論 文 の 内 容 の 要 旨

論文題目　　A Framework Toward Better Specification of the Building Envelope　Characteristics with Respecting Cooling Demands

（冷房負荷を中心とした外皮性能の特性評価の改善に向けたフレームワーク）

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Energy conservation in buildings is deemed to be one of the most critical issues of this century. This issue is driven by the global concerns regarding the energy resources depletion, global warming, climate changes and Co2 warnings. In this regards, the energy surveys agree that a big portion of the world's energy is exhausted in buildings where the major part goes to supply the cooling and heating demands. The need for cooling is increasing and became a need even in cold climates because of many factors, whereas the most critical factors are the climate warm up, the Urban Heat Island effect (UHI) and the people migration to these energy-insatiable cities. Moreover, since new buildings are built to be tighter, they result in trapping more of the internal heat, which in turns requires further cooling loads. One of the countermeasures to reduce such growing cooling needs is to optimise and have more environmentally conscious building envelopes. Unfortunately, the current trends that dictate the envelope properties seemed to neglect such rising needs for cooling. For example, the energy-oriented standards and legislations are prescribing the buildings envelope in a static manner (steady state), which is not a realistic perception and leads to an incorrect understanding of the envelope dynamic characteristics. These limited perceptions are reflected on disregarding the high potentials behind utilising the thermal mass materials as to provide passive and energy saving buildings. In this research, the point that is seen to be the most critical is that the current building codes are encouraging designers to comprise very thick insulations with minor attention to the local climatic cooling needs and without considering possible drawbacks like the overheating risks and the "anti-insulation" behaviours. Not to forget, it is not seen anywhere that codes pay attention to the constructions layer arrangements (layer configurations), although

they are well addressed in the literature and have been proven to have profound effects on reducing the cooling and heating demands alike. For these reasons, this study aimed to provide a framework that stimulates and rethink the current trends of how the building envelopes are being prescribed in codes. In a wider perspective, the proposed framework comprises three key issues that are rarely hinted in literature and can be listed as in the following.

Firstly, the framework is centred in proving means of mitigating the anticipated propagation of anti-insulation negative behaviour. In this regards, it was hypothesised that altering the layer configuration will enable designers to reduce the anti-insulation effects. This issue was addressed in chapter 3 and 4 and had the majority of the research efforts. Thousands of environmental cases that covers 13 climatic conditions and four occupancy schedules have been simulated using the EnergyPlus software. The simulation results have proved that anti-insulation could be mitigated by altering the envelopes layer configurations, whereas a particular layer arrangement - which is subjected to the occupancy profile- would enable damping the anti-insulation effect. Also, and against what most people think, it was revealed that Mild climates are more prone to anti-insulation as when compared to Hot climates. In conclusion, it was demonstrated that the anti-insulation behaviour needs be integrated into the insulation optimisation, as well to be considered when prescribing the building envelope characteristics.

The second issue that the research has tackled is revolving around providing a practical solution to compose the finite thermal mass layers. For this part, it was proposed that the thin rubber layers can compensate the need for the conventional thermal mass materials, like the brick and the concrete. The initial surveys showed that the rubber has a great heat capacity while being very elastic at the same time. These physical and thermophysical properties of the rubber make it an excellent candidate to eliminate the thickness, mobility and acoustic problems that are typically associated with the conventional thermal mass materials. The Piltier device was sued to examine the rubber under a sinusoidal thermal fluctuation conditions, whereas the experiment is focused on testing the rubber efficiency in providing competent delays to the heat wave (time lag). The results have shown that the rubber could provide a time delay of more than eight hours for a wall of 11cm that have a 4 cm of rubber and 7cm of insulation material. Moreover, the experiment has supported that the layer’s segmentation (the number of layers) have a profound effect on the resultant time lag and the decrement factor of the construction.

Lastly, the research delved into investigating the facial properties of the envelope, whereas the solar paints application was experimented in two stages. In this part, the solar paint effect, the paint colour and glossiness and the presence of the paint sealer are all considered in the investigation. The overall findings, from both experiments, it was found that the factors mentioned above are interactive whereas one factor may change the other performance. For instance, it was discovered that the black solar paint may perform better than the grey paint if applied on non-transparent sealer base, and its performance dramatically degrades if directly applied to the concrete surface. On the other hand, the white solar paints performance has shown to be unaffected by the sealer application. In summary, it is to state that solar paints have shown excellent abilities as a heat mitigation measures, as they have contributed to mostly keep the painted tiles below the tiles with conventional paints. When bearing in mind that such heat mitigation strategy is entirely passive and is easy to apply, then it is recommended that it should be prescribed as part of the envelope description. This technique is particularly important in the cooling dominant climates'. For the mild climates, the winter heating penalties are to be considered, despite that in both experiments, there was no significant risk of such drawbacks, since the paint have only contributed to dampening the maximum temperature, and did not extend to lower the daily minimum temperatures.

Ultimately, the findings from all the investigations have been compiled to provide a framework that local legislation bodies can utilise to provide a better envelope specification for the sake of conserving the energy being drained in cooling the buildings.