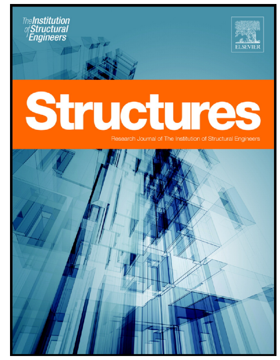

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Multi-scale modeling approach to predict the nonlinear behavior of CNT-reinforced concrete columns subjected to service loading

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Abstract

Due to the susceptibility of concrete structures to severe damage under earthquake loading, an increasing demand on high-strength and high performance concrete materials has been arising recently. Among several new materials, carbon nanotubes (CNTs) with their superior mechanical properties are being widely used in construction industry. In this study, a multi-scale method is proposed to identify the mechanical properties of CNT-reinforced concrete columns under monotonic loading. At the nano-scale, the mechanical properties of CNTs are obtained using a molecular dynamics approach. These properties are fed into a larger scale framework to estimate the ultimate tensile and compressive strengths of CNT-reinforced cement paste based on the finite element simulation. Furthermore, the mechanical properties of a concrete sample, including three major phases, cement, aggregate and interfacial transition zone is derived at the meso-scale using finite element simulations. Ultimately, the monotonic behavior of two concrete columns containing ordinary concrete and CNT-reinforced concrete is investigated by OpenSees software. A comparision between the responses of the two columns indicates that, adding CNTs to the concrete columns can increase the key mechanical properties of concrete such as ultimate moment capacity, energy absorption capacity and curvature ductility.

Keyword: Multi-scale modeling; Carbon nanotubes; Finite element analysis (FEA); Mechanical properties; Nano composites.