

NATURAL VENTILATION: A PASSIVE DESIGN STRATEGY IN DESIGNING HOTEL LOBBIES – CASES FROM TROPICAL MALAYSIA

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Abstract

When the Malaysian government increased electricity tariff by up to 12% in early 2006 and also another increase in early July 2008, most commercial buildings were affected by the move. The hardest hit would be the hotel industry as they are among the economic forefronts of the nation. Already burdened with the rigorous efforts of filling their rooms with guests, they now have to re-strategize to sustain business. Energy bills to pay for cooling have always been the biggest burden. Cooling the air is an intangible and a never-ending wasteful activity. Cold room for food is on for 24 hours for obvious reasons. To overcome this, one strategy was considered to be part and parcel of the overall building design so as to contribute to the reduction of the high dependency of energy consumption for cooling. The challenge here is to reduce electricity consumption without compromising the comfort of the guests and also reduce the overhead costs to give a more competitive edge in hotel room rates. Among other passive design elements this paper considers two natural ventilation occurrences and locations that can be relied upon for Malaysian hotel designs.

Keywords

Natural ventilation; hotel lobbies; land and sea breeze; prevailing winds of valleys.

Introduction

In Malaysia, as in other parts of the world, the success of the tourism industry depended very much on the success of the hotel industry. The star ratings (two-, three-, four- and five stars) would indicate the kind of services provided by the hotels. It also indicates the levels of comfort that can be experienced, namely, material comfort, activities and facility conveniences and also thermal comfort. The hot humid climate of Malaysia necessitates the use of all kinds of mechanical systems to cool the surroundings. To feel comfortable one has to be under shade and experiencing ample air movement concurrently (Abdul Malek, 1994). Discomfort would set in when one element is missing. When being exposed under the tropical sun one would experience the stifling heat unless the wind is of ample velocity (normally > 2m/s) to rid off the radiant heat. When under shade an air velocity of 1m/s is sufficient. At night time (i.e. with no sun) the surrounding areas needed ample wind to get rid off the high relative humidity. Otherwise the high humidity in the air gives stickiness to the human skin and this is a discomfort. It is unfortunate that the tropical

climate in Malaysia is described as hot and humid and has no reference to wind. This means that the much desired wind in Malaysia for natural thermal comfort cannot be depended upon because of its characteristic behavior in that it is unpredictable, multidirectional and erratic i.e. when there is wind the velocity may not be of the required speed. As a result air conditioning, fan and misting fountain were resorted to. These then add to running cost especially where air-conditioning takes up nearly 70% of the electricity bill in most hotel buildings (Buttgen, J., A personal conversation with the General Manager, Copthorne Hotel, Penang, Malaysia, June 2003).

Only two natural phenomena (Abdul Malek, 2004) can be identified to provide ample air velocities which can have an influence in the design of buildings. They are normally experienced at locations (i) by the beach, geographically termed as land and sea breezes and (ii) the prevailing winds of the hill slopes. Generally, Western tourists would flock to Malaysia, among other activities, was to bask under the Malaysian sun. A typical and habitual behavior was that after sightseeing tours they would bask in the sun by the beaches. So for the same reason as most other hotels in other parts of the world, most hotel locations would be along the fringes of attractive beaches.

An increase in the cost of electricity tariffs up to 12% in May 2006 for commercial activities, including hotel industry (News Straits Times, May 2006), the increase in petrol price and another hike in electricity tariff (News Straits Times, July 2008), have compelled almost those in business activities to brace themselves to be frugal. A General Manager of a particular hotel in

Penang resorted to switching off air conditioning for one hour at the administrative section in order to save energy (Buttgen, J., A personal conversation with the General Manager, Copthorne Hotel, Penang, Malaysia, June 2003).. This is not the right move as productivity of the staff would be affected. Steps should be taken towards energy efficiency in all activities. The normal approach would be proposed to be as listed below:

- a. Incorporate as many passive design elements in the building layout, fabric and envelope. This should be the first line of strategy as apart from initial construction costs there would not be any running cost after implementation.
- b. Gradually change all obsolete electrical appliances, equipment and installations. To change all at once would be too drastic on the budget and furthermore the problem of disposing immediately or storage with all the replaced appliances, equipment and installation may arise.
- c. Set up an energy management program and form an energy management committee. The leader is to report energy issues to the board of directors. Energy issues has to be in the agenda all the time to be as center stage otherwise the exercise towards energy efficiency without compromising comfort would be futile.
- d. Finally, when budget allows, installing the photovoltaic system would be a wise move as once installed no further running cost would be incurred. The energy obtained is free from the sun. The advantage is that it is maintenance-free except for the topping up of battery fluid.

It can last for at least thirty years and very friendly to the environment. It is clean energy.

The hypothesis is that temperature discomfort can be alleviated by higher air velocity. Higher air velocities in tropical Malaysia are normally found in two locations (Abdul Malek, 2004), namely (i) the perpetual wind of hill-slopes and (ii) the land and sea breeze. Thus this investigation is of an exploratory nature to verify the hypothesis.

Methodology and Field Investigation

The passive element here is to make full use of the wind both from the land and sea breezes phenomenon and the prevailing wind from the hill slopes. Two locations of hotels were identified to represent the situations, namely, one located by the sea and the other perched on top of a small hill. The study limits itself to the hotel lobby as this would be ideal for natural cross ventilation. Hotel rooms are normally single opening for security and privacy and would not be appropriate to be experimented upon. Furthermore there are more people at the hotel lobby than at their own individual rooms.

Two hotel lobbies are chosen for the experiment because most hotel lobbies in Malaysia have high ceilings and therefore big volumes of air. In city hotels air-conditioning is resorted to for thermal comfort because to have an open design concept would not be suitable due to several factors such as noise pollution, dusts and thermal discomfort from outdoor heat islands. Hill hotels and beach hotels can therefore explore to make full use of the hypothesis mentioned above with the intention to reduce dependence on energy consumption from conventional electric supply (i.e. sourced

from burning the fossil fuels). The hotel industry would benefit a lot from reducing its running cost because its occupancy rate fluctuates seasonally. Low occupancy rates would reduce the profitability gap and with low running costs would make the profitability gap even better in times of high occupancy.

So designing hotel lobbies to adapt and capitalize on good natural ventilation would help hill hotels and beach hotels to enhance not only their profitability and at the same time saves the environment. Using good natural ventilation means less dependence on conventional electric supply, a process that depletes the fossil fuel.

To seek hotels perched up on hill slopes was not an easy task to do because most hotels would rather be located near beaches. Beaches are popular with tourists from the temperate and cold countries. In Malaysia, not many are on hills but most can be found on mountains tops. Mountain locations do not pose any problems with heat thermal discomfort. The cool temperature is usually most welcome by the locals. So a hotel on a hill slope in this investigation was identified not for comparison with all hill hotels but taken as an exploratory investigation to verify the hypothesis that hill slopes locations can make full use of the air velocity into designing of buildings. Several beach hotels are also located by the seaside but only one particular hotel was investigated because of the same scale and size of building mass with the other two hotels adjacent to it both left and right. The adjacent hotel on the right side of the experimented hotel i.e. the Copthorne Hotel has its lobby totally enclosed and air-conditioned throughout and this was found to be energy inefficient. It was also observed that even when there were only

two or three staffs behind the counter the air-conditioning was still switched on all the time. Unlike the hotel under investigation where the lobby has no air-conditioning at all but depended solely on the natural behavior of the outdoor climate. This is an ideal building to be investigated as it took consideration of the land and sea breeze thermal behavior and incorporated in its design.

The objective was to determine whether the average natural air velocity can reduce thermal discomfort at hotel lobbies so as to depend less on air conditioning to be designated as one of the best practices. The climatic elements of air velocity, air temperature and relative humidity are measured by means of respective sensors and the data was logged into a BABUC environmental data logger which was then transferred into a computer for further analysis. This reading was carried out for a period of one week to give an average picture of the indoor environment's climatic performance. One week is deemed as adequate to give some indications of the indoor climate. This one-week reading is a typical week which does not represent the rainy season as worst case condition. The challenge here is to provide reasonable comfortable atmosphere during hot seasons. Malaysia does not have four seasons unlike other countries up north and south. The hot humid characteristics of the Malaysian climate need to be compensated by generous winds. Malaysia does not have generous winds to rely on. The characteristics of wind conditions in Malaysia are that they are unpredictable. By observation and experience it was identified that only two geographical settings would provide promising wind conditions that can be utilized and incorporated in the building

designs, namely the land and sea breeze and the prevailing wind of hill slopes.

The Land and Sea Breeze

A hotel at Batu Feringghi, Penang is by the side of a beach facing the Malacca Straits. It was chosen as representative of the land and sea breeze situation. The arrow in the diagrammatic cross section as shown in Figure 1 indicates natural ventilation. The land and sea breeze phenomenon is termed because of the different surface masses meeting at a junction. Land is denser than the sea and therefore during daytime it is heated more rapidly than the sea. Heated land would create a zone of low pressure as the hot air rises to the above atmosphere. This low pressure is then filled up with relatively cooler air from above the sea mass by the process known as thermo-siphon and is referred to as the sea breeze since the breeze comes from the sea. At night time the reverse is known as the land breeze because again land being the denser surface would release heat absorbed during the day rapidly than the sea thus becomes cooler than the sea.

The top right picture shows the hotel lobby looking towards the sea. The sea is located at the far end behind the two betel nut trees at the background. The location of the BABUC environmental data logger is also shown as indicated in white arrow (bottom left). The BABUC environmental data logger comprised of sensor probes for air temperature (dry), relative humidity, hot wire probe for detecting air velocity. Care was taken in setting up the environmental data logger so that the probes were measuring the climatic elements under shaded environment and away from the sun

rays. The readings were taken every fifteen minutes interval continuous twenty four hours for one week to find an average pattern of the indoor climate.

The Prevailing Winds of Hill Slopes

A hotel at Bukit Jambul, Penang perched up on top on a small hill was chosen to represent the test case for a hill slope with a prevailing wind condition. The arrows in the diagrammatic cross



Figure 1: (Top left): Diagrammatic cross section of hotel. (Top right): Hotel lobby looking towards the sea. (Bottom left): Hotel lobby as seen from Main Entrance and location of the BABUC environmental data logger. (Bottom right): The BABUC environmental data logger measuring air temperature, air velocity and relative humidity/ (Source: Authors).

section as shown in Figure 2 below indicate natural ventilation. The hill slope's prevailing wind phenomenon is termed because of the thermal properties of air mass being warm or cool. Warm air mass would rise up due to its low density, and cool air, usually occurring in the evenings and into the night would be heavier than warm air and would therefore slide along the slopes of the hill to the bottom of the valley. This process creates air movement that can be tapped for use in buildings built along ridges of hills or along hill slopes.

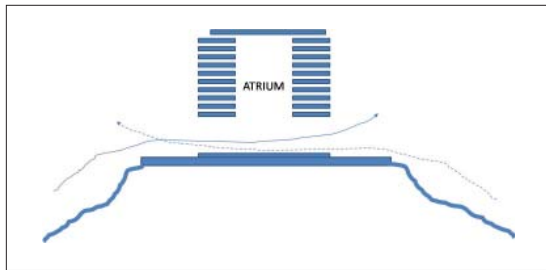


Figure 2: Diagrammatic cross section of hotel. (Source: Authors).

The top right picture in Figure 3 shows the hotel lobby and atrium. It is opened to receive natural ventilation from all sides of the atrium. The only glass wall is the wall flushed with the main glass door to prevent vehicular noise from encroaching the peaceful lobby and atrium, otherwise totally opened to the natural wind. From the lobby and at the opposite end of the main entrance one can see a panoramic view of the 13.5 kilometer long Penang Bridge supposedly to be the longest bridge in South East Asia. The location of the BABUC environmental data logger is also shown as indicated in illustration.

Discussion

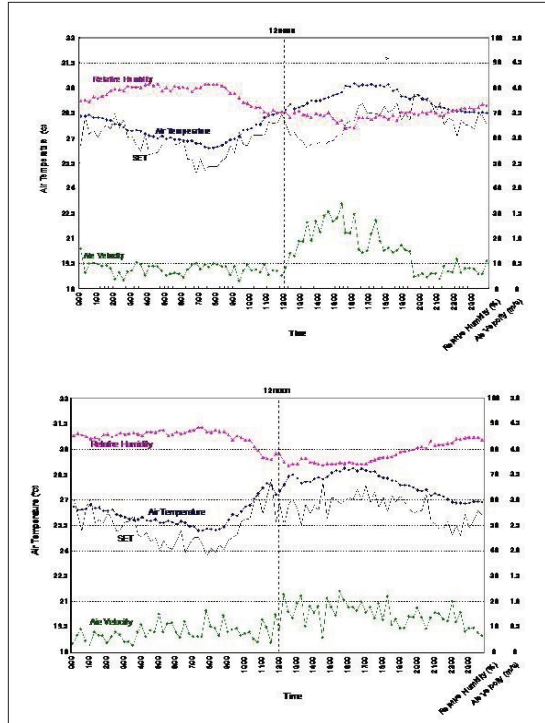
The hypothesis is that capitalizing on the natural ventilation helps to reduce the cost of monthly bills for cooling the hotel interiors to provide comfort for the hotel guests and local occupants. The two experiments carried out in the previous section showed that by identifying and understanding the natural behavior of wind in tropical Malaysia, the hotel industry can employ the idea of using predictable wind conditions to reduce the business overheads. In Malaysia only two locations were identified as having more predictable wind conditions than any other parts of Malaysia. Though it cannot be totally relied upon for 100% all the time but identifying where such locations are, would help to influence the hotel designs for new buildings and, while for existing ones renovations can be done to retrofit the idea. Land and sea breeze and prevailing winds of hill slopes are the two locations that provide predictable wind conditions. Other parts of Malaysia such as the country lowlands interior and urban settings would describe the wind condition as unpredictable, multi-directional with erratic wind speeds.

The Standard Effective Temperature is a temperature indicator as it takes the considerations of other climatic elements and not just relying on the air temperature alone. From here graphs were created to help interpret the thermal performances of the hotel lobbies. In the graphs are four lines representing average one week readings, the relative humidity (%), air temperature (0C) and air velocity (m/s). The fourth line is the standard effective temperature (0C) which is also the skin temperature. It is the result of the interaction of the three basic

climatic elements, namely the air temperature, the air velocity and the relative humidity. The discussions that can be derived from these two graphs are as follows (Graph 1):



Figure 3: (Top left): The main entrance glass door and wall (Top middle): Hotel lobby and atrium (Top right): The panoramic view to the sea and Penang bridge (Bottom left): Top end of the atrium allowing for daylight. (Bottom right): The BABUC environmental data logger measuring air temperature, air velocity and relative humidity. (Source: Authors).



Graph 1: Average readings for (above) Beach hotel and (bottom) Hill hotel. (Source: Authors).

1. Both the investigations showed that the SET are below the air temperature averaging 10C-1.50C. When it comes to thermal comfort a 10C drop would make a significant difference in comfort and also in the reduction of energy consumption. This saves a lot of energy monthly bills.

2. There is somehow a general mirror image between the SET and the air velocity, especially from 12.00 noon to 6.00 pm for the beach hotel

and from 8.00 am to 3.00 pm for the hill hotel. This means that when there is wind the temperature of a particular space will drop. But the indoor climatic behavior differs during the evening. Without the presence of wind the temperature still drops simply because there is no sun to heat any air mass.

3. Both the SETs falls within the Malaysian Thermal Comfort zone, i.e., within 240C to 280C (Abdul Shukur, 1993). The SET of the beach hotel seemed to be on the higher side within the comfort zone and for the hill hotel was more towards the mid-section of the comfort zone. Since the period of measurement was taken at different weeks it is highly likely that the week taken for the beach hotel was experiencing higher air temperatures. Nevertheless it is important to note that both are within the stipulated comfort zone and that air velocity was the determinant factor to bring down warm temperatures.

Conclusion

The above investigations showed the hypothesis has been verified. Architects and other building professionals are to take heed that these proven findings specifically at these two geographical locations and phenomena, wind can influence the building design of hotel lobbies. A 7 to 8-day period for measurement at 15 minutes interval was taken as reference just to check on the consistency for worst case conditions. The worst case condition for a tropical climate is usually during the hotter parts of a typical day. There has been no base reference for the number of days for measuring in tropical climates especially in the Equatorial climate of Malaysia because any typical day would be described as either hot or wet. So one year reading seems unnecessary.

Most hotel lobbies in Malaysia were cooled by air-conditioning. Apart from the cold rooms to keep food fresh, air conditioning has been one source of high energy consumption in a typical hotel. These two hotels under investigation were wise enough to design their lobbies capitalizing on natural ventilation. Air-conditioned hotel lobbies normally would set their temperature indoors at 22°C. The designed outside air temperature for air-conditioners was set at 33°C by mechanical engineers of air-conditioners. The lower the temperature set at the air-con unit the more energy is consumed to extract the moisture from the outside air before releasing the dry cold air into the interiors (Ismail, M.R, 2000). Therefore the best practice is to reduce the gap between the outdoor temperature and the indoor temperature. Twenty-two degrees centigrade is far too low and the difference between outside air temperature and indoor temperature is too wide. Sometimes this can be wasteful when there were not many people around the hotel lobby and the whole air volume of the lobby was cooled unnecessarily.

At times when there is equilibrium in temperature there may not be any wind at all (calm situation). Discomfort would then set in and this situation is common to all hotels in Malaysia. When this happens it is highly recommended that electrical fans may be needed to achieve comfort level thereby obliterating the dependency on air-conditioning. Between fans and air-conditioning, fans are much cheaper to operate. Reduction in energy consumption means overheads are less and thereby pose more competitive in the hotel industry.

References

- Abdul Malek, A. R. (1994). Design for natural ventilation in low-cost housing in tropical climates (PhD Thesis, University of Wales College of Cardiff, Wales, UK, 1994).
- Abdul Malek, A. R. (2004). Low energy cooling technology for Malaysian homes. Malaysia: Universiti Sains Malaysia.
- Abdul Shukor, FIRST INITIALS (1993). Human thermal comfort in tropical climates (PhD Thesis, School of Architecture, Building, Environmental Design and Planning, University College London, 1993).
- Editor. (2006, May). Cut air-conditioning usage: Government offices urged to save energy. News Straits Times, pp. 12.
- Ismail, M.R. (2000). An investigation into the choice of air-conditioning design conditions for Malaysian offices and the effect on energy consumption in Malaysia (PhD Thesis, University of Liverpool, 2000).