Outdoor Comfort Analysis using Rhino + Grasshopper Software

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In many developments that we have either been personally involved in or had the chance to visit and experience in Malaysia, we've generally found that comfort and year-round useability of the outdoor spaces have not been given too much thought and planning. The design of many of these outdoor spaces tends towards complimenting the aesthetics of building and architecture design language, and not specifically designed for attracting more usage. Yet, we see examples of buildings, particularly retail and food & beverage type developments that are particularly successful because the outdoor spaces are attractive and comfortable. This just shows how important it is to design these outdoor spaces well for thermal comfort.

Living in Malaysia, we know that our biggest problem is the heat and humidity. This coupled with the lack of consistent breeze means that being outdoors can get uncomfortable very quickly. The main source of heat we experience is from the direct heat of the sun's rays, indirect heat from warm surfaces nearby (e.g. feeling the heat radiating from nearby cars in a traffic jam), and the warm air

Short of installing an air conditioning system in outdoor spaces, which would be impractical for most instances since the operating cost would make it non viable, it would not be possible to change the air temperature. However, we can certainly do something about reducing direct heat from the sun and nearby warm surfaces.

In this write-up, we present a brief idea of how we utilized Rhinoceros 3D with Ladybug and Grasshopper plug-ins to model and predict outdoor thermal comfort conditions. The performance metrics that were modeled were Solar Radiation exposure, Solar Adjusted Mean Radiant Temperature and UTCI (Universal Thermal Climate Index).

The Solar Radiation exposure study provided us a quick review of how exposed the outdoor spaces would be to the sun's rays throughout the day and year. As the sun's position shifts throughout the year, even spaces below a canopy can be exposed to direct sunlight at some time of the year.

Our skin is very sensitive to radiation. Solar radiation landing on our skin directly affects our thermal comfort perception. This is akin to moving from a shaded covered walkway out into the open on a hot sunny day. The air temperature around us has not changed, but suddenly feel it's gotten a lot hotter. This sensation of feeling as if it's gotten hotter can be quantified by the Solar Adjusted Mean Radiant Temperature (Solar Adjusted MRT), which quantifies how much warmer our body feels when exposed to direct sunlight.

UTCI is a useful perimeter for evaluating comfort in outdoor conditions. UTCI is most commonly utilized in weather information to provide a "Feels Like" temperature. UTCI is influenced by air temperature, solar radiation, mean radiant temperature, relative humidity as well as air movement. Using UTCI as a benchmark index, we are able to evaluate additional strategies to enhance comfort in these outdoor areas e.g. introducing ceiling fans.

In our simulations, we utilize Solar Adjusted MRT and UTCI as qualitative means to compare different passive design options (street width, shading depth, tree location and size)

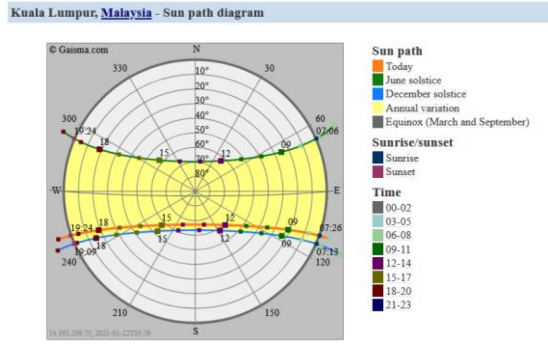

Image 1: Sun Path diagram for Kuala Lumpur, Malaysia. The Sun path shows the position of the sun at different times of day throughout the year. Sun path differs for depending on the location relative to the equator. Understanding the movement and position of the sun is possibly the most fundamental step in good design for outdoor spaces. (Sun path diagram source: www.gaisma.com)

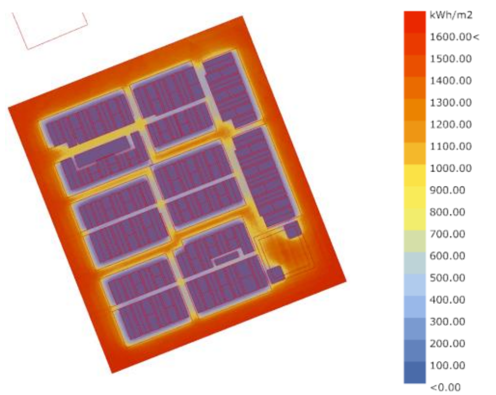

Image 2: Solar radiation analysis of the outdoor spaces for the entire masterplan development. This provides a very quick analysis if any areas are already well shaded or poorly shaded throughout the year.

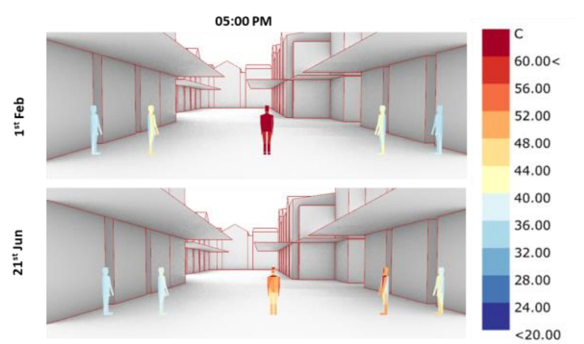

Image 3: Solar Adjusted MRT mapping at different locations (exposed between buildings, under canopy) and different time of year (1st February and 21st June). As can be seen from the results, the Solar Adjusted MRT for the person in the middle much higher on 1st February compared to on 21st June. It is therefore important to evaluate this metric for the entire year for year round useability of the outdoor space.

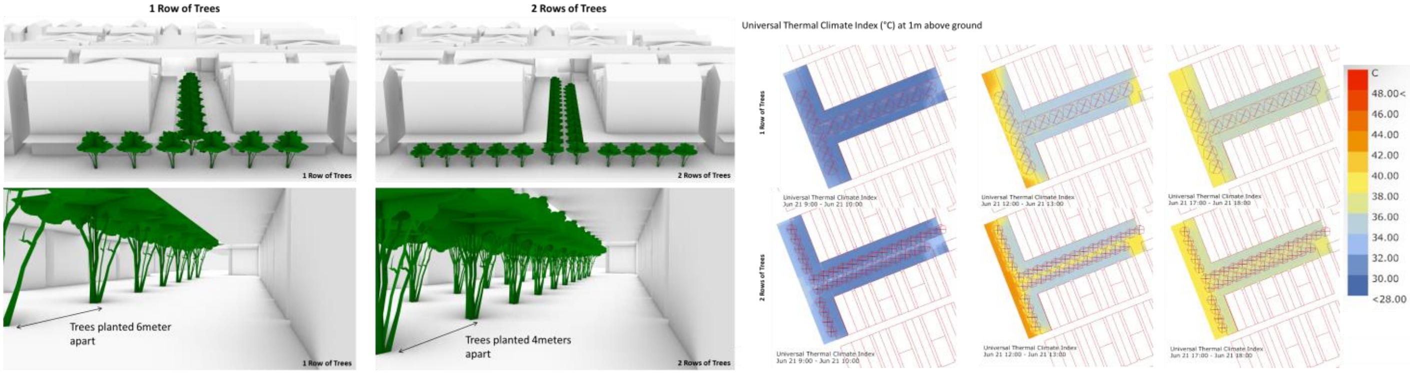

Image 4: Modeling UTCI for 2 options of tree selection and positioning. This was used to advise developer on the optimized tree sizing (Overall Height, Canopy Size) and tree positioning – middle of open space or on each side of the open space based on the UTCI temperature at different times of day and year