Environmental durability of carbon nanotube modified mortars

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A great amount of research is focusing nowadays on the modification of cement-based materials with carbon nano-inclusions (carbon nanotubes, carbon nano-fibres, grapheme, etc) in order to create multi-functional structural elements with enhanced mechanical performance, fracture toughness, and smartness, i.e. health monitoring capability. Key parameter to achieve the aforementioned characteristics is the dispersion quality of the nano-phase in the cement paste without altering the physical characteristics of the nano-modified cement-based materials. It is further acknowledged that the dispersion quality play a decisive role on the microstructure of the nano-modified composites. This in turn may influence their transport properties, durability and monitoring capability when exposed to environmental loadings. Transport properties define the rate of ingress of deleterious species (e.g., water, chlorides, and sulfate) from the service environment into the cement-based structures and components throughout their service life. Next to that environmental conditions of great importance for cement-based materials include the freezing-thawing (F-T) conditions encountered in cold environments, as well as the exposure to ionic environments. Cracking, swelling and surface scaling that appear due to these conditions may cause changes in the microstructure and at the same time may result in deterioration of the mechanical integrity of a cementitious structure.

Based on the above an understanding of the environmental response of the nano-modified mortars is of paramount importance for their long-term performance. As part of this understanding the effect of carbon nanotube addition on the microstructure, transport properties, structural properties and damage detection capabilities of cement mortars will be discussed here. We will demonstrate that the dispersion medium is a critical parameter of durability because it does not merely specify the quality of the dispersion but also has a significant effect on both microstructure and transport properties. At the same time we will prove that nano-modification is beneficial for the durability of cementitious mortars exposed to freezing and thawing conditions as it results in up to 73% higher breaking energy. However, we will show that the level of improvement is dictated not only by the carbon nanotubes content and their dispersion level, but also by the nature of the dispersants. Finally, we will prove that the damage detection capability resulting from the addition of carbon nanotubes is degraded after environmental exposure, but it is still possible to monitor damage in nano-modified mortars.