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The encumbrance of constructing on a swampy terrain

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Abstract. All through the ages, the provision of shelter has remained an ever-present challenge of mankind. Perennial difficulties of shelter provision are posed by varying strains dependent of numerous conflicting factors. Civil engineering and other specialty of science and humanity join hands in providing solutions to man's basic housing and infrastructural needs, thereby adding values to what nature has provided. Constructing on different terrains cost different amount of resources and energy. This research evaluates the burden of constructing on swampy terrain. Mende-Maryland in Lagos is adopted as the area of study. This research analyzed the methods of constructing a duplex on a swampy terrain and modelled the behaviour of the same structure on a normal terrain. Successively, the economic burden of constructing on a swampy terrain is compared to that of constructing on a normal terrain. The result showed that constructing on a swampy terrain is a cost intensive process with the cost of pile foundation alone taking about 38 percent of the whole cost of construction when compared to the 17 percent cost of raft foundation for a normal terrain. This cost will go higher when the cost of engaging experts and equipment for soil consolidation, construction of superstructures on weak terrain and extra safety measures are computed.

Keywords: Building collapse, Concrete structure, Pile foundation, Swampy terrain, Raft foundation

1. Introduction

Buildings are designed by qualified professionals to meet basic needs of man and the principal design criteria are safety and economy with the main intent of avoiding damages to life, property and the environment. The safety standards focuses on predictable self-weight and probablistic imposed loads due to usage and environmental factors. Once a building project is conceived, one of the factors that will determine if the project will see the light of day is the ground soil condition of the proposed location. Many proposed projects never proceeded to completion around the world due to the difficult situation posed by the proposed construction site because the terrain is an important factor in any construction. The sub-structure on the terrain is of the highest importance to the stability of a structure. Factors that influence the stability of structures after construction are numerous and the current trend of building collapse around the world and in particular within developing nations like Nigeria is very alarming. Among the known causes of collapse in Nigeria are poor quality materials, climate change and its complex effects such as flooding, faulty prop-ups and scaffolding systems, incompetent professionals, artisans and contractors, non-enforcement of codes and standards, quackery, poor work ethics of Nigerians and endemic corruption [1-4]. The colossal loss of building collapse in terms of human casualties and economic values run against the UN Sustainable Development Goals that strive to make the world safer for human habitation [5]. Past

researches [6, 7] have proved that most building collapse in Nigeria occur during the raining season. The effects of rain and flooding upsets principally the substructure of buildings. Substructure design is based on the geotechnical properties of soil. An unstable soil of low load bearing capacity is bound to influence negatively the cost of building. Site practicability study for building projects is of very useful before a project takes off since it facilitates insights of the characteristics of subsoil upon which the decision on location of the project can be made [8].

Swampy terrain are made of soils of low strength with a lot of ground movement and difficult geotechnical properties. The presence of many aquatic organisms and plants adds to the complexity of the terrain. Swampy terrains usually become plain in flooding situations and therefore has the capacity to withhold a lot of water and this is why it poses a lot of challenges with respect to normal construction site. The major difficulty is in designing the sub-structure that can withstand the risk of sinking or collapse. The normal process of building design involves determining the geotechnical properties of the soil through tests to derive the soil bearing pressure which will help in forecasting the most suitable type of foundation to be adopted. This shows that the type of foundation to be adopted will depend on the type terrain and the soil properties. Any movement of the soil not adequately contained by the foundation on a terrain would probably lead to a collapse. Therefore the soil properties of the soil on a building site can make or mar the structure, giving worth or waste to the client's financial investment. The approach to improve the property of problematic soils is by stabilization. Soil stabilization tries to improve soil strength and resistance to softening by water through bonding the soil particles together and water proofing the particles [9]. Common stabilization processes include compaction and drainage or by improving gradation of particle size through use of binders to hold together weak soils [10]. But the process of stabilization escalates the cost of construction. Today, with right choice of materials, the cost of stabilization can be scaled down [11, 12].

This research attempts to identify the challenges of constructing on a typical swampy terrain of Lagos environ. Lagos being on the coast of Atlantic Ocean and exposed to all the typical problems of a delta, is a very good case study of evaluating the challenges of constructing on a swampy terrain, with Mende-Maryland Lagos being the area of focus. This research will analyze the methods of constructing a duplex on a swampy terrain and model the behavior of the same structure on a normal terrain. Successively, the economic burden of constructing a substructure on a swampy terrain will be compared to that of a normal terrain. This research will not dwell much on the comparison of the superstructures for the swampy and normal terrain, but it noted from experience that constructing on marshy terrain will require the service of experts and more costly equipment. This will generally contribute to increase the total cost of construction.

2. Methodology

This study analyses the scenario of constructing in swampy area of Mende, Maryland, Lagos. The approach consisted of analyzing the burden of constructing a residential duplex building in a swampy terrain and then comparing it to second option of a fair terrain within Lagos area. This will entail adopting Pile Foundation for one and Raft Foundation for the other, with the application of the principles governing each condition.

Lagos is open to the effects of the water flow from the Atlantic Ocean and torrential rain. The occasion of flooding is usually alarming to Lagos residents, as the effect can be devastating to structures constructed by the main drainage canals. The challenge of Lagos being over populated with an estimated population of 9,000,000 [13], have compelled many to relocate to low cost areas of poor quality land and usually swampy or water logged, thereby causing the building investment to be too complex. An image of Maryland area of Lagos is shown in figure 1.The study will be on Mende, Maryland, Lagos appearing with just the features needed for the case study on swampy terrains and the challenge of constructing in the terrain. A typical free land in a swampy area of Mende could look like Figure 2.

The swampy terrain of Mende allows for growth of plants as seen. Thus in the process of clearing a parcel of land requires special skill and thus imparts on the difficulty of construction. After clearing, the land will need to be stabilized and refilled to prevent sinking of structures built on the site. Then follows the setting out and identification of the positions of piles. After the setting out, the foundation begins with the installation of steel pile casings. Figure 3 shows pile driving machines in place.

Figure 1: A Google satellite image around the study area between Maryland and Kosofe

Figure 2: Virgin land in Mende, Maryland , lagos.

Figure 3: Pile driving machines in place

Thus, after casting the piles, the formworks are made for the pile caps and the ground beams and reinforcements are also placed. After that, the ground floor raft slab is casted, follows the columns and beams for the next suspended floor and up till the frame is completed.

Among the difficulties encountered is that there will be movement of many heavy materials to be used on the site, such as piling machines, steel reinforcements, cement, aggregates, etc. On the site, movement is limited to the areas that are stable to prevent injuries and loss of life. Then, extra provisions need to be made for drainage

of storm water by providing for floor drains. Other dificulties on swampy site include the risk of props shifting during construction because of weak soil, the welding of the different parts must be very rigid to avoid peat entering the casing. Settlement in the terrain would definitely occur but if the base of the foundation for the structure is equal althrough, the constructed would settle equally, thus there would not be any noticeable deflection especially, if the pile foundation is properly constructed.

2.1. Designing of the proposed structure

The plan of the proposed five bedroom detached two storey duplex building was drafted on AutoCAD2016, while Orion 18 was used for structural analysis and design. The dimension of the edifice was 8.725m x 14.225m for the ground floor, and 8.725m x 16.425m for the first and second floors. Storey height of 3 m was adopted. The architectural plan of the first floor and the structural arrangement are shown in figures 4 and 5, respectively, while the materials adopted are shown in table 1.

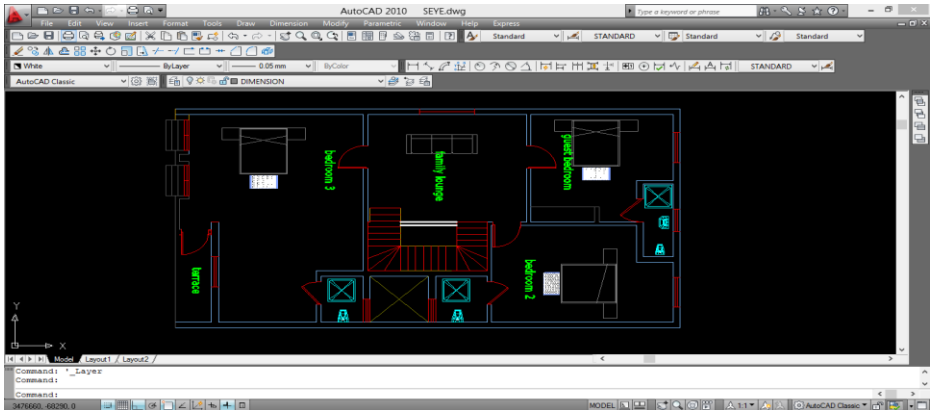

Figure 4: First floor plan

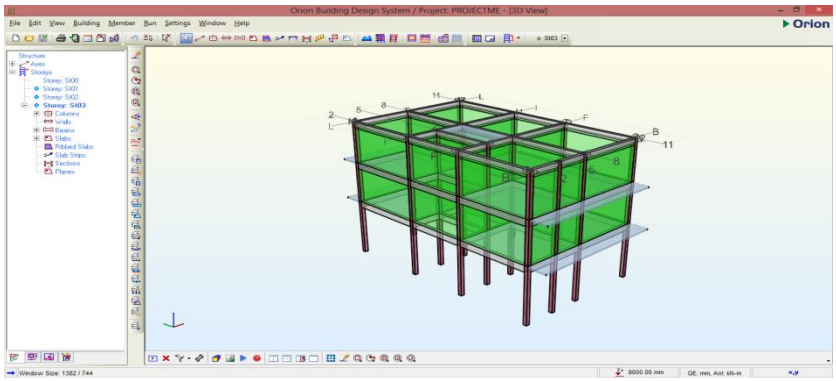

Figure 5: The structural arrangement shows the flow of loading from slab to beam and column

Table 1: shows concrete and steel data

Concrete				
Members	Class	Fcu (N/mm^2)	Ec (N/mm^2)	
Columns	C25/30	30.00	26000.0	
Beams, Slabs, Foundations	C20/25	25.00	25000.0	
Steel				
	Steel Grade	Fy (N/mm^2)	Es (N/mm^2)	
All members	Grade 460 (Type 2)	460.00	200000.0	

3. Results

Results from the work carried out in this research is hereby presented. For the same structure, pile foundation and raft foundation options were considered, based on the soil bearing capacity of Mende area of Maryland, Lagos. Results of these two cases were compared as to have insight to the burden of constructing in swampy environ. For the pile foundation on swampy conditions, the soil unit weight of 8kN/m^3, pile cap depth of 900mm, pile size of 300m, pile safe working load of 150kN for compression and 15kN for tension and spring coefficient of 500kN/m were adopted. The cost of pile foundation installation stood at 38 % of the total cost of the construction as shown on the pie chart of Figure 6.

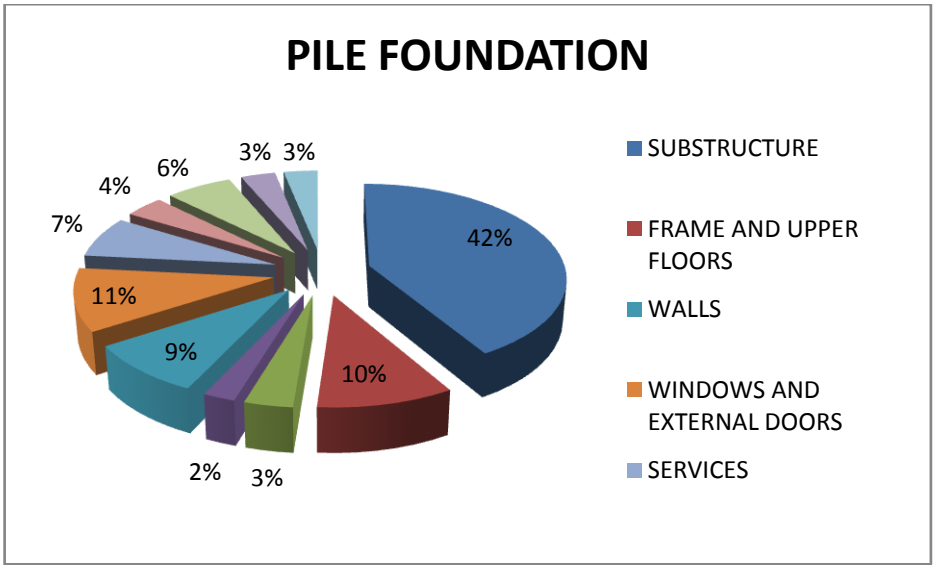

Figure 6: Cost of Building using pile foundation

Designing a raft slab 200mm thick for the superstructure on a loose sand option of about 4800kN/m^3 sub grade reaction will lead to the failure of the structure as deflection is beyond 100mm, while the clay soil option of about 12000kN/m^3 sub grade reaction will lead to a maximum deflection of 4mm. But the deflection under extreme cases of swampy soil cannot accommodate raft foundation because it is too unstable. For the sake of comparison, the raft foundation option was considered for the same superstructure assumed to be on a stable terrain. In this case, the cost of raft foundation stood at 17% of the total cost of construction as shown on the pie chart of figure 7. Thus, the economic burden of building the duplex on pile foundation method is much higher than that of raft foundation option because of the depth of peat in the site.

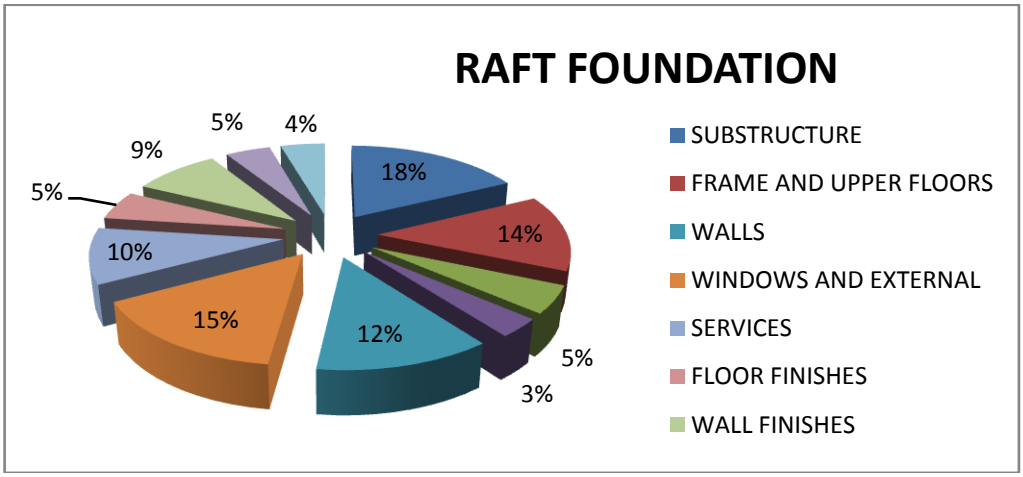

Figure 7: The cost raft foundation

4. Conclusion

The research considered the challenges of constructing on a swampy terrain, which is very typical of Lagos environment. Mende-Maryland Lagos was the area of focus for this research. The burden of constructing a two storey duplex on a swampy terrain environment was considered. The same superstructure was modelled for a normal terrain and the economic burden of constructing on a swampy terrain was compared with that of a normal terrain. The result showed that constructing on a swampy terrain is a cost intensive process with the cost of pile foundation alone taking about 38 percent of the whole cost of construction when compared to the 17 percent cost of raft foundation for a normal terrain. This excludes the elevate cost of consolidating the terrain and shoring up the site before building the pile foundation and also, the high risk of accidents the construction workers are exposed in swampy environment. Based on the findings of this research, it is recommended that intending clients must weigh the burdens related to constructing in swampy terrain before acquiring the terrain as to avoid regrets after acquisition.The difficulties to be expected include high cost of strengthening the terrain before construction, high cost of engaging experts in all operations in this delicate environment and the high risk of worsening environmental conditions due to climate change.

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