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Integrated Passive Cooling Systems for Tropical Residential Buildings: A Review through the Lens of Latent Heat Assessment

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Abstract : Residential buildings are responsible for 22% of the global end-use energy demand and 17% of global CO_2 emissions. Tropical climates particularly present higher latent heat gains, leading to more cooling loads. However, the cooling processes are all based on conventional mechanical air conditioning systems which are energy and carbon intensive technologies. Passive cooling systems have in the past been considered as alternative technologies for minimizing energy consumption in buildings. Nevertheless, replacing mechanical cooling systems with passive ones will require a careful assessment of the passive cooling system heat transfer to determine if suitable to outperform their conventional counterparts. This is because internal heat gains, indoor-outdoor heat transfer, and heat transfer through envelope affects the performance of passive cooling systems. While many studies have investigated sensible heat transfer in passive cooling systems, not many studies have focused on their latent heat transfer capabilities. Furthermore, combining heat prevention, heat modulation and heat dissipation to passively cool indoor spaces in the tropical climates is critical to achieve thermal comfort. Since passive cooling systems use only one of these three approaches at a time, integrating more than one passive cooling system for effective indoor latent heat removal while still saving energy is studied. This study is a systematic review of recently published peer review journals on integrated passive cooling systems for tropical residential buildings. The missing links in the experimental and numerical studies with regards to latent heat reduction interventions are presented. Energy simulation studies of integrated passive cooling systems in tropical residential buildings are also discussed. The review has shown that comfortable indoor environment is attainable when two or more passive cooling systems are integrated in tropical residential buildings. Improvement occurs in the heat transfer rate and cooling performance of the passive cooling systems when thermal energy storage systems like phase change materials are included. Integrating passive cooling systems in tropical residential buildings can reduce energy consumption by 6-87% while achieving up to 17.55% reduction in indoor heat flux. The review has highlighted a lack of numerical studies regarding passive cooling system performance in tropical savannah climates. In addition, detailed studies are required to establish suitable latent heat transfer rate in passive cooling ventilation devices under this climate category. This should be considered in subsequent studies. The conclusions and outcomes of this study will help researchers understand the overall energy performance of integrated passive cooling systems in tropical climates and help them identify and design suitable climate specific options for residential buildings.

Keywords : energy savings, latent heat, passive cooling systems, residential buildings, tropical residential buildings
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