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RECENT DEVELOPMENTS IN MICRO-LEVEL MODELLING OF TRANSPORT AND STORAGE PHENOMENA IN COMPOSITE MATERIALS

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Abstract. In the last century, the use of concrete as a structural building material has grown towards vast quantities, while at the same time, the construction industry committed itself towards reducing its carbon footprint dramatically by turning its “grey” image into a “greener” and a more environmentally-friendly one. Significant efforts still have to be done in enhancing a concrete’s sustainability perspective by, for instance, increasing its efficiency in energy storage ability. Existing building stocks, as well as the majority of the newly established buildings and infrastructures, are largely made of concrete composites, which have the implicit ability to store and transport heat. Up till now, innovations in this particular field of building physics have been mainly focusing on improvements of the mechanical properties of construction materials in terms of durability and sustainability leading to systems with high performance, high strength or self-compacting properties, by applying ecological supplementary cementitious materials like fly-ash, lime stone, silica fume, clays, etc. Innovations are now asking for more progressive answers in terms of reusing construction demolishing waste, closed cycle materials systems, energy saving concepts, implicit heat storage concepts, etc. This trend has been pushed further by the construction materials research community, which turned their focus more towards the ability of cementitious systems to enhance their transport and storage ability. These developments made it possible to go even a step beyond these ambitions by turning cement-based materials into smart energy storing, balancing and/or reducing elements, via the integration of Phase Change Materials (PCMs) and possibly adding graphene to enhance its conductivity. Modelling these energy saving composite systems requires a multi-scale approach where the impact of phase change materials has to be considered at the micro-scale level and where its thermo-mechanical consequence acts at the meso- to macro-scale level. Recent developments also include ultra-light cementitious foams embedded with PCMs. These are ultra-low-density composites that combine an extremely low heat conductivity with the ability to store heat. These multi-functional materials can be modelled by applying a multi-scale and multi-physics approach while taking into account various coupling strategies. Computational methods enable the simulation and design of these smart composites that are eco-friendly and encompass an enhanced energy efficiency.