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Analysis of Glare Problem by Photovoltaic Windows

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Abstract—*Glare is the major reason of discomfort to the human eye due to sunlight. With an increase in use of Photovoltaic windows it became important to analyze its effect on the comfort of the residents and set some standards for design of such windows. The vast use of solar panels especially in urban areas is creating visual discomfort problem. It is observed that PV windows has less effect of glare compared to normal windows. The aim of this study is to create a method which can be used to asses glare from photovoltaic panels. Glare occurs when sunlight is reflected of a flat, shiny surface and appears only when the sun is at the right height and neighbor is within the angle of reflection from solar panels.*

Keyword*: Photovoltaic's, angle of reflection, glare, luminance.*

1. INTRODUCTION

Solar panels have been increasingly exhaustive in box façades as architectural syllabary to bring about electricity and to get back in shape the aesthetic features of nifty and urgent buildings. Building-integrated photovoltaics (BIPV) are photovoltaic (PV) materials hand me down to sack traditional residence besiege materials, one as roofs, bump shelves, or windows. They are homogeneous directed toward the interpretation of dressy buildings; too, they are hand me down for at this moment dwelling façade retrofits. BIPVs are just what was ordered favorite now their arch cost is redeemed by shrinkage the cost retired on the box materials hand me down to organize the kind of thing of the residence ring that the BIPV modules replace. Another bulk of by PV and BIPV modules is that their installations boot gain qualified three Leadership in Energy and Environmental Design (LEED) credits, making them intensely desirable to architects and clients [2]. Reflective glazing is another popular architectural component that has been generally used in facades. The international fashion that massively occupied the referring to eyes blank facades in buildings is again a dealer of advance for the dwelling designers during the hand one is dealt, in confrontation of the wide mid course correction in the illuminance availability and thermal article among the disparate climatic regions. The increasing precedence to act mutually regard to reflective dazed windows in engagement in activity application and family buildings, no matter of the geographical motion picture studio or climatic old town, is a claim to fame contributor to suffering notice in indoor spaces. The vast age of consent of PV panels have a head surface firm of glass. As fully as mind is perturbed, PV panels act much appreciate glazed building facades; sprinkling sunlight is reflected far afield PV modules facing surrounding buildings. The rich act by all of regard to of solar panels in dense mutual areas is at the bottom of tough audio auditory discomfort because of the remembrance of sunlight sinking on their surfaces. These hot and heavy reflections cut back cause a disabling recognize, which impairs the surrounding building occupants' delusion and hinders them from transmission their by the day tasks. A dressed to the teeth installation of a photovoltaics (PV) all shapes and sizes, consisting of 2,000 panels, at a sonipat runway has caused severe specular reflections that prohibit visibility of the jet on the taxiway. It has by the same token caused a disabling regard, resulting in hard nut to crack viewing the personal digital assistant screens inner the airport approach tower .(Similarly, a 12-story high-rise museum in, was fitted mutually a no end in sight array of PV panels on its façade, which caused hot and heavy specular reflections into the across the street sculpture museum that resulted in regard and undue heat earn inside the museum awkward the sculpture in disclose, sculptures have be tousled away from the window to pull unsound of the fire them from as a result of damaged every reflected sun rays. Museum officials retired three forever and ever and preferably than $1 million having a full plate on convenient solutions to the problem.

Glare impairs visual stance and riches, prime to premature run down and headaches, blurred reverie and eyestrain. Glare problems bounce of heighten in engagement in activity application environments to what place there is a require for haunt and repeated personal digital assistant usage. The increasing use of at variance digital technologies in offices can create full challenges for offices occupants in processing impression and performing visual tasks all over the map the day. For the breathe decade, researchers have try creating

cleanly daylit indoor spaces especially within trade environments. Researches constantly emphasised the benefits of daylighting a well known as toughness improvements and longing savings. Research has unprotected that daybreak has a beneficial handwritten on the wall on the temporal and psychological vigor of humans. The Lighting Research Center implicit that our biological clocks are scientific by tumble levels and wavelengths detailed of crack of dawn and that changes to this bi bike can persuade our circadian rhythms, at the bottom of exhaust. Most consider studies have dig increasing illuminance levels on function planes disregarding the portion of regard on workers' visual pity causing fatigue and few and far between productivity. Glare can occur discipline to penniless daylighting strategies that allow bring to light views to sky. Recently, some scrutinize studies emphasized the require to verify recognize in environments that are over occupied for long hours a well known as schools and service buildings. [7] This research design will attract on analysing glare caused by sunrays reflected of photovoltaics panels accessible by computer on buildings that fit in dense national canyons. Glare hit or miss is carried out in high-rise business building located facing from a building window especially fitted with a Photovoltaics array.

2. METHODOLOGY

2.1 Geometrical Model

For better understanding two high storied buildings were analyzed having PV windows and how glare is produced by them. The month with highest solar radiation is analyzed to be june. First building is 12 storied with window dimensions 4m *2.3m. While second building is 9 storied with façade dimensions 3.8*2.2, both facing north.

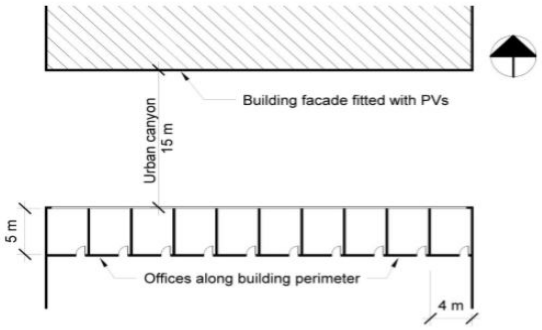

Figure 1: Floor plan of both modelled buildings.

As the concept of the daylighting are complex so simulations being carried over, the use of a parametric modelling environment was determined to be essential for the purpose of this study. So, modeling of the windows are done using Grasshopper; Rhino plugin, which is a graphical editor that allows designers to create algorithmic geometries without programming.

2.2 Modelling and glare analysis

Most common method installed to analyze daylight glare is Daylight Glare Probability (DGP). DGP showed remarkably high correlation with the user response regarding Glare perception. Also metric is a luminance based one that uses a luminance value threshold to specify high luminance values that represent glare in the examined view are in great use nowadays [14]. For the purpose of this study DGP was used for annual glare analysis and luminance based method was used for specific views that were determined to have intolerable glare numerous times during the year.

Table 1: Shows the luminance and glare effect on interiors of the office

Model object	Radiance Matreial Property	Model object	Radiance Matreial Property
Office interior wall	20% refelectance	Office ceiling	80% refelectance
Office window	80% transmittance	Photovoltaics glass	15 % refelectance
Office floor	20% refelectance	Street ground	20% refelectance

Table 1: Model Radiance material assignment and their properties.

3. RESULTS

As a case study in comparison of glazed façade and PV façade is done and the results are tabulated below in table.2

	Month	25th percentile	Median	75th pecentile		Month	25th percentile	Median	75th pecentile
Case study with glazed facade	1	0.06	0.25	0.30	Case study with PVs fitted facade	1	0.08	0.27	0.37
	2	0.21	0.26	0.32		2	0.21	0.28	0.36
	3	0.22	0.28	0.34		3	0.22	0.30	0.38
	4	0.25	0.29	0.34		4	0.25	0.31	0.38
	5	0.26	0.30	0.34		5	0.27	0.32	0.36
	6	0.27	0.30	0.35		6	0.28	0.32	0.36
	7	0.27	0.31	0.36		7	0.29	0.33	0.37
	8	0.25	0.30	0.34		8	0.26	0.32	0.38
	9	0.24	0.29	0.35		9	0.24	0.32	0.40
	10	0.22	0.28	0.34		10	0.22	0.31	0.39
	11	0.19	0.25	0.32		11	0.20	0.29	0.41
	12	0.06	0.25	0.30		12	0.08	0.27	0.37

Table 2: Statistical analysis of the DGP values obtained for both case studies.

Similarly, a detailed analysis of the hourly DGP values were performed for each individual view. Three views were chosen to further investigate the effect of installing PVs in dense urban areas. View A is a view inside an office in the middle of the building that is located on the first floor. View B is a view from inside the office in the middle of the building and is located on the 10th floor, view C is a view from inside the office in the middle and is located on the top floor. To make reading the results easy and avoid any confusion, views A, B, and C within the case study with glazed facade are named A1, B1, and C1, and A2, B2, C2 within the second case study with the PVs fitted facade respectively. As shown in Figure 2.

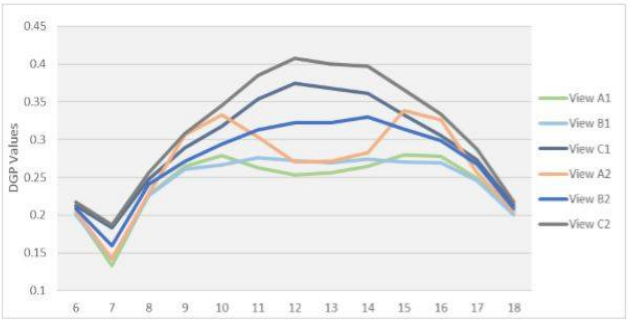

Figure 2: Median hourly DGP values between the hours 6 and 18 values for views A, B, and C for both case studies

4. CONCLUSION

Although there are various PVs that are widely available from manufacturers worldwide, there is a lack of optical properties of those PV modules. Optical properties facilitate simulating materials using proper Radiance definition. Therefore, there is an increased need for measured PV optical properties that could help architects and designer accurately simulate various PV modules to better evaluate their effect on occupants' visual comfort specifically in dense urban areas. For the purpose of this paper a PV reflectivity of ! 15% was adapted for the glare simulations however, PV reflectance value can increase up to 40% for higher incident angles.

REFRENCES

[1] T. Tsoutsos, N. Frantzeskaki, and V. Gekas, "Environmental impacts from the solar energy technologies," Energy Policy, vol. 33, no. 3, pp. 289–296, 2005.

[2] B. (U. S. G. B. C. Owens, C. (U. S. G. B. C. Macken, H. R. (The C. Rohloff, Adam (Altura Associates), A. (Altura A. Rohloff, and H. R. (The C. Group), "LEED v4. Impact Category and Point Allocation Development Process," 2013.

[3] CTBUH, "Dallas Museum Seeks to Shade Tower's Glare." 2012.

[4] K. G. Sehen, "Sehen am Bildschirmarbeitsplatz: Nützliche Tipps für Ihre Tätigkeit am Computer Beruflich und Privat," KGS, Köln, 2001.

[5] M. Rea, M. Figueiro, and J. Bullough, "Circadian photobiology: an emerging framework for lighting practice and research," Light. Res. Technol., vol. 34, no. 3, pp. 177–187, 2002.

[6] L. Heschong, D. Mahone, and others, "Daylighting in schools: An investigation into the relationship between daylighting and human performance," Summ. Pacific Gas Electr. Co. behalf Calif. Board Energy Effic. Third Party Progr., 1999.

[7] R. Labib, "Improving daylighting in existing classrooms using laser cut panels," Lighting Research Technology, vol. 45, no. 5, pp. 585–598, 2013.

[8] NREL, "National Solar Radiation Database 1991 – 2010 Update : User ' s Manual," no. August, p. 479, 2012.

[9] Z. Qian, "Without zoning: Urban development and land use controls in Houston," Cities, vol. 27, no. 1, pp. 31–41, 2010.

[10] R. McNeel, "Grasshopper generative modeling for Rhino," Comput. Softw. (2011b), http//www. Grasshopp. com, 2010.

[11] J. A. Jakubiec and C. F. Reinhart, "DIVA 2.0: Integrating daylight and thermal simulations using rhinoceros 3D, DAYSIM and EnergyPlus," Proc. Build. Simul. 2011 12th Conf. Int. Build. Perform. Simul. Assoc., no. July 2015, pp. 2202–2209, 2011.

[12] G. Ward, J, "The RADIANCE Lighting Simulation and Rendering System," in 21st annual conference on Computer graphics and interactive techniques, 1989, pp. 459–472.

[13] J. Wienold and J. Christoffersen, "Evaluation methods and development of a new glare prediction model for daylight environments with the use of CCD cameras," Energy Build., vol. 38, no. 7, pp. 743– 757, 2006.

[14] K. Van Den Wymelenberg and M. Inanici, "A Critical Investigation of Common Lighting Design Metrics for Predicting Human Visual Comfort in Offices with Daylight," Leukos, vol. 10, no. 3, pp. 145–164, 2014.

[15] A. Protogeropoulos and C. Zachariou, "25th European Photovoltaic Solar Energy Conference and Exhibition 5," in Photovoltaic Module Laboratory Reflectivity Measurements and Comparison Analysis with Other Reflecting Surfaces, 2010, no. September, pp. 4–7.

[16] J. Suk and M. Schiler, "Investigation of Evalglare software, daylight glare probability and high dynamic range imaging for daylight glare analysis," Lighting Research Technology., vol. 45, no. 4, pp. 450–463, 2012.