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Editorial: New Materials and Design of the Building Enclosure

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Editorial on the Research Topic

New Materials and Design of the Building Enclosure

Buildings account for about 40% of the global energy consumption and contribute over 30% of the global CO_2 emissions, and a large proportion of this energy is used for thermal comfort (Yang et al., 2014). Improvements in the materials and design of the building enclosure including both opaque regions and windows are contributing to the reduction in energy use. The improvements typically pertain to reduced heat transfer and air and water vapor infiltration across the building enclosure. Unintended heat gains and losses through the building enclosure (thermal bridges) need to be identified and eliminated. These defects result in uncomfortable conditions for occupants and wasted energy. Thermal insulation, thermal mass, moisture management and controlled ventilation (air tightness) have been used successfully in the past to control utility loads. New and emerging technologies that control radiative transport, alter heat-flow characteristics, or apply optimized control of the interior environment (smart systems) with attention to indoor air quality are being developed to improve building energy performance.

This special issue on advanced materials and design of the building enclosure contains submissions on advances in building materials, design and construction. Six original research articles were selected for publication. The article topics span from novel and advanced materials such as vacuum insulation, phase change materials (PCMs), thermoelectric materials, and natural fiber-based composites for affordable housing to studies of energy performance and moisture durability of cool roofs.

PCMs have been applied to building envelopes to utilize their latent heats of melting and freezing to enhance the thermal performance and comfort conditions in buildings. Sun et al. presents a case study of salt hydrate PCMs in test houses under a range of weather conditions. The study showed the ability of PCMs to reduce energy consumption and improve interior conditions. The study also discussed the need for appropriate selection of PCMs and design of test walls to maximize benefits.

Chan et al. presents evaluation of long-term field performance of vacuum insulation panels (VIPs) applied to an exterior concrete wall of a building. VIPs contain an evacuated porous core material that is encapsulated within barrier films. The internal vacuum and incorporation of radiation suppressers allow VIPs to achieve very low apparent thermal conductivity, typically 10-20% of traditional foam and fibrous insulation materials. This research represents the continuation of a multi-year study to develop a better understanding of the long-term field performance of glass fiber core VIPs.

Brose et al. evaluates natural fiber composites for affordable housing projects located in India and Nepal with the goal of addressing issues of thermal comfort and lateral loading from seismic activity. The study used coconut husk fiber, rattan, and pine wood fibers as well as Portland cement, fly ash, and hydrated lime in the fabrication of fiber cement composite samples. Thermal performance and flexural strength characterization as well as energy simulations showed the

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potential of the fiber composites in reducing heating and cooling loads in houses and applications as wall cladding to reduce out-of-plane failure during seismic events.

Aksamija et al. presents the concept of an active exterior enclosure. Thermoelectric (TE) materials have the ability to produce a temperature gradient when electricity is applied or generate a voltage when exposed to a temperature gradient. Thus, TEs can be used for heating, cooling, or electricity generation. In this study two prototype facades were constructed, one with TE modules as stand-alone elements and another integrating TE modules and heat sinks. Both prototypes were tested for heating and cooling potential. The results indicated that while stand-alone facade-integrated TE modules were unstable, addition of heat sinks significantly improved their performance and can allow them to operate in heating and cooling modes under varying exterior environmental conditions.

Saber et al. and Saber and Maref are companion, two-part studies that were focused on the thermal performance and durability aspects of cool or white roofs under hot and humid climatic conditions in Saudi Arabia. Cool/white roofs use coatings and membranes with high solar reflectivity to lower the roof surface temperatures in comparison to conventional black roofs and, consequently, reduce cooling energy consumption. However, there is also the potential for greater moisture accumulation in white roofs that might result in damage to the roof. The first study evaluated the risk of condensation and mold growth as well as the energy performance of insulated white and black roofs in Saudi climates. The study evaluated a wide range of insulation thicknesses and solar reflectance values. The results indicated that while white roofs did show greater moisture accumulation than black roofs, both white and black roofs remained below the critical relative humidity above which condensation and mold growth might occur. From an energy performance perspective, the white roofs caused an increase in heating load compared to black roofs. However, in the Saudi climate, the cooling load reduction with white roofs outweighed the heating penalty and, therefore, were recommended for both new buildings and to upgrade the roofs of old buildings. The second study further assessed the energy performance of white and black roofs with different combinations of thermal insulation thickness and solar reflectance values. Further, the results were used to develop a practical design tool for use by building engineers and architects for determining appropriately reduced insulation thickness and solar reflectivity of white roofs that can provide the same energy performance as black roofs with thicker insulation. The results of these studies and the design tool can be used in the future to upgrade the Saudi building code to include white roofs with recommended insulation thicknesses.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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