3D Global/Local Analysis of Cracking of Reinforced Concrete

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The assessment of crack features — pattern, spacing, opening — is a requirement for the design of reinforced concrete structures. Those assessments cannot rely on formula or experiment only, the first one being too simplistic and the second one too heavy. Therefore, numerical tools are developed to tackle the problem.

On one hand, non-linear finite element analyses based on continuum damage mechanics [1,2] are efficient to obtain the global behavior of large reinforced concrete structures. RicRag [3] is a finite element model coupling elasticity, isotropic damage and internal sliding. It can describe the local mechanisms related to concrete such as the asymmetry between the tensile behavior and the compressive behavior, the inelastic strains and the unilateral effect. Moreover, it is robust and can handle large-scale computation. However, this model does not model the discontinuities and thus makes the study of the cracks complex.

On the other hand, discrete element models [4,5] are inherently capable of representing discontinuities such as cracks. DEAP [6] is a lattice model for which the main physical mechanisms of quasi-brittle materials rupture are recovered, such as spatial correlation, crack tortuosity or scale effects. Unfortunately, the mesh density needed for such modeling is prohibitive to treat the case of industrial structures.

A global/local analysis has been proposed [7] to take advantage of each model at their adequate scale. This non-intrusive technique allows the use of finite element models at a structural scale and a decoupled local analysis of some interesting areas, i.e. around cracks, for which a discrete element model is used.

The presentation will focus on the extension of the global/local method for 3D analysis of reinforced concrete beams. The treatment of reinforcement and interface will be addressed.

The numerical strategy is confronted to two different experiments to show its capabilities. The experimental crack pattern and crack openings are obtained on the surface with a digital image correlation analysis. The first experiment is a laboratory three points bending test performed on a concrete beam with light reinforcement. The second experiment is an industrial four points bending test on a massive concrete beam with heavy reinforcement.

References

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