

## Education

# Eucentre

## Reducing earthquake risks through PLM

### Products

NX, Femap

### Business challenges

Solve complex seismic engineering and nonlinear dynamics problems in civil, mechanical, plant and industrial engineering

Quickly develop 3D models for structural analysis and solving

### Keys to success

NX and Femap for modeling, NX Nastran for numerical model validation

Huge number of solving algorithms offering a high degree of freedom to set parameters with Nastran

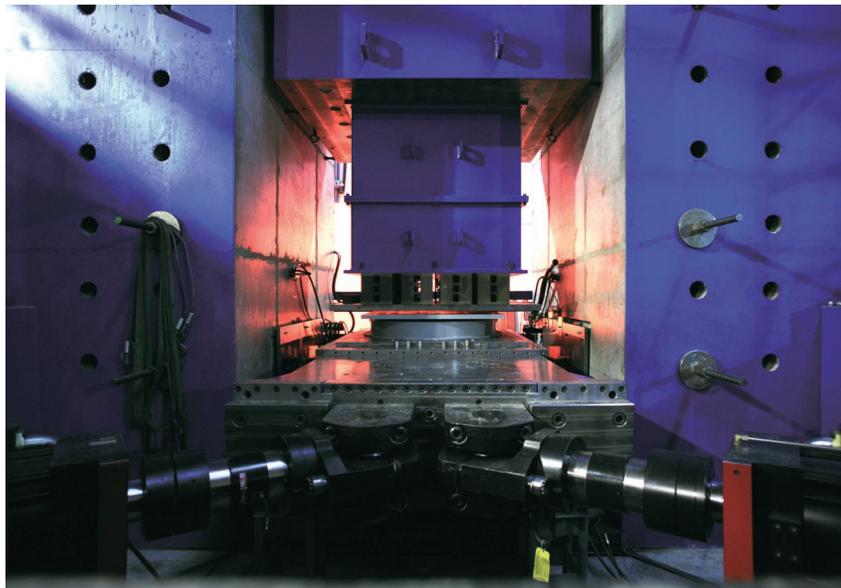
Femap as a modeling tool that complies with the "mental approach" of engineers

### Results

Complete 3D modeling of a base isolator in few days

Nonlinear dynamic analysis on steel structures with accurate and reliable results

Validation of numerical models through comparison with experimental data and specific software



*Eucentre, the European Center for Education and Research in Seismic Engineering, promotes, supports and carries out training and research in the field of seismic risk reduction. Image courtesy of Massimo Brega.*

**NX software, NX Nastran and Femap are used to help solve seismic engineering problems; also employed to deliver critical data for nonlinear, dynamic conditions**

### Two-fold research focus: academic and business

The collapse of the elementary school in San Giuliano di Puglia during the Molise earthquake in 2002 was a turning point in the seismic history of Italy. After that tragedy, new laws were introduced immediately to redefine critical areas and public buildings that needed to be adapted to

seismic safety standards. In 2003, a joint initiative by the Civil Protection Department, the Institute of Geophysics and Volcanology (INGV), the University of Pavia and the University Institute for Upper Studies in Pavia (IUSS), led to the creation of Eucentre, the European Center for Education and Research in Seismic Engineering, to promote, support and carry out training and research in the field of seismic risk reduction.

Eucentre has two major activity areas. The organization carries out research for academic purposes, and research directly related to the business needs of companies. The research includes civil

## Results (continued)

Greater analyst creativity/  
innovation

Identification of significant  
future opportunities

*The Structural Analysis sector of Eucentre solves complex seismic engineering and nonlinear dynamics problems in civil, mechanical, plant and industrial engineering. Image courtesy of Eucentre.*



**“After only a few months of full-time use, Eucentre has obtained significant results using Siemens PLM Software’s solutions.”**

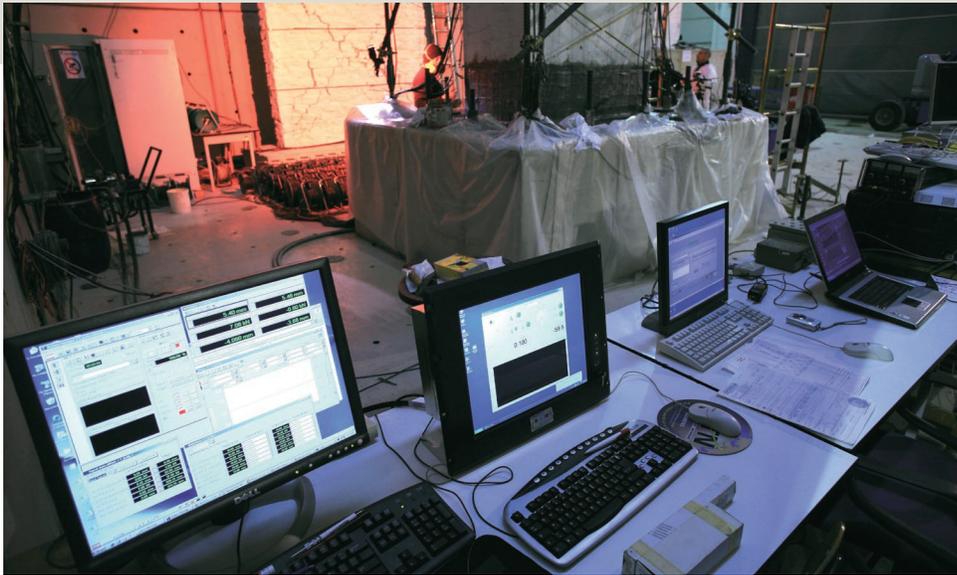
Roberto Nascimbene, PhD  
Researcher  
Structural Analysis  
Sector Coordinator  
Eucentre

engineering (masonry, steel, reinforced concrete, prefab), applications for cross-industry numerical analysis, and seismic risk analysis for the evaluation of earthquake-related risks in Italy and around the world. For example, on the business side, the Geotechnology and Applied Seismology sector of Eucentre, coordinated by Professor Carlo Lai, was entrusted with a project to evaluate and mitigate seismic risk in the Eastern Caribbean, while in L’Aquila the institute engineers were among the first to reach the disaster area to check the conditions of strategic constructions, such as hospitals and public buildings. On the academic side, Eucentre offers advanced training and education, selecting about fifty of the “most brilliant minds” out of 800 applications submitted from 130 countries every year. These students can attend courses within masters of science and doctorate curriculums, which offer exchange programs,

joint exams and degrees in collaboration with other “excellence sites” around the world: Patras, Grenoble and Middle East Technical University Ankara. “We apply the US model, with few classroom hours and many research tasks,” says Roberto Nascimbene, PhD, coordinator of the Structural Analysis sector of Eucentre. “More than 60 percent of our PhD students find a job at a university, while the rest pursue a professional career in leading organizations worldwide.”

### **Ideal tools for applied research**

The Structural Analysis sector of Eucentre uses numerical analysis to handle and solve seismic engineering problems and, more generally, highly nonlinear dynamics. “We carry out applied research, directly responding to the needs of companies,” explains Nascimbene. “In this context, we need to solve problems in civil, mechanical, plant and industrial engineering.



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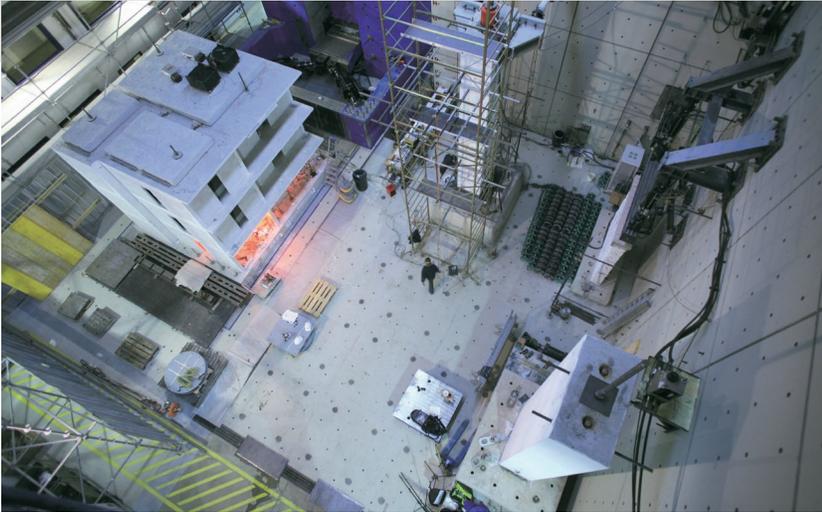
Unlike a company, we are lucky because we can choose the best tool in each area. When we were introduced to Siemens PLM Software technologies, we immediately realized that packages that included NX, NX Nastran and Femap would be the ideal toolsets to develop innovative solutions and to adapt existing solutions in specific application fields.”

Among important applications where Siemens PLM Software systems are providing answers for Eucentre is civil engineering – specifically steel structures. “Steel structures have been a niche product for many years,” says Nascimbene, “but their diffusion has increased recently, as shown by the L’Aquila reconstruction project, generating the necessity to study problems that were well known to mechanical engineers but not to construction engineers: instability of concentric bracing systems, low-cycle fatigue problems, advanced instances of nonlinear behavior in structure connections, nonlinear dynamic conditions typical of earthquakes, and accurate predictions. The accuracy and reliability of results are essential,” emphasizes Nascimbene. “We do nothing without a comparison with experimental data or other software, and NX Nastran is essential for the validation of our numerical models.”

Another key area to address is isolation. The base isolator, extensively used in L’Aquila, is a structural element placed between the base of a building and the ground to “absorb” the effect of seismic waves. Nascimbene explains, “The isolator is studied with mechanical rather than civil engineering software, with an easy user interface that does not require an engineer with several years of experience in numerical analysis. An MSc (master of science) or PhD (doctor of philosophy) student should be able to readily handle the task. NX Nastran offers the right compromise between model complexity and easy data and parameter input. However, you also need sophisticated algorithms to analyze highly nonlinear behavior, including large displacements and deformations, use of

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Roberto Nascimbene, PhD  
Researcher  
Structural Analysis Sector Coordinator  
Eucentre



innovative materials, complex geometry and friction as a key factor.”

The third field where the Eucentre Structural Analysis sector has obtained great benefits from NX™ Nastran® software is “lifelines,” such as shell structures, tanks and reservoirs for combustion oil or just water. In case of an earthquake, these containers are exposed to risks of leaks, explosion or collapse, a critical issue in Europe, more so in America, especially in territories with many extraction and mining sites like Alaska. “The analysis of steel tanks with deformable walls was handled by our researchers using NX Nastran, which includes a specific package for water as an essential element to analyze vibrations in these systems,” says Nascimbene. “The first parameter to evaluate is the vibration modes of a tank with

different filling levels or while it’s being emptied, analyzing different features of nonlinear dynamic analysis with very fast modeling capabilities. The Siemens PLM Software solution offers great flexibility as the user can set 99 percent of the parameters. While other software packages adopt a ‘black box’ strategy, where the application handles all values, we do prefer the NX Nastran approach, which leaves great freedom for variable selection and parameter settings to achieve very accurate results.”

#### **The power of simplicity**

For all of its structural operations, Eucentre relies primarily on Femap™ with NX Nastran software, comparing their results with other open-source software solutions specific to seismic research, in order to validate their models. The software is mainly used by two types of users, namely MSc and PhD students, who possess a basic knowledge of dynamics and numerical analysis that enables them to input data and select the types of analysis and convergence criteria. “With their user friendliness, NX and Femap with NX Nastran stand out among all other solutions on the market,” says Nascimbene. “The user interface to these solutions is amazing, it is so simple; at the same time it enables you to model complex 3D geometry with no support. We had never created a base isolator in just a few days, developing the entire model with

**“It is hard to find nonlinear dynamics software that also offers an easy and intuitive interface to solve the problems we have to analyze.”**

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minimum support from an expert researcher who just gave general instructions and checked inputs and outputs.”

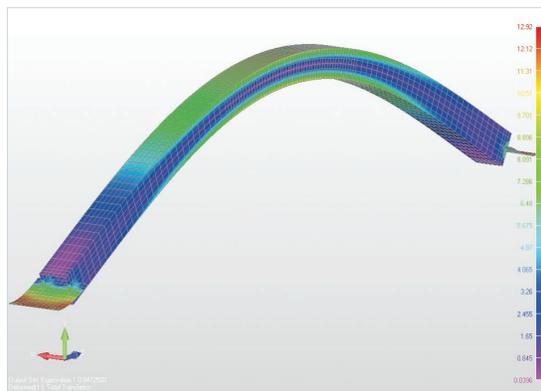
Another benefit that Nascimbene defines as “exceptional” is represented in the way in which NX Nastran solves algorithms. “When you open the window, you find a huge number of solving algorithms, where each can be set with several parameters,” says Nascimbene. “Nonlinear dynamics is a core feature of NX Nastran, it has helped us fill a gap in civil and structural engineering. It is hard to find nonlinear dynamics software that also offers an easy and intuitive interface to solve data input problems.”

Nascimbene notes, “There are tools to solve reinforced concrete, some with an adequate interface and others with excellent pre- and postprocessors; but when working with complex geometrical models, no product on the market offers the same combination of an advanced modeling and preprocessing environment, NX, and dynamic analysis capabilities, NX Nastran. I think Siemens PLM Software’s technology can be very useful in civil engineering to design big construction projects like steel bridges, where it can offer unique solutions.”

Another software benefit highlighted by Nascimbene is the innovative approach that an analyst can take towards the application using NX Nastran: “The ease of use of NX Nastran does not mean that the analyst is constrained in his work, but rather he can leverage a number of automated mechanisms to his own benefit.”

## An unusual approach

Eucentre uses Siemens PLM Software solutions in an unusual way. Nascimbene explains, “The initial model is created using Femap, not NX, and then we move on to detailed analysis with NX Nastran. From the very start, we decided to use Femap with NX Nastran, because the concept of this application is very similar to the mental



First vibration mode of a hollow section of steel bracing.

## Solutions/Services

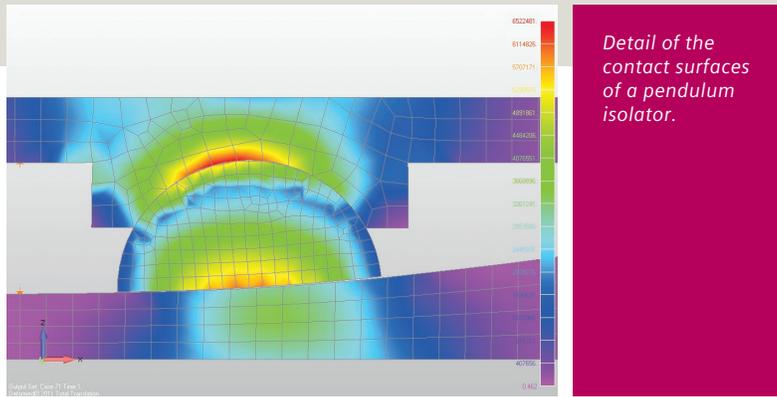
NX  
NX Nastran  
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Femap  
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## Client's primary business

Eucentre is a nonprofit foundation created to promote, support and carry out training and research in the field of seismic risk reduction.  
[www.eucentre.it](http://www.eucentre.it)

## Client location

Pavia  
Italy



approach of engineers. The geometry and global input methods of Femap are compliant with the techniques learned by an engineer with a university degree. For advanced or complex geometry model creation, we use NX. I know the idea of modeling with Femap may seem strange, but the rationale for us is simple: the solver is more important than the preprocessor." Nascimbene notes, "After only a few months of full-time use, Eucentre has obtained significant results using Siemens PLM Software's solutions."

## Looking ahead

There are two more aspects the Structural Analysis sector wants to improve. First, Eucentre wants to parameterize models in order to optimize products in civil engineering projects. "A steel structure typically has four elements: column, beam, bracing and gusset plate," Nascimbene explains. "Our goal is to ensure an efficient seismic behavior for these structures using one single parameterized model. With

NX, we will be able to develop a structure within a very short time frame, adjusting a few parameters. A short-term objective, for instance, is to create parameterized models of the bolted connections of steel structures, where geometry is important for the shapes of steel parts and to model bolts and welds. It is inconceivable having to redraw structures over and over when you can have a parametric model."

The second development is computational fluid dynamics (CFD), an area the Structural Analysis sector still has not addressed. Nascimbene clarifies, "We are gradually discovering all the functions and potential of NX Nastran. The software's analysis capabilities are deep and represent exceptional opportunities; we are exploring it gradually and finding out ever new possibilities. Among these, CFD will help us analyze the profile of a bridge or a suspended or elevated structure swept by wind."

## Siemens PLM Software

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[www.siemens.com/plm](http://www.siemens.com/plm)

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