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Nanomaterials for Archaeological Stone Conservation: Re-Assembly of Archaeological Heavy Stones Using Epoxy Resin Modified with Clay Nanoparticles

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Abstract : The archaeological large stone used in construction of ancient Pharaonic tombs, temples, obelisks and other sculptures, always subject to physicomechanical deterioration and destructive forces, leading to their partial or total broken. The task of reassembling this type of artifact represent a big challenge for the conservators. Recently, the researchers are turning to new technologies to improve the properties of traditional adhesive materials and techniques used in re-assembly of broken large stone. The epoxy resins are used extensively in stone conservation and re-assembly of broken stone because of their outstanding mechanical properties. The introduction of nanoparticles to polymeric adhesives at low percentages may lead to substantial improvements of their mechanical performances in structural joints and large objects. The aim of this study is to evaluate the effectiveness of clay nanoparticles in enhancing the performances of epoxy adhesives used in re-assembly of archaeological massive stone by adding proper amounts of those nanoparticles. The nanoparticles reinforced epoxy nanocomposite was prepared by direct melt mixing with a nanoparticles content of 3% (w/v), and then mould forming in the form of rectangular samples, and used as adhesive for experimental stone samples. Scanning electron microscopy (SEM) was employed to investigate the morphology of the prepared nanocomposites, and the distribution of nanoparticles inside the composites. The stability and efficiency of the prepared epoxy-nanocomposites and stone block assemblies with new formulated adhesives were tested by aging artificially the samples under different environmental conditions. The effect of incorporating clay nanoparticles on the mechanical properties of epoxy adhesives was evaluated comparatively before and after aging by measuring the tensile, compressive, and Elongation strength tests. The morphological studies revealed that the mixture process between epoxy and nanoparticles has succeeded with a relatively homogeneous morphology and good dispersion in low nano-particles loadings in epoxy matrix was obtained. The results show that the epoxy-clay nanocomposites exhibited superior tensile, compressive, and Elongation strength. Moreover, a marked improvement of the mechanical properties of stone joints increased in all states by adding nano-clay to epoxy in comparison with pure epoxy resin.

Keywords : epoxy resins, nanocomposites, clay nanoparticles, re-assembly, archaeological massive stones, mechanical properties
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