A Study an Impact of Daylight with Period Time on Illuminance and Uniformity for Building

S. Sripramong, S. Ananwattanaporn, A. Ngaopitakkul, and C. Jettanasen

***Abstract*—The daylight can be applied for lighting system in building to reduce energy consumption. Although the illuminance on the task area can be increased using the daylight but various factors must be taken into account. This research aims to study an impact of illuminance with daylight in term of each time period. The illuminance is calculated with daylight function in DIALux program. In addition, the fluorescent T5 tube lamp is used in simulation. The case study room without daylight (base case) is compared, in term of illuminance, with the case study room with daylight of each time period. The obtained results show that the daylight can increase the illuminance in the building so the lighting system in many modern buildings has applied daylight in order to achieve specific result of energy savings. The obtained results are useful for design of the interior lighting system.**

***Index Terms*— Fluorescent lamp, Daylight Control, lighting system, Energy Saving, Illuminance**

I. Introduction

IN past decade, energy and environmental issue have become major problem in many countries due to increased fossil fuel consumption rate for economic growth. Other than investment into renewable energy, energy management of end user plays an important role to increase energy efficiency that is another way to reduce energy problem. The lighting system in urban area consumes up to 20-30% of overall electrical usage including exterior applications. Many buildings try to apply daylight technology to reduce energy cost in lighting sector [1]-[6]. To appy daylight in building, location of building, time, climate, size and material of window, are factors that must be considered because these factors are affected in term of illuminance contributed by daylight [7]-[10]. Many researches have been studied on daylight and application to lighting system in building. A criterion to evaluate daylight and impact on energy performance of interior lighting system has been described in [11]-[13]. The optimal design of control system, combining artificial light and daylight systems has been proposed in [14]. The daylight factor in different types of window has been investigated in [15]. This research aims to study an impact of illuminance with daylight in term of each time period. The fluorescent T5 lamp is investigated and performed with various periods of time. The illuminance is simulated using the daylight function in DIALux program.

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II. Simulation and Results

This fluorescent T5 tube lamp has been simulated to evaluate effect of illuminance with combined daylight and artificial light. The luminous intensity for fluorescent T5 lamps obtained in simulation is recorded on a polar plot as shown in Fig. 1. Detail of fluorescent T5 is shown in Table I.

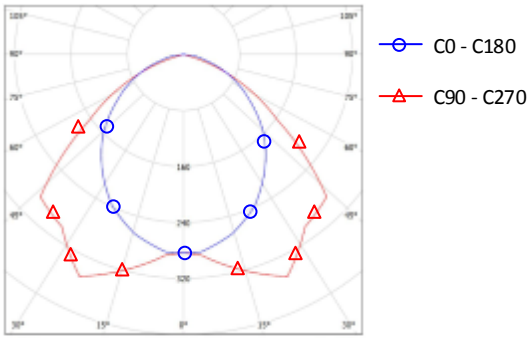

Fig. 1. Polar curve of T5 luminaire used in Simulation

TABLE I Data for fluorescent T5 lamp

Type of Luminaire	Lumen flux per luminaires	Total luminous flux (Lumen)	Watt per luminaires	Total wattage (Watt)
Fluorescent T5	4516	67737	56	840

The case study room is a lecture room with dimension of 12 x 8 x 2.7 m^3 and total room area is 96 m^2. Simulation is performed using DIALux program, the floor plan of case study room is shown in Fig. 2. The height of task area (or workplane) is 0.75 meter. The fluorescent T5 luminaires are 2 x 28W which are installed with 15 luminaire sets in case study room as shown in Fig. 2(c).

To evaluate effect of illuminance with daylight, the case study room without daylight (or base case) is simulated. The standard average illumanace on workplane is considered as 500 lux. The obtained result from simulation in case of base case is illustrated as isolux diagram and false color rendering in Fig. 3.

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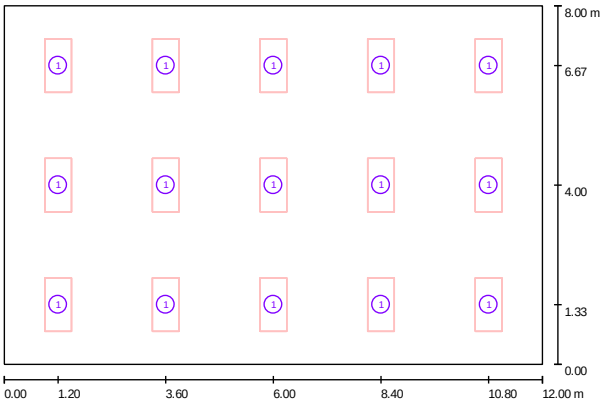
(a) Lecture room model in DIALux program

(b) Lecture room model and luminare layout in DIALux program



(c) Detail of luminare layout in lecture room

Fig.2 Detail of lecture room in simulation

By considering the case study with daylight, the illuminance is simulated with each time period. In this paper, the daylight at 10AM., 12AM., 2PM., and 4PM., are specified in the function of daylight in DIALux program. The obtained results, in term of isolux diagram and false color rendering, were shown in Fig. 4-7, respectively. The case study room without daylight (base case) is compared, in term of illuminance and uniformity on workplane, ceiling, floor and wall section, with the case study room with daylight of each time period as shown in Table II.

By considering the Table II, the results can be observed that, in case of case study room with daylight, the illuminance on workplane near window side is more than 1000 lux but the average illuminance on workplane does not exceed this value due that the daylight from window has an effect only 1/3 of workplane area. In other area of room, the illuminance has approximately value with 600 lux. By considering the daylight at 10 AM., the illuminance is much higher than that of other time period because of location of building and direction of sunlight passing through window. On the other hand, for the daylight at 4 PM., the illuminance value is lower than the other period of time because it is sun set period. Data from simulation reveals that with luminaire with dimming ability applied in this room, luminaire at area affected by daylight can be dimmed or turned off to reduce energy consumption in daytime.

III. CONCLUSION

This paper aimed to study the effect of daylight on each period in term of illuminance of workplane. Simulation with the lecture room was performed using DIALux program. The case study room without daylight (base case) was compared, in term of illuminance and uniformity on workplane, ceiling, floor and wall section, with the case study room with daylight of each time period. The obtained result from simulation revealed that the daylight could increase the average illuminance of workplane but the uniformity of workplane was lower than in case of base case because the illuminance of workplane near window side was higher than the other section area of lecture room. To increase uniformity, artificial light with dimming ability must be applied to control illuminance of workplane at desired value. The improvement of daylight for building must be considered to achieve both energy efficiency and comfort of user.

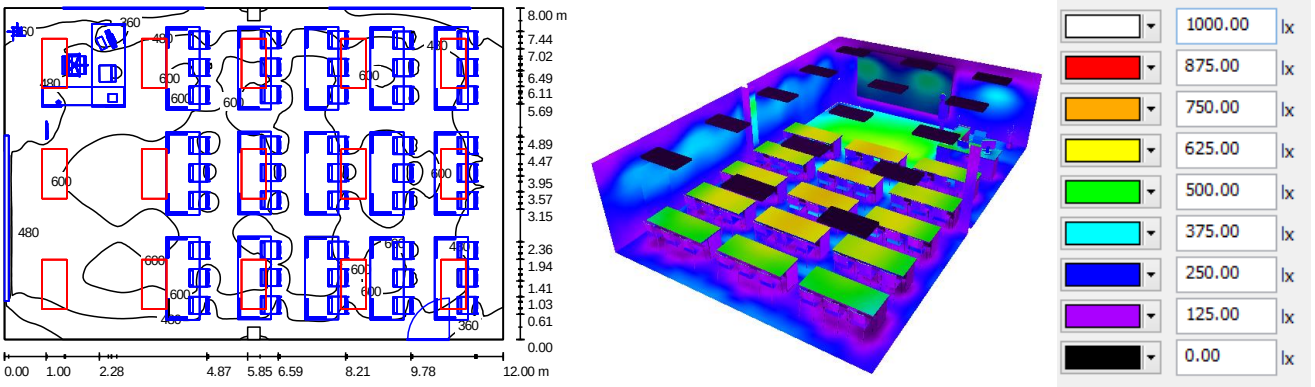


Fig. 3. Isolux diagram in case of the case study room without daylight

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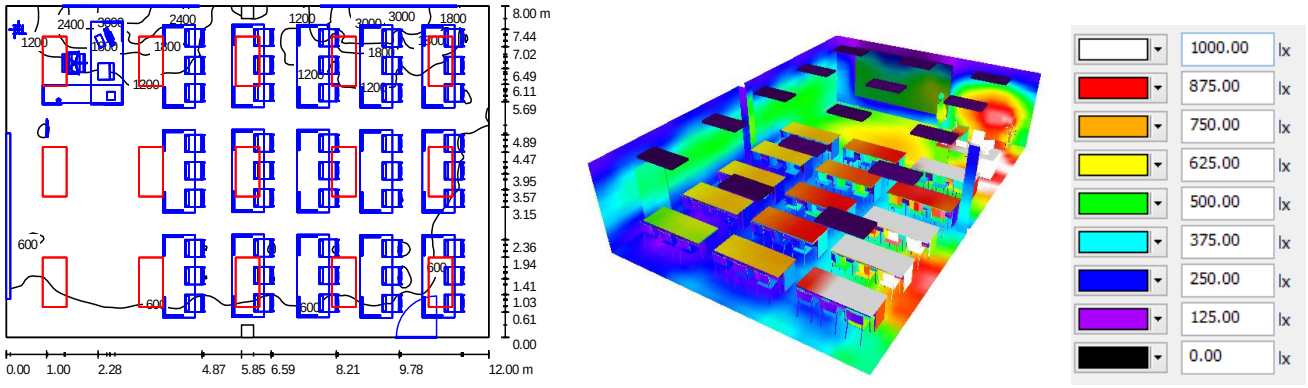

Fig. 4. Isolux diagram in case of the case study room with daylight at 10 AM.

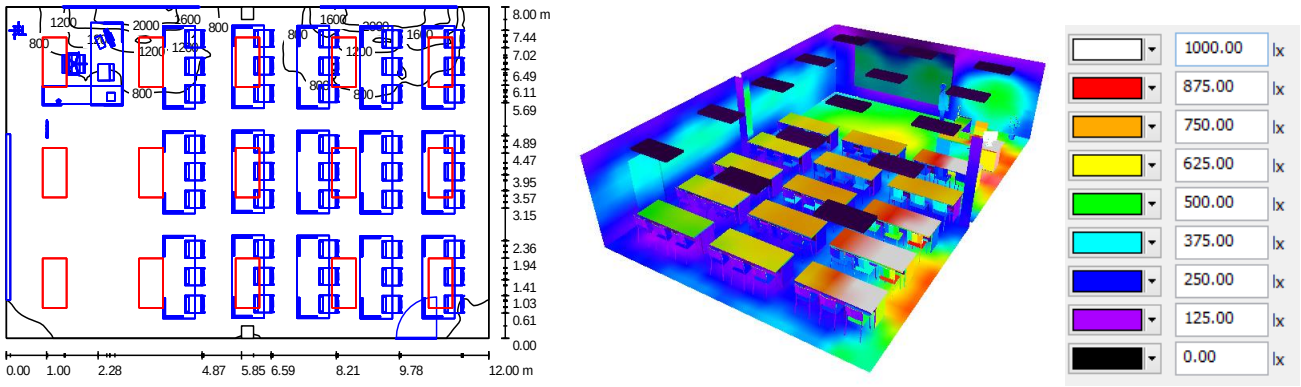

Fig. 5. Isolux diagram in case of the case study room with daylight at 12 AM.

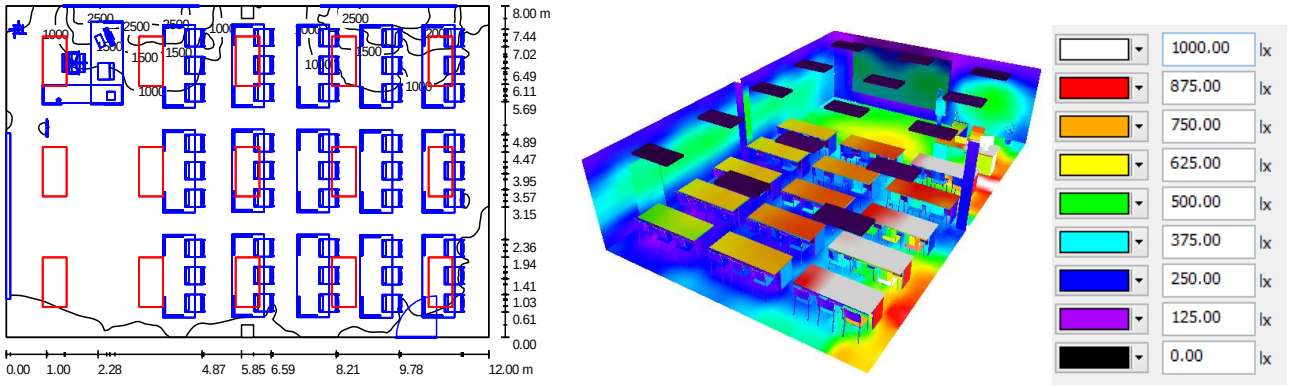

Fig. 6. Isolux diagram in case of the case study room with daylight at 2 PM.

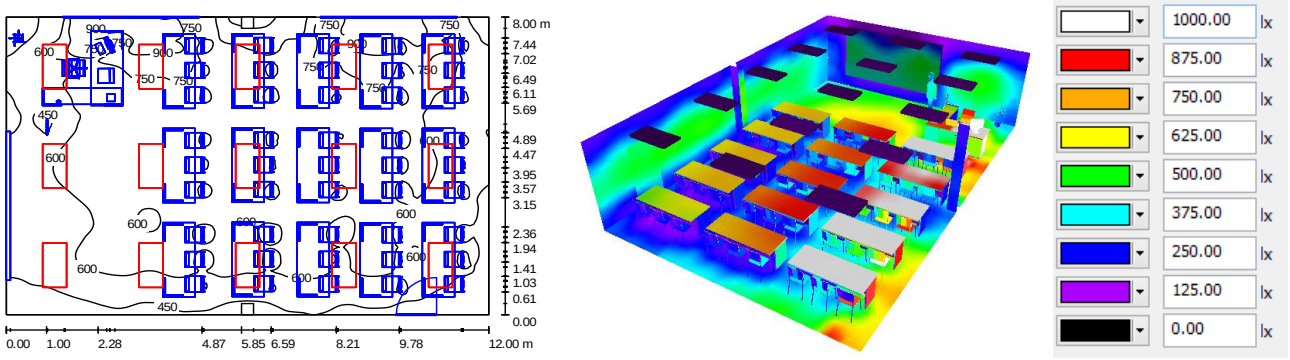

Fig. 7. Isolux diagram in case of the case study room with daylight at 4 PM.

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TABLE II Comparison of illuminance and uniformity for various period of times

Time	Surface	Reflectance coefficient [%]	E_{av} (lux)	E_{min} (lux)	E_{max} (lux)	Uniformity (u_0)
Without Daylight	Workplane	-	536	136	694	0.253
	Floor	20	273	42	595	0.155
	Ceiling	70	138	48	189	0.347
	Wall	52	215	17	432	-
10 AM	Workplane	-	901	369	3171	0.409
	Floor	20	440	98	1362	0.223
	Ceiling	70	222	89	351	0.403
	Wall	52	340	36	1023	-
12 AM	Workplane	-	724	335	2236	0.463
	Floor	20	367	95	1096	0.258
	Ceiling	70	179	71	254	0.399
	Wall	52	271	29	596	-
2 PM	Workplane	-	822	348	2787	0.424
	Floor	20	402	106	1235	0.263
	Ceiling	70	203	79	316	0.388
	Wall	52	312	35	1000	-
4 PM	Workplane	-	615	309	1031	0.503
	Floor	20	309	66	624	0.214
	Ceiling	70	156	49	215	0.318
	Wall	52	239	14	501	-

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