Making Sustainable Impact with Existing Buildings

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Making Sustainable Impact with Existing Buildings

Mohd Hamdan AHMAD, PhD [1]; Danny Santoso MINTOROGO [2]; Pau Chung LENG [3]; Feryl Rezaee MOOD[3]

[1] Institute Sultan Iskandar of Urban Habitat and High-rise, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia

[2] Department of Architecture, Faculty of Planning & Engineering, Petra Christian University, Surabaya, Indonesia

[3] Department of Architecture, Faculty of Built Environment, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia

Corresponding Author's Email: b-hamdan@utm.my

Abstract- Sustainability in built environment is an important agenda. It is now no longer a healthy trend but an obligation to future generation. For new buildings, sustainable ideas can easily be addressed as early as in the design stage. Simulating the performance of buildings before construction has been proven contributing further to attaining best sustainable solution. However, for existing buildings, sustainability has to be carefully treaded as any upgrading made may have adverse impact to existing structures and envelopes of the buildings. The existing buildings present greater challenge to sustainability as their ratios are much higher than new buildings. This paper shares innovative and novel ideas on finding new materials within reach locally that can easily be applied without major changes to the existing buildings. All attempts are with specific interest on providing good thermal performance and human comfort of existing buildings thus reducing need for mechanical cooling with conscious effort towards energy saving, low carbon emission and mitigating UHI. Three different studies are discussed. Each tries to reduce indoor air temperature with its own novel solution but yet interestingly straightforward, friendly application and economical. It is hoped that they can show that caring for existing buildings is also matter to us as we seek comprehensive solution in achieving sustainable natural environment and built form.

Keyword: Sustainability, Existing Building, New Material, Thermal Performance, Local

I. INTRODUCTION

Sustainability in built environment is an important agenda worldwide. It is now no longer a trend but an obligation to the future generations. For new buildings, sustainable ideas can easily be addressed as early as in the design stage. Simulating the performance of buildings before construction has been proven contributing further to attaining best sustainable solution especially for new building constructions. However, for existing buildings, sustainability has to be carefully treaded as any upgrading made may have adverse impact to existing structures and envelopes of the buildings including the cost factor. The existing buildings present greater challenge to sustainable designers and policy makers as the ratios of existing buildings to new buildings are much higher. This paper shares innovative and novel ideas on finding additional features or new materials within reach within the local context that can easily be applied without major changes to main structures of the existing buildings.

The three innovative applications:

Three different studies are discussed. Each tries to reduce indoor air temperature with its own novel solution but yet interestingly straightforward, friendly application and rather economical. These three are part of the current work of PhD candidates in the Faculty of Built Environment, Universiti Teknologi Malaysia. They show different solutions but with similar intention of reducing energy used in existing buildings.

ATTEMPT 1: PAU CHUNG LENG - SOLAR CHIMNEY

A Computational Fluid Dynamic (CFD) simulation has been conducted to compare the thermal performance of an existing terrace house in Malaysia. The experiment was conducted in a 2 level basement cum 2-storey terraced house with solar chimney in Bayan Lepas, Penang, Malaysia. The house was designed with a shaft, without functioning as the solar chimney which is useful for stack ventilation. The existing shaft was served as the ventilation shaft for bathroom. The terrace house is located at the hill slope, which facing north-south direction. The bedroom is facing north. The simulation date was set at 21 February 2012 17:00 with air temperature 34°C, which marked as the hottest hour of the year. In this case, master bedroom was selected as the case study to verify the functionality of the solar chimney as the ventilation tool. The bedroom is equipped with full height glass louvers opening with 230mm double brick party wall and 150mm single brick thick wall as internal partition. The master bedroom is located at the ground level, with enclosed floor area of 28.03m². The modification of the shaft into the solar chimney would be carried out through CFD simulation and verifying the solar chimney as the stack ventilation tool. The input data for the CFD simulations including the problem type, flow domain (material, type of flows and so forth), boundary conditions (building components, inlet and outlet and wall), and calculation method. [1] The calculation in this case, used the standard k-e epsilon turbulent model with 5000 iterations. The external walls and solar chimney were covered with adiabatic wall to avoid external heat calculation taken part in the simulation.

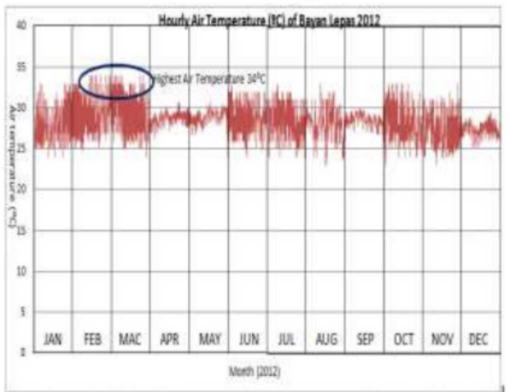

Figure 1: The overall hourly weather data (air temperature) of 2012 in Bayan Lepas, Penang. February and March stated as the month with most hottest day of the year 2012

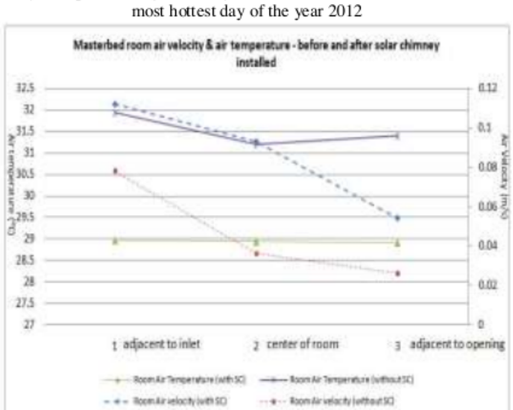

Figure 2: The graph shows the effect of solar chimney to the bedroom in term of air velocity and air temperature

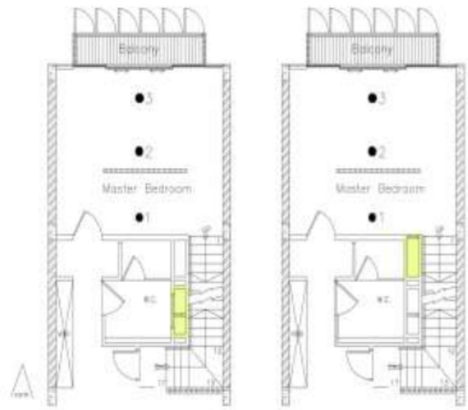

Figure 3: The black dots indicate the measuring point (1,2, & 3) of CFD simulation and the yellow shade indicates the location of solar chimney before and after modification has done.

The impact of the solar chimney as the natural ventilation tool that keep the internal building in ventilated and cool condition, could be influenced by various factors: the length and width of solar chimney, the outlet and inlet opening size, the material of the solar chimney, the window opening types and sizes of the room that connected to solar chimney and so forth. Thus, in modeling the geometry of solar chimney house, the measurement of the basic components does take into consideration and bound into the boundary condition set by simulation software. According to the results shown in figure 2, in overall the air velocity from external environment has increased from point 3 to 1 while the air temperature has decreased. This is due to the venturi effect, which increase the speed of the air from the huge opening towards smaller opening in the solar chimney. The opening of the window is set as 100% opening, with 100% wall to window ratio. The sizes of the inlet opening is 24 times smaller than the window opening, and thus the air speed pass through the bedroom from the window to the inlet and escape through the solar chimney is faster, compared to the existing room which not connected to solar chimney. The wind speed at point 3 to point 1, recorded as 0.054m/s and 0.112m/s respectively has shown the 48% of wind speed improvement, which is 0.058m/s differences. In term of air temperature, from point 3 to point 1, the air temperature has increased slightly from 28.91ºC to 28.96ºC, which is 0.19% of insignificant increase.

Compared to the existing room which is not connected to solar chimney or considered as single sided ventilated room, the air velocity from point 3 to point 1 only shows 33% increase, which is 15% lower than the room with solar chimney inlet. For the temperature aspect, the room without solar chimney posses high air temperature, which is 2.25ºC or 7.7% higher than the room with solar chimney inlet. The increase of the air speed could reduce the air temperature which increase the comfort level of the indoor environment. In figure 4, the effectiveness of the solar chimney in giving the thermal comfort for the indoor environment could be predicted by Predicted mean vote (PMV) indicator. For the master bedroom with solar chimney inlet, the predicted mean vote of the 3 points giving the satisfactory range, which are +0.48 to +0.53 while the room without solar chimney inlet shows the PMV range between +1.7 and +1.8. The effective range of wind speed which gives the positive and acceptable PMV range is 0.11m/s and above. The optimum room depth in respond to solar chimney geometry could be developed in order to obtain the better comfort range of indoor environment.

In this case study, solar chimney has proved that the thermal comfort of the indoor environment, especially the existing terraced housing in Malaysia could be improved without major changes. The long hour of solar radiation and high outdoor temperature enabled the solar chimney to function well, which could increase the performance of the ventilation in building during the hot afternoon and evening hour. The PMV evaluation shows that the natural ventilation performances could be enhanced by modified the existing terraced housing with the solar chimney. Further research needed in order to determine the best air temperature and wind speed for thermal comfort with optimum room depth and solar chimney geometry in hot and humid tropical climates.

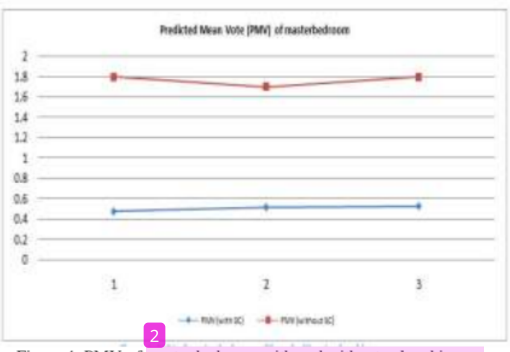

Figure 4: PMV of master bedroom with and without solar chimney

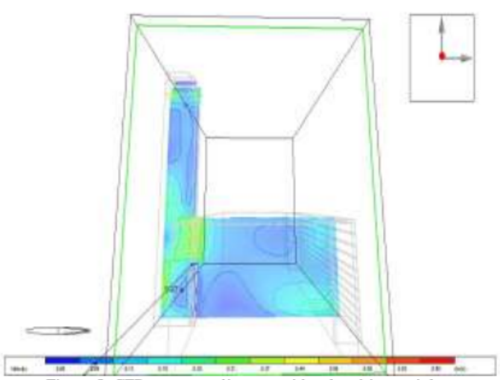

Figure 5: CFD countour diagram with solar chimney inlet

ATTEMPT 2: DANNY SANTOSO MINTOROGO - PAKIS BLOCK

Surabaya with latitude of 7º 17-21' South, on year 1995 till now, a lots of business places are needed to develop. Middle-class businessmen or presenting business firms can't afford to rent office spaces on high-rise buildings. Therefore, single-houses, town-houses, shop-houses, and even dwellings along the main roads become favorite places for business. The Surabaya's city exhibits a lot of new towns, shops, and office-houses built to two or three stories with majority of flat concrete rooftops of around 12,400 m2 at Manyar Kertoarjo's business-zone (C), Putro Agung's zone of 5,900 m2 (A), Klampis Jaya CBD of 31,00 m2 (B) as well Galaxy's Shop houses of 24,000 m2. All of these flat bare concrete rooftops are not insulated on top or beneath the concrete roof deck. Less greenery rooftops and high trees are planted along the business zones. Concrete-block paving's are dominantly covered for walk-ways, and street-ways are built up of dark-asphalt. Could we imagine how much watt per square meters of out-going solar heat irradiance from those materials will bounce back to the built-up areas, and how much air temperature of thermal conduction, convection and irradiation will add up to the urban-business heat island?

By applying rows of pieces of Pakis blocks over the flat bare concrete rooftops mainly as external environmental friendly roof-thermal insulation, the reflected solar heat irradiation to build- environment will be controlled. Pakis blocks will absorb much of those heat solar irradiation to prevent too much reflected heat to the environment.

What are the pakis-stem blocks? Generally, knowledge of pakis-stem blocks are commonly sold by orchid flower shoppers, and flower users always attach the orchid on top of Pakis blocks. These Pakis blocks come from Pakis trees which could be found in the tropical forest; the Pakis tree's stems are then sliced into pieces of Pakis blocks (figure 6).

Figure 6. Pakis Trees, Pakis-Stem Blocks, and Orchid on Pakis Block (Source: Mintorogo, 2012)

Pakis Blocks in the market are sold in different sizes as shown in A & B (figure 7). Pakis Blocks small size (7A) in 1 m2 will have 33.3 blocks and weights 5.2 kgs for dry pakis blocks; in wet condition, small size pakis blocks in 1 square meter have weight of 7.3 kgs. Meanwhile for big size pakis (figure 7B), 1 square meter will be contain 20.83 blocks, and the weight = 5.2 kgs (dry condition), and 7.4 kgs (wet condition).

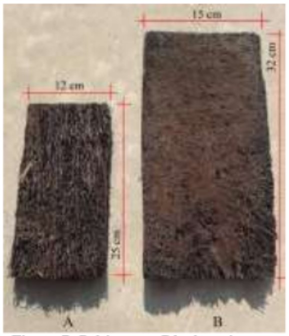

Figure 7. Pakis-stem-Block variances

The research is a field experiment which has been conducted at Petra Christian University's flat concrete rooftop. The global solar irradiation data were recorded hourly and were taken at least 2 to 3 days or more respectively and simultaneously on rooftops with digital data logger and pyranometer of HOBO.

Three unit of pyranometers are used to have a figure of global solar irradiance intensity; one unit is measured for the horizontal global solar irradiation, and two unit pyranometer are turned over to measure the reflected global solar irradiation (albedo) from different materials like grey rooftop concrete, stopsol classic dark blue glass, grey paving blocks, wooden blocks, lawn, soil, yumen board and white pakis blocks; meanwhile one flipped pyranometer is continuously placed on site to measure the brown pakis blocks respectively. In order to know the temperature and emission of longwave heat energy from brown Pakis blocks and white Pakis blocks (lighter color cooler surface)(figure 8).

The reflected global solar irradiation measurements were taken to compare to brown pakis blocks with other materials respectively; each measurement with different material to brown pakis blocks was measured between two to three days period. The major measurement on this research is to know how much the white pakis blocks reflect outgoing global solar irradiation to the space environment than the brown pakis blocks.

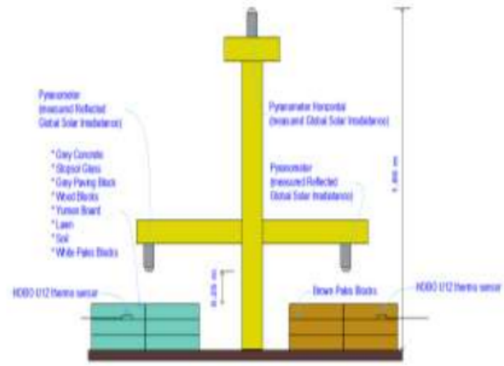
Figure 8.Ways of measuring Reflected Global Solar Irradiation and Longwave heat energy

The white pakis blocks could not only handle well the incoming solar irradiation but it also lessens the outgoing longwave solar irradiance by emitting much irradiation to atmosphere and performing as insulator to the flat concrete rooftop. The research is concentrated on the ability of brown Pakis-stem blocks to reflect less outgoing solar irradiation to space, to absorband and to emit as much possible of longwave heat solar irradiation. The results of brown Pakis-stem blocks have proven to reflect as low as 18.2 to 23.8 W.m-2 of outgoing global solar irradiance to atmosphere. The highest temperature of one piece brown Pakis blocks hold is around 46.9ºC with compare to 45.6ºC at white Pakis blocks.

The contribution of brown Pakis blocks to lessen an over-heated environment is as solar irradiation controller and as solar irradiation container. [2-11]

ATTEMPT 3: FERYAL– MSWI-BA RECYCLING PLASTERING

Malaysian buildings - especially existing buildings - need more feasible thermal insulation methods to reduce energy dissipation. Utilizing Municipal Solid Waste Incinerator – Bottom Ash (MSWI-BA) to produce a thermal insulator coating, appropriate for warm and humid climate is another novel attempt. The required BA was collected from town of Langkawi federal incinerator plant, while the waste composition of this island was studied to find out its composition. Later the mixture was undertaken and tested in the laboratory to identify the new material properties (figure 9).

Figure 9: .Materials and equipment to test the new material from Bottom Ash (MSWI-BA)

Furthermore, two test chambers were design and constructed on chosen site to test the application of the material as coating on building walls as shown in figure 10

Figure 10. Designed test chamber to test on the coating material

The most effective orientation of the wall should face the warming indoor environment or toward west. In principal, the two chambers, one as the testing room and another as the controller, were constructed in UTM Campus whereas three walls, roof, and floor have been insulated and the forth wall has been made by regular bricks in the west orientation. The temperature and moisture inside the designed chamber applied with new coating were monitored and compared with the reference chamber applied with regular coating, by utilizing these data, energy consumption to achieve the comfort zone has been calculated and analyzed. The results showed that by applying new component on the west walls in Malaysia climate, the waste of energy would decrease by minimum of 12%.

CONCLUSION

The three attempts above were academic and experimental in nature. However, they are very easily applied in real situation as part of caring for the existing buildings. Attempt by Pau Chung Leng requires the simulated solar chimney to be constructed to replace the existing bathroom shaft. We will need to monitor the effectiveness on site whether it will have great impact providing good natural ventilation and reducing indoor air temperature. Attempts by Danny and Feryal were about using natural and recycled materials respectively. However, since they both are thinking of patenting their product only part of the research can be made available. Most importantly the three attempts are part of current thinking towards caring for existing building. It is hoped that they can show that caring for existing buildings is also matter to us as we seek comprehensive solution in achieving sustainable natural environment and built form.

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