Fonctionnalités de *Code_Aster* version 13
Outline

- Version 13 in a nutshell
- Verification & Validation
- Fracture mechanics
- Non-linear constitutive laws
- Linear and non-linear dynamics
- Numerical methods
- Architecture, ergonomics, performances
Version 13 in a nutshell
Version 13 release date

- **June 2016**: Code_Aster available in **Salome-Meca 2016**:
  - v12.6: stable-updates version
  - v13.2: testing version

- **December 2016**: Code_Aster available in standalone form only
  - v12.7: stable-updates version
  - v13.3: testing version

- **June 2017**: Code_Aster available in **Salome-Meca 2017**:
  - v12.8: stable-updates version
  - v13.4: stable version
Verification & Validation
Improvement of V&V

- **Improvement of verification**
  - Adding some test-cases on uncovered features
  - Adding some test-case documentations (about 50)

- **Improvement of validation**
  - Creation of a validation file for structures under seismic loading domain
  - About 40 tests

~83% of source code covered with verification tests
Some deletions for code simplification

- **TEST_TEMPS** operator
- **LIAISON_SOLIDE** in **AFFE_CHAR_MECA_F**
- **POU_C_T** model (curved beam)
- **COQUE_C_PLAN** and **COQUE_D_PLAN** models (lineic shell)
- **GDEF_HYPO_ELAS** (replaced by **GDEF_LOG**)
- **GATT_MONERIE** (elasto-visco-plastic law without hardening for fuel behavior)
- **CALC_THETA** operator
- **G_BILI***, **G_MAX*** and **CALC_K_MAX** options in **CALC_G** operator
- **ASPIC** and **ASCOUF** tools
- Assignments on **NOEUD/GROUP_NO** in **AFFE_MODEL** operator
- **DRUCK_PRAGER_FO** material
- Discrete lagrangian method of contact (**ALGO_*='LAGRANGIEN'**) in **DEFI_CONTACT**
Fracture mechanics
Fracture mechanics

- **Extension of XFEM features**
  - Development of quadratic elements
    - Quadratic elements cut into quadratic elements for integration
  - Coupling THM and XFEM elements
  - Multi-cracking with junction
  - Prescribed flux into fractures

PhD
Fracture mechanics

- Extension of XFEM for thermics
  - Introduction of XFEM in THER_LINEAIRE
  - Use temperature field as an input for mechanical computation

Continuous field of temperature
thermal transient resolved on a non-cracked FEM thermal model

Discontinuous field of temperature
thermal transient resolved on an adiabatic cracked XFEM thermal model
Fracture mechanics

- 3D results (displacement DX at T=20s)
Non-linear constitutive laws
Non-linear constitutive laws

- **New feature of the scalar damage law**
  - Take into account the difference between compression and traction limits
  - Restoration of stiffness when crack reclosing
    - COMPORTEMENT='ENDO_FISS_EXP', MODELE='3D' or '3D_GRAD_VARI'

- **New feature in DEFI_MATER_GC**
  - Concrete material parameters from more physical parameters
  - According to BAEL and now to Eurocode2

- **New feature for non local damage computation in case of mesh refinement**
  - CALC_ENDO operator
  - Chain different steps
    - Read a damage field
    - Continue damage computation
    - Managed multiple degrees of convergence

Experimental crack path

Crack path prediction
Non-linear constitutive laws

- New constitutive law with metallurgical transformations in MFront formulation
  - elastoplastic law with linear isotropic hardening
  - Equivalent to Code_Aster law
    - META_P_IL_PT
      - STAT_NON_LINE/COMPORTEMENT/RELATION = "MetaAcierEPIL_PT"

- Consideration of a pseudo restoration work hardening with mixed hardening
  - During multipass welding simulation, the level of residual welding stresses is overestimated without restoration
  - Results on Satoh test
Non-linear constitutive laws

- Industrialization of the new constitutive law for reinforced concrete structures under cyclic solicitations and seismic loading
  - homogenised constitutive model DHRC
    - COMPORTEMENT='DHRC'

![Diagram of building with energy dissipator](image)

![Graph of acceleration over time](image)
Non-linear constitutive laws

- **MFront**
  - A code generator to simplify the implementations of new material properties, mechanical behaviours and simple material models
  - Allow fast prototyping
  - Better performances
  - Two ways to use
    - Straight forward mode for implemented laws
    - Prototyping mode for user law

- **Upgrade to version 2.0.3**
- **Checking of the validity of constitutive laws parameters depending on temperature, strain**
- **Better management of error messages**

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Linear and non-linear dynamics
Dynamics

- New single operator for linear dynamics
  DYNA_VIBRA
  - Fusion of DYNA_TRAN_MODAL, DYNA_LINE_TRAN and DYNA_LINE_HARM
  - New data structure for sharing time-stepping schemes
  - Homogeneized and compact output message
  - FSI compatible with all time-stepping schemes
  - Improvement of time step storage:
    - upon a list of time step of interest

- Distributed mass on line or surface
  - Ease definition of distributed mass to figure equipment in buildings
Numerical methods
Numerical methods

- New how-to document for discrete elements
  - U2.02.03 How to use discrete elements
    - How to choose
    - Constitutive laws, computation options
    - Post-treatments
    - Application domains
Numerical methods

- New operator for error computation for FEM and XFEM models
  - In energy norm
  - In L2-norm on displacement
  - In L2-norm on contact pressure
  - Usefull for convergence analysis

- New default values for the non-linear solver
  - Paradigm shift!
  - From pedagogic values
  - To values that ease convergence

- New feature for plate
  - Eccentricity for DKTG model
  - \texttt{AFFE\_CARA\_ELEM/EXCENTREMENT}
Numerical methods

- New method of contact for curved interfaces
  - Local Average Contact method
  - Accurate value on pressure of contact

- New operation to prepare mesh for LAC
  - CREA_MAILLAGE/DECOUPE_LAC

- Improvement of contact pairing in parallel
  - the outer search loop is now distributed across processes
Architecture, ergonomics, performances
Architecture, ergonomics and performances

- **Ergonomics improvement**
  - Visualization on integration points for structural element
    - Post-treatment to prepare data for Salome-Meca
    - IMPR_RESU_SP operator
  
  - Visualization of generalized forces for structural element
    - IMPR_RESU/CONCEPT/REPERE_LOCAL='ELNO'

- **Refactoring of AFFE_CARA_ELEM**
  - Improvement of checking user’s data
  - Error are raised earlier (syntax checking)
  - Improvement of performance of reading data

- **Output of statistics from STAT_NON_LINE in a table/file**
  - STAT_NON_LINE/TABLE='OUI'
Architecture, ergonomics and performances

- **Performances improvement**
  - Parameters recovery for behavior laws with very large number of parameters
    - Speed-up of 111 on an elementary case
    - Speed-up of 17 on real study

- **Transformation from regular element to Barsoum element**
  - Speed-up of 300 on a big case
  - Negligible cost

- **Field projection on XFEM models (PROJ_CHAMP)**
  - Field on Gauss points on XFEM models
  - Speed-up of 100
Architecture, ergonomics, performances

- **New version of Mumps library 5.0.1**
  - New level of parallelism
    - Activation of threads
  - Another level of improvement
    - Bloc low-rank compression

- **Version of Petsc library 3.6.3**
  - Better integration in Code_Aster
    - Improvement of error recovery from Petsc to Code_Aster

- **New hybride mode of distribution**
  - SOUS_DOMAINE well fitted for linear solver
  - GROUP_ELEM well fitted for elementary computations
  - Results on CALC_CHAMP operator
Thank you for your attention