A Method to Determine a Single Point Percentage Daylight Factor (% DF) Value from Field Work Data

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ABSTRACT

The daylight factor is an established way to measure daylight level in an indoor space, whereby natural illumination level indoors (Ei) is compared to the simultaneous illumination outdoors (Eo). The relative values Ei/Eo is considered constant under varying sky conditions. The %DF however does not consider direct sunlight intensity as the occasional occurrence of direct sunlight entry will not make the ratio constant as %DF assumes a uniform and overcast sky. In Malaysia, skies are in the cloudy to near overcast. Direct sunlight do enter the interiors occasionally especially in the mornings and late afternoons depending on the orientation of the window openings. This paper suggests a way to measure %DF using field work data taking samples of 2 room with the worst case scenario of facing directly East and West for comparison. Two varied window to wall (WWR) and window to floor (WFR) ratios were tested for this experiment. The %DF values calculated from this research were in the range of 0.8 to 2.3% and natural illumination levels were found to be more than adequate for normal bedroom activities.

INTRODUCTION

The most popular and most used formula to measure and analyze day lighting performance in buildings is the percentage daylight factor [1],[2][3]. The daylight factor quantifies daylight levels and distribution pattern in the interiors of a building. The formula assumes overcast skies condition and it does not consider the excessive illumination caused by direct sunlight penetration. The formula for %DF is derived as follows:

%DF = Ei/Eo X 100% whereby
Ei is the illuminance due to daylight at a point on the indoors working plane
Eo is the simultaneous outdoor illuminance on a horizontal plane from an unobstructed hemisphere of an obstructed sky [4]. By using relative values which compare indoor to outdoor illuminance, this factor is constant under widely varying outdoor sky and day lighting conditions [5]. The real sky conditions vary throughout the world depending on location, climate and sunpath but generally skies can be divided into 3 categories [6]and they are:

- Clear skies
- Cloudy and partly cloudy skies
- Overcast skies

Realistically, there is no uniform sky that is uniformly illuminated so that values of the percentage daylight factor in building spaces can be directly measured. The real skies are a dynamic phenomena with the movement of the sun via its sunpath and also the availability of clouds along with the conditions of dust, water vapour and other gaseous molecules in the air that affects the level and quality of illumination.

The Malaysian skies has been categorized as being very cloudy to near overcast. From meteorological stations like Alor Setar Kedah and Bayan Lepas Penang, cloud cover data was given at 6.4 octa and 6.9 octa respectively [7]. The value “0” octa indicate a totally clear sky and “8” octa a completely overcast sky thus the very cloudy description suits the sky condition well indeed.

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Sunshine hours, on the other hand, is an indication of the amount of time during daylight hours that direct light from the sun is received. It is measured with a sunshine recorder and data from meteorological stations has Alor Setar Kedah at 6.9 sunshine hours’ daily average, and Bayan Lepas Penang 7.0 hours [3]. From the 12 hours daylight duration experienced in Malaysia, about half is sunshine hours.

Due to the very cloudy skies and long duration of sunshine hours experienced, direct sunlight entry in buildings are common especially when the buildings have a lot of windows and glazing areas. This is made even more critical when the orientation of the glazing is toward the East and West directions when direct sunlight penetration in buildings can occur extensively in the hours after sunrise and the late hours before sunset.

The problem is how then can %DF be measured in East and West facing spaces in Malaysia considering the dynamic real sky conditions and the extensive direct sunlight entry?

Methodology:

A case study building was selected from one of the residential blocks of the Universiti Sains Malaysia campus called Fajar Harapan, which is located in Penang Malaysia. The rooms selected faces the East and West direction directly (Figure 1). The rooms measure 2.9m by 4.43m with floor area of 12.85meters square. The window area is 4.43 meter square which makes up 50% of window wall ratio (WWR) and 35% of window floor ratio (WFR).

To get more %DF readings, the windows were also half covered using polystyrene boards (Figure 2) making 25% WWR and 17% of window floor ratio (WFR).

Fig. 1: Fajar Harapan : Plan and section of investigated rooms and probes locations

Indoor illumination were taken at mid points of east and west rooms (Le and Lw) using luxmeter probes located 1m above floor level. Readings were logged every 10 minutes using a data logger simultaneously with an outdoor weather proof light probe (Lo). Similar techniques were carried out with the window areas covered by half (Figure 3) All measurements were carried out from in March. March days were chosen as the sun path for the locality of Penang is more directly perpendicular to the room’s orientation.
RESULTS AND DISCUSSION

Indoor illumination at the East room usually peaked at around 9am while in the West room at around 5pm and this is an indication of some direct sunlight penetration according to the sun’s location and altitude at the particular times. In the field work daylight factor calculations ie Le/Lo X 100 and Lw/Lo X 100 the readings which were seen to have the influence of direct sunlight were disregarded. This is because the daylight factor calculations do not consider the component from direct sunlight and assumes completely uniform and overcast skies. Readings, which were too early in the morning and too late in the evening, were also disregarded due to the skies not being uniformly illuminated. Only readings from 10.30am to 3.30 pm (Figure 4) are considered as those are the approximate times that direct sunlight penetration do not occur in both rooms. This duration is derived through observation and pattern of data from field work.
Summary:

table 1 below summarizes the data collected and described above. It could be seen that the west room experiences slightly lower average %DF values compared to east room. From the average %DF values, how bright they translate into illuminance level in the rooms under the real Malaysian skies could be seen in the average, max and min Li data collected. Data on Lo, on the other hand describe the high illumination of the Malaysian skies. Here in Malaysia, 1%DF and even 0.5% DF may be sufficient for activities in a residential room like resting, reading or just taking a nap.

<table>
<thead>
<tr>
<th>WWR</th>
<th>Li (lux)</th>
<th>Lo (klux)</th>
<th>DF (%)</th>
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<tbody>
<tr>
<td></td>
<td>min</td>
<td>max</td>
<td>ave</td>
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<tr>
<td>50% (10 - 15 Mar)</td>
<td>586.67</td>
<td>2104.33</td>
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<td>Difference</td>
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<thead>
<tr>
<th>WWR</th>
<th>Li (lux)</th>
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</thead>
<tbody>
<tr>
<td></td>
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REFERENCES


