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Empirical Validation of IES<VE> Simulation in Term of Daylight in Self-Shading Office Room in Malaysia

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ABSTRACT

In order for using building simulation tools, validation of building simulation should be evaluated. Integrated Environmental Solution<Virtual Environment> (IES<VE>) is Considered an environmental simulation tools for analyzing the buildings performance in term of different criteria such as daylighting and heat gain and energy consumption The objective of this study is to test IES simulation software in self shading room in term of daylight through comparison the simulation result with experimental measurement of office room in actual self shading building in Kuala Lumpur Malaysia. Comparative method was used to find out the differences between experimental measurement and simulation result in term of daylight factor as a performance indicator of daylight.. Finding of this study reveals that the differences between simulation result and empirical measurement is in the acceptable range, It can be concluded IES<VE> has enough validity to calculate the amount of daylight factor in self shading rooms. Therefore IES<VE> can be used for developing the design of self shading buildings especially in pre-design stage of self shading office buildings.

KEYWORDS: Daylight, Empirical Validation, Simulation Program. Self shading, Office buildings

INTRODUCTION

Energy Commission Diamond Building is the most recently built at Putrajaya Malaysia. The building form is symbolizing a diamond shape, which creates self-shading effect that eliminates direct sunlight while allowing diffuse daylight. Besides, the building form ratio and extensive use of glazing façade are actually not suitable for tropical climate. However, with the use of self-shading, and some other technologies, this building is successful to achieve energy saving. Due to most of the internal surfaces are in white color to enhance the daylight reflection, a monotonous working environment is created.

The diamond form with the Tilting Façade avoid direct sun rays Into building Tilting Façade results in smaller building footprint which allows for more area for landscape. Surrounding landscape reduce heat gain into the building (figure 1) [1].

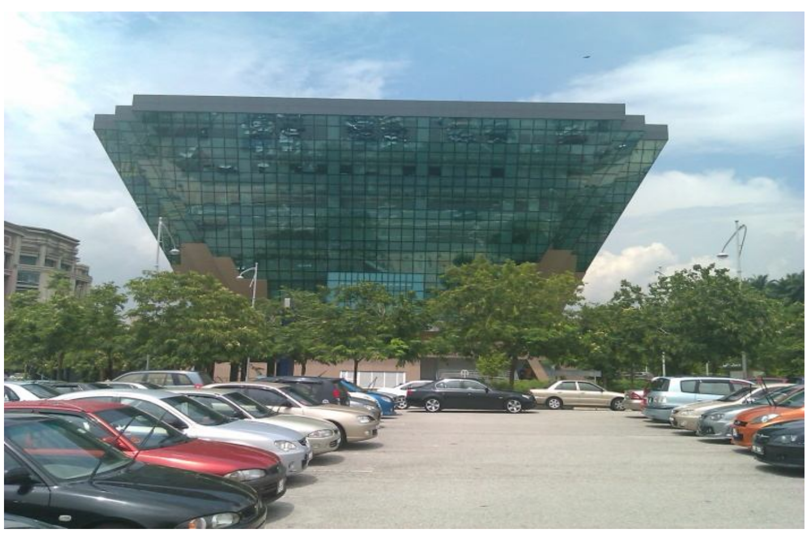

Figure 1 Energy Commission Diamond Building

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IES (VE) software can simulate numerous results for the energy flow and environmental conditions within a building. Beevor (2010) validated the accuracy of the real world testing, and of the ability of IES (VE) simulations to provide accurate building performance data [2].

In order for using building simulation tools, Validation of simulation software should be evaluated. Simulation results were compared with the results of other simulation software or results of standard tests in the process of validation of any simulation tools. CIBSE specified simple methods for verification of simulations[3].

BESTEST is based on comparative testing, by comparing prescribed models with models simulated by the tools. IES virtual environment 5.8.0 is validated with BESTEST[4].

The IES (VE) energy analysis software tool offers high accuracy and interoperability with Building Information Modeling (BIM) tools. Integrated Environment Solutions is a software for integrated building performance analysis, providing tools for thermal analysis, cost planning, lifecycle, airflow, lighting, , in one integrated system. IES (VE) has the capability to store the thermal information about the building. IES (VE) calculates the heat gain calculations and cooling load calculations for a selected design day of the week, and for a range of design months. IES (VE) includes thermal, solar, lighting, energy costs, and heating/cooling load calculations [5].

IES (VE) simulation result passed both the normality test and the equal variance test. In the case of the total energy values, the analysis concluded that there was no considerable statistical difference in the mean values between simulation result and measuring data [5].

A study comparing 20 different building simulation programs concluded that IES (VE) is one of the most comprehensive and complete simulation packages, with its wide range of interlinked modules, and its unrivalled ability to analyze the heating and ventilation and lighting in buildings. The study also reports that IES (VE) has been tested and verified by both CIBSE and ASHRAE [6].

It has been demonstrated that the IES (VE) model is capable of making estimates and predictions to a reasonable level of accuracy for the purpose of examining design changes. It is unreasonable to expect any model to provide perfect predictions, but through the comparison of model predictions against real measurements, a reasonable level of confidence in the IES (VE) model estimates has been achieved [6].

IES (VE) use available data about the mount of direct and diffuse radiation. Results which were derived from IES (VE) hourly were close to calculation results Amount of direct and global radiation used in simulation are derived from the weather file[7].

IES (VE) was selected as the most favorable computer simulation software to evaluate energy efficiency in building industry out of 249 respondents in U.S. by 2009 (Attia et al., 2009). IES (VE) claimed to be the high accuracy simulation software due to its validated system [8].

However the validation of IES<VE> has been investigated by many researcher but The validation of IES<VE> in specific form of building (self-shading) need to be investigated in term of daylight..Daylight quality of 2 office rooms in Energy Commission Diamond Building has been investigated by Nikpour, et al.(2012)[9].

MATERIAL AND METHODS

This research has been conducted using two different methods, Experimental measurement of daylight in existing self-shading building and simulation of self shading room using simulation program IES<VE> Then experimental measurement result s were compared with simulation results in same condition.

Therfore Data Logger and illuminance sensor were used for experimental measurement the amount of global illuminance and work plane illuminance The first step for measuring daylight parameter in Energy Commission Diamond Building was to set date, time and 10 minutes interval between each recording for Data Logger. Then the Data Logger was connected to illuminance sensor. The next step is to locate the devices on the roof top of the Energy Commission Diamond Building without any obstacle of solar radiation. The recording of exterior illuminance was started every 10 minutes by pushing the button “LOG”.

Two individual office rooms were selected for measurement on the 6th floor. All Geometrical characteristics of each room such as length, width, height, window size, projected ceiling with respect to floor were measured and the compass was used to determine the orientations of each room. The room index should be specified for identified the number of installed illuminance sensors in each office rooms. Equation 1 shows the computed room index for each room.

$$\text{Room index} = (\text{width} \times \text{lengths}) / [\text{Mounting height} \times (\text{width} + \text{length})] \qquad (1)$$

Table 1 shows the minimum number of required illuminance sensors according to the value of room index.

Table 1: Number of points for work plane illuminance measurement

Room index	number of points for measurement
<1	4
>1 and < 2	9
>2 and < 3	16
>3	25

Based on room index equation, room No.1 need 9 illuminance sensors and work plane illuminance for room No.2 required 4 illuminance devices. The Data Loggers were connected to illuminance sensors and were located at specified measuring positions on the height of work plane, then the amount of work plane illuminance were measured for all positions simultaneously, in addition to compare the mean interior illuminance with mean external illuminance the duration of measurement is recorded.

Two selected office rooms in Energy Commission Diamond Building were measured and their physical features were collected and recorded. Table 2 and 3 shows the physical features of these two selected rooms, in addition figures 2,3,4and 5 show the plan and real pictures of surveyed rooms. WWR is determined as the ratio of the window's area to the total gross wall area. For room No. 1, WWR was equal to 0.54 and for room No.2, it was equal to 0.61[9].

Table 2: Physical features of measured rooms

	Type	Floor Level	Internal shading	Room Plan Shape	Artificial lighting Flourescent
1	Individual	6	venetian blind	Linear	4 (2 tubes)
2	Individual	6	venetian blind	Linear	2 (2 tubes)

Table 3: Geometric characteristics of measured rooms

	Window Height (mm)	Cill Height (mm)	Window Orientation	Ceiling Height (mm)	Geometry (W x L x H) (mm)
1	2150	900	East (N10°)	3600	6650 x 5000 x 3600
2	2150	900	East (N10°)	3600	4800 x 3000 x 3600

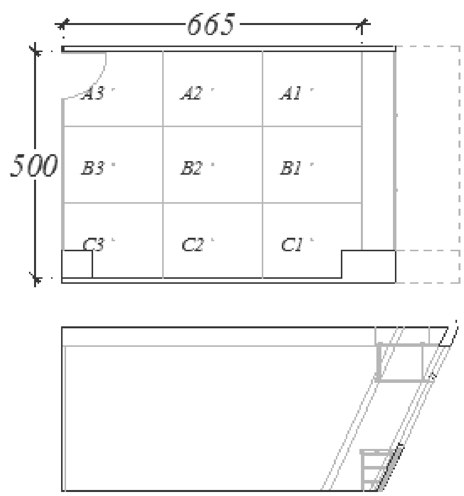

Figure 2 Measured room No.1 (plan, Section)

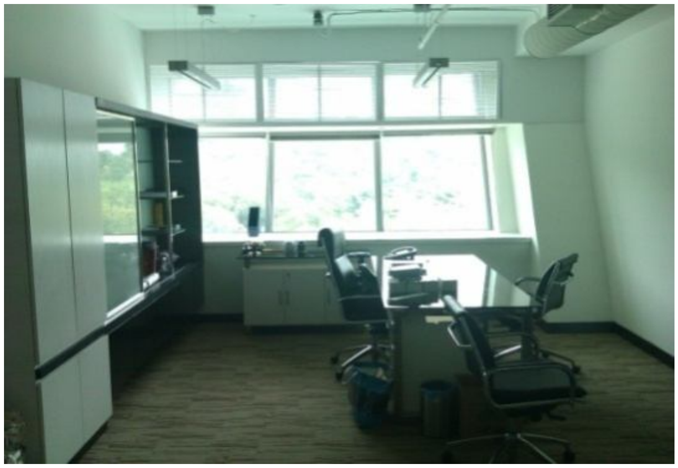

Figure 3 Measured room No.1 (Photo)

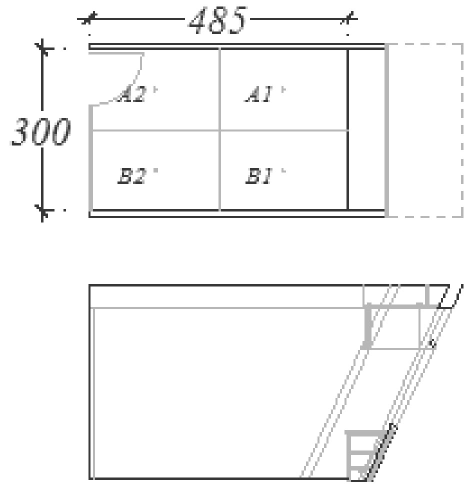

Figure 4 Measured room No.2 (plan, Section)

Figure 5 Measured room No.2 (Photo)

In the other hand IES<VE> simulation program was used to get simulation result in term of daylight. Therefore two Models were made in IES<VE> under ModelIT option in IES<VE>.The weather data was selected Kuala Lumpure under aplocate. All characteristics of simulated rooms were look like the measured rooms in Energy

Commission Diamond building such as geometrical and physical characteristics, wall and window construction type, surface reflectance(figure 6,7)

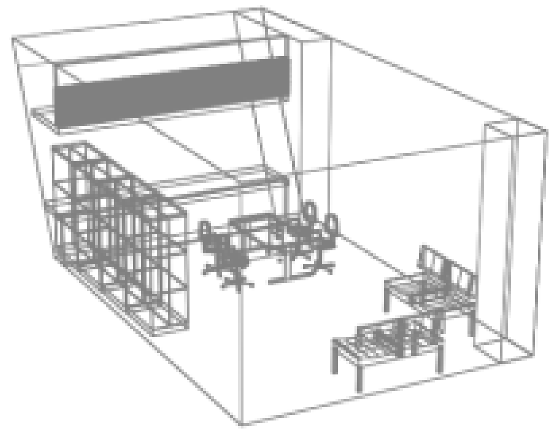

Figure 6 Simulated Room No.1

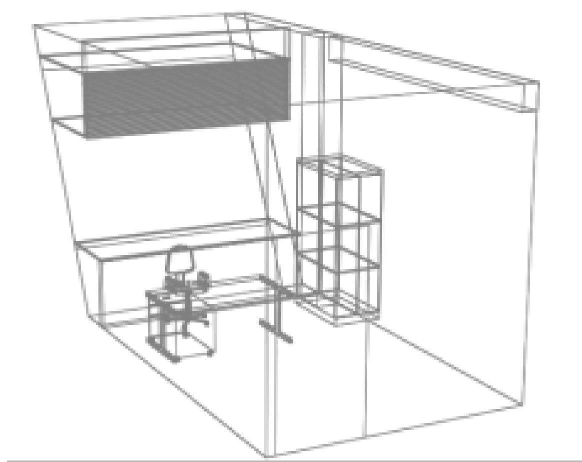

Figure 7 Simulated Room No.2

Then FlucsDL option under lighting menu was used for lighting analysis. FlucsDL is a module available in IES(VE) for performing day lighting analysis calculations. The menus and toolbars for this view provide tools for performing FlucsDL calculations. The program can perform daylighting analysis using the point-by-point method. Analysis can be performed in single-room mode or in multi-room mode.

This tool displays the APLocate dialogue box where it is possible to set the building location. The only items of importance for the lighting calculations are the latitude.

The Analysis dialogue box allows running an analysis calculation. Preferences can be set using the Settings followed by Analysis option. Page dialogue box is as shown in figure8:

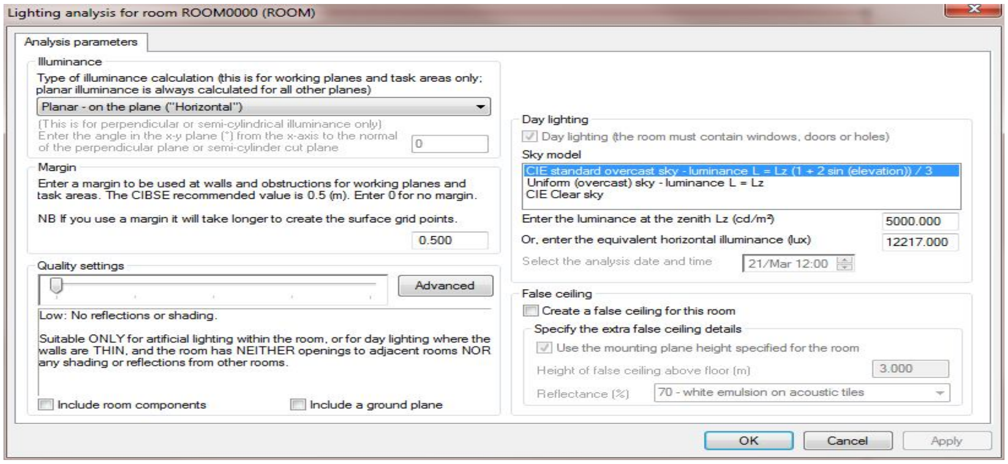

Figure8 Daylight Analysis page

After making models with Model IT option in IES (VE). Each selected model was simulated with FlucsDL option which is located under lighting in IES(VE) software. Before lighting simulation, some parameters should be set. Type of illuminance calculation is planar on the horizontal plane for working plane and task areas only. Daylight Analysis have been done under same sky condition with experimental measurement

FINDING AND DISCUSSION

Working Plane Illuminance

This experimental measurement was held on October 11, 2011. Table 4 shows the reported of mean outdoor illuminance for both selected rooms during measurement. In addition the work plane illuminance for each point of selected rooms is shown in Table 5 when lights were off.

Table 4: Mean global illuminance during measurement

Time	Mean global Illuminance
During measuring room No.1	41920.00
During measuring room No.2	44645.00

Table 5: Work Plane Illuminance, (Lux)

Points	A1	A2	A3	B1	B2	B3	C1	C2	C3	Ave
Room 1	1591	338	148	1738	352	147	1084	311	132	649
Room 2	1055	267	-----	915	242	-----	-----	-----	-----	619.75

Daylight Factor

Daylight factor means the probable of each space for using the daylight Equation.2 shows the computed daylight factor by dividing the mean internal work plane illuminance with the mean external illuminance.

Daylight factor = (internal illumination/external illumination) × 100 (.2)

According to MS1525, for having a space with sufficient potential for proper using of daylight, the daylight factor should be above 1.5 %. Table 6 shows the amount of daylight factor in different points of both selected rooms and their averages.

Table 6: Daylight factor for two measured rooms

Points	A1	A2	A3	B1	B2	B3	C1	C2	C3	Average
Room 1	3.79	0.8	0.35	4.14	0.83	0.35	2.67	0.74	0.31	1.5
Room 2	2.36	0.59	---	2.04	0.54	----	---	----	---	1.38

Surface Reflectance

Reflectance of each plane is a proportion of to the amount reflected light to the amount of received light by a plane. In order to measure the reflectance of each surface in the room, the amounts of light which were received by illuminance sensor were recorded in two positions of sensor when the sensor was facing to the surface and when the sensor was located in the reverse to the surface. 20, 50 and 70% are acceptable surface reflectance for floor, wall and ceiling respectively.

Reflectances of surfaces are 0.70 and 0.78% for walls in room nq.1 and room no.2 respectively. Furthermore surface reflectance were 0.89 and 70% for the ceiling in room no.1 and room no .2 respectively. Therefore surface reflectance for wall and ceiling in both measured office rooms in Energy Commission Diamond building are more than the recommended value for wall and ceiling. Surface reflectance for floor in room no.1 was 20 %. As the floor-covering was carpet, the floor reflectance in room no.1 was by 10% (Table 7)[9].

Table 7: Surface Reflectance (%)

	Wall	Floor	Ceiling
Room 1	0.70	0.20	0.89
Room 2	0.87	0.10	0.70

For Validation of IES (VE) in this research, two individual office rooms in Energy Commission Diamond Building were modeled in IES (VE) as similar as real measured rooms. Dimensional properties, orientation and construction type of materials were set like the existing rooms in Energy Commission Diamond Building.

Simulation result shows that the amount of mean daylight factor were 1.5 and 1.3 for room no.1 and no 2 respectively while the experimental results shows daylight factor 1.5 and 1.38 for room no.1 and no.2 respectively

Conclusion

Simulation results and experimental measurement in one of office room exactly is same in term of daylight factor. and the differences between simulation results and experimental measurement in the other office room is not more than 10% in term of daylight factor. The comparison between experimental and simulation results shows that IES has enough validity for daylight analysis in term of daylight factor as an important performance indicator of daylight in rooms with inclined walls. Therefore daylight factor can be selected as performance indicator of daylight for conducting the future research in self shading building for daylight analysis.

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The authors declare that they have no conflicts of interest in the research.

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