Smart and Cool Home in Malaysia

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Abstract. Achieving thermal comfort in the tropical climate of Malaysia is always a great challenge for any house designer or builder. Although some practical solutions have been developed over centuries through the slow but constant evolution of indigenous houses such the Malay house, the longhouses in Borneo and the Chinese townhouses in Melaka, their integration into contemporary designs have been hampered by various modern constraints. For instance, building the Malay house in urban areas is deemed unsuitable due to the need for wide land lots and their perceptively fragile building materials that do not allay any security worries. The lack of skilled carpenters for building such a house is also a worsening problem. Hence, new and innovative strategies to achieve thermal comfort for contemporary houses are greatly needed to serve the needs and expectations of an urbanized society. One method that has been studied and proved successful is the Smart and Cool Home system which was first used at a private bungalow in Semenyih, Malaysia. The overarching principle of this system is to reverse the role of the building envelope from being a thermal mass into a heat sink which effectively reduces heat gains and allow the occupants inside to easily adapt to a milder indoor environment. This paper describes this house in detail and provides some understanding of the principles involved.

Introduction

In the quest for achieving thermal comfort, more home owners in Malaysia have opted for the easy but inefficient way of air-conditioning their homes. A study by CETDEM showed that 692.62 kWh of electricity was used by two communities or 45.78\% of their total monthly electricity consumption in 2006 on air-conditioning and fans alone, emitting nearly 693kg of carbon into the atmosphere [1]. This trend has to change to reduce fossil fuel consumption from electricity generation and mitigate carbon emissions. Much of this behavior is attributable to the unavailability of houses which are thermally efficient in Malaysia. These houses could be classified as green buildings or green homes and they should be able to perform more than just providing thermally comfortable indoor environments. Hence, the scope of this paper is to highlight the green building characteristics and advantages of the Smart and Cool Home (SCH) system. The case study is a green building as defined by the Vales [2], Cole [3], Retzlaff [4] and Roaf [5, 6] among many more.

The Case Study

SemenyiH House. This bungalow was constructed on a 400m\textsupersquare\textsupersquare\textsupersquare area piece of land located near the rural township of Semenyih in the state of Selangor. The gross floor area is 167.2m\textsupersquare\textsupersquare\textsupersquare over two stories with three bedrooms and accommodates a family of five and a maid [7]. The owner-occupants live and work full-time at home with the help of a full-time staff who arrives every morning for work at the house [8]. The unique Smart and Cool Home (SCH) system was integrated into the design and construction of the house and which yielded significant reduction in construction costs due to the reduction of various building materials that will be detailed later and the ensuing reduction in labor.
demand. 60% less than conventional numbers of laborers was needed to construct the house because SCH is a modularized system that can be constructed easily by fewer but well-trained builders [9]. The most challenging part of the construction process was to train the builders while convincing the architects and structural engineers to design with the system. Otherwise, the unique structure and building envelope function as designed and intended although more physical research on them are needed to validate the perceived thermal comfort as reported by the occupants [8, 10] and Sh. Ahmad et al. [7].

A: Front view from South-East  
B: Rear view from North-East

Fig. 1: The exterior of Semenyih house

**Smart and Cool Home System.** This system was the brainchild of Lee Su May, Lincoln Lee’s wife who is a physicist and an energy management specialist [11, 12]. The main principle for achieving thermal comfort inside this house is the use of the sub-structure of the house as a heat sink to effectively cool the building envelope throughout the day [7, 9, 13]. This was achieved by substituting the concrete which was often used to build ground floor slabs with recycled rubber tires [9]. Even the hard-surfaced areas including the driveway outside were similarly built. This material substitution has three advantages as firstly, the resulting overall U-value of the ground floor slab is only 1.951 W/m²K [7] that permits rapid transfer of heat from the superstructure and building envelope constructed above into the surrounding earth as compared to conventional solid reinforced concrete (RC) foundations and ground floor slabs [9, 13]. Secondly, this substitution presents a new lease of life for usable rubber tires which are dumped in large numbers every day because it is expensive to recycle [9, 12], relieving environmental pressures on existing garbage disposal systems. Thirdly, the overall construction cost was reduced significantly due to the reduction of Portland cement, steel reinforcements, aggregates, sand and water used during construction by as much as 18.1% of the cost of conventional RC construction [9]. Other components of the building fabric were also designed to further improve the intended function of the foundations and ground floor slab. For instance, the mass of the first floor suspended RC slab had been reduced significantly by being casted on arched and corrugated steel formwork that can be reused [9, 12, 14]. The end result was a multi-barrel-vaulted and ribbed slab that has less concrete and steel reinforcements as compared to conventional flat slabs of other Malaysian houses. This suspended floor slab has more surface area to absorb the surrounding heat and transfer it through the walls to the sub-structure [9, 14]. The rest of the superstructure was built according to conventional designs to carry the weight and transfer forces to the RC pad foundations. All walls were then built using autoclaved aerated concrete (AAC) blocks which were light and easy to cut and built [9]. Less mortar was needed to coat both internal and external walls surfaces as AAC block walls can be accurately built with less wastage [9]. On top of this, the U-value of AAC is only 1.091 W/m²K, severely restricting heat transfer from happening [7]. All glass fenestrations at Semenyih house were double glazed to keep
up with the adjacent walls [8]. Besides glazed openings, solid timber doors are also used. All fenestrations were protected from direct sunlight by deep eaves and overhangs. The dominant ventilated ‘Venturi’ roof that covers the house was built of clay tiles on galvanized aluminum roof trusses [7, 9, 12]. A 100mm layer of Rockwool insulation has also been added along with a layer of aluminum foil to reflect heat from coming through the roof [7]. In essence, all of the mentioned building components act as a unit to keep the heat out while dispersing any heat left in the building envelope to the surrounding earth efficiently and passively.

A: Mock-up cassettes of recycled tires  
B: Recycled tires used in the fence  

Fig. 2: Components of the Smart and Cool Home (SCH) system

**Building Operations.** Even without any active cooling devices, the internal temperature at ground floor level is a maximum of 7°C lower than the outside temperature of 35.9°C at 3.30 p.m. [7]. However, the building envelope retains some heat from daytime which is released at night resulting in an average indoor temperature of 26.5°C or 0.9°C warmer from outside [7]. Despite this, the large temperature difference during the day alone could not induce thermal comfort as there is no air movement and the air is still damp with a very high relative humidity (RH) of 80% [15, 16]. This is because the house is not fully sealed and there are leakages through gaps at doors. The gaps are actually essential at replenishing the spent air indoors with new supply of air from the outside. As mentioned earlier, all fenestrations are protected from direct sunlight and similarly the solid timber front door is protected by a deep porch. Hence, the supplied air is cooler than air around the house and this helps to reduce the cooling load on the house. In order to achieve a much higher air velocity indoors, ceiling and wall mounted fans are used when needed [8, 10].

No air-conditioning is installed and used at the house as the occupants are willing to show to the public that it can be comfortable to live in a house without air-conditioning [11, 12, 14]. Air-conditioning has become part of home buyers’ expectations in Malaysia. In order to fully utilize the potential of Semenyih house, the occupants also perform night ventilation to purge any warm and stale air inside the house while replenish it with fresh and cooler night air by opening a number of major windows and switching on an extractor fan at the highest point in the house [8, 9]. This daily routine helps to keep the day time indoor temperature low and the internal air clean and healthy. Almost all of the electricity demand in this house is catered by the building integrated photovoltaic (BIPV) panels fitted as part of the roof. This system is one of the first recipients of the SURIA 1000 government grant that funds showcase residential photovoltaic (PV) installations to promote this newly available technology in Malaysia [17]. Since the completion of the house, the PV system functions have been monitored closely by researchers from Universiti Teknologi Malaysia (UTM) and their reports showed that this system produces up to 339.49 kWh per month for 2009 [18] or about 91.75% of December 2009 electricity consumption [8].

**Other installed systems.** As part of the push to make this house energy efficient, energy efficient lights and appliances were installed and used by the occupants [11, 12, 14]. They also switch-off any unused appliances without leaving them on stand-by modes to reduce the consumption of electricity [8, 10]. A major feature in front of the house is the very large fish tank. Interestingly, this
tank was also constructed using the SCH system with walls of recycled tires rather than conventional bricks [11] keeping the water cool even during hot afternoons. The water is purely collected rainwater from the large roof [8]. No potable water from the municipal water supply system is pumped into the tank [8]. The surrounding garden is irrigated solely from this tank to reduce dependency on publicly supplied potable water. Any outdoor washing is also done using the same supply [10]. Unfortunately, no other water efficient fixtures were installed at the house except for the dual-flush toilet cisterns [8]. This is understandable as the availability of water-efficient fixtures was scarce during the construction of Semenyih house. Although supplies of such fixtures are better these days, there is still a lack of guidelines, standards and ratings for water fixtures unlike electrical appliances in Malaysia. This has to improve in order to significantly reduce the amount of treated water used daily from the wasteful 226 liters per person per day average [19]. However, this amount could be difficult to control due to the rapid population and urban area growth as water authorities throughout the country struggle to upgrade and expand existing infrastructures amid the exorbitantly high costs of upgrades. Another feature of the house that was constructed with recycled rubber tires is the boundary fence [9]. In order to enhance the thermal ambience around the house, creepers were planted in the earth-filled tires. The tires were also plastered for rigidity and safety. Effectively, the net vegetated area has increased beyond the original size of the land lot that the house sits on. However, more time is needed before the trees which were planted in the compound are matured.

Fig. 3: Components of the SCH system used at another project (Source: Lee, 2007)

Issues with Green Building Certification. This house is situated far from any public transport options and public amenities in a rural area with limited developments just beyond the 1km proximity radius as required by the “Green Building Index for Residential New Construction” (GBI-RNC) Malaysian green building certification scheme [20]. Despite the lack of acknowledgement through GBI-RNC because of the location, the building envelope is far superior to any other Malaysian houses. Lee has admitted during an interview in December 2009 that he has to travel far for work and it is far more practical to own and drive his own car to do so although he was aware that driving his car would increase his carbon footprint while polluting the air, contradicting the overarching living sustainably package that he was promoting [8]. In all fairness, green building certification systems should recognize more flexible standards for houses in different areas. This is to prevent any green homes built in less developed areas from suffering the same fate as Semenyih house when rated against schemes such as GBI-RNC. Semenyih house only scored a measly 46 points out of 100 and could not be certified as a green home by losing many points in the “Sustainable Site Planning and Management” (SM) indicator of GBI-RNC. SM is the largest indicator with a maximum of 39 points [20].
Summary

Nevertheless, the future of the SCH is bright as more and more projects are built using it although the prevalent underlying reason is to reduce construction costs. However, this could still be considered as a success despite early setbacks when convincing potential users of SCH was difficult
[8, 11]. Positively, the SCH is not the only solution to constructing houses in tropical Malaysia. Another party has developed strategies to induce thermal comfort in existing terrace houses by retrofitting building components. Meanwhile, a more radical approach has been to reverse the function of building envelopes in colder climates from keeping the heat in to keeping the heat out and seal the house while using active systems for ventilation. Above all, more research is needed to ascertain the effectiveness of all proposed and built systems including the SCH because only through studying them, their advantages can be highlighted and promoted in order to build more environmentally friendly houses for the masses.

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