EFG and XFEM - methods to model discrete cracks in concrete for high dynamic loading?

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Abstract. Concrete under tensile load fails very fast by developing cracks. Calculating cracks in computational mechanics is a multiple task for an engineer. In contrast to the smeared crack method there are two possibilities to include discrete cracks in numerical simulations.

Moes et al. [1] described a possibility for modelling cracks by adding degrees of freedom with a jump function. This method is called the extended finite element method (X-FEM). It is very effective combined with the level set method, that uses distance fields to the crack and the crack tip to save all necessary information about the crack.

Belytschko et al. [2] proposed the element-free Galerkin method (EFG) which approximates a field (e.g. displacement field) by using moving least-squares. Cracks can be implemented in EFG by cutting off the shape functions at the location of the crack.

In the presented work cracks were modelled on the one hand with EFG and on the other hand with XFEM to compare both ways of crack modelling. A rankine criterion with a fracture process zone is used to identify the growth of the crack. The numerical results are compared with the test results of standard beams.

There are two effects to consider for the calculation of concrete under high dynamic load: the tensile and the compression strength are increasing with high strain rates. The nonlinear volumetric stress-strain-relation is the cause for shock waves. After the destruction of the micro-pores (decreasing stiffness) the stiffness of concrete is getting higher by compacting of the material (Hugoniot). The increased stiffness is the basis for the development of the shock waves. Both effects were implemented in the used constitutive law and for the development of the cracks.

The aim of the presented research is the simulation of blasting of concrete. The results of these calculations will be compared with experimental results.

References

1 T. Belytschko, Y.Y. Lu, L. Gu: Elementfree galerkin methods. *IJNME, 37:229–256, 1994.*
2 N. Moes, J. Dolbow, and T. Belytschko: A finite element method for crack growth without remeshing. *IJNME, 46:131–150, 1999.*