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FRACTURE PROPERTIES OF CEMENTITIOUS COMPOSITES REINFORCED WITH CARBON NANOFIBERS/NANOTUBES

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Abstract: *The main objective of this work is to determine the mechanical properties of a new cementitious nano-composite material. Carbon nanotubes/nanofibers were synthesized directly on the particle surfaces (Portland cement, fly ash, sand). Mixing these carbon-modified particles with ordinary Portland cement creates a cementitious binder, where the carbon nanofibers are perfectly dispersed in the volume. Previous attempts to create nano-reinforced composite materials suffered from flocculation and improper dispersion of admixed nanofibers. Now, the hybrid material can be intermixed directly with water creating strong and brittle composite.*

Keywords: ***Carbon, nanotubes, mortar, paste, fracture energy***

1. Introduction

The main objective of this work is to determine the mechanical properties of the cement paste/mortar reinforced with carbon nanofibres/nanotubes (CNF/CNT) directly synthesized on the cement and sand particles. The synthesis of the CNF/CNT directly on the particles surface brings the advantage in elimination of the tedious dispersion process. The cement hybrid material (CHM – cement with carbon nanofibers) can be directly mixed with water and/or sand, creating a strong and quasi-brittle composite material. Fig. 1 shows the SEM image of the CHM, the Portland cement particles are completely covered with the CNF.

CNT/CNF reinforcement on the nanoscale brought fruitful results for a variety of materials (Hammel et al., 2004). Previous experiments have shown the twofold increase of CNF/CNT admixtures on a paste compressive strength (Nasibulina et al., 2010). This would imply reduction of cementitious binders in ordinary concrete in a similar manner as replacement by supplementary cementitious materials.

To elucidate the effect CNF/CNT on surfaces, two batches from CHM and modified sand were prepared. Samples in the first batch were prepared from the CHM and water in the case of paste, or CHM, water and unmodified sand in the case of mortar. The second batch was fabricated from ordinary Portland cement, water and sand with surface synthesized carbon nanofibers.

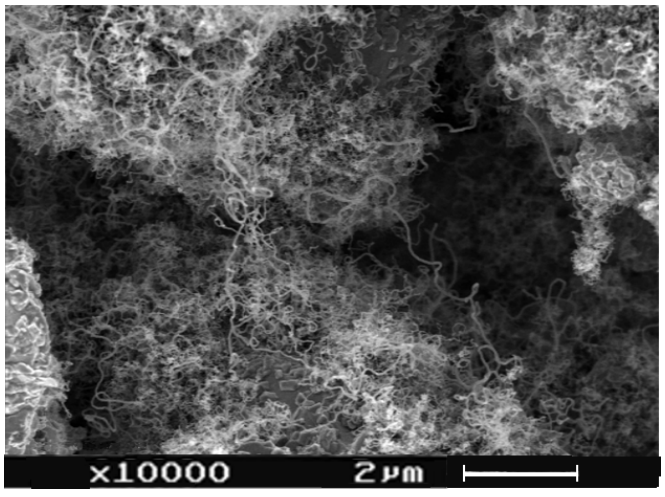

Fig 1. SEM image of the CNF synthesized directly on the cement grains surface. Reprinted from L. Nasibulina et al. (2010).

2. Results

The results on the mortar made from fine cement with the carbon-modified sand show that replacing 30% of sand with the carbon

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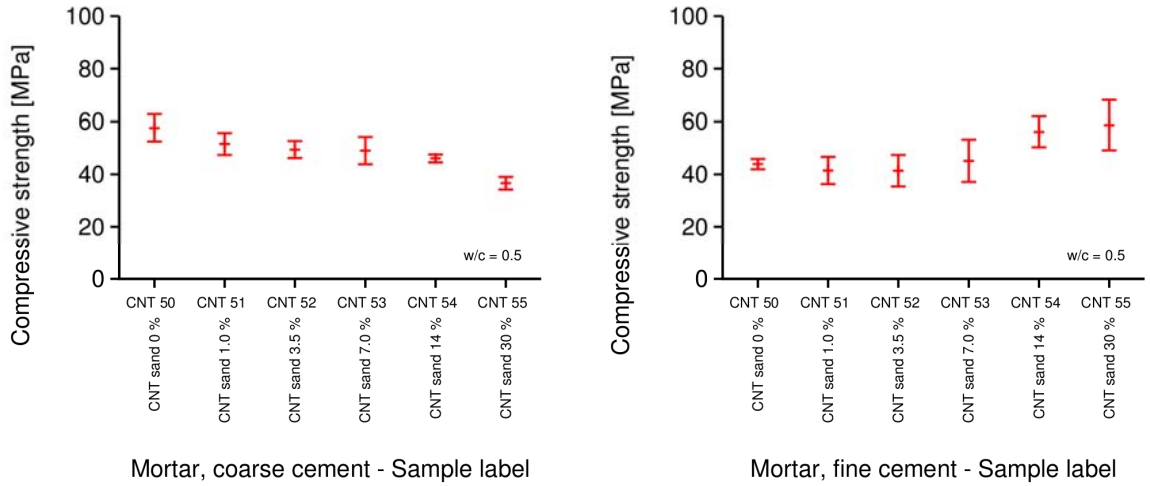

Fig. 2 Compressive strength and fracture energy of mortar with different weight ratii of carbon modified sand/raw sand, left coarse cement, right fine cement.

modified sand could increase the compressive strength by 25%, in our case from the average value of 44 MPa to the average 58 MPa (Fig. 2). It should be noticed, that the compressive strength of the mortar based on the coarse cement with unmodified sand is 57 MPa.

The evolution of the compressive strengths from the Fig. 2 required additional measurements to identify the source of the changes. The plot of compressive strength of all mortar samples versus the density is given in the Fig. 3. As is obvious from this figure, the mortars prepared from the carbon-modified sand do not exhibit any evident effect of CNT to the compressive strength and all the changes from Fig. 2 could be explained by different densities of the samples.

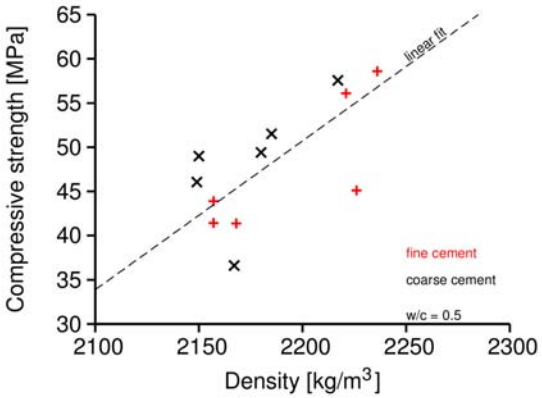

Fig. 3 Dependence of compressive strength on density of mortar from carbon-modified sand.

3. Conclusion

The cement paste/mortar reinforced with CNT/CNF directly synthesized on the surface of the grains exhibit comparable mechanical properties as the cement paste/mortar reinforced with the separately added carbon nanotubes as mentioned in Metaxa et al. (2010). Since we have not proven any effect of CNT/CNF to the compressive strength of composites, dare we say that our results are in strong contrary to the measurements of Ludvig et al. (2011) and Nasibulina et al. (2010), who published a 2-3 times higher compressive strength of mortar when the CNT/CNF are used. Unfortunately these sources do not provide densities or porosities of the samples.

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