Zebulon

Non-linear finite element solver

- Non-linear finite element solver
- Z-mat native solver
- Multi-physics analysis
- User extensible

Zébulon is the state-of-the-art finite element solver part of the **Z-set suite**.
It is the result of a long-term collaboration between **Mines PARISTECH** (France),
Onera – the French Aerospace Lab and **NW Numerics**, Inc (USA)

Zébulon is specifically tailored to the resolution of non-linear structural mechanical problems, and particularly those with non-linear constitutive laws. It also solves thermal and diffusion problems and handles the coupling of those models

The finite element solver Zébulon addresses the whole range of problems arising in structural mechanics.

Zébulon solves implicit static and transient dynamic problems and provides as well a modal analysis solver.

Material models are natively managed by Z-mat; they range from simple isotropic elasticity to anisotropic elasto-viscoplasticity through complex polymer behaviors, damageable composites or even multiscale models.

Non-linearities arising from material models, finite transformations or contact-friction are handled by a complete set of non-linear solvers, offering full control of both physical and numerical convergence parameter

A thermal analysis module solves steady state and transient thermal problems; multi-phase Fick's diffusion problems are handled as well. In fact, any other type of elliptic or parabolic problems can be addressed similarly. A weak coupling module handles an arbitrary number of such problems (e.g. thermo-mechanical-diffusion analysis).

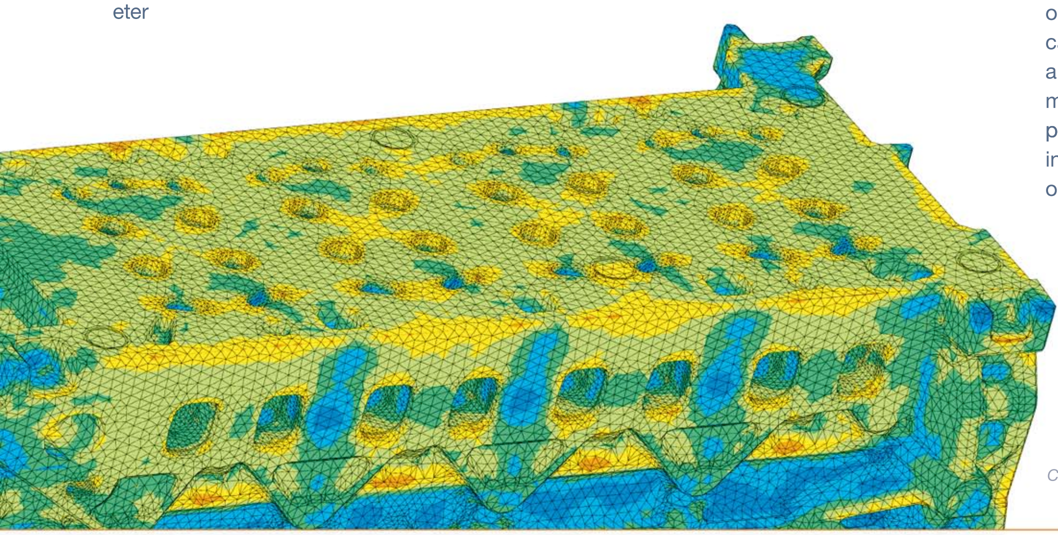
To deal with more complex multi-physics models, Zébulon also comes with external software coupling capabilities, with fluid flow or radiation software for instance.

Crack propagation is carried out by the Z-cracks module. With both remeshing techniques and X-FEM/level-sets strategies, Z-cracks is a very robust and efficient tool for fatigue or brittle crack propagation problems.

High performance computing strategies are used on recent SMP processors and clusters through a 2-level parallelization approach: on a single shared memory machine, multi-threading is used to accelerate both material integration and linear system resolution; on distributed memory cluster architectures, the problem is parallelized by domain decomposition techniques to spread the memory requirements over several machines.

User additions and dynamic extension mechanism. User have a choice between two methods to extend the code capabilities: Z-program or plug-in mechanism.

Z-program is a complete interpreted scripting language based on C++ and allowing interaction with the principal Z-set's internal objects. Unlimited number of user extensions can be handled within the Object Oriented architecture by using the derivation/plug-in mechanism. Specific boundary conditions, post-increment procedures, post-processings and many other features can be developed and linked to the main code in this way.



Courtesy of RENAULT

Element library

General purpose elements

- 2D elements : linear and quadratic triangles and quadrangles
- 3D elements : linear and quadratic tetrahedra, hexahedra, prisms and pyramids
- 1D and 1.5D elements
- elements : shells, beams and trusses
- layered elements for composite laminates
- interface elements with cohesive zone models

Specialized elements

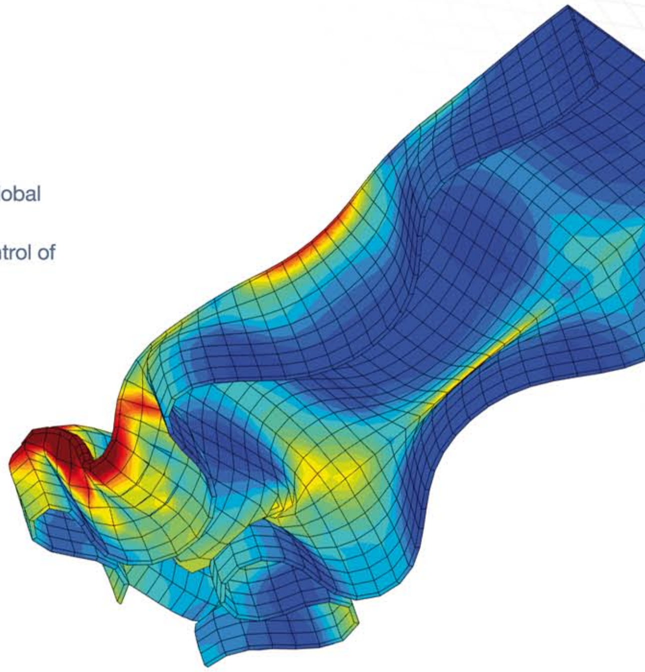
- periodic elements
- bubble-elements (pressure-displacement formulation) for incompressible materials
- non-local and micro-morph elements

Element formulations

- plane stress, plane strain and axisymmetric
- small or finite strain formulations
- 2.5D for generalized plane strain formulations
- Cosserat continuum models with 2nd grade continuum
- micromorphic formulations

Resolution algorithms

- Quasi-Newton with optional BFGS
- Arc-length algorithm for buckling and more general softening behaviors
- Time-stepping control automatically adjusted to material state variable evolution or global Newton iterations
- θ-method and implicit or explicit Runge-Kutta integration scheme with automatic control of local time-stepping
- Direct and iterative state-of-the-art linear solvers



High performance computing

- Multithreading of material integration
- Multithreading of linear systems resolution
- Parallelization through domain decomposition : BDD, FETI-DP, FETI-2LM

Model reduction

- Innovative techniques for acceleration of resolution of non-linear problems

Methods to reach the stabilized cycle

- Skip cycle method
- Explicit cycle acceleration method

Homogenization

- Specialized boundary conditions
- Periodic element

Remeshing/Crack propagation

- Automatic remeshing
- Various field transfer methods
- Stress Intensity Factor computing by G-θ method coupled to various crack propagation models

External parameters

- Unlimited number of external parameters – uniform and non-uniform

Multiscale and multiphysic analysis

- FE^2 for multiscale FE analysis: behavior at each macro-scale integration point is defined by a micro-scale FE problem
- Structural zoom
- Arlequin patch methods
- Code coupling, both internally with other Zébulon instances or with other software for fluid-structure simulations