NANO-INDENTATION RESPONSE OF GRAPHENE REINFORCED CEMENT MORTAR COMPOSITES

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1. Introduction

The effect of adding graphene nanoparticles with different weight fractions on the mechanical properties of the cement matrix composite is investigated. The mechanical properties of cemented paste have improved by adding carbon nanomaterials, such as graphene particles (GN), graphene covered over with monosilane (GN+Si), graphene covered over with oxidized monosilane (GN-OX+Si) or carbon nanotubes (CNT) [1, 2]. As a matrix Portland cement CEM I 42.5R produced in Poland (according to the PN-EN 197 Standard) was used. This study adopted a cemented paste with graphene platelets percentages of 0.05% and 0.1% with respect to the weight of the cement. A mix with a water-to-cement ratio of 0.4 was designed. The samples used for perforation tests were a disc-shape type of diameter and thickness equal to 23 mm and 5 mm, respectively.

The nanoindentation experiment was conducted using a Alemnis AG nanoindenter (Switzerland) with Alemnis Mechanical Indentation Control Software [3]. A maximal penetration load of 100 mN was chosen for the Berkovich tip. All tests were performed at room temperature equipped with use of the Berkovich three-sided pyramidal indenter. The load was increased in 20 s with velocity 5 mN/s, followed by 5 s holding and 20 s to decrease the load. The indented zone was randomly chosen. For each mix, nanoindentation technique was used for measuring the hardness (H), stiffness (S) and Young's modulus (E) over time.

The basic experimental process of depth sensing indentation can be divided into three steps. First, apply a static load to contact the specimen with the indenter. Then, the load increases as required, and a dwell load is added after loading, and finally, the load is reduced with the predetermined rate. When the applied load reaches the maximum P_{max}, the maximum depth of the sample is h_{max}. When the load is completely removed, the permanent residual depth left is obtained. The core principle of the Oliver and Pharr method is to extract Young's modulus and hardness of the sample by analysing the elastic recoverable unloading data corresponding to the indentation depth [4, 5]. As expected, the loading segment of the P–h curves exhibit a parabolic shape. During the load hold period, the tip displacement increases due to the viscous creep phenomenon. On unloading, viscoelastic displacements are recovered, leaving an indentation imprint on the sample surface. Experiments display very good reproducibility as judged by the overlapping of the loading portions of P–h curves obtained at Pmax.

The main research of this experiment is to develop cemented carbide with high hardness and stiffness by introducing graphene as a reinforcing phase. Hardness measurements were developed using a Berkovich hardness tester, and the results were averaged over 5 random points in each sample.

2. Conclusions

It was found that the addition of graphene platelets increased Young modulus, and hardness. The highest improvement was achieved for the 0.05 wt.% GN-OX+Si cement composite. Moreover, the addition of graphene platelets covered over with no oxidized monosilane increased the bulk. On the other hand, an overall increase toughness of the matrix composite was noticed.

References

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