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# OPERATOR SPLIT FE SOLUTON METHOD FOR RC STRUCTURES

**A. Ibrahimbegovic[*], A. Boulkertous[*] and L. Davenne[*]**

[*] Ecole Normale Superieure de Cachan, LMT, 61 avenue du president Wilson, 94235 Cachan, France
e-mail: ai@lmt.ens-cachan.fr, web page: http://www.lmt.ens-cachan.fr

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**Summary.** In this work we review the main ideas on how to construct a FE model of reinforced concrete structures, which is capable of accounting for fine details of the inelastic behavior of this complex material, without the need to enforce the same complexity on the user. The key ideas concern the proper use of the modeling ingredients between the cracking of concrete, bond-slip and plasticity of steel, as well as the sufficiently rich representation of the strain field. The latter uses both the local enhancements, with incompatible mode method, and the global enhancements with X-FEM method.

## EXTENDED ABSTRACT

In this work we address several issues pertaining to modeling of RC structures by a FE method. The main difficulty one has to tackle when constructing the finite elements model of this kind pertains to the presence of different failure mechanisms which ought to be represented between the cracking of concrete, relative sliding between the steel bar and concrete due to bond slip and yielding of reinforcement. With the recent advances that are made in representing the localized failure under heterogeneous strain field [1,2,3] and the failure of heterogeneous materials [4,5], the latter has become possible.

The ingredients of such model are as follows; we make use of the novel representation of concrete cracking which combines the diffuse cracking in the fracture process zone with the localized cracking in the cohesive zone of the macro crack. The role of the bond-slip is very important for enforcing the proper redistribution of the stress between the straining in steel and in concrete, and the corresponding concrete cracking which is thus produced. The mode of failure in a reinforced concrete structure that is of main interest to us for computing its ultimate limit load considers the failure of concrete in compression and/or failure of steel by yielding in tension. It is interesting to note that while the failure of concrete is represented by element-wise embedded discontinuity modes, the failure of bond slip is best represented by extended finite element global modes that concern the representation of the total reinforcement bar. Another crucial ingredient of our solution strategy concerns the operator split solution procedure, which separates the global step providing the total strain field from the local step providing the inelastic strain.

Further details can be found in our recent works [1,2,3,4,5].

## REFERENCES


[1] Ibrahimbegovic A., I. Kozar (eds.), Man-made and natural hazards in dynamics of structures, Springer, Berlin, (ISBN-10 1-4020-5654-0) pp 1-397 (2007)

[2] Ibrahimbegovic A., 'Mécanique non linéaire des solides déformables : Formulation théorique et résolution numérique par éléments finis', Hermes Science Publication - Lavoisier, Paris (ISBN 2-7462-1489-X) pp 1-604 (2006)

[3] Brancherie D., A. Ibrahimbegovic, 'Fracture of massive structures: a novel approach to constructing an anisotropic damage model combining continuum-type hardening and discrete-type softening models', *International Journal of Computers and Structures, in press* (2007)

[4] Ibrahimbegovic A., S. Melnyk, 'Embedded discontinuity finite element method (ED-FEM) versus extended finite element method (X-FEM) for representing the localized failure of heterogeneous materials', *Computational Mechanics*, 40, 149-155 (2007)

[5] Dominguez N., D. Brancherie, L. Davenne, A. Ibrahimbegovic, 'Prediction of crack pattern distribution in Reinforced Concrete by coupling a strong discontinuity model of concrete cracking and a bond-slip of reinforcement model', International Journal of Engineering Computations, 22, 558-582 (2005)