The GRIHA Summit 2015

High Performance Habitat

- Real-time Daylight and Glare studies
- Comparison with Simulations
- User Survey
- Learnings

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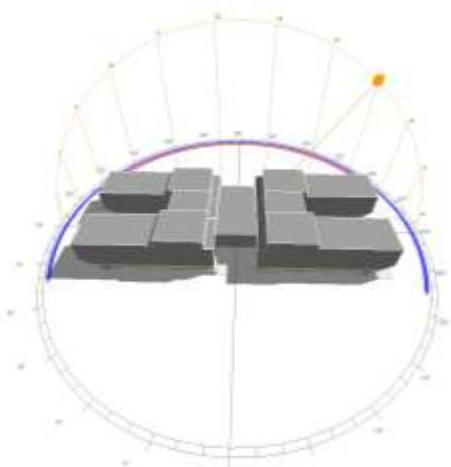
TerraViridis

Building Summary

The building comprises a six story structure orientated along an east-west axis. The east and west elevations are stepped in a series of cantilevers. The central zone is open from north to south providing a protected central entrance point to the building.



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Day lighting and Glare control – Glass and shading

South Facade

North Facade

Daylight Calibration – Set 1

Winter Solstice – Dec

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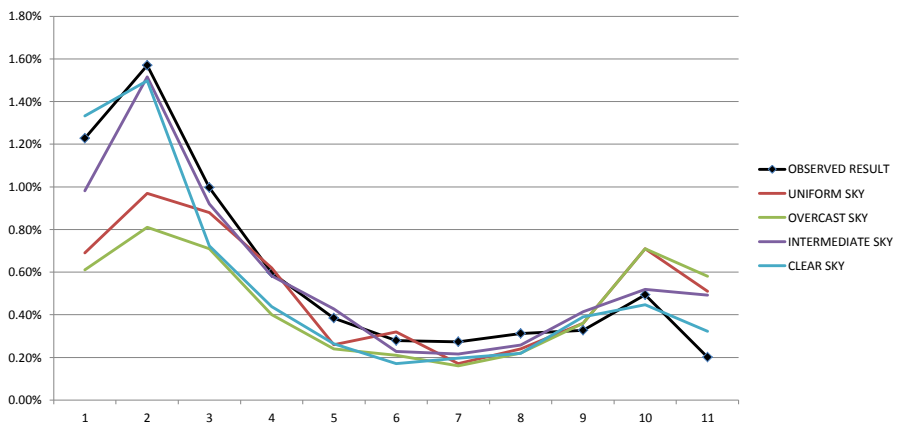
Day 1 – Daylight Panes only on all facades – Before Calibration



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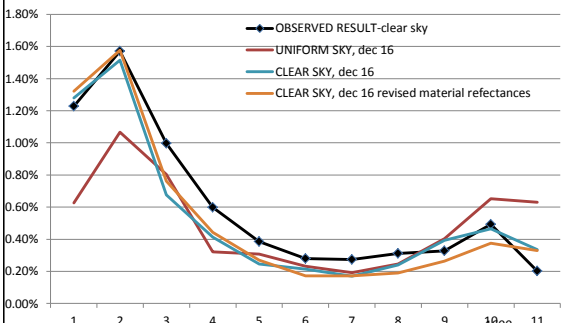
Day 1 – Daylight Panes only on all facades – After Calibration

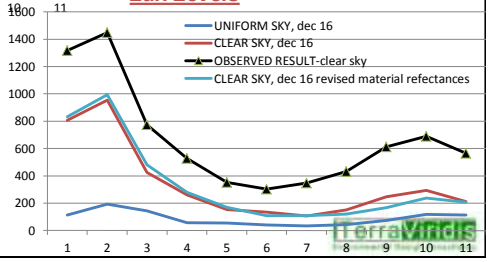


Daylight Factors

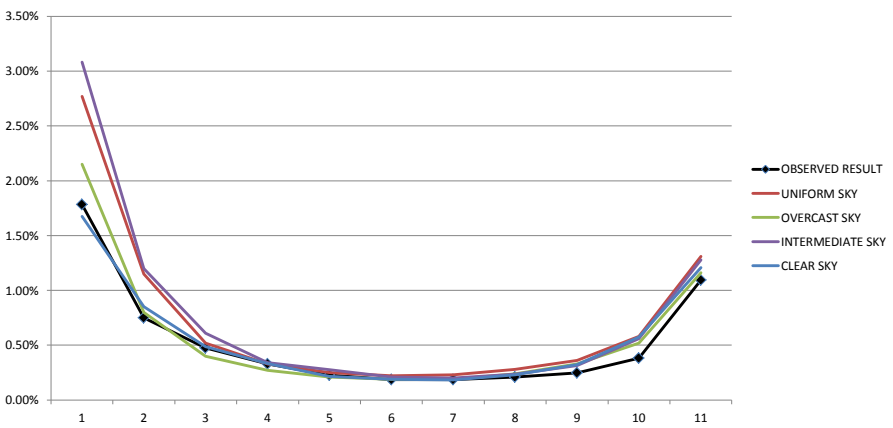
Note:

1. *Internal reflectance set to*
    1. *Floor – 0.3*
    2. *Ceiling – 0.8*
    3. *Wall – 0.5*
    4. *External – 0.23*
2. *Realistic results for clear sky – 16th Dec*
3. *Deviation clear sky -*

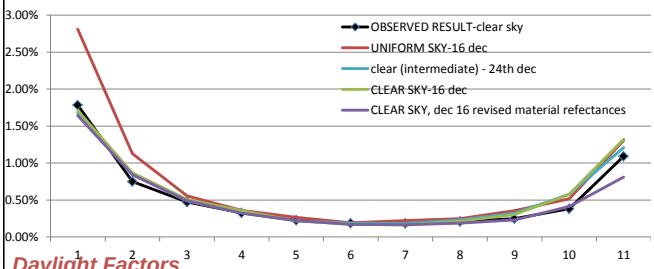
Lux Levels



Day 4 – View Panes only on all facades – Before Calibration



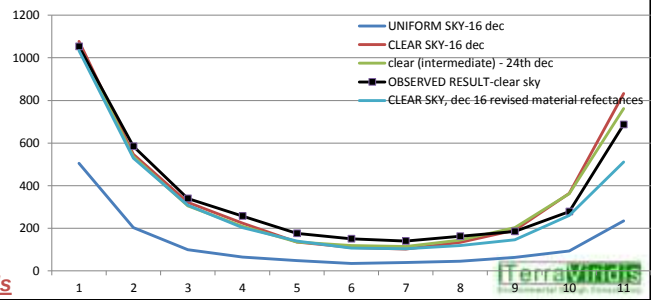
Day 4 – View Panes only on all facades – After Calibration



Note:

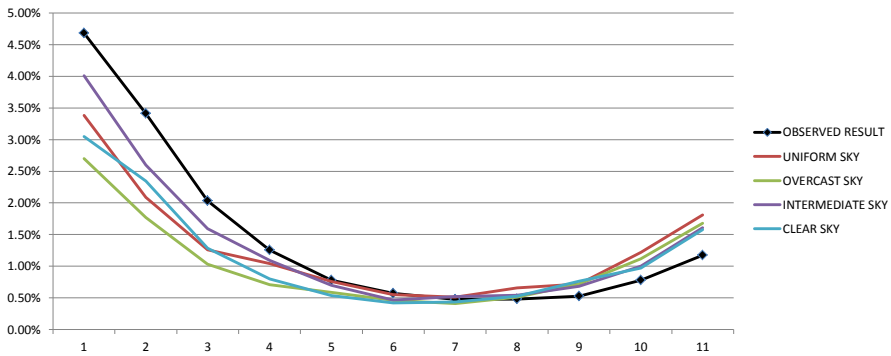
1. *Internal reflectance set to*
    1. *Floor – 0.3*
    2. *Ceiling – 0.8*
    3. *Wall – 0.5*
    4. *External – 0.23*
2. *Clear sky simulation on – 16th Dec*

Daylight Factors

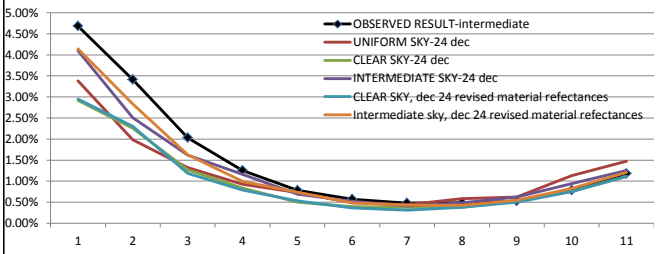


Lux Levels

Day 5 – All Panes on all facades – Before Calibration



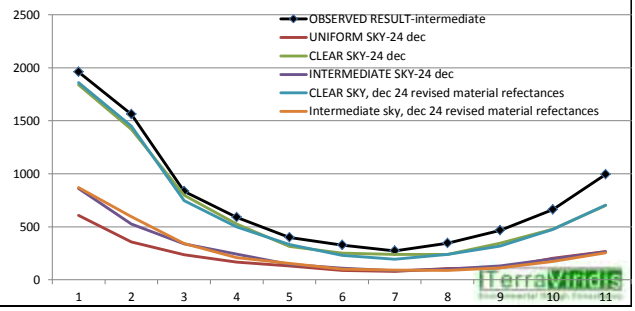
Day 5 – All Panes on all facades – After Calibration



Note:

1. *Internal reflectance set to*
   1. *Floor – 0.3*
   2. *Ceiling – 0.8*
   3. *Wall – 0.5*
   4. *External – 0.23*
2. *Intermediate sky simulation on – 24th Dec*

Daylight Factors



Lux Levels

Conclusions

Rectified internal and external reflectance assuming these will correlate to future buildings

- **Wall – 0.5**
- **Ceiling – 0.8**
- **Floor – 0.3**
- **External – 0.5 for opaque surfaces**
- **External glazing – 0.1**

For all future simulations, we could do the following

1. **Run clear sky simulations to predict absolute values on any given day**
2. **Run overcast sky simulations for parametric studies and compliance requirements**

Daylight Calibration – Set 2

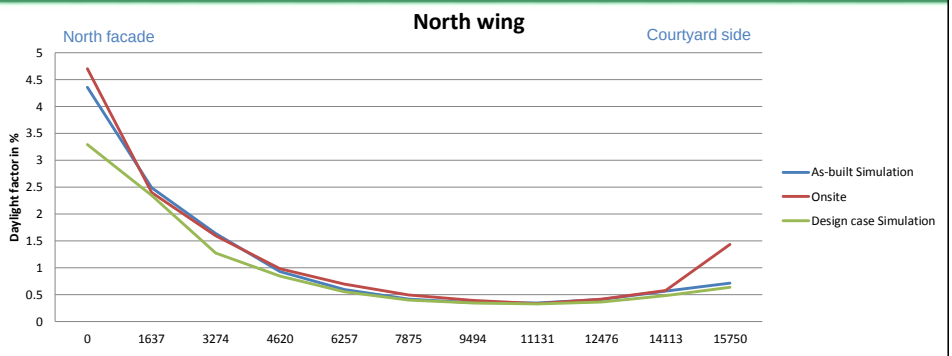
Summer Solstice

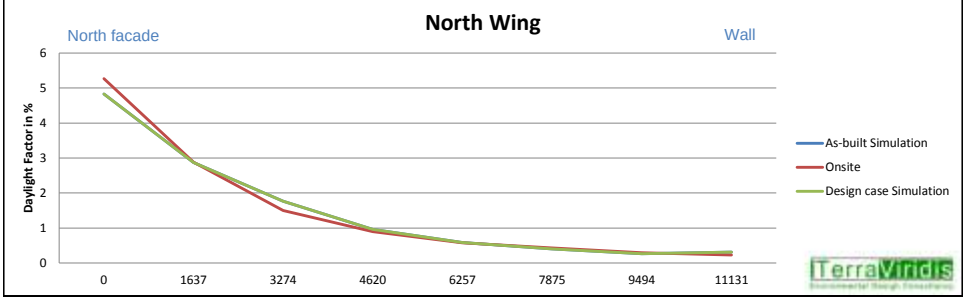
METHODOLOGY

- The Daylighting studies were conducted on June 20th, under overcast, diffused light conditions. 2 readings were taken for each point – indoor and outdoor. The readings were taken at specific points across the floor plate on the third and fourth floors of the building between 12 noon and 4 pm. The points are as indicated in the drawing below.
- The only equipment used were a light meter each for the indoor and outdoor reading and communication equipment enabling the surveying personnel to take simultaneous readings.
- The readings were taken in complete daylight during a workday and all artificial light in the space was turned off during the survey.
- All Material reflectance's / transmissions were assumed as follows:

Element	Material	Reflectance
CEILING	WHITE PAINTED CEILING	0.8
FLOOR	CONCRETE FLOOR WITH TILE	0.3
WALLS	LIGHT COLOURED WALL	0.5
LIGHTSHELF	WHITE PAINTED TIMBER/ Aluminium	0.6
Glazing mullion	WHITE PAINTED Aluminium	0.6
VERTICAL FINS	FROSTED GLASS	0.5
Element		**Transmittance**
DOUBLE GLAZING (planitherm mint green for Daylight pane) *as built case*		0.62
DOUBLE GLAZING (SKN 454 mint green for View pane) *as built case*		0.41
FROSTED GLASS IN VERTICAL FINS		0.15

Measurement and Simulation - 13.00, 20th June (Overcast Sky)





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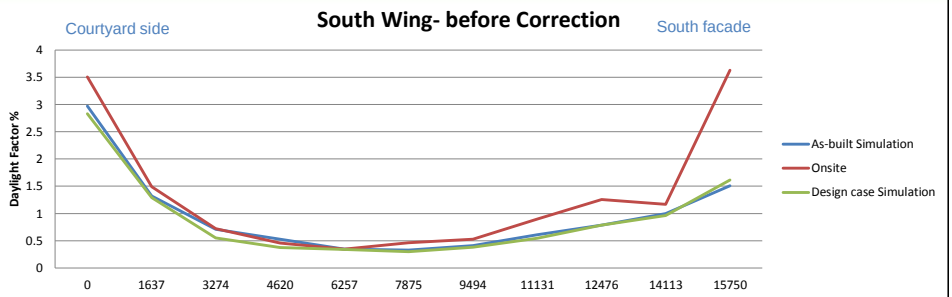
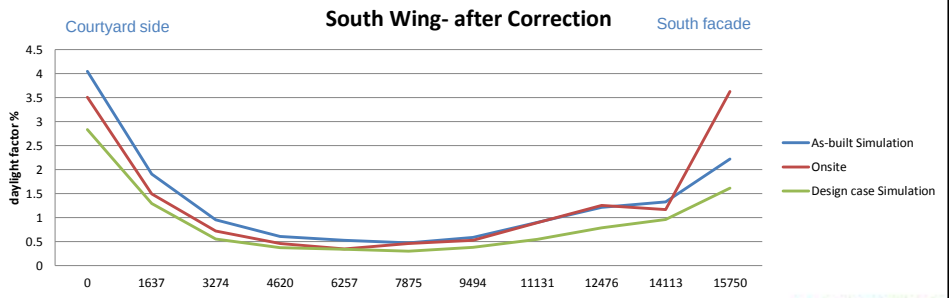
Measurement and Simulation - 16.00, 20th June (Overcast Sky)





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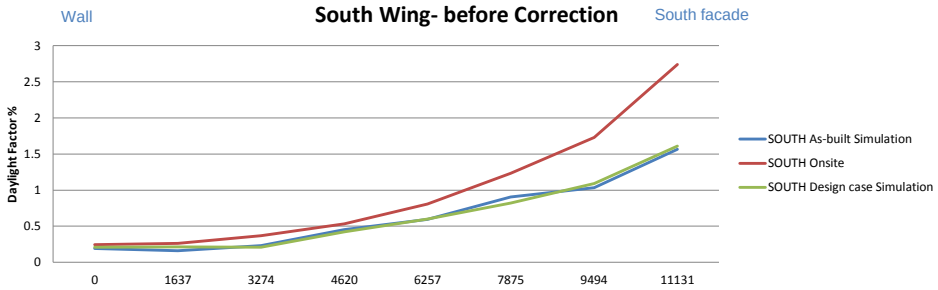
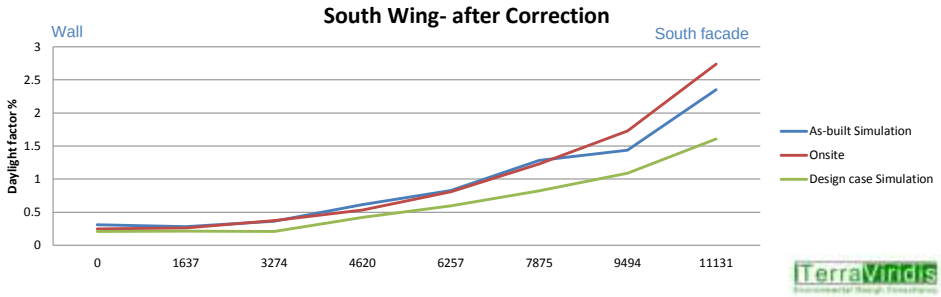
Measurement and Simulation - 16.00, 20th June (Overcast Sky)





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Conclusion

- For the as built simulation the reflectance of the light shelf has been reduced to 0.6 from 0.8, which was used in design case simulation. this is to account for the dust that is accumulated on the lightshelf over period of time.
- Other reflectance's are as identified in the previous study from SDB 1.
- The most important inference from this exercise are the revised simulation parameters.
- In the simulation exercise it was noted that simulation model predicted on par with the actual observed daylight distribution, however on south side it under predicted.
- This was because of the difference in geometry on north and south side.
- On north side there was no external lightshelf and it was only fins. In simulation this configuration is a simple geometry.
- On the south, presence of the external lightshelf with louvered half,geometry needs to be assumed as complex geometry and sampling parameters like *ambient division*[1] and *ambient super sampling*[2] and *ambient accuracy*[3] had to be increased.

- *[1] Setting the number of ambient divisions to N. The error in the Monte Carlo calculation of indirect illuminance will be inversely proportional to the square root of this number. A value of zero implies no indirect calculation.*
- *[2] Setting the number of ambient super-samples to N. Super-samples are applied only to the ambient divisions which show a significant change.*
- *[3] Setting the ambient accuracy to acc. This value will approximately equal the error from indirect illuminance interpolation. A value of zero implies no interpolation.*

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OCCUPANTS SURVEY RESULT

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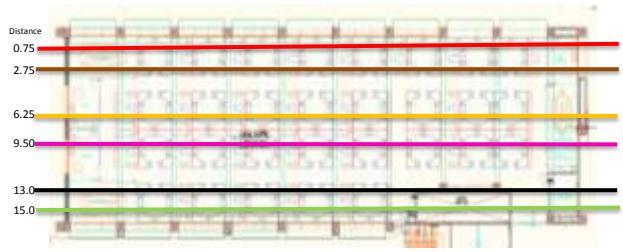
- A survey sheet was distributed amongst the daily users of the building. To maintain anonymity, these were not marked to position, but generalised into groups based on Orientation, Location and distance with respect to windows. This was achieved by colour coding the sheets and distributing them as shown in the image below.
- A Sample size of 320 persons were asked to fill in a questionnaire on visual comfort.

The inquiry questions were divided based on the following:

- Building usage
- User preferences
- User perceptions
- Discomfort conditions



Hereafter in this study, occupied zone with North as primary façade is referred to as ***North Wing*** *and vice versa for South façade.*

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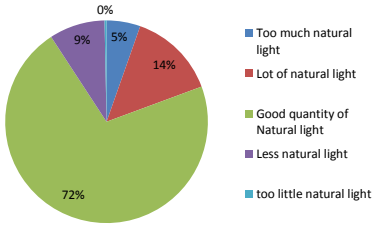
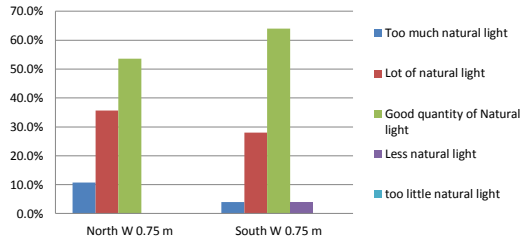
USER PERCEPTION OF NATURAL LIGHT

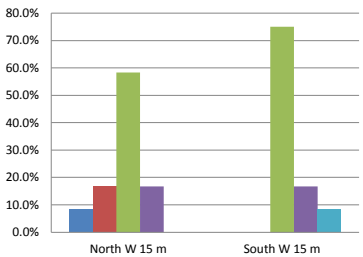
NATURAL LIGHT PERCEPTION - OVERALL



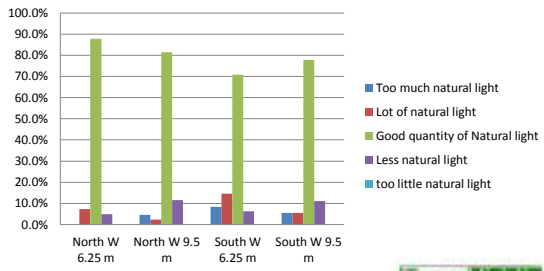
LIGHT PERCEPTION- USERS AT FACADES



LIGHT PERCEPTION - USERS COURTYARD SIDE

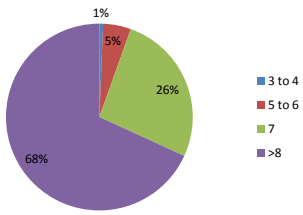


LIGHT PERCEPTION- USERS IN THE CENTER OF THE BUILDING

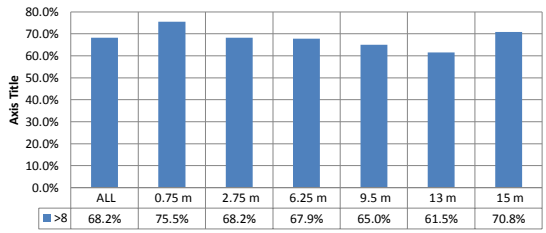


BUILDING USAGE

OVERALL TIME SPENT IN BUILDING - ALL USERS

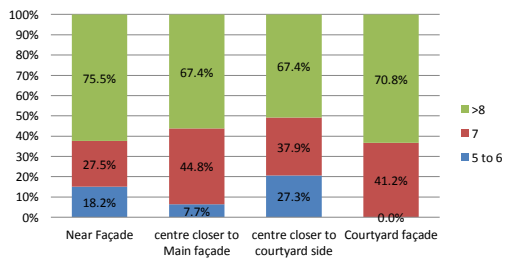


PERCENTAGE OF USERS WHO SPEND 8 HRS IN THE BUILDING - BY DISTANCE FROM FACADE

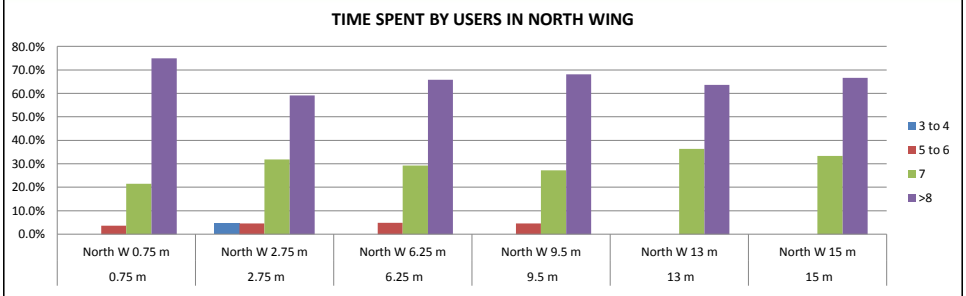


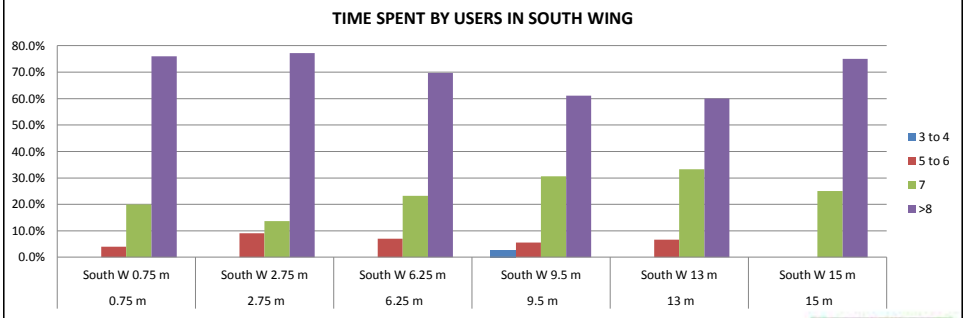
- ALL Users spend more than 4 hours per day in the building
- Users in the centre of the building (centre-courtyard and centre-façade spend the least percentage of time in the building
- Users closer to the façade spend the most amount of time in the building
- Users close to the courtyard spend more time than those in the central aisle
- The range difference is around 20%

Time spent in building - by location



BUILDING USAGE

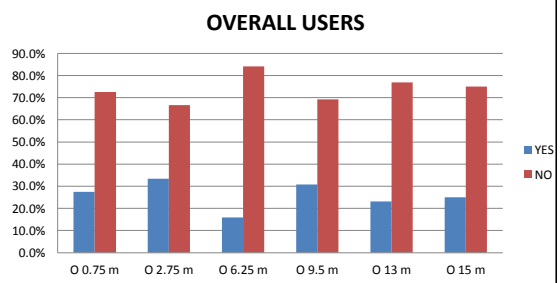


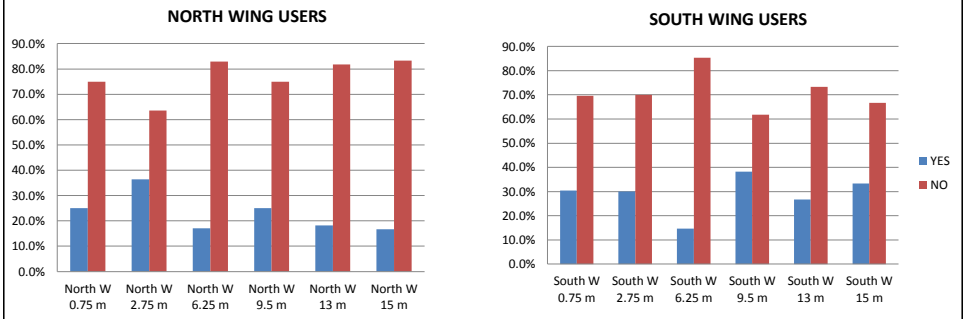


USER PREFERENCE OF SWITCHING ON LIGHTING DURING DAYTIME

INFERENCE

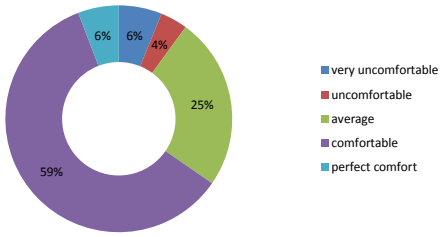
- On overall basis 75% of occupants didn't prefer to turn on the lights during daytime.
- Occupants along the South Façade displayed a larger need for artificial lights during daytime.





USER PERCEPTION OF OVERALL COMFORT LEVEL

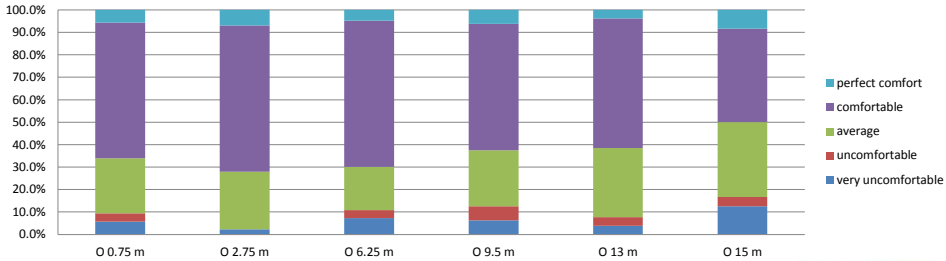
OVERALL COMFORT LEVEL



INFERENCE

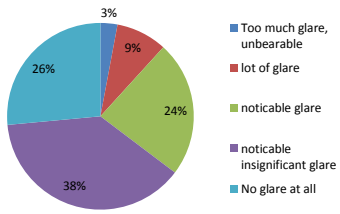
- On overall basis 71% of occupants are content with the comfort conditions inside the space.
- Of the 4% occupants who claimed uncomfortable comfort conditions, predominant sample size is from South Wing.

OVERALL

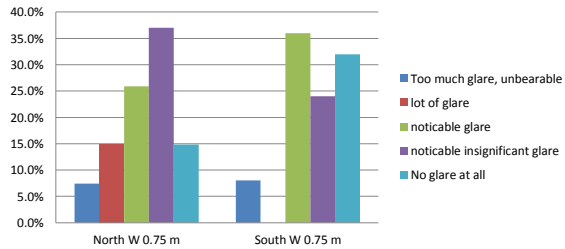


USER PERCEPTION OF GLARE DUE TO DAYLIGHT

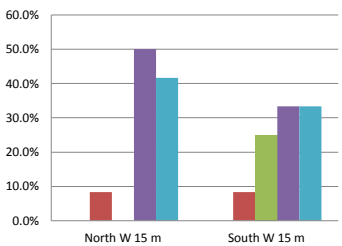
OVERALL - GLARE FROM NATURAL LIGHT



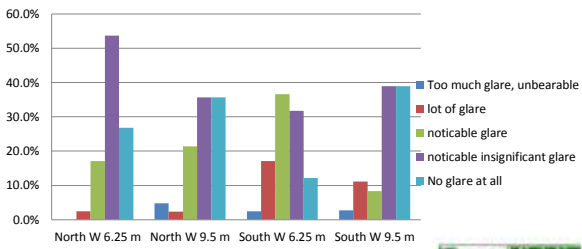
GLARE FROM NATURAL LIGHT - USERS AT FACADES



GLARE FROM NATURAL LIGHT – USERS AT COURTYARD SIDE

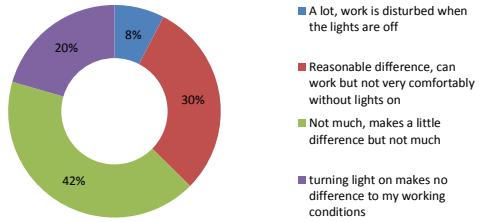


GLARE FROM NATURAL LIGHT - USERS IN THE CENTER OF THE BUILDING



USER PERCEPTION OF OVERALL LIGHT QUALITY WHEN ARTIFICIAL LIGHTS ARE TURNED ON

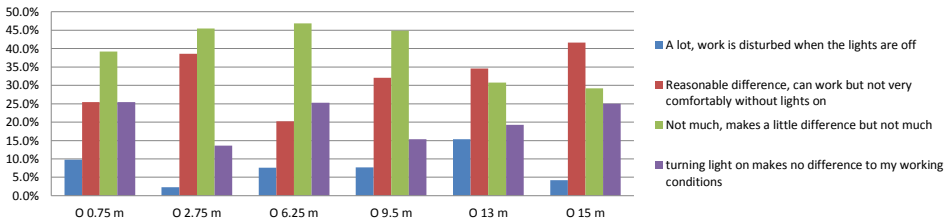
OVER ALL - IMPROVEMENT IN LIGHT QUALITY WHEN ARTIFICIAL LIGHTS ARE TURNED ON



INFERENCE

- Only 8% of Total Occupants said Artificial lights is necessary to work during daytime.
- Alarming fact is that occupants sitting close to the façade are majority of that 8% total occupants. Especially occupants sitting close to courtyard side.

LIGHT QUALITY CHANGE - OVERALL



CONCLUSION

- User behaviour and response for an identical scenario seems as varied as North pole and South pole in both the wings.
- As survey was conducted on June 21st, Responses of North wing occupants w.r.t. Perception of Quality and amount of light might be influenced by fact that sun is in the northern hemisphere.
- Responses of the occupants sitting next to Courtyard might be influenced by the external conditions as bits of construction work was in progress.
- Behavioural response to lighting may also be influenced by the fact that occupants were working in low light prior to building was finished.
- W.r.t glare it was noticed from onsite observations that it was largely a visual discomfort because of Higher contrast ratio. Especially on the north side level 2 where the roof of the food court is in line of sight. also for the person sitting right next to facade the contrast ratio between screen and wall. This is reflected in the survey.
- Most of the occupants seem to be in favour of blinds and glare restrictors. Need for these stems out of the perception that *"blinds is a privilege."*
- Only genuine concern from the users was the fact that they had no control over the artficial lights. Once the automated system based on daylight sensor is installed we might overcome this.
- Overall this survey stands as a base case to further survey after a year of occupancy , which might lead to meaningful insights.

LESSONS LEARNT and CHANGES

Glare control

- Aisle spaces were introduced next to the windows on both sides

User Control

- Task lighting was provided
- For the workstations closest to the glazing, clear glazed partitions were provided with localised blinds