

Building Information Modelling-Based Projects in Nigeria: Evidences from Eko Atlantic City

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ABSTRACT

Building Information Modelling (BIM) is a global digital construction technology that is being deployed in every country in the world. Several case studies of BIM-based projects have been reported globally, such as, Sutter Medical Centre in the United States, Research Laboratory at University of Colorado-Denver in the United States, Cathay Pacific Cargo Terminal in Hong Kong, Heathrow Airport in the United Kingdom, and Capitol Theatre in Alberta. This study aimed to investigate BIM-based project in the Nigerian construction industry using Eko Atlantic City as a case study. The study focused on BIM adoption indices, and found that the level of development of the geometries and the structural systems of the city and its buildings were made possible by the usage of BIM. The information models were integrated, and collaboration took place among the primary stakeholders. Also, it was found that BIM was also used to develop animation of districts, water supply and drainage design model, and simulation of sea wall construction for the city.

Keywords: Eko Atlantic City, Building Information Modelling, BIM Adoption Indices.

1.0 INTRODUCTION

Modern buildings are complex edifices and the design, construction and commissioning of a new building is a long complicated process that involves input from a number of parties (Aina and Wahab, 2011). The dynamic nature of human needs and development has caused the construction processes to undergo a great deal of metamorphosis (Mosaku et al., 2006). Traditional process of communication and exchange of information is responsible for about two-thirds of construction problems and has led to the proliferation of adversarial relationships between the parties to a project (Nuria, 2005; Chen and Kamara, 2008; Smith, 2013).

To address these problems, Bhargav (2014) argued that the built environment is not two-dimensional and should no longer be represented in two-dimensional (2D) drawings but in three-dimensional (3D) with models. The adoption of Building Information Modelling (BIM) as a way of representing building information in 3D and other obtainable dimensions has ushered the construction industry into a new digital construction renaissance, where projects are being built twice, once in the computer and then once flawlessly on site (Building Information Modelling Guide, 2013). Around the globe, BIM is significantly altering the way that the Construction Industry creates and cares for its assets; mostly because it allows organizations to identify and resolve issues before they actually happen, optimize outcomes and reduce process waste, especially rework. Her Majesty's Government (2012) explained BIM as the first truly global digital construction technology and predicted that the technology will soon be deployed in every country in the world. The study noted that the UK Government has embedded BIM into the UK

Construction Sector and the initial estimated savings to UK Construction and its clients is £2billion per annum through the widespread adoption of BIM and is therefore a significant tool for government to reach its target of 15-20% savings on the costs of capital projects by 2015.

Several case studies of BIM-based projects have been reported globally. For example, Sutter Medical Centre in the United States, Research Laboratory at University of Colorado-Denver in the United States, Cathay Pacific Cargo Terminal in Hong Kong, Heathrow Airport in the United Kingdom, and Capitol Theatre in Alberta. Sabol (2005) studied the adoption of BIM in Australia using Sydney Opera House as a case study. The study observed that BIM provides a unified digital repository of all building components, and as a full 3D model, it is capable of displaying views with a clarity that are typically eludes users not schooled in interpreting standard 2D building drawings. The study also noted that in the U.S Federal Government, BIM is a requirement for projects at General Services Administration, the U.S Army Corps of Engineers, and the Department of State. The study found that BIM is an appropriate and beneficial approach enabling storage and retrieval of integrated building, maintenance and management information for construction projects. BIM has been identified as a key agent for economic growth in both domestic and international markets; and as a tool that construction exporting countries can use BIM to compete in construction (MacLeamy, 2012). Staub-French and Khanzode (2007) reported the case studies of Camino Medical Center and Sequus Pharmaceuticals Pilot Plant Facility in California. The finding of the studies showed that BIM has the potential to significantly improve design coordination and construction execution.

The aim of this study is to investigate BIM-based project in the Nigerian construction industry using Eko Atlantic City as a case study with a view to enhancing widespread adoption of BIM for construction projects by the Governments of Nigeria and construction firms in Nigeria.

2.0 BACKGROUND INFORMATION ON EKO ATLANTIC CITY PROJECT

Eko Atlantic City is an on-going construction projects located on Lagos Bar Beach and adjacent to the Victoria Island in Lagos State, Nigeria. A dynamic new city that was designed to rise from the Atlantic Ocean and is being developed to rebuild and protect Victoria Island's shoreline and coastal erosion problem. The project is a public-private partnership based project between South Energy X and Lagos State Government. The Lagos State Government serves as a strategic partner for the project, while South Energy X is the developer and financier. Eko Atlantic City is designed to become Nigeria's most exclusive suburb and a symbol of Africa's future (Channels Television, 2010). The City is meant to restore land lost to coastal erosion over the last century, provide a permanent solution to the erosion problem along the Lagos coastline, protect Victoria Island from ocean surge, create job opportunities as well as providing a state of the art business district for West Africa, and construction of 7km of revetment (Adelekan, 2012). The city is classified as its own municipality and will run on its own bureaucracy. It will also be an offshore banking zone and allow free movement of capital by investors.

The project's primary stakeholders include South Energy X Nigeria Limited, Julius Berger Nigeria Limited, Tabet Atelier d'Architecture, Dredging International Services Cyprus Limited, Eko Development Company Limited, HOK Architects (America and UK), ECAD Architect Nigeria Limited, Royal Has Konung DHV Consultant and Designer, Dando Geotechnical Drilling Rigs UK, First Bank of Nigeria PLC, First City Monument Bank Nigeria, Guaranty

Trust Bank Nigeria, BNP Paribas Fortis, KBC Bank, Orlean Invest, ESLA International, RMCK Construction Limited, Gensler Architects, and China Communications Construction Company.

The city is for residential, financial, commercial, tourists accommodation and leisure activities, and it is anticipating 400, 000 residences and 3,000 buildings upon completion. The city will have 10 districts, namely; Business Districts, Harbour Lights, Marina Districts, Downtown, Eko Island, Avenues, Four Bridges, Eko Drive, East Side Marina, and Ocean Front. The city was also designed as a high-tech infrastructure and in line with modern and environmental standards. Eko Atlantic City has been affirmed as one of the newest and ultramodern city in the world. The city was designed to be built on a 4 square miles of land reclaimed from the Atlantic Ocean and will have independent source of power generation and offer water, security, and transportation systems. The project started in 2009, 10 million square meters of land is allocated for development, but only 6 million square meters of land is available for sale. The average area of the city was given as 7km by 1.4km, with 100km length of internal roads, and 20km length of internal waterway (Channels Television, 2014; South Energy, 2013).

3.0 BIM ADOPTION INDICES IN EKO ATLANTIC CITY PROJECT

Levels of information details, exchange and integration of building information, and collaboration are considered as BIM adoption indices for a project (Jung and Lee, 2005). As shown in Figure 1 and 2, the Architectural Information Model for Eko Atlantic City comprised of Eko Corporate Tower, Eko Boulevard, Le Reve Tower, Afren Tower, Eko Pearl Towers (Champagne Pearl, White Pearl, Black Pearl, Indigo Pearl, Acqua Pearl), Azuri Peninsula, Arep Towers, International School, Atlantic Business and Residence, Eko Mall, Eko Atlantic Medical center, 3-Marinas, and Eko Energy Estate. Without the adoption of BIM, it would be impossible to show this level of architectural details for the project. Most of the buildings are skyscrapers, and these skyscrapers were developed to step back as they go higher in order to minimize shadows cast over other buildings (Oyedeki, 2014). The Eko Pearl Towers are named after the most precious pearls in the sea and comprised exclusively of deluxe apartments of two-bedroom, three-bedroom, and penthouse-type apartments with sea and marina views. The garden terrace is 22,738 square metres, and comprises a swimming pool, 2 tennis courts, a squash court, children’s playground, landscaped paths, sitting areas, and an open-air bar (Eko Brochure, 2013).





Figure 1: Architectural Building Information Models of Buildings in Eko Atlantic City (a) Corporate Tower. (b) Atlantic Resort. (c) Azuri Peninsula. (d) Eko Pearl Towers. (e) Eko Energy Estate. (f) Eko Boulevard. Sources: Eko Brochure (2013), The Business Year (2016), South Energy (2013)

Afren Tower comprised of 15-floor; while Eko Corporate Tower is a 37-floor of office space with restaurants and high-end retail shops. The facilities in Eko Energy Estate include swimming pools, spas, tennis courts, squash courts, multipurpose sport areas, and fitness centre. Le Reve Tower is a 40-floor building with special low-emissivity glass which lets sunlight flood into rooms but repels heat. The tower is illuminated with fibre-optic lighting, window shutters open by remote control, marbled bathrooms, rainfall showers, and solid wood furnishings. The phase one of Azuri Peninsula consists of Oban Tower (26-floors), Orun Tower (26-floors), Zuma Tower (24-floors), and Town Houses (4-floors). All these make up 120 luxury apartments, villas, townhouses and other residences (South Energy X, 2013; Eko Brochure, 2013).



Figure 2: Animation of Districts in Eko Atlantic City (a) Marina Residences. (b) Eko Pearl Towers. (c) Atlantic Resort. (d) Southern Boulevard. (e) Business Districts. (f) Marina Districts. Sources: Eko Brochure (2013), The Business Year (2016), South Energy (2013)

Atlantic Resort consists of 3 towers, 2 residential blocks and 1 mixed use tower. The residential tower is made up of unit types 1 and 2 bedroom apartments, 3 bedroom maisonettes, 1 unit 4 bedroom terrace apartment, and 2 units 5 bedroom penthouse maisonettes. The resort boast of

world-class facilities and amenities which includes; spa, swimming pool, retail store, café, restaurant, ballrooms, library, gym, and parking space (Grenadines Homes, 2013).

The structural information models show that the revetment for the city was designed not only as coastal protection, but also as an amenity to provide a view across the Atlantic Ocean and provide foundation for an esplanade. Tests were undertaken in both 2D flumes and 3D basins to investigate the stability and overtopping characteristics of the sea defence revetment. Pile foundation was designed for the bridges and post-tensioning system was selected for reinforcing the bridges; while pile foundation and basement foundation were designed for the towers (Seckington, 2012). Figure 3 and 4 show the water supply and drainage design model and daylighting analysis of Buildings in Eko Atlantic City. The analysis shows that the buildings comply with carbon emission standards. Smoke detectors, CCTV, fire extinguishing system, and central air conditioning were some of the services modelled for Atlantic Resort. All electricity and telecommunication utility services for the city are designed to be installed below street level. Other mechanical, electrical and plumbing services modelled for Eko Atlantic City are exterior building shading systems, natural ventilation (daylighting), vegetation, poly-generator (combined cooling, heat and power systems), building orientation, surface water drainage, and sewage treatment plant (Oyedeji, 2014; Oniru, 2011).





Figure 3: Daylighting Analysis of Buildings in Eko Atlantic City (a) Eko Pearl Towers. (b) Atlantic Resort (External). (c) Atlantic Resort (Internal). (d) Azuri Peninsula (External). (e) Marina District. (f) Azuri Peninsula (Internal). Sources: Eko Brochure (2013), The Business Year (2016), South Energy (2013), Grenadines Homes (2013).



Figure 4: Water Supply and Drainage Design Model for Eko Atlantic City (a) Water Supply. (b) Sewage Distribution. (c) Storm Water Drainage. Source: Channelstv (2010).

As contained in the construction management and schedule models (Figure 5, 6, 7 and 8), the construction of water, sewage and storm drains is scheduled to commence from Marina District, Downtown and Avenue, Eko Boulevard, and Avenue 1. Ductwork for electricity and telecommunication utility services is scheduled to commence from Eko Boulevard. Eko Pearl Towers were scheduled to be constructed as follows: Phase A (White Pearl), 1st- 18th floor, 19th floor (royal apartment), and 20th-24th floor; Phase B (Black Pearl), 1st-23th floor and 24th-30th floor; Phase C (Indigo Pearl), 30 floors; Phase D (Champagne Pearl), 33 floors; and Phase E (Acqua Pearl), 24 floors. It was scheduled that the construction of the revetment should run ahead of the major sand filling operations in order to provide access to construction vehicles, so that sand filling operations would be done in a fully sheltered environment (Eko Brochure, 2013; Seckington, 2012).



Figure 5: Site Analysis of Eko Atlantic City (a) Eko Atlantic. (b) Atlantic Report. (c) Eko Pearls Towers. (d) Marina District. Sources: Eko Brochure (2013), The Business Year (2016), South Energy (2013), Grenadines Homes (2013).

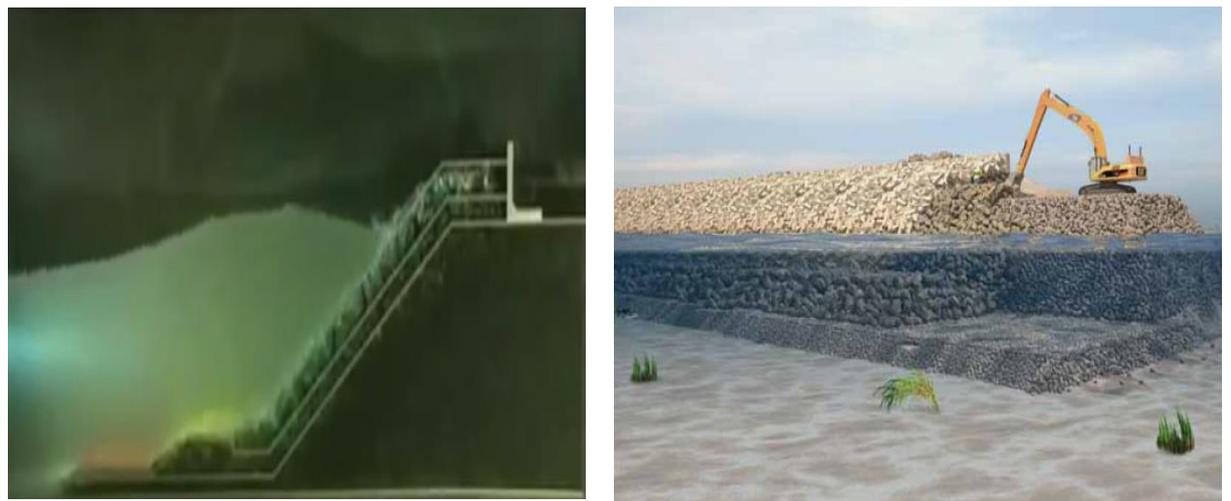


Figure 6: Simulation of the Sea Wall of Eko Atlantic City (a) Sea Wall Behaviour. (b) Sea Wall Construction. Sources: Channelstv (2013), Eko Brochure (2013), The Business Year (2016), South Energy (2013)



Figure 7: Construction Timeline of Eko Atlantic City (a) construction of Sea Wall and Land Reclamation. (b) - (f) Construction of Buildings in Eko Atlantic City. Sources: Channelstv (2013), Eko Brochure (2013), The Business Year (2016), South Energy (2013)



Figure 8: Construction Timeline of Buildings in Eko Atlantic City: (a) - (d) Eko Pearl Towers. (e) - (f) Eko Energy Estate. Sources: Channelstv (2013), Eko Brochure (2013), The Business Year (2016), South Energy (2013), Grenadines Homes (2013).

Ten firms collaborated for Eko Atlantic Resort, HOK Architects and ECAD Architects as the architectural firms. HOK is based in America and UK; while ECAD is based in Nigeria. The building construction firms are Cappa De' Alberto, Julius Berger, and Ehlan Construction Company. Tillyard Nigeria Limited and Ove Arup and Partners (London and Nigeria) as quantity surveying firm and structural engineering firms. The building services engineering firm and facilities management firms are CA Consulting Limited and Mace UK and Billfinger International. The following firms collaborated for Eko Pearl Towers: Tabet Atelier

d'Architecture (architectural firm), SERT (building services engineering firm), Bernard Zeinoun (structural engineering firm), and TAA Construction (Building construction firm). The means of collaboration for Eko Atlantic City are Eko Atlantic Mobile Application (EAMA) and Augmented Reality (AR). EAMA is an easy-to-use and regularly updated project presentation, it features a gynscope-enhanced virtual tour enabling users to navigate through the construction works by moving their mobile device around; while AR adds layers of digital information videos, photos, sounds, and graphics (South Energy X, 2013).

The cost models revealed that the waterfront plots will cost \$2,000 per square metre, while the inner city will cost \$1,000 per square metre. The whole project is estimated to cost \$6 billion (Meseko, 2014). The maintenance and sustainability information for the project shows that the use of environmentally-efficient construction methods and locally sourced construction materials were part of the plan to minimize Eko Atlantic City's carbon footprint. Waste management was developed to be managed with separate bin receptacles and chutes; while kitchen sinks were equipped with garbage disposal grinders that crush waste and have them collected at locations where it can be processed into bio-mass fuel and manure via compost heaps and bins. Also, the manures are planned to be used for the lawns and gardens (Oyediji, 2014).

The adoption of BIM for Eko Atlantic City has significantly impacted the project. The estimated completion date for the first of Eko Pearl Towers is 2015 and 2016 for the 2nd tower. The phase one of Eko Energy Estate which entails the construction of the first three buildings is slated for completion by the end of 2017. One floor is being built every 9 days in Eko Pearl Towers, and as at June 2014, 8 out of 15 floors of Afren Tower have been completed and the Builder, ITB Nigeria Limited is confident that the target delivery date will be met.

4.0 CONCLUSION

The study explained the adoption of BIM in Eko Atlantic City project with a focus on BIM adoption indices. The level of development of the geometries and the structural systems of the city and its buildings were made possible by the usage of BIM. The architectural information models of buildings show various views of the proposed development of the city and also reveal how the buildings were developed to minimize shadows cast over one another.

BIM was also used to develop animation of districts, water supply and drainage design model, and simulation of sea wall construction. The information models were integrated, and collaboration took place among the primary stakeholders. Site analysis and sustainability analysis of the city was carried out, daylighting was simulated, and the construction of the city was scheduled and timelined using computer models.

The impact of BIM adoption for the project can be seen in the presentation and visualization of building designs, improved communication and collaboration among project team members, simulation and scheduling of construction process, and better understanding of the project.

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