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Simulation and Thermal Evaluation of Containers Using PCM in Different Weather Conditions of Chile: Energy Savings in Lightweight Constructions

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Abstract : Climate control represents an important issue when referring to energy consumption of buildings and associated expenses, both in installation or operation periods. The climate control of a building relies on several factors. Among them, localization, orientation, architectural elements, sources of energy used, are considered. In order to study the thermal behaviour of a building set up, the present study proposes the use of energy simulation program Energy Plus. In recent years, energy simulation programs have become important tools for evaluation of thermal/energy performance of buildings and facilities. Besides, the need to find new forms of passive conditioning in buildings for energy saving is a critical component. The use of phase change materials (PCMs) for heat storage applications has grown in importance due to its high efficiency. Therefore, the climatic conditions of Northern Chile: high solar radiation and extreme temperature fluctuations ranging from -10°C to 30°C (Calama city), low index of cloudy days during the year are appropriate to take advantage of solar energy and use passive systems in buildings. Also, the extensive mining activities in northern Chile encourage the use of large numbers of containers to harbour workers during shifts. These containers are constructed with lightweight construction systems, requiring heating during night and cooling during day, increasing the HVAC electricity consumption. The use of PCM can improve thermal comfort and reduce the energy consumption. The objective of this study was to evaluate the thermal and energy performance of containers of 2.5×2.5×2.5 m3, located in four cities of Chile: Antofagasta, Calama, Santiago, and Concepción. Lightweight envelopes, typically used in these building prototypes, were evaluated considering a container without PCM inclusion as the reference building and another container with PCM-enhanced envelopes as a test case, both of which have a door and a window in the same wall, orientated in two directions: North and South. To see the thermal response of these containers in different seasons, the simulations were performed considering a period of one year. The results show that higher energy savings for the four cities studied are obtained when the distribution of door and window in the container is in the north direction because of higher solar radiation incidence. The comparison of HVAC consumption and energy savings in % for north direction of door and window are summarised. Simulation results show that in the city of Antofagasta 47% of heating energy could be saved and in the cities of Calama and Concepción the biggest savings in terms of cooling could be achieved since PCM reduces almost all the cooling demand. Currently, based on simulation results, four containers have been constructed and sized with the same structural characteristics carried out in simulations, that are, containers with/without PCM, with door and window in one wall. Two of these containers will be placed in Antofagasta and two containers in a copper mine near to Calama, all of them will be monitored for a period of one year. The simulation results will be validated with experimental measurements and will be reported in the future.

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