d1+d2+d3+d 4	Numbe r of septic tank per hall	Rate ₦80,000/ septic tank
Adeleke	400.00	12.00	118.67	57,719	160	288,000	400	160,000	960	288,000	400	320,000	1,056,000	4	320,000
Ameyo Adadevoh	440.00	12.00	118.67	63,479	176	316,800	440	176,000	1,056	316,800	440	352,000	1,161,600	4	320,000
Bethel Splendor	440.00	12.00	118.67	63,479	352	633,600	440	176,000	1,056	316,800	440	352,000	1,478,400	4	320,000
Courage court	300.00	12.00	118.67	43,319	240	432,000	300	120,000	720	216,000	300	240,000	1,008,000	3	240,000
Crystal	480.00	12.00	118.67	69,239	384	691,200	480	192,000	1,152	345,600	480	384,000	1,612,800	4	320,000
Endeavour	400.00	12.00	118.67	57,719	320	576,000	400	160,000	960	288,000	400	320,000	1,344,000	3	240,000
Endurance	300.00	12.00	118.67	43,319	240	432,000	300	120,000	720	216,000	300	240,000	1,008,000	3	240,000
Felicia Adebisi	530.00	12.00	118.67	76,439	424	763,200	530	212,000	1,272	381,600	530	424,000	1,780,800	6	480,000
Gamaliel	300.00	12.00	118.67	43,319	240	432,000	300	120,000	720	216,000	300	240,000	1,008,000	3	240,000
Gideon Troopers	530.00	12.00	118.67	76,439	424	763,200	530	212,000	1,272	381,600	530	424,000	1,780,800	6	480,000
Havillah Gold	530.00	12.00	118.67	76,439	424	763,200	530	212,000	1,272	381,600	530	424,000	1,780,800	6	480,000
Justice Jeborah	480.00	12.00	118.67	69,239	384	691,200	480	192,000	1,152	345,600	480	384,000	1,612,800	4	320,000
Kings Delight	300.00	12.00	118.67	43,319	240	432,000	300	120,000	720	216,000	300	240,000	1,008,000	3	240,000
Neal Wilson	530.00	12.00	118.67	76,439	424	763,200	530	212,000	1,272	381,600	530	424,000	1,780,800	6	480,000
Nelson Mandela	480.00	12.00	118.67	69,239	384	691,200	480	192,000	1,152	345,600	480	384,000	1,612,800	4	320,000
Patience A	300.00	12.00	118.67	43,319	240	432,000	300	120,000	720	216,000	300	240,000	1,008,000	3	240,000
Patience B	300.00	12.00	118.67	43,319	240	432,000	300	120,000	720	216,000	300	240,000	1,008,000	3	240,000
Peace court	300.00	12.00	118.67	43,319	240	432,000	300	120,000	720	216,000	300	240,000	1,008,000	3	240,000
Platinum	400.00	12.00	118.67	57,719	320	576,000	400	160,000	960	288,000	400	320,000	1,344,000	4	320,000
FSD BLOCK	200.00	12.00	118.67	28,919	160	288,000	200	80,000	480	144,000	200	160,000	672,000	3	240,000
BIG BLOCK	200.00	12.00	118.67	28,919	160	288,000	200	80,000	480	144,000	200	160,000	672,000	3	240,000
Queen Esther	400.00	12.00	118.67	57,719	320	576,000	400	160,000	960	288,000	400	320,000	1,344,000	4	320,000
Samuel Akande	480.00	12.00	118.67	69,239	384	691,200	480	192,000	1,152	345,600	480	384,000	1,612,800	4	320,000
Trust court	300.00	12.00	118.67	43,319	240	432,000	300	120,000	720	216,000	300	240,000	1,008,000	3	240,000
Rehoboth	530.00	12.00	118.67	76,439	424	763,200	530	212,000	1,272	381,600	530	424,000	1,780,800	6	480,000
Diamond	400.00	12.00	118.67	57,719	320	576,000	400	160,000	960	288,000	400	320,000	1,344,000	4	320,000
Marigold	560.00	12.00	118.67	80,759	448	806,400	560	224,000	1,344	403,200	560	448,000	1,881,600	6	480,000
Welch	400.00	12.00	118.67	57,719	320	576,000	400	160,000	960	288,000	400	320,000	1,344,000	4	320,000
White hall	400.00	12.00	118.67	57,719	320	576,000	400	160,000	960	288,000	400	320,000	1,344,000	4	320,000
Winslow	560.00	12.00	118.67	80,759	448	806,400	560	224,000	1,344	403,200	560	448,000	1,881,600	6	480,000

Table 2.0: Details of Life Cycle Cost (Continued)

Projects	Recuring cost (All Cost details are Carried to Table 4.4 & 4.5)										
	Periodic cost										
	Finishes and Services to be replaced every 10 years										
	All WC Pan connector		All WHB magic waste		Replacing WC flow master		Toilet wall and floor tiles to be replaced		Sliding Window Panel to be replaced		Total cost of finishes and services to be replaced every 10 years
	No of Pan connector	Cost @ ₦3,000 per one	No of Magic waste	Cost @ ₦3,000 per one	40% of WC flow master	Cost @ ₦5,000 per flow master	Area (Sq.m)	Cost @ ₦6,500 per sq.m (all-in-rate)	30% of Windows	Cost @ ₦10,000 per panel	
Adeleke	400	1,200,000	400	1,200,000	160	800,000	500	3,250,000	360	3,600,000	10,050,000
Ameyo Adadevoh	440	1,320,000	440	1,320,000	176	880,000	550	3,575,000	396	3,960,000	11,055,000
Bethel Splendor	440	1,320,000	440	1,320,000	176	880,000	850	5,525,000	396	3,960,000	13,005,000
Courage court	300	900,000	300	900,000	120	600,000	1,200	7,800,000	270	2,700,000	12,900,000
Crystal	480	1,440,000	480	1,440,000	192	960,000	1,150	7,475,000	432	4,320,000	15,635,000
Endeavour	400	1,200,000	400	1,200,000	160	800,000	1,240	8,060,000	360	3,600,000	14,860,000
Endurance	300	900,000	300	900,000	120	600,000	1,120	7,280,000	270	2,700,000	12,380,000
Felicia Adebisi	530	1,590,000	530	1,590,000	212	1,060,000	1,350	8,775,000	477	4,770,000	17,785,000
Gamaliel	300	900,000	300	900,000	120	600,000	1,410	9,165,000	270	2,700,000	14,265,000
Gideon Troopers	530	1,590,000	530	1,590,000	212	1,060,000	800	5,200,000	477	4,770,000	14,210,000
Havillah Gold	530	1,590,000	530	1,590,000	212	1,060,000	750	4,875,000	477	4,770,000	13,885,000
Justice Jeborah	480	1,440,000	480	1,440,000	192	960,000	880	5,720,000	432	4,320,000	13,880,000
Kings Delight	300	900,000	300	900,000	120	600,000	1,260	8,190,000	270	2,700,000	13,290,000
Neal Wilson	530	1,590,000	530	1,590,000	212	1,060,000	1,180	7,670,000	477	4,770,000	16,680,000
Nelson Mandela	480	1,440,000	480	1,440,000	192	960,000	980	6,370,000	432	4,320,000	14,530,000
Patience A	300	900,000	300	900,000	120	600,000	550	3,575,000	270	2,700,000	8,675,000
Patience B	300	900,000	300	900,000	120	600,000	650	4,225,000	270	2,700,000	9,325,000
Peace court	300	900,000	300	900,000	120	600,000	850	5,525,000	270	2,700,000	10,625,000
Platinum	400	1,200,000	400	1,200,000	160	800,000	1,200	7,800,000	360	3,600,000	14,600,000
FSD BLOCK	200	600,000	200	600,000	80	400,000	500	3,250,000	180	1,800,000	6,650,000
BIG BLOCK	200	600,000	200	600,000	80	400,000	550	3,575,000	180	1,800,000	6,975,000
Queen Esther	400	1,200,000	400	1,200,000	160	800,000	860	5,590,000	360	3,600,000	12,390,000
Samuel Akande	480	1,440,000	480	1,440,000	192	960,000	1,400	9,100,000	432	4,320,000	17,260,000
Trust court	300	900,000	300	900,000	120	600,000	1,480	9,620,000	270	2,700,000	14,720,000
Rehoboth	530	1,590,000	530	1,590,000	212	1,060,000	1,550	10,075,000	477	4,770,000	19,085,000
Diamond	400	1,200,000	400	1,200,000	160	800,000	1,540	10,010,000	360	3,600,000	16,810,000
Marigold	560	1,680,000	560	1,680,000	224	1,120,000	1,620	10,530,000	504	5,040,000	20,050,000
Welch	400	1,200,000	400	1,200,000	160	800,000	1,200	7,800,000	360	3,600,000	14,600,000
White hall	400	1,200,000	400	1,200,000	160	800,000	1,350	8,775,000	360	3,600,000	15,575,000
Winslow	560	1,680,000	560	1,680,000	224	1,120,000	1,400	9,100,000	504	5,040,000	18,620,000

Table 2.0: Details of Life Cycle Cost (Continued)								
Projects	Recuring cost (Total Cost details are Carried to Table 4.4 & 4.5)							
	Periodic cost							
	Finishes and Services to be replaced every 20 years							
	Replacing all WCs		Replacing all WHBs	Replacing complete shower	Pipes and fittings to be replaced	Replacing all wardrobes	Replacing all beds	Total cost of finishes and services to be replaced every 20 years
	No of WCs	Cost @ ₦25,000 per WC	Cost @ ₦9,000 per one	Cost @ ₦7,500	Prov sum	Cost @ ₦45,000 per one	Cost @ ₦40,000 per one, 2 per room	
Adeleke	400	10,000,000	3,600,000	3,000,000	8,300,000	18,000,000	32,000,000	74,900,000
Ameyo Adadevoh	440	11,000,000	3,960,000	3,300,000	9,130,000	19,800,000	35,200,000	82,390,000
Bethel Splendor	440	11,000,000	3,960,000	3,300,000	9,130,000	19,800,000	35,200,000	82,390,000
Courage court	300	7,500,000	2,700,000	2,250,000	6,225,000	13,500,000	24,000,000	56,175,000
Crystal	480	12,000,000	4,320,000	3,600,000	9,960,000	21,600,000	38,400,000	89,880,000
Endeavour	400	10,000,000	3,600,000	3,000,000	8,300,000	18,000,000	32,000,000	74,900,000
Endurance	300	7,500,000	2,700,000	2,250,000	6,225,000	13,500,000	24,000,000	56,175,000
Felicia Adebisi	530	13,250,000	4,770,000	3,975,000	10,997,500	23,850,000	42,400,000	99,242,500
Gamaliel	300	7,500,000	2,700,000	2,250,000	6,225,000	13,500,000	24,000,000	56,175,000
Gideon Troopers	530	13,250,000	4,770,000	3,975,000	10,997,500	23,850,000	42,400,000	99,242,500
Havillah Gold	530	13,250,000	4,770,000	3,975,000	10,997,500	23,850,000	42,400,000	99,242,500
Justice Jeborah	480	12,000,000	4,320,000	3,600,000	9,960,000	21,600,000	38,400,000	89,880,000
Kings Delight	300	7,500,000	2,700,000	2,250,000	6,225,000	13,500,000	24,000,000	56,175,000
Neal Wilson	530	13,250,000	4,770,000	3,975,000	10,997,500	23,850,000	42,400,000	99,242,500
Nelson Mandela	480	12,000,000	4,320,000	3,600,000	9,960,000	21,600,000	38,400,000	89,880,000
Patience A	300	7,500,000	2,700,000	2,250,000	6,225,000	13,500,000	24,000,000	56,175,000
Patience B	300	7,500,000	2,700,000	2,250,000	6,225,000	13,500,000	24,000,000	56,175,000
Peace court	300	7,500,000	2,700,000	2,250,000	6,225,000	13,500,000	24,000,000	56,175,000
Platinum	400	10,000,000	3,600,000	3,000,000	8,300,000	18,000,000	32,000,000	74,900,000
FSD BLOCK	200	5,000,000	1,800,000	1,500,000	4,150,000	9,000,000	16,000,000	37,450,000
BIG BLOCK	200	5,000,000	1,800,000	1,500,000	4,150,000	9,000,000	16,000,000	37,450,000
Queen Esther	400	10,000,000	3,600,000	3,000,000	8,300,000	18,000,000	32,000,000	74,900,000
Samuel Akande	480	12,000,000	4,320,000	3,600,000	9,960,000	21,600,000	38,400,000	89,880,000
Trust court	300	7,500,000	2,700,000	2,250,000	6,225,000	13,500,000	24,000,000	56,175,000
Rehoboth	530	13,250,000	4,770,000	3,975,000	10,997,500	23,850,000	42,400,000	99,242,500
Diamond	400	10,000,000	3,600,000	3,000,000	8,300,000	18,000,000	32,000,000	74,900,000
Marigold	560	14,000,000	5,040,000	4,200,000	11,620,000	25,200,000	44,800,000	104,860,000
Welch	400	10,000,000	3,600,000	3,000,000	8,300,000	18,000,000	32,000,000	74,900,000
White hall	400	10,000,000	3,600,000	3,000,000	8,300,000	18,000,000	32,000,000	74,900,000
Winslow	560	14,000,000	5,040,000	4,200,000	11,620,000	25,200,000	44,800,000	104,860,000

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