MESINIAGA TOWER

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ABSTRAK

Mesiniaga Tower is one of first generation buildings design for low energy consumption purpose. The building itself was completed in 1992 and was designed by Ken Yeang, an architect whose concern is to create a better performance of a building without having to increase its cost of operation. It is located in Malaysia, South East Asia, where the tropical climate has heat and humidity almost the same throughout the year. The concept of the building is bioclimatic design with the original concept of fully natural ventilation, but later the conventional cooling system was added. The architect's idea is a tube shaped building with multiple terraces and openable windows to provide more wind and humidity in order to have a comfortable thermal condition. However these ideas lead to the problem of increasing yearly energy consumption. This paper then suggest the possible design strategies to improve the thermal comfort of Mesiniaga Tower as well as lower its annual cost such as radiative cooling, night cooling, ground cooling and passive downdraught evaporated cooling. The radiative cooling then gives the building of 8% cooling potential.

Keywords*: Bioclimatic design, Mesiniaga Tower, Radiative Cooling*

1. INTRODUCTION

The Mesiniaga Tower, is one of many buildings designed with the purpose of reducing energy consumption. This building was designed for IBM headquarters office by Aga Khan Award's winner, Kenneth Yeang. The building has 16 floors (including 1 basement) with a total site area of 6,503 m^2 and 12,345.69 m^2 for total floor area. It has 6-classrooms, a demo centre, lounge, cafeteria, a 130-seat auditorium and prayer room. Completed in 1992, this 63 metre building was one of the first pioneers for eco-design skyscraper in South East Asia.

Described as a 'bioclimatic' skyscraper by its architect, the Mesiniaga Tower performed well in energy consumption for a skyscraper building which was built in a hot-humid climate region. It consumes less energy than conventional building (without sustainable design strategies) which was built around 1990-1995. This building is located in Subang Jaya, Malaysia where the climate is considered tropical. The heat and humidity are fairly similar throughout the year. The temperature between day and night are slightly different, approximately 8 to 10 degree in Celsius.

2. ARCHITECT'S DESIGN CONCEPT AND SUSTAINABLE STRATEGIES

The building was designed by Ken Yeang as an eco-building in response to the tropical climate in South-East Asia, especially Malaysia, using a tropical architecture environmentally friendly approach. Yeang's aims were to make this building efficient and inexpensive when compared to other high-rise buildings. He also tried to create the best working environment by maintaining the best thermal temperature for the building and creating a less energy consuming building. His design for Mesiniaga Tower brought Yeang the Aga Khan Award for Architecture in 1995.

Figure 1 Northwest and East Elevation

(source: Courtesy of architect, ArchNet Digital Library, 1995)

Figure 2 North and South Elevation
(source: Courtesy of architect, ArchNet Digital Library, 1995)

Passive design strategies are applied in this building. By having passive solar design that should minimize the requirement for on-going cooling cost as well as having low operating maintenance cost. The architect originally wanted the building to be fully provided built natural ventilation. However, the client of Menara wanted the building to have a conventional cooling system beside natural ventilation. Ken Yeang then provided this building with air conditioner (AC) to maintain comfortable temperature, especially in office area where heat usually comes not only from people but also from office equipment (this is included computers, photocopy machines, etc).

The building is shaped like a tube with multiple side sections that have “holes” which serve as terraces to bring fresh air into the rooms. Yeang’s aim for the terrace design was for it to function as a space to grow green plants and to create a healthier atmosphere around the working environment.

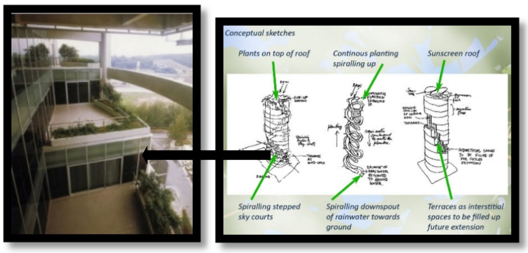

Figure 3 Terraces & Conceptual Sketches of Skycourt (source: http://www.yangsquare.com)

One of the famous designs for The Mesiniaga Tower, the roof garden (skycourt), serves as a sport and a recreation spot, a place to release tiredness and to socialize for its employees after working for the whole day. From the sketch above, it appears that Ken Yeang also used green plants at the top of the tower. Green plants were planted in addition to provide beauty and to control temperature from getting very hot. Besides vegetation, the roof in the Mesiniaga Tower also provides pools and gymnasium.

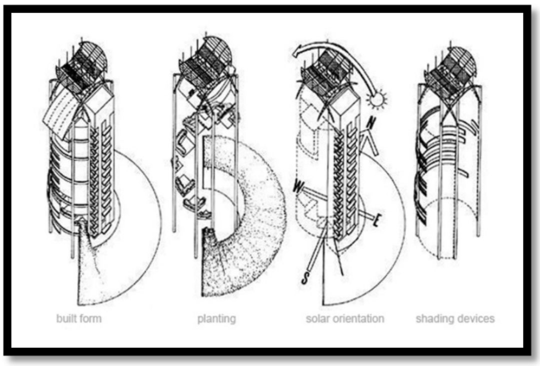

Figure 4 Analytical Axon (source: Safamanesh, 1995)

Figure 4 shows the analytical axon of the Mesiniaga Tower which includes tube-like built form, circular planting, solar orientated building (it exposes the South and North façade and put shading devices in the East and West) and shading devices as a strategies to block unreasonable heat for coming into building.

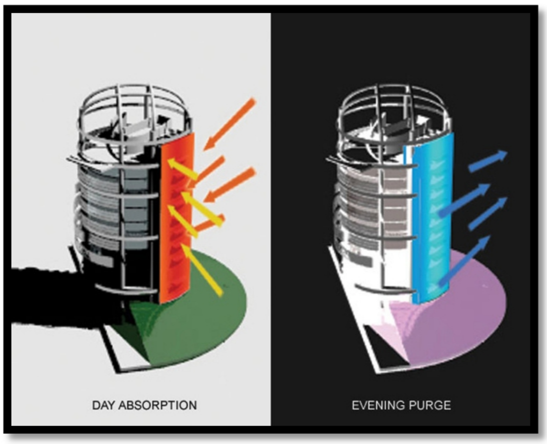

Figure 5 East Core Day Absorption and Evening Purge (Donnely, 2003)

Furthermore, the architect also tried to minimize the necessary intervention of the Mesiniaga Tower cooling system. By absorbing heat from the sun during the daytime, Yeang wanted this building to achieve ***thermal homeostasis*** after its purge the absorbed heat energy into the cooler surrounding during the nighttime. In Biology, ***homeostasis*** means a "constant or internal environment". As for building, it means, thermal mass is applied in indoor environment to keep indoor temperature varying within a small range

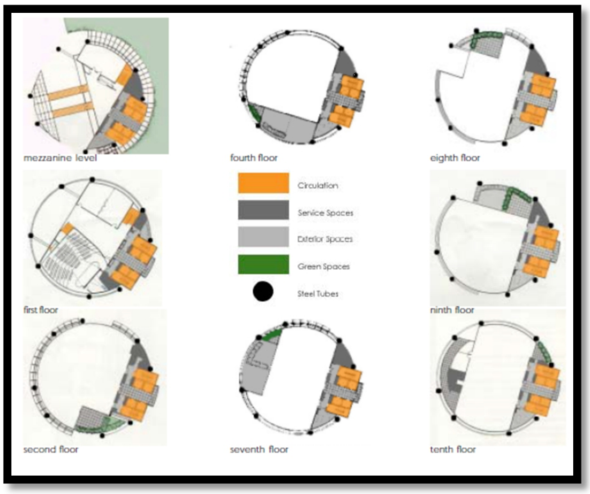

Figure 6 Mesiniaga Tower Floor Plan (Safamanesh, 1995)

Next point to be mentioned in Yeang's design for the Mesiniaga Tower is the windows. The windows were made opendable so that it can be opened by the people inside the building. They were placed on the East and West and were recessed and shaded by sunshading while on the North and South, curtain wall glazing is placed.

As for shading and lighting, ambient light is optimized by the existence of Menara's circular form. While adding to Yeang's palette of architectural tools, there are two types of shading devices that maximize Menara's solar exposure and minimize harmful heat gain. One of the shades is a continuous screen and the other one is a series of three attached to the building's structural system directly. Acting as a secondary system and allow for more individualized lighting control while accounting for unforeseen shadows and glare is **window blinds.**

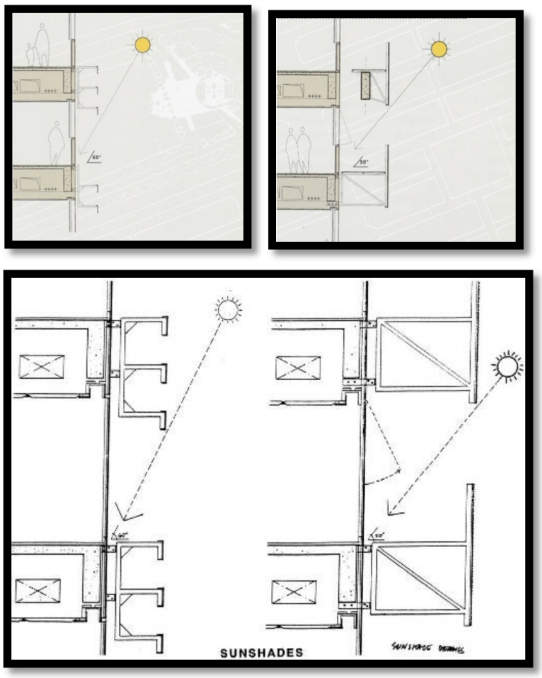

Figure 7 Sunshades in Detail (source:http://www.trhamzahyeang.com/project/skyscrapers/mesin14.htm)

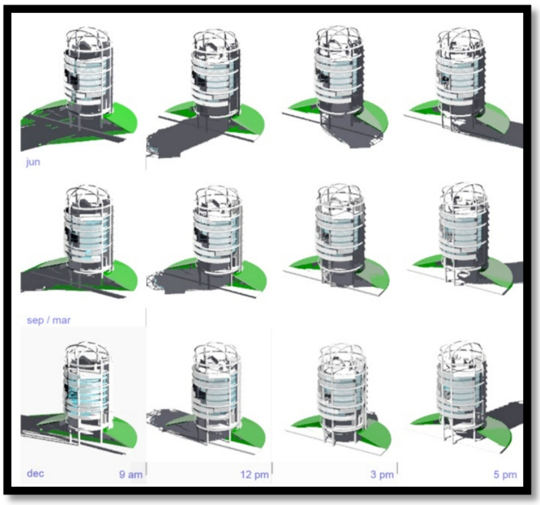

Figure 8 Sunshades location (Donnelly, 2013)

3. BUILDING CRITICS

A technical review of the building (the flat roof, water stains and panel warping in the gymnasium) showed that some parts of the building rusted due to the high level of humidity in Malaysia (Safamanesh, 1995).

The skycourt is exceptionally warm during the greater part of the day from the impact of direct western sun directly (Jahnkassim & Kenneth IP, 2000).

Openable windows leak the conditioned air from indoors to outdoors and can create a higher consumption of energy to cool the building. While spiral hanging gardens increase the humidity of the air that can enter the indoor area, especially during the rainy season when humidity is at its highest level.

4. POSSIBLE ALTERNATIVE DESIGN STRATEGIES

Ken Yeang's design for The Mesiniaga Tower was undoubtedly a very impressive design for a skyscraper built in 1990's. This was shown in the study that thermal comfort was very satisfactory for the office area and reasonable in the service core. Nevertheless, some parts of the design have not functioned well, such as the skycourt which is unacceptably warm especially during the hottest part of the day. To prevent unwanted conditions and to maintain the sustainability aspect of the building, some possible alternative design strategies have been investigated.

1. Radiative Cooling

   "Radiative cooling is based on the heat loss by long wave radiation emission from a body towards another body of lower temperature, which plays the role of heat sink. In the case of a building, the cooled body is the building and the heat sink is the sky, since the sky temperature is lower than the temperatures of most of the objects upon earth" (Asimakopouslus, 1996)

   The idea is to have an open space from which the sky can be seen without obstruction in order to radiate heat away to the sky. This strategy is most effective with a dry clear atmosphere. As a result, the cooling power can be collected to reduce the cooling load of the building.

   The cooling load of Mesiniaga building is 709,145 (approximately 710kW). Diameter of Mesiniaga Tower rooftop is 23 m. It gives the total area of 415.3 m^2 and radiative cooling potential approximately 29kW.

   Extended the diameter of roof area to 40% was the strategy in order to create a bigger area for sky to radiate. The extended diameter for the building is 32.2 m and it gives the total area of 814 m^2. The radiative cooling potential for this extended roof will be approximately 57kW. This will give 8% of cooling potential for the building.

2. Night Cooling

   "Night cooling refers to the operation of natural ventilation at night in order to purge excess heat and cool the building fabric. A building with sufficient thermal mass, which can be exposed to nighttime ventilation, can reduce peak daytime temperatures by 2° to 3° using this strategy" (Passivent, 2013)

   The idea is to bring cool night air into the unoccupied room with the purpose to cool the building and drive the heat inside the room out.

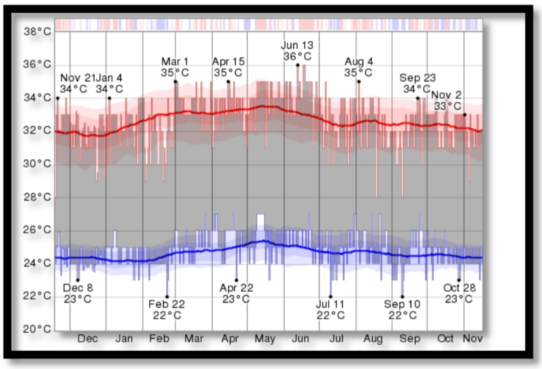

Figure 9 Average annual Temperature of Subang Jaya (source : https://weatherspark.com/history/34046/2013/Subang-Jaya-Selangor-Malaysia)

The chart above shows the last 12 months daily low (blue) and high temperature for Subang Jaya, Malaysia, while the thick line shows the average temperature during the hottest part of the day (red) and the coolest part of the day (blue). The average daily high temperature was between 32° C and 33°C while the average daily low temperature was between 22°C and 24°C.

As the building will be unoccupied for 12 hours each day, the cooling strategy can be a good suggestion to improve thermal comfort and sustainability of Mesiniaga tower. However, the variety of day and night temperature is only around 8°C to 10°C. This low different temperature between day and night made it difficult to apply the night cooling strategy in the building.

3. Ground Cooling

"A ground-source cooling system relies on the relatively constant temperature of ground water throughout the year" (Vollmer Engineering, 2011)

The variation between air temperature and ground temperature can make a good strategy to cool the building down. By pumping the air from underground tube, it can be used as cooling system to the building. It can be used with chilled beam as one strategies to maintain the building comfort temperature. However, in Malaysia case study, the average temperature only vary a little between day and night make ground temperature is around 28°C as seen in Figure 9. In this temperature, ground cooling is less effective and expensive if applied to cool the building.

4. Passive Downdraught Evaporative Cooling

" Passive downdraught evaporative cooling (PDEC) is a representative term that is defined as a passive and low energy technique for cooling and ventilating spaces in hot, dry climates" (Cook et al., 2000).

"A passive down-draught evaporative cooling (PDEC) system, or cool tower, is a passive evaporative cooling technology that is designed to capture the wind at the top of a tower and cool the outside air using water evaporation before delivering the cooled and humidified outside air to a space" (Kang and Strand, 2009)

Passive evaporative cooling technology is generally considered to be suited to hot and arid climates as it can provide cooling without significant energy use and can also produce a better indoor environment by providing fresh, cool air into a space. With the benefits of energy efficiency, cost effectiveness and sustainability, the demand for passive evaporative cooling systems has grown in hot climates, often competing with or complementing conventional air conditioning systems. The idea is to have micro water sprinkler at the top of the building, for example at the stack.

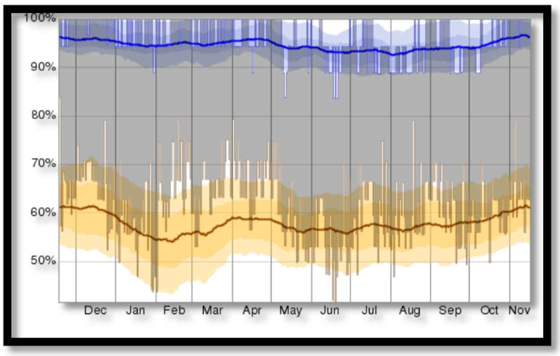

Figure 10 Annual Humidity of Subang Jaya (source : https://weatherspark.com/history/34046/2013/Subang-Jaya-Selangor-Malaysia)

The chart above shows the annual humidity of Subang Jaya, Malaysia where the Mesiniaga building located. It shows that the least humid month of the last 12 months was June with an average daily low humidity of 54%, and the most humid month was April with an average daily low humidity of 67%. Consider to have high humidity condition, PDEC strategies cannot be applied as it will result to uncomfortable feeling.

According to Patricia Christie, a lecturer in MIT's Experimental Studies Group, the body normally cools itself during humid days. It opens pores and evaporates water while transferring the body's heat to the air. However the rate at which water (sweat) evaporates depends on how much water is already in the air.

5. THE MESINIAGA TOWER VERSUS THE DIAMOND BUILDING

While The Mesiniaga Tower was built more than two decades ago and received a lot of attention for its impressive performance in energy preserved, todays acknowledged building went to The Diamond Building which is located at the same region and has similar weather condition. This building received enormous compliment for its surprisingly low measurement in energy consumption. This is the first building to carried the Malaysian Green Building Index (GBI) Platinum award and the Singapore Building & Construction Authority (BCA) Green Mark for Building (Overseas) Platinum Awards as well as ASEAN Energy Award in 2012 and the newest one is ASHRAE Technology Award 2013 (Second Place, Category I).

Figure 11 The Diamond Building, Putrajaya, Malaysia (source: IEN Consultants)

Completed in 2010, The Diamond Building is a home to the Energy Commission of Malaysia which is located in Putrajaya, Malaysia. The architect for this building is NR Architect (with its principal architect, Dr. Soontorn Boonyatikarn) collaborated with IEN Consultants Sdn Bhd for sustainability design. Design strategies which are applied in this building as following:

a. Low-e (Low emissivity) glazing
   Low-e glazing helps reducing heat gain while blinds help preventing glare, especially in the East and West facades that receive morning and afternoon sun.
b. Floor slab cooling
   In the slab, 18^{o} Celsius water is circulated to cool them down to approximately 21^{o} Celsius. While the system is shutting off during day time, the floor slab absorbs heat from people, computers, and solar gains passively.
c. Air-side system addressing the latent load, air movement and air filtration

Figure 12 Low-e Glazing Façades
(source: Lin Ho. Courtesy of Senandung Budiman Sdn. Bhd)

The performance summary of the Diamond building included electricity savings for 57%, 71.4 kWp solar PV plant, water efficient fittings, rainwater harvesting and grey water recycling, conducive working environment (50% daylighting, good air quality and passive slab cooling) and additional 35% savings on the district consumption for the building.

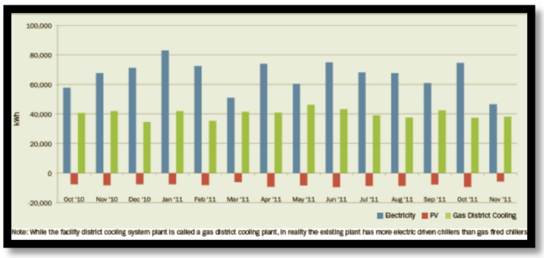

Figure 13 Energy Use, PV Generation, Oct 2010 - Nov 2011 (kWh)

(source: *Malaysia Energy Commission Headquarters: Putrajaya, Malaysia | Hpbmagazine.Org*)

6. CONCLUSION

The Mesiniaga Tower is perhaps a great start for a sustainable design approach to skyscraper building in tropical and humid weather conditions. It consumes less energy than any conventional building (buildings without the application of eco-design strategies) when completed in 1992. Even better performance can be achieved by applying alternative design strategy apart from the eco-strategies which already applied. One possible alternative design strategy which can be applied is radiative cooling. The application of radiative cooling will give 8% of cooling potential for the building.

However, compared to the energy consumed of the recent eco-friendly building in the same climate and area, this building fall out of the number. The recent building that is being compared to Mesiniaga Tower is The Diamond Building (completed in 2010), a headquarters of the Energy Commission (Suruhanjaya Tenaga) of Malaysia. While Mesiniaga Tower consumes 248 kWh/m^2 each year, The Diamond Building consumes just under one fourth of that, or 65 kWh/m^2 per year.

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