

## Architectural Design Considerations for Building along Slopes in Okigwe Zone, South-Eastern Nigeria

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### ABSTRACT

Over the years, property developers have frequently avoided building on slopes for reasons associated with flood, erosion, and lack of established order on how such development should be handled to check building failure. The purpose of the study is to outline control standard for building against erosion prone failures along slopes. The methodology of data collection was through tests and analysis of results obtained by reconnaissance survey, primary and secondary data collections. Ex-post facto design survey was used to compare the results of the architectural model analyses. Bore-hole findings proved material occurring at the depth of 6m across the Zone to be good medium for conventional shallow foundations. Footings of width 0.7m in Okigwe Zone will not settle more than the acceptable 25mm if the safe bearing pressure is kept at 70KN/m. The conclusion identified and recommended five findings for consideration in the design and construction of buildings along slopes.

**Keywords:** architectural design, design concept, slopes, runoff, buildings adaptability, duct system, erosion prone.

### INTRODUCTION

Architectural design, through a concise concept development and lines configuration, can contribute positively to the development of buildings adaptability and integration parameter against erosion prone failures along slopes. It is in practice that the Architect is often referred to as, “*primus inter pares*,” that is, “the first amongst equals” in the building industry because he is the initiator of the project to which other members of the industry are contributors. This premise lends credence to the conviction of this research that buildings adaptability against erosion prone failures on slopes, is as important as adopting slopes for sustainable housing development, and should as a practice, be initiated right from the outset, on the Architect’s drawing board.

Over the last hundred years, according to Teme (2016); Onyebuchi (2017); Platt and Dovel (2017), it has become increasingly possible to incorporate land forms and topography into

architectural designs and construction plans. It is therefore the concern of this research which 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, so as to create adaptable and well integrated buildings along slopes. The purpose of architecture and land-use planning, according to Singh and Singh (2017), is to make the best, most sensible, practical, safe, and efficient use of each parcel of land whether on a plain or slope. This purpose literarily translates to providing housing accommodation for the teeming population of the people and inhabitants of Okigwe Zone in south-eastern Nigeria, for which this research is poised to outline runoff and rain water control standard for buildings development against erosion prone failure along slopes. However, basic susceptibility of building failure on slopes is determined by a combination of factors, including geology (nature and strength of

materials), geometry (slope steepness), soil moisture content, and human activities (removal of topsoil and green cover).

### The Importance of the Study

The devastating effect of the predominant erosion forces in Okigwe Zone calls for a resolute professional input at completely remediating their negative impact on buildings and buildings environment, especially after rainfall along slopes. Even as the world has awakened to the conscious effort of providing habitation by sustainable development effort, for the world growing population by year 2030, slopes should also be considered for development and habitation with well designed architectural concept that meets environmental needs.

The 2030 Agenda for Sustainable Development, according to U.N Habitat (2016), gives a prominent role to urbanization and cities with the inclusion of a stand-alone goal for cities and human settlements. This comes in recognition that cities are a string that connects all other goals together; their density and economies of agglomeration link economy, energy, environment, science, technology and social outputs. These interactions are important to formulate integrated policies that enhance the transformative role of urbanization and contribute to achieve sustainable development. There is one major factor which contributes to erosion in Okigwe Zone, and which building design concepts must consider in the development of slope architecture. This factor is.

### The Climate of Okigwe Zone

The climate of Okigwe Zone is predominantly conditioned by the tropical wind patterns. The adaptability of buildings against erosion prone failure along slopes was important to the study to work out how such factors as microclimate and rainfall can be controlled from architectural design to building construction. The study is therefore important in four different ways:

- It stipulates how rainwater, runoff, and surface erosion on slopes can be controlled
- Using architectural design elements.
- It outlines the types and causes of slope failure and the architectural control measures
- That can be utilized in building along slopes.
- The results of this research provides parameters for requisite architectural design

- Standard for buildings development against erosion prone failures along slopes.
- This research brought to fore the need to utilize slopes for sustainable
- Housing development not prone to erosion engendered failure.

### STUDY OBJECTIVES

Given the factors which influence slope stability, it is possible to see many ways in which human activities increase the risk of slope failure, and how architecture can best tackle them. One way is in the clearing away of stabilizing vegetation. Many types of construction and farming lead to over-steepening of slopes. Slopes cut in unconsolidated materials at angles higher than the angle of repose (the maximum slope angle at which the bearing material is stable) of those materials, are by nature unstable, especially if there is no attempt to plant stabilizing vegetation.

Fubara et al (2018) in their engineering geology analysis emphasized that putting a house above a naturally unstable or artificially steepened slope adds weight to the slope, thereby increasing the shear stress acting on the slope. Miles (2018); WRI et al (2016); Fullerton (2018) posited that other activities connected with the presence of housing developments along slopes can increase the risk of slope failures in more subtle ways.

According to WRI et al (2016), watering the lawn, using a septic tank for sewage disposal at head water regions, and even putting in an in-ground swimming pool from which water can seep slowly out are all activities that increase the moisture content of the soil besides rainwater, and render the slope more susceptible to failure.

Types of slope failure include; creep, falls, slumps and slides, flows and avalanches. The majority of these factors involve water as the chief causative of slope failure and/or building failures on slopes. Water can significantly reduce the strength parameters of soils, especially the friction strength parameter.

Where strength criterion is given as:

$$S=C + \sigma \tan \phi \quad (1)$$

S=shear strength

C=Cohesion strength parameter of soil mass joint surface.

$\sigma$ =applied normal stress on the soil medium

$\phi$ =friction strength parameter of soil joint or soil mass.

The presence of water in soils changes this equation to

$$S=C + (\sigma -\mu) \tan \phi \tag{2}$$

$\mu$ =pore water pressure (Teme, 2016)

Rainfall intensity is considered a force to reckon with in designing buildings to be sited on slopes for two reasons: (1) intense rains have large drop sizes, which results in much greater kinetic energy being available to detach soil particles; and (2) the higher the rate of rainfall, the more runoff that occurs providing means to transport detached particles with a resultant effect of foundation wash off (Sukhtankar, 2018).Runoff water plays the major role in the transportation step of soil erosion.

The soil particles sent spiraling by raindrop impact, usually end in runoff water which eventually carries them down the slope. If slopes are indeed to be successfully developed, then these water related factors have to be taken into account, understood and evaluated fully by the Architect, before pen is put on paper in the preparation of any design.

For this study to be relevant, runoff water must be controlled using building components design and architectural design concept for buildings development on slopes. Against this background, the objectives of this study are:

- To identify factors worth considering at the conceptual stage of any architectural
- Design of buildings to be sited on a slope.
- To analyze sites up to 25% to 65% slope for adaptable building development.
- To ascertain the impact of landscape architecture in runoff and erosion control
- Along slopes.
- To assess the use of roof design, parapets, and duct service systems in checking

Rainwater discharge from buildings on slopes

### THE STUDY AREA

Okigwe Zone is one of the three Senatorial zones in Imo State. It comprises six Local Government Areas with topographic slopes and undulating terrain. The LGAs 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 Umuduru
- Obowo L.G.A, with Headquarters at Otoko
- Okigwe L.G.A, with Headquarters at Okigwe
- Onuimo L.G.A, with Headquarters at Okwe

Table 1 shows the population and population density of the six LGAs in Okigwe Zone.

**Table1.** Okigwe Zone: Local Governments by Headquarters, Land Areas, Population and Population Density, 2006–2016.

	Name Of Lga	Hqtrs.	Area In Km <sup>2</sup>	Population	Population Density / Km <sup>2</sup>
1	Ehime Mbano	Ehime	139.70	130,575	1,064
2.	Ihitte Uboma	Isinweke	104.50	120,744	1,582
3	Isiala Mbano	Umuduru	203.30	198,736	1,642
4.	Obowo	Otoko	97.80	117,432	1,739
5	Okigwe	Okigwe	320.60	132,701	570
6.	Onuimo	Okwe	87.40	99,368	1,340
	TOTAL		953.3	799,556	7,937

**Source:** Imo State Ministry of Lands, Survey and Urban Development, 2017

Figure1 Shows map of the study area location in Nigeria, Imo State, and Okigwe Zone 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 953.3 sq. km Okigwe as a zone is strategically located in the heart of the Eastern Region; 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, as shown in Figure 1. The Okigwe Zone total population, according to

the 2006 population census, stood at 799,556 as shown in Table 1. 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,2015).

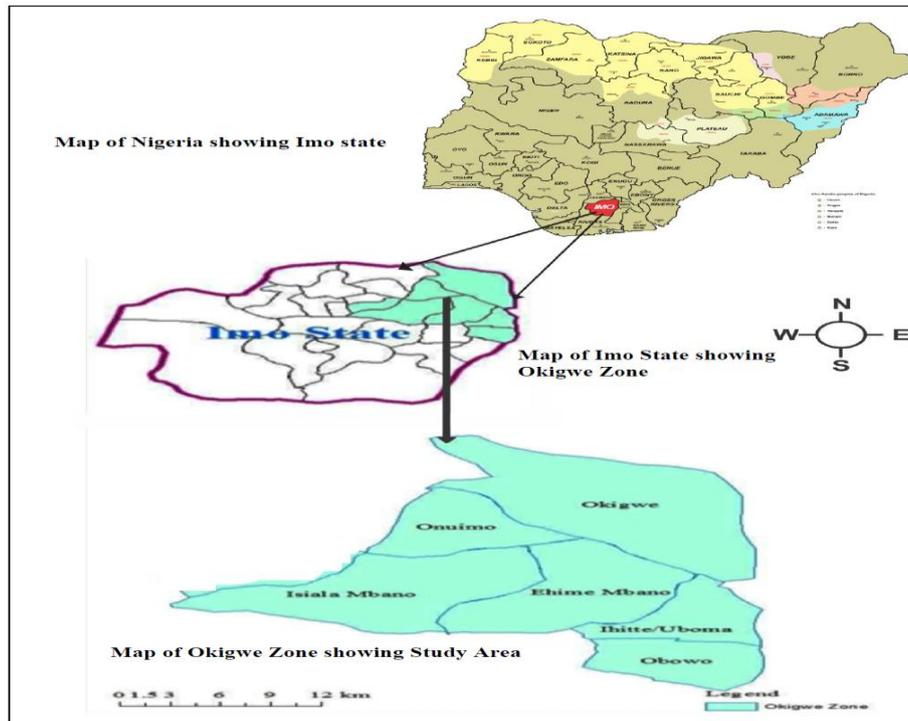


Figure 1. Map of Nigeria, Imo State, and Okigwe Zone showing Study Area

## RELATED LITERATURE

Sambhu (2016); McKay (2017); Aina and Salau (2015) advised that possible slope 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. Immediate settlements however, must be considered in the design of shallow foundations.

But how much settlement depends on the rigidity of the soil skeleton, which is a function of the structure of the soil. Watering the lawn, using a septic tank for sewage disposal at head water regions, and even putting in an in-ground swimming pool from which water can seep slowly out, are all activities that increase the moisture content of the soil, besides rainwater, and render the slope more susceptible to failure (WCED, 2018; Abdulkarim, 2017; Sambhu, 2016; White, 2017). These are all considerations that should determine the architectural and landscape design concept for buildings adaptability against erosion prone failures along slopes. The insight drawn from these authors' specifications is that, it is important to investigate slopes of more than 15 percent for likely failure, but they did not point out what soil parameters should be investigated for appropriate geotechnical engineering conclusions about the slope soil bearing

capacity, consolidation, and settlement analysis. This research however, investigated soil parameters in Okigwe Zone to determine the soil properties as; moisture content (%); coefficient of permeability (m/s); infiltration capacity (If); cohesion (KN/m<sup>2</sup>) etc, to arrive at a conclusion and make recommendations for future engineering foundation design for housing developments.

In the slope areas of Okigwe Zone, one of the attendant effects of surface erosion is foundation wash off, and if not checked in any building development and developed areas, is capable of engendering building failure when the foundation begins to be affected. Lal (2016); Sagada (2015); WCED (2018); Murthy (2017) stated that a common problem of most urban and suburban areas is that the prevalence of pavement and rooftops causes more runoff to occur from the landscape in comparison to natural watershed dominated by vegetation.

According to Julius (2016), the consequence is that streams and rivers which drain through developed landscapes typically experience flooding and erosion due to the increased quantity and rate of runoff. This can be very destructive, he added. This research pointed out that the reference – “developed landscape,” was generalized without any particular consideration for “topographic landscape.” 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 (White, 2017; Osuji, 2015; Moffat & Schiler 2014; Odongo, 2016; Houghton and Wood well, 2016). Topography (slope) 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.

## METHODOLOGY

Data collection about the research was carried out through tests and analysis of results obtained by (1) Reconnaissance survey (2) Primary data collection (i) Experiment on the impact of parapet/duct service system and landscaping in erosion control along slopes (ii) Soil test investigation and laboratory analysis(iii) Determination and analysis of Okigwe Zone Soil Properties(3) Secondary data collection (i) Climate and soils of Okigwe Zone(ii) Rainfall data and erosion information(iii) Frequency of rainfall and average rainfall.

### Reconnaissance Survey

The reconnaissance survey identified all the vital conditions about the Okigwe Zone slopes and determined how they should influence the eventual architectural design concept in buildings development against erosion prone failure. During the course of the study, the reconnaissance survey became as familiar as possible with the Okigwe Zone building character so that standard design considerations was developed to suit the particular conditions of the Zone. The peculiarity of slopes with its attendant environmental influences on buildings, informed the identification and examination of

the Okigwe Zone conditions, which include: Location, Topography, Drainage, Climate, and Existing Buildings.

### 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:

- Experiment on the Impact of Parapet/Duct Service System and Landscaping in erosion control along slopes.
- Soil test investigation and laboratory analysis
- Determination of Okigwe Zone Soil Properties

### Experiments on the Impact of Roof Parapet, Duct System, and Landscaping in Erosion Control

The slope under consideration was divided into four portions along the width of its central area using in-situ simulated architectural models with pitched hip roofs and enough room for rainwater catchment. However, each model is independent of another in terms of treatment and control. For distinction of results, the slope divisions were further grouped under “open soil portion” and “covered soil portion” as shown in Figure 2 to 5 with nomenclature as follows:

#### Open Soil Portion Experiment

Figure 2 shows the architectural model/roof design experiment without parapet gutters and duct service system on open soil.

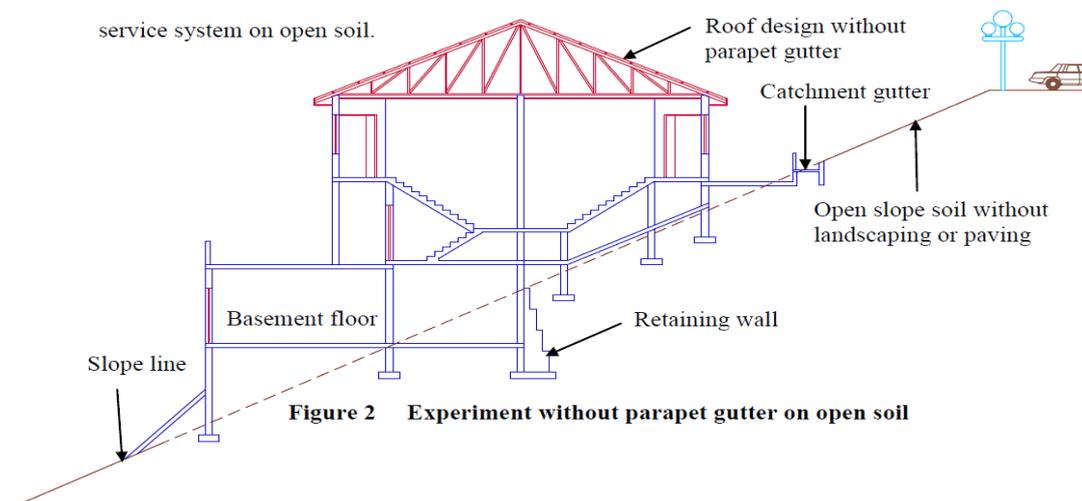


Figure2. Experiment without parapet gutter on open soil

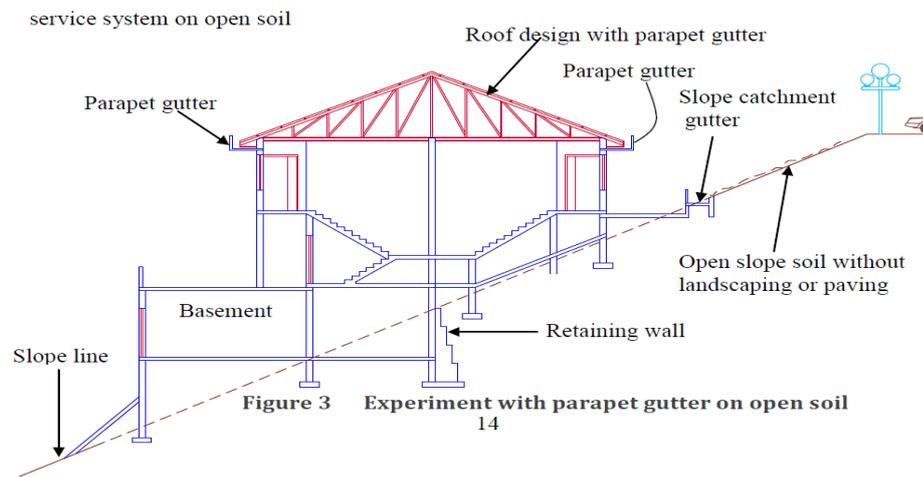


Figure 3. Experiment with parapet gutter on open soil

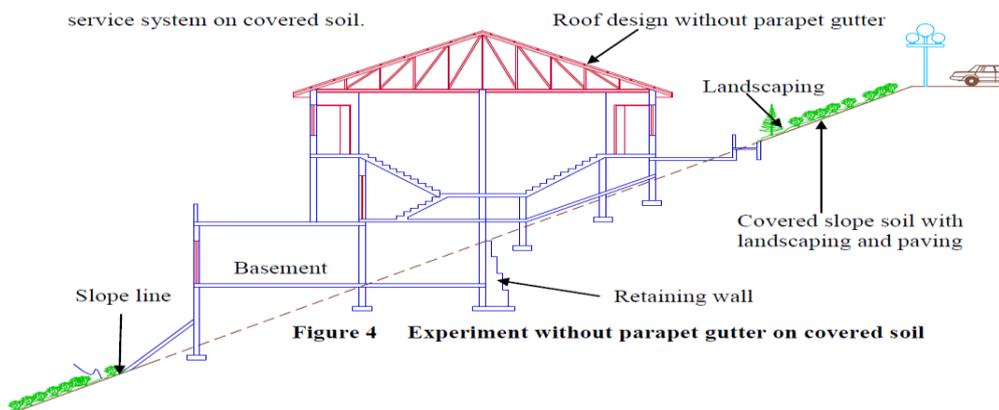


Figure 4. Experiment without parapet gutter on covered soil

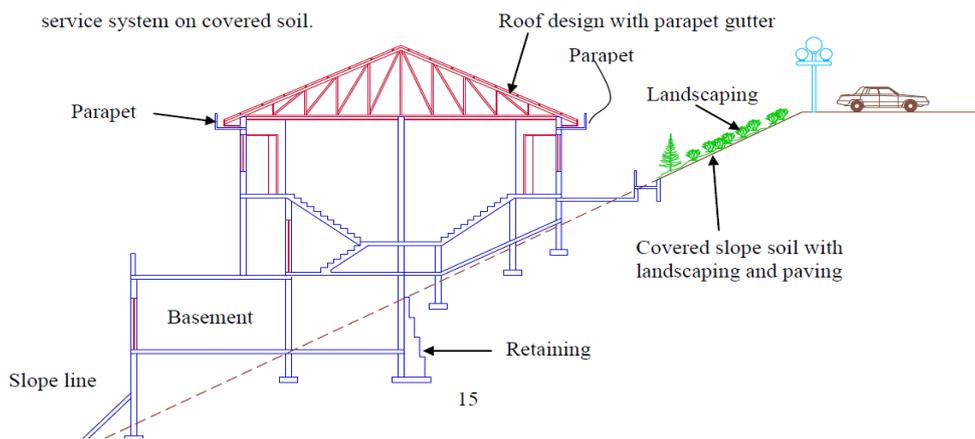


Figure 5. Experiment with parapet gutter on covered soil

This research adopted the ex-post facto design survey in which in-situ simulated architectural design models were used for comparing the in-situ effect of parapet gutters/duct service system (treatment) against the non-parapetted roof design (control) on open and covered soils respectively.

#### Covered Soil Portion Experiment

Figure 4 shows the architectural model/roof design experiment without parapet gutters and duct service system on covered soil.

#### Soil Test Investigation and Laboratory Analysis Field Work

An important consideration in contemporary architectural and engineering design practices is the nature of soil deposit over which a proposed building will be placed. To obtain this critical design input(s), this 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 36 Nos boreholes to a depth of 6.0m across the six Local Government Areas in Okigwe Zone, Imo State. 2 Nos boreholes were drilled in each of the 3 randomly selected towns in each of the six Local Government Areas.

The boreholes were sunk at specified random and dispersed positions within the respective Headquarters and towns using the auger boring (see Appendix A) the augured boreholes were executed with hand auger in April, 2017.

### Soil Stratigraphy

Information on the soil stratigraphy of Okigwe Zone was obtained from soil borings, field observation and laboratory tests. Essentially, one soil type was encountered at the site; a continuous layer of sandy clay up to the termination of the boreholes. 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 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 Etit, from classification tests 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 (Paul, 2018). The secondary data are:

- Climate and soils of Okigwe Zone
- Rainfall data and Erosion Information
- Frequency of rainfall and average rainfall

## RESULTS AND DISCUSSION

### Results of Reconnaissance Survey

Results gathered with respect to Okigwe Zone Reconnaissance Survey were determined at the instance of the study firsthand inventory and inventory analysis of findings, and are as follows:

#### Site Location

- The surrounding land uses of Okigwe Zone are mainly rural, agrarian, and residential.
- The Okigwe Zone neighborhoods 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 Etit.
- 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 recorded 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.

**Analysis of parapet/duct service system and landscaping experiment**

The apportioning and ranking of “percentage impact” according to the extent of damage after rainfall, on the slope under consideration, based on the parapet/duct service system and landscaping experiment, engendered the following analyses which were obtained from the field survey.

- Very heavy impact 40%
- Heavy impact 30%
- Moderate impact 20%
- Light impact 10%
- No impact 0%

**Treatment (Experiment) Analysis**

Table 2 shows the treatment (experiment) analysis of the impact of parapet/duct service system and landscaping in erosion control along slopes.

**Table2.** Impact of parapet/duct service system and landscaping in erosion control along slopes (Treatment)

Roof design with parapet/duct service system	Erosivity impact	Runoff impact	Wash off impact	Mean percentage impact (%)
Open Soil	Light Impact (10%)	Moderate Impact (20%)	Moderate Impact (20%)	16.7% Mean Impact
Covered Soil (with greenery)	Light Impact (10%)	Light Impact (10%)	No Impact (0%)	6.7% Mean Impact
Covered Soil (with paving)	No Impact (0%)	No Impact (0%)	No Impact (0%)	0% Mean Impact
Covered Soil (with greenery and paving)	No Impact (0%)	No Impact (0%)	No Impact (0%)	0% Mean Impact
GRAND Mean Impact (% Percentage)	5% Erosivity Impact	7.5% Runoff Impact	5% Wash off Impact	5.9% Mean Percentage Impact

Source: Field experiment survey carried out in April, 2017

**Table3.** Impact of parapet/duct service system and landscaping in erosion control along slopes (Control)

Roof design without parapet/duct service system	Erosivity impact	Runoff impact	Wash off impact	Mean percentage impact (%)
Open Soil	Very Heavy Impact (40%)	Very Heavy Impact (40%)	Very Heavy Impact (40%)	40% Mean Impact
Covered Soil (with greenery)	Heavy Impact (30%)	Heavy Impact (30%)	Heavy Impact (30%)	30% Mean Impact
Covered Soil (with paving)	Moderate Impact (20%)	Moderate Impact (20%)	Moderate Impact (20%)	20% Mean Impact
Covered Soil (with greenery and paving)	Light Impact (10%)	Light Impact (10%)	Light Impact (10%)	10% Mean Impact
GRAND Mean Impact (% Percentage)	25% Erosivity Impact	25% Runoff Impact	25% Wash off Impact	25% Mean Percentage Impact

Source: Field experiment survey carried out in April, 2017

**Control Analysis**

Table 3 shows the Control Analysis of the Impact of Parapet/Duct Service System and Landscaping in Erosion Control along Slopes.

**Grand Mean Percentage Impact (5.9%)**

On the treatment experiment data, that is, experiment with parapet and duct service system in Table 2, the Mean Percentage Erosivity

impact, Runoff impact, and Wash off impact on the open soil and on the landscaping elements (greenery and concrete paving) were obtained as follows; mean percentage impact on open soil (16.7%); mean percentage impact on covered soil with greenery (6.7%); mean percentage impact on covered soil with paving (0%); and mean percentage impact on covered soil with greenery and paving (0%).

The Grand Mean Percentage impact of these impacts is 5.9%, which is the total expected rainwater and surface runoff impact on slopes (25% and above) carrying a building with good roof design; all round parapet gutters and duct service system; and combined hardcover and soft cover landscaping.

This is quite an infinitesimal percentage impact when compared to the grand mean impact in the control experiment at 25% devastating impact as shown in Table 3.

### 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:

$$q_u = c N_c S_c + \bar{\sigma} N_q + 0.5\gamma B_f N_\gamma S_\gamma \quad (3)$$

Where,  $q_u$  = ultimate bearing capacity

$c$  = cohesion ( $k N/m^2$ )  $\bar{\sigma}$  = over burden surcharge at foundation level =  $\gamma D_f$

$N_c, N_q, N_\gamma$  = bearing capacity factor

$S_c, S_\gamma$  = 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

The settlement analyses for the soil samples from the site locations consist of both consolidation and immediate settlements. Going by the result of the settlement analysis, it is evident that a foundation footing of width 0.7m at the locations in Okigwe Zone will not settle more than the acceptable 25mm if the safe bearing pressure is kept at  $70kN/m^2$ .

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

$$34KN/m^2 \div 70kN/m^2 = 0.486m \quad (4)$$

Thus the proposed 0.8m is for foundation footings in accordance to the architectural

design considerations for buildings along the slopes profiles of Okigwe Zone.

Table 4 shows the Consolidation Settlements Values for Foundations in Okigwe Zone.

**Tables4.** Consolidation Settlement values (all locations)

Depth, D (m)	Width, B (m)	Safe Bearing Pressure (k N/m <sup>2</sup> )	Settlement (mm)
1.0	0.8	80	23
1.0	0.8	70	20

**Source:** *Deduced from Field Results*

Values indicated in Table 4 shows that structures placed on foundation footings with dimensions not exceeding those indicated will not settle excessively if the safe bearing pressures are not exceeded.

### CONCLUSION

The study makes it evident that there are numerous concepts that can be employed for making a building responsive to nature and the natural processes of slopes. This is desirable because of both the environmental consequences as well as the potential economic and functional benefits, as outlined in the importance of the study.

Buildings adaptability against erosion prone failures along slopes require insight in carrying out feasibility studies, and in making sure the design process is carried out with the utmost care and sensitivity to the broader and ever present natural processes of slopes.

### RECOMMENDATIONS

There are five specific factors identified and recommended for the design and construction of buildings for adaptability along slopes in Okigwe Zone. These factors which also proffer answers to the research objectives cannot be dissociated from slope architecture the culmination of findings for buildings adaptability against erosion prone failures along slopes, and they are: Slope factors, Microclimate of the slope area.

Soils properties and foundation design, Roof design/duct system/landscaping, and subsurface drainage. Slope factors summarily stipulates the design and construction considerations given to the control of natural occurrences capable of causing slope failure, or/and building failure along slopes.

These occurrences include; slope angle, credibility and Erosivity of the slopes, erosion,

runoff, slope steepness and gradient, and flooding. Microclimate determines the direct and immediate climatic conditions of the slope area under consideration for building design and construction, otherwise known as the building site. The slope sites microclimate in Okigwe Zone are influenced by the presence of steep slopes and gullies to warrant giving proper conceptual considerations to the building design process. Sites microclimate particularly, influenced the settlement and development pattern of Okigwe Zone. Soil test investigation determines the soil properties and appropriate foundation design for buildings structure.

The slope angle and gradient determines the architectural floor integration method, while the foundation base and layout adopts the pattern of the architectural floor integration method.

Consideration for roof design, duct service system, and landscaping determines the control of roof runoff, surface runoff, flooding and erosion around the building. The use of high pitched hip-roof with all-round gutters and duct service systems provides soft landing for roof runoff and averts devastating effects from the building roof height.

While the parapet gutters gathers the roof runoff and channels it down through the duct systems, the duct systems in turn open into the subsurface drainage channel which leads and evacuates the runoff into the main drainage catchment. The combined use of hard and soft covers for landscaping provides control over rain splashes and surface runoff.

Consideration for drainage marks the meeting point between the building and the environment. Subsurface drainage channels runoff from the duct service systems and landscaped areas of the building to a main drainage catchment, such as streams and rivers.

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