Researchers: Energy-efficient construction materials work better in colder climates

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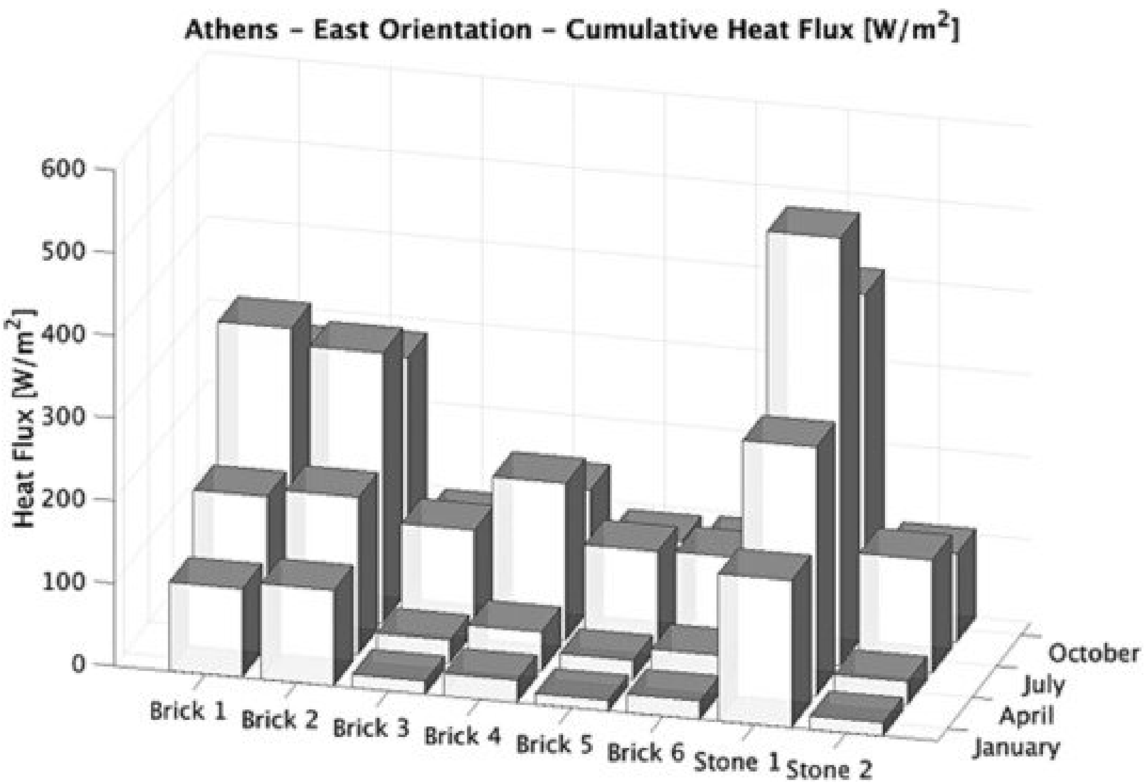

Credit: *Construction and Building Materials* (2022). DOI: 10.1016/j.conbuildmat.2022.129984

Researchers from Lithuania and Cyprus claim that the energy payback period of using phase change materials, new technology in the construction industry, is the shortest in a colder climate. The optimal location for their usage is the interior on the northern side of the building. The study provides informed answers regarding the application of PCMs to improve buildings' energy efficiency.

In recent years, phase change materials (PCMs) used to improve the energy efficiency of buildings are gaining momentum. PCMs can store and release large amounts of energy—when in a solid phase, they can absorb heat, providing a cooling effect and when a PCM is in its liquid phase it can release heat, providing a warming effect.

"The ice melting to water is a phase change material, as is butter melting to oil. Why is it special? When material changes phase, it also absorbs and releases energy. In construction, these materials are encapsulated, i.e. the micro PCM capsules are integrated into a building element, such as concrete," explains Paris Fokaides, a principal investigator at Kaunas University of Technology (KTU), Lithuania.

Together with colleagues from Frederick University in Cyprus, KTU researchers were conducting a study in different European regions aiming to calculate the efficiency of the application of PCMs for the energy upgrade of the existing buildings. Their research revealed that the efficiency and energy payback period of PCM depends on certain conditions, such as the geographical location and the wall orientation of the building.

"The thermal performance assessment of existing buildings is highly valuable information, which can be useful when making renovation decisions," says Eglė Klumbytė, a researcher at KTU Faculty of Civil Engineering and Architecture, a co-author of the study.

According to her, it is important to understand how and where to use the appropriate materials for maximum efficiency.

In cold climates, the investments pay off in less than a

year

The work examines the application of PCM coatings in diverse meteorological conditions in Europe, for all major buildings' orientations. In total, 16 numerical simulations were carried out for the four calendar months of January, April, July and October and for three latitudes of Athens, Milan and Copenhagen.

"We wanted our research results to be globally applicable, that's why we chose the locations with typical climatic conditions in Southern, Central and Northern Europe," says Fokaides.

The first 8 numerical simulations were performed with phase change material integrated into the building element structure and the other 8 simulations—in the absence of PCM. The PCM thickness incorporated was 4 cm. The annual energy saving was calculated for four typical months, representing the four seasons of the year (winter, spring, summer, and autumn).

"One of the main study outcomes highlighted the fact that PCM performed better under cold conditions," says Klumbytė.

According to the researchers, this makes perfect sense—firstly, in colder conditions, PCM absorbs more energy, and secondly, since in colder climates the buildings use more energy (electricity, heating, etc.) the energy saving in these conditions is more efficient.

"In the study, we have developed the energy payback period concept, which means the balance between the energy used to produce these materials and gained while using them. Energy payback period indicates how long it will take for the energy that is saved in the PCMs to eliminate the energy costs of their production," explains Fokaides.

The study revealed that PCM implementation can contribute to energy savings in certain cases, varying from 0.24 up to 29,84 kWh/m2a and energy payback periods from less than a year to almost 20 years. The longest energy payback period was calculated in warmer climates, and the shortest—in colder locations. The optimal orientation for placing PCMs is west and east in Athens, east and north in Milan, and north in Copenhagen. Also, PCMs work best when they are integrated into interior structures.

Researched topics never discussed before

"The developed numerical model demonstrates the ability to carry out a thermal assessment under diverse conditions with accurate results. The main goal of the European Union is sustainable environmental development. Our study can greatly contribute towards achieving this goal," Klumbytė is convinced.

According to Fokaides, the above-described study is researching topics that have not been discussed in scientific literature before. The optimal location of the phase change material in the building, its optimal orientation and the energy payback period are entirely new concepts in the broad theme of the energy performance of the built environment.

"However, being a Greek, I cannot overlook the fact that the first description of an eco-friendly building was written by Socrates 2.5 thousand years ago. Back then, he indicated that the northern wall of a building needs to be thicker compared to the southern, thus our idea that wall orientation is crucial when considering its structural composition is related to that of Socrates," says a KTU researcher.

The KTU researchers claim that the methodology and dataset provided in this work can be used for further development of the buildings' thermal assessment tools. Currently, the team is starting a new research project, which will focus on the digitalization of the findings. This could include developing smart sensors to measure building elements' thermal performance in real-time and other aspects. According to scientists, this topic has vast potential for commercialization.

The work is published in the journal *Construction and Building Materials*.

More information: Loucas Georgiou et al, Numerical and environmental analysis of post constructive application of PCM coatings for the improvement of the energy performance of building structures, *Construction and Building Materials* (2022). DOI: 10.1016/j.conbuildmat.2022.129984

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