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Effect of Natural Light Glare on Passive Design in Malaysian Government Office Building

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ABSTRACT

Starting in 2009 the government of Malaysia has stipulated that all government offices building to be incorporated with sustainable design features. However, the questions on the design still ponders and requires a research especially in the adoption of passive design strategies whether they have met the occupant visual comfort and taken all the consideration on the penetration of daylight. Qualitative survey has been conducted on the occupant's perception toward visual comfort in selected working space and by using DAYSIM simulation to obtain an explicit comparison on the effect of glare inside the room to verify the survey analysis done earlier. Finding from the survey showed that 61.2% of the respondents agreed that there is glare from the windows of the office and 52.2% respondent agreed that internal shading reduced the discomfort glare from the windows. The research will be useful as basic recommendation on the indoor comfort environment especially for the occupant visual comfort in designing a government office building.

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1. Introduction

Since the launched of the Green Technology Policy on 24 July 2009, the government of Malaysia has and will introduce several plans and roadmaps such as the Energy Efficiency Master Plan, The Renewal Energy Policy Action Plan and Green Technology. Through this, it is a task to the designer especially to the architect who always known to be the lead designer in every building project in this country to archive the objective and able to produce a sustainable building. In order to support the Green Technology Policy, under the 10th Malaysia Plan, the government of Malaysia has stipulated that all new government office building be incorporated with sustainable design features such as energy efficiency and renewal energy. Indirectly, the awareness of the designer especially among of the architects in the public sector to the needs and interests of daylight in buildings is growing. Observation shown that most of the designers such as the architect in the public sector will choose a simple rule design and their past experience to determine the method in designing a building (Reinhart & Fitz, 2006; Ibrahim & Zain-Ahmed, 2006). One of the common methods is by using passive design strategies, which is known to be the fastest and easiest way for the architect to archive daylit office. This was known as a simple rule of thumb for the architect to design a daylit office (Ibrahim. & Kosman 2007).

There is very significant relation between archiving energy efficiency building and daylit office building (Lam and Li 1996). Daylight contribute to a good indoor environment, permitting natural light into the building giving occupant fell pleasant and at the same time given the view to the outside thought the window opening. The optimum use daylight in an office building will reduce the use of artificial light and at the same time produce energy efficient in the office building. In reality, it will not be a simple task to the designer especially architect, although successful architect designing a building that is said to optimize energy efficiency with the use of natural light through the application of passive design strategy, but some question pounding and need to have research. According to Piccolo. & Simone (2009), excessive daylight levels in interiors, however, do not always correspond to optimum visual conditions as they could produce an excessive luminance range in the visual field with high risk of unwanted glare effects. The question occur whether the design on the government office building in Malaysia has met the occupant visual comfort criteria or does the adoption of passive design strategies such as building orientation, window size and internal control window system such as blind has taken all the consideration on the penetration of natural light into the building without compromising the outside view and visual comfort to the occupant in the office building.

This paper studies on quantitative and qualitaitve method that can be recommended to the architect in public sector to identifiy glare problem in government office building in designing energy efficiency office building throught passive design strategy and to compare the finding with a result from survey done at the existing government office building.

Table 1: Daylight Factor and Distribution (Malaysia Standard (M.S) 1525 2007).

Zone	DF %	Distribution
Very Bright	6	Very large with thermal and glare problem.
Bright	3 – 6	Good.
Averange	1 – 3	Fair.
Dark	0 - 1	Poor.

Note : The figures are average daylight factor for windows without glazing.

Table 2: Performance indicator on the daylight quality, Dubois (2001).

Performance indicator	Interpretation
WORK PLANE ILLUMINANCE	
< 100 lx	Too dark for paper and computer work
100-300 lx	Too dark for paper work / acceptable for computer work
300-500 lx	Ideal for paper work / ideal for computer work
> 500 lx	Ideal for paper work / too bright for computer work
ABSOLUTE LUMINANCE	
> 2000 cd/m^2	Too bright, anywhere in the room
> 1000 cd/m^2	Too bright, in the visual field
< 500 cd/m^2	Preferable
< 30 cd/m^2	Unacceptably dark
DAYLIGHT FACTOR	
< 1 %	Unacceptably dark, negligible potential for daylight utilization
1-2 %	Acceptable, small potential for daylight utilization
2-5 %	Preferable, large potential for daylight utilization
> 5 %	Ideal for paper work, too bright for computer work, total daylight autonomy

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2. Methodology

Malaysian climate is hot and humid with monsoon rain occuring between November to January. It is situated between the latitude 1^{o}N to 7^{o}N and Longitude 120^{o}E to 100^{o}E with intermideate sky condition (Ling, *et al.* 2007). According to Malaysia Standard M.S. 1525 (Department Of Standard Malaysia 2007), glare problems occur inside the office building when daylight factor (DF) is more then 6% (Table 1).

The CIBSE (1994) has recommended that luminance ratios should not exceed 3:1 between the task and immediate surroundings and 10:1 between the task and general background. According to Dubois (2001), the performance indicator on the daylight quality through his study on literature review is shown in Table 2.


Building A


Building B


Building C


Building D


Building E

Figure 1: Photos of five government offices : Kuala Lumpur Federal Building(Building A), Gua Musang Federal Building(Building B), Temerloh Federal Building(Building C), Taiping Federal Building(Building D), and Penang Federal Building(Building E).

2.1 A Qualitative Method in Finding Occupant Perception Toward Glare Discomfort on Government Office Building

Occupant perception toward glare discomfort was determine through a survey of 5 government office building blocks completed in differant years and situated at 5 different state. Sample were identified in earlier stage before the survey was conducted according to data of the selected office buildings collected from the original design documents including the building and floor layout drawings. A set of questionnaires were established into three part using Likert scale as a rating scale. The Likert scale is designed to exermine how strongly subjects according to a 5-point scale (Sakaran 2003), which can thereafter be summated across the items. The first part described the awareness of the occupant toward the glare discomfort. The second part of the question described the knowledge of the occupant in regard of glare discomfort and the third part was on the overall occupant perception in general toward the glare discomfort. In order to simplify the survey analysis the five building were rename Building A for Kuala Lumpur Federal Building, Building B for Gua Musang Federal Building in Kelantan, Building C for Termeloh Federal Building in Pahang, Building D for Taiping Federal Building in Perak and Building E for Penang Federal Building (Figure 1). The survey was done in the month between November 2010 until February 2011. It is shown that the survey was done in early beginning of the monsoon season in Malaysia until end of the monsoon season.

Result form the survey was analysed using IBM SPSS Statistic V.19. Descriptive statistis analysis was used to analyse the percentage of the result by using cross tabulation between each building and the questionnaire. This result will be the basic in finding building to have high glare discomfort problem through occupant perception. A further analysis through computer simulation will be done base on this result to verified the survey result base on the passive design strategy.

Figure 2: Photo of State Federal Building in Taiping Perak.

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2.2 A Quantitative Method İn Finding Glare Discomfort On Government Office Building

In this study, a 3D computer simulation using Daysim was carried out based on a selected government office building from the results of the survey analysis from five government office buildings. The building chosen was the State Federal Building in Taiping Perak as shown in Figure 2.

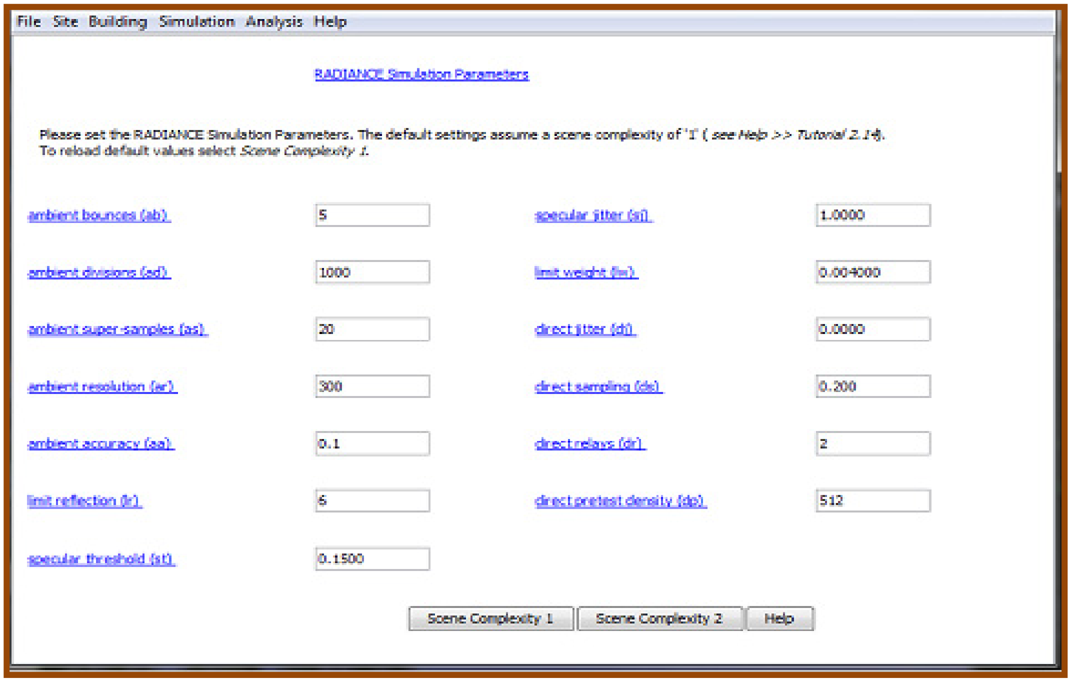

Figure 3: Screen shot of the setting up parameter for the simulation.

DAYSIM is a RADIANCE-based (Bourgeois., et al. 2008), daylight simulation tool that uses the concept of the Daylight Coefficient method (Tregenza., 1983) and the Perez all-weather sky luminance model (Perez *et al.*, 1993). Daylight Coefficient is a method to calculate indoor illuminance levels due to daylight under arbitrary sky conditions. Daysim calculates illumination at a point in the space throughout all of the year. It is a climate-based daylighting analysis tool that calculates a short-time step development of indoor illumination level with the time varying sky luminance distribution (Jeff and Kota 2009). In this simulation, glare discomfort will be identified through the result from Useful Daylight Illuminance (UDI) where according to Mardaljevic and Nabil (2006) suggested that the percentages of the occupied times of the year when the UDI was achieved (100-1000 lux), fell-short (<100 lux), or was exceeded (> 2000 lux). The last bin is meant to detect the likely appearance of glare. A 3D building model is created base on the geometry of the selected building by using 3D Sketchup software due to it popularity among the architect and to it user friendly use. Three main factors in design strategy are including as part of this design to determine the effect of the glare discomfort in the building. The simulation will be setup in standard Malaysia climate, where it is to be considering as intermediate sky condition (Haberl and Kota 2009). A set of parameter is setup in Daysim to produced optimum results in an acceptable calculation of time. This parameter is based on the recommendation by Dubois (2001) as Figure 3.

A complete 3D building model in sketchup to be export into 3ds format where then it can be import into Daysim. Before the simulation start, a sensor point file (*.pts) must be create. A Daysim sensor point file (*.pts) is a Radiance/Daysim input file that contains the coordinates and orientations of all points in the building that are relevant for a daylighting simulation (Zain-Ahmed *et al.*, 2002), e.g. occupant work places, positions of photocells, etc. In this simulation, a sensor point file (*.pts) is show in Figure 4.

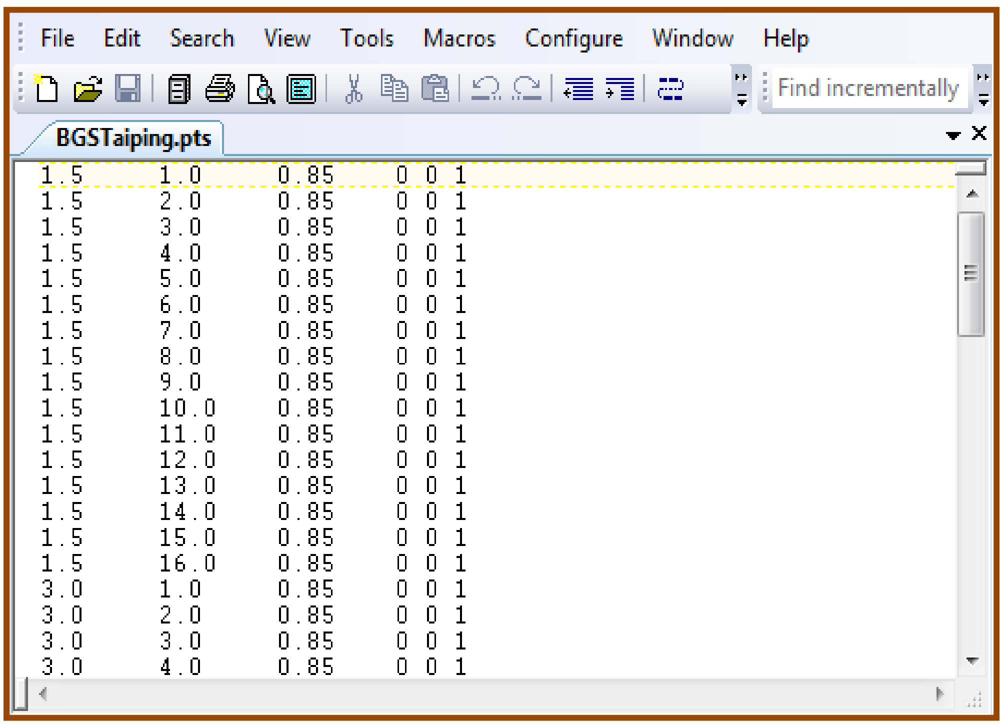

Figure 4: Screen shot of the sensor point file.

Result from Daysim also will determine the user behavior model esspecially in study with personal controls such as blinds and window openings. A 3D building model by SketchUp is show in Figure 5.

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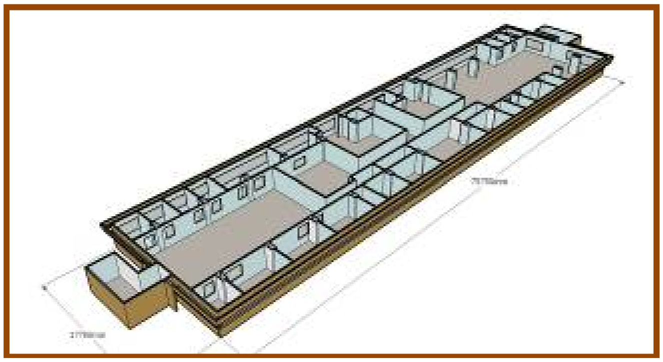
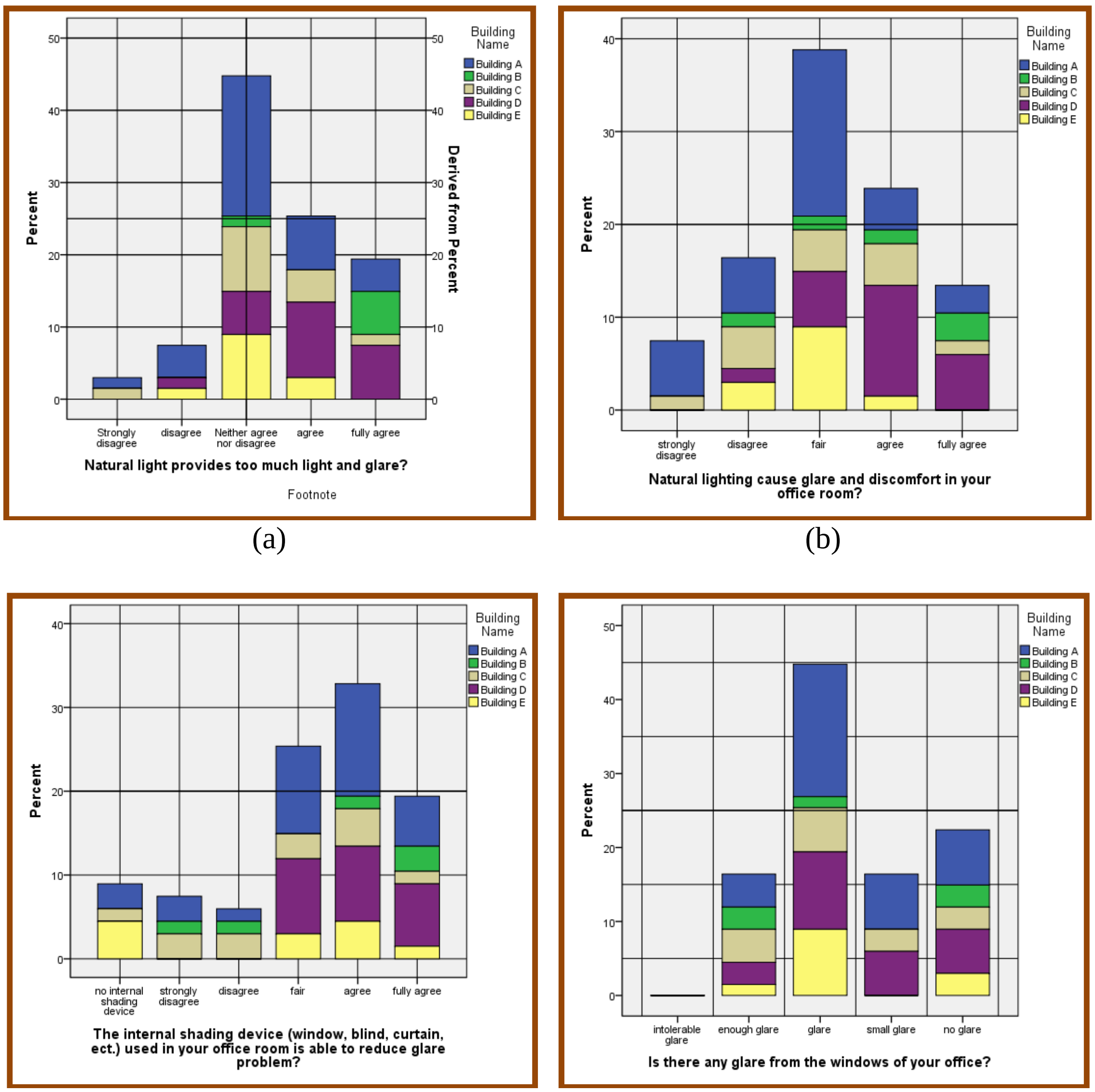


Figure 5: Photo of 3D building model using SketchUp.



(a) (b) (c) (d)

Figure 6: Result from survey with 4 differant set of variable.

3. Analysis and Finding

A total of 67 respondens from 5 government office building have answered a set of questionnaire given. A result from Cronbach α for reliability shown 0.689 which can be acceptable. Analysis using crosstabulation was done between buildings and questionnaires (Figure 6) and result shown that about 57.7% of the respondens think that natural daylight cannot be control and 44.8% of the respondens think that natural light provided too much light and glare (a). The survey shown that 86.5% of the respondens prefer tho have window in their office room. There were about 13.5% of the respondens fell uncomfortable with the level of natural light that penetrates through the window of their office room and 38.3% of the respondens fell that there was glare discomfort cause by natural light in their office room (b). 52.2% of the respondens fell that internal shading device was vary inportant element in reducing glare problem in their office room (c) and 60.2% of the respondens fell that there was glare problem from the windows of their office room (d).

An overall result from the survey shown that Building D there is Taiping Federal Building has the highest percentage in term of glare problem and was choosen to further analyse using Daysim simulation. Result from Daysim simulation shown that daylight factor (DF) analysis has a daylight factor below 2%. Useful Daylight index (UDI) analysis shown that UDI $_{<100}$ has a result of 100%.

The result also verify from HDR photo imaging (Figure 7) taking from CCD camera showing the false color indicating the amount of illuminance in the field view. The amount of absolute luminance which more than 1000cd/m^2 can be consider as visual discomfort as according to Dubois (2001). It also can   possible be as a glare source.

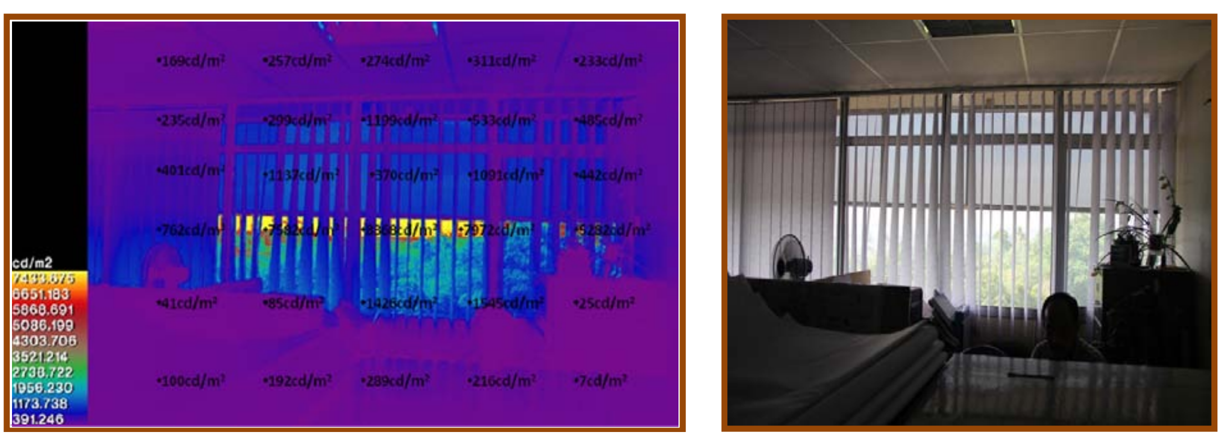


Figure 7: HDR photo imaging indicate absolute luminance threshold.

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4. Conclusion

As a conclusion, from field survey, most of the occupants in government office building have visual discomfort especially because of glare.Through the result from Daysim simulation, it verified the survey that Building D was not designed for daylight utilization, with average DF lower than 2% (Figure 8). The contrast between the window and internal surfaces brightness was considerably too high (average luminance ratio window/average internal surfaces > 40 when light off). The study found that tinted glasses and vertical blind and curtain were used without considering orientation. Since UDI shown that overall internal office it is below 100 lux, it means that most of the spaces in that building can be considered, as it is possible that there will be high contract between internal luminance to external luminance. This was shown from the HDR photo imaging result where high luminance threshold more than 1000 cd/m^2 can be identifying as glare.

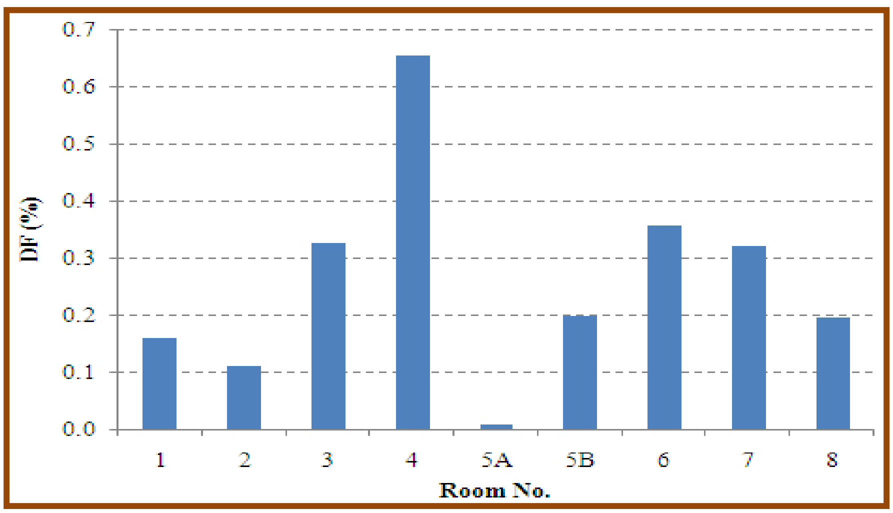

Figure 8: Graph shown daylight factor (DF%) taken from rooms (as indicate in sensor point file at a distance of 1.5m from origin and 1m from each sensor poin).

From this result, it shown that with a simple software and within reseonable time frame, it can be a basis for the architect to create a simple analysis and simulation within the process of design stage that able to produce sustainable government office building. The complementary tools using Digital Canon (HDR image) and computer simulation has a potential for a new method to measure lighting .This is based on the capability to captures the wide angle and can be used for complex research project in daylighting.

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