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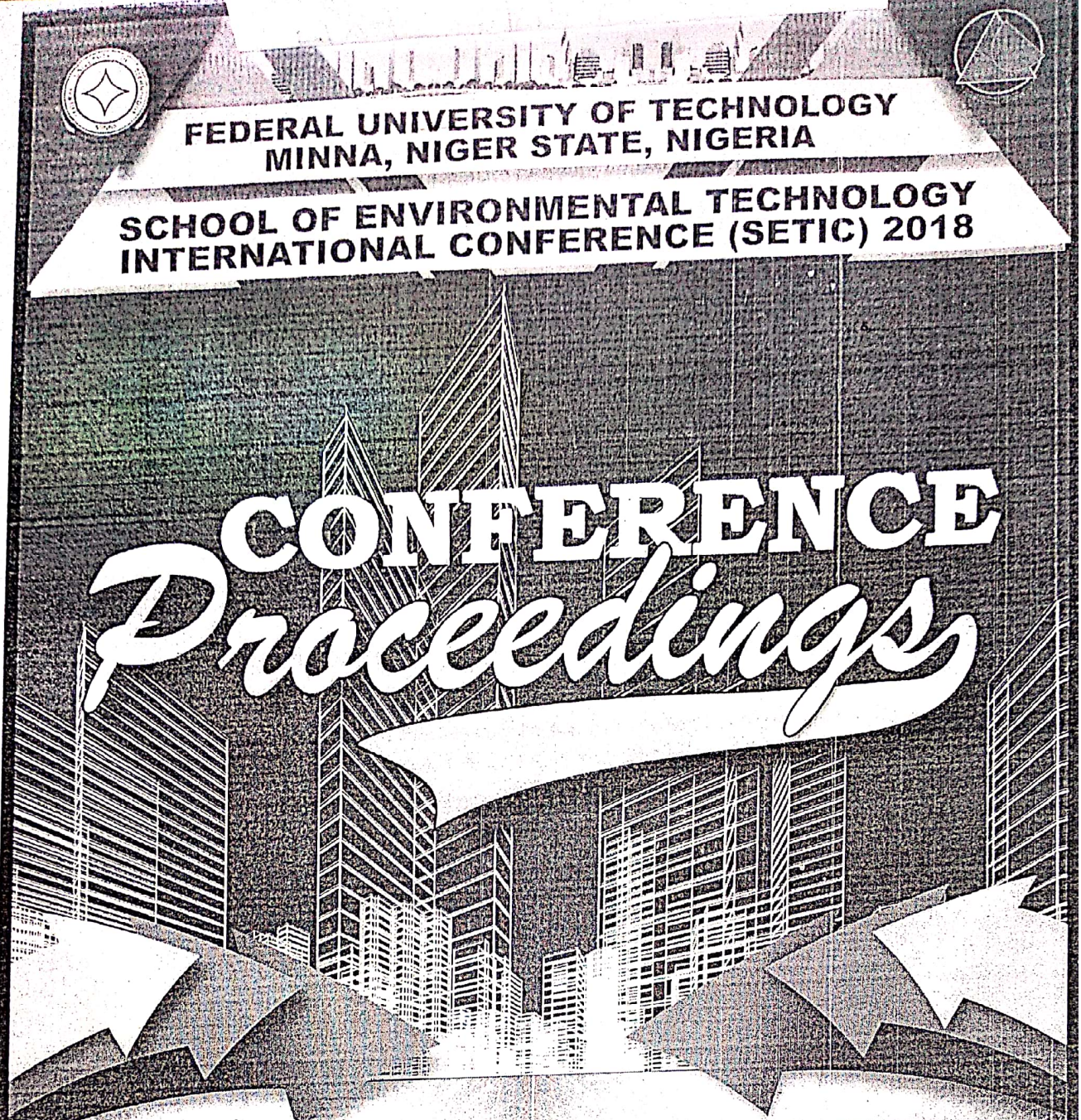

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CONTEMPORARY ISSUES AND SUSTAINABLE PRACTICES IN THE BUILT ENVIRONMENT

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EVALUATION OF NATURAL LIGHTING AS A SOLUTION TOWARDS ACHIEVING SUSTAINABILITY IN THE DESIGN OF SHOPPING MALLS IN F.C.T ABUJA MUNICIPAL AREA

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The philosophy of natural lighting in buildings' interiors is a significant development in the transition to sustainable buildings. Natural lighting enhances human and environmental sustainability by providing healthier interior spaces and reducing the demand on non- renewable sources of energy. This study assessed natural lighting in ten shopping malls within the Municipal Area of the F.C.T of Abuja. The methodology adopted to carry out this research was a descriptive survey method with the use of questionnaires and structured observation schedules. These were used to obtain knowledge on the source of power supply and assess the design features that were integrated to achieve natural lighting in each shopping mall. Data collected were analyzed by simple descriptive analysis with the use of statistical figures in the form of percentages. Tables were used to visually display the extracted data from the research instruments. The results from this research showed that the major source of power supply was from PHCN. Diesel generators were used as an alternative source of power supply when there was power interruption. This indicates that most shopping malls in the Municipal Area of F.C.T of Abuja, depends largely on electricity from PHCN and non- renewable sources of energy. The results of the evaluation carried out in the ten shopping malls revealed that although fenestrations were integrated in all the shopping malls, natural lighting was inadequate due to; the number of these fenestrations was relatively small when compared to the overall building envelope. Generally, efforts have been made so far to achieving natural lighting in shopping malls. However, there is more to be considered in order to maximize the efficacy of natural lighting. It is hoped that the outcomes from this research provides relevant information and direction for designers on the possibilities of maximizing natural lighting in shopping malls.

Key words: Buildings' interiors, Natural Lighting, Shopping Malls, Sustainability

INTRODUCTION

Prior to the invention of artificial lighting, natural lighting was the primary source of illuminating buildings' interiors. With the advent of electricity, artificial lighting gradually took partial or virtual dominance in illuminating buildings' interiors, consequently increased electrical costs (Brain, 2015). This alongside other non- sustainable building practices especially in the building sector- as they are significant consumers of energy- has led to severe environmental, economic and human detriments through increased greenhouse gas emission, and carbon dioxide (IEA, 2013). The relationship of sustainability and the building sector is best understood by considering the concept of sustainability in broadly two aspects; human and environmental sustainability. Human and environmental sustainability can be achieved by the optimization of passive design strategies. Natural lighting is a passive design strategy that utilizes natural light to illuminate buildings' interiors thereby providing healthier and comfortable interior spaces and reducing the demand on nonrenewable sources of energy (Modscape, 2015). The aim of this research is to evaluate natural lighting as a solution towards achieving human and environmental sustainability in the design of shopping malls.

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Light has been vital to the livelihood and activities of mankind. The perception of natural lighting has evolved over time, from the earliest ancient cave dwellers who experienced day light initially merely as sunrise and its fading away as sunset; to the times when crude openings were introduced in buildings transmitting day light along with heat, cold, and air; to mankind devising a means to cover these crude openings particularly during the pre-sixteenth century, in order to protect the interior spaces against adverse weather conditions with the use of thin slabs of marble, sheets of mica or oiled paper and later shutters that could be opened and closed as when required; to the use of small panes of glass during the roman period and; larger panes of glass during the seventeenth century (WDC, 2007).

The history, evolution and development of windows is synonymous to the history of natural lighting; consequently architecture. Glass which replaced marble, mica, thatch and paper was discovered as early as 3000BC in Egypt and were used mainly for ornamental purposes such as beads, until the roman period where small panes of glass quarrels were used as window openings. Subsequently, during the seventeenth century, larger panes of glass were developed in England which helped to provide advanced fenestration possibilities. Over these periods, the nature of windows informed the appearance of buildings. For instance, during the mediaeval periods, the shape and location of the windows were functionally related to the role played by natural lighting, however; during the renaissance period, window placement was primarily based on the external appearance of buildings, as its seen even today (Phillips, 2004).

The growth of the workplace in the nineteenth century influenced the increasing need for more adequate lighting requirements which was partly solved by providing long horizontal windows, there by leading to higher floor to ceiling depth, consequently; uneconomical space utilization. The need to ensure more economical space utilization led to reduced ceiling heights, and reduced natural lighting in buildings' interiors. The pressure to effectively and adequately illuminate building interiors came from utility companies who saw this as an opportunity to encourage the marketing and sales of artificial and electrical means of lighting in the early twentieth century. Soon, artificial illumination replaced natural lighting and windowless factories and schools were constructed (Brain, 2015).

Meanwhile, the threat posed by energy crisis and substantial petroleum shortages (Macalister, 2011) in the 1970s motivated people to consider alternatives to interior illumination other than artificial means and natural lighting was one of the obvious alternatives towards achieving sustainability. In addition to the economic advantage of the optimization of natural lighting in buildings interiors, natural lighting has positively affected the education, health, and commercial sector- where it has been properly applied. A number of studies have proven that natural lighting leads to increased productivity by workers; higher class grades by students; quicker recovery of patients and the prevention or treatment of rickets- due to the presence of vitamin D in sunlight, seasonal affective disorder, hypertension and circadian rhythm disorders; and also enhances attractiveness and increased sales in shopping centers and malls (Edwards et al, 2002, Wymelenberg, 2014, Dodson E.R, 2010, Brain, 2015).

Successful and effective natural lighting, involves the holistic consideration of; the orientation of buildings with respect to the site; the size and type of fenestrations; the function of a space; the use of solar control or remediation devices and daylight responsive electrical lighting controls; the type of interior finishes to be installed and position of interior partitions (Ander, 2016). Despite the additional cost to the technology of natural lighting by these considerations, there has still been significant reduction in electrical bills, ranging from 15 to 40% in buildings where natural lighting was employed thereby contributing to sustainability (Facilitiesnet, 2009).

Sustainability and Buildings

Buildings have a significant impact on the natural environment and its inhabitants as they; consume resources, generate waste, discharge harmful atmospheric emissions and alter the function of land, as such, builders, designers, and users are constantly faced with the challenge of designing, and constructing buildings that are healthy, safe and comfortable while minimizing any negative effects on the environment and the economy (WBDG, 2017). OECD Project, defined sustainable buildings as those buildings that have minimum adverse impacts on the built and natural environment, in terms of buildings themselves, their immediate surroundings and the broader regional and global setting. Furthermore, according to, Paola Sassi (2006), the two main aims for sustainable architecture design are;

1. Sustainable buildings should minimize environmental impacts associated with their construction, usage or operation and degradation or disposal
2. Sustainable buildings should positively contribute to their social environment by meeting the needs of its inhabitants and enhancing the physical and psychological well-being of its inhabitants.

Summarily, minimizing environmental impacts of buildings without considering its psychological and physical conformability and receptiveness by its inhabitants is a waste of resources and a detriment to the community (Gander, 2016). Hence sustainability in buildings is a holistic approach that aims to create environmentally responsible buildings that also meets the needs of its inhabitants.

Natural lighting technology and design philosophy

A number of studies have shown that effective natural lighting in buildings can be achieved using the following technology and design philosophies (Ander, 2016, Lyons, 2013, ECBCS, 2010)

High performance glazing system

Contrary to the historical use of glass as windows to allow air and light, recent design complexities and differing needs of different designs, has led to the innovation of high performance glazing systems to meet these distinct and varying needs of clarity and view, thermal performance, occupant comfort, and aesthetics (Arsenault, 2016). To achieve natural lighting, the concept will be to carefully choose a high performance glazing system that will prevent or allow heat- depending on the climatic condition while enhancing clarity and light transmittance (Ander, 2016). This can be achieved through spectrally- selective films with double or triple panes. High performance glazing systems are sustainable because they improve the energy performance of buildings by reducing energy consumption and lowering carbon dioxide emissions.

Exterior Shading devices

Exterior shading devices helps to control and diffuse natural light in buildings' interiors, and also prevent the effect of glare on occupants. This often leads to user satisfaction and increased productivity. Examples of such devices are light shelves, overhangs, horizontal louvers, vertical louvers, and landscape features (Prowler, 2016). The position of windows on a building determines the kind of shading device best suited for it. While overhangs, horizontal louvers, and trellis over windows are more suitable for south windows; vertical louvers, horizontal slats, and deciduous trees are more suitable for east/ west facing windows. Additionally, shading devices are not necessarily needed on north facing windows (Brown, 2017)

Daylight redirection devices

Daylight redirection devices helps to transmit light deeper into a space. There are two kinds of redirection devices; light shelves and baffles. A light shelf is a horizontal slat integrated in a window and divides it into a view area on the bottom and a day lit area above eye level. They serve basically two functions, as a shading device for the part of the window below, while bouncing the light upward to improve light distribution and penetration and prevent glare effect on users. When light shelves are oriented vertically, they are known as baffles. (Sustainability Workshop, 2017)

Skylights

Skylights if properly installed are energy efficient devices for effective users' comfort and illumination of buildings' interiors. Unlike vertical windows, they admit more light and distribute it evenly. They come in different types and configuration depending on the design requirements of functionality, aesthetics or performance (Lyons, 2013).

Reflectance of room surfaces

Reflectance values of room surfaces significantly impact daylight performance and transmittance, therefore should be kept as high as possible. It is desirable to keep ceiling, walls and floors reflectances, over 80%, over 50% and around 20% respectively (Ander, 2016).

Tubular daylight devices

Tubular daylighting devices (TDD) are used to collect and channel natural light through the roof of a building into interior spaces. They economically admit light into areas of a building that has no windows or skylight. TDD typically consist of three parts: a collector on the roof to gather sunbeam light and diffuse skylight, a hollow pipe to channel the light down and a diffuser at a ceiling level to spread the light. A typical device can illuminate an area of 14 to $28m^2$. The area coverage is dependent on the floor to ceiling depth, the higher the ceiling; the more widely the light will be uniformly distributed (Laouodi et al 2014).

Natural light responsive electric lighting controls

Natural light responsive electric controls should be integrated with the use of natural light for natural lighting in interior spaces to be effective. These natural light responsive electric lighting controls sense the availability of natural light and moderates, either by reducing or in some cases switching off the artificial lights according to the amount of natural light available. The types available are switching controls, stepped controls, and dimming controls (Ander, 2016).

Open Spaces

The atrium and courtyard are typical examples of central open spaces in building interiors. They help to enhance sustainability by naturally illuminating building interiors (WBDG, 2017). An atrium is an open- air or skylit court space. The types of atria configuration are: centralized, semi- enclosed, attached and linear (Hung, 2003). Courtyards can be defined as an enclosed area surrounded by walls or buildings and open to the sky. The configuration of courtyards can be in U, L, T or Y depending on the design (Almhafdy, 2013). They also enhance visual connectivity with the exterior environment.

RESEARCH METHODOLOGY

The research methodology employed was descriptive survey method with the use of questionnaires and structured observation schedules. A total of ten shopping malls within the Municipal Area of the F.C.T of Abuja were assessed. Elements were drawn into the sample using convenience or accidental non probability sampling. This was because some shopping malls were not willing to disclose vital information needed for the research. Ten questionnaires were administered to the management of each shopping mall, to obtain information on the source of power supply in each shopping mall. Structured observation schedules were used to assess the natural lighting features that were integrated in the design of each shopping mall. The data collected were analyzed by simple descriptive analysis with the use of statistical figures in the form of percentages obtained from the crunched data which was computed and tabulated in Microsoft Excel Spread Sheet Program. Tables were used to visually display the extracted data from the data gathering instruments. The shopping malls that were assessed are listed in Table 1.0 below:

Table 1.0: List of shopping malls assessed

S/No	Name of Shopping Mall in Abuja
1	Novare Gateway Mall Lugbe Airport Road
2	Jabi Lake Mall Bala Sokoto Way Jabi
3	Silverbird Entertainment Centre, C.B.D
4	Next Cash and Carry Bannex- Gwarimpa Express Way, Kado-Kuchi
5	Park n Shop Aminu Kano Crescent Wuse 2
6	Metro Plaza Zakaria Maimmalari Street C.B.D
7	Ceddi Plaza Tafawa Balewa Way C.B.D
8	Sahad Stores Tafawa Balewa Way C.B.D
9	Exclusive Stores Ademola Adetokunbo Crescent Wuse 2
10	Rock of Ages Mall Obafemi Awolowo Way Utako

FINDINGS AND DISCUSSION OF RESULTS

The results obtained using observation schedules were recorded using the following representations:

- \- Not available
- ✓ Available

Table 2.0: Source of power supply in the shopping malls

S/ No	Name of mall	Source of power supply				
		PHCN	Solar power	Hydro-electric power	Wind turbines	Diesel Generator
1	Novare gateway mall	✓	-	-	-	✓
2	Jabi lake mall	✓	-	-	-	✓
3	Sliverbird entertainment center	✓	-	-	-	✓
4	Next cash and carry	✓	-	-	-	✓
5	Park n shop	✓	-	-	-	✓
6	Metro plaza	✓	-	-	-	
7	Ceddi plaza	✓	-	-	-	
8	Sahad stores	✓	-	-	-	✓
9	Exclusive stores	✓	-	-	-	✓
10	Rock of Ages Mall	✓	-	-	-	✓
	Total	100%		Total		100%

Findings on Table 2.0 shows that the major source of power supply in all the ten shopping malls is from PHCN, while the alternative source of power supply used when there's no light from PHCN are diesel generators. This indicates that the shopping malls assessed, depends largely on electricity from PHCN and non- renewable sources of energy.

Table 3.0: Natural Lighting Design Features

S/N	LIST OF SHOPPING MALLS	EXTERNAL SHADING DEVICES	CLERESTORIES	WINDOWS	OPEN SPACES	SKYLIGHTS	TOTAL
1	Novare Gateway Mall	-	-	✓	-	-	20%
2	Jabi Lake Mall	-	✓	-	-	-	20%
3	Silverbird Entertainment Centre	-	-	✓	-	-	20%
4	Next Cash and Carry	-	-	-	-	✓	20%
5	Park n Shop	-	✓	✓	-	-	40%
6	Metro Plaza	-	-	✓	✓	-	40%
7	Ceddi Plaza	-	✓	✓	✓	✓	80%
8	Sahad Stores	-	✓	✓	✓	-	60%
9	Exclusive Stores	-	✓	✓	-	-	40%
10	Rock of Ages Mall	-	✓	✓	✓	-	60%
	Total	0%	60%	80%	40%	20%	

The results on Table 3.0 show that although there are fenestrations in all the ten shopping malls assessed, shading devices or light redirection devices were not integrated in all the designs. Seven of the ten shopping malls had below 50% of the variables that were assessed in each shopping mall. This indicates that generally efforts have been made so far to achieve natural lighting in shopping malls. However, there's still more to be considered in order to maximize the efficacy of natural lighting.

Table 4.0: Position of clerestories

S/ No	Name of Mall	Position			
		Supermarket	Individual Shop Units	Staircases	Other Spaces
1	Jabi Lake Mall	-	-	-	✓
2	Park n Shop	✓	-	✓	-
3	Ceddi Plaza	-	-	-	✓
4	Sahad Stores	-	✓	-	-
5	Exclusive Stores	✓	-	-	-
6	Rock of Ages Mall	-	✓	-	-

Table 4.0 displays the position of clerestories within the shopping malls. Park n shop and Exclusive stores had clerestories in the supermarket areas. This is a fenestration design possibility that allows natural light into supermarkets where stalls would otherwise obstruct the entry of natural light through windows. Jabi Lake mall had clerestories above the individual shop units. The natural light transmitted through the clerestories contributes to the overall interior environment lighting. Ceddi plaza had clerestories at relaxation spaces while Sahad Stores and Rock of Ages Mall had clerestories at each individual shop units.

Table 5.0: Position of windows

S/ No	Name of Mall	Position			
		South	East	West	North
1	Novare Gateway Mall	✓	✓	-	-
2	Silverbird Entertainment Center	✓	✓	✓	✓
3	Park n Shop	✓			
4	Metro Plaza	✓	-	-	✓
5	Ceddi Plaza	✓	✓	✓	✓
6	Sahad Stores	✓	✓	✓	✓
7	Exclusive Stores	✓	✓	✓	✓
8	Rock of Ages Mall	✓	✓	✓	✓

Table 5.0 displays the position of windows within the shopping malls. In all the eight shopping malls listed above, shading devices or light redirection devices were not used to control natural light especially on the east and west facing windows.

Table 6.0: Description of open spaces

S No	Name Of Mall	Open Space		Nature of Atrium			Configuration of Courtyard				Total Number Available
		Atrium	Courtyard	Centralized	Semi Enclosed	Attached	Linear	O	C	L	I
1	Metro Plaza	✓		✓							1
2	Ceddi Plaza	✓		✓							2
3	Sahad Stores	✓	✓	✓					✓		2
4	Rock Of Ages Mall	✓	✓		✓				✓		2

Table 6.0 shows the description of open spaces within the shopping malls. In all the four shopping malls listed above, the atria and courtyards helps to transmit natural light into the building interiors or spaces where they are integrated. In Sahad Stores, some the artificial lights on the passage surrounding the courtyard and relaxation spaces were switched off. In Ceddi Plaza, the artificial lights where one of the atria is located were all switched off.

Table 6.1: Position of atrium

S/ No	name of mall	Position of atrium		Total Number Available
		Relaxation Spaces	Circulation Space/ Centralized	
1	Metro Plaza	✓	✓	1
2	Ceddi Plaza	✓	✓	2
3	Sahad Stores		✓	1
4	Rock of Ages Mall		✓	1

Table 6.1 displays the position of Atrium in the four shopping malls where it was integrated.

Table 6.2: Position of courtyard

S/ No	Name of Mall	Position of Courtyard		Total Number Available
		Relaxation Spaces	Circulation Space/ centralized	
1	Sahad Stores		✓	1
2	Rock of Ages Mall		✓	1

Table 6.2 displays the position of Courtyard in Sahad Stores and Rock of Ages Mall.

SUMMARY OF FINDINGS

The results of the evaluation carried out in the ten shopping malls reveals that although fenestrations are integrated in all the shopping malls, natural lighting is inadequate due to; the number of these fenestrations are relatively small when compared to the overall building envelope. Additionally, skylights are not integrated in the design of 80% of the malls assessed as such natural light is only transmitted through vertical fenestrations while none comes in from horizontal fenestrations. The vertical fenestrations alone are limited as they do not give even distribution of natural light as much as horizontal skylights. Generally, it is observed that there is high demand and use of artificial light in shopping malls, as natural light is used alongside artificial lights or for emergency lights when there is power interruption, and in some cases, it is completely shut out in spaces where there are no fenestrations at all.

RECOMMENDATION

Stake holders, design professionals, developers, building owners and users are all responsible for human and environmental sustainability, during the design, construction, and operation phases of Shopping malls and buildings in general. First and foremost, buildings should be designed with respect to the micro climate to take advantage of the maximum available light so as to minimize electrical bills. Uncontrolled natural light results to excessive brightness and heat transmission into buildings' interiors as seen in some of the selected shopping malls. As such, the negative effects of excessive brightness and heat transmission in interior spaces that comes with natural light should be remedied with; shading devices, and light redirection devices like light shelves. Building orientation should allow for north and south facing glass while minimizing east and west facing glass. High performance glazing systems should be used instead of the common single glazing, as they help to satisfy differing needs of different designs as regards aesthetics, thermal performance, view, occupant comfort and environmental sustainability. Clerestories should be used in areas where obstructions would block the entry of lights through windows. This should especially be integrated in spaces like supermarkets, where stalls are used. Given the health benefits of natural light, light tubes should be used in spaces that are surrounded by other functions and are difficult to position fenestrations.

CONCLUSION

Natural lighting in buildings enhances human and environmental sustainability through improving and maintaining human health and reducing the exploitation of non- renewable

resources. As such, the philosophy of natural lighting if properly employed is a significant contribution to the transition to sustainability in the building sector, and world at large.

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