11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20–25, 2014, Barcelona, Spain

RECOVERY-BASED ERROR ESTIMATION FOR THE POLYGONAL FINITE ELEMENT METHOD FOR SMOOTH AND SINGULAR LINEAR ELASTICITY

Octavio A. González-Estrada[1], Sundararajan Natarajan[2], Juan José Ródenas[3], Stéphane P.A. Bordas[4], Claire Heaney[5]

[1] School of Mechanical Engineering. Universidad Industrial de Santander. Bucaramanga, Colombia, e-mail: agonzale@uis.edu.co
[2]School of Civil & Environmental Engineering, University of New South Wales, Sydney, Australia, e-mail: s.natarajan@unsw.edu.au
[3] Research Centre for Vehicle Technology, Universitat Politècnica de València, Camino de Vera s/n, 46022 Valencia, Spain, e-mail: jjrodena@mcm.upv.es.
[4] Faculté des Sciences, de la Technologie et de la Communication, University of Luxembourg, 6 rue Richard Coudenhove-Kalergi, L-1359 Luxembourg, stephane.bordas@uni.lu.
[5] Institute of Mechanics and Advanced Materials, Cardiff University, The Parade, Cardiff CF240JZ, UK, e-mail: heaneyc4@cardiff.ac.uk

Key words: *polygonal finite element method, Laplace interpolants, error estimation, statical admissibility, SPR-CX, singularity, recovery.*

Most common in the finite element literature is the use of triangular or quadrilateral elements in 2D, or their generalisations in 3D. Until recently, finite elements in the shape of pentagons, hexagons and in general $n-$ sided polygons have remained absent from the literature. Generalizations of the finite element method to arbitrary polygonal and polyhedral meshes have been the subject of increasing attention in the research community, both in computational physics [1, 2, 3, 4, 5] and in computer graphics [6, 7]. In polygonal finite elements, the use of elements with more than four sides can provide flexibility in meshing and an improvement in solution accuracy [8].

In general, numerical simulations are affected by an approximation error. In order to validate the results it is necessary to provide tools to guarantee a given level of accuracy. Recovery-based error estimators in energy norm for finite element formulations have been proposed in the seminal work by Zienkiewicz-Zhu [9], and this approach has been largely extended later on by many authors. In this paper, we investigate the use of a recovery-based error indicator to perform mesh adaptivity and quality control for the polygonal finite element method, for smooth and singular linear elasticity.

Acknowledgements

This work was supported by the EPSRC grant EP/G042705/1 "Increased Reliability for Industrially Relevant Automatic Crack Growth Simulation with the eXtended Finite Element Method" and the European Research Council Starting Independent Research Grant (ERC Stg grant No. 279578) "RealTCut Towards real time multiscale simulation of cutting in non-linear materials with applications to surgical simulation and computer guided surgery". This work has been carried out within the framework of the research project DPI2010-20542 of the Ministerio de Ciencia e Innovación (Spain). The financial support of the Universitat Politècnica de València and Generalitat Valenciana (PROMETEO/2012/023) are also acknowledged.

REFERENCES

[1] Moorthy S, Ghosh S. Adaptivity and convergence in the Voronoï cell finite element method for analyzing heterogeneous materials. *Computer Methods in Applied Mechanics and Engineering* 2000; **185**:37–74.

[2] Dasgupta G. Interpolants within Convex Polygons: Wachspress' Shape Functions. *ASCE - Journal of aerospace engineering* 2003; **16**(1):1–8.

[3] Sze K, Sheng N. Polygonal finite element method for nonlinear constitutive modeling of polycrystalline ferroelectrics. *Finite Elements in Analysis and Design* 2005; **42**(2):107–129.

[4] Pavankumar P, Jayabal K, Arockiarajan A. A comparative study between finite element and polygonal finite element approaches for electromechanical coupled linear problems. *Intergrated Ferroelectrics* 2010; **120**:90–101.

[5] Jayabal K, Menzel A, Arockiarajan A, Srinivasan S. Micromechanical modelling of switching phenomena in polycrystalline piezoceramics: application of a polygonal finite element approach. *Computational Mechanics* 2011; **48**:421–435.

[6] Floater MS. Mean value coordinates. *Computer Aided Geometric Design* 2003; **20**(1):19–27.

[7] Warren J, Schaefer S, Hirani A, Desbrun M. Barycentric coordinates for convex sets. *Advances in Computational Mechanics* 2007; **27**(3):319–338.

[8] Sukumar N, Tabarraei A. Conforming polygonal finite elements. *International Journal of Numerical Methods in Engineering* 2004; **61**(2045-2066):2045–2066.

[9] Zienkiewicz OC, Zhu JZ. A simple error estimator and adaptive procedure for practical engineering analysis. *International Journal for Numerical Methods in Engineering* 1987; **24**(2):337–357.