Pavement Functional Design and Management
PFDM 2023
27 - 29 April 2023, Guimarães, Portugal

Review on the Incorporation of Phase Change Materials (PCM) into asphalt mixtures to mitigate Urban Heat Island

Claver Pinheiro[1], Nathalia Hammes[2], Orlando Lima Jr.[3], Salmon Landi Jr.[4], Elisabete Freitas[5], Manuel Filipe Costa[6], Natália Homem[7], Iran Rocha Segundo[8], Joaquim Carneiro[9]
[1]clavergiovanni@gmail.com, University of Minho, Portugal
[2]nathi_hammes@hotmail.com, University of Minho, Portugal
[3]orlandojunior.jr@hotmail.com, University of Minho, Portugal
[4]salmon.landi@ifgoiano.edu.br, Federal Institute Goiano, Brasil
[5]efreitas@civil.uminho.pt, University of Minho, Portugal
[6]mfcosta@fisica.uminho.pt, University of Minho, Portugal
[7]natalia.homem@dtx-colab.pt, University of Minho, Portugal
[8]iran@civil.uminho.pt, University of Minho, Portugal
[9]carneiro@fisica.uminho.pt, University of Minho, Portugal

Serious environmental problems are attributed to the uncontrolled growth of cities. Usually, highly populated areas suffer from soil sealing caused by the construction of infrastructure, such as road pavements and buildings. Regarding the Transportation Engineering, the most common material applied in road pavements is bitumen as binder constituent. Usually dark-coloured, the surface temperature of asphalt pavements may reach values higher than 60 °C during summer. This fact can significantly contribute to the formation of thermal cracks and deformations in asphalt binders and, in large urban centres, promote the formation of warmer microclimates since all the accumulated heat is released to the surrounding environment. The formation of Urban Heat Islands (UHI), a type of microclimate that arises from the increase in temperature of a location that does not match the region, caused by anthropic changes, for some time now, is a problem that has attracted a range of research to minimise harmful effects caused to the environment. Some of the most promising studies to decrease the temperature of pavements are using Phase Change Materials (PCM). PCM are materials that can accumulate a large amount of thermal energy and are widely used in the textile industry, smart tissues, and construction, improving thermal comfort. PCM can minimise the problems arising from seasonal temperature variations when used in conjunction with asphalt materials. In this work, a review was made about which types of PCM are mainly used to achieve a significant decrease in pavement temperature—evaluating the material's thermal performance and the most used strategies to avoid its leakage. A systematic review of recent papers published in peer-reviewed journals (available in the Scopus database) involving asphalt mixtures with phase change materials revealed that the most used type of PCM is polyethylene glycol (PEG). Asphalt mixtures containing PCM generally have lower mechanical performance than conventional asphalt mixtures. There are problems related to leaking the material into the asphalt, sometimes reaching the soil and possibly causing contamination. On average, the temperature values decrease 4 °C, in some cases reaching 9 °C of difference, compared to conventional asphalt-based binders. To avoid leaking of this material, the most applied strategy is the PCM encapsulation within particles composed of silicon dioxide (SiO_2) or polyacrylamide (PAM). According to the literature surveyed, it can be concluded that incorporating PCM into asphalt pavements can mitigate the formation of UHI acting as a thermoregulation factor, with acceptable mechanical and improved environmental performance.