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Application of Multiwall Carbon Nanotubes with Anionic Surfactant to Cement Paste

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Abstract : The discovery of the carbon nanotubes (CNT), has led to a breakthrough in the material engineering. The CNT is characterized by very large surface area, very high Young's modulus (about 2 TPa), unmatched durability, high tensile strength (about 50 GPa) and bending strength. Their diameter usually oscillates in the range from 1 to 100 nm, and the length from 10 nm to 10-2 m. The relatively new approach is the CNT's application in the concrete technology. The biggest problem in the use of the CNT to cement composites is their uneven dispersion and low adhesion to the cement paste. Putting the nanotubes alone into the cement matrix does not produce any effect because they tend to agglomerate, due to their large surface area. Most often, the CNT is used as an aqueous suspension in the presence of a surfactant that has previously been sonicated. The paper presents the results of investigations of the basic physical properties (apparent density, shrinkage) and mechanical properties (compression and tensile strength) of cement paste with the addition of the multiwall carbon nanotubes (MWCNT). The studies were carried out on four series of specimens (made of two different Portland Cement). Within each series, samples were made with three w/c ratios – 0.4, 0.5, 0.6 (water/cement). Two series were an unmodified cement matrix. In the remaining two series, the MWCNT was added in amount of 0.1% by cement's weight. The MWCNT was used as an aqueous dispersion in the presence of a surfactant – SDS – sodium dodecyl sulfate ($C_{12}H_{25}OSO_2ONa$). So prepared aqueous solution was sonicated for 30 minutes. Then the MWCNT aqueous dispersion and cement were mixed using a mechanical stirrer. The parameters were tested after 28 days of maturation. Additionally, the change of these parameters was determined after samples temperature loading at 250°C for 4 hours (thermal shock). Measurement of the apparent density indicated that cement paste with the MWCNT addition was about 30% lighter than conventional cement matrix. This is due to the fact that the use of the MWCNT water dispersion in the presence of surfactant in the form of SDS resulted in the formation of air pores, which were trapped in the volume of the material. SDS as an anionic surfactant exhibits characteristics specific to blowing agents – gaseous and foaming substances. Because of the increased porosity of the cement paste with the MWCNT, they have obtained lower compressive and tensile strengths compared to the cement paste without additive. It has been observed, however, that the smallest decreases in the compressive and tensile strength after exposure to the elevated temperature achieved samples with the MWCNT. The MWCNT (well dispersed in the cement matrix) can form bridges between hydrates in a nanoscale of the material's structure. Thus, this may result in an increase in the coherent cohesion of the cement material subjected to a thermal shock. The obtained material could be used for the production of an aerated concrete or using lightweight aggregates for the production of a lightweight concrete.

Keywords : cement paste, elevated temperature, mechanical parameters, multiwall carbon nanotubes, physical parameters, SDS
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