Energy storage for load shifting cairo

One of these actions is to decrease the cooling load to reduce the energy consumed for air conditioning unit. The construction of the building envelope is critical in influencing the building"s thermal performance and energy consumption, where the building envelope acts as a barrier to external influences such as periodic changes in ambient temperature and the solar irradiance on external walls. To help achieve the objective of lowering energy usage in buildings, several new technologies are developed. Some of these technologies are concerned with thermal insulation in building envelopes [3]. Another technique is the use of thermal energy storage materials. Thermal energy storage systems are divided into two types: sensible heat storage and latent heat storage.

Several research papers have adopted the increase in the envelope thermal resistance as a strategy to reduce the cooling load, and consequently the building energy use. Baetens et al. [5] found that the energy usage decreased as an effect of integrating gas-filled panels in buildings. In other studies, Vacuum insulation panels (VIPs) have shown a high-performance as thermal insulation for construction applications [4, 20, 34]. Also, Aerogels are applied as thermal insulation [4, 19].

Another approach is to implement a material to add a storage effect to the thermal resistance effect. Phase change materials "PCMs", work on the premise of thermal energy storage via latent heat. It has a great energy density storage at a range around the melting point [11]. PCMs undergo a phase transition at a nearly constant temperature from solid to liquid during this period (charging), it absorbs high thermal energy. This stored energy is released back during solidification (discharging). They appear to be reducing cooling energy usage and peak cooling loads, as well as deferring peak loads to later hours [7, 17, 28, 40].

However, as mentioned before it is critical to choose the right PCM type based on the wall orientation where the solar radiation changes on each wall orientation. A study aimed to investigate the effect of PCM on cooling load reduction by implementing a PCM layer into different wall orientations, the results show that a certain PCM cannot be chosen as the best choice without specifying the wall orientation first, for a given climate, we can choose the proper PCM only after comparing the performances of the PCMs in all relevant orientations [30].

Depending on the literature review, the current research fills the gap in two areas. First, the optimum PCM is highly dependent on the environmental conditions (solar irradiance and ambient temperature). This research considered a validated model for solar irradiance and acceptable distribution for ambient temperature in Cairo, Egypt. Also, the typical wall construction was used as a base wall. Therefore, the results are tangible to the application in Cairo and similar cities. Second, this study considered the real dependence of specific heat on temperature as obtained from differential scanning calorimetry (DSC). The results of this research could be used to validate any approximation of the specific heat.

The effect of adding a PCM layer to a typical wall used in construction in Cairo, Egypt, is studied numerically. Several walls having a PCM layer at different position inside the wall were studied. A MATLAB code is used to solve the heat diffusion equation through several layers of construction material under real conditions representing the Summer and Winter design day in Cairo.

The following assumptions were considered in the mathematical model:

Conduction heat transfer is assumed to be unidimensional.

For each wall material, the thermo-physical properties are assumed to be constant except for the phase change materials layer, since their properties depend on the liquid and solid phases, as well as the temperature.

To analyze the contribution efficiency of the PCM layer by the comparison, two walls were built as shown in Fig. 1. One was the base wall, while others were the wall with a PCM layer.

Wall composition. a Base wall. b Inner PCM wall. c Middle PCM wall. d Outer PCM wall

Three different scenarios of integration of PCM to the base wall were considered: