

Istituto di Scienza e Tecnologie dell'Informazione "A. Faedo"



Consiglio Nazionale delle Ricerche



Mechanics of Materials and Structures Laboratory

http://www.isti.cnr.it/research/unit.php?unit=MMS

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The Laboratory carries out research, software development and consulting in the field of continuum mechanics, with particular focus on structural engineering.

The main research subjects are

- 1. Mathematical modelling in continuum thermo-mechanics
- 1.1 Study of the constitutive response of materials, with particular emphasis on nonlinear elastic, elastic-plastic and masonry materials.
- 1.2 Study of the equilibrium and evolution problems in continuum mechanics; in particular the statics and dynamics of solids.
- 2. Numerical methods for the solution of equilibrium and evolution problems.

The models studied and the algorithms formulated have been implemented in the finite element code for nonlinear analyses **NOSA**.



SOFTWARE TOOLS

NOSA is a finite element code developed by the MMS Lab with the aim of testing new constitutive models for materials, checking the algorithm used for integrating the equations of the motion, as well as other numerical techniques for solving structural engineering problems. Development of the code has been made possible through the funding of CNR (progetto finalizzato Informatica, progetto finalizzato Materiali Speciali per Tecnologie Avanzate, progetto finalizzato Beni Culturali, progetto COMES-network for the computational solids mechanics) and funding of the region of Tuscany.

COMES-NOSA is a freeware version of **NOSA** for the nonlinear static analysis of masonry buildings <u>http://www.isti.cnr.it/research/unit.php?unit=MMS§ion=software</u>

MARC is general-purpose nonlinear finite element code distributed by MSC Software

http://www.mscsoftware.com/Products/CAE-Tools/Marc.aspx

RESEARCH TOPICS



Plasticity and metal-forming processes

The activity is aimed at studying the mechanical behaviour of elastic-plastic solids in the presence of finite strains and finds relevant applications in the modelling of several processes of metal-forming. The problem of the contact with friction between a deformable body and a rigid surface has also been addressed. The constitutive equations and methods for numerical integration of the equations

of motion have been implemented in the finite element code NOSA



Applications: mechanical, aerospace and shipping industries.



Thermal analysis

Programmes **MARC** and **NOSA** can be used for the numerical solution of the heat transfer problem in solids. The temperatures fields calculated during the thermal analysis may be used in a mechanical analysis to calculate the stress field due to the presence of thermal dilatations.

The available codes have been used to study the thermal behaviour of a container for biological experiments in the flights of stratospheric balloons. This analysis has been commissioned by the Italian Spatial Agency in 2001.



Applications: mechanical, electronic, aerospace industries.

Masonry-like materials and masonry constructions

A constitutive equation for masonry materials has been studied. Masonry is modelled as a non-linear elastic material with zero tensile strength and infinite or bounded compressive strength. The constitutive model and the numerical techniques have been implemented in the **NOSA** code, which allows for determining the static and dynamic behaviour of masonry constructions, as well as modelling restoration and consolidation operations, such as the application of metal chains and rods, and evaluating their effectiveness before their execution. The code has been applied to the study of several monuments and structures of particular historical and architectural value.



Applications: Cultural heritage, historical buildings, strengthening.

Lucchesi M., Padovani C., Pasquinelli G., Zani N., Masonry constructions: mechanical models and numerical applications. <u>Lecture Notes in Applied</u> <u>and Computational Mechanics</u> Vol. 39, Springer-Verlag, Berlin Heidelberg 2008







Masonry-like solids subjected to thermal loads

The constitutive equation of masonry materials has been generalised in order to take into account the presence of thermal expansion, as well as the dependence of the elastic moduli on temperature. This equation has been implemented in the **NOSA** code used to study the thermo-mechanical behaviour of refractory linings of converters and ladles employed in the iron and steel industry.





Applications: iron and steel industry.

NOSA can be used for the thermo-mechanical analysis of masonry constructions subjected to seasonal thermal variations

SELECTED PROJECTS



EU Regional Development project OPTOCANTIERI

The project, funded by the Region of Tuscany (2002-2003) was aimed at assessing, disseminating and increasing awareness of the many opto-electronic and computer-based technologies developed by research institutions (CNR, University of Florence, public restoration laboratories) and private companies.



In the framework of the activities of the project, MMS Lab has studied the static behaviour of the right longitudinal wall of the S. Pietro Vinculis in church Pisa, by using located in NOSA.



National project "Diagnostic and safeguard of architectural buildings with particular focus on the effects of seismic events and other natural disasters"

MIUR, Fondo Speciale per la Ricerca di Interesse Strategico (2003-2005.) The activity of MMS Lab was aimed at developing a national finite element code for the solids mechanics and the modelling of the structural behaviour of masonry constructions.

Static analysis and strengthening of masonry vaults

Funded by the Cassa di Risparmio di Lucca Foundation (2004-2005)





The church of San Ponziano, Lucca



Static analysis of the dome of the Santa Maria Maddalena church in Morano Calabro (CS)

This study (2004-2005), commissioned by the Office for the Arts and Environment of the Region of Calabria, is aimed at assessing the structural behaviour of the dome and modelling some strengthening operations, as the fitting of metallic rings.







Dynamic behaviour of ancient masonry constructions

Funded by the Cassa di Risparmio di Lucca Foundation (2006-2007)



The vault of the church of San Ponziano, Lucca



Masonry vaults and domes: classical methods and finite element modelling

Funded by the Cassa di Risparmio di Lucca Foundation (2007-2008)



The vaul of the church of San Ponziano, Lucca



Dynamic analysis of the church of Santa Maria della Roccella

commissioned by the Office for the Arts and Environment of the Region of Calabria (in collaboration with the University of Florence, 2008-2009)



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ST@RT – Sciences an tecnologies for the Tuscany artistic, architectural and archeological heritage

Funded by the Region of Tuscany (2007-2010), the project is aimed at modelling the dynamic behaviour of masonry constructions and assessing their seismic vulnerability. Computational tools for Cultural Heritage have been developed and the Rognosa tower in San Gimignano inscribed in the Unesco World Heritage List in 1990, analysed.





The Rognosa tower, San Gimignano (SI)

Seismic analysis of masonry towers

Funded by the Cassa di Risparmio di Lucca Foundation (2009-2010)

This research is devoted to study mathematical models for the nonlinear dynamic analysis of masonry towers and bell towers



The tower of the Hours, Lucca

5.000e02
4.500e02
4.000e-02
3.500e02
3.000e02
2.500e02
2.000e-02
1.500e-02
1.000e-02
5.000e-03
0.000e+00







Tools for the modelling and assessment of the structural behaviour of ancient constructions: the NOSA-ITACA code Funded by the Region of Tuscany, PAR-FAS (2011-2013)



The NOSA-ITACA project aims to develop a new tool, the NOSA-ITACA code, for the structural analysis of masonry buildings of historical interest. The project conducted in collaboration with the Department for Constructions and Restoration of the University of Florence, is aimed at upgrading the NOSA code via the open source GUI platform SALOME and developing a technical support service to provide consultancy, assistance and training in the field of maintenance and restoration of the architectural heritage.

