New members
Since 07 / 2019

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December 2019

Active members in 23 countries in the world

Best wishes

Best grade for the Community

code_aster professional network
user community of code_aster and salome_meca

Fourteenth edition in English
in Spanish (SCOPE Ingenieria)
in Italian (Alter Ego Engineering)

Information content:
• Open source and ProNet
• code_aster as a research platform
• code_aster as an industrial platform
• code_aster as an educational platform
• code_aster for service providers

Jean-Raymond Lévesque
Sylvie Courtier-Arnoux
Representatives of code_aster ProNet
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Regional meeting

Second edition - FIRENZE 14/02/2020
Contact Pr. Michele BETTI - michele.betti@unifi.it

Webinars and on line training in the world

TRAINING

In 2020 several training sessions for code_aster and salome_meca are proposed

Webinars and online training in the world

ProNet UPDATE – 14 – December 2019
Numerical and experimental validation of SMArt thermography for the inspection of wind blade composite laminate

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Non-Destructive Technique based on thermography is widely used for the detection of defects in materials and structures. These techniques consist on the experimental measurement and elaboration of the thermal response of the structure excited by a thermal input. Important improvements of the technique could be achieved developing a reliable thermal transient FEM model. At this purpose, a numerical model of thermal transient and steady state using code_aster has been built in order to evaluate the detectability of artificial defects in a 0° unidirectional composite laminate using traditional and SMArt thermography.

In the first model, the heat source is applied as a uniform temperature over the surface of the plate, simulating the temperature of all superficial point at the end of the heating phase. In the case of SMArt thermography simulation, the transient thermal analysis was performed applying the thermal load as the power density (power for volume unit) on the Shape Memory Alloy (SMA) wires.

The three-dimensional geometric model of the panel, comprehensive of SMA wires and defects, was built using CATIA V5 software in order to reproduce the panel having dimension 210x210x8 mm. The model was obtained assembling 8 volumes having the thickness of 1 mm, corresponding to the one of a single layer. The first two layers were modelled simultaneously to include the 0.25 mm diameter SMA wires between 1st and 2nd layers. Defects are defined as surface entities in the Generative Shape Design. In this manner, the defects are simulated as regions, corresponding to the modelled surfaces, where the nodes are disjointed. All the parts are finally assembled, saved in STEP format and subsequently imported into salome_meca using the Geometry module. The model was discretized imposing a mapped configuration and adopting hexahedral elements HEXA8 in the Mesh module of salome_meca. The final model consisted of 247783 nodes and 1075360 elements, able to define correctly the geometrical detail around the SMA wires.

As a result, the thermal map on the model surface during the heating and cooling phase was stored as text file containing the data of digital thermal images. The structure of this text file is composed by the nodes coordinates and temperature values for each instant and is conceived to be identical to thermograms data files obtained by experimental measurement. In this manner, these file are therefore suitable to be elaborated with the same Matlab algorithms used for experimental maps. The numerical thermal maps on the panel surface are showed in Figure for traditional and SMArt thermography (a-b).
Fondsis is an advanced numerical tool developed by Terrasol for the analysis of nonlinear soil-structure interaction (SSI) problems under dynamic and seismic actions. It allows to consider nonlinearity at the soil-structure interface for the dynamic and seismic design of several types of structures and foundations by means of equivalent analytical models developed for different types of foundations, i.e., shallow foundations, deep foundations, foundations on rigid inclusions and retaining walls. Calculations are several orders of magnitude faster than a classical finite element model accounting for the surrounding soil, the foundation and the structure which makes it the appropriate tool for the treatment of SSI problems within a complete performance-based design framework. Huge parametric studies can be performed to obtain best design.

**Formulation**

The supported construction can be modeled using different types of models:

- An assembly of masses, dashpots and springs whose parameters are calibrated to reproduce the fundamental eigenmodes of the structure;
- A stick model with Timoshenko beams, lumped masses, etc.;
- Or directly by means of a full structure model using the stiffness, damping and mass matrices of the structure assembled by a third-party FE software (e.g., code_aster).

The soil-structure interface behavior is modelled using the corresponding SSI macroelement for each type of foundation: shallow foundations, deep foundations, foundations on rigid inclusions and a macroelement inspired from Newmark’s sliding block theory for the analysis of retaining walls. These macroelements describe the nonlinear behavior of the foundation in terms of bearing capacity, sliding and overturning, and are formulated within the framework of classical plastic theory. Elastic and plastic (irreversible) displacements can thus be directly calculated.

**Implementation in code_aster**

The modular and incremental formulation used in Fondsis makes it possible to increase the capabilities of existing finite element software by adding to them some of the modules of the program such as the SSI macroelements. For example, the SSI macroelement for shallow foundations used by Fondsis is being implemented in code_aster as a new finite element. The validation procedure is in this moment ongoing and soon the SSI macroelement for shallow foundations would be available in stable versions.

**Validation**

The performance of this tool has been proven by a comprehensive validation process, comparing its results to nonlinear finite element models, cross-validation studies between different code implementations and direct comparison to analytical formulae that are available in the literature for chosen case studies. Results from experimental tests are also used to verify the cap
Numerical modeling on the tensile behavior of mineral-based composites

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In recent years, mineral matrix composites have gained great interest in the field of civil engineering, they have successfully used for the prefabrication of new lightweight structures and for repairing or strengthening old structural elements made of reinforced concrete or masonry. To deepen the knowledge of the tensile mechanical behavior of this type of composites, we have carried out, in the framework of a PhD thesis defended in 2019 at the University Claude Bernard Lyon1, an experimental and numerical study on parallelepiped specimens consisting of three glass yarns and an ettringitic matrix.

Code_Aster was used to establish a 3D finite element model. This modeling was based on a microscopic approach that considers the composite as a heterogeneous material, and that requires defining the properties of the matrix, the yarn and the interface.

- To simulate the tensile behavior of the mineral matrix, a combination of elastic linear law and cohesive law was used to describe the matrix cracking process. The yarn-matrix bond was modelled by cohesive law.
- The yarns were modelled using an elastic linear law.
- The matrix cracks and the yarn-matrix interface were modelled by 3D finite elements of joints.

The mesh of the composite has been produced using the tools integrated in the mesh module of Salome-Meca. The yarn and the matrix are meshed in six-node pentahedrons while the interface is meshed in eight-node hexahedrons. We have conducted mesh convergence tests to determine the optimal mesh size.

This modeling allowed to

- Well reproduce the global behavior of the composite. In fact, the comparison of numerical and experimental results showed a good agreement in terms of global tensile behavior, cracking and failure mode.
- Understand the mechanical behavior of this type of materials by analyzing the strain and stress states for distinct loading steps at the level of the yarn, the matrix and the interface.
- Make parameter sensitivity analysis to evaluate the effect of the reinforcement rate and the effect of the mechanical properties of matrix

Composite tensile behavior, experimental vs numerical

Distribution of damage D at the yarn-matrix interface at times \(i_1, i_2, i_3\) and \(i_4\); \(D = 0\) sound material and \(D = 1\) damaged material

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New approach for the Modelling of Technical Joints in Elastic MBS by proper Elasticity Distribution
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The coupling of rigid Multibody Systems (MBS) with flexible components modelled using the Finite Element Method (FEM) is one of the most common approaches in Flexible Multibody Dynamics and is typically referred to as FEM-MBS-Coupling.

This works deals with the representation of the interface between MBS and FEM, which is called interface modelling (IM). The effect of the IM on the quality of surface contact representations is discussed. The floating-frame-of-reference-formulation customarily applied in Flexible Multibody Dynamics leads to an Elastic Multibody System (EMBS) and requires a model order reduction (MOR) of the FE-model. If the model order is reduced, surface contact modelling also requires a reduction of coupling nodes or inputs and outputs of the FE-model respectively while a sufficient approximation quality has to be ensured. This is one of the main challenges, since the interface modelling has a significant and frequently underestimated effect on the approximation quality of reduced FE-models.

We present the deficits of conventional approaches to IM followed by the introduction of a novel approach, which is tested and evaluated by means of virtual models. To realize the novel approach, a new constraint formulation – the elastic coupling – is developed and implemented in a suitable simulation environment. Initially the virtual tests focus on rolling bearings with fully uncoupled linear stiffness properties.

This limits the scope of application for the approach derived here to a few simple bearing elements, such as some cylindrical rolling bearings or rubber bearings, for example. Nevertheless, it allows an effective and extensive validation of the underlying assumptions. It can be shown that the new method is effective and the constraint formulation can be extended to more general cases.

This paper aims at the development of a new constraint formulation based on the elastic coupling meeting the aforementioned requirements. To render the new approach industrially usable, the new constraint formulation is going to be implemented in the open-source FE-software, namely code_aster.

A new software module for the IM (IM-module) is going to be implemented in code_aster. This module calculates the system matrices of the elastic coupling based on the bearing stiffness matrix and bearing mass matrix and then integrates both in the FE-model.
Modelling the seismic behaviour of saturated embankment dams with code_aster

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Marc KHAM, Vinicius ALVES FERNANDES – EDF R&D – France

CFBR conference: "Justification of dams: State of the art and Perspectives", CHAMBÉRY, November 27 and 28, 2019

Embankment dams are the most sensitive type of dam to earthquakes, as can be seen from the disturbances observed on several of them following the liquefaction of the materials constituting the embankment or foundation. On the other hand, modern embankments are able to withstand very high seismic loads.

Methods of analysis must be able of accounting for these two findings in order to be safe and economical. Highly nonlinear numerical modelling approaches satisfy both objectives. This work describes the methodology developed by EDF around the constitutive model of HUJEUX and code_aster to analyze any phase of the life of an embankment dam (construction, impoundment, earthquake, aftershock, rapid drawdown).

Using a finite-element code makes it possible to model the whole geometry of the structures, in particular zoned dams or the particular stratigraphy of their loose foundation materials which are likely to show pore pressure increases. The coupled effective stress approach allows for the integration of the favorable effects of pore pressure dissipations, but also predicts the post-seismic behavior of the structures, or possibly several seismic calculations or to justify the effects of a static or seismic reinforcement.

The HUJEUX model is briefly described and its ability to represent the essential physical phenomena of cyclic behaviour is illustrated. The numerical specificities of the methodology concerning boundary conditions, initial conditions and damping are explained.

Finally the methodology is applied on an extreme historical cases of embankment dams subjected to strong motions: the sliding of the upstream face of Lower Von Norman dam during the San Fernando earthquake. The lower Van Norman Dam is the historical case of liquefaction in the world of dams. Reproducing the slip following the liquefaction of the upstream embankment during the San Fernando earthquake is an imperative to validate the methodology developed.
Fracture mechanics: a fundamental domain for expertise
Code_Aster team – EDF R&D – France

## R&D in Code_Aster

### Fracture Mechanics

#### CONTEXT

Assessment of defects in metallic components

- Hypothetical defects
- Real defects

#### Rotor

- Reactor Pressure Vessel
- Shrinkage cavities
- Turbine blade

Interpretation of laboratory experiments

#### USING IN SALOME_MECA / CODE_ASTER

- Defect explicit modelling in mesh
- Zcracks/blocfissure GUI in salome_meca
- Defect implicit modelling: X-FEM

#### DAMAGE MODELS

- ROUSSELIER, GTN
- CZM

#### SCIENTIFIC CHALLENGES

- Defect modeling
  - Surfaces intersection
  - Automatic remeshing
  - Crack front refinement
  - Complex structures
- Ductile damage modeling
  - Mesh dependency
  - Volumetric locking
  - Mesh large deformation
- Structural effect
  - Transposition from laboratory specimen to full size structure

#### SOME PhD THESIS

- E. Lorentz, Lois de comportement à gradients de variables internes : construction, formulation variationnelle et mise en œuvre numérique, 1999
- J. Lavina, Formulation énergétique de la rupture par plis de forces cohésives : considérations théoriques et imitations numériques, 2004
- S. Geniaux, Approche X-FEM pour la fissuration sous contact des structures industrielles, 2006
- S. Cuvelier, Passage d’un modèle d’endommagement continu sigmoidal à un modèle de fissuration cohésive dans le cadre de la rupture quasiplastique, 2012
- G. Ferri, Développement de l’approche X-FEM cohésive pour la modélisation de fissures et d’inter faces avec le logiciel libre EDF R&D Code_Aster, 2014
- Y. Zhang, Modélisation et simulation numérique robuste de l’endommagement ductile, 2016
- T.-H. Pham, Modélisation de l’amorçage et de la propagation de fissures en mécanique de la rupture ductile, 2016
- M. Ndefo, Implementation robuste pour minimiser le conditionnement et la précision des modélisations X-FEM, 2017

- M. Le Cren, Propagation robuste de défauts en 3D, 2018 (now employed at EDF)

#### SOME PUBLICATIONS

Dedicated web site for code_aster in China
Jiesheng MIN – EDF R&D – China