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Best Practice Building Integration Methods along Slopes (15% To 65% Gradient) N Okigwe Zone, Southeastern Nigeria

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ABSTRACT

To create integral buildings along slopes require that the land form and topography of the slope be incorporated into the architectural designs and construction plans from the outset. The relevance of the study was informed by the need to bring man closer to natural environment visibly manifest in the form of slopes. The study, through data collection, analyses, and concept development determined five architectural floor methods of building integration along slopes. Different building integration methods fit into slopes of different gradients and angles which are classified by percentage characteristics as: Split level (4 – 6% slope); Build up above the slope (6 – 10% slope); Build into the slope (10 – 16% slope); Cut and fill (16 – 25% slope); and Multi-level (25% slope and above). For ease of analysis, the architectural floor methods of integration were catalogued into A, B, C and D systematic order for appropriate results presentation relative to slope factors.

Keywords: *Building integration, Concept, Slopes gradient, Slope angle, Slopes profile, Architectural floor method.*

INTRODUCTION

The research on best practice building integration methods along slopes took into account, factors which impact the surfaces of slopes; and which can likely lead to building failure, to proffer architectural solution through design concept and building components development for the creation of adaptable buildings that are well integrated along slopes. Rahn (2020); Emma and Gary (2019) stated that, it is most important to consider not only what can safely be done with a given piece of land, but the optimum use to which the land can be put. New buildings on slopes should involve special foundations that are in accordance to the most appropriate architectural floor method of integration along slopes of different slope angles. In simple terms, the architectural design has to make sure that the whole building will not slide down the slope. One advantage of slopes is that they invariably come with an interesting view, but to achieve this view, the foundation type and floor method of integration into the slope site, has to be properly considered architecturally from the perspective of the slopes gradient and angles (Armor and Snell, 2019; Fadamiro and Ogunsemi, 2020; Green sheet, 2019). The topography of Okigwe Zone is hilly and undulating compared to the rest of Imo State with relatively flat and low-lying relief. Few hilltops around Okigwe Zone reach 300m, while the average height of the crest lies between 120 and 180m above sea level. Steep slopes and gully erosion are principally found in the vicinity of Umuduru, Okigwe town, and Etiti axes.

Before the plans of any building can be drafted, the design of the building components and their relationship to one another and to the environment must be determined. It is against this background that this research determined the different architectural floor methods of buildings integration according to slope angle or percentage of slope, using the Okigwe Zone contour map profiles. Different building integration methods go well for different slope angles. Consequently, according to Ahmadu (2020), it is critical that buildings be conceived and designed with the utmost care and sensitivity peculiar to the site so it indeed fulfills its vital role in the overall environment.

The Importance of the Study

The successful integration of any building along a slope should be borne out of a clear-cut slope site inventory and inventory analysis resulting from the exercise of several professionals who are coordinated by the Architect, and they include: the Surveyor – who makes graphical representation of the site (including contours) and its area features on paper; the civil and geological engineers – who uses the information from the slope soil test investigation and the architectural drawings to design appropriate foundation and structure for the building.

Bergsma (2018) in his analysis of the influence of relief on erosion outlined seven classes of slopes that are related to those of soil survey.

- Nearly level	0 – 2%
-Gently undulating	2 – 4%
-Steeply undulating	4 – 6%
-Gently rolling	6 – 10%
-Steeply rolling	10 – 16%
-Hilly	16 – 25%
-Steep	25% - ?

Whereas Brady and Weil (2019) advised that possible failure should be investigated particularly on a site with more than 15 percent slope (15 meters of rise over 100 meters of horizontal distance); on a site with much steeper slopes above or below it; or in any area where erosion is a recognized problem. Slope is typically expressed as percentage, an angle, or ratio. The average slope of a terrain feature can conveniently be determined from contour lines on a topographic map (Philip et al., 2018; Paul, 2018; Singh, 2020).

It is noteworthy that any careless development on slopes vulnerable to increase in environmental risks would equally give birth to unfavourable environmental consequences. The study of best practice building integration methods along slopes in the built environment is important to the generality of the environment in that the hazards of building failure are not limited to the soil structure. No sooner a building gives signs of failure on slopes, than the man built environment and landscapes begin to deteriorate. This menace continues to grow in intensity and seriousness for as long as the building is not properly integrated along the slope profile using the most appropriate architectural floor method for the slope angle or gradient.

Nevertheless, the determination in this study is to pursue change in the negative attitude towards building along slopes, by outlining standards for best practice building integration methods along slopes of different gradient (15% to 65% and more). The study is important for the following reasons:

- The need to outline standard for building integration methods along slopes of different slope angles to avoid failure.
- The need to utilize slopes for sustainable housing development amid scarce land commodity.
- The need to develop an environmental friendly approach towards the integration of buildings along slopes for sustainability and strength in erosion prone areas.
- The results of the research provides parameters for requisite architectural design standards for buildings interation along slopes.

Study Objectives

There are five types of building integration methods that can be used successfully along slopes as identified by the study. The type chosen depends upon many factors. If a basement is desired, the foundation forms the basement wall. If a house is to be built over a crawl space, the foundation may be masonry wall or piers.

A curtain wall may become part of a foundation. In areas where soil does not offer sufficient support for usual foundations, pilings must be used to support the foundation wall. Whatever may be the soil condition of the site, it is up to the engineer to come up with a foundation solution that will suit the Architect's concept for floor method of integration.

However, it is a must that the specified foundation design solution must be in agreement with the architectural design floor method of integration. Figure 1 to Figure 4 below, shows the different architectural floor methods of building integration along slopes. The determination of the most suitable building integration method on slopes of different slope angles is a function of how "gently undulating" or "steep" the slope gradient might be. In some instances where the slope is gentle, Architects design to suite the site with split levels. Other times, when the slope gradient is steep, the design principle of "cut and fill" may be administered in the design concept. Steeper slope gradient up to 65% and more can warrant the introduction of basement floors in the design concept. Stepped buildings cut at intervals along hilly slopes, is another integration option, though not advisable in areas with leachate soil like Okigwe Zone. A typical example of "stepped buildings" is found in colliery camp, Enugu State, south-eastern Nigeria.

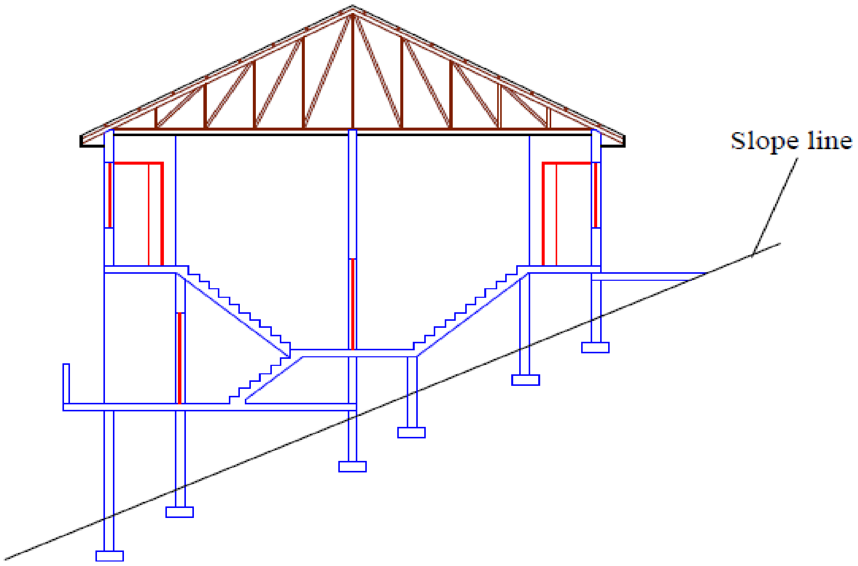

Figure1. *Build up above the Slope*

This method involves suspended floors, some additional costs, and the need for very careful landscaping to conceal the large area of masonry work below floor level. This method will improve view, especially from the balcony.

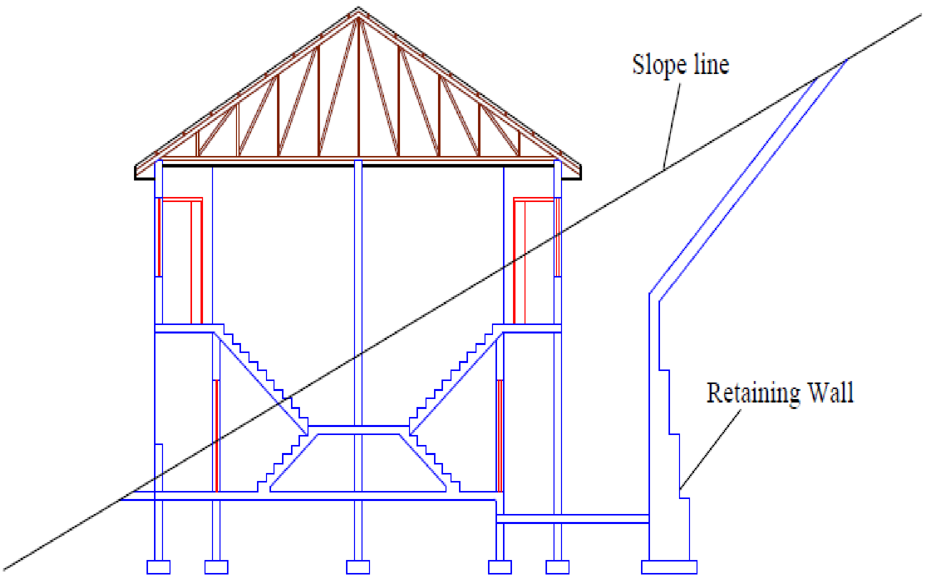

Figure2. *Build into the Slope*

This method permits a cost effective solid floor on natural ground, but may require a retaining wall or steep garden to the rear. Excavated materials can be used for landscaping or be carted away from the slope area.

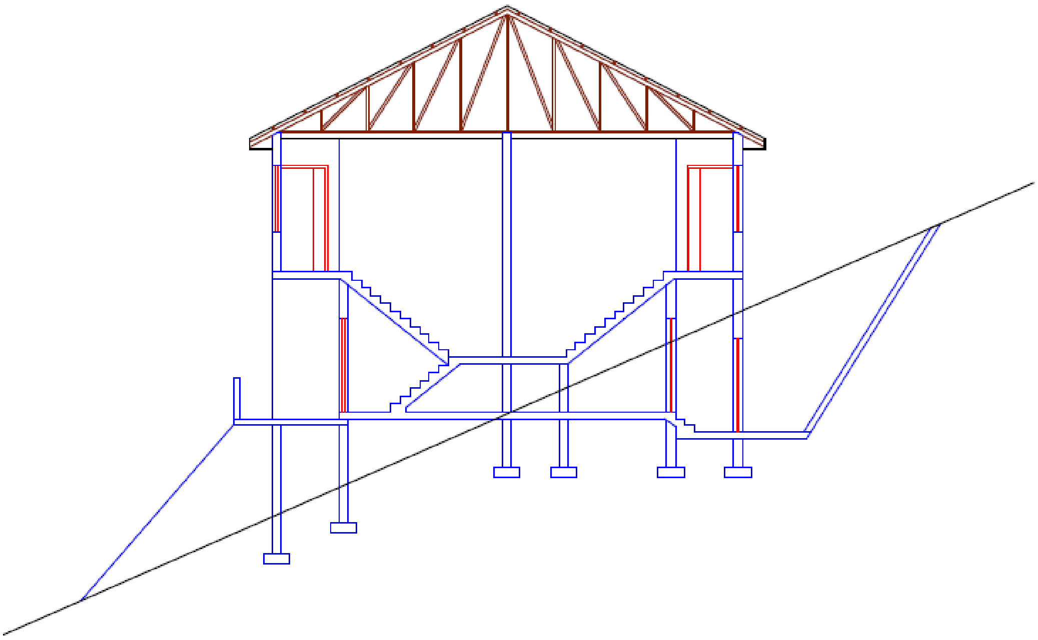

Figure3. *Cut and Fill*

This is the usual approach, combining the minimum foundation costs with the look of being built into the slope. With this method, absolute care is required for landscaping.

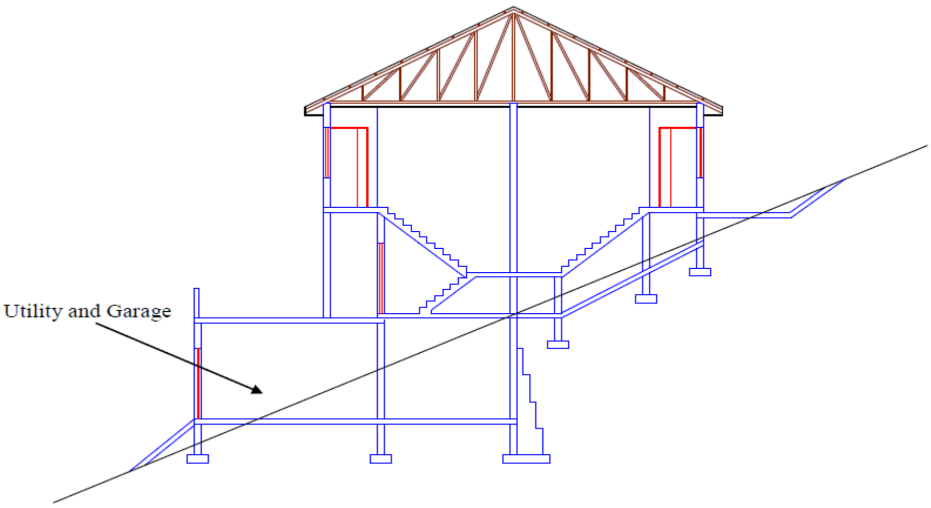

Figure4. *Multi-Level*

This method allows for garage and utility spaces below with living accommodation above, following the slope. This method gives interesting layouts with opportunities for balconies to take advantage of views, but required construction cost is usually high

According to UNEP (2020), sustainable urban development requires considerations of the carrying capacity of the entire ecosystem supporting such development, including prevention and mitigation of adverse environmental impacts occurring outside the development. That is to say, the mode of building integration, considering slope factors, is very vital to the carrying capacity of the slope environment to guard against building failure. For this study to be relevant, buildings must be adapted along slopes, particularly in erosion prone areas, using the architectural floor methods of integration. Against this background, the objectives of the study are:

- To identify factors worth considering at the conceptual stage of any architectural design of buildings to be integrated along slopes.
- To analyze slopes up to 15% to 65% gradient for sustainable housing development, using the best practicable building integration methods.
- To analyze slopes profiles cut across the Okigwe Zone contour map for the adoption of best practicable building integration method along the slopes of different slope angles.

THE STUDY AREA

Okigwe Zone is one of the three Senatorial zones in Imo State. It comprises six Local Government Areas all of which have topographic slopes and undulating terrain. The local government areas are;

- Ehime-Mbano L.G.A, with Headquarters at Ehime
- Ihitte-Uboma L.G.A, with Headquarters at Isinweke
- Isiala-Mbano L.G.A, with Headquarters at Umuelemai
- Obowo L.G.A, with Headquarters at Otoko
- Okigwe L.G.A, with Headquarters at Okigwe
- Onuimo L.G.A, with Headquarters at Okwe

Table1. *Okigwe Zone: Local Governments by Headquarters, Land Areas, Population and Population Density, 2019.*

	NAME OF LGA	HQ.	AREA IN KM^2	POPULATION	POPULATIONDENSITY/KM^2
1	Ehime Mbano	Ehime	139.70	145,660	1,042
2.	Ihitte Uboma	Isinweke	104.50	125,540	1,201
3	Isiala Mbano	Umuelemai	203.30	222,543	1,094
4.	Obowo	Otoko	97.80	186,723	1,909
5	Okigwe	Okigwe	337.60	179,650	532
6.			69.40	199,475	2,874
	TOTAL		**952.3**	**1,059,591**	

Source: *Imo State Ministry of Lands, Survey and Urban Development, 2020*.

Figure 5 shows map of the study area location in Nigeria, Imo State, and Okigwe Zone.

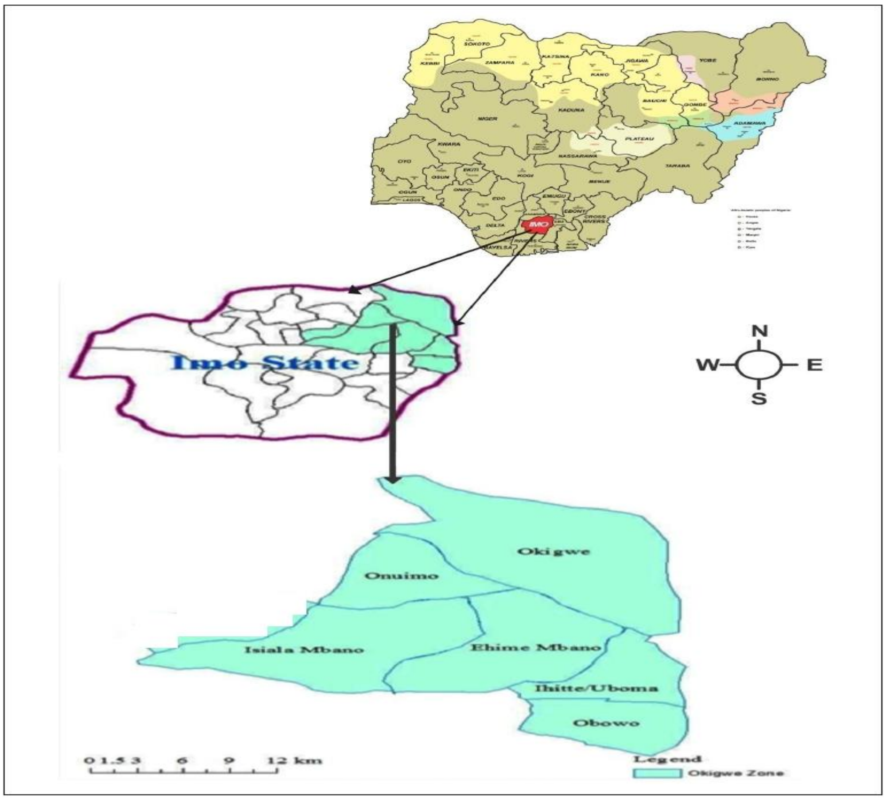

Figure5. *Map of Nigeria, Imo State, and Okigwe Zone showing Study Area*

Okigwe Zone is the study area. It lies between latitude 5o 30' – 5o 57' N and longitude 7o 04' – 7o 26' E covering a land area of about 952.3 sq.km. Okigwe as a zone is strategically located in the heart of the Eastern Region of Nigeria; bounded on the East by Abia State, on the West by Orlu Zone, and on the North by Enugu State, while Owerri Zone lies to the South (see Fig. 5). The Okigwe Zone total population density as at 2019 stood at 1,059,591 (Imo State Statistical Year book, 2020). The inhabitants of Okigwe Zone are Igbos, a culturally homogenous group. The Igbo language is spoken throughout the Zone with minor differences in dialects. The official language of the Zone, however, is English. Okigwe Zone has a very rich cultural heritage with abundant agro and mineral based raw material resources. The occupations of the people are mainly farming, pottery, and carving. (Imo State Ministry of Information,2020).

Related Literature

The site surrounding a building is a most important environment. It serves numerous utilitarian, aesthetic and psychological functions for the users as well as for visitors, neighbours, and passersby. As a setting for the building, the site is the context or surroundings within which one views the architecture of the building concept. Slope architecture simply means concept, design and integration of buildings along slopes. Best practice building integration methods along slopes are borne out of the Architect's concept, which is in turn, influenced by environmental microclimate, building type, and slope factors (Bolt et al. 2018; Berner and Berner, 2017; Helweg, 2019; David, 2019).

Consequently, it is critical that the architectural floor method of integration be conceived and designed with utmost care and sensitivity peculiar to the site so it indeed fulfills its vital role in the overall environment. A proper review of the impact of architectural concept on a slope, establishes the fact that all architectural scheme is an infringement on the natural environment. However, whether an architectural scheme involve a single building or a group of buildings, in the form of master plan, its influence on the environment cannot be undermined and so must be well conceived at the design stage for proper integration relative to the site (Levenson, 2017; Legget, 2019).

Topography relates to the configuration of the land surface and is described in terms of differences in elevation, slope and landscape position – in other words, the lay of the land (Moffat and Schiler 2018; Onyemelukwe, 2020; Tim, 2019). Topography can hasten or delay the work of climatic forces. Steep slopes generally encourage erosion of surface layers and allow less rainfall to enter the soil before running off, thus preventing soil formation from getting far ahead of soil destruction (Brady and Weil, 2019; Christiana and Tom, 2020)The identification of existing drainage locations, size and type in use, in addition to the local authorities stipulation for construction of private ones in the area of proposed building, is of utmost importance in the design and integration of buildings along slopes (Lawal, 2020; Onyemelukwe, 2020)

Data Analysis Technique

Data collection about the research was carried out through tests and analysis of results obtained by (1) Reconnaissance survey (2) Primary data collection, including; (i) Sample contour survey (ii) Soil test investigation and laboratory analysis (iii) Determination and analysis of Okigwe Zone Soil Properties (3) Secondary data collection, including; (i) Okigwe Zone Contour Map Profiling. (ii) Weather Conditions in Okigwe Zone (iii) Rainfall data and erosion information in Okigwe Zone.

Reconnaissance Survey

The reconnaissance survey identified all the peculiarities of slopes with their attendant environmental influences on buildings in Okigwe Zone, and tried to determine how they should influence architectural design concepts for practicable buildings integration along slopes. The reconnaissance survey involved a preliminary examination of the topographic angle of elevation and gradients of the Okigwe Zone slopes; types of vegetative covering; existing buildings and floor methods of integration; and possible erosion impacts on the slopes. This was done in order to get acquainted with the Okigwe Zone slopes features and acquire insight into the task required for best practice building integration pattern in the Zone, and make recommendations.

Primary Data Collection

The primary data collection constitutes the field survey of the study area and the direct field measurements of all the surveyed data within the study area. The measurements undertaken focused on research methodology that addressed the problems and study objectives of the research. The methodology includes:

- Contour survey of a sample slope location in Okigwe Zone.
- Soil test investigation and laboratory analysis
- Determination of Okigwe Zone Soil Properties

Contour Survey of a Sample Slope Location in Okigwe Zone

Contour surveys are for the purposes of preparing area or site plans to show location of natural and artificial features, and elevation of points on the ground. Leveling on the other hand is the process by which the elevations of spaced contours in an area are determined. The information gathered from the final outcome of the contour survey plan in Figure 6, was used to plot the site slope profile as shown in Figure 7 below. A profile line cut across the contour plan between the highest contour reading and the lowest contour reading was used to determine the elevation of points along the slope.

From these readings, a plot was made of Elevation vs Distance (often called a profile or section) to determine the gradient, slope angle, and percentage of slope of the site; as well as carry out sequential analysis of the site expectations relative to the slope profile orientation.

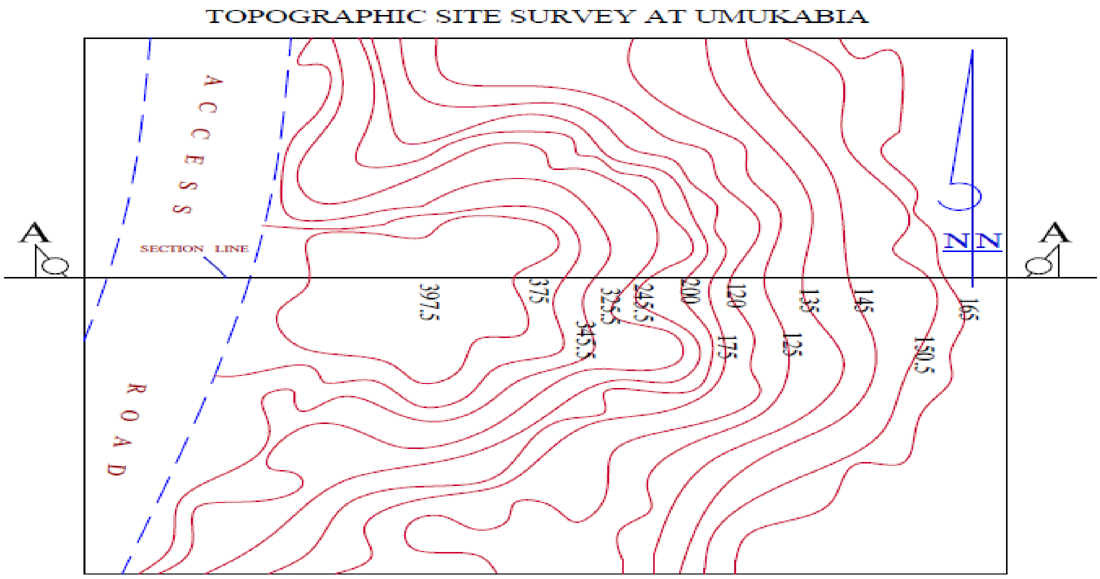

Figure6. *Tropographic site contour survey at umukabai (scale1:500)*

Soil Test Investigation and Laboratory Analysis

Field Work

An important consideration in contemporary architectural and engineering design practices is the nature of the soil deposit over which a proposed building will be placed. To obtain this critical building integration input(s), the research, in fulfillment of its purpose, conducted an extensive survey of soil deposits across the six Local Government Areas in Okigwe Zone, Imo State, Nigeria.

The aim was to obtain relevant soil parameters for effective, efficient and optimal foundation design of proposed buildings by the Civil Engineers who are coordinated by the Architects. The scope of investigation involved the drilling of 30 Nos boreholes to a depth of 3.0m across the six Local Government Areas in Okigwe Zone, Imo State. A total of 5 Nos borehole points were drilled in the randomly selected towns in each of the six Local Government Areas. The borehole points were sunk at specified random positions in the respective towns using the auger boring. The augured boreholes were executed with the hand auger in May, 2020.

Soil Stratigraphy

Information on the soil stratigraphy of the Okigwe Zone was obtained from field observations, soil borings, and laboratory tests. Essentially, one soil type was encountered at the sites; a continuous layer of sandy clay up to the termination of the boreholes at 3m. The stratum of the soil encountered across the respective Local Government Areas is as captured in the boring logs.

Laboratory Testing

Soil samples collected from the boreholes were tested in the laboratory for the measurement of their classification properties such as; moisture contents, coefficient of permeability and infiltration. All tests were carried out in accordance with B.S. 1377 (1995) – Methods of Soil Tests for Civil Engineering Purposes.

Determination of Okigwe Zone Soil Properties

The geotechnical/engineering attributes of the Okigwe Zone soils were determined from the laboratory works. The information gathered indicates that the soil deposits exhibits properties intermediate between clayey sand and sandy clay, possessing both cohesion and angle of internal friction. They are generally of low plasticity and compressibility but with a significantly high bearing capacity. However, some part of the deposit at Etiti, from classification test results, shows significantly higher clay content and plasticity.

Secondary Data Collection

Secondary data collection may be defined as the historical past and present information obtained from various publications to supplement the primary data originated from field survey in order to arrive at a definitive decision which can stand the test of time (Crane, 2017). The secondary data used are:

- Okigwe Zone Contour Map Profiling.
- Weather Conditions in Okigwe Zone
- Rainfall data and Erosion Information in Okigwe Zone

Results And Discussion

Results of Reconnaissance Survey

Results gathered with respect to Okigwe Zone reconnaissance survey were determined at the instance of the research firsthand inventory and inventory analysis of findings. The results are as follows:

Site Location

The surrounding land uses of Okigwe Zone are mainly rural, agrarian, and residential. The Okigwe Zone neigbourhood character is mainly residential with dispersed settlement by communities and hamlets arrangement, having concentration of buildings only at the local government headquarters and other small towns.

Topography

The topography of Okigwe Zone is hilly and undulating compared to the rest of Imo State with relatively flat and low-lying relief. Few hilltops around Okigwe Zone reach 300m, while the average height of the crest lies between 120 and 180m above sea level. Steep slopes and gully erosion are principally found in the vicinity of Umuduru, Okigwe town, and Etiti. Potential areas of erosion and poor drainage are areas with lots of human development activities without consideration for runoff control.

Drainage

The natural surface drainage of Okigwe Zone is gravitational and flows according to the gradient and angle of the slope area or profile. After rainfall, the flood effects record high detachment of soil particles especially in areas with several pedestrian track roads without greenery or hardcover surface

Climate

The natural phenomenon of sunrise and sunset also prevails in Okigwe Zone in the morning and afternoon periods of each day. The vertical angle of the sun above the horizon in Okigwe Zone shifts from east to south; and from south to west; and down to the north where the sun fades each day. The gully areas of Okigwe Zone are mostly shady and cooler in the day, while the steep slope areas are mostly sunny during the day.

Existing Buildings

House type in Okigwe Zone is mainly residential with a mix of traditional and classic / neo-classic architectural style in both design and construction. No conscious effort of landscaping for erosion control after buildings construction. There are indeed some buildings with roof runoff elements like parapet gutters, spouts, and water spigots, but hardly up to 7% of buildings with duct service systems. Building integration pattern in Okigwe Zone is mainly “Build into” the slope. There is no conscious recognition or use of the other erosion mitigating architectural floor methods of buildings integration along slopes.

Analysis of Contour Survey of a Sample Slope Location in Okigwe Zone

The data on survey points reading recorded from the survey field work, was used to plot the survey plan from where the site slope profile was cut to determine the site slope gradient, angle (at36o), and the most suitable architectural floor method of building integration, as shown in Figure 7 below. The two-dimensional survey plan was also instrumental to the analysis of the slope site environmental features and influences as recorded in Figure 8 to Figure 11.

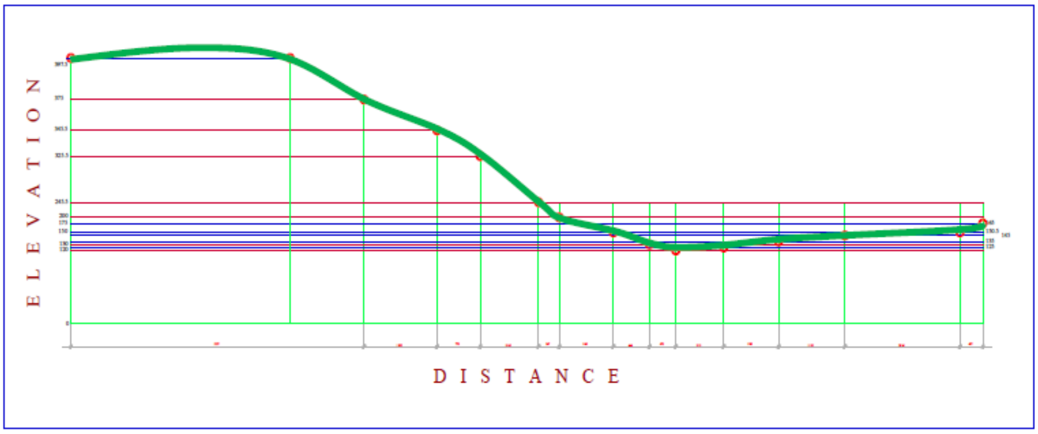

Figure7. *Site Topography profile at umukabia (scale1:500)*

SITE TOPOGRAPHY AND NATURAL DRAINAGE

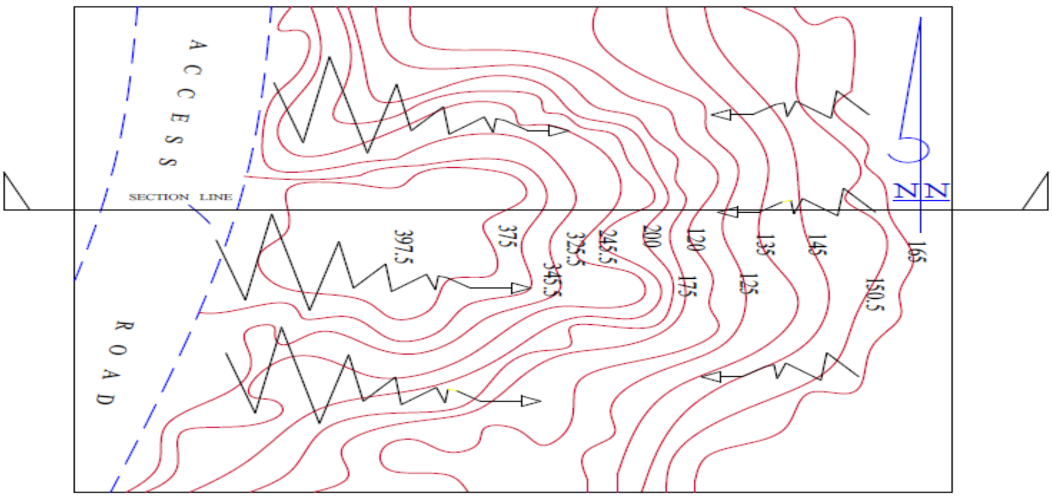

Figure8. *Site Topography and Natural Drainage at umukabia (scale1:500)*

SITE PREVAILING WIND DIRECTIONS

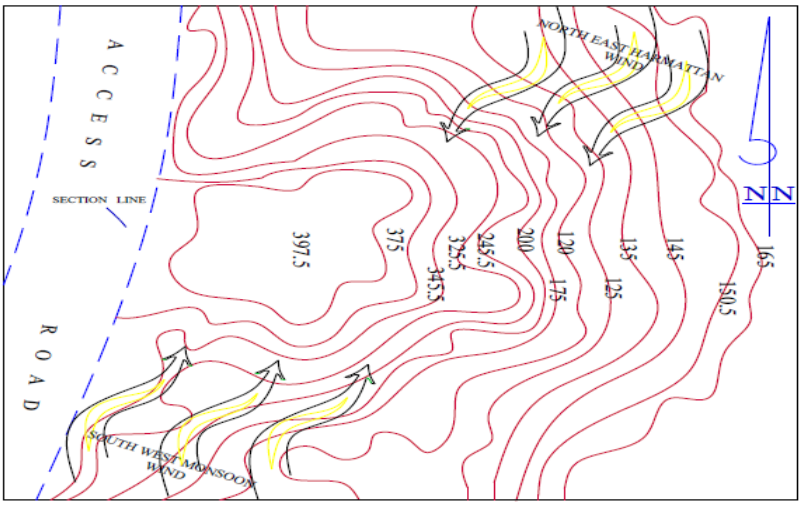

Figure9. *Site Prevailing Wind Directions at umukabia (scale1:500)*

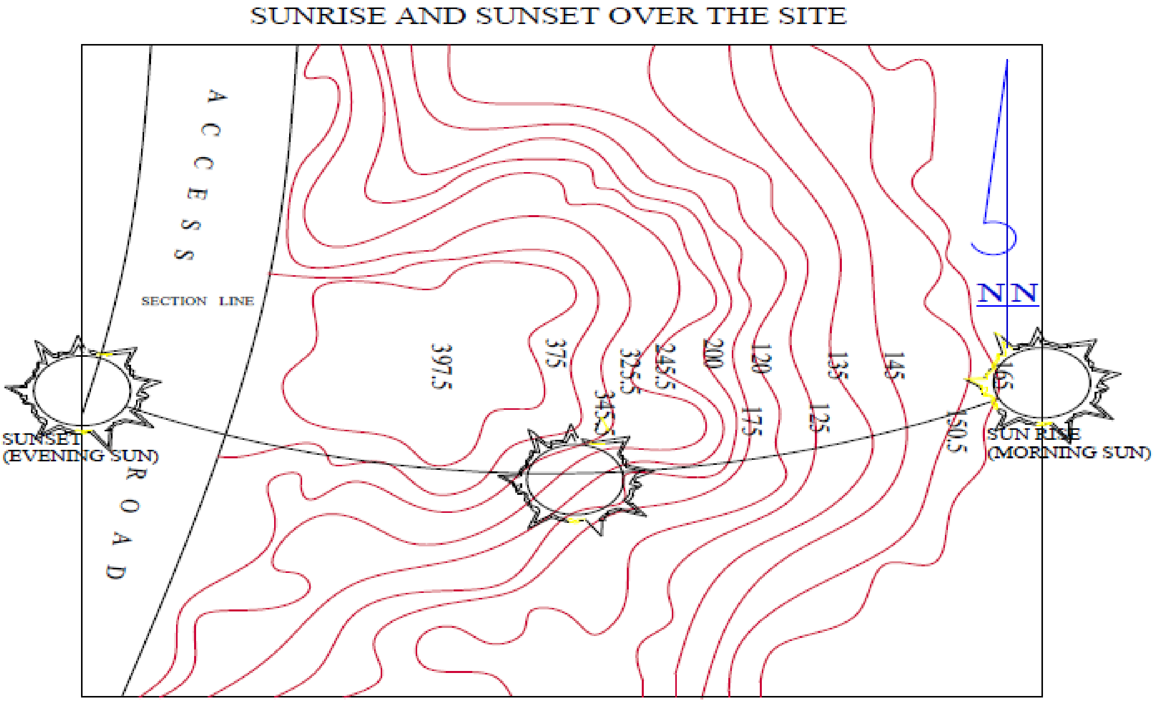

Figure10. *Sunrise and sunset over site at umukabia (scale1:500)*

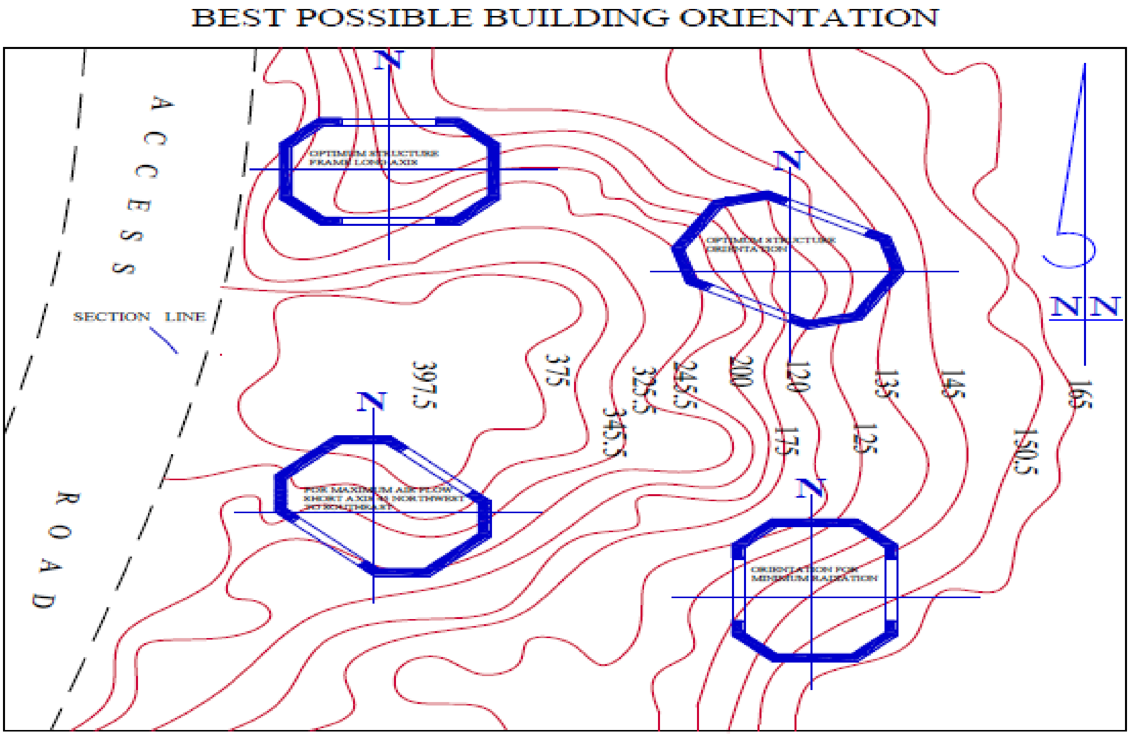

Figure11. *Best possible Building Orientation at the site in umukabia (scale1:500)*

Analysis of Building Integration Methods With Respect To Slope Angle

For ease of analysis of buildings integration along slopes in relation to the five independent variables, that is; slope angle (x1), integration method (x2), microclimate (x3), runoff/erosion control (x4), and landscape design (x5), the four different architectural floor methods of building integration along slopes were catalogued into A, B, C and D systematic order as follows:

Build Up Above the Slope	A
Build into the Slope	B
Cut and Fill	C
Multi-Level	D

Table 2 below shows the analysis of best practice architectural floor methods of building integration for different slope angles according to slope profile in relation to microclimate, runoff/erosion control and landscaping.

Table2. *Relationship between the Dependent Variable (Y) and Independent Variables (x_i), with Particular Reference to Buildings Integration Methods*

Building Development(Y)	Slope Angle (x_1)	Integration Method(x_2)	Microclimate (x_3)	Runoff/Erosion Control (x_4)	Landscape Design (x_5)
Gently Rolling Slope (6 – 10%)	6 – 10%	A or B	By site Orientation	Parapet/Duct/ Drainage	Evergreen or/and Deciduous Trees
Steeply Rolling Slope (10– 16%)	10 – 16%	B or C	By site Orientation	Parapet/Duct/ Drainage	Evergreen or/and Deciduous Trees
Hilly Slopes (16 – 25%)	16 – 25%	B or D	By site Orientation	Parapet/Duct/ Drainage	Evergreen or/and Deciduous Trees
Steep Slopes (26% to 65%)	26% (and above)	D only	By site Orientation	Parapet/Duct/ Drainage	Evergreen or/and Deciduous Trees

Source: *Deduced from Field Results and Analyses*

The slope gradient and angle as determined by the slope profile, to a large extent influences the Architect's concept in the design and application of the most appropriate floor method of building integration along slopes. The formation of the slope gradient can also result in the combination of two or three architectural floor methods of building integration in new developments. Whatever method adopted should be a function of the Architect's discretion in developing his design concept.

Analysis of the Engineering Properties of the Soils of Okigwe Zone

The soil investigation was carried out with the specification to determine the soil stratigraphy, and geotechnical characteristics of the underlying deposits at Okigwe Zone. It was also required that recommendations be made for suitable foundation type for proposed buildings in the Zone. To this effect, the bearing capacity analysis is restricted to a depth of 1.2m of the sandy clay encountered. Static ultimate bearing pressure has been computed using the formula proposed by Terzaghi for shallow footings:

$$qu = cNcSc + \bar{o}\ Nq\ + 0.5\gamma\ Bf\ N\gamma S\gamma$$

Where,

qu = ultimate bearing capacity

c = cohesion (kN/m2)

q = overburden surcharge at foundation level = γDf

Nc, Nq, Nγ = bearing capacity factor

Sc,Sγ= Shape factors

Safety factor not less than 3 should be applied to the ultimate bearing pressures to obtain the maximum allowable bearing pressure of the soil. The safe bearing pressure is determined from settlement analysis values.

Settlement Analysis

Because of the nature of the deposit at the site, the settlement analyses for the soil samples from the site locations consist of both consolidation and immediate settlements. The analysis is for foundation footing of width 0.8m. The following relationship is adopted for the analysis:

$$ST = Si + Sc$$

$$= [\ qo.B(1-\mu 2)If \div E\ ] + [\ (Cc * Hc/1+eo\ )\log(po+ \Delta p\ /po)\ ]$$

Where,

Sc = consolidation settlement

ST = immediate settlement

Cc = compressibility index

qo = soil-footing contact pressure

B = footing width

µ = Poisson ratio

If = influence factor

E= soil elastic modulus

Hc = height of compressible layer

eo = void ratio

po = pressure at middle of compressible layer before construction of foundation

Δp = pressure increase at middle of compressible layer after foundation construction

Going by the result of the settlement analysis, it is evident that a foundation footing of width 0.7m in Okigwe Zone, will not settle more than the acceptable 25mm if the safe bearing pressure is kept at 70kN/m2. (See Table 3 below).

Foundation width = total load of building per meter/safe bearing capacity of subsoil

= 34KN/m2 ÷ 70kN/m2 = 0.486m

Thus the proposed 0.8m is for foundation footings in accordance to the specified architectural floor method of integration most suitable for the site along the slopes profiles of Okigwe Zone.

Table 3 shows the Consolidation Settlement Values for Foundations in Okigwe Zone.

Table3. *Consolidation Settlement values (all locations)*

Depth,D (m)	Width,B (m)	Safe Bearing Pressure (kN/m^2)	Settlement (mm)
1.0	0.8	80	23
1.0	0.8	70	20

Source: *Deduced from Field Results*

Values indicated in Table 3 above shows that buildings placed on foundation footings with dimensions not exceeding those indicated in the table will not settle excessively if the safe bearing pressures are not exceeded.

Analysis of Okigwe Zone Contour Map Profiling

The analysis of the profiles of slopes in Okigwe Zone was carried out using the Okigwe Zone contour map as shown in Figure 12 below. It has been stated that topographic map profiling is a graphical technique of determining slopes gradients and angles using cross-section lines that are cut across the contour lines with respect to elevations and features to be captured for analyses. Five cross-section profiles were cut across the Okigwe Zone contour map with nomenclature and graphical identification letters as follows: Slope Profile A-A; Slope Profile B-B; Slope Profile C-C; Slope Profile D-D; and Slope Profile E-E. These slopes profiles were instrumental to the determination and analyses of the slopes orientation, gradient, angle and influences on existing buildings with respect to building integration.

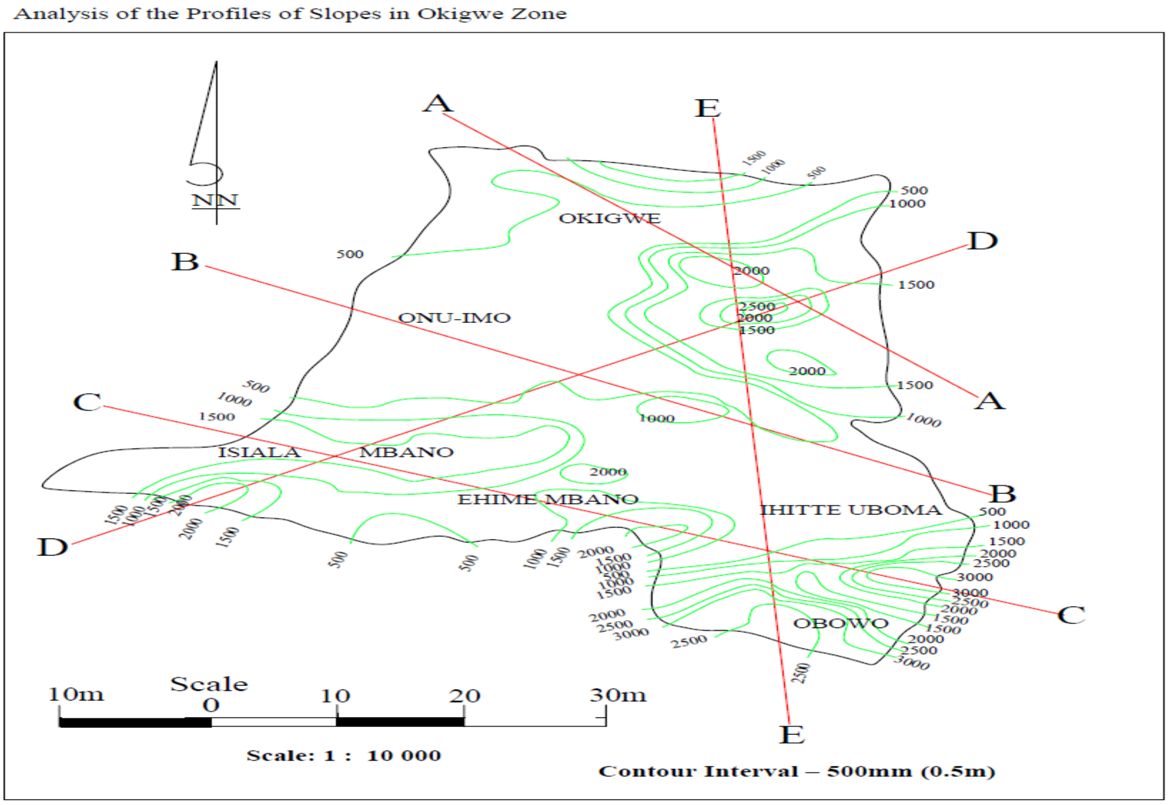

Figure12. *Okigwe Zone Topographic Map Showing Contours and Profile Lines*

Analysis of Slope Profile A-A (Through Okigwe LGA Only)

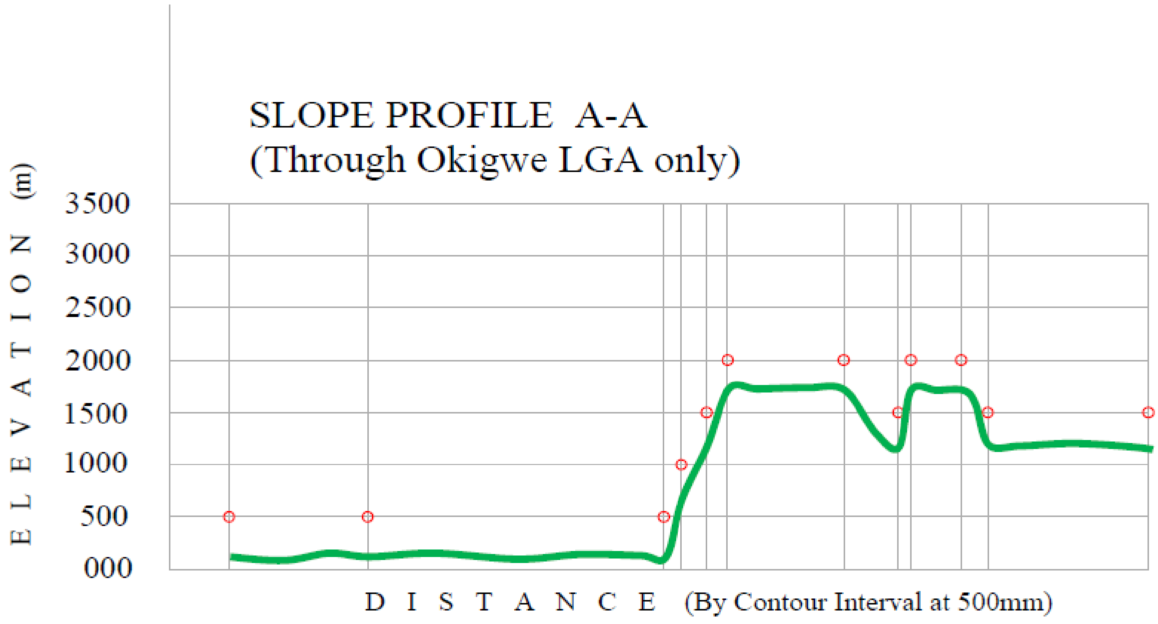

Figure13. *Slope Profile A-A (through Okigwe Local Government Area only)*

Slope profile A-A as shown in Figure 13 cuts across the high and low lying elevation points in Okigwe Local Government Area to capture the gradient and area profile of the slopes as it exists. The topographic angle of elevation of the slope is 69o, whereas the slope profile is oriented at 47o to the east of the North arrow. As shown in the slopes profile, the plain land area is the axes accommodating the Okigwe town, whiles the hill summits covers the area from Okigwe town towards Uturu, where steep slopes and gullies are the area features. There is virtually no development around the steep slope area in the exception of a radio station mast standing on one of the slopes, and some skeletal settlements. This slope profile axes at 69o is too steep and beyond the consideration of this research for best practice building integration along slopes.

Analysis of Slope Profile B-B (Through Onuimo and Ihitte-Uboma LGAs)

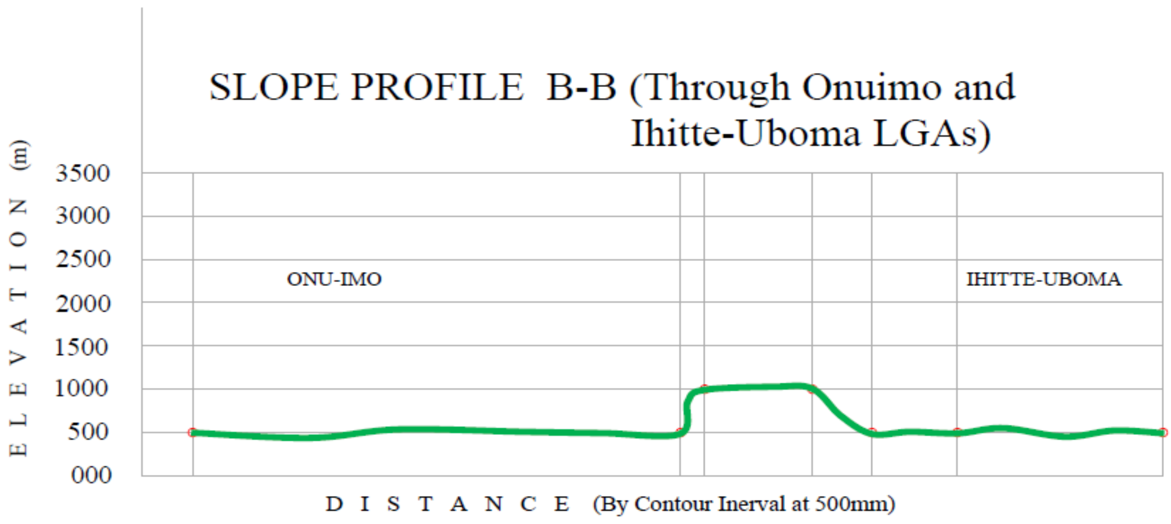

Figure14. *Slope Profile B-B (through Onuimo and Ihitte- Uboma LGAs)*

Slope profile B-B as shown in Figure 14 cuts across the high and low lying elevation points through Onuimo and Ihitte-Uboma Local Government Areas to capture the gradient and profile of the area as it exists. The topographic angle of elevation of the slope is 63o, whereas the slope profile is also oriented at angle 63o to the east of the North arrow. As shown in the slopes profile, the plain land area is the axes accommodating Okwe town, the Headquarters and more developed center in Onuimo Local Government area, while the gentle slope and adjoining plain land area to the east accommodates Etiti in Ihitte-Uboma Local Government area. The slope profile of these axes will permit the use of any of the architectural floor methods of building integration by the Architect's discretional concept.

Analysis of Slope Profile C-C (Through Isiala-Mbano, Ehime-Mbano and Obowo LGAs)

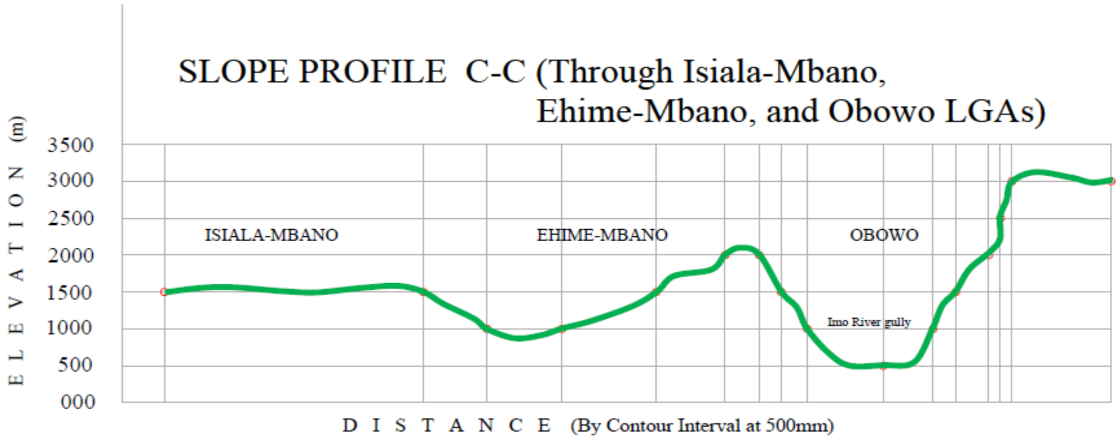

Figure15. *Slope Profile C-C (through Isiala-Mbano, Ehime-Mbano and Obowo LGAs)*

Slope Profile C-C as shown in Figure 15 cuts across the high and low lying elevation points in Isiala-Mbano, Ehime-Mbano, and Obowo Local Government Areas to capture the gradient and area profile of the slopes as it exists. The topographic angle of elevation of the slope after the gentle valley at Ehime-Mbano is 23o, whereas the slope topographic angle of elevation at Obowo, immediately after the gully, is 60o. The slope profile C-C is oriented at angle 69o to the east of the North arrow and at 21o to the east arrow. As shown in the slopes profile, the plain land area is the axes accommodating the Isiala-Mbano local government Headquarters and environs, while the undulating slopes and valleys as represented in the slopes profile, covers the areas from Isiala-Mbano Headquarters towards Ehime, with rigorous upward and downward vehicular movement where slopes and gullies are the area features. These axes slope profile gradient, and angle at 60o, permits the use of the architectural floor methods of building integration along steep slopes – preferably the "build up above the slope" and the "multi-level" floor methods.

Analysis of Slope Profile D-D (Through Isiala-Mbano and Okigwe LGAs)

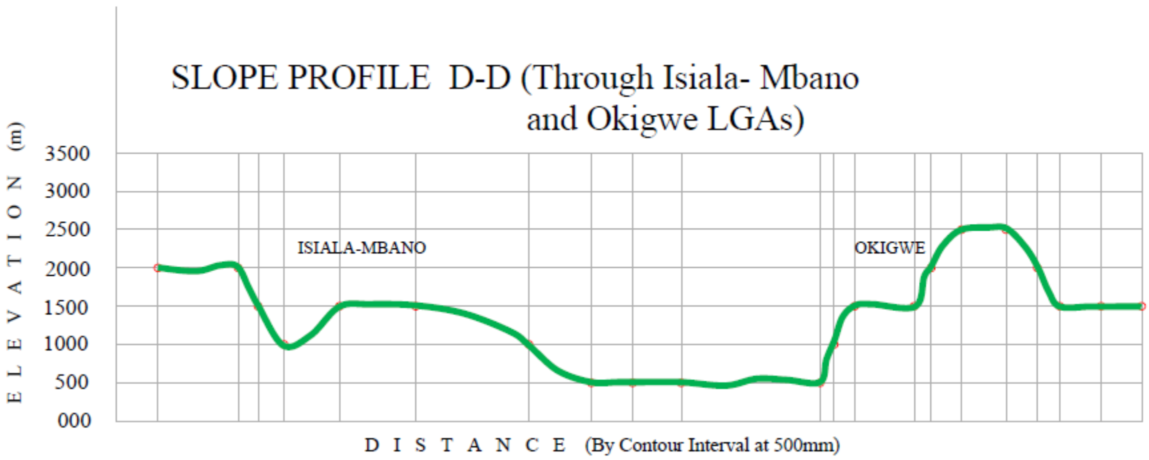

Figure16. *Slope Profile D-D (through Isiala-Mbano, and Okigwe LGAs)*

Slope Profile D-D, as shown in Figure 16, cuts across the high and low lying elevation points in Isiala-Mbano and Okigwe Local Government Areas to capture the gradient and area profile of the slopes as it exists. The topographic angle of elevation of the slopes at Isiala-Mbano ranges between 15o and 56o inclination, whereas the slopes topographic angle of elevation at Okigwe ranges between 96o and 102o inclination. As shown in the slopes profile, the plain land area is the axes accommodating part of Umuna and Arondizuogu communities in Okigwe local government area. The undulating gentle slope area shows the terrain in Umuduru and Umuelemai axes of Isiala-Mbano local government area, while the steep slopes, as represented in the slopes profile D-D, covers the Okigwe main town axes. This slope profile clearly shows the high topographic formation of Okigwe Zone slopes. Throughout the entire Okigwe Zone, Okigwe and Obowo local government areas are the most elevated in terms of topography and slope angle. Any of the architectural floor methods of building integration along slopes would, by the Architect's design concept, fit into the Isiala-Mbano profile axes with 15o to 56o inclination.

Analysis of Slope Profile E-E (Through Obowo, Ihitte-Uboma And Okigwe LGAs)

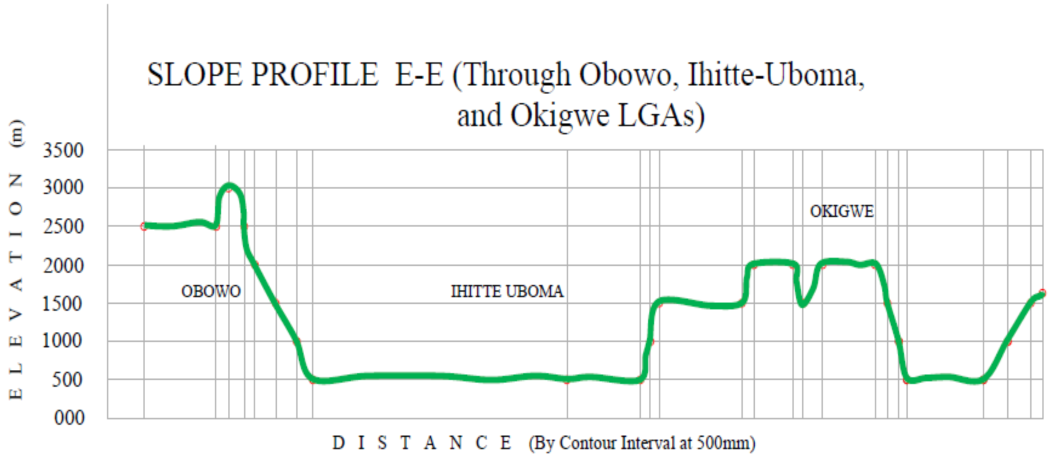

Figure17 *Slope Profile E-E (through Obowo, Ihitte-Uboma and Okigwe LGAs)*

Slope Profile E-E as shown in Figure 17, cuts across the high and low lying elevation points in Obowo, Ihitte-Uboma, and Okigwe Local Government Areas to capture the gradient and area profile of the slopes as it exists. The topographic angle of elevation of the steep slope at Obowo is at 60o inclination, whereas the slopes topographic angle of elevation at Okigwe along this profile ranges between 90o and 50o inclination. As shown in the slopes profile, the plain land area is the axes accommodating Ihitte-Uboma local government area.

The undulating steep slopes at angle 90o and 50o to the right of the profile shows the topography at Okigwe local government area and environs, while the steep slope at angle 60o to the left side of the slopes profile E-E, covers the Obowo local government area axes. This profile axes clearly shows the high topographic formation of Okigwe and Obowo local government areas slopes. The slopes profile at 50o and 60o inclination in Okigwe and Obowo LGAs respectively, are permissible for the use of "build up above the slope" and the "multi-level" floor methods of building integration.

CONCLUSION

The sharply rising rate of population growth in Nigeria calls for concerted effort in every sphere of human enterprise to control and harness the natural and physical resources for the benefit of everyone and the environment at large. Whether or not the available resources can support the growing population, it depends in part on the quality of life, the level of technological development, and other standards that societies wish to develop and maintain. Such other standards include the development of slopes for human habitation and comfort amid scarce land resources. To make slopes indeed tolerable and habitable for buildings development, the architectural design concept for buildings integration, and the different architectural floor methods of building integration along slopes, should be critically analyzed in accordance to the area slopes or survey plan profile angle, gradient formation, and the site prevailing factors, before pen is put on paper for the design of the building. The input of the study in outlining best practice building integration methods along slopes, would serve as a standard to avert all environmental hazards related to erosion, and other slope factors tending to cause building failure, in designing for slopes and in determining how buildings should integrate into the slope environment.

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