Congress on Numerical Methods in Engineering
Lisboa, June 29 to July 02, 2015

RESUMO N° 93

ON THE ALLEVIATION OF LOCKING PATHOLOGIES IN ISOGEOMETRIC ANALYSIS: AN ASSUMED NATURAL STRAIN (ANS) NURBS SOLID-SHELL FORMULATION FOR THE ANALYSIS OF THIN STRUCTURES

João Caseiro, jfmcaseiro@ua.pt
Universidade de Aveiro, Portugal

Robertt Valente, robertt@ua.pt
Universidade de Aveiro, Portugal

Josef Kiendl,
University of Pavia, Italy

Alessandro Reali,
University of Pavia, Italy

Ferdinando Auricchio,
University of Pavia, Italy

Ricardo Alves de Sousa, rsousa@ua.pt
Universidade de Aveiro, Portugal

Keywords: Isogeometric Analysis, Locking, Assumed Natural Strain, Solid-Shell

The core idea of the Isogeometric Analysis (IGA) consists in employing the basis functions that exactly define the geometry for the numerical simulation. This contrasts with the classical Finite Element Method (FEM), in which the geometry is only approximated. Although presenting a superior performance, NURBS-based elements are still affected by locking pathologies. For instance, when modelling thin structures using solid elements, the solutions are often polluted by shear and membrane locking effects that can significantly impair the final solution. As an alternative, shell element can also be considered but also present disadvantages, such as the use of rotational degrees-of-freedom that lead to more complex numerical implementations (especially in the nonlinear regime) and require special assumptions to model 3D constitutive relations. In order to combine the advantages of both worlds, solid-shell elements were proposed and received a great amount of attention in past years. In the present work, it is proposed an extension of the Assumed Natural Strain method for Isogeometric Analysis, leading to the development of a second-order NURBS-based solid-shell element suitable for the analysis of thin structures. The nonlinear formulation of the proposed element is based on the additive split of the Green-Lagrange strain tensor and the use of a corotational coordinate system to integrate the constitutive laws, ensuring incremental objectivity. The performance of the formulation is assessed using a set of benchmark problems in the linear and nonlinear (geometric and material) regimes. The results demonstrate that the methodology is able to successfully alleviate shear and membrane locking effects and presents good predictability characteristics in the analysis of elasto-plastic thin structures subjected to large displacements and rotations.