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The Fundamentals of Building Construction in the Flood-Plains of Ogbaru Local Government Area, Anambra State, Nigeria

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ABSTRACT:
The study evaluates the building construction forms and components in the flood plains of Ogbaru with a view to establishing how the buildings responds to flood events in the study area. Being a survey research, data were collected through structured questionnaire administered to the selected building construction practitioners and occupants in Ogbaru. Accordingly, a total of three hundred and eighty-four (384) questionnaires were administered and a total of two hundred and ninety-three (293) questionnaires were completed and returned. This corresponds to a response rate of 76.3%. Data collected were analyzed using mean score, standard deviation and t-test. The study found out that the 47%, 30%, 18%, 4% and 3% of the buildings in the study area were made up of sand-crete, mud, timbers/thatch, burnt brick and reinforced concrete respectively. However, the percentage of Burnt Bricks home, Sand-crete homes and Plain/Reinforced concrete homes to other forms (i.e. mud homes and Bamboo/wooden/thatch homes) is 54% to 48%. This correspond to a percentage difference of 6%. Also, 94.6% of buildings in Ogbaru are found on flooded- plains. Therefore, the probability of the homes in Ogbaru being flooded during rainy season is high.Also, the study found out that more than 70% of the building foundations found in Ogbaru between 0-300mm high above the natural ground level and more than 45% of the building foundation and floors were made with muds/timbers. Hence, the building foundations and floor often affected by flood disaster annually. Furthermore, the study observed that the most of lowest floor elevation of the buildingsexamined is not high enough to prevent flood enteringinto building envelope; the building foundations are not intact and functional during and after flood events and the envelope (lowest floor, walls, openings, and roof) is not structurally sound and capable of minimizing penetration of wind, rain, and debris among others. Therefore, the study recommends that concrete and sand-crete block homes and any durable building typologies/forms should be encouraged in the area. Also, existing mud homes should be retrofitted to be flood resilient.

Keywords: Buildings, Building construction, Floods, Flood-plains, Ogbaru

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I. INTRODUCTION:

The built environment provides the foundation, upon which society exists, develops and survives [1]. The built environment according to Bartuska [2], is anything humanly made, arranged or maintained to fulfil human purpose (i.e. needs, wants, and values). Put differently, it is a collection of products and processes of human creation. These products include roads, bridges, buildings and other facilities that are not put in place by nature. Being a construction product, Architecture, Engineering and Construction (AEC) industry is the main provider and life cycle custodian of the built environment and as such plays a critical role in determining the quality, integrity and longevity of its foundation [1]. Also, the patterns of development of the built environment directly or indirectly affect the natural environment [3]; [4]. Research by Okoye, Ezeokoli and Ezeokonkwo [3] has proven that recent cases of disaster in Nigeria and the globe today, have a direct link to pattern of development. With this, natural disaster has become ubiquitous [5]. Consequently, natural disaster has continued to threaten all parts of the world today and appears to be increasing in frequency, scale, and intensity [6]; [7]. Flooding according to [3], [5], [8-13] is becoming a greater threat when compared with other natural disasters. This rise in frequency of flood disaster according to McAllister [14] is a combined effect of urban development and continuous population growth. Whenever a disaster occurs, built environment generally is affected most. Based on this, Ofori [15] stressed that “the built environment bears the brunt of the damages from disasters of all sort. This is because of the physical characteristics of the constructed items, i.e. they cannot be moved elsewhere even if the imminent disaster could be accurately predicted [15]. Therefore, the most visible and striking effects of any major disaster besides human casualties, is massive destruction of houses/buildings [16-18].

Conversely, each rainy season in most Nigeria communities comes with its own flood events, ordeals and traumas. However, the most prominent of them is the 2012 flooding. This flooding alone destroyed over 500,000 buildings in Nigeria [3], [5], [11], [19 – 22]. During 2012 flooding in Anambra State, the raging flood submerged several communities. Worst hit isOgbaru, Anyamelum, Anam and other areas of the lower Niger River basin. At the peak of the crisis in the state, a total of 125, 000 people were internally displaced [23]. Although the state recorded no fatalities, numerous buildings and industries were fully or partially submerged for more than four (4) months [23]. This, puts the structural integrity of these buildings into question. The overall damages incurred were enormous. Cumulatively, the state and the nation suffered losses valued at N22, 995,100,000 (approximately 23 million naira) and N2.6 trillion respectively [23], [24]. Even after the 2012 flooding, the problem persisted and its impacts, particularly on buildings have been increasing without any sign of abatement each year,coupled with the fact the demand for building keep rising in most communities of Ogbaru due to its proximity to Onitsha. Therefore, prohibition of buildings construction in the flood plain of Ogbaru is not feasible. On this note, this study evaluates the building construction forms and componentsin the flood plains of Ogbaru with a view to establishing how the buildings responds to flood events in the study area.

II. LITERATURE REVIEW:

2.1 Flooding &Building:

Introduction of flood water into the building according to Mbina and Edem [25] increases the cost of building since it impedes construction and may eventually cause costly damages to the building fabrics and components. Hence, the cost of rehabilitation of the damaged infrastructure, as well as upgrading existing infrastructure to withstand future occurrences maybe quite high [26]. Usually, Flood disaster has catastrophic impact on houses built with mud, thatch, bamboo sticks andflimsy or sub-standard materials because, they not resilient enough to withstand the flood eventsthus increases the rate of displacement after flood occur [27], [28]. Accordingly, [5], [29] after studying the impact of 2012 flooding in Ogbaru and Aguleri respectively, observed that the houses particularly those built with mud were totally washed away whereas those built with blocks were recovered after the flood event. Equally, Orimoogunje et.al., [8] after studying the flood vulnerability in selected locations of Southwestern Nigeria, observed, that 45% of the structures were built with brick cement, 28% reinforced concrete cement and 27% with mud brick; All the buildings with mud brick quickly cave in during flood while the ones with brick cement still remained intact.

Furthermore, Orimoogunje et.al., [8] established that the age of the building, quality of materials and the location of the building are major factors that tend to increase vulnerability to flooding disaster. In-addition, Brujin [30];Tezak, Low and Reeder [31] outline the factors that contribute to damages on buildings at micro-level with respect to flooding as:

i. Physical factors such as: flood depth and flow velocity, rate of water depth rise, flood duration, sediment carried, wind, temperature, season, water quality
ii. Socio-economic factors such as: number of inhabitants, land use or economic value of the area, warning period in advance of the flooding; preparation of the people and experience with floods; behaviour of people; and
iii. Ecological factors such as: type of ecosystems, shelters/availability of higher location.

Conversely, control measures that is most appropriate depends largely on the source of floodrisk [32]. Equally, to reduce the likelihood of floodwater entering into the building, it is important to identify the potential points of flood entry into the building, which depend on the type of construction, the underlying ground conditions and the expected flood depth [33]. Flood routes in buildings according to [33]; [34]are:Ingress around closed doorways; Ingress through airbricks and up through the ground floor; Backflow through overloaded sewers discharging inside the property through ground floor toilets and sinks;Seepage through the external walls (i.e. Brickwork and blockwork); Seepage through the ground and up through the ground floor; Ingress around cable services through external walls; Party walls of terraced or semi-detached buildings if the attached building is flooded; Expansion joints between walls where different construction materials meet or between the floor slab and wall;Cracks and openings due to settlement, poor construction, and services all provide water entry routes;Damp proof course (DPC), where the lap between the wall damp proof course and floor membrane is inadequate;Services entries e.g. utility pipes, ventilation ducts, electricity and telephone cables;Gaps in mortar in masonry, stonework and blockwork walls, usually at perpends;Seepage from below ground through floors and basements; and

Sanitary appliances from backflow from surcharged drainage system

2.3: Flood damages in Buildings

When flood water finds its way into the building, it causes severe damages to the building structures and fabrics. These damages according to [35] arises from the following:

- **Corrosion:** Salt-laden, moist air can corrode exposed metal surfaces and penetrate any opening in the building. Also, corrosion attack metal connectors, fasteners for siding and connectors for attaching exterior-mounted heating, ventilation, and air-conditioning units, electrical boxes, lighting fixtures, and any other item mounted on the exterior of the building;
- **Moisture:** Trapped moisture increases the moisture content of the material and potentially leads to decay. The potential for wood frames in low-lying coastal areas to decay is high. Therefore, connectors should be designed to shed water to prevent water from accumulating between the connector and the material the connector is attached to.
- **Weathering:** The combined effects of sun and water on many building materialscauses weathering damages in form of: Fading of finishes;Accelerated checking and splitting of wood; Gradual loss of thickness of wood; and Degradation of physical properties (e.g., embrittlement of asphalt shingles). The effects of weathering reduce the life of building materials unless they are naturally resistant to weathering or are protected from it, either naturally or by maintenance.
- **Termites:** The likelihood of termite infestation in coastal buildings can be reduced by maintenance that makes the building site drier and otherwise less hospitable to termites, others are: Keeping water pipes, water fixtures, and drainpipes in good repair; Avoiding dampness in crawlspaces by providing adequate ventilation or installing impervious ground cover membranes; and avoiding frequent plant watering adjacent to the house and trimming plants away from the walls.

Accordingly, [33]; [36]categorizeflood damages on building elements/components as:

Table 1: Flood depth and its Impacts of building elements.

Depth of floodwater	Damage to the building Elements
Below ground floor level	▪ Minimal damage to the main building. ▪ Floodwater may enter basements, cellars and voids under floors. ▪ Possible erosion beneath foundations.
Up to half a metre above ground floor level.	▪ Damage to internal finishes, such as wall coverings and plaster linings. Wall coverings and linings may need to be stripped to allow walls to dry. ▪ Floors and walls will become saturated and will require cleaning and drying out. ▪ Damp problems may result. ▪ Chipboard flooring likely to require replacement. ▪ Damage to internal and external doors and skirting boards.
More than half a metreabove ground floor level.	▪ Differential heads of greater than 0.6m across walls could cause structural damage, although this will vary depending on the structure of the building. Damage to windows can be caused by much smaller differential pressures ▪ Possible structural damage/failure

III. METHODOLOGY

The population of this study constitutes all the households/residents, construction professionals, disaster management agencies and building development control units (Anambra State Physical Planning Board -ANSPPB) in the study area. According to the 2006 National population and housing census, the population of persons in Ogbaru LGA of Anambra State was 223,317[31] while the number of households in the area was 49,501 [37]. Using a population growth rate of 2.83% as recommended by National Population Commission for Anambra State [37], the population of Ogbaru LGA in 2017 was 303, 559. Therefore, the population of this study was 303,559 persons.

Cochran's sample size calculation procedure was employed to determine the appropriate sample size in this study. The sample size of the respondents for this study is 384. Data were collected through structured questionnaire administered to the selected building construction practitioners and occupants in Ogbaru. In addition, few interviews and direct observation survey were conducted to substantiate the validity of the result of this study. Accordingly, a total of three hundred and eighty-four (384) questionnaires were distributed to the building occupants and practitioners in Ogbaru. A total of two hundred and ninety-three (293) questionnaires were completed and returned. This corresponds to a response rate of 76.3%. (See Table 2). Table 3 also shows the personal flood experiences of the respondents in the study area.

Table 2: Population Distribution of Questionnaire and Percentage Response

Categories	Number of questionnaires distributed	Number of questionnaires received	Percentage (%)
Professionals	256	185	72.3
Households	128	108	84.4
Total	**384**	**293**	**76.3**

Source: Field Survey (2018)

IV. RESULTS& DISCUSSIONS

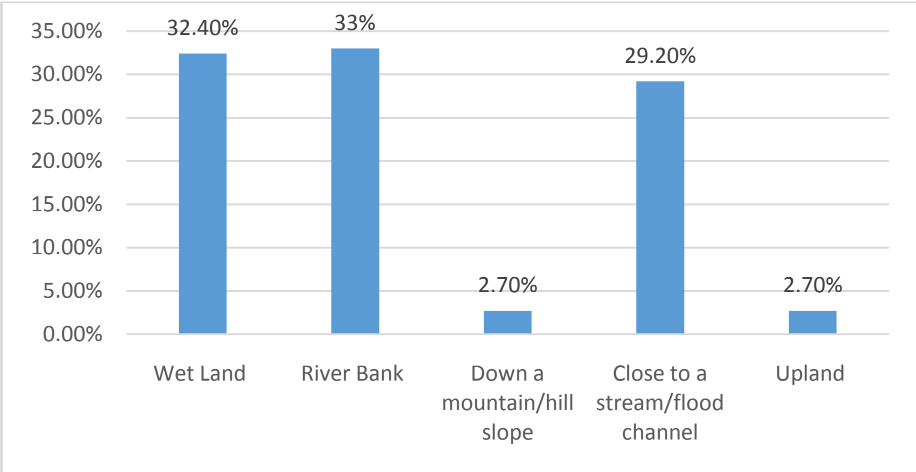

Fig. 1: Building Location

Source: Field Survey (2018)

The result in Fig. 1 shows that, 32.4%, 33%, 2.7%, 29.2% and 2.7% of the buildings examined are found on wetland, a river bank, down a mountain/hills/slope, streams and flood channel and up land respectively. Accordingly, the proportion of buildings on flood plain to the ones on upland stood at 94.6% against 5.4%. Therefore, the probability of the homes in Ogbaru being flooded during rainy season is high.

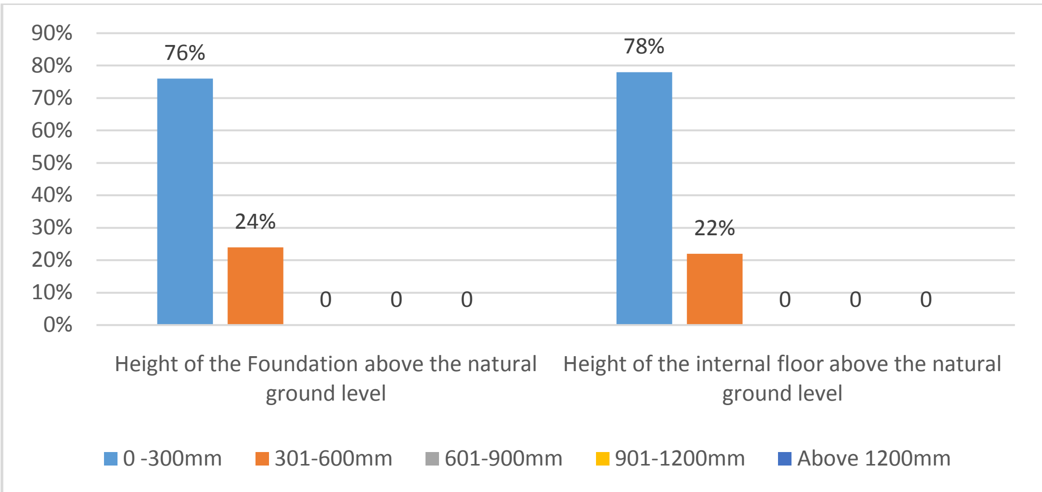

Fig 2: Foundation & Internal floor Height of Buildings in Ogbaru.

Source: Field Survey (2017).

The results in fig 2 indicates that 76% and 78% foundation and internal floorexamined are between 0-300mm above the Natural Ground Level (NGL) respectively. Also, 24% and 22% of the foundation height and internal floor height of buildings examined are 301-600mm above NGL respectively. Conversely, the results in Fig 2 revealed that none of the building foundations and internal floors examined exceeded 600mm high in the study area. Comparing this, to the findings of the study by [40] as regards to flood depth in Ogbaru which they discovered to up-to not more than 1.8m shows that the foundation depths is grossly inadequate.

Table 3: Building Components &Material typologies

Foundation	Walls	Floors	Roof Structure	Roof cover
Sand-crete (47%)	Sand-crete block (50%)	Plain/ Reinforced Concrete flooring (54%)	Wood (74%)	Aluminium (37%)
Reinforced concrete (3%)				Zinc (52%)
Burnt Bricks (4%)	Burnt Brick (4%)			
Mud block/wattle (30%)	Mud blocks/wattle (38%)	Mud flooring 30%		Thatch (11%)
			Bamboo (26%)	
Timber (18%)		Cement screeding (18%)		
	Timber (10%)			

Source: Field Survey (2017)

The results in table 3 indicates that 47% of the building foundation examined were made of sand-crete blocks, closely followed by Mud blocks/Wattle mud (30%) and timber (18%). However, reinforced concrete (3%) and burnt brick (4%) were rarely used as shown in the results in table 3. In continuation, the results in table 3 indicates that 50% and 38% of the walls examined were made-up ofsandcrete blocks and mud block/wattle respectively. Timber reduced to 10% and burnt bricks maintain 4% in wall construction. For floor construction, plain/reinforced concrete (50%) were mainly used. Mud flooring and cement screeding stood at 38% and 18% respectively. Building with burnt brick, sand-crete and stone walls/foundation used either plain/reinforced concrete floors. Whereas that of mud and timber mainly were either mud flooring or cement screeding flooring. Furthermore, majority of the roof structure were built with wood (74%) and the remaining 26% were bamboo. The bamboo was found in timber and mud home only. For the roof cover, it was observed all the block home, brick home, stone home and some fraction of mud homes were covered with Aluminum (37%) and zinc (52%). Some percentages of mud and timber homes were covered with thatch roof (11%).

In-summary, the percentage of Burnt Bricks home and Sand-cretehomes and Plain/Reinforced concretehomes as against others is 54% to 48%. Therefore, the percentage difference between them is 6%. However, during the walkthrough survey and interview, its discovered:

i. That greater percentage of mud and timber homes are found in the rural area, and;
ii. They have been a drastic reduction in the percentages of mud and timbers houses after 2012 flood disaster.

This scenario supports ARUP [39] findings in Sindh Pakistan where it was discovered that prior to 2010 flooding concrete blocks and burnt bricks were not presently used and its only used for about 1%; following the 2010 flooding, most of the homes reconstructed by the humanitarian were made with burnt bricks or sand-crete blocks.

Table 4: Effect of flood water on building components

Building components	MA	A	D	SA	RA	Mean	Std.
Foundation	145	35	05	00	00	4.76	0.489
Walls	129	39	11	03	03	4.56	0.813
Floors	138	38	00	04	05	4.62	0.832
Roofs	89	49	13	14	20	3.94	1.354
Household appliance	129	39	07	05	05	4.52	0.903
Utilities e.g. electricity supply, water supply and sewers etc	119	59	05	02	00	4.59	0.602
Cluster mean and Std. deviation						**4.50**	**0.832**
MA= Mostly Affected; A= Affected; D= Don't Know; SA= Seldom Affected; RA= Rarely Affected							

Source: Field Survey (2017)

The result in table 4 indicates that every part/components of a building as out-listed are affected by flood water in the study area (4.50 > 3.00 and 0.832 < 1.581). Particularly, the result as indicated in the strata mean and standard deviation shows that foundations and floors are the mostly affected part while the least affected is the roof of the building. The findings of the walkthrough survey support the result in table 4 (see plate 1-6).

Plate 2: collapsed walls/foundation

Plate 3: collapsed foundation wall

Plate 4: wall separation

Plate 5: Collapsed foundation wall

Plate 6: Collapsed wall and foundation

Table 5: Condition assessment of Building components in Ogbaru

Building Component Conditions	Households		Professionals		$\bar{\bar{X}}$	$\overline{Std}$
	Mean	Std	Mean	Std		
The building foundation is intact and functional	2.93	1.327	3.17	1.019	3.05	1.173
The envelope (lowest floor, walls, openings, and roof) is structurally sound and capable of minimizing penetration of wind, rain, and debris.	3.22	1.250	2.71	0.996	2.97	1.123
The lowest floor elevation is high enough to prevent floodwaters from entering the building envelope	1.92	1.040	3.15	1.075	2.54	1.058
The utility connections (e.g., electricity, water, sewer, natural gas) remain intact or can be easily restored	2.37	1.292	3.01	1.249	2.69	1.271
The building is accessible and habitable	2.59	1.295	2.96	1.135	2.78	1.215
Any damages to the part of the building below the lowest floor does not result in damage to the foundation, utility connections, or elevated portions of the building or nearby structures	2.56	1.314	2.60	1.215	2.58	1.265
During flood event, the building protects life and provides safety, even if the structure itself sustains significant damages	2.86	1.380	2.40	1.387	2.63	1.384
Cluster Mean & Std. deviation	**2.64**	**1.271**	**2.86**	**1.154**	**2.75**	**1.213**

Source: Field Survey (2017)

From the results in table 5, the mean of the cluster means (mean = 2.75 < 3.00(likert mean)) and associated standard deviation (std. = 1.213 < 1.581) indicates that the both the professionals and households disagreed that the buildings in the area are in good conditions. Particularly, the professionals agreed that the lowest floor elevation is high enough to prevent floodwaters from entering the building envelope; that the utility connections (e.g., electricity, water, sewer, natural gas) are intact and can be easily restored. They disagreed that the envelope (lowest floor, walls, openings, and roof) is structurally sound and capable of minimizing penetration of wind, rain, and debris; that the building is accessible and habitable; that any damages to the part of the building below the lowest floor does not result in damage to the foundation, utility connections, or elevated portions of the building or nearby structures; and that during flood event, the building protects life and provides safety, even if the structure itself sustains significant damages.

On the other hand, the households were of opinion that the building foundations are not intact and functional (mean = 2.93 < 3.00) but that the envelope (lowest floor, walls, openings, and roof) is structurally sound and capable of minimizing penetration of wind, rain, and debris. Moreover, they disagreed that the lowest floor elevation is high enough to prevent floodwaters from entering the building envelope; that the utility connections (e.g., electricity, water, sewer, natural gas) remain intact or can be easily restored; that the building is accessible and habitable; that any damages to the part of the building below the lowest floor does not result in damage to the foundation, utility connections, or elevated portions of the building or nearby structures; and that during flood event, the building protects life and provides safety, even if the structure itself sustains significant damages.

In order to appropriate the use of cluster analysis, the studycompared the opinions of the two groups using the independent sample t-test techniques. The result is as presented below:

Independent Samples t-test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
Mean ratings	Equal variances assumed	.430	.524	-1.140	12	.276	-.22143	.19416	-.64447	.20161
	Equal variances not assumed			-1.140	10.688	.279	-.22143	.19416	-.65030	.20744

The student's t-test result (|t| = 1.140; p-value = 0.276) revealed that there is no significant difference in opinions of the professionals and that of households. The levene's test of equality of variance (with F-stat. = 0.430; p-value = 0.524) shows that the variances in the series of each group are equal. Thus, approves the use of pooled analysis.

V. CONCLUSION & RECOMMENDATIONS:

Flooding has been discovered to be a regular phenomenon in Ogbaru. Because, most of the communities in Ogabaru is situated either on River Niger bank, wet land or water channels. Therefore, buildings in Ogbaru are subjected to flood risk annually. Based on this the study examined the forms and components of buildings in Ogbaru and observed that the forms of building constructed in responses to flood events in the study area are sand-crete/concrete block homes, Mud & Timber homes and burnt brick. Large concentration of sand-crete/concrete block homesare found within the urban areas while the rural areas and farm settlement are grappling with mud & timber homes. However, thenumbers of the mud and timber homes in the rural areas is gradually reducing since after the 2012 incidence.

Also, the study revealed that the probability of homes being flooded in Ogbaru is high because most buildings are found on flood-plains with foundation/internals floor height not more than 600mm. In-addition, more than 45% of the building foundation and floors were made with muds/timbers. Hence, the building foundations and floor often affected by flood disaster annually. Furthermore, the study observed that the most of lowest floor elevation of the buildings examined is not high enough to prevent flood entering into building envelope; the building foundations are not intact and functional during and after flood events and the envelope (lowest floor, walls, openings, and roof) is not structurally sound and capable of minimizing penetration of wind, rain, and debris among others. Therefore, the study recommends that concrete and sand-crete block homes and any durable building typologies/forms should be encouraged in the area. Other form of building construction such as mud or timber home should be discouraged expect if they are properly reinforced. Also, existing mud homes should be retrofitted to be flood resilient

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