# A Comparative Study of Finite Strain Formulations in the Buckling of Cruciform Columns

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## ABSTRACT

Cruciform columns are often used in seismic protection of structures [1] as part of energy dissipators, and have been taken as case study to compare the total deformation and incremental theories of plasticity [1-3] in the vicinity of the critical load of elastoplastic buckling.

In this work, the postcritical behavior of imperfect cruciform columns subjected to uniaxial compressive load is analyzed. To this end, three-dimensional numerical experiments are performed with finite strain formulations such as updated Lagrangean hyperelastic, updated Lagrangean hypoelastic and total Lagrangean hyperelastic. These formulations are available in the large strain finite element codes SOGDE [4-5], Metafor [6-7] and FEAP [8] respectively.

In particular, nonlinear equilibrium paths for imperfect structures are obtained, not only in the neighbourhood of the critical state, but also for configurations far away from the critical one. Limit and residual loads are determined; and finally, the results obtained with the three formulations are compared and discussed.

## REFERENCES

[1] N. Makris, "Plastic torsional buckling of cruciform compression members", *J. Eng. Mech.*, **129(6)**, 689-696 (2003).
[2] L. Damkilde, "Elastic-plastic buckling of a finite length cruciform column", *Comput. Struct.*, **21(3)**, 521-528 (1985).
[3] M. Schurig and A. Bertram, "The torsional buckling of a cruciform column under compressive load with a vertex plasticity model", *Int. J. Solids Struct.*, **48(1**), 1-11(2011).
[4] C. García Garino, *Un modelo numérico para el análisis de sólidos elastoplásticos sometidos a grandes deformaciones*, PhD thesis, Universidad Politécnica de Catalunya (1993).
[5] C. García Garino, F. Gabaldón and J.M. Goicolea, "Finite element simulation of the simple tension test in metals", *Finite Elem. Anal. Des.*, **42**, 1187-1197 (2006).
[6] J.-P. Ponthot, *Traitement unifié de la Mécanique des Milieux Continus solides en grandes transformations par la méthode des éléments finis*, PhD thesis, Université de Liège (1995).
[7] J.-P. Ponthot, "Unified stress update algorithm for the numerical simulation of large deformation elasto-plastic and elasto-viscoplastic processes", *Int. J. Plast.*, **18**, 91–126 (2002).
[8] S. R. L. Taylor, *FEAP: A Finite Element Analysis Program, theory manual*, Department of Civil and Environmental Engineering, University of California, Berkeley (2008).