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Zero Cost Daylight Harvesting Strategy for a High Rise Office Tower

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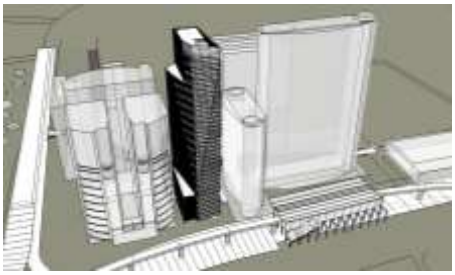

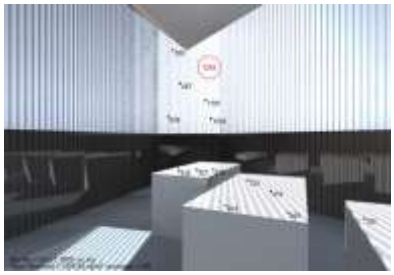

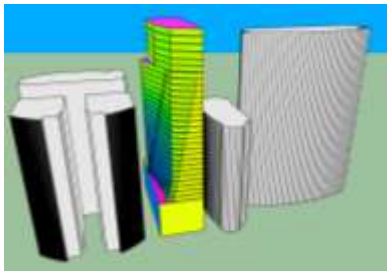

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Introduction

Simple daylight harvesting system strategy using existing conventional building material without increasing development cost to the building developer.

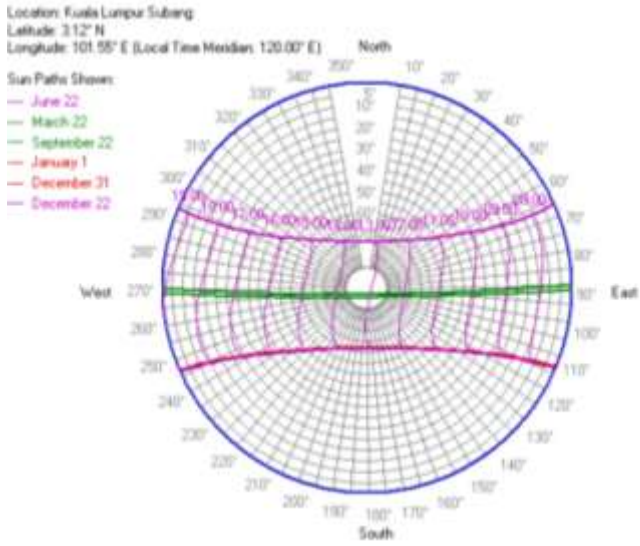
Daylight harvesting strategy proposed was based on addressing glare from two distinct sources:

- The glare due to direct sunlight
- The glare due to the bright tropical sky.

Tropical Climate and Daylight Harvesting

Tropical sky:

- clear to intermediate cloudy in the morning
- intermediate cloudy to overcast sky in the afternoon.
- sunny sky in the morning, while in the afternoon, it is usually cloudy, punctuated by sunny sky occasionally.



Daylight Harvesting in Malaysia

- Daylight is consistently available daily from the hours of 8am to 6pm, coinciding the typical office building operating hours.
- No significant changes over the entire year (no winter, spring or autumn).

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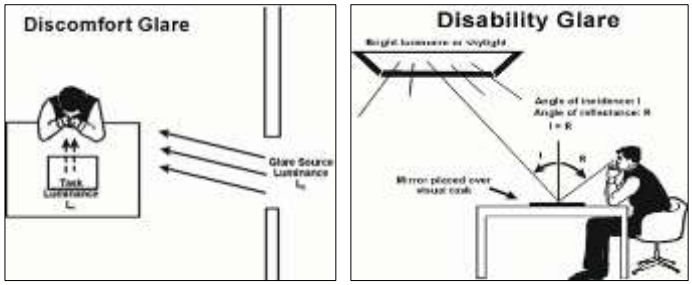
Glare

- Glare discomfort is one of the main cause of buildings not harnessing daylight in this climate.
- Glare within an office environment is generally caused by a significant differences in the ratio of luminance between the task and the glare source.
- In the case of harvesting daylight from the windows for an office space, the glare source is the window itself, while the task area is the building occupant working desk.



Picture Source: Florida Solar Energy Center

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Daylight Harvesting Rule of Thumbs for Tropical Climate for an office environment

Solar Heat Gain Minimization	Glare Protection	Deep Daylight Penetration	Uniform Daylight Distribution
use of low-emissivity (or low-e) glazing	impossible to harvest daylight without glare protection	ensure that more building occupants have access to the benefits of daylight	important for visual comfort
selected glazing (VLT 40%) to be transmitted, less than 25% of the heat.	glare protection devices - usually reduce the amount of daylight harvested	more electrical lights can be switched off for energy efficiency in the building.	design criterias (Ratio of Brightness Contrast)
light coloured blinds-to reflect the solar heat out	A balance between glare protection and daylight harvesting needs to be done. Deep Daylight Penetration		

Ratio of Brightness Contrast

3	• Between task and adjacent surroundings
10	• Between task and more remote areas
20	• Between window and adjacent surfaces
40	• Anywhere in the field of view

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Case Studies- Successful Daylight Harvesting in Malaysia

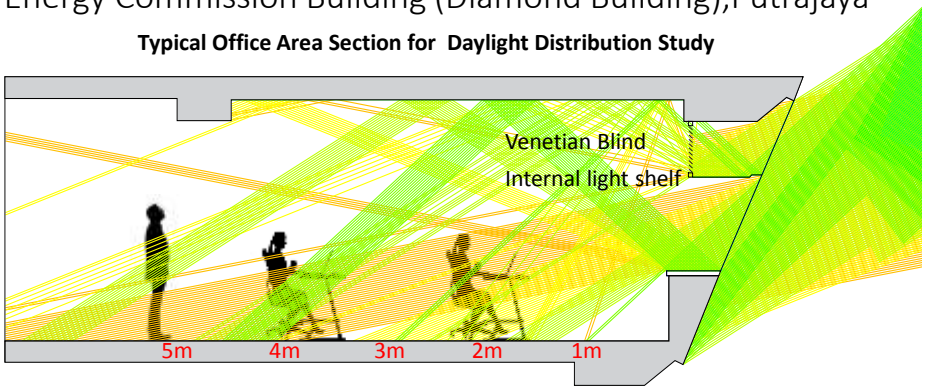
Energy Commission Building (Diamond Building),Putrajaya

Sarawak Energy Building, Sarawak, Malaysia

Green Energy Office Building (Pusat Tenaga Malaysia), Bangi

Energy Commission Building (Diamond Building),Putrajaya

Typical Office Area Section for Daylight Distribution Study



- Designed to be 50% daylit with an internal light shelve façade daylighting system.
- During operation, more than 70% of the electrical lights in the office spaces are switched off when daylight is available.

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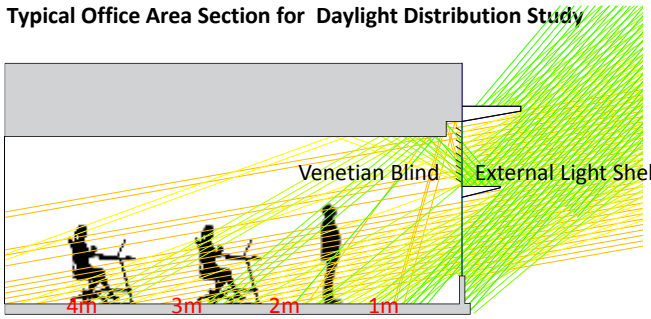
Sarawak Energy Building Berhad, Malaysia

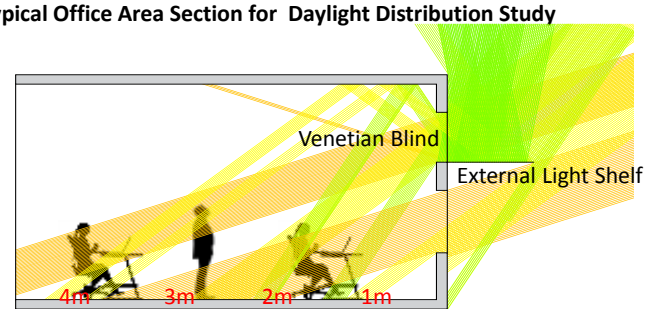
Typical Office Area Section for Daylight Distribution Study



- Daylight harvesting system implemented are Venetian Blind, External Light Shelf and white painted ceiling.
- Approximately 4 meter depth of area daylit is available from the facade perimeter.
- Daylight Responsive lighting. Photo sensor.

Green Energy Office Building (Pusat Tenaga Malaysia), Bangi

Typical Office Area Section for Daylight Distribution Study



- Daylight harvesting system implemented in GEO Building are Venetian Blind, External Light Shelf and Reflector surface finished at the ceiling perimeter.
- Approximate 6 meter depth of daylight is available from façade perimeter.
- On the 2nd floor, a tannenbaum "christmas tree" profile ceiling is provided to deflect daylight up to 7 meter depth.

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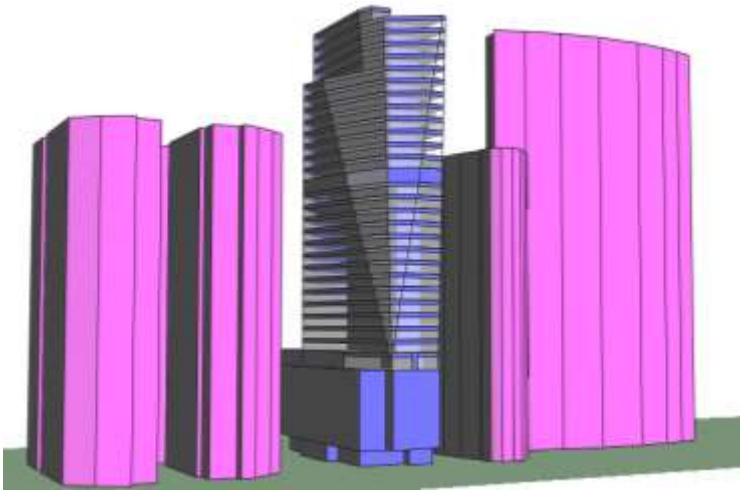
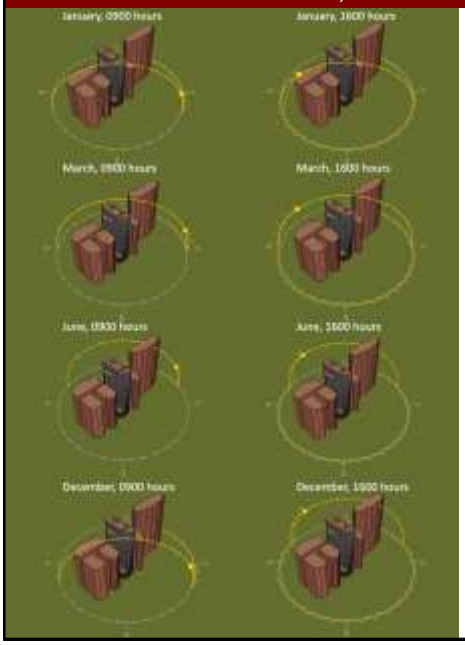
A Zero Additional Cost Solution

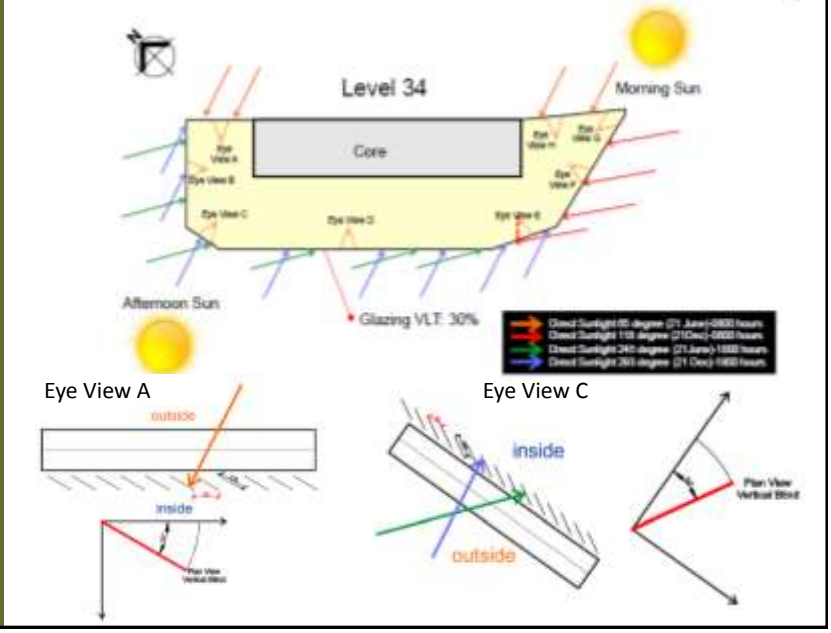


3 distinct studies were carried out using range of tool (Radiance Software) to access:

- The possibility of glare from the direct sunlight
- The possibility of glare from a bright cloudy sky
- Depth of daylight available from the building façade were conducted

The vertical blinds were designed specifically for each façade of the building to prevent direct view of the sun from all possible sitting position in the office space, without requiring the blinds to be fully closed.





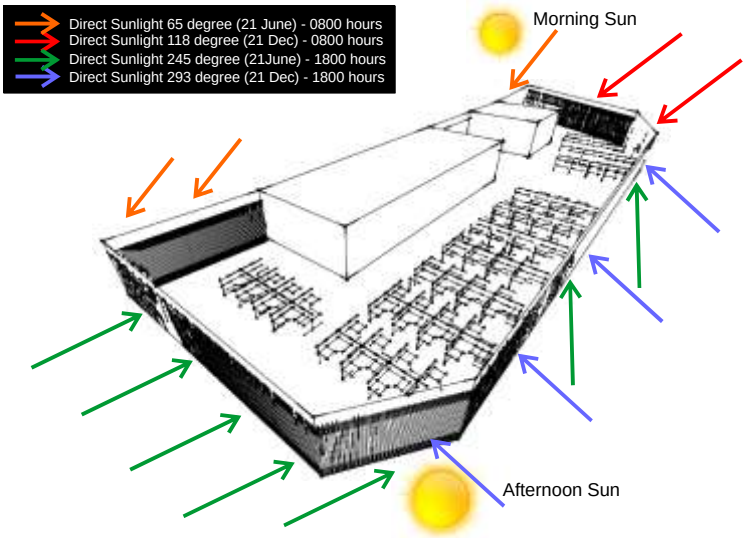
Glare Evaluation Analysis : Based on Luminance Intensity in candela per meter square (cd/m²)

<1000 cd/m²	• Luminance intensity is deem acceptable for the most building occupants in office environment
1000 -2000 cd/m²	• Acceptable range for building occupants in office environment
>2000 cd/m²	• Deemed unacceptable for the most building occupant. Young building occupants would normally be able to accept higher luminance intensity (up to 2000 cd/m²), while older building occupants would prefer luminance intensity below 1000 cd/m²

Note: This glare evaluation method was used successfully for all 3 buildings example. ST Building, SEB Building and GEO Building.

Glare Prevention from Direct View of the Sun

- Positioning of the vertical blind to prevent any line of sight with the direct sunlight.
- The daylight is then filtered through a high performance glazing to reduce the heat gain, while allowing daylight into the building.
- The vertical blind solution provided is a fixed system that does not require the building occupants to make any changes to the blind throughout the year to maintain simplicity and to ensure success of the system during operation.



All the extreme angle of direct sunlight was tested for these studies. The extreme angle of direct sunlight are:
1) June 21, 8am and 6pm 2)December 21, 8 am and 6 pm

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Glare Prevention from the View of a Bright Cloudy Sky

- The proposed solution of a semi-open vertical blind system in an office building will expose some of the building occupants to the direct view of the sky.
- To ensure that all building occupants are not being exposed to glare, the glazing properties were carefully selected to prevent glare from a bright sky condition.
- Simulation studies were conducted to test the maximum allowable glazing VLT under a bright sky condition to prevent glare.

Visible Light Transmission of Glazing	Simulated Maximum Luminance Intensity (cd/m²)
15%	664
20%	888
25%	1118
30%	1335
35%	1573
40%	1797
45%	2007
50%	2242

Simulation Studies with 3 different sky conditions

Sky Condition	Surface Properties Included
Sunny Sky	• Glazing Visible Light Transmission 40% • Vertical Blind Visible Light Transmission 30%
Uniform Sky	• Glazing Visible Light Transmission 40%
CIE Overcast Sky	• Glazing Visible Light Transmission 40% • Vertical Blind Visible Light Transmission 30%

Sunny Sky. This represent times when the sky is clear with direct sunlight on the building. Sunny sky condition is used to test for glare protection by the vertical blinds.

Uniform Cloudy Sky. This represents a bright cloudy sky scenario. A bright clouds is a source of glare. This sky conditions is used to test for glare protection from a view of the sky from a semi-open blind condition.

CIE Overcast Sky. This represent a uniformly overcast sky scenario. This condition is used test depth of daylight factor.

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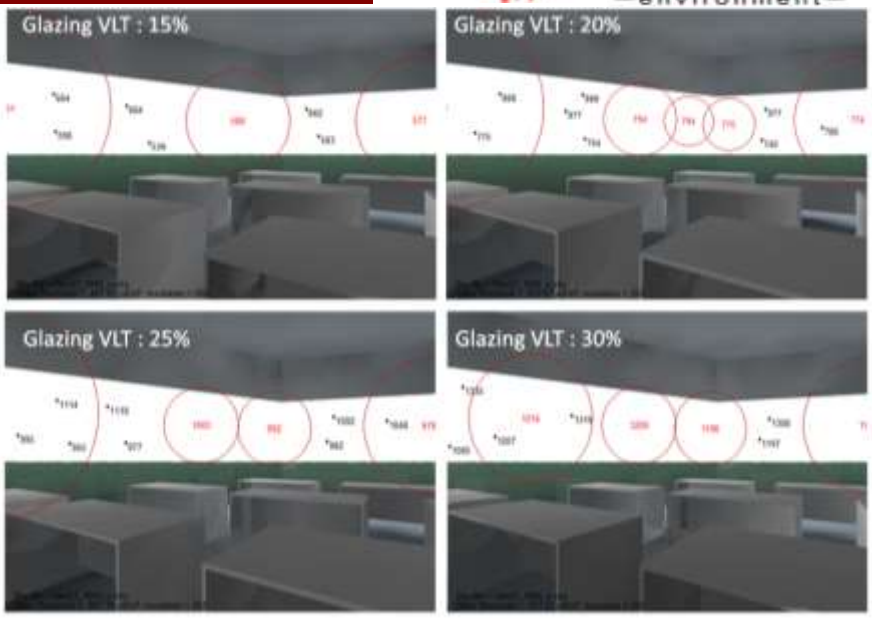
Glare Simulation Result for Uniform Cloudy Sky Condition

- Simulated outputs shows with Glazing VLT of 15% to 30%, luminance intensity does not exceed 2000 cd/m².



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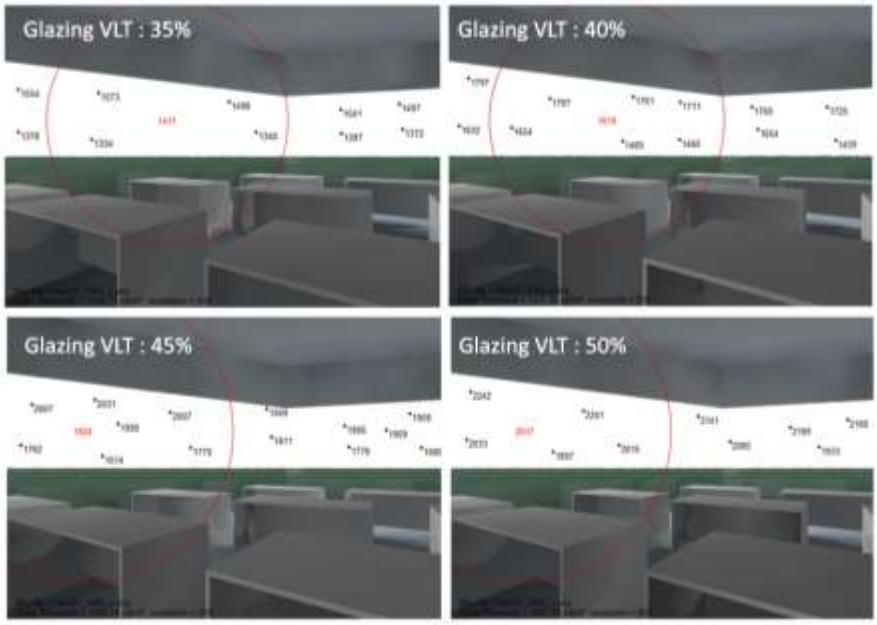
Glare Simulation Result for Uniform Cloudy Sky Condition

- Glazing VLT of 40% and below will be able to maintain glare intensity below 2000 cd/m² for this building.
- Although it is more comfortable for the building occupant to select lower VLT, it is not the most optimum solution because it will reduce the amount of daylight available to be harvested.
- Therefore the ideal glazing visible light transmission is around 30% VLT to give a balance between daylight harvesting and glare prevention, but no more than 40%.



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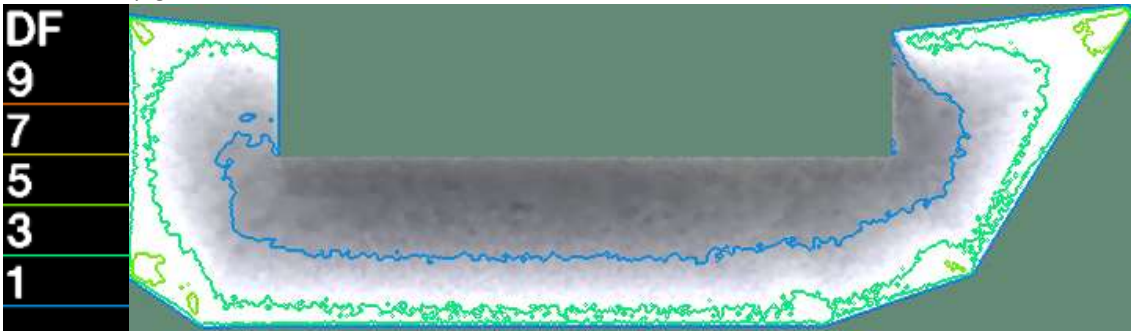
Glare Simulation Result for Sunny Sky Condition

Based on the simulation facing direct sunlight in March, June and December for worst case scenario, the luminance shows below than 2000 cd/m² and Lux Level below than 2000 on the table.

Depth of Daylight

The simulated studies indicates that approximately 50% of the building office area will benefit from the harvested daylight.



- A daylight factor of 1% will ensure that 90% of the hours from 8am to 6pm, more than 100 lux will be available from the diffuse light available in Malaysia.
- It would also means that over 50% of the hours from 8am to 6pm will be above 300 lux level.
- A daylight factor of 1% have been used as the indicator of depth of daylight available in Malaysian buildings.

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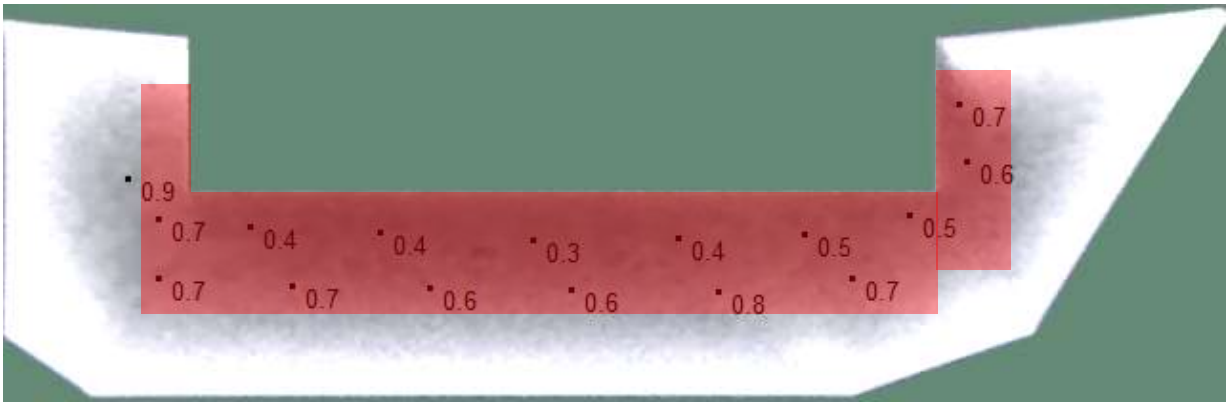
Depth of Daylight – Lighting Layout

Electric lighting needs to be permanently switched on during daytime due to daylight factor is lower than 1.0.



- Tenant has potential to reduce energy bill by 14% by adopting daylight use
- Building owner save up to RM22,000 per year from the air conditioning energy bills due to use of daylight by the tenants.

Design Risks

- Direct sunlight will penetrate the building façade up to 1 meter depth from the hours of 1pm to 2pm everyday. An installation of a horizontal blind will be able to resolve this issue.
- Another potential risk is that Malaysian tenants are not aware of the benefit of daylight in buildings.
- Reduction of uniformity of daylight provided for the office spaces. The use of light shelves would have reduced the intensity of daylight near to the façade while increasing the daylight deeper in the building space. However, due to the lack of funds for such design implementation, a decision is made to address only the core reason that daylight harvesting fails in this climatic zone – glare.

Summary

- To prevent glare from the view of the sky, the glazing visible light transmission was carefully selected to provide glare protection while allowing a reasonable amount of daylight transmission into the building. Simulation studies were conducted for this proposed solution. Results indicates that it was possible to daylit 50% of the office building, while ensuring that all the building occupants are protected from glare.
- Finally, it is envisioned that the daylight harvesting solution proposed for this building will enable building to be fairly transparent looking during operation. This aspect of the building is expected to increase the building aesthetic value to the building.

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Quality of Daylight

In terms of Daylight Harvesting…

"***Quality is more*** *important than Quantity*"

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Thank you