Dynamics of Sustainable Building Façades and Aesthetic Perception of Fenestrations in University Administrative Building

Obaleye J. Oludare, Ezema .I .C and A. B. Adeboye

Abstract— Building facades are very important contributors to the comfort parameters and attractiveness of any building. Fenestrations as key elements of the building façade are essential in achieving the dual role of comfort and attractiveness. This study seeks to discuss sustainable façade design methods and identify aesthetic perception of façade fenestrations by users of university administrative buildings in southwest Nigeria with the view of improving occupants comfort and building attractiveness. In achieving this, the literature discussed the design strategies, characteristics and properties of sustainable facades, while the quantitative study focused on aesthetic perception of fenestrations was carried out using a self-administered questionnaire survey. Ten still photographs of selected university administrative building facades in southwest Nigeria were attached to elicit response from 577 respondents, in a stratified random sampling. Results were analysed using frequencies, mean ranking and factor analysis. For an efficient sustainable façade, the qualitative study established climate-specific design strategy. The quantitative study identified fenestration with a high mean score as the fifth important aesthetic element out of 14 others. Fenestration perception revealed that façade with uniformly symmetrical distribution; vertical orientation and approximately about 40% window-to-wall ratio (WWR) coverage was most preferred by respondents in the study area. The findings contributed to the environmental sustainability of the building facade by ensuring occupants comfort and creating an attractive built environment.

Index Terms— Aesthetics, Administrative Building, Building Facades, Fenestration, Sustainability, University, Windows

1 INTRODUCTION

The first impression of a product or service is tied to its physical appearance. The interior or exterior of a building irrespective of its height, span, volume, complexity, function or location can be first appreciated by the aesthetic property of the façade [1]. Building facades as the first impression of an architectural product to the public is of great importance in the designing and construction process. Besides this, the façade as an external envelop encapsulating an interior space also plays a key role in determining the level of comfort of the user [2]. This dual requirement of comfort provision (that is promoting health and productivity) and aesthetic property of the building façade are essential ingredients in the subject of sustainability of the built environment as required in the Millennium Development Goals [3]. Sustainable building façades as exterior enclosures are tied to different factors of which fenestrations are very important in determining a comfortable interior as well as aesthetic appreciation. Building facades vary in relation to the functional requirement of the building typology. This study addressed the fenestration of the university administrative building façade.

The university campus as a community saddled with the primary responsibility of research and education has a central administration that controls the functioning of the entire system, known as the university senate building. The university senate building as the seat of authority in a campus is expected to be outstanding in its comfort for users and aesthetic quality for enhancing the overall outlook of the campus [4]. Façade fenestration as an aesthetic element has been known to be synonymous with building comfort and visual appeal. However, its level of importance as an aesthetic element in relation to other aesthetic elements is unknown. Consequent upon the foregoing, this study seeks to discuss sustainable façade design methods and identify aesthetic perception of façade fenestrations by users of university administrative buildings in southwest Nigeria with the view of improving occupants comfort and building attractiveness. The objectives in achieving this aim are:

i .identification of fenestration as an aesthetic element on the façade of the university administrative building in southwest Nigeria.
ii. examining users perception of the fenestration on the façade of university administrative buildings in southwest Nigeria.

2 LITERATURE REVIEW

2.1 Sustainable Building Facades

The concept of sustainability has surfaced to become a guiding paradigm in creating the evolution of the built environment in meeting the needs of humans in the present without denying the future generations the ability to meet their own needs [5]. Diverse professionals have sort different ways of meeting this paradigm shift in the built environment by developing design

- *Obaleye J. Oludare PhD candidate, Department of Architecture, Covenant University, Ota, Ogun State, Nigeria. E-mail: obaleyeoludare@yahoo.com*
- *Dr Isidore C. Ezema, , Department of Architecture, Covenant University, Ota, Ogun State, Nigeria*
- *Professor Albert. B. Adeboye, Department of Architecture, Covenant University, Ota, Ogun State, Nigeria*

concepts, elements and materials that will ensure the achievement of sustainability. One of such building aspect that plays an important role in achieving building sustainability is the building façade. The word façade according to Chris van Uffelen in [1] is derived from the Latin word "facies", or outward appearance which depicts the outward visible surface structure of buildings. The façade can be the major side of the building having the main entrance or facing the major access to the building. Facades are basically of two types namely the opaque and glazed facades. However, other sides of the building can also be referred to as the façade. Sustainable facades therefore can be described as an external envelop that requires the minimum quantity of energy to ensure a comfortable internal space. This in essence is to promote the health and productivity of the building's users [2]. Sustainable facades create a balance between the building's external environment, and internal comfort by ensuring significant reduction in the buildings' energy consumption. In ensuring a sustainable façade, the key approach according to [2] is to understand the climate-based design approaches and an application of the characteristics and properties of sustainable facades. Climate-specific design approaches entails understanding the climate of the specific location as different indices are applicable for different climate. The climate classifications according to [2] are: hot climates, cold climates and mixed climates. In line with the climates, the basic approaches/methods for designing sustainable facades include: Orienting and developing geometry and massing of the building in relation to solar position and providing solar shading to influence cooling effects and promote thermal comfort; using natural ventilation to enhance air quality and reduce cooling loads. The last approach is minimizing energy used for artificial lighting, mechanical cooling and heating by optimizing exterior wall insulation and the use of day lighting.

In reducing the energy consumption of buildings as an impact area of sustainable facades, the properties of these facades need to be considered during the design process. They can be described as: providing adequate daylight for interior space; shielding undesired heat entering the interior; decreasing thermal exchange and keeping heat inside the wall by means of a proper insulation; being a barrier to prevent air/vapour passing through; and providing natural ventilation to make the interior spaces cooler. These properties are closely linked to the function of the building, orientation, occupancy pattern, façade type, as well as climatic conditions [6]. Further to the properties of sustainable facades, the distinguishing characteristics of sustainable facades of key consideration in designing include orientation and fenestration, selection of material, heat and moisture movement, thermal comfort and daylight. The orientation of a building determines its exposure to sunlight. This is usually considered during site analysis in the design process as. The angle of the earth in relation to the sun varies throughout the year and the sun moves across the sky during the day, solar exposure on a facade is continually changing. A strategy for controlling solar heat gain is determined by the building's orientation. Considering the scope of this work, fenestration will be discussed in the next section of this study.

2.2 Fenestration Perception

Fenestration in lexical sense as it relates to construction can be defined as the openings in the building envelope which includes installations such as windows, doors and skylight. In a similar view, [2] identified components of fenestration as windows, curtain walls and clerestories and described fenestration as an important element of façade design which serves both performance and aesthetic purposes. A window in general view is an opening in the wall of a building, fitted with glass or other materials in a frame to let in light or air and permit visual contact between the internal and external spaces. A curtain wall as different from a window is a non-structural wall system used as an outer covering of a building to keep the weather out of an interior space, while a clerestory is normally positioned in a part of the buildings that rises above the roof. It can also be a side window that is placed high in the wall. Generally, it does not allow views of the exterior but enhances a deeper travel of daylight beyond the impact of regular windows [7]. The general characteristics of the different component of fenestration are the permission of natural light access into interior spaces, heat exchange between the exterior and interior space, as well as influence a building's overall consumption of energy, occupants' well-being, comfort, health and productivity. In the selection of materials for fenestration, it is important to note the properties of glass such as U-values, SHGC and visual transmittance. Other important factors to be considered in fenestration design are the framing system and the window-to-wall ratio (WWR) as a façade metric [7],[8],[2]. The WWR is the proportion of glazed to opaque façade area which is an important factor in a facade's heat gain from the exterior as well as energy consumption. The specification for WWR in designing of facades is highly dependent on the climatic condition of the location in variants such as hot, cold and mixed climates [2].

Fenestration as an architectural element as well as aesthetic element in a building façade has a great influence on a building aesthetic judgment [9], [10]. Aesthetics as a branch of philosophy can be defined as a discipline that studies the beauty and attributes of an object and their perception through our taste [11], [12]. Aesthetic study directly or indirectly addresses and has great influence on the users. Therefore, the users' opinion as the principal component of the physical environment is of great importance to the designer before taking decision for an objective view [13]. [14] described perception as the process of identifying and interpreting sensory stimuli, using one or more of the senses, which involve the way people, think about or understand things in the natural and built environment. The users' perception of the fenestration of the university administrative building façade is important as a public building. This is to ensure a balance between the parameters for comfort and the expected visual quality of this building typology. Identification and perception of aesthetic elements is however vast and relative to users and building typology. Fenestration within the context of the university administrative building

façade will be surveyed adopting the broudy aesthetic model [15] and other physical building attributes.

3 METHODOLOGY

The study population for the study cuts across the three categories of university based on ownership. These included all the 54 Universities found in Southwest Nigeria which comprises of 7 Federal universities, 11 State universities and 36 Private owned universities. The sample frame comprised of 34 universities that met the expected requirements of been established between 1948 and 2015 (2015 being the commencement of the study); having a senate building above one floor height; building solely dedicated to administrative purpose and having the senate chamber within it. The 34 universities in the sample frame consisted of 7 federal, 10 state and 17 private owned universities respectively.

Considering the 34 universities in the sample frame, a total of 10 universities were selected [16]. In selecting the required 10 universities, the stratified random sampling method (proportionate random sampling) was applied to the sample frame along ownership line and a proportion of 2:3:5 was arrived at. This implied, 2 federal universities, 3 state universities and 5 private owned universities within the study area. The federal universities are: University of Ibadan, Oyo state and University of Lagos, Lagos state. The state universities selected are Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Adekunle Ajasin University, Akungba, Ondo State and Tai Solarin University of Education Ijebu Ode, Ogun State, while the private universities selected are Covenant University, Ota, Ogun State; Fountain Univeristy, Oshogbo, Osun State; Adeleke University, Ede; Elizade University, Ilara-Mokin, Ondo State and Augustine University, Epe, Lagos State. The building fenestrations of ten senate buildings from the selected ten universities were considered for users' perception. The facades were presented to respondents in high quality, A5 (14.8x21cm) sized, still photographs. Quantitative data were collected using close-ended questionnaire and based on the 5 Likert-type scale rating of not attractive, less attractive, un-attractive, attractive or very attractive. Data analyses were done using frequencies, percentages, mean ranking and factor analysis. The questionnaire was distributed to students and staff of 10 universities in southwest Nigeria using the stratified random sampling. The sample size for users was calculated using the Yemane formula for calculating a finite population. A total of 788 questionnaires were distributed and 73% or 577 were subsequently analysed. Data analysis was done using SPSS Version 20.

4 RESULTS AND DISCUSSIONS

4.1 Façade Images

Figure 1 presents the images of the ten selected university administrative building facades from southwest Nigeria.

Image 1:Augustine University | Image 2: Ladoke Akintola University

Image 3: Fountain University | Image 4: Adeleke University

Image 5: Elizade University | Image 6: Tai Solarin University of Education

Image 7: University of Ibadan | *Image 8: Adekunle Ajasin University*

Image 9: Covenant University | Image 10: University of Lagos

Fig. 1: Ten Selected University Senate Building Facades

4.2 Socio-Economic Characteristics of Respondents

Table 1 presents respondents' profiles. It is evident from Table 1 that most of them were between the age group of 21 and 30 years, predominantly male and majority of the respondents were students.

TABLE 1
SOCIO-ECONOMIC CHARACTERISTICS OF RESPONDENTS

Attributes	Frequency (n=577)	Percentage (%)
Age Group		
20 years and below	87	15.1
21-30 years	255	44.2
31-40 years	67	11.6
41-50 years	88	15.3
51 years above	80	13.9

Gender		
Male	337	58.4
Female	240	41.6
Status in University		
Staff	205	35.5
Student	372	64.5

4.3 Identification of Architectural Facade Elements by Respondents

In order to verify the identification of fenestration as an aesthetic element in assessing a university administrative building façade, fourteen elements were considered based on the outcome of interviewing 10 professional architects, the Broudy Aesthetic Model sensory elements were reviewed, alongside other physical elements from observation of selected façade photographs. These reviewed final elements are: height, façade colour, texture, shape, fenestrations, columns, foreground, roof shape and/or parapet wall at roof level, entrance canopy/design, terraces/balconies, railings, screen walls, services, inscription. Table 2 presents the mean ranking for the architectural element identification by users.

This study used a five point likert scale and these elements were rated to identify their level of importance as an aesthetic element on a university administrative building façade. A questionnaire was administered in line with the listed attributes and refined to reduce the respondents' time. A summary of the scoring is shown in Table 2. The lowest scored formal elements identified by users for a university senate building assessment as presented on Table 3 are railings, services, terrace/balconies with mean scores of 3.15, 3.31 and 3.33, respectively. Elements considered most important by respondents are building shape, façade colour, building height, foreground and fenestration with mean scores of 4.27, 4.18, 4.16, 4.01 and 4.00 respectively. The mean scores and the ranking implies that the respondents identified fenestration as an important façade element in the fifth position.

TABLE 2
DESCRIPTIVE STATISTICS OF ARCHITECTURAL ELEMENT IDENTIFICATION

Factors	Mean	Std. Deviation	Rank
Building Shape	4.27	0.90	1
Façade Colour	4.18	0.99	2
Building Height	4.16	1.00	3
Foreground	4.01	1.08	4
Fenestrations	4.00	1.00	5
Texture	3.83	1.12	6
Entrance Design	3.79	1.14	7
Columns	3.65	1.05	8
Roof shape and/or Parapet wall at roof level	3.63	1.12	9
Screen Walls	3.50	1.11	10
Inscriptions	3.38	1.16	11
Terraces/Balconies	3.33	1.14	12
Services (Ducts, outdoor AC units, pipes)	3.31	1.27	13
Railings	3.15	1.18	14

Further to the identification of architectural aesthetic elements presented in Table 3, the dimensional reduction of the 14 elements to the key elements was considered and a principal component analysis was carried out. A correlation matrix was first carried out on the 14 façade elements and most of the correlations were observed to be above 0.3 which is a good indication that the expected result will be obtained according to Beaumont (2012). The Kaiser-Meyer-Olkin Measure (KMO) indicates a value of 0.864 which is acceptable as it is greater than 0.6. The Bartlett's test of sphericity with an associated p value of 0.000. Factor extraction was done using Varimax Rotation method with Kaiser Normalization was used to identify the dimensions to best represent the set of variables used in identifying the architectural elements.

Using the Factor Analysis extraction method, three main dimensions were extracted as shown in Table 3. Table 3 shows that the total variance accounted for by the four dimensions that have eigenvalue of 1 and approximately 55%. The loadings considered significant were readings above 0.5.

TABLE 3
TOTAL VARIANCE OF COMPONENTS

Total Variance Explained						
	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.971	35.507	35.507	3.313	23.666	23.666
2	1.621	11.579	47.086	2.906	20.758	44.424
3	1.116	7.969	55.055	1.488	10.630	55.055
4	.933	6.662	61.717			
5	.820	5.857	67.574			
6	.747	5.333	72.907			
7	.650	4.645	77.551			
8	.605	4.322	81.873			
9	.551	3.933	85.807			
10	.515	3.678	89.484			
11	.419	2.991	92.475			
12	.381	2.722	95.197			
13	.354	2.527	97.725			
14	.319	2.275	100.000			
Extraction Method: Principal Component Analysis.						

Table 4 presents three dimensions which summarises the identified elements (variables) by respondents. They were named: Primary aesthetic elements, secondary aesthetic

elements and comfort elements.

TABLE 4
PRESENTATION OF RESULT OF FACTOR ANALYSIS

Identification of Architectural Elements on University Administrative Building Façade	Factor Loadings	Eigen Value	% of Variance	Cum' %
Dimension 1: Primary Aesthetic Elements		3.313	23.666	23.666
Building Shape	.761			
Facade Colour	.725			
Building Height	.662			
Foreground (Landscape)	.610			
Fenestration (Doors And Windows)	.591			
Texture	.566			
Roof Shape	.540			
Entrance Canopy/Design	.530			
Dimension 2: Secondary Aesthetic Elements		2.906	20.758	44.424
Roof Shape	.508			
Terrace/Balconies	.808			
Railings	.794			
Screen Walls	.629			
Columns	.629			
Dimension 3: Comfort Elements		1.488	10.630	55.055
Fenestration (Doors And Windows)	.528			
Services (Ducts, Outdoor AC Units, Pipes Etc)	.778			
Inscription	.541			

The primary aesthetic elements have eight out of the 14 variables loading on it. This dimension accounts for about 23.6% of variance in the 14 variables included in the analysis; hence it is the dimension with the highest contribution to the aesthetic perception of the university administrative building in southwest Nigeria. Building fenestration is the third factor loading on this dimension. The second dimension, secondary aesthetic elements have five elements out of the 14 elements loading on it. They account for about 20.7% of variance in the 14 variables and it is the second most important dimension contributing to the aesthetic perception of the university administrative building in southwest Nigeria. The third dimension: comfort elements which are three in number, account for about 10.6% of variance in the 14 variables. The outcome of the factor analysis confirms the importance of fenestration as an aesthetic element in the university administrative building façade.

4.4 Users' Assessment of Fenestrations

The assessment of the fenestration (windows) by respondents was also based on the 5 Likert-type scale rating of not interesting, less interesting, un-decided, interesting and very interesting.. These ratings are presented in Table 5 showing the percentage of rating, mean score for the assessment of building façade images 1 to 10. Also indicated for easy recounciliation are the fenestrations' brief arrangement description for each of the selected university senate building images.

TABLE 5
ASSESSMENT OF FENESTRATIONS

Image	**A**	**B**	**C**	**D**	**E**	**Mean Score**	**Ranking**	**Description**
9	1.7	1.4	8.5	42.3	46.1	**4.30**	1st	US
8	1	2.3	10.1	47.7	39	**4.21**	2nd	US
4	2.3	6.1	9.4	43.8	38.5	**4.10**	3rd	US
7	4.7	5.5	8.3	49.4	32.1	3.99	4th	LA
10	5	8	10.2	40.4	36.4	3.95	5th	SA
6	2.6	6.4	9.7	61	20.3	3.90	6th	US
2	3.5	7.1	16.6	58.6	14.2	3.73	7th	US
3	4.5	15.1	23.4	44.5	12.5	3.45	8th	US
5	5.5	16.1	26.9	39.3	12.1	3.36	9th	SA
1	9.7	23.1	12.5	48.4	6.4	**3.19**	10th	LA

A= Not Interesting, B= Less Interesting, C=Un-decided,
D= Interesting, E=Very Interesting
US= Uniform symmetrical,
LA= Linear asymmetrical
SA=Staggered asymmetrical

Table 5 revealed that images 9, 8 and 4 with mean scores of 4.30, 4.21 and 4.10 respectively were assessed highest by users in appreciation of their fenestration arrangement on their façade as being most interesting. Images 1, 5 and 3 with mean scores of 3.19, 3.36 and 3.45 were rated to be least interesting. Image 9 has almost half of the respondent at 46.1% assessing it as very interesting, with 42.3% assessing it as interesting also. Image 8 has about 39% of the respondent assessing it as very interesting, while Image 4 has 38.9% assessing it as very interesting also.

The three top rated façade fenestration arrangements have two factors in common, which are uniformity and symmetry. The facades have two equal sides and same is reflected in the fenestration arrangement with simplicity and clarity. However, this assertion may not be completely correct as images 2, 3 and 6 have equally uniform and symmetrically configured fenestrations but were rated below the mean score

of 4.00. A further observation of Image 9 as having the most interesting façade fenestration arrangement, in addition to uniformity and symmetry, the WWR is higher in comparison to other facades. The central curvilinear shaped, glaze wall is accentuated by the vertical orientation of the façade with distinct base and shaft typical of tall buildings. The preference of this fenestration arrangement can be linked to the identification of other aesthetic elements such as height, shape, colour and foreground which were considered to be important aesthetic elements in Table 3. In summary, the result shows a high appreciation of fenestration arrangement with close relationship with building height and shape.

5 Conclusion

This study has emphasised the guidelines for designing a sustainable building façade and fenestration perception to ensure the comfort of occupants as well as meeting the aesthetic requirement of the university administrative building façade. A sustainable façade design should be a climatic-based approach. This dictates the material, building orientation and fenestration requirements of the building. In line with the climate-based design approach, the fenestration arrangement best appreciated is a window-to-wall ratio of approximately 4:6, with a vertical symmetrical orientation. In addition, a combination of basic geometric shapes can be added to give the fenestrations form and character. This is a reflection of elements such as height and shape being chosen first as being more important as aesthetic elements. Designers can leverage on these elements to accentuate the fenestration and ensure harmonizing it with a good understanding of the local climate of building location. Furthermore, material specification by designers based on understanding of the immediate and current global climate change is crucial as this will determine the final comfort of occupants, reduced energy consumption and also visual sustainability of this building typology. Further studies can be carried out on the subject of sustainable university administrative façade fenestrations in other geopolitical zones of Nigeria as well as other campus building types for other views.

Acknowledgment

The authors sincerely thank the Covenant University Centre for Research, Innovation and Development (CUCRID), for the sponsorship of this work.

References

[1] Menzel, L. (2012). *Facades: design, construction & technology* (Braun)

[2] Aksamija, A. (2015). High-performance building envelopes: design methods for energy-efficient facades. *In Proceedings of the Building Enclosure Science and Technology (BEST) 4 Conference* (Vol. 12, p. 15). Kansas City, MO: National Institute of Buildings Sciences.

[3] Sachs, J. D. (2015). Achieving the sustainable development goals. *Journal of International Business Ethics*, 8(2), 53.

[4] University of Ibadan (2018). The senate secretariat. Retrieved 17th May 2019 from https://ui.edu.ng/content/senate-secretariat

[5] Pearce, A. R., & Vanegas, J. A. (2002). Defining sustainability for built environment systems: an operational framework. *International Journal of Environmental Technology and Management* **2(1-3)** 94-113.

[6] Nejadriahi, H. (2017). Role of facade in sustainability enhancement of contemporary iranian buildings. *International Journal of Architectural and Environmental Engineering* **11(6)** 729-733.

[7] Aman, J. (2017). Impact of windows for daylighting on thermal comfort in architecture design studios in Dhaka.

[8] Alibaba, H. (2016). Determination of optimum window to external wall ratio for offices in a hot and humid climate. *Sustainability*. ***8*(2)** 187.

[9] Ghomeshi, M., & Jusan, M. M. (2013). Investigating different aesthetic preferences between architects and non-architects in residential façade designs. *Indoor and built environment* **22(6)** 952-964.

[10] Mura, M., & Troffa, R. (2006). Aesthetic, perception and preference for historical and modern buildings. *Cognitive Processing*. **7** 66-67.

[11] Nikolov, A. (2017). Design principle: Aesthetics The power of beauty in design Retrieved 5th May, 2019 from https://uxdesign.cc/design-principle-aesthetics-af926f8f8

[12] Strati, A. (2015). *Aesthetics and design*. The routledge companion to philosophy in organization studies, hugh willmott and michelle greenwood, routledge handbooks online

[13] Mahdjoubi, L., & Wiltshire, J. (2001) Towards a framework for evaluation of computer visual simulations in environmental design. *Design Studies* **22(2)** 193-209.

[14] Sholanke, A. B. (2019). *Compliance of Academic Buildings with Universal Design Parameters in Selected Universities in Ogun State, Nigeria* (Doctoral dissertation, Covenant University, Ota, Nigeria)

[15] Architeacher (2002). l. H. agency, producer, & the center for the study of art and architecture. Retrieved 2017, January from architeacher.org: http://www.architeacher.org/aesthetics/archi-main.html

[16] Casakin, H., & Mastandrea, S. (2009) Aesthetic emotions and the evaluation of architectural design styles. *Int. conf. on engineering and product design education*. University of Brighton. U.K.