Computational Modeling and Advanced Simulation in Structural and Geotechnical Engineering

Contact details

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Acronym	**CMASSGE**
Logo	-
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Areas of expertise

Domain: Civil Engineering-*Structural and Geotechnical Engineering*
Computational and experimental techniques with emphasis on the development and application of advanced nonlinear analysis of structural limit states, progressive collapse analysis of structures, push-over analysis for seismic performance evaluation of structures, analysis of structures subjected to wind actions, finite element simulation of composite materials subjected to extreme loads such as ballistic impact and explosions, design and behaviour of composite steel-concrete structures, and application of FEM for geotechnical problems.

Team and key skills

Prof. Cosmin G Chiorean: Prof. Chiorean's research interests focus on improving the computational methods for design of civil structures, industrial buildings and bridges. His research includes both computational and experimental techniques with emphasis on the development and application of advanced numerical methods to solve problems relevant to structural and geotechnical engineering.
Prof. Adrian M. Ioani: Prof. Ioani is full professor of structural engineering at Structural Mechanics department. His research interests focus on advanced mechanics of materials, progressive collapse analysis of structures, reinforced concrete structures.
Dr. Gobesz Zsongor: Dr. Gobesz is associate professor at Structural Mechanics department and research activity focus on application of numerical methods in structural engineering, knowledge-bases, decisional- and expert-systems, computer programming and computer aided design. (*coordinator of the computational laboratory*).
Dr. Mihai Nedelcu: Dr. Nedelcu is senior lecturer at Structural Mechanics Department and research activity focus on twin-walled structures, strength of materials, theory of elasticity and experimental modal analysis techniques (*coordinator of the structures laboratory*).
Dr. Vasile Farcas: is senior lecturer at Engineering Structures Department and reserach activity focus on geotechnical engineering (*coordinator of the geotechnical laboratory*).
Dr. Ovidiu PRODAN: Dr. Prodan is assistant professor at Structural Mechanics Department and research activity focus on application of advanced numerical methods and software in seismic and structural engineering and computer aided design. *(coordinator of the structural modelling laboratory*).
Dr. Alexandru Chira: Dr. Chira is assistant professor at Structural Mechanics Department and research activity focus on application of advanced numerical methods and software in structural engineering and computer aided design.
Mr. Marius Botos: Mr. Botos is assistant professor at Structural Mechanics department and his research interests focus on steady and unsteady seepage problems, dams with non-permanent reservoirs. He is the *coordinator of the hydraulic laboratory*.
Dr. Iulia Molnar: is assistant professor at Engineering Structures Department and research activity focus on application of the advanced numerical methods in geotechnical engineering.
Phd Students: Marius Buru, Ioana Marchis, Cristian Ciplea: research activity focus on application of advanced numerical methods and software in structural engineering and computer aided design.

Infrastructure

Licensed software packages:

- ABAQUS v. 6.11 (http://www.3ds.com/products/simulia/portfolio/abaqus/overview/)
- Extreme Loading for Structures (ELS) http://www.extremeloading.com/
- ANSYS
- TrueGrid v. 2.3.4 (http://www.truegrid.com/)
- CompaqVisual Fortran
- MATLAB v. R2011b.
- Geostru Software Applications (www.geostru.com)
- SAP2000 V.14
- Robot Millenium

Equipment:

1. PULSE, the Multi-analyzer System Type 3560, is a versatile, task-oriented analysis system for noise and vibration analysis. It provides the platform for a range of PC-based measurement solutions from Brüel&Kjær

2 **Wind tunnel (HM170 (GUNT Hamburg)**

3. Hydraulic laboratory equipment consists of a flexible and modular-based system for Basic Fluid Mechanics, divided by thematic areas.

Development strategy

The research and development activities of the research group are focused on application of advanced nonlinear techniques to describe the complex behaviour of real structures with emphasis on the following topics: *Advanced pushover analysis of 3D composite steel-concrete frameworks*; *Progressive collapse analysis of Structures; Advanced numerical modelling of real-large 3D frameworks*; *Software developing based on FEM in Structural and Geotechnical Engineering; Finite element simulation of composite materials subjected to extreme loads such as ballistic impact, explosions and fire*. The research group have good scientific contacts with similar research groups from other universities such as New University of Lisbon, Portugal, University Federico II, Naples, Italy; Technical University of Catalonia, Barcelona, Spain, etc.

- Master courses and programmes –research activity
- MSc and PhD students from other universities (Korea, Portugal, Italy)
- Scientific OUTPUT: Research articles published mainly in the leading journals
- Applications for research grants (national and international)
- Collaborations with other research groups from foreign universities
- Collaborations with Geostru Software Company
- Results dissemination on the research group webpage (free access)

Representative projects

1. **Design and seismic performance evaluation of 3D frame structures using advanced nonlinear static analysis method (granted by CNCSIS, PNII-IDEI 193/2008)-** http://www.cosminchiorean.com/projects.html

With the rapid advancement of computer technology, research works are currently in full swing to develop the advanced inelastic analysis methods. In spite of the availability of some FEM algorithms and powerful computer programs, the non-linear inelastic analysis of real large-scale frame structures still posses huge demands on the most powerful of available computers and still represents unpractical tasks to most designers. The need for accurate yet computational efficient tools for the non-linear analysis of 3D frame structures forms the main motivation behind of this work. The research project is intended to overcome the existing inconveniences and develop an integrated system for advanced structural analysis and seismic performance evaluation of 3D steel and reinforced building frameworks with rigid or flexible connections.

2. **GFAS-A finite element system for geotechnical applications (granted by GEOSTRU SOFTWARE);** Application of

finite element method in Geotechnical Engineering- http://www.cosminchiorean.com/projects.html

GFAS is a finite element package that has been developed specifically for the analysis of deformation and stability analysis in geotechnical engineering problems. The basic program features include: Graphical input of geometry models, Automatic mesh generation, Staged construction analysis, Beam-column elements and soil structure interaction, Steady state flow analysis, Dynamic and seismic analysis, Elasto-plastic material models (Mohr-Coulomb, Von-Misses, CamClay, Drucker-Prager etc).

Significant results

A. Selected publications (http://www.cosminchiorean.com/)

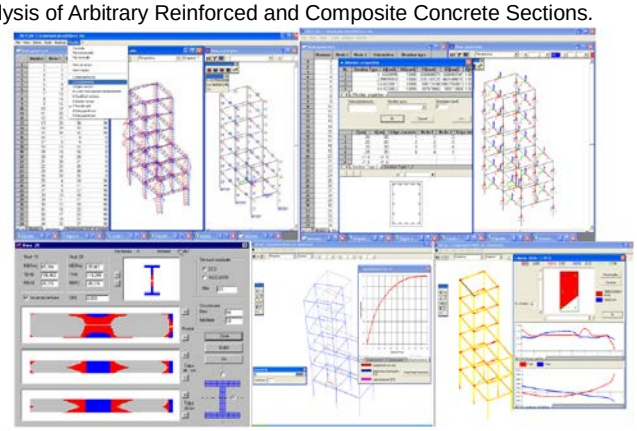
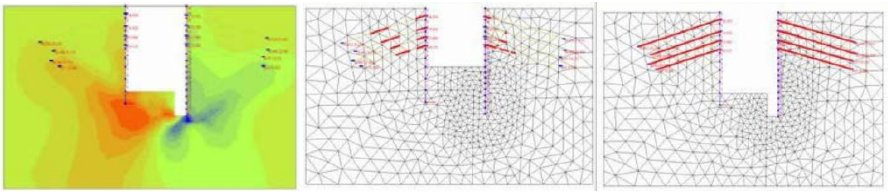
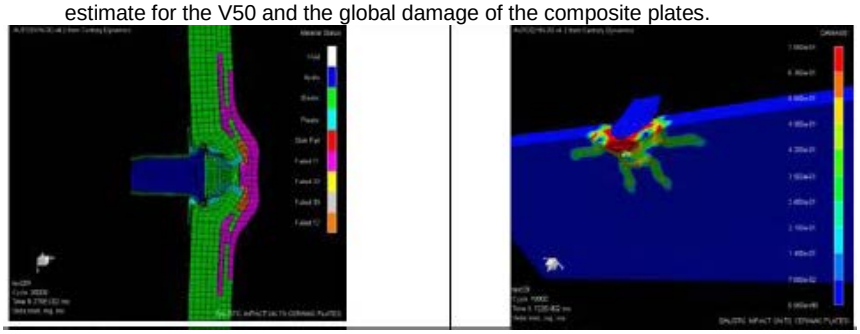
1. Chiorean, C.G., A Computer Method for Nonlinear Inelastic Analysis of 3D Composite Steel-Concrete Frame Structures, *Engineering Structures*, **57**, pp. 125-152, *Elsevier Science Publisher, 2013. http://dx.doi.org/10.1016/j.engstruct.2013.09.025*
2. Chiorean C.G., A Computer Method for Rapid Design of Composite Steel Concrete Cross-Sections, *Open Civil Engineering Journal*, **7,** pp. 1-17, *Bentham Science Publisher*, 2013. DOI: 10.2174/1874149501307010001.
3. Chiorean, C.G., Computerised Interaction Diagrams and Moment Capacity Contours for Composite Steel-Concrete Cross-Sections, *Engineering Structures*, **32 (11)**, pp. 3734-57, *Elsevier Science Publisher*, 2010. http://dx.doi.org/10.1016/j.engstruct.2010.08.019
4. Chiorean, C.G., A Computer Method for Nonlinear Inelastic Analysis of 3D Semi-Rigid Steel Frameworks, *Engineering Structures*, **31 (12)**, pp. 3016-33, *Elsevier Science Publisher*, 2009. http://dx.doi.org/10.1016/j.engstruct.2009.08.003
5. Nedelcu, M., GBT formulation to analyse the behaviour of thin-walled members with variable cross-section, *Thin-Walled Structures*, **48 (8)**, pp. 629-638, Elsevier Science Publisher, 2010.
6. Chiorean C.G., A fast incremental-iterative procedure for ultimate strength analysis of composite cross-sections of arbitrary shape, *WIT Transactions on Modelling and Simulation*, **51**, WIT Press Publisher, pp. 363-375, 2011. DOI: 10.2495/CMEM110321.
7. Chiorean, C.G., Barsan, G.M., Large Deflection Distributed Plasticity Analysis of 3D Steel Frameworks, *Computers & Structures*, **83 (19-20),** pp. 1555-71, *Elsevier Science Publisher*, 2006. http://dx.doi.org/10.1016/j.compstruc.2005.02.011
8. Silva, M.A., Cismasiu, C., Chiorean C.G., Numerical Simulation of Ballistic Impact on Composite Laminates, International Journal of of Impact Engineering, **31 (3),** pp. 289-306, *Elsevier Science Publisher*, 2005. http://dx.doi.org/10.1016/j.ijimpeng.2004.01.011
9. Barsan, G.M., Chiorean C.G., Computer Program for Large Deflection Elasto-Plastic Analysis of Semi-Rigid Steel Framework, Computers & Structures**, 72 (6)**, pp. 600-711, *Elsevier Science Publisher*, 1999. http://dx.doi.org/10.1016/S0045-7949(98)00310-1.
10. Marchis, A.G., Moldovan, T.S., Ioani, A.M. The Behaviour of an Old Representative Reinforced Concrete Building subjected to Abnormal Loads, *Proceedings of the Eleventh International Conference on Computational Structures Technology*, Dubrovnik, Croatia, September 4-7, CST 2012, in B.H.V. Topping, *(Editor)*Civil-Comp Press, Stirlingshire, UK, Paper 243, 2012. doi:10.4203/ccp.99.243.
11. Bredean, L., Botez, M., Ioani A.M., 2012, Progressive Collapse Risk and Robustness of Low-Rise Reinforced Concrete Buildings, *in B.H.V. Topping, (Editor), The Eleventh International Conference on Computational Structures Technology*, Dubrovnik, Croatia, September 4-7, CST 2012, in B.H.V. Topping, (Editor), Civil-Comp Press, Stirlingshire, UK, Paper 244, doi:10.4203/ccp.99.244;
12. Ioani, A.M., Petran, I., Botez, M., Bredean, L. Limit analysis fast methods for assessment of progressive collapse potential in RC structures, *Proceedings of Performance, Protection & Strengthening of Structures Under Extreme Loading - PROTECT 2013*, Mysore, India, 26-27 August, pp.19, 2013.
13. Chiorean,C.G., Chira, A., Buru, M., A computer method for design and M-N-Phi analysis of composite steel-concrete cross-sections, *Proceedings of the Fifth International Conference on Structural Engineering*, Mechanics and Computation (SEMC2013), CRC Press, pp. 1385-1390, 2013. DOI:10.1201/b15963-249.
14. Chiorean,C.G., Buru, M., Chira A., Marchis I., Nonlinear inelastic analysis of 3D composite steel-concrete frameworks, *Proceedings of the Fifth International Conference on Structural Engineering*, Mechanics and Computation (SEMC 2013), CRC Press, pp. 1409-1414, 2013. DOI:10.1201/b15963-249.
15. Chiorean C.G., Tarta G., Marchis.I, Buru. M, Computer-Based Nonlinear Analysis Method for Seismic Performance Assessment of 3D Steel Frameworks, *Eleventh International Conference on Computational Structures Technology, CST 2012, Civil Comp Proceedings, Stirlingshire, UK 2012. Paper 22*, doi:10.4203/ccp.99.22.
16. Chiorean C.G., A Fast Incremental-Iterative Procedure for Ultimate Strength Analysis and Design of Composite Steel-Concrete Cross-Sections, *Thirteen International Conference on Civil, Structural and Environmental Engineering Computing*, Civil-Comp Press, 2011. Paper 51, doi:10.4203/ccp.96.51.
17. Chiorean, C.G., Barsan, G.M., Large deflection distributed plasticity analysis of 3D semi-rigid steel frameworks, *Proc. Of International Journal of Structural Stability and Dynamics*, Hong Kong, China, 16-18 December, pp. 84-92, 2009, http://www.hkisc.org.

B. Software developed

1. **GFAS** – (*A Finite Element System for Geotechnical Applications*) a product developed for Geostru Corporation (www.geostru.com) is a finite element package that has been developed specifically for the analysis of deformation and stability analysis in geotechnical engineering problems. http://www.geostru.com/EN/Geotechnical-and-F.E.M.-analysis-system.aspx
2. **NEFCAD –** Advanced Nonlinear Inelastic Analysis System for Seismic Performance Evaluation of 3D Steel and Composite Steel-Concrete Frameworks (http://www.cosminchiorean.com/software.html)

ASEP- A Computer Program for Inelastic Analysis of Arbitrary Reinforced and Composite Concrete Sections (http://www.cosminchiorean.com/software.html)

The offer addressed to the economic environment

Research & development in core areas	Development of advanced nonlinear analysis methods able to describe the complex behaviour of 3D steel and composite steel-concrete frame structures with a minimum computational effort. Ultimate strength analysis and design of composite-steel concrete cross-sections with arbitrary shapes subjected to biaxial bending and axial force; Computer automated optimal structural design in seismic zones based on structural performance criteria; Analysis of structures subjected to extreme actions.
Research & development in applied fields	1. **Development of specialized software concerning application of nonlinear analysis to describe complex behaviour of frame structures:** *NEFCAD*- Advanced Nonlinear Inelastic Analysis System for Seismic Performance Evaluation of 3D Steel and Composite Steel-Concrete Frameworks; *ASEP:* **-** A Computer Program for Inelastic Analysis of Arbitrary Reinforced and Composite Concrete Sections.  2. **Application of FEM in geotechnical problems:** Development of general purpose and dedicated purpose finite element package (GFAS) specifically for the analysis of deformation and stability analysis in geotechnical engineering problems. GFAS is an easy-to-use yet powerful geotechnical-engineering tool for the linear and nonlinear analysis of homogenous or nonhomogenous structures. It features a full graphical interface for pre-processing or post-processing and uses the Finite Element Method (FEM) for 2D solids for its analysis purposes.  3. **Numerical simulation of balilistic impact on composite laminated plates:** The ballistic performance of the lightweight armour systems can be examined to obtain an estimate for the V50 and the global damage of the composite plates. 
Consulting	Application of nonlinear analysis methods for seismic peformance evaluation of spatial structures; Application of FEM in structural and geotechnical engineering; Composite materials.
Applied engineering services	Advanced analysis and Design of Structural Systems in Civil and Geotechnical Engineering. Software development for structural and geotechnical engineering.
Training	Advanced software applications such as: Abaqus, Ansys, GFAS, TrueGrid, MatLab; Extreme loadings, etc. Application of nonlinear analysis for seismic peformance evaluation of spatial structures; Application of FEM in Structural and Geotechnical Engineering.