An eXtended IGABEM formulation for the direct determination of SIFs in three-dimensional cracked bodies

M. Rocha[1,2*], J. Trevelyan[2], E. D. Leonel[1]

[1] Dept. of Structural Engineering, São Carlos School of Engineering, University of São Paulo, Av. Trabalhador Sãocarlense 400 São Carlos, Brazil, rocha.matheus@usp.br
[2] Dept. of Engineering, University of Durham, DH1 3LE Durham, UK

The Boundary Element Method (BEM) has been successfully applied in various fracture mechanics problems, since it can accurately capture mechanical fields in discontinuous problems. Moreover, once the method requires a boundary-only mesh, the remeshing process is simplified for crack growth analyses. In addition, its coupling with the isogeometric analysis concept becomes straightforward, in which the same parametric curves used in Computer-Aided Design (CAD) software also represent the interpolation of mechanical fields. As a result, the Isogeometric BEM (IGABEM) arises as a powerful tool to determine the mechanical response of solids and structures, for both elastostatics [1-2] and fracture mechanics [3-4].

On the other hand, it has been a challenge to simulate three-dimensional fracture mechanics applications when the crack intersects the external boundary using IGABEM. In such a scenario, it is necessary to carefully create the geometry by placing the NURBS patches so that they will not be crossed by the crack, to generate a discontinuous mesh. However, this approach can be unfeasible, depending on the crack's position. To overcome this issue, this presentation will describe an eXtended IGABEM (XIGABEM) formulation in which the strong discontinuous displacement field is naturally introduced by a Heaviside enrichment. Then, additional unknowns represent the crack opening at the crossed patch, which requires a technique to generate additional equations.

Besides, standard BEM and IGABEM formulations are not capable of describing accurately the displacements near the crack tip. Neither the standard polynomials nor the NURBS used in IGABEM offer an efficient approximation of the $1/\sqrt{r}$ behaviour in this location. In fact, at the crack tip, the solution given by the method contains non-physical displacement discontinuity at the crack front. This problem is herein circumvented by using the crack tip enrichment based on the Williams solution. Once the additional unknowns are the Stress Intensity Factors (SIFs), this technique also allows us to directly determine them from terms in the solution vector, which becomes another advantage of the XIGABEM. It is worth mentioning that the direct evaluation of SIFs is significantly more efficient than J-integral in terms of computational effort and more accurate than other procedures, such as Displacement Extrapolation Technique.

In this context, this presentation will discuss the methodology and results associated to a three-dimensional XIGABEM formulation for a pure mode I fracture mechanics application. Therefore, it will be possible to attest the robustness and accuracy of the developed techniques.

References

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