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HIGH-RISE BUILDING STRUCTURES IN THE DELTAIC REGION IN NIGERIA.

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ABSTRACT

High-rise buildings have been rapidly increasing worldwide due to insufficient land availability in populated areas and their primary role as essential buildings in modern cities and capitals. However, high-rise buildings are very complicated due to the huge number of structural components and elements unlike low-rise buildings, as well as these high-rise buildings demand high structural stability for safety and design requirements. This paper aims to provide brief information about high-rise buildings regarding the basic definition, safety features, structural stability, and design challenges. The Deltaic region is characterized with a low soil bearing capacity due to the high water table within the soil. Bayelsa State as an example of the States in South-south and the topography is made up of 90% water body and 10% land mass. As noted, Bayelsa State is 90 percent water, and 10 percent land. Sixty percent of the water is saline, while the remaining 40 percent is

fresh. Source: The Paradox of Water Crisis and Rural Poverty in the Niger Delta of Nigeria. Daniel A. Omoweh p. 201-220, (2009). Key words: Deltaic, High-Rise, Structural Systems, Fire safetyand Vertical Circulation.

NTRODUCTION

The term Deltaic region refers to an area of land where a river or stream divides into smaller channels before emptying into the Rivers through to the Seas. Louis Cohen (2017).

The required foundation footing for high-rise building structures within the Niger Delta Region would require strict use of the Pile foundation footing method which is cost effective. Piles are vertical or slightly inclined, relatively slender structural foundation members. They transmit loads from the superstructure to competent soil layers. Length, method of installation, and way of transferring the load to the soil can vary greatly. These studies have been done through careful investigation of the architectural, planning, marketing, and financial aspects. It is the most significant reason that encourages technological advancement by seeking to utilize the latest systems and materials. High-rise buildings have been rapidly increasing worldwide due to insufficient land availability in populated areas and their primary role as essential buildings in modern cities and capitals. However, high-rise buildings are very complicated due to the huge number of structural components and elements unlike low-rise buildings, as well as these high-rise buildings demand high structural stability for safety and design requirements. This paper aims to provide

brief information about high-rise buildings regarding the basic definition, safety features, structural stability, and design challenges.

LITERATURE REVIEW

High rise building structures are multi story building which enables the saving of land mass Within the Deltaic region of Nigeria, these areas are mostly made-up of water bodies than available land space. High-rise Buildings are cost effective though, they also serve as a land mark on development. Structural Systems implies the backbone of a building, every long-lasting and well-constructed building needs a high-quality structural system at its base. The term structural system, also known as structural frame serves in transferring all forms of load on the building form to the ground beneath the substructure. It is the interconnection of structural members or elements designed in by structural engineering professionals for stability of the building in resisting all forms of load acting on the building structure. The forms of load acting on the building forms are dead load (weight of the building form and fixed components), live load (the end users), axial load (force of wind acting on the building and seismic load (such as vibration from earth moving equipment or explosion)

Engineering Design Consultant (EDC) defines a tall building as a building having a height of 35 m or greater, divided at uniform intervals into accessible levels. To be count as a tall building, the tower should be constructed on solid flooring and fabricated over its entire height through a thoughtful process. High

rise building (tower) can be defined as a building that has an overall height exceeding 36 m or more than 12 stories and its usage varying between administrative, residential or as a hotel. Except for height, it is always a relative issue and the building could not be defined utilizing the expression of height only, as the judgment of the building is based on the surrounding environmental conditions, so it is impossible to set an accurate definition of high-rise buildings.

With the end of the 20th century, numerous countries started tomake progression by preparing comprehensive plans to construct high-rise investment projects with the developments of many principles and standards to guarantee the success of these plan.The concept of building high-rise structures in the Deltaic region in Nigeria calls for deliberate and concise approach in achieving a structurally stable building systems and technological principles.

The basis of this article is keyed on finding the best methods of high-rise construction within such water logged environment that would not only serve the test of time but also to improve the use of available land spaces as high-rise buildings have less floor ratio area (FRA) while ensuring amenities are available in serving the user need. The movement of people from various states of the country into the Niger Delta Region from other state as a case study has prompted a rise in population and as such, the introduction of high rise buildings would help cater for the expansion in population in a very large sense since obviously the terrain is

more of water space is than available land.The major consideration is the fact that the soil is of low bearing soil bearing capacity.

FLOOR RATIO AREA IN URBAN DEVELOPMENT

Floor area ratio (FAR) is the measurement of a building's floor area in relation to the size of the lot/parcel that the building is located on. FAR is expressed as a decimal number, and is derived by dividing the total area of the building by the total area of the parcel (building area ÷ lot area). LilisWidaningsih, January (2018)

The rationale behind the use of high rise building include but not limited to advancement in technology, economical and infrastructural development. It also makes room for effective use of available land mass and to avoid sprawling of building forms that occupy greater land space use.

SAFETY OF HIGH-RISE BUILDINGS

The safety of tall buildings is the most important problem in construction. All of the design codes and safety criteria should be practiced in construction.

The unanticipated collapse of the World Trade Center towers has motivated to re-examine the way exit systems are designed for high-rise buildings. The current design designates s specific number, breadth and spacing of stairways that relied on the supposed occupant weight and building usage.

The exit system on each story is sized for the number of occupants of that story, indicating the presumption that high-rise buildings will be vacated through partial or phased evacuation procedures.

While discussing the demand for designing the simultaneous evacuation of tall buildings, concerns were raised about the sufficiency of depending just on stairways to vacate huge numbers of people from a great height. It is anticipated that if the design of future buildings is required for simultaneous evacuation under existing exit design procedures, there would be a building height beyond which stairways will occupy a significant portion of floor area that such buildings

Would be unpractical. Therefore, to achieve a safe tall structure, we should be careful about all problems in order to find out a perfect structure for design, construction, appearance, and architecture and to use it for constructing tall buildings in the future.

RESEARCH METHODOLOGY

A case study method was carried out on building forms as applied in existing high-rise buildings. Such building as the Nigerian Content Development and Monitoring Board (NCDMB) Tower in Yenagoa and A 3 Star Hotel under construction in Yenagoa.

CASE STUDY ONE: NIGERIAN CONTENT TOWER – YENAGOA

Fig. 5. SETTING OUT OF SITE - AERIAL VIEW & SITE LAYOUT (

Fig. 6. CONSTRUCTION IN PROGRESS – AERIAL VIEW OF SITE

Fig. 7. TOWER STRUCTURE UNDER CONSTRUCTION 2 (MEGASTARNG.COM)

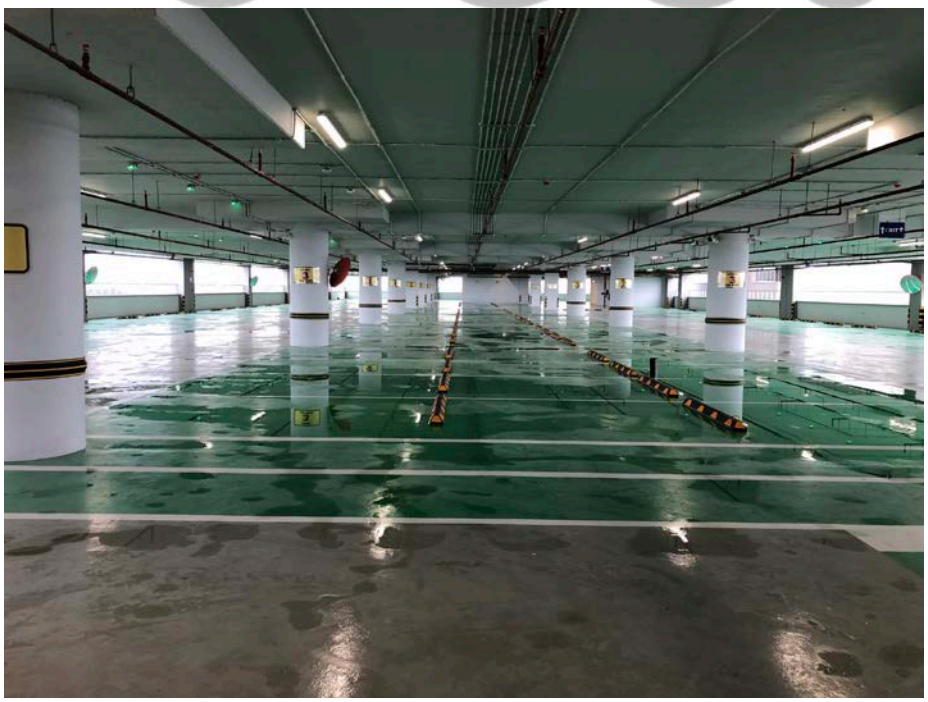

Fig. 8. COMPLETED CAR PARK – LEVEL 3 INTERNAL

CASE STUDY TWO: 3 STAR HOTEL YENAGOA

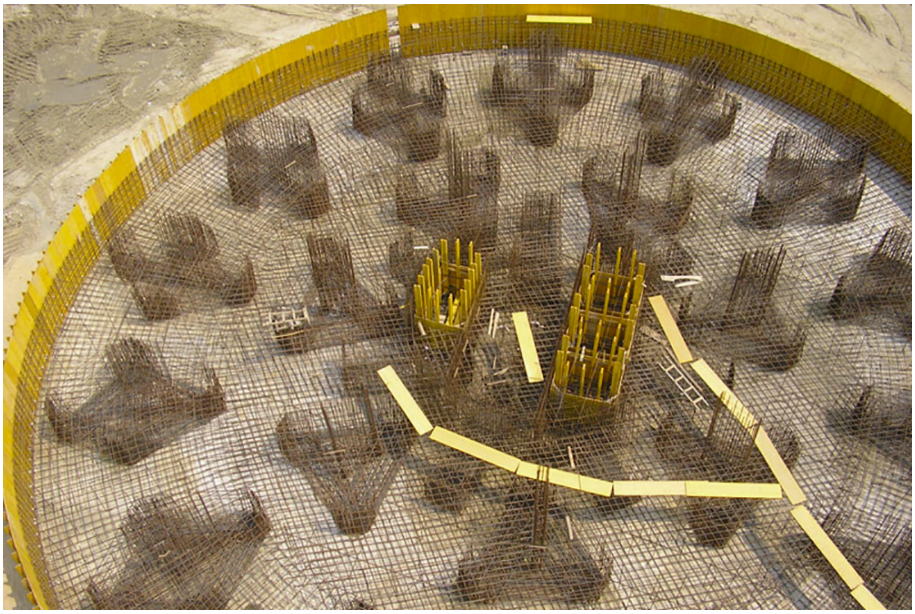

Fig. 9THREE STAR HOTEL PILE FOUNDATION FOOTING – YENAGOA

Fig. 10. THREE STAR HOTEL UNDER CONSTRUCTION – YENAGO

Fig. 11. THREE STAR HOTEL AERIAL VIEW

Fig. 12. MODEL OF 3 STAR HOTEL– 18 STOREY

SUB-STRUCTURE

PILE FOUNDATION

PILE foundation is basically the most viable foundation type to be used. Pile foundations are deep foundations. They are formed by long, slender, columnar elements typically made from steel or reinforced concrete, or sometimes timber.

A foundation is described as ‘piled’ when its depth is more than three times its breadth. (Atkinson, 2007)

These conditions apply to the use of Pile Foundation within the Deltaic Region of Nigeria. The groundwater table is high foundation pilings are the best solution. When soil excavation is not possible up to the desired depth due to low soil bearing capacity.

1. Heavy and un-uniform loads from superstructure imposed in the soil.
2. The soil shallow soil depth is compressible.
3. The possibility of erosion, due to its location near the river bed or seashore.
4. It is impossible to keep the foundation trenches dry by pumping or by any other measure due to heavy inflow of ground water seepage.
5. Also, situations exist when both vertical and horizontal load are expected to act on structures. For example, in case of retaining walls, bridge piers and abutments and machinery foundation.

SUPER STRUCTURE SYSTEMS

BRACED FRAME STRUCTURAL SYSTEM:

Braced frames are cantilevered vertical trusses resisting laterals loads primarily diagonal members that together with the girders, form the “web” of the vertical truss, with the columns acting as the “chords’’. Bracing members eliminate bending in beams and columns.It is used in steel construction. This system is suitable for multistory building in the low to mid height range.Efficient and economical for enhancing the lateral stiffness and resistance of rigid frame system. This system permits the use of slender members in a building.An outstanding advantage of braced frame is that, it can be repetitive up the height of the building with obvious economy in design and fabrication.However, it might obstruct internal planning and the location of doors and windows. That is why it shall be incorporated internally along with lines of walls and partitions.

RIGID FRAME SYSTEM

In rigid frame structure, beams and columns are constructed monolithically to withstand moments imposed due to loads.The lateral stiffness of a rigid frame depends on the bending stiffness of the columns, girders and connections in-plane

it is suitable for reinforced concrete buildings.It may be used in steel construction as well, but the connections will be costly.One of the advantages of rigid frames is

the likelihood of planning and fitting of windows due to open rectangular arrangement.

Members of rigid frame system withstand bending moment, shear force, and axial loads.20 to 25 storey buildings can be constructed using rigid frame system.

Advantages of rigid frame include ease of construction, labors can learn construction skills easily, construct rapidly, and can be designed economically.

Maximum beam span is 12.2m and larger span beams would suffer lateral deflection. A disadvantage is that the self-weight is resisted by the action from rigid frames.Finally, Burj Al Khalifa which is the tallest structure in the world is constructed using rigid frame system.

WALL – FRAME SYSTEM (DUAL SYSTEM)

It consists of wall and frame that interact horizontally to provide stronger and stiffer system.The walls are usually solid (not perforated by openings) and they can be found around the stairwells, elevator shafts, and/or at the perimeter of the building.The walls may have a positive effect on the performance of the frames such as by preventing a soft storey collapse.Wall-frame system suitable for buildings with storey number ranges from 40-60 storey which is greater than that of shear or rigid frame separately.Braced frames and steel rigid frames provide similar advantages of horizontal interaction.

SHEAR WALL SYSTEM

It is a continuous vertical wall constructed from reinforced concrete or masonry wall.Shear walls withstand both gravity and lateral loads, and it acts as narrow deep cantilever beam. Commonly, constructed as a core of buildings. It is highly suitable for bracing tall buildings either reinforced concrete or steel structure. This because shear walls have substantial in plane stiffness and strength.Shear wall system is appropriate for hotel and residential buildings where the floor-by floor repetitive planning allows the walls to be vertically continuous.It may serve as excellent acoustic and fire insulators between rooms and apartments.Shear wall structural system can be economical up to 35 stories building structure.Shear walls need not to be symmetrical in plan, but symmetry is preferred in order to avoid torsional effects.

OUTRIGGER SYSTEM

Outrigger are rigid horizontal structures designed to improve building overturning stiffness and strength by connecting the core or spine to closely spaced outer columns. The central core contains shear walls or braced frames. Outrigger systems functions by tying together two structural systems (core system and a perimeter system), and render the building to behave nearly as composite cantilever. The outriggers are in form of walls in reinforced concrete building and trusses in steel structures.Multilevel outrigger systems can provide up to five times

the moment resistance of a single outrigger system.Practically, Outrigger systems used for buildings up to 70 stories. Nonetheless, it can be used for higher buildings.Not only does the outrigger system decline building deformations resulting from the overturning moments but also greater efficiency is achieved in resisting forces.

FLAT SLAB (PLATE) STRUCTURAL SYSTEM

This system consists of slabs (flat or plate) connected to columns (without the use of beams).flat plate is a two-way reinforced concrete framing system utilizing a slab of uniform thickness, the simplest of structural shapes.The flat slab is a two-way reinforced structural system that includes either drop panels or column capitals at columns to resist heavier loads and thus permit longer spans.Lateral resistance depends on the flexural stiffness of the components and their connections, with the slab corresponding to the girder of the rigid frame.Suitable for building up to 25 stories.

TUBE STRUCTURAL SYSTEM

This system consists of exterior columns and beams that create rigid frame, and interior part of the system which is simple frame designed to support gravity loads.

The building behaves like equivalent hollow tube.It is substantially economic and need half of material required for the construction of ordinary framed buildings.

COUPLED WALL SYSTEM

This system composed of two or more interconnected shear walls. Shear walls connected at the floor levels by beam or stiff slabs.Stiffness of the whole system is far greater than that of its components.The effect of the shear-resistant connecting members is to cause the sets of walls to behave in their partly as a composite cantilever, bending about the common centroidalaxis of the walls. The system is suitable for buildings up to 40 storey height.Since planer shear walls support loads in their plane only, walls in two orthogonal directions need to withstand lateral loads in two directions.

HYBRID STRUCTURAL SYSTEM

It is the combination of two or more of basic structural forms either by direct combination or by adopting different forms in different parts of the structure.

Its lack of torsional stiffness requires that additional measures be taken, which resulted in one bay vertical exterior bracing and a number of levels of perimeter vierendeel “bandages”

FIRE SAFETY IN HIGH-RISE BUILDINGS

But high-rise buildings tend to present a lower risk of fire and associated losses than lower-rise building, according to a report by the National Fire Protection Association (NFPA).The use of fire prevention systems including wet pipe sprinklers in tall buildings as well as emergency escape passages must be in place for effective control of fire out break and safety of occupants.

VERTICAL CIRCULATION

Vertical circulation refers to moving up and down a building, accessing the various floors and levels it has. The circulation path should be clear, unobstructed, and accessible to all. The vertical circulation system can be choreographed to give the users a unique experience. The 5 major types of vertical circulation are; Ramps, Stairs, Escalators, Elevators and Ladders.

CONCLUSION

The construction of high-rise buildings can stimulate economic growth through job creation, attracting investment, and increasing property values in surrounding areas. Urban transport is another dimension influenced by these remarkable structures: high-rises are often strategically located near public transportation hubs, reducing commuting time and promoting city walkability.While critics may argue against their aesthetic or environmental impacts, it is undeniable that high-rise buildings are essential catalysts for urban development, providing efficient

solutions for growing populations while unlocking economic potential in thriving cities worldwide.

While challenges like structural stability, access to natural light, and social cohesion need to be addressed in these vertical communities, it is undeniable that vertical cities hold great promise as a viable option for our urban future. The future of high-rise building concepts will undoubtedly prioritize sustainable practices ensuring functionality, safety, environmental responsibility, and improved quality of life for occupants.

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