069 - Computational Modeling of Phase Transitions

069 - 069 - Session 1: Computational Modeling of Phase Transitions

071 - Computational Methods in Composite Materials Research

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Track(s): 071 - Computational Methods in Composite Materials Research
071 - Computational Methods in Composite Materials Research
072 - Computational Aspects of Fibrous Materials
047 - Recent Advances in Modeling of Engineering Materials/Systems

No: 399

Title: A serial/parallel mixing theory for the seismic analysis of RC structures reinforced with FRP

Abstract: Keynotes: Serial/parallel mixing theory, FRP reinforcement, composite materials, pushover analysis.

Abstract
Strengthening or retrofitting of existing structures in order to increase their ductility and improve their seismic response has traditionally been accomplished using conventional materials and constructions techniques. Composite materials with a polymeric matrix reinforced with long fibres (FRP) have emerged as an alternative to these methods.

This paper develops a numerical procedure, based on the finite element method, able to perform numerical simulations of RC structures reinforced or retrofitted with FRP. Composites are treated using the Serial/Parallel mixing theory, which formulates the composite behaviour starting from the properties of each component material. Each component is simulated with its own constitutive equation. This theory takes into account the unidirectional behaviour of fibrous materials such as carbon fibres or steel reinforcements, defining an iso-strain behaviour of the composite in the fibre longitudinal direction and a iso-stress behaviour in the other ones. A construction stages algorithm has been developed in order to compute retrofitted structures. This algorithm allows including the composite in the calculation when the structure has a certain damage level.

The numerical procedure presented is validated using available experimental data for a reinforced concrete beam reinforced with FRP. This is a simply supported beam in which two equidistant loads are applied producing a constant bending moment zone between them. The good agreement obtained between experimental and numerical results allow considering the proposed numerical procedure as an accurate numerical tool for this sort of simulations.

The same experimental results are used to validate the construction stages algorithm which has been developed. These retrofitting simulations show that, even if the structural stiffness does not depend on when the reinforcement is applied; its capacity strength reduces if the FRP is applied on the already damaged structure.
To illustrate the performance of FRP reinforcements when seismic loads are considered, this work studies the structural response of a framed structure subjected to a horizontal increasing load (pushover analysis). When the structure is subjected to a seismic load, the frame joints are one of its weakest parts and, therefore, these will be the structural component to be reinforced. The response of a 2D concrete frame joint is compared with its response obtained when it is reinforced using FRP. Different configurations of FRP reinforcements are considered to compare their behaviours. The framed structure is studied using two dimensional and three dimensional finite element models. The comparison of the results obtained with each simulation shows the necessity to work with three dimensional elements to obtain an adequate structural behaviour.

Finally, all the simulations included in this work conclude on the ability of the serial/parallel rule of mixtures to simulate composite structures, as well as the improvement obtained in the structural performance when it is reinforced or retrofitted with fibre reinforced polymers.

Comments:

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