INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
PhD-17 SHORT ABSTRACT OF THESIS

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Thesis Title: Development of novel bio-composite phase change material for passive design interventions in rural households for thermal management

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SHORT ABSTRACT

The continuously increasing demand for high-quality energy for space cooling, coupled with the associated environmental emissions, necessitates the development and adoption of alternative and sustainable solutions. The present study focuses on developing an affordable material for building envelopes to passively reduce the energy demand for space cooling in hot and humid climates. Porous biochar for providing shape stability to organic PCM (OM35) has been systematically explored by using three abundant biomasses. Sugarcane bagasse (SCB), water hyacinth (WH), yellow oleander (YO), and their binary and ternary blends have been pyrolyzed at a temperature of 550°C to produce biochar. The biochar has been mixed with OM35 through simple impregnation method for the preparation of seven different form-stable biocomposite PCMs. In addition to exhibiting substantially enhanced leakage resistance relative to pure OM35, the WH-PCM demonstrates a marked improvement in thermal transport properties, with its thermal conductivity increased by 50.5 %. A controlled study in a developed thermal chamber demonstrates that the WH-PCM-impregnated brick achieves a maximum temperature difference of 7.98°C across its thickness compared to an identical red clay brick. Following the preliminary results, a (1m × 1m) wall section has been constructed using clay bricks incorporated with WH-PCM. The optimum results in terms of reduction in inside wall temperature and heat flux are found in the west direction when the WH-PCM layer is applied in the middle of the wall thickness. The maximum peak temperature reduction is found to be 4.66°C compared to the control wall, and the average reduction in daily heat flux is found to be 76%. WH-PCM-enhanced walls are beneficial in reducing the overall room temperature during peak summer hours, with a maximum temperature difference of 6°C compared to a reference room of identical dimensions. Based on directional analysis, the application of WH-PCM is recommended for the west and south walls for that particular climate.Techno-economic results showed that with WH-PCM integration, the annual cooling energy load has decreased by 31.5%. PCM intervention in walls results in an approximate 30% reduction in global warming potential. The present study provides a comprehensive analysis and techno-economic comparison, offering critical insights into the optimal preparation of biochar-based PCMs and their cost-effective application in rural housing, as well as the most effective placement and orientation of PCM layers within brick walls to achieve indoor temperature reduction in hot and humid climates.