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Assessment of Daylighting Strategies in Selected Convention Centres for Improved Sustainability

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Abstract. The study aims to assess the extent to which daylighting strategies are implemented in selected convention centres. The objectives are to identify daylighting strategies utilized in selected convention centres, and evaluate their adequacy. The study focused on convention centres as they are commercial buildings that consume large amounts of energy. Three convention centres were conveniently selected at random in Lagos State, Nigeria due to the easy access for observation. The study used the mixed-method approach. 100 questionnaires were issued to respondents in each centre and 131 were retrieved and used for analysis. The data collected were descriptively analyzed using the Statistical Package for Social Sciences (SPSS), and the results were sorted from the highest to the lowest in terms of their mean item score (MIS), and presented in tables. The sizes and functions of the identified strategies in the case studies were analyzed in relation to standards, and the findings were discussed in relation to other researches. It was revealed that the selected convention centres did not utilize daylighting strategies effectively as they rely largely on artificial lighting. The findings further revealed that daylighting is not very well considered at the conceptualization stage of this building typology. The pieces of evidence show that as the elements in a space are considered, adequate daylight can enter that space and create the potential for energy savings in lighting. Further studies can be carried out in existing convention centres in other developing countries to explore the influence of daylighting on energy savings. This paper provides valuable information on acceptable daylighting strategies based on the observations made which could be incorporated in convention centres from the design stage, and insight into measuring the adequacy of daylighting strategies in convention centres in comparison with other researchers' findings as discussed below.

Keywords: Convention Centres, Daylight, Daylighting, Daylighting Adequacy and Daylighting Strategies.

1. Introduction

The utilization of energy in commercial buildings is a significant contributor to the total global energy demand, and lighting is a majority end user of electricity [1]. Commercial buildings utilize large amounts of energy that comprise 20% of the total energy delivered worldwide [2;3]. A convention centre is a commercial building designed majorly for holding rallies, meetings, and seminars, and can be adapted for particular events such as concerts and conventions. It aims to provide a productive environment for various events by meeting sustainability and energy efficiency standards. [4] revealed that successful centres need to expand to remain competitive while failing centres need added space to succeed based on convention centre myths. With this, it can be deduced that more spaces in a convention centre can lead to more energy consumption if not properly provided according to sustainability standards.

Commercial buildings are major contributors to energy demand [5], with convention centres being a part of this typology, hence daylighting is one technique that can reduce energy usage and improve sustainability. Daylighting is a technique that utilizes natural light to achieve specific lighting effects in the building. It contributes to building energy savings, provides connections to outdoor spaces, and helps to reduce the dependence on artificial lighting [6]. Daylighting can be used in different building types and through various strategies. In art galleries, adequate daylighting serves as both an element of pleasure and an element of pain at



the same time as they tend to interfere with one another because revealing artwork to a source of concentrated light can sometimes affect its eminence [7]. According to [8], daylighting is typically avoided in high-performance houses with atriums due to poor thermal comfort. Among other elements, daylighting is a very crucial factor to consider when designing spaces, especially for learning spaces as noted by [9]. A review of daylighting in schools was carried out by [10] and it was discovered that using daylighting is a complex task where various requisites are to be met, such as sufficient and uniformly distributed illuminance levels at various areas of a class.

There is also the possibility of integrating daylighting with energy-efficient artificial lighting systems, as proven by [11] who evaluated the users' satisfaction with lighting strategies in some art museums in Nigeria. The findings revealed that users were satisfied with the artificial lighting systems rather than the daylighting provided. From the foregoing study, it is discovered that little to no research has been carried out on daylighting strategies in convention centres. With this, the question posed before the research community is why is daylighting not a vital aspect of the design of convention centres? Leaving this question unanswered can lead to a lack of definite understanding of the situation, as utilizing daylighting systems can help reduce energy consumption [12]. However, there is a need for proper knowledge and understanding of daylighting and its strategies and how it can be adequately implemented and utilized in different building types to mitigate the issue of energy consumption. Consequently, this study focuses on assessing the implementation of daylighting strategies using existing convention centres in the selected study area. With this, the objectives are:

- To identify the daylighting strategies utilized in selected convention centres and evaluate their adequacy
- To recommend the approach for implementing daylighting strategies in the design of convention centres.

This paper provides valuable information on universally acceptable daylighting strategies that could be incorporated into convention centres from the design stage. It also provides insight into measuring the adequacy of lighting strategies in convention centres and related buildings, based on universally acceptable benchmarks.

2. Convention Centres

A convention centre is a commercial building that holds massive crowds for events like concerts and conventions. This is one of the major players in the events industry and also in tourism, making important economic contributions and affecting economic activities in its location [13]. The evolving economic conditions and the preference of attendees have both had an impact on the evolution of convention centre design over time. They were much like an amphitheatre, which were large circular spaces that were surrounded by ascending seating [14]. They have been developed into a multipurpose structure with multiple halls for different simultaneous uses including lectures, seminars, and banquets. It was discovered that there are no types of convention centres based on research carried out, however, they can be classified based on regions, which include local, regional, national and international convention centres. [15] identified the features of a convention centre, which include auditorium halls, exhibition spaces, multipurpose halls, recreational spaces, conference spaces, and administrative spaces, with restaurants and galleries. An example of a convention centre is the Shijiazhuang International Convention and Exhibition Centre (SICEC) in Zhengding New District of Shijiazhuang, Hebei, China (Plate 1). The centre has 7 standard exhibition halls and a large multipurpose hall for exhibitions. The spaces are designed as open urban spaces surrounded by no

walls for easy access and movement and have pleasant landscapes to promote people and nature interactions [16].



Figure 1: Aerial view of Shijiazhuang International Convention and Exhibition Centre

3. Daylighting Strategies

[17] noted that light is a medium that shows the eye colour, texture, shape, and space, because there is no vision without it. The sun is the only and ultimate source of daylight, and it comes in the form of direct sunlight and diffused light. The amount of daylight that is available depends on the different sky conditions. An overcast sky produces the brightest atmosphere in an outdoor space; a cloudy sky is produced when there are fluctuations between direct sunlight and diffused daylight; and a clear sky produces the brightest shadow-forming light rays [18]. Daylighting is an important factor to consider in designs today because of its many benefits. For [19], the use of significantly more sustainable and renewable natural resources is central to modern concepts in the field of passive design. With the advancements of technology, daylighting in architecture has become far more sophisticated, enabling more innovative designs [20]. Daylight provides a better lighting environment because according to [21], “daylight...matches the visual response that humans have compared with all other light through evolution.” The absence or presence of natural light can affect how people perceive an area and create intense emotional reactions [22]. On a cloudy day, the inability to perceive the colours from light can influence levels of energy and mood [23].

Top and side-lighting are the two strategies used in the daylighting technique. Light coming from the side of a structure is called a sidelight. It exploits the building's vertical surfaces to let light in. This method has the benefit of providing ventilation and a variety of views of the external environment. When lighting a room from just one side, attention must be considered to balance the opening's size, shape, and placement in relation to both the interior and the exterior of the structure [24]. Using apertures like skylights, light pipes, and clerestories is the method known as top-lighting. It is situated atop the building's roof. Its benefit is that it can be used in a flexible manner because it isn't limited by wall orientation. It also aids in reducing the electricity utilized by artificial lighting. [25] postulated that if skylights are installed properly in various kinds of building climates and typologies, the energy consumption of lighting annually might be reduced by 35% to 55%. Figure 1 shows how the daylighting strategies function in a building.

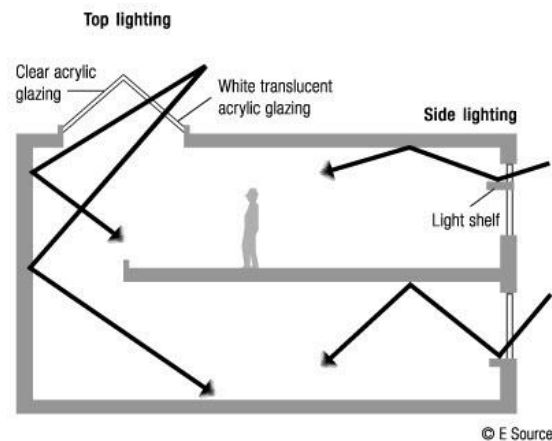


Figure 2: Various Daylighting Strategies

Daylighting is a technique that requires strategies to perform, and these strategies have elements that they utilize to create adequate indoor environmental quality. The elements include windows, light pipes (Plate 2), light wells, clerestories, skylights, and light shelves (Figure 2). In a study by [26], the structures identified for daylighting in a room are skylights, light pipes atria, light wells, domes, and windows which are traditional solutions. Approaches are another thing to consider when constructing daylighting. This deals with considering the building site and orientation on the site, building area and shape, a room's geometry, the location and size of openings (Figure 3), internal and external reflected surfaces (Figure 4), and shading devices. An example of one of these approaches can be found in a study carried out by [27] on the passive design strategies used in the hostel buildings at Covenant University, Nigeria. It was revealed that the building shape and orientation were considered to provide adequate natural ventilation, which was used to minimize heat gain and solar glazing from daylighting.



Figure 3: How light pipes light a space in a building (left)

Figure 4: A light shelf pulling daylight deeper into the room (right)

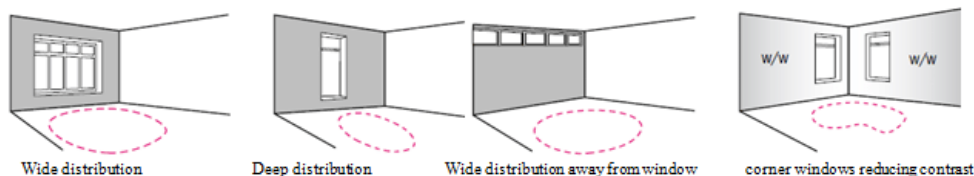


Figure 5: How the shape, size and position of windows affect the way in which daylight is distributed within the interior space

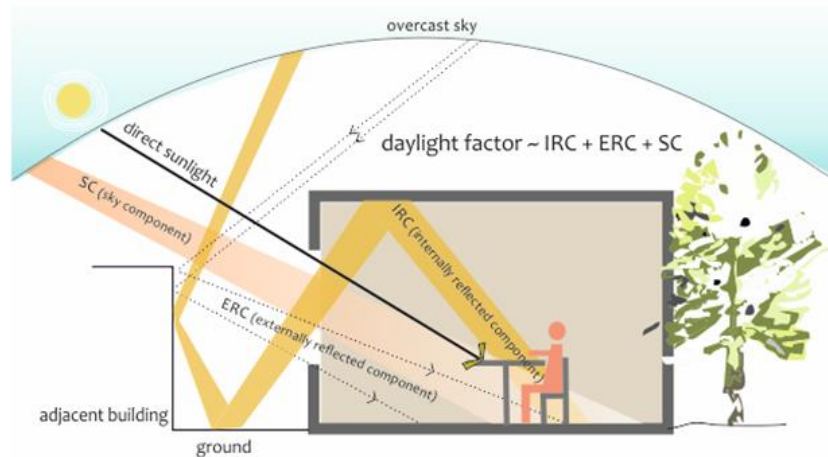


Figure 6: Daylight factor components in an occupied space

Daylighting can be a major contributor to the decline in energy consumption. Convention centres as commercial buildings are examples of large energy consumers, one of the major causes being lighting. Without adequate knowledge and skill in lighting and building typology design, one would fail to achieve an energy-efficient design. Convention centres usually utilize artificial lighting such as fluorescent and LED light fixtures. However, this can be improved by introducing daylighting strategies like top lighting (skylights). [28] pointed out that some venues use translucent panel systems, which are perfect for convention centers since they evenly distribute daylight throughout enormous indoor spaces. Both advantages and disadvantages come with daylighting. For designers, striking a balance between heat gains and daylighting can be challenging [29;30]. To prevent direct glare, brightness contrast must also be optimized. Keeping a balance between energy optimization and user comfort is the key issue facing modern energy optimizers [31]. These challenges can be overcome with proper installation skills to optimize daylighting benefits. Based on the study of [32], it was discovered that the use of domes, atriums, clerestory windows, anti-solar windows, and light pipes were most adequate for daylighting and energy efficiency optimization.



Figure 7: Fluorescent lamps (left)



Figure 8: LED lights (right)

4. Research Methodology

This study was conducted in Lagos State, Nigeria. The number of convention centres cannot be discovered as there are no proper records of this building type in the state. However, three convention centres were conveniently chosen as the target population to represent the total convention centres in the state. The centres were chosen as case studies because they are one of the state's most popular centres [33;34]. The study used the mixed method to quantitatively collect data by issuing questionnaires to the selected case studies, and qualitatively observing the selected centres. The users of these centres were chosen as respondents and were issued the questionnaires. These users were in two categories; the staff and visitors. Lagos State was chosen for this study because it has one of the largest populations in the country. The case studies used an observation guide to analyze the adequacy of the available daylighting strategies identified in the literature review. Through a convenient purposive sampling method, 300 (three hundred) questionnaires were administered to the respondents and 131 (one hundred and thirty-one) were retrieved. This study used convenient random sampling because it was easier to select 100 (one hundred) respondents each due to the difficulty in determining the actual number of users of each centre. It is easier to collect samples conveniently located around a location or internet service [35]. The questionnaire was designed into two sections: a 3-point Likert scale using Not Available=1, Not Sure=2, and Available=3; and a 5-point Likert scale using Not Adequate=1, A little adequate=2, Undecided=3, Somewhat Adequate=4, and Very Adequate=5. The respondents were also asked questions about their sex, age, marital status, and the convention centres they visited. After computation using the IBM Statistical Package for Social Sciences (SPSS), the results were sorted from the highest to the lowest in terms of their mean item score (MIS). Means are significant in descriptive research as they reveal the average respondent score on a given measure [36]. The study adopted descriptive statistical tools to analyze how the respondents rated various questions in the survey. This helped assess the adequacy of the identified daylighting strategies in the selected convention centres.

5. Research Results

5.1 Case Studies

In assessing the cases, the identified daylighting strategies used were windows, shading devices (blinds), louvres, light wells, light shelves, and light pipes.

i. Landmark Centre, Lagos, Nigeria

The Landmark Centre is situated at Victoria Island, the centre of the thriving Lagos business area, and on the grounds of Landmark Village (Plate 5), a stunning beachfront location overlooking the Atlantic Ocean. It features a distinctive location that gives the ideal setting for a variety of events, including exhibits, conferences, live events, product launches, tradeshows, concerts, and weddings, when combined with the centre's well-established commitment to environmental sustainability. The centre is comprised of three main halls, each space can be sub-dividable and configured into separate venues for banquets for conferences, and smaller exhibitions. The daylighting strategies available are the tinted curtain walls at the entrance of the building which do not provide light or ventilation (Plate 6), and large drapes that cover the curtain wall (Plate 7).



Figure 9: Landmark Centre (right) in Landmark Village



Figure 10: Entrance of the building showing the tinted curtain walls (left)

Figure 11: Interior view of the hall showing the drapes covering the curtain walls (right)

ii. The Civic Centre, Lagos, Nigeria

The Civic Centre represents Lagos as the Centre of Excellence and is a major landmark (Plate 8). Among other activities, it hosts luxurious special occasions, exclusive conferences, seminars, culturally immersive art exhibitions, and one-stop shops. Since Lagos' Victoria Island enjoys a warm, sunny temperature throughout the year, the building's design was specifically adapted to the local climate. Floor-to-ceiling windows are the daylighting strategies available in this building. They come in the form of a large curtain wall that provides adequate daylight in the conference hall and in the form of narrow windows that provide insufficient daylight for certain areas of the building but are supported with artificial lighting (Plates 9 and 10). The building also uses its east-west orientation to provide shade against the Northern midday sun.



Figure 12: The Civic Centre, Lagos, Nigeria



Figure 13: Narrow floor-to-ceiling windows

iii. LCCI Conference and Exhibition Centre, Lagos, Nigeria

The Lagos Chamber of Commerce and Industry (LCCI) Conference and Exhibition Centre is used as a multilevel training facility for seminars and other kinds of events (Plate 11). Used mostly for official purposes such as trade shows, conferences, seminars, exhibitions, and training, the centre can accommodate about 500 people. Its features include fully air-conditioned conference rooms and office space, supporting facilities and equipment such as P.A. systems, projectors and screens, furniture, etc. The windows in the centre provide natural light and ventilation and it is complemented with artificial lighting (Plate 12).



Figure 14: LCCI Conference and Exhibition Centre (left)

Figure 15: A room in the building with natural and artificial lighting (right)



Figure 16: A small office providing daylight to work surfaces

5.2 Questionnaire

This section provides the results of the survey conducted. A structured questionnaire was issued to 300 respondents, 100 from each case study. Out of 300, 131 responses were returned and analyzed using Statistical Package for Social Sciences (SPSS). Table 1 below shows the results of the user's responses about their sex, age, marital status, and visited convention centres. The results of Table 2 show that most respondents identified windows as the most available and the most adequate based on their comfort. The results were analyzed by sorting them from the highest to the lowest in terms of their mean item score (MIS) to check the rating of the responses. The respondents identified blinds as the second most available and adequate. Louvres came next to the blinds in terms of both availability and adequacy, putting light wells, light shelves, and light pipes at the bottom of the list in terms of both availability and adequacy.

Table 1: Analysis of the Socio-demographic characteristics of the respondents

Variable	Categories	Frequency (N=131)	Percentage (%)
Sex	Male	87	66.4
	Female	44	33.6
Age	18-22	32	24.4
	23-27	36	27.5

	28-32	15	11.5
	33-37	16	12.2
	38 and above	32	24.4
Marital status	Single	65	49.6
	Engaged	14	10.7
	Married	52	39.7
	Separated	0	0
	Divorced	0	0
	Widowed	0	0
Convention centre visited	The Civic Centre	52	39.7
	Landmark Centre	45	34.4
	LCCI Conference and Exhibition Centre	34	26.0

Table 2: Analysis of Availability and Adequacy of Daylighting Strategies in Selected Case Studies

Daylighting Elements	No. of Respondents (131)		Mean	Standard Deviation	Rank
	Valid	Missing			
Availability					
Windows	131	0	2.618	0.6258	1 st
Blinds	131	0	2.534	0.6939	2 nd
Louvres	131	0	2.260	0.6860	3 rd
Light Shelf	131	0	2.229	0.7078	4 th
Light Wells	131	0	2.198	0.7170	5 th
Light Pipes	131	0	2.122	0.6327	6 th
Adequacy					
Windows	131	0	3.786	1.2216	1 st
Blinds	131	0	3.603	1.1346	2 nd
Louvres	131	0	3.260	1.2063	3 rd
Light Wells	131	0	3.198	1.2491	4 th
Light Shelf	131	0	3.031	1.2212	5 th
Light Pipes	131	0	2.924	1.1410	6 th

6. Discussions

The study focuses on assessing the implementation of daylighting strategies using existing convention centres in the selected study area, Lagos State, Nigeria. Daylighting is crucial to sustainability and energy efficiency. The results from the questionnaire show that windows, ranked 1st, are widely known and commonly used in this building type. This can be seen in case studies (ii) and (iii) as they utilized windows to provide enough daylight into each space and exterior views. The findings align with [37] that vertical windows on the side offer visual contact to exterior space compared to top-lighting, as seen in Figure 13 while minimizing the amount of glazing on the building, which helps to reduce heat gain. [37] also concluded that side windows are recommended to be higher to allow daylight transmittance into the depths of a room.

The findings also show that curtain walls are used in place of windows, which is seen in case study (i) (Figure 12). Curtain walls are commonly used to provide adequate daylight and a direct connection to exterior environments. However, they can also allow negative effects like heat gains and glare due to the high specular reflections, especially in dense environments [38]. Case study (i) made use of tinted curtain walls, which hinders this negative effect but greatly limits the amount of daylight that entered the building. This finding aligns with the notions of [28] on event centres adopting translucent panel systems as the centre majorly used artificial lighting and large drapes to cover the curtain wall, creating an aesthetic atmosphere in the halls, as seen in Figure 13. [39] found that because daylight enters the workspace through windows, rooms that are wider and smaller have greater potential for energy savings in lighting. This happens as a result of the smaller rooms having a higher window-to-floor ratio. This can be seen in case study (iii) as the rooms are small and have a large width, making the windows provide daylight to the work surfaces in the space, as seen in Figure 16.

From the study's findings, it was deduced that light walls, light pipes, and light shelves are uncommon with building users in this part of the country, putting them at the bottom of the list. However, just because they are uncommon does not mean they are inadequate for use in this building type, as strategies like light shelves have been agreed to be suitable solutions for controlling daylight in side-lit spaces [23]. Hence, as these elements are to be implemented, they must be properly studied, understood, and installed with the right skill to achieve an adequate and functional result. This study leads to further research, which can be on the user's comfort and satisfaction levels with the daylighting strategies of various building types.

7. Conclusion and Recommendation

The study looked at daylighting and its strategies, and some approaches to designing for daylighting. It also studied the features of convention centres, existing convention centres as case studies, the available daylighting strategies in the case studies and their adequacies. The elements of daylighting strategies used for the case studies were windows, light shelves, light pipes, light wells, louvres and blinds as shading devices. To conclude the study, it is seen that:

- Daylight is an important aspect of design, construction and sustainability.
- Large commercial buildings like convention centres use a lot of energy for their HVAC and lighting systems.

- Taking the daylighting technique into the field can lower energy usage and increase sustainability.
- Many daylighting strategies were absent in the selected case studies, and curtain walls and windows were commonly used, which could be due to not considering daylighting at the conceptual stage of the building design.
- Many convention centres do not utilize the technique of daylighting as they largely depend on artificial lighting and ventilation systems because of the large number of users of the buildings.

Daylight can be applied in various ways and in different building types. The pieces of evidence noted by [28, 37, 39] show that as the elements in a space are considered, along with the window-to-floor ratio, adequate daylight can enter that space and create the potential for energy savings in lighting. The building type also determines the size and shape of the daylight element. Hence, it is advised that to apply this technique appropriately in convention centres and other building types, designers should be aware of and understand it, thereby reducing energy consumption and improving sustainability. One implication of the study is that the results found can be implemented when designing convention centres in other states in Nigeria with careful consideration. To include daylighting into modern design, additional research on how it affects user comfort in various building types can be conducted.

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