PalArch's Journal of Archaeology of Egypt / Egyptology

Concise Elements Model for Enhancing Visual Comfort in Malaysia Single Office Space

Mohamed Ahmed Said Mohamed[1a&b], Yakubu Aminu Dodo[2c&d], Fatima Baba Ciroma[3e] & Abubakar Yahaya Muhammad[4f]

[a]Architectural Engineering Department, College of Engineering, the University of Hail, Saudi-Arabia,
[b]Architecture Department, College of Architecture and Planning, Sudan University of Science and Technology Khartoum, Sudan
[c]Department of Architecture, Faculty of Architecture and Engineering, Istanbul Gelisim University, 34310 Istanbul Turkey
[d]The Community Planning & Design Initiative Africa, 30068 Atlanta, Georgia, USA
[e]Department of Architecture, College of Environmental Studies, Kaduna Polytechnic, Kaduna Nigeria
[f]Department of Architecture, Abubakar Tafawa Balewa University Bauchi, PMB 0248, Nigeria
mo.said@uoh.edu.sa yadodo@gelisim.edu.tr ciromafb@gmail.com aymuhammad@atbu.edu.ng

Mohamed Ahmed Said Mohamed[1a&b], Yakubu Aminu Dodo[2c&d], Fatima Baba Ciroma[3e] & Abubakar Yahaya Muhammad[4f] , Concise Elements Model for Enhancing Visual Comfort in Malaysia Single Office Space- Palarch's Journal Of Archaeology Of Egypt/Egyptology 17(9). ISSN 1567-214x, Keywords: CEMVC, enhance, Malaysia, single-office, visual-comfort

Abstract

With the world moving toward achieving sustainable development goals (SDGs) by 2030, There is a need to address the issues that are directly and indirectly responsible for climate change especially those influence the use of a non-renewable source of energy. To promote the using of passive means to attain a good visual comfort in an office space this study proposed a concise elements model for visual comfort (CEMVC). The proposed "model" was developed from critical analysis of available visual-comfort theories and benchmarking with standards; ISO 89951-1:2002, ISO 89951-1:2008 and MS1525: 2019 the Malaysian standard 2019. The result is a concise model named *"CEMVC*" with elements arranged in a chart that can aid in the maximizations of visual comfort level in a single office space using Malaysia as a case study. The study needs to be extended and carried out in a complete season-spanning an ideal period to inferred the outcome of the research *"CEMVC*".

Keywords: CEMVC, enhance, Malaysia, single-office, visual-comfort

INTRODUCTION

With the world moving toward achieving the sustainable development goals by 2030, all aspect of life is being considered to adjust to what energy they consume in which buildings are not left out. One of the aspects we use energy is toward comfort in our buildings most especially office buildings. This was part of what lead to the craving for energy efficiency

and designing of green buildings. Visual comfort is one of its four criteria has the key to enhancing the effective reduction of energy consumed in office space. The power needed to run office spaces is expected to surge by 4.7% annually to reach 274 TWh by the year 2030. The objective of this study is to design a model that would optimize visual comfort in Malaysia single office space to reduce energy consumptions. Using an offices spaces in Universiti Teknologi Malaysia (UTM), This research makes a comprehensive evaluation of visual comfort criteria; illuminance, luminance, glare and view from an architectural point of view in single office spaces in Malaysia from literature, guidelines, standards and visual comfort policies. The method used is documentation analysis. The outcome of this document analysis is a model (CEMVC) that enhances visual comfort in office space.

The proposed "model" provides possible knowledge that would help policymakers and architects; (1) Save cost for UTM through the use of the proposed model (2) Aid architects in designing optimize visual comfortable single office space with and without shading devices (3) Proposed an addendum that of visual comfort criteria to be added to be possibly added to latest version MS1525: 2019 standard as the previous revised standards did include the visual comfort but not comprehensively. Therefore, this study puts forward elements that can aid in the maximizations of visual comfort in a single office space using Malaysia as a case study.

BACKGROUND

Research has shown that the use of daylighting in the Asian regions can decrease by about 20% energy consumption by 20% (Zain-Ahmed *et al.*, 2002). To mitigate this effect and be just to the environment, sustainability was conceptualized as a checking measure. In the building sector, the quest for the sustainable building was established. This quest gave birth to Green Buildings which are being determined by a rating system that is based on different countries or the region's climatic system. In Malaysia, the recommendation and guidelines for visual comfort and daylighting are not fully considered. For commercial buildings, 10% is the minimum required for Window to Floor Ratio (WFR) by Universal Building Bye-Law (UBBL). Nevertheless, the UBBL does not outline any requirement for daylighting. A more recent recommendation can be found in Malaysian Standard MS1525: 2019 (Department of Standards Malaysia, 2019). Using passive idea as a design strategy possible reduction of millions of tons of carbon dioxide could be realized. A kilowatt-hour (kWh) of energy could be saved to prevent the carbon dioxide emission of 680.39g globally (Lancashir *et al.*, 1996). If daylighting strategies are applied, 10% to 20% of energy usage for cooling of the building can be reduced. Furthermore, in another study (Dodo, 2015) economic benefits of daylighting have the potential to provide significant cost savings from 0.16Rm to 0.64Rm per square foot annually for an office space. This savings can be achieved is guideline and bye-laws and building codes that are related to visual comfort are adhere to.

RESEARCH PROBLEM

Indoor Environmental Quality (IEQ) is the second criteria with high points that deal with thermal, Acoustic, and Visual comforts as well as indoor air quality. Visual comfort seems to be criteria that can contribute to the efficiency of energy in the office building as it features criteria (illuminance, luminance, glare and view) that when manage effectively would reduce energy usage and consumption in office buildings the tree of solar strategy.

Lechner (2015) shows that it is more efficient to go for the lower fruit in which the visual comfort criteria are among these low fruits criteria low for hanging fruit first the easy and free approaches should be used then consider the difficult and expensive ones.

Many passive solutions are been proffered across the globe and Malaysia on reduction on energy consumption still with all these advantages visual comfort presents, little or no exploration on most our office buildings across the world with Malaysia inclusive.

Minimal research attention has been directed toward other aspects of IEQ elaborated by (Zain-Ahmed *et al.*, 2013, Abu-Sadin, Nik-Ibrahim and Sopian 2013) which all focus on either quantitative or simulation research approach only. Moreover, a combination of both methods would provide the opportunity to involve office space users as well as triangulating the data for a better result.

Therefore, by examining these visual comfort criteria, as well as further improve the Malaysian standard MS1525 with a possibility of improving the Malaysian green building rating systems (Green Building Index 2007).

RESEARCH METHOD

The proposed "model" was developed from critical analysis of available visual-comfort theories and benchmarking with standards; ISO 89951-1:2002, ISO 89951-1:2008 and MS1525: 2019 the Malaysian standard 2019. Phase one of the methods was a critical review of available theories using "document analysis" to established important criteria that enhance visual comfort. The second stage was to categorise the elements identified into three (3) tiers of the level of importance which forms the bases of the CEMVC.

Table 1: Planning process for establishing document analysis for CEMVC in the study: adopted from (Bowen, 2009 & O'Leary, 2014)

No	Items used for carrying out the document analysis	Level of importance	Remarks
	Standards		
1	ISO 89951-1:2002		
2	ISO 89951-1:2008		
3	MS1525: 2019 the Malaysian standard		
4	The Scottish Government 1993		
	Theories		
5	Autodesk Building Aperture, 2014		
6	Iitvegar 2013		
7	Hellinga, 2010		
8	Lechner 2015		
9	***Related research works and model***		
10	Dodo, 2015		
11	Berk, 2010		
12	CHPS, 2002		
13	O'Connor et al., 1997		

14	Zain-Ahmed et al., 2013,		
15	Abu-Sadin, Nik-Ibrahim and Sopian 2013		
16	Lim, 2011		
17	Edmonds and Greenup (2002)		
18	Abu-Sadin et al 2014		

RESULT AND DISCUSSION

The result of this research shows a review of theories, standards and other of related works on visual comfort as shown in Table 1: Planning process for establishing document analysis for CEMVC (Bowen, 2009 & O'Leary, 2014). The result is segmented into the reviewed standards, critical analysis of theories and other related work on visual comfort.

OCCUPANTS COMFORT VISUAL COMFORT

Good lighting is important because it helps produce a productive and happy setting. This is much more achieved by natural light than by artificial lights. Getting clear views and sightlines offers us a sense of temperature control and a sense of well-being (Autodesk Building Aperture, 2014).

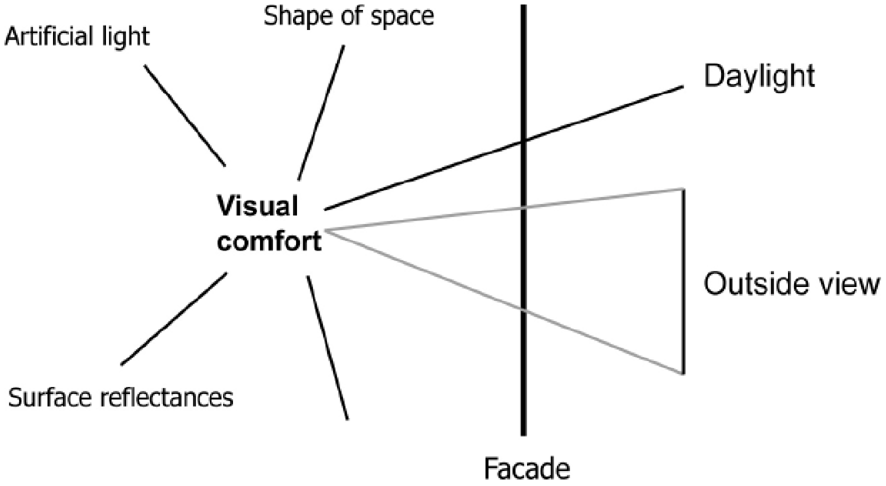


Figure 1 Assessment of visual comfort criteria: Source (Hellinga, 2010)

VISUAL COMFORT AND ITS CRITERIA

GOOD LIGHTING

An important factor when working towards zero-emission buildings is the usage of natural daylight as a replacement for artificial light sources (Autodesk Building Aperture, 2014). However, the goal is not to use as much daylight as possible, but to use the right amount and the right type all-natural light comes from the sun. But the light may travel many different paths before entering the room. Let's look at the following Figure 2. As we can see, Figure 2 separates between three main light components. The Sky component (SC) part is light coming right from the vault of the sky. Light reflected from an exterior component is the external reflected component (ERC), such as the surface, a building wall, etc. And light reflected from an internal surface is the internal reflected portion (IRC). Some of these components are more desirable than others. Most of you have probably experienced glare and discomfort due to direct sunlight. This is because of the extreme brightness of direct sunlight.

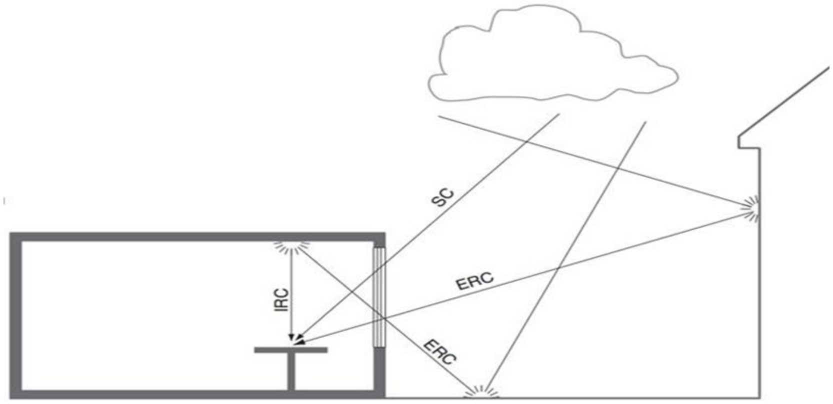


Figure 2: Three main light components. Source (iitvegar 2013)

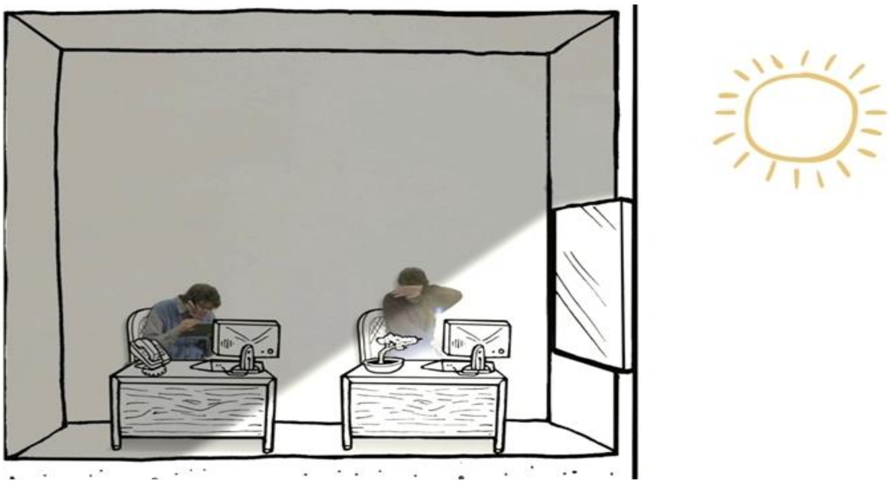


Figure 3: Glare from direct sunlight due to an ill define solution (iitvegar 2013)

BASIC METRICS

In another study, Lim (2011) shows that although side lighting is the most commonly used daylight system in an office building, the effects of glare reduces the usability of the space as it has a strong directionality because the illuminance diminishes as the distance from the aperture increases (Figure 4.) Therefore there is a need to determine an appropriate zone that is comfortable to perform a task while considering the glare from daylight and accessibility to a view.

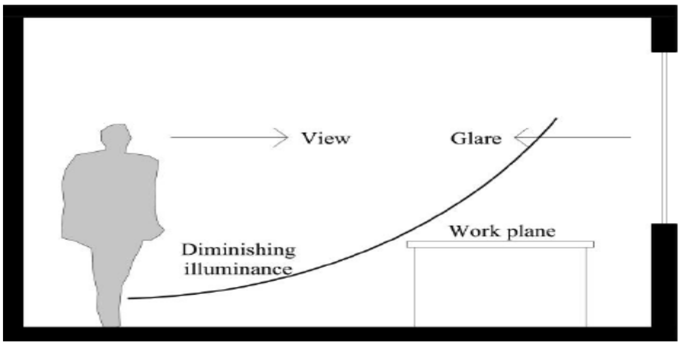


Figure 4: Side-Lighting with Illuminance and Glare Problem (Source: Lim, 2011)

Abu-Sadin, Nik-Ibrahim and Sopian (2013) in an experimental study simulated different sizes of shading devices in an overcast condition to determine the internal illuminance in lux with an approximately 20% WWR in Kuala Lumpur. The result shows that even with shading device of 2m long, 200-250 lux is achievable see Figure 4. Edmonds and Greenup (2002) identify that 1.3m to 2.3m from the window in a daylight space can only yield 150 to 200 lux in the west-east elevation, except when complemented with artificial lighting.

Abu-Sadin *et al*. (2014), modify existing daylighting rules of thumb, this introduces a new Kuala Lumpur sky formula focused on the smallest academic office space at a public university. They further developed that the most reasonable option is one (1) meter shading device that meets the daylighting requirements within the room. These thumb rules will help architects plan ample day-lit office space with a shading device. The experiments also show that limited office space, 4.5 meters wide with full-width window and 1-meter horizontal external shading, as seen in Figure 5, will provide ample interior illuminance. Findings from the research by Abu-Sadin et al. (2014) as shown in Figure 5 shows that owing to thinner walls, the illuminance at the rear of the rooms is usually smaller than those at equal heights, whereas the illuminance at the back of rooms that are shallow rises marginally due to reflecting from the back walls.

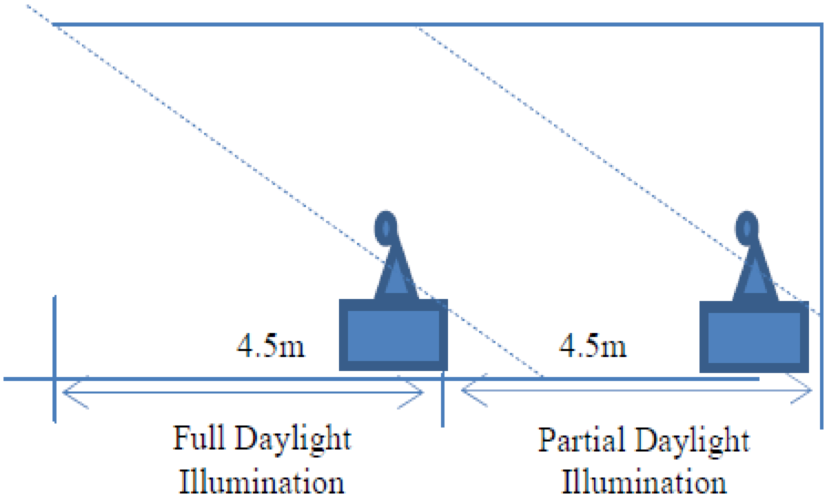


Figure 5: Fully and partially daylit area at of 4.5m interval (Abu Sadin *et al*., 2014)

OPTIMAL TASK PERFORMANCE ZONE (OPTZ)

The office design recommendations of 25% and 40% WWR for private office space are presented in Figure 6 and Figure 7. The OPTZ inferred that with a recommendation of (25% WWR and 40% WWR) for single office space in Malaysia (Dodo, 2015). as a design model for single private office space in Malaysia from existing guidelines and rule of thumbs for openings on façades, (Dodo, 2015). The optimal task performance zone shows the zone where the task can be performed comfortably within a single private space in conformity with maximum daylighting penetration of six (6) meters (The Scottish Government 1993) and with an overcast condition for Malaysian region (20,000lux) with illuminance needed in the OPTZ be ideal for users of the space (ISO 89951-1:2002 minimum work plane illuminance for continuous work should not be less than 200lux and 300lux to 500lux MS 1525: 2007 the Malaysian standard).

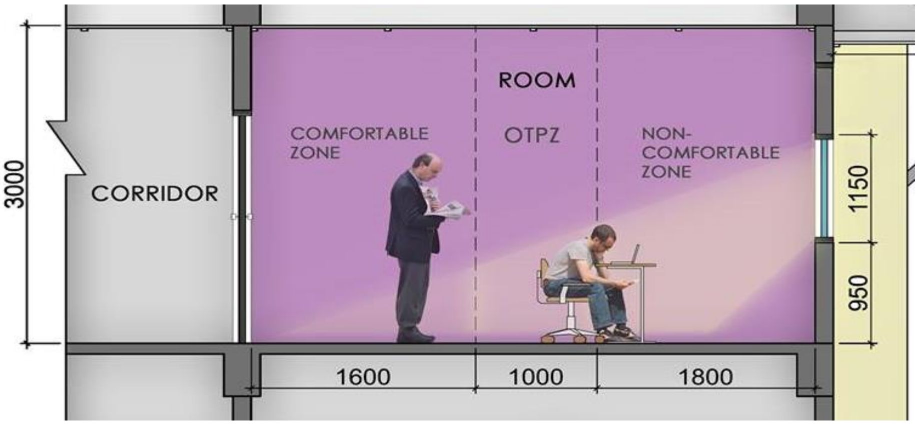


Figure 6: Task Performance Zone (OPTZ) with a recommendation of 25% WWR for Single Office Space in Malaysia (Dodo, 2015)

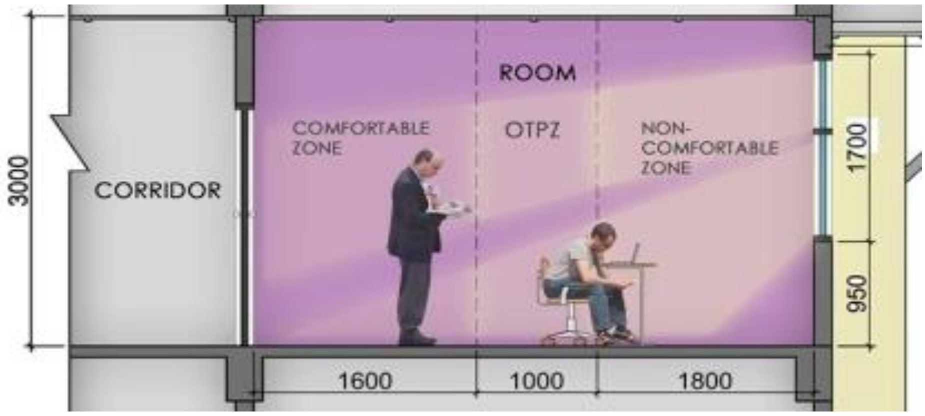


Figure 7: Optimal Task Performance Zone (OPTZ) with a recommendation of 40 % WWR for single office space in Malaysia (Dodo, 2015)

The indoor environment requires a variety of elements, including temperature, humidity, consistency of Indoor Air Quality (IAQ), illumination, ventilation, noise and occupational crowding (Clements-Croome and Baizhan, 2000). The efficiency of the indoor atmosphere is a major factor that is taken into consideration in assessing a healthy building concerning the health and productivity of building occupants. It depends on four varying factors of; indoor air quality, thermal comfort, acoustic and access to daylight and views (Global Perception, 2010). Few relevant standards of IEQ have been addressed with the main concerns being poor thermal comfort and IAQ caused by energy saving. Initially, standards seemed to optimize the indoor environment without considering climate-responsive and energy-conserving design, as the priority was given to universal application across all building types, populations and climate zones (de Dear and Brager, 1998).

Table 2.: Selected guideline and standard available on office spaces source: adapted from (Dodo, 2015)

Title	Organization	Primary Content
ISO 7730: 1994 Moderate thermal environments (ISO 1994)	International Organization for Standardization (ISO)	The acceptable range for temperature, humidity, and air velocity

ANSI/IESNA — RP-1-1993	ANSI IESNAc	For office lighting, topics covered include design process, office tasks, lighting criteria for visual performance and comfort, the lighting system, luminous environmental factors, light areas, energy and energy management and maintenance.

A view which contains three layers (sky, surrounding environment and ground) is most preferred by people. In all cases the quality of daylight is not sufficient to meet all year long visual and non-visual criteria, electric lighting should be supplemented (Berk, 2010).

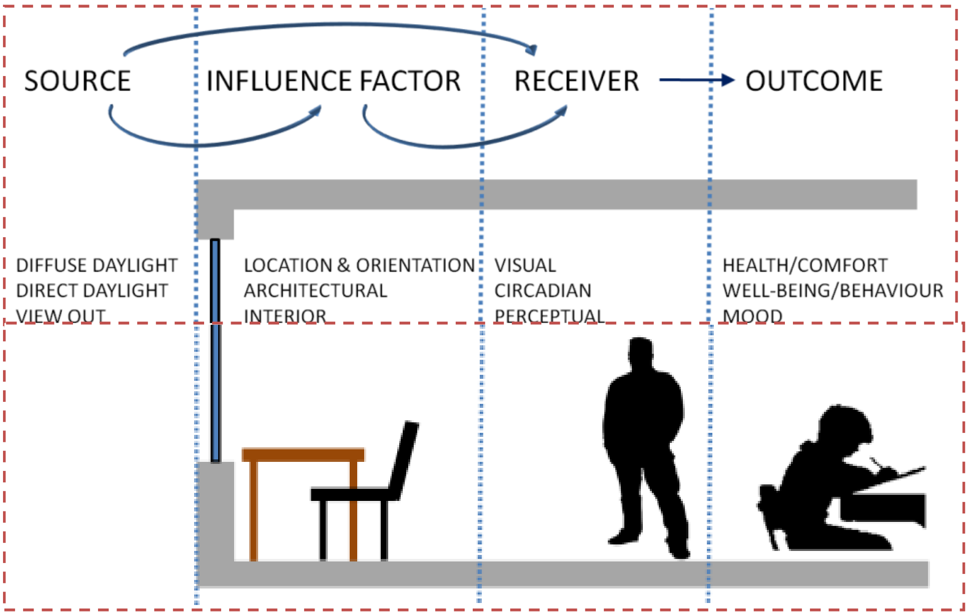


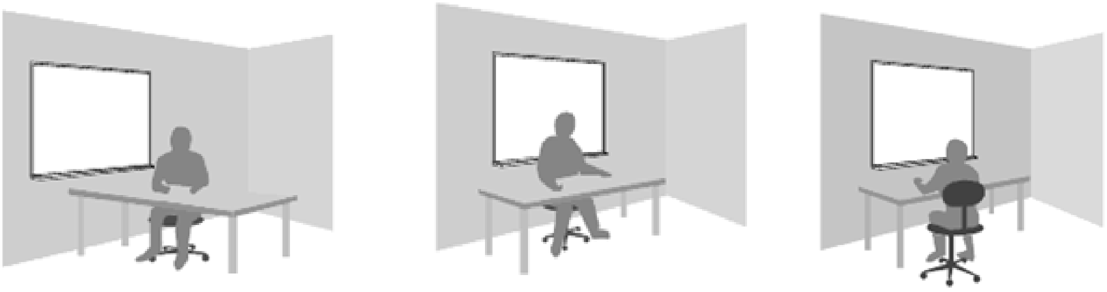
Figure 8: Concept Model Windows and People (Berk, 2010)

Collaborative for High-Performance Schools (CHPS, 2002), describes the view window as eye-level vertical glazing that offers a view of adjacent spaces indoors or outdoors. The view window offers calming views and information on the environmental conditions outside and also helps visitors outside a room to see and interact with the events inside. It should be planned in the schematic design stage; they can also be applied to all climate regions.

Figure 9: Daylighting Windows vs. View Window (Source: CHPS, 2002)

VWs (vision glazing), typically referred to as view windows, are known by one rule of thumb to be any glazing above 750 mm and below 2300 mm from the finished floor in a room. Skylights and very high windows should not count, and at least 25 % and at most 40 % should be the WWR. In identifying a VW, the Skylight and very high windows do not count. At times it could be the designer’s inability to provide a view for window (underground space) or the window is available but no access to view due to adjacent building obstruction. In this scenario, the occupants who find themselves in such spaces are forced to provide artificial views or surrogate views to enhance their task performance or could have another alternative to the conventional window (the inside window) which occupants prefer to no window at all (Biner, Butler and Winsted, 1991) shown in Figure 10. Not every office buildings can have a view of nature and the probably windowless situation can be improved or compensated for by the use of surrogate windows while some office space users prefer surrogated window to window without a view at all (Altomonte, 2009). The significance of lighting quality for effectiveness was shown by a study at Carnegie Mellon University. Seeing that expenses for the salaries and benefits of people are usually 100 times the energy cost of a house, even a minor productivity increase would be the equivalent of covering the energy bill many times over.

The seating arrangement is one aspect that affects the comfort of an occupant in an office building in the sense that the way occupant seats in relations to a view window would be influenced by the amount of light reaching the task area. Seating adjacent to the window is the most comfortable seating arrangement because occupant's source of light will not cause discomfort to his eyes (Figure 10a). Seating backing the window has a possibility of shading the occupant’s task and making it too dark to see easily as seen in Figure 10b while seating facing the window create a harsh environment and tiring for the eyes to accommodate the amount of light in task environment as exemplified in Figure 10c (O’Connor *et al*., 1997). Therefore, occupant’s choice in seating arrangements in office buildings is related to satisfaction and task performances (Lee and Guerin, 2009).



Adjacent to the Window (10a)

Backing the Window (10b)

Facing the Window (10c)

Figure 10: Graphical Representations for Appropriate Seating Arrangement in a Single Office Room (Source: O’Connor *et al.*, 1997).

FINDINGS

1) Policymakers could be used to promote visual comfort model (CEMVC)as this can contributes to greater energy efficiency in building (Edward, 2009), and in turn, this greater energy usage reduction can help improve a sustainable world and a better one for our future generation
2) CEMVC will assist Interior designers as a guide on how to situate furniture and plan for office space utilization.
3) Adherence to CEMVC would possibly reduce the cost of running the building and increase productivity as considering the ideal visual comfort in a building will enhance the psychological performance by occupants as it will reduce all adverse effect that comes with a poor visual comfort

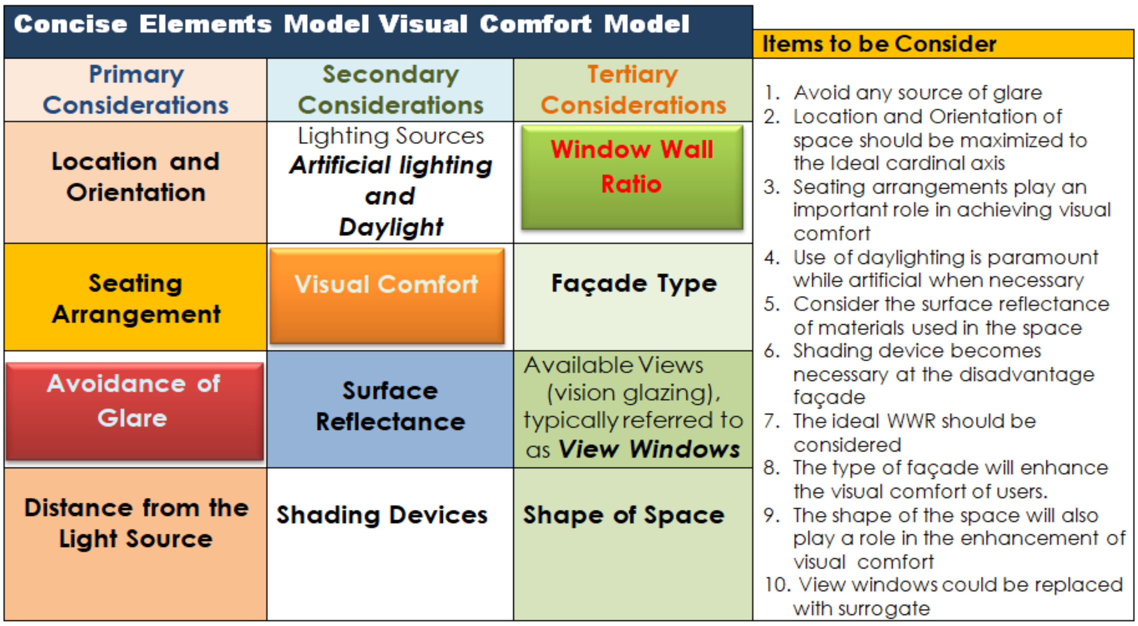
VISUAL COMFORT ENHANCEMENT MODEL

The concise elements model for enhancing visual comfort in a single office was conceived from several standard and research carried out on visual comfort concerning usability and optimization of daylighting in an office space. The work of (Hellinga, 2010) on criteria for visual comfort, form the basis for this model. This was supported by (Autodesk Building Aperture, 2014). The model is benched marked with standards; ISO 89951-1:2002; ISO 89951-1:2008 minimum work plane illuminance for continuous work should not be less than 200lux and 300lux to 500lux MS 1525:2019 (The Malaysian Standard 2019). The model consist of considerations needs to achieve comfort. The degree of comfortability depends on the usability of the elements. The primary and secondary elements are very necessary to achieve visual comfort in an office space, while the tertiary elements might not have a serious consequence but its good they are considered as well.

The primary elements are location and orientation (Berk, 2010), seating arrangement (O’Connor *et al.*, 1997 and Guerin, 2009). Avoidance of Glare (Lim 2011 & Iitvegar 2013), distance from the light Source (Lim 2011 and Abu-Sadin *et al*. 2014).

The secondary elements are; Lighting Sources Artificial lighting and Daylight (CHPS, 2002 Hellinga, 2010 & Autodesk Building Aperture, 2014). Surface Reflectance (Hellinga, 2010) Shading Devices (Abu-Sadin, Nik-Ibrahim and Sopian (2013).

The tertiary element is Window Wall Ratio (Dodo, 2015). Façade type (Hellinga, 2010),



Concise Elements Model Visual Comfort Model

Primary Considerations	Secondary Considerations	Tertiary Considerations
Location and Orientation	Lighting Sources *Artificial lighting and Daylight*	Window Wall Ratio
Seating Arrangement	Visual Comfort	Façade Type
Avoidance of Glare	Surface Reflectance	Available Views (vision glazing), typically referred to as ***View Windows***
Distance from the Light Source	Shading Devices	Shape of Space

Items to be Consider

1. Avoid any source of glare
2. Location and Orientation of space should be maximized to the Ideal cardinal axis
3. Seating arrangements play an important role in achieving visual comfort
4. Use of daylighting is paramount while artificial when necessary
5. Consider the surface reflectance of materials used in the space
6. Shading device becomes necessary at the disadvantage façade
7. The ideal WWR should be considered
8. The type of façade will enhance the visual comfort of users.
9. The shape of the space will also play a role in the enhancement of visual comfort
10. View windows could be replaced with surrogate

view window (Altomonte, 2009) and the shape of the space (Hellinga, 2010).

Figure 11: Concise elements model for the visual comfort of a single office space

CONCLUSION

The proposed "model" was developed from critical analysis of available visual-comfort theories and benchmarking with standards; ISO 89951-1:2002, ISO 89951-1:2008 and MS1525: 2019 the Malaysian standard 2019. The result is a concise model named *"CEMVC*" with elements arranged in a chart that can aid in the maximizations of visual comfort level in a single office space using Malaysia as a case study. The items also have a range of elements arranged in ascending order. The study established that passive design could be used to prevent the release of millions of tons of carbon dioxide; with a kilowatt-hour (kWh) of energy saved to prevent the carbon dioxide emission of 680.39g adapted from (Lancashir *et al.*, 1996). If daylighting strategies are applied, about 10% to 20% of energy usage for cooling of the building can be reduced. As the research topic implies concise elements model for enhancing visual comfort in Malaysia single office space with a case-study of office space in Malaysia further studies could be carried out in (i) having more case studies within the region for sound comparativeness, (ii) a full-blown model to cover most parameters not mentioned, (iii) research on guidelines to be incorporated in building codes & standards that deal with visual comfort especially the Malaysian Standards and Uniform Building by Laws UBBL–Malaysia, (iv) carrying out a similar study in different regions with a different climatic conditions.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the Tertiary Education Trust Fund (TETFund) Nigeria and the International Doctoral Fellowship (IDF –UTM) Malaysia for partial funding of the research.

REFERENCES

1. Abu-Sadin, M. F. M, Nik-Ibrahim, N. L. and Sopian, K (2013). Ed in Azami Zaharim, Kamaruzzaman Sopian The Performance of External Shading Devices and Daylighting Rule of Thumb for a Tropical Climate *Latest Trends in Renewable Energy and Environmental Informatics (res '13),(eninf '13) Volume 8 of Energy, Environmental and Structural Engineering Series* pp 131-134 North Atlantic University Union; Kuala Lumpur, Malaysia, April 2-4, 2013 ISBN: 978-1-61804-175-3.
2. Abu-Sadin, M. F. M, Nik-Ibrahim, N. L., Sopian, K. and Sallah, I. E. (2014). The Effects of Different Depth of Floor towards Internal Daylighting and Rules of Thumb for Office Room *Advanced Materials Research* Vol. 935 Pp 92-96 www.scientific.net DOI:10.4028/www.scientific.net/AMR.935.92
3. Altomonte, S. (2009). Daylight and Occupant Visual and Physio-Psychological Well Being in Built Environment. 26th Conference on passive and Low Energy Architecture, Quebec City, Canada, 24th -24th June 2009.
4. Autodesk Education (2011) Light Distribution & Glare retrieved on 7 February 2016 from, available @ http://sustainabilityworkshop.autodesk.com/buildings/light-distribution-glare
5. Berk, A. B. M. (2010). Window and People: A Model-Based On a Literature Study to Identify the Influence of Windows on People in an Office Environment Concerning Daylight and View. A Review Unit Building, Building Physics of the Environment. Technische Universiteit Eindhoven Faculteit Bouwkunde.

6. Biner, P. M., Butler, D. L. and Winsted III, D. E. (1991). Inside Windows: An
7. Alternative to Conventional Windows in Offices and Other Settings. Environment and Behavior. DOI: 10.1177/0013916591233006
8. Bowen, A.G. (2009) 'Document Analysis as a qualitative research method', Qualitative Research Journal, 9(2) Pp. 27-40 RMIT Publishing, DOI:10.3316/QRJ0902027
9. Clements-Croome and Baizhan, (2000) Productivity And Indoor Environment Proceedings of Healthy Buildings held 6-10 August 2000, Espoo 2000, Vol Pp-629-634 Finland, paper 104.
10. Collaborative for High-Performance Schools - CHPS (2002). Best Practices Manual "Daylighting" 2002 CHPS, Inc Pp 209-256
11. De-Dear, R. J. and Brager, G. (1998). Developing an Adaptive Model of Thermal Comfort and Preference. ASHRAE Transactions 104(1A), 145-167
12. Department of Standards Malaysia (2007). *MS 1525:2007* Code of Practice on Energy Efficiency and Use of Renewable Energy for Non-Residential Buildings ICS: 91.040.01 (First Revision) Malaysia. http;//www.standardsmalaysia.gov.my
13. Department of Standards Malaysia (2014). *MS 1525:2014* Code of Practice on Energy Efficiency, Renewable Energy, Non-Residential, Buildings, Code of Practice, Energy 91.040.01 (Second Revision) Malaysia. http;//www.standardsmalaysia.gov.my
14. Department of Standards Malaysia (2019). MS 1525:2019 Code of Practice on Energy Efficiency, Renewable Energy, Non-Residential, Buildings, Code of Practice, Energy 91.040.01 (Third Revision) Malaysia. http;//www.standardsmalaysia.gov.my
15. Dodo Yakubu Aminu (2015) Office window opening influence on occupants' task performance Unpublished Doctor of Philosophy, Faculty of Built Environment, Universiti Teknologi Malaysia Skudai
16. Edmonds I. R. and Greenup P. J. (2002). Daylighting in the Tropics. Solar Energy 73 2(2) 111-121
17. Edwards, B. (2005). Rough Guide to Sustainability. (2nd ed.) London, RIBA Enterprises Limited
18. Global Perception (2010). Indoor Environmental Quality (IEQ), Elsevier. DOI:10.1016/B978-1-85617-691-0.00007-2
19. Green Building Index (2007) Code of Practice on Energy Efficiency and Use of Renewable Energy for Non-Residential Buildings. *MS1525 PAM CPD Seminar: Applying MS1525:2007* 14 February. Kuala Lumpur, Malaysia Pp. 1-22
20. Hellinga H. I. J. (2010) Assessment of Daylight And View Quality: A Field Study in Office Buildings CIE conference: Lighting Quality & Energy Efficiency 17-03-2010
21. iitvegar (2013) PVGU Windows – Reducing Glare and Generating Power Retrieved on 7th February 2016 available @ https://iitbuildingscience.wordpress.com/2013/09/04/pvgu-windows-reducing-glare-and-generating-power
22. International Standard Organization(2002). ISO 9002:1994, Quality systems -- Model for quality assurance in production, installation and servicing 13-Jun-2002; retrieved on 21st January 2021 available @ file:///C:/Users/MY%20LAB/Downloads/ISO_CIE_8995_1_2002_E_Character_PDF_document.pdf
23. International Standard Organization (2008) ISO 8995:1989 - Principles of visual ergonomics; The lighting of indoor work systems 15-Apr-2008 retrieved on 21st January 2021available @ https://standards.iteh.ai/catalog/standards/iso/a0fbda5e-47cc-4d79-bead-bc08671c4023/iso-8995-1-2002

24. Lancashir, E. S. and Fox. A. E. (1996). Lighting: The Way to Building Efficiency. Consulting-Specifying Engineer: 34–6.

25. Lechner, N. (2015). Heating, Cooling, Lighting, Sustainable Design Methods for Architects. Fourth Edition. New Jersey, Canada: John Wiley & Sons, Inc., Hoboken.

26. Lee, S. Y. and Guerin, A. D. (2009). Indoor Environmental Quality Related to Occupant Satisfaction and Performance in LEED-certified Buildings. *Indoor and Built Environment.* 18(4): 293-300.

27. Lim, Yaik-Wah. (2011). *Internal Shading for Efficient Tropical Daylighting in High Rise Open Plan Office.* Unpublished Doctor of Philosophy, Faculty of Built Environment, Universiti Teknologi Malaysia Skudai.

28. O'Connor, O. J., Lee, E., Rubistein, F. and Selkowitz S. (1997). Tips for Daylight with Windows: The Integrated Approach. The University of California, Ernest Orlando Lawrence Berkeley National Laboratory, LBNL-39945, 1997.

29. The Scottish Government (1993). Sustainable Housing Design Guidelines for Scotland Energy uses http://www.archive2.officialdocuments.co.uk/document/deps/cs/shdg/ch04 /.

30. Zain-Ahmed, A., Sopian, K., Othman, M. Y. H., Sayigh, A. A. M. and Surendran, P. N. (2002). Daylighting as a Passive Solar Design Strategy in Tropical Buildings: A Case Study of Malaysia. Energy Conversion and Management, 43: 1725–1736.