SCHOOL OF ARCHITECTURE, BUILDING & DESIGN

Centre for Modern Architecture Studies in Southeast Asia (MASSA)

BUILDING SCIENCE 1

Case Study: Identifying innovative passive design strategies

Project: SOLARIS

Architect: T. R. Hamzah & Yeang Sdn. Bhd.

Tutor : Miss Suja

	Group Members	IC/MyKad No	Student ID No
1	Fam Li Kian	950101135270	0310639
2	Leong Carmen	930819086182	0314953
3	Kian Soon Jean	930318105920	0314978
4	Wong Jian Kai	940304015675	0314794
5	Yiew Qunhe	940920015839	0314809
6	Yaseen Fatima Syed	bn806368	0309021

Content

INTRODUCTION

Project Information

Type: Vertical Eco Infrastructure
Location: Singapore
Climate Zone: Tropical
Vegetation Zone: Rainforest
Site Area: 7,734 m2
Gross Building Area: 51, 282 m2
Height: 79.2 meters (15 storeys excluding 2 basement floors)

Certification

BCA green mark platinum rating

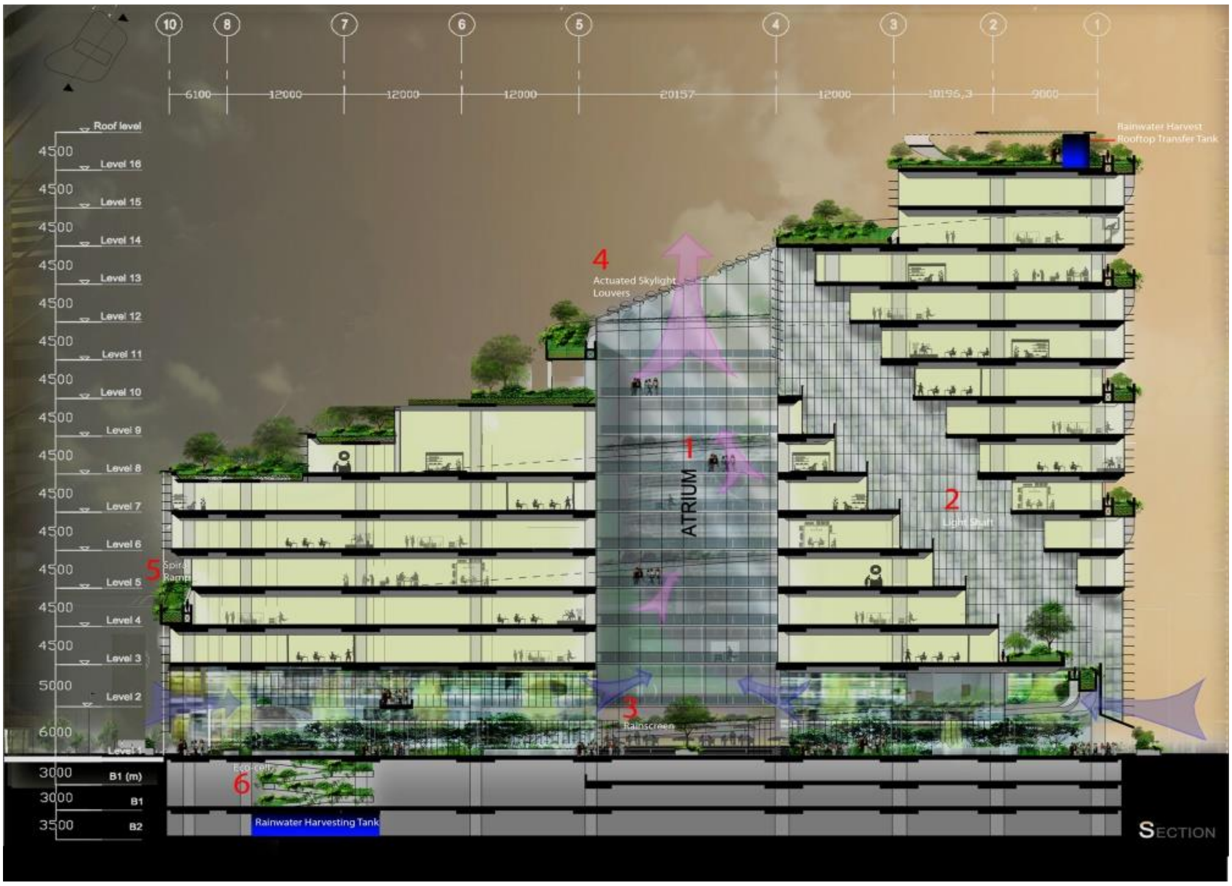
Buildings which gain 90 points under Singapore's Green Mark Certification system are awarded a Platinum rating. The Solaris project was awarded 97.5 points.

Awards

First Prize - Skyrise Greenery Awards 2009
Singapore Institute of Architects & Singapore National Parks

"Best Tall Building award"
CTBUH Awards 2012

SOLARIS is one of Ken Yeang's greenest building, occupying a 30-hectare Fusionopolis development site (*which is part of a master plan designed by Zaha Hadid Architects in 2008*) situated to the West of Singapore's Central Business District.



It is a 15-storey high stepped building that serves businesses involved in R&D within the IT industry. Public spaces, flexible offices and laboratories wrap around a central and naturally ventilated atrium (labelled 1). Office floors are linked by a series of sky terraces (labelled 2) which span diagonally across upper floors. Through the eco-building concept, sustainable design features and innovative vertical green concept, SOLARIS aims to empower its surrounding's ecosystems. *(Harl,S 2011)*

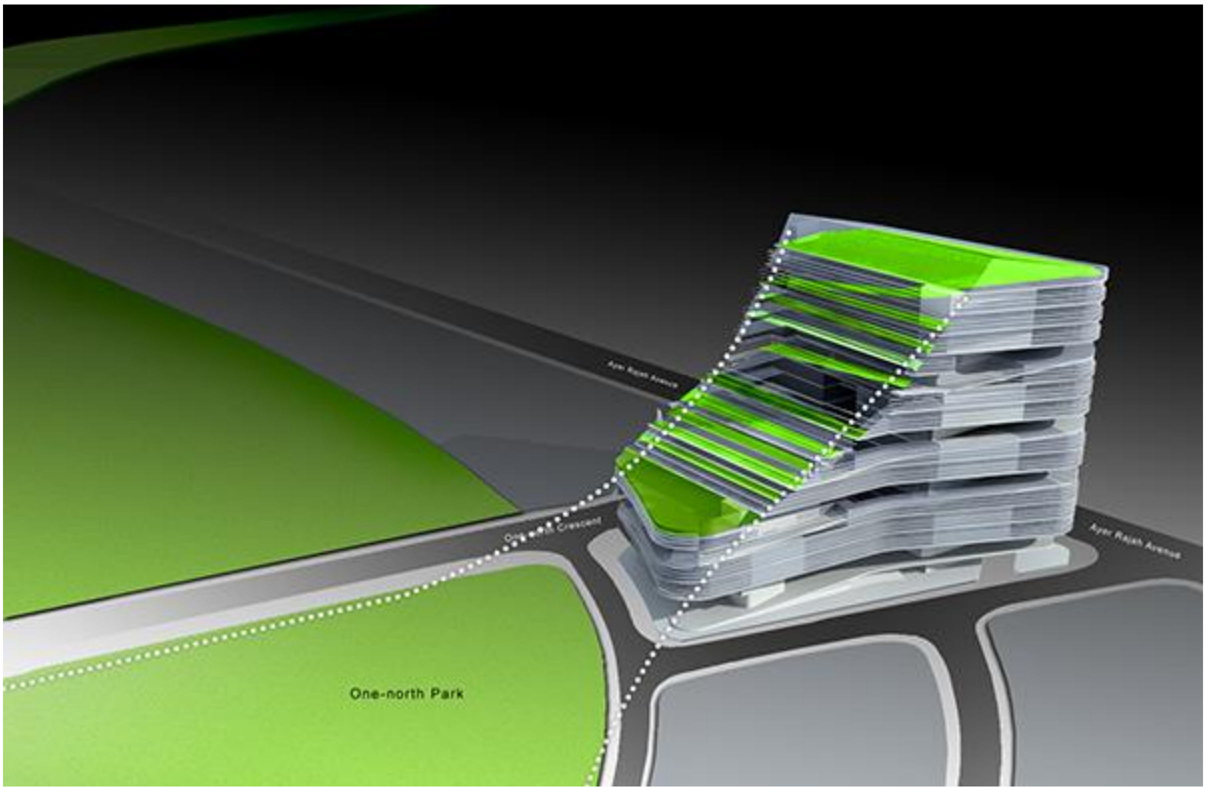
Building Green Design Strategies

The building achieves a 36% reduction in overall energy consumption through the integration of landscaping with its facade.

Solaris' high performance facade has an External Thermal Transfer Value (ETTV) of 39 W/m^2. With over 8,000 m^2 worth of landscaping, it further introduces vegetation beyond its original site. *(Harl,S 2011)*

The green design features:

· Continuous Perimeter Landscape Ramp
· Rainwater Harvesting
· Roof Gardens and Corner Sky Terraces
· Climate Responsive Facade
· Naturally Ventilated and Day Lit Grand Atrium
· Pocket Park / Plaza
· Solar Shaft
· Extensive Sun-Shading Louvers
· Eco-cell



The Green Areas, include:

Roof Gardens: 2,987 m2

Atrium Planter Boxes: 304 m2

Green Ramp: 4,115 m2

Ground Level Landscaping: 487 m2

Green Walls: 164 m2

Total Landscaped Area: 8,363 m2

Ratio of Landscaping to GFA: 17% Green

Ratio of Landscaping to Site Area: 108% Green

Percentage of Total Landscape Area above Ground Level: 95%

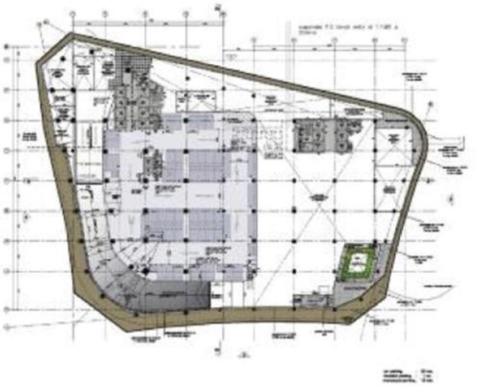
(Harl,S 2011, Harl,S (2011) “Eco Architecture,the work of Ken Yeang”, London Vol 3. 200-209)

Orthographic Drawings

FLOOR PLANS

(Source : http://www.archello.com/en/project/solaris)

Typical basement plan



First floor plan

Upper floor plan (Level 2)

Typical upper floor plan (Levels 3-7)
Level 3 shown below

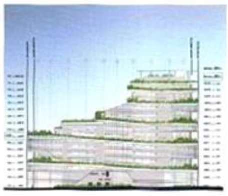
Typical upper floor plan (Levels 8 & 9)
Level 8 shown below

Upper floor plan (Level 10)

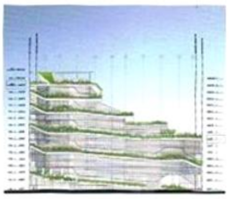
Typical upper floor plan (Levels 11-15)
Level 13 shown below

Level 16 Roof Garden

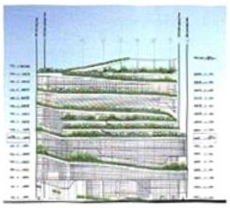
Level 17 Roof Garden



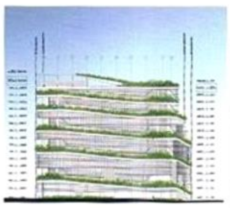
West Elevation



East Elevation



North Elevation

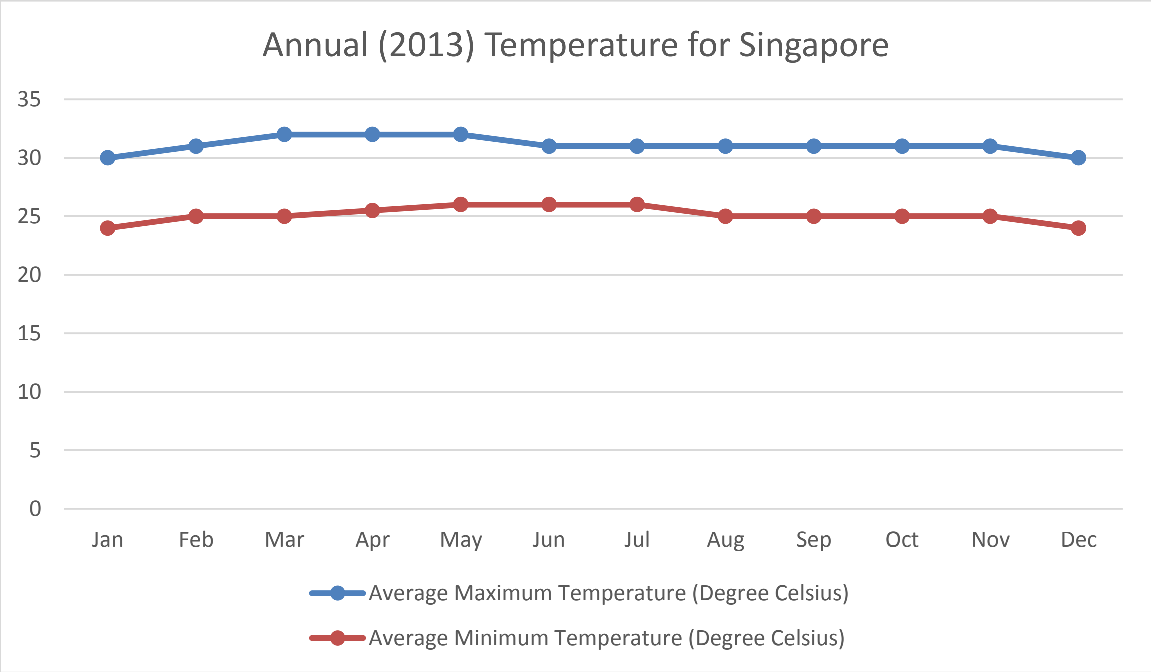


South Elevation

(Source : http://www.archello.com/en/project/solaris)

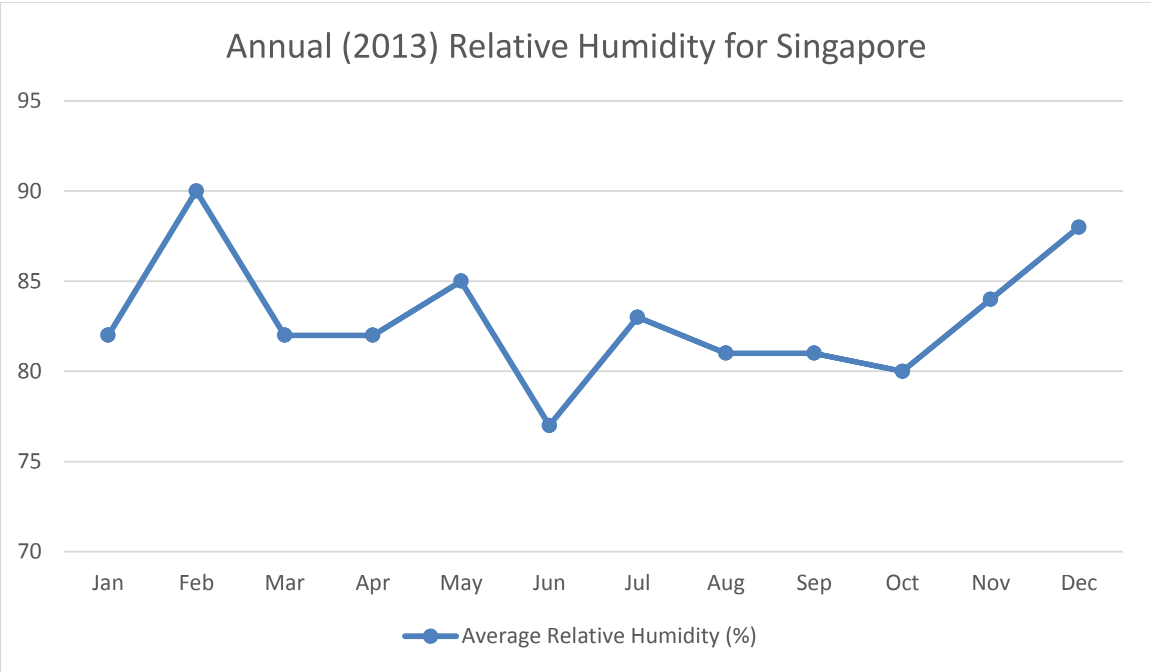
CLIMATE DATA

Annual (2013) Temperature



Over the course of a year, the maximum daily temperature for Singapore typically varies from 30 D.C. to 32 D.C. whereas the minimum daily temperature typically varies from 24 D.C. to 26 D.C.

Annual (2013) Relative Humidity

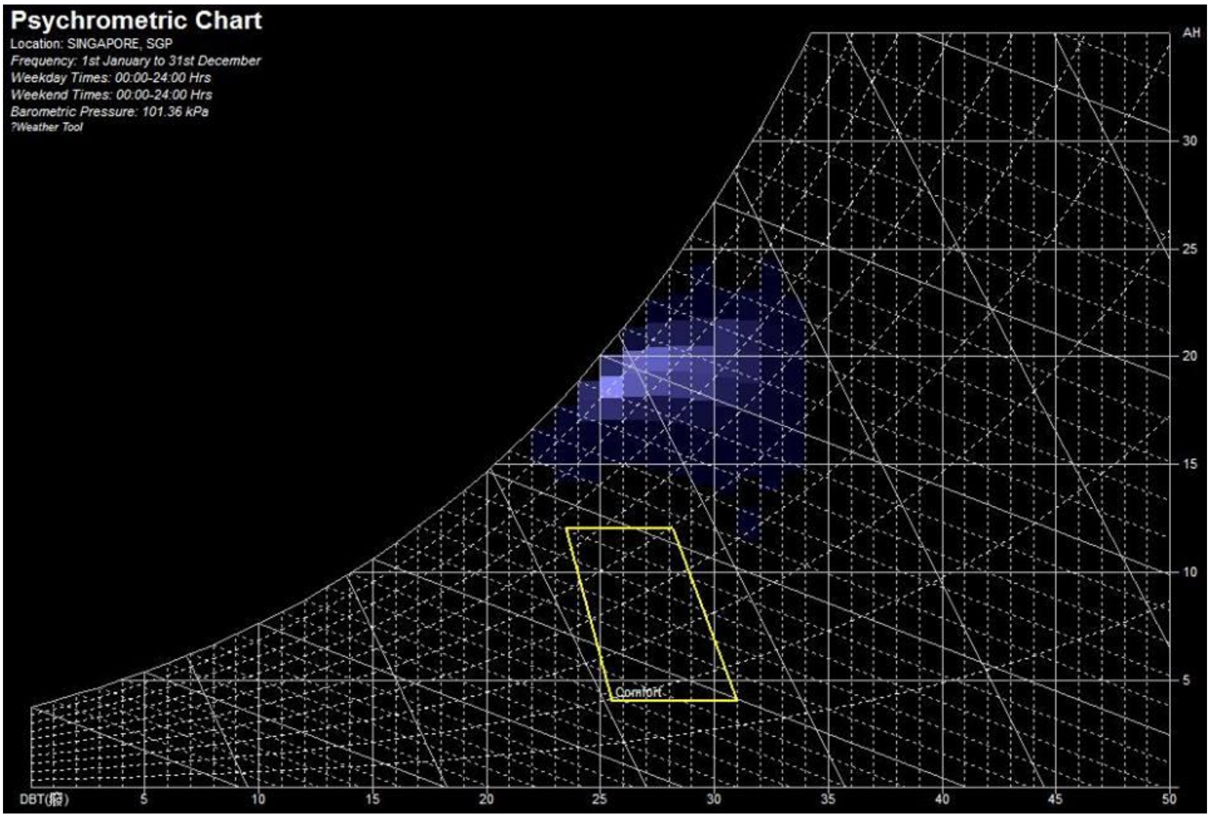


In Singapore, the relative humidity (RH) typically ranges from 77% to 90% over the course of the year.

ANALYSIS :

A RH of 100% denotes a foggy, wet, and saturated atmosphere. Levels below 40% RH suggest dryness while levels above 80% RH suggest high presence of moisture. Between 40% and 80% RH, it is a comfortable environment if the temperature is also comfortable. According to the chart above, Singapore’s climate is rather humid as RH levels are mainly above 80% RH.

PSYCHROMETRIC CHART (Derived from Ecotech 2011 software)

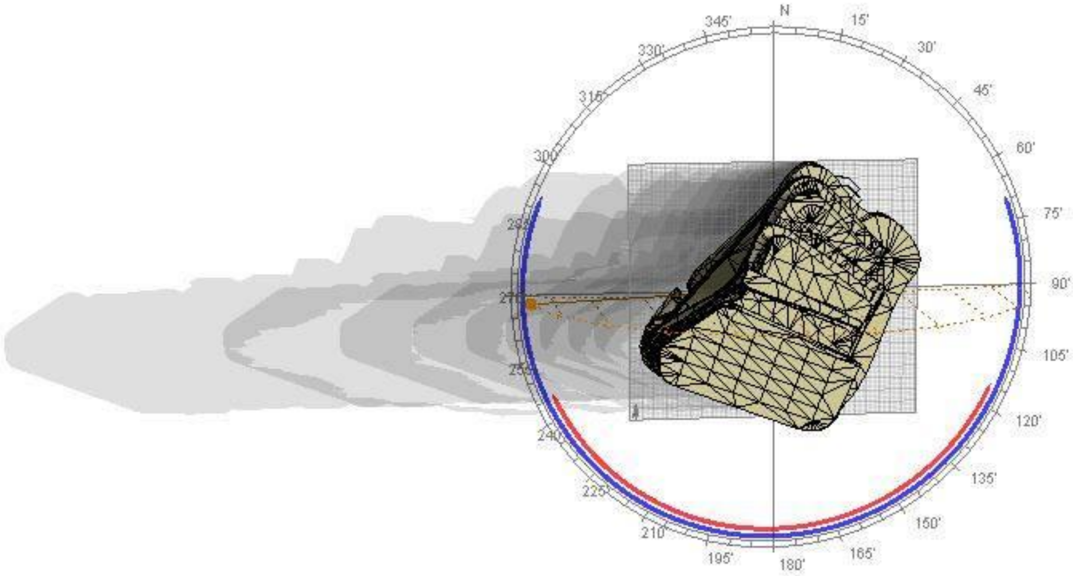


The psychrometric chart above shows that Singapore's dry bulb temperature is around 25 -30 °C , which is the comfort zone . However, absolute humidity (AH) is laid between 15-22 (g/m3), which is higher than the comfort zone - laid between 4-12 (g/m3) .

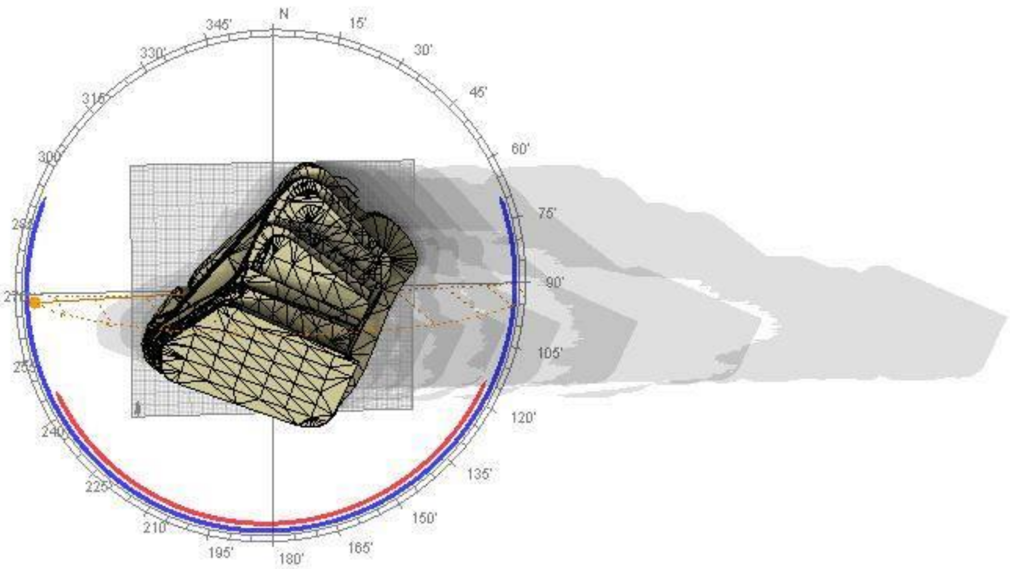
SUNPATH & LIGHTING (Derived from Ecotech 2011 software)

SHADOW RANGE DIAGRAM

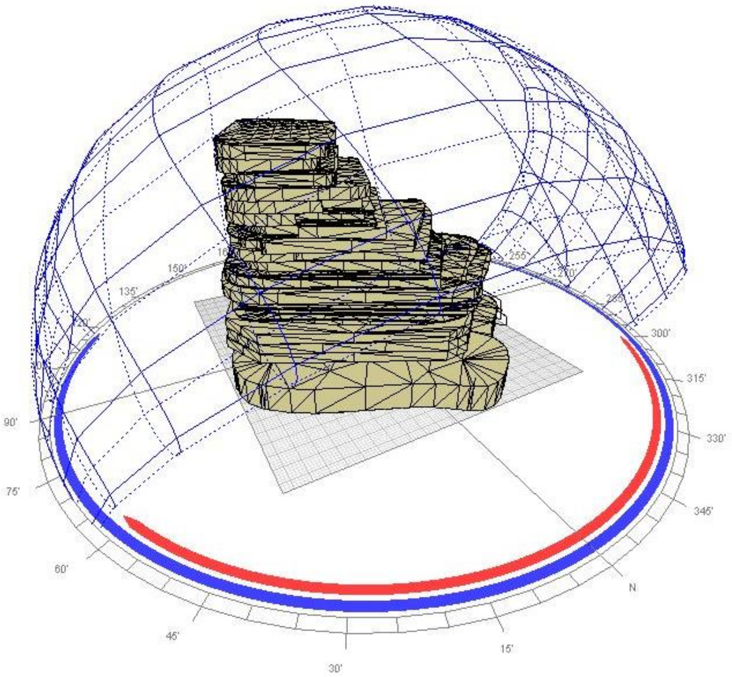
0800-1200



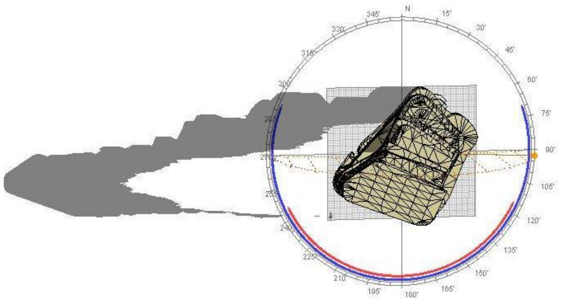
1200-1700



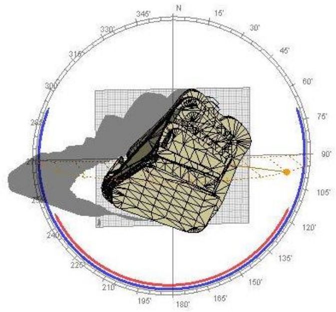
ANNUAL SUNPATH



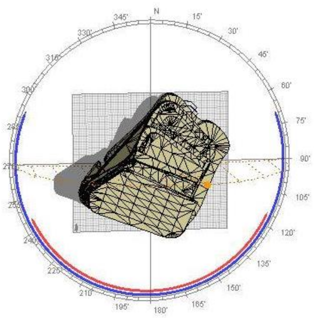
DAILY SUNPATH DIAGRAM



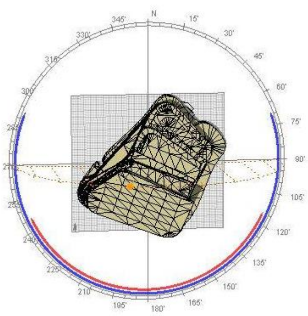
0700



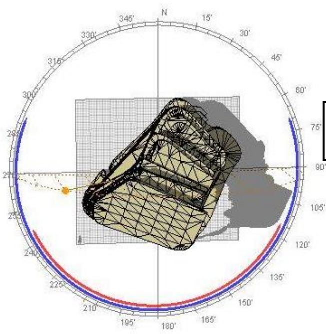
0900



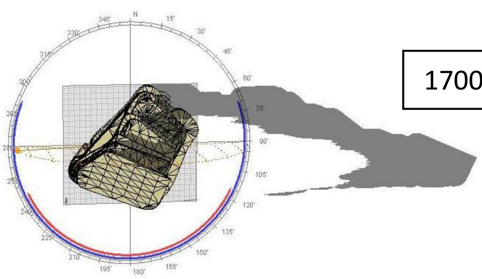
1100



1300



1500

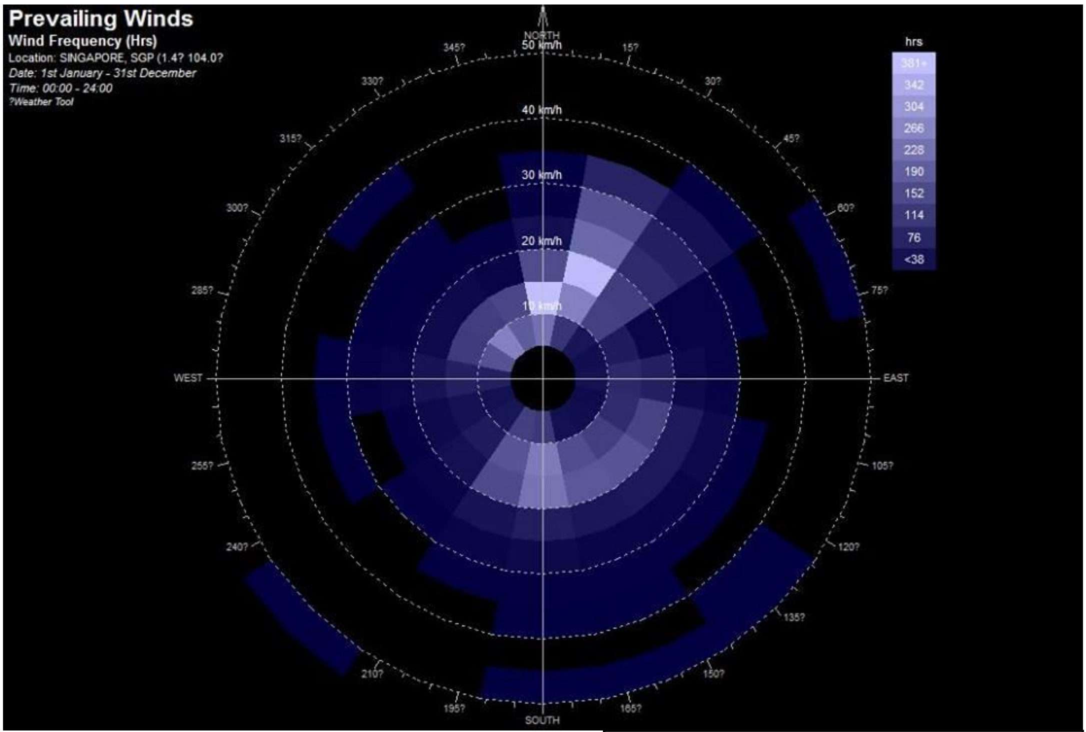


1700

WIND DATA

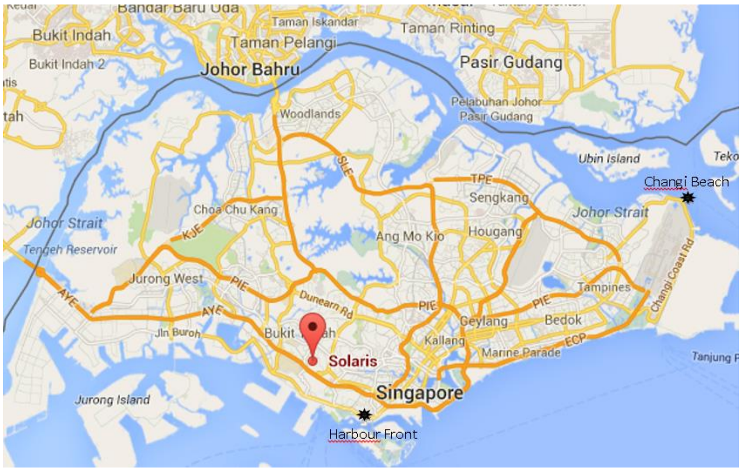
WIND SPEED AND DIRECTION

Wind circulates centrally throughout the layers of Solaris, resulting in a cool internal temperature. Its surrounding landscape is consistently irrigated in order for cool air to move around the building. The wind speed and its direction can be analysed using the diagram below:



(Derived from Ecotech 2011 software)

Analysis



(Source: Google Map)

The main source of wind in Singapore originates from the North East direction marked by the location of Changi beach. Solaris in particular may experience greater wind movements originating from the South-East marked by Harbourfront due to its closer vicinity to it.

Winds that approach Solaris would run through the pocket parks surrounding the building, contributing to the natural process of air filtration with plants. The pocket parks function like open plazas, allowing cross-ventilation within the building through entrance openings into the atrium.

SOLARIS Passive Designs Features

Passive Design Feature 1: Continuous Perimeter Landscape Ramp

Figure1*: Continuous Perimeter Landscaped Ramp surrounded the façade of the building.*

The most prominent passive design feature that can be found in Solaris, Fusionopolis is the **Continuous Perimeter Landscape Ramp**. It has a total length of 1.5km that begins from the basement level eco-cell (Figure 3) and slowly rises up to the roof garden by wrapping itself around the building façade in a continuously ramp form. (Harl, 2011)

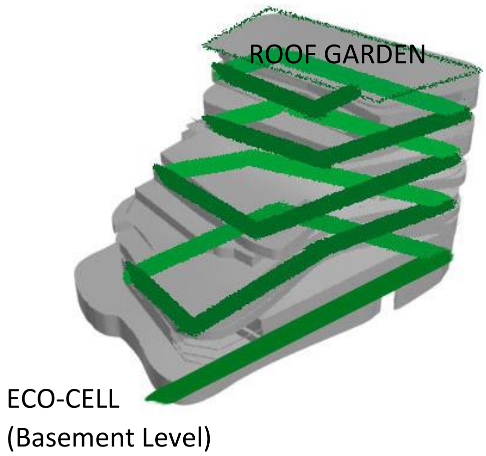


Figure 2*: The conceptual idea of ramp distribution wrapping the building.*

Figure 3*: Eco-cell which located at the basement level which contains a storage tank for rainwater harvesting system.*

The maximum gradient of the ramp is 1:20 and it has a minimum width of 3 meters including a parallel pathway that has been surrounded by a landscaped planters. (Solaris Fusionopolis, Singapore. (n.d.). *Solaris Fusionopolis*. Retrieved May 21, 2014, from http://www.designbuild-network.com/projects/solaris-fusionopolis/) It hence turned into an accessible park where users could walk on it. This has also eased the maintenance of the greenery surrounded. These plants are important in filtering the air and also providing better air quality into the space.

The ramp was designed in such a way that it will be opened up once it meet the corners of the building, which is called sky terrace. Sky terrace is not only a pathway, it is an open space where people can spend their time relaxing. Sun shading louvers above the sky terraces will be following the rise in height of ramp and this allows more light to permit. Those special elements of the ramp corporate well together and make it important in providing passive insulating, shading, and cooling to the building.

Figure 4*: Greeneries and the pathway on the ramp.*

Figure 5*: Sky terrace, where the ramp is opened up.*

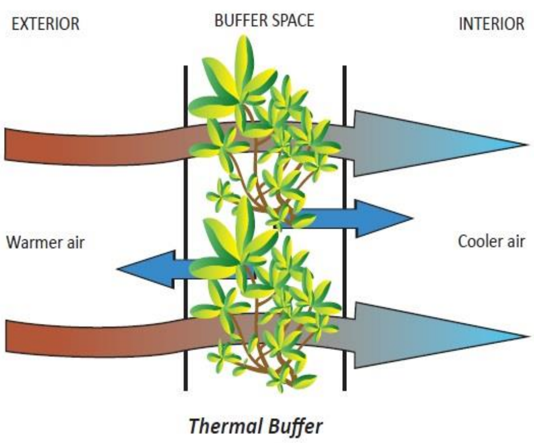
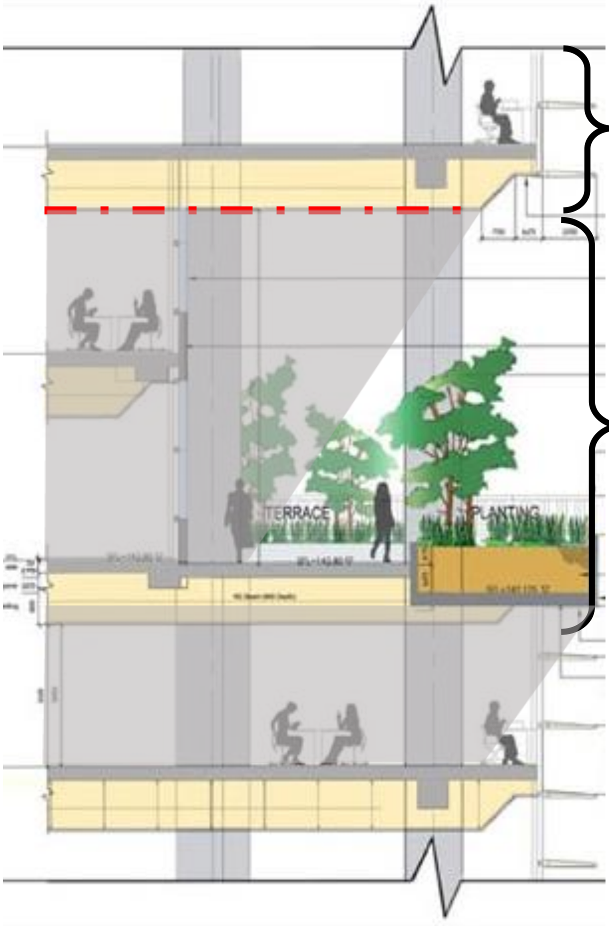


Figure 6: *The process of thermal buffering*

The vegetation acts as a thermal buffer since it is the first to be in contact with the exterior surrounding. Through the transpiration process, water absorbed by plants evaporate into the air from their leaves which serves to cool themselves and the surrounding environment. Therefore, air moving into the building (via wind) is filtered and cooled, providing a fresh airflow within the building incorporated with both solar shading louvers and double glazed wall system.

SKY TERRACES



The ramp does not meet the corner of the building at this point. Hence, slab is extended and it acts as an overhang to shade the space underneath it.

A larger area of plants at this level, Sky Terrace. It shows how the space was opened up once it meets the ramp. It consists of two level at a time where both are well shaded by plants, sun shading louvers and the overhang slabs. Users are allowed to access the roof garden through the ramp as well. The function of shading has naturally decrease the amount of heat absorbed and passively cools down the indoor temperature.

Figure 7*: A sectional cut of Solaris at the corner of the building where sky terrace exists.*

(Source : http://www.archello.com/en/project/solaris)

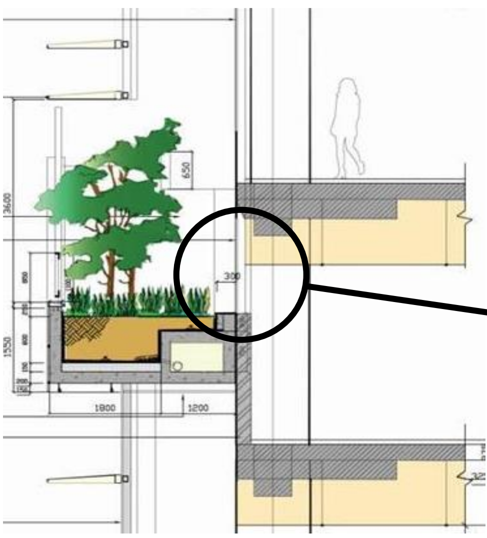


Figure 8*: Section of the perimeter ramp* (Source : http://www.archello.com/en/project/solaris)

Figure 9: When the ramp reaches a certain height where it covered up the wall, a small opening was created. This is to enable natural sunlight to penetrate into the space although it was blocked by the ramp. This space will gain less natural lighting compare to the others.

Figure 10*: Naturally ventilated and day lit grand atrium*

Passive Design Feature 2: Naturally Ventilated Grand Atrium

The second passive design feature that makes Solaris a Green Mark System Platinum certified building is the **Naturally Ventilated Grand Atrium**. It is a public gathering space or plaza which plays an important role in connecting two tower blocks of Solaris building. It is also the first space where all the entrances lead the visitors to.

Tower A consists of nine floors whereas Tower B has sixteen floors (including roof gardens). These vertical landscaping shows a connection in every level and it acts as a thermal buffer and create relaxation for users while experiencing the space.

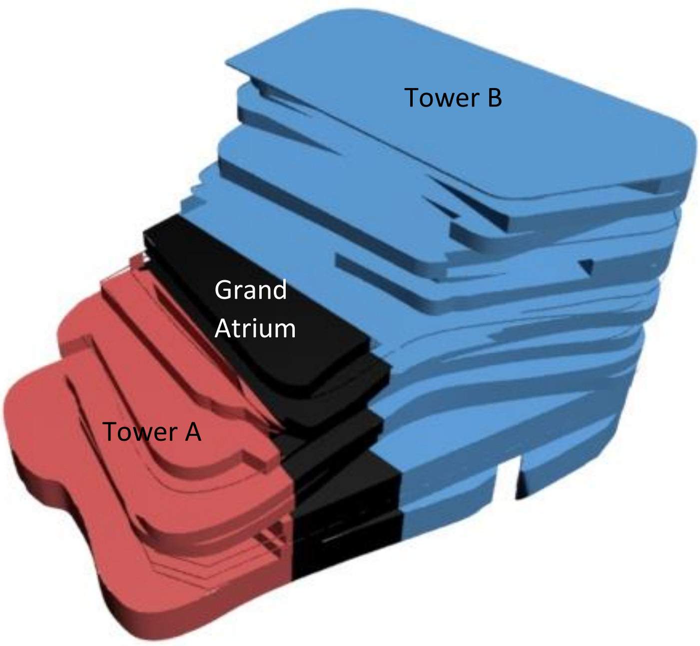
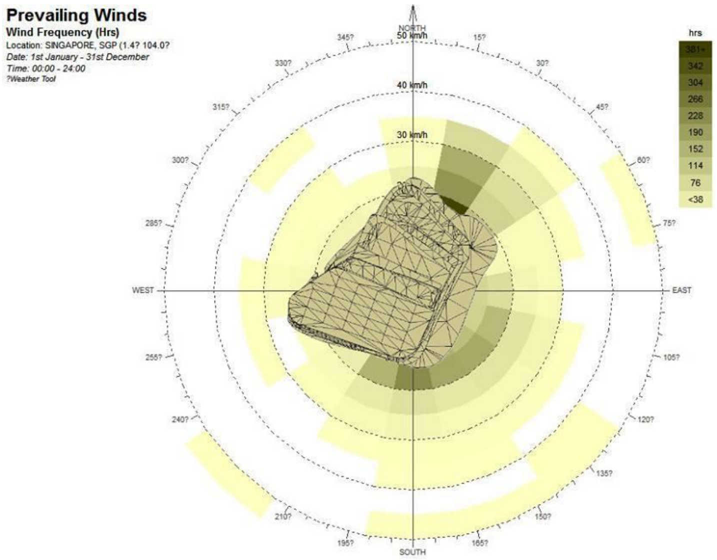


Figure 11*: A model shows the distribution of spaces and how did the atrium falls in between two tower blocks.*



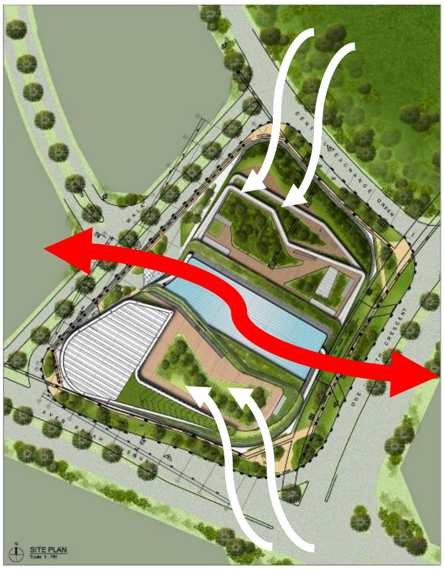


Figure 12: *The wind frequency is higher at Northeast and Southeast direction.*

Figure 13: *The orientation of building shows less consideration in responding to the wind direction since the wind will not be passing through the main atrium directly (red arrow). This reduces the opportunity for a better flow of air circulation.* (Source : http://www.archello.com/en/project/solaris)

Besides connecting two spaces together, the atrium together with the solar shaft are important in providing sufficient sunlight and ensuring well ventilation in the building. The atrium is well-designed to ensure that warm air can exit through the overhead glass louvers and cool air is able to circulate the lower spaces, thus increasing human comfort in non-air conditioning zone. From first-hand observation, there is minimum use of mechanical cooling systems in the building, however the temperature is generally cool and pleasant from first-hand experience.

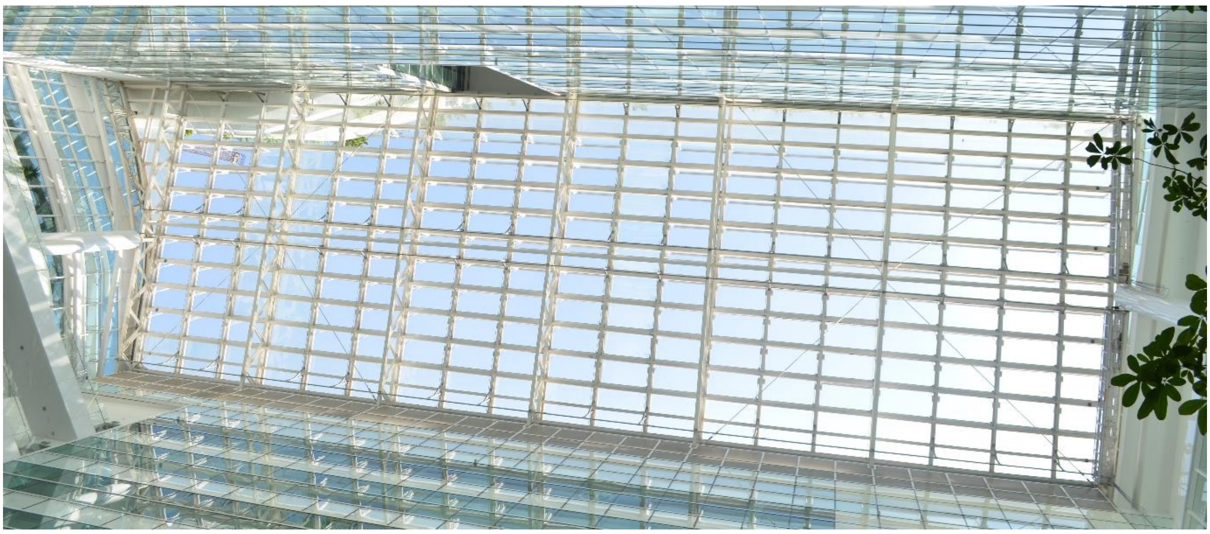


Figure 14: *Overhead glass louvers made by low efficiency double glazing glass to reduce the absorption of heat.*

Figure 15*: Section shows the flows of air circulation throughout the atrium, stack ventilation*
(Source : http://blog.cpgcorp.com.sg/wp-content/uploads/2012/03/Solaris_Section.jpg)

The type of air ventilation happened in the atrium is stack ventilation. The RIBA website defines stack ventilation as the most efficient natural ventilation where air is driven through the building by vertical pressure differences developed by thermal buoyancy. (http://www.architecture.com/) When the air inside the building is warmer than the air outside, high dense of cold air will be forced into the building. The warm air will be replaced and slowly escaped upward through opening above, which in this case is the overhead glass louvers. Even though no wind pressure occurs, stack ventilation is still available. In Figure 13, the building orientation seems to have less consideration in response to maximise the flows of wind towards the building. This explain how air ventilation inside the building works although the building orientation is not well-designed.

The atrium's walls at both entrance sides were fitted with "rain-check" glazing which admits wind but keeps rain out. The pieces of glass walls are all slanted out in and fitted with the perforated panels. The rain screens prevent any external rain or moisture driven by the wind from entering the building, however rain-check wall allow the air movement to persist in different weather conditions.

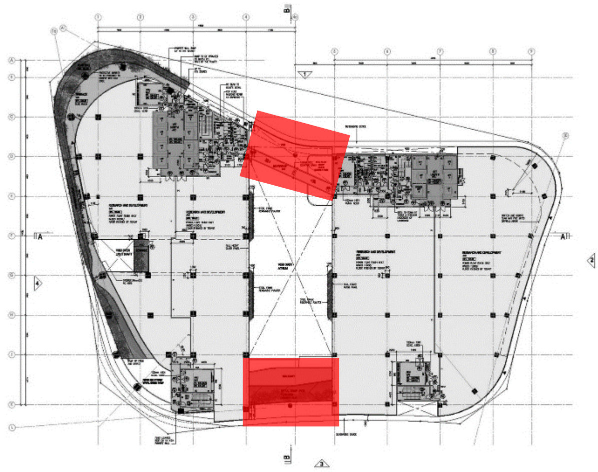
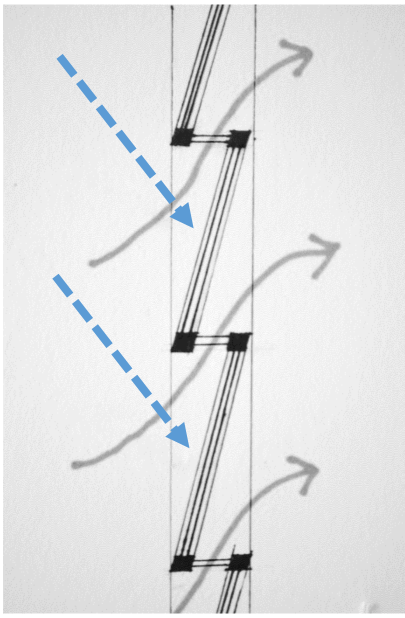


Figure 16: *Location of Rain-check wall at both ends of the naturally-ventilated atrium*

(http://www.archello.com/en/project/solaris)

^Figure 17: *"Rain-check" Glazing wall*



>Figure 18: Section of *"Rain-check" Glazing showing how rain water is prevented from entering the space without blocking the flow of air.*

REFERENCES

Bierig,A ,(2009) http://greensource.construction.com/people/2009/05_Ramping-Up-Green.asp Retrieved on 30 April,2014

Bullivant,L (2011). Vol 2, 17-33)

http://books.google.com.my/books?id=kJ1MG2ROycgC&pg=PA43&lpg=PA43&dq=solaris+pocket+park+plaza&source=bl&ots=CDSlvLYsYO&sig=MMqrS6mioCe7UyT2lwTvBGmWqwE&hl=en&sa=X&ei=8g1hU-K4MIq2uATjzICoAQ&redir_esc=y#v=onepage&q=solaris%20pocket%20park%20plaza&f=false Retrieved on 30 March,2014

Harl,S (2011) "Eco Architecture,the work of Ken Yeang", London Vol 3. 200-209

http://www.greenroofs.com/content/articles/126-SOLARIS-at-Fusionopolis-2B-From-Military-Base-to-Bioclimatic-Eco-Architecture.htm#.U2i3hfmSw Retrieved 5 May,2014

N.A.Sidd,(2011) "World's Green Buildings",Routledge 24-47

http://www.ctbuh.org/TallBuildings/FeaturedTallBuildings/FeaturedTallBuildingArchive2012/SolarisSingapore/tabid/3854/language/en-GB/Default.aspx Retrieved 26 April,2014

http://www.trhamzahyeang.com/project/large-buildings/solaris_01.html Retrieved 23 April,2014

http://www.worldbuildingsdirectory.com/project.cfm?id=4241 Retrieved 27 April,2014