Cyclic uniaxial testing and constitutive modelling of cementitious composite materials

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Innovative cementitious composite materials are drawing considerable interest due to their substantially improved mechanical properties, as compared to ordinary cement-based materials: among the others, higher tensile strength, tensile strain hardening, flexural strength, fracture toughness [1] and resistance to fatigue. Their enhanced ductility appears to be promising and particularly suited to structural applications under severe dynamic loading conditions (earthquake, impact, blast) [2]. Accurate constitutive models to simulate the dynamic behaviour of cementitious composites are hence needed, as well as corresponding appropriate testing protocols for their experimental characterisation [3].

In this study, the response of cementitious composites to cyclic uniaxial loadings has been investigated. Cyclic response is essential to understand the effects of unloading and reloading on the material, to examine how it behaves in the transition from tension to compression and to characterise its properties in terms of energy dissipation and strain-rate sensitivity. Different loading schemes have been considered, including reversed cyclic tension/compression loadings, in order to identify the complete stress-strain curve and the transition behaviour, which can occur, for instance, under seismic, fatigue and wind loads. Monotonic quasi-static tension and compression tests have been also performed, to provide a benchmark for the evaluation of the envelope curve of cyclic response.

The experimental campaign was carried out on cylindrical specimens, a standard geometry in compression testing of cement-based materials. Several series of homothetic specimens (height to diameter ratio fixed as 2) with different dimensions were tested, to evaluate the influence of scale effects. Variability and reproducibility of the testing results have been taking into account by employing a minimum number of three specimens per loading condition. All the tests were performed, under deformation-controlled regime, on an MTS servo-hydraulic testing machine with 250 kN load cell. The testing machine was customised with accessories designed to meet specific test requirements, avoiding instability and bending moments during the alternating phases of uniaxial compression and tension. Linear variable displacement transducers (LVDT) and strain gauges were used to measure vertical displacements and lateral deformations, respectively. The results obtained experimentally represent a reliable basis for the development of constitutive models suited to numerical simulation.

References

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