# DOMSOLIDO 1.0 - Development of a software for perform 3D elastic analysis

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Structural analysis and safety assessment of the advanced nuclear reactors should be done by the Design by Analysis (DBA) route, a modern trend in pressure vessel and piping design codes. However, to apply the DBA to structures under variable mechanical and thermal loads, it is necessary to assure that the plastic collapse modes, low cycle fatigue and incremental collapse (with instantaneous plastic collapse as a particular case), be precluded. The tool available to achieve this target is the shakedown theory. Unfortunately, the practical numerical applications of the shakedown theory, even in simple cases, can result in very large nonlinear optimization problems with nonlinear constraints. To face real problems in an industrial level, it is necessary to develop precise, robust and efficient algorithms to solve the problem in finite dimension [3][4]. This is a recent achievement in other countries but the resulting software is proprietary. Our work seeks to endow IEN with a software to perform this kind of analysis [1]. In a first stage, for elastic–ideally plastic materials, using 3D irreducible quadratic finite elements [2] instead of the usual, but more complex, mixed elements.

Realistic situations arising in industry, frequently require a 3D analysis, particularly nuclear ones. For our purposes, as a preliminary step, we need to know the 3D temperature distribution through the solid and this was made by a software for heat transfer, which we developed, called DOMTRFCAL.

On the other hand, a 3D elastic analysis - to know the corresponding generated mechanical stresses fields due to temperature field, loads and support displacements - is necessary as input for the shakedown analysis. A 3D elastic analysis software already exists commercially but it is expensive and its source code is not available. Aiming to take advantage of the need for the software, we considered creating a software, DOMSOLIDO, as we did with DOMTRFCAL, which can be used by others.

The code can accommodate solids with n materials and any type of kinematic element. DOMSOLIDO was developed for a most complex situation: the 10 nodes quadratic tetrahedron (nine components stress tensor and three freedom degrees by node) in order to create a more comprehensive overall structure from which, equivalent or least complex situations, can be easily derived, such as 3D cubic or linear elements and 2D and 1D elements. DOMSOLIDO is also a spin-off of the shakedown research. Developed in FORTRAN 90, it was designed, from the beginning, to be a tool which allows for the easy introduction of new irreducible finite elements by any student or researcher who intends to use it for his or her specific work. For this purpose, the commented source code is attached to an IEN Technical Note to permit anyone introducing new finite elements to make corrections, improve it and make adaptations and extensions. The following elements will be in the IEN Technical Note: the source code, a presentation of the theory that supports the software, the description of the subroutines, the structure of the code and of the methods used to impose boundary conditions and solve the linear system generated, as well as examples, will also be in the IEN Technical Note. The loads taken into account were gravity loads (body loads), surface loads and thermal loads, in addition to supports displacements. The DOMTRFCAL was conceived to be used (but not exclusively) in conjunction with a commercial software GiD, which functions only as its pre and postprocessor, independently.

**References**

[1] NERY, D. E. S.; JOSPIN, R. J. A finite element to perform 3D shakedown analysis for limited kinematic hardening materials. **Mecanica Computacional**, Buenos Aires, v. 29, p. 1423-1444, 2010.

[2] ZIENKIEWICZ, O. C., TAYLOR, R. L.; ZHU, J. Z. **The finite element method**: its basis and fundamentals. [S. l.]: Elsevier, 2005,

[3] HUGHES, T. J. R. **The finite element method**. 2. ed. Mineola: Dover Publications, 1987.

[4] Rao, S. S. **The finite element method in engineering**. 1. ed. Michigan: Pergamon Press, 1982.