Managing Light & Daylight Efficiently for Tropical Office Buildings

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  - desirable
  - cool
  - green

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  - ST Diamond building
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  - PTM building

Finish with Q&A

Buildings by IEN Consultants where daylighting plays a key role to achieve energy efficiency
Survey among 46 building professionals in Singapore

Would a fully day lit office concept with supplementary electric lighting for heavily overcast days be marketable to tenants?

Daylit offices are deemed marketable
Suppose daylight can be controlled just like electrical lighting. If this is the case, please indicate how you believe a typical office worker would prefer to have his workplace lit:

- Fully lit with electric light
- Fully lit with daylight

**Offices preferred to be mostly daylit**
Survey among 569 office building occupants in Manila, Philippines

“Regarding the balance between electrical and natural light, which do you prefer?”

- Total reliance on electrical light: 4%
- Predominant reliance on electrical light with supporting daylight: 13%
- Equal reliance on daylight and electrical light: 46%
- Predominant reliance on daylight with supporting electrical light: 31%
- Total reliance on daylight: 6%

Offices preferred to be mostly daylit
Daylight is ‘Cool’

Luminous Efficacy

<table>
<thead>
<tr>
<th>Light Type</th>
<th>Lumen/watt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incandescent</td>
<td>15</td>
</tr>
<tr>
<td>Low voltage halogen</td>
<td>18</td>
</tr>
<tr>
<td>Fluroscents lamp</td>
<td>65</td>
</tr>
<tr>
<td>Direct Sunshine</td>
<td>100</td>
</tr>
<tr>
<td>Clear sky daylight</td>
<td>130</td>
</tr>
<tr>
<td>&quot;Cool Daylight&quot;</td>
<td>200</td>
</tr>
</tbody>
</table>

Less Heat & More Light!
Different Glazing Performances

Examples

a) Suncool HP Brilliant 50
   - VLT: 51%
   - SHGC: 26%
   - VLT/SHGC ratio: 1.96
   NB. Spectrally selective, allowing light, blocking heat

b) Optifloat Clear
   - VLT: 81%
   - SHGC: 73%
   - VLT/SHGC ratio: 1.11
   NB. Only slightly spectrally selective
Orientation for Daylighting

North & South windows can easily be shaded by horizontal overhang
Daylighting Design Strategies

- Control solar heat gain
- Control glare from clear sky and direct sun
- Make daylight factor more uniform
- Increase daylight factor deep in building

Malaysian MS1525 requires 300 lux for offices.

Most people can work down to 100 lux with daylight before switching on lights.
Case study

ST DIAMOND BUILDING
(MALAYSIAN ENERGY COMMISSION)
Solar Geometry

The solar path was used to sculpt the building geometry. The 25° tilt angle of the facades ensures that North and South facades are fully self-shaded during the hottest mid-day hours. For the East and the West facades, the tilting façade helps to reduce the solar impact by 41%.

The tilted glazing admits more of the desirable diffuse light reflected off the landscape for glare free daylighting use in the building.
Façade Daylight Design
The building is 50% daylit. The façade daylighting system consists of a mirror lightshelf and a white painted window sill. Both deflect daylight onto the white ceiling for improved daylight distribution until 5 meters from the façade + 2 additional meters of corridor space. Fixed white louvres with top surface mirror finish on the top side are mounted with a 30° tilt angle above the lightshelf for glare protection while still allowing daylight to be deflected onto the ceiling. To increase daylight throw into the rooms, the suspended ceiling was omitted giving a floor to ceiling height of 3.7 m.
Atrium Daylight Design

The atrium has been carefully designed to optimize daylight utilization for each floor employing the combination of the following three strategies:

1. Automated blind with six different configuration to maintain the appropriate daylighting levels at all times. The blinds with 30% light transmittance are adjusted every 15 minutes and follow a three different control strategies for morning, mid-day and evening.
2. The windows size becomes larger deeper into the atrium to cater for lower daylight levels.
3. A band of Tannenbaum reflector panels are applied to 4th and 5th floor to deflect daylight across the atrium to 1st and 2nd floor where daylight levels are the lowest. The ‘christmas tree’ profile reflectors have an inclination of 10° and reflect about 85% of the light in semi-diffuse manner, hence, avoiding visual glare issues for the building occupants.
Zoning & control of daylight responsive lighting

Daylight responsive lighting control + use of task lighting

<table>
<thead>
<tr>
<th>Lux-sensor</th>
<th>Switch</th>
<th>General lighting</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Light off</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
<td>Light off</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>Light off</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>Light on</td>
</tr>
</tbody>
</table>

(“Manual on”; switch default setting is 0)
Daylight Availability in Kuala Lumpur

Global illuminance

Global diffuse illuminance
Typical Daylight Case (Level 6, East)
Façade Furniture Layout

Lux meter III  Lux meter II  Lux meter I
Corridors in the Centre of the Building

Lux meter V  Lux meter IV  Lux meter III
Atrium Furniture Layout

Lux meter V
All values
ST Daylight, Level 6, East facade

- Logger I (lux)
- Logger II (lux)
- Logger III (lux)
- Logger IV (lux)
- Logger V (lux)

Table 1
Table 2
Table 3
Table atrium
Case study

ADB ATRIUM
(ASIAN DEVELOPMENT BANK)
Atrium Daylight Retrofit

- Daylight level increased 6-fold without glare
- 92% of occupants preferred atrium after retrofit
Measured daylight in Atrium

Good daylight levels in 100 – 2000 lux range
Case study

PTM BUILDING
(GREEN ENERGY OFFICE BUILDING)
Split Window Design
Daylight Responsive Lighting
Daylight Measurements

- Lighting consumption: 0.56 W/m²
- Code requirement: 15 W/m²

25 times more efficient
Conclusions

• Daylighting is big untapped renewable energy source in the tropics

• Daylit office spaces are preferred

• Daylight is cool & free

• Design issues: Orientation, daylight distribution, glare control & daylight responsive lighting

"Yes we can!"

QUESTION:
Can we really make daylit buildings in the tropics?