The sensitivity of Sequential Linear Analysis schemes to the number of saw-teeth in the material softening diagram

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ABSTRACT

Although nonlinear analysis techniques have reached an advanced level over the past years, convergence problems remain an important issue due to strain softening material behaviour. These problems are avoided by the sequentially linear analysis (SLA) technique – proposed by Rots and Invernizzi [1] – which is driven by directly specifying a damage increment instead of a load or displacement increment. This is accomplished by replacing the incremental-iterative procedure by a series of scaled linear-elastic calculations. For every step a critical point is identified – based on material utilization – in which the stiffness and strength are reduced in the next calculation. To obtain the reduced stiffness and strength, the descending strain softening curve is replaced by a so-called 'saw-tooth' diagram. This 'saw-tooth' diagram is constituted by a number of secant lines of which the inclination (stiffness) and ultimate value (strength) progressively decrease as damage increases. Similar to discrete lattice models, the structural response calculated with sequentially linear analysis often shows a lot of jumps and snap-backs.

Rots et al. [2] showed that this procedure is objective with respect to the mesh size by keeping the fracture energy invariant. This presentation focuses on the sensitivity of the sequentially linear analysis technique with respect to the number of saw-teeth. In other words, it reveals to which extent jumps and snap-backs can be attributed to true structural behaviour (e.g. crack initiation) and to which extent they can be attributed to the roughness of the 'saw-tooth' diagram. This objectivity is demonstrated by presenting results of numerical simulations performed with an adapted version of DIANA. These simulations include an un-reinforced concrete beam subjected to a four-point bending test and an un-reinforced masonry façade subjected to imposed settlements.