Training

ISSUE #2 . NOVEMBER 2020

AGENDA of the 2nd TRAINING SCHOOL

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No INSPIRE-813424

Foreword

The INSPIRE training program encompasses unique features, which guarantee not just the employability of the 15 researchers to be trained, but their central role as actors in creating a new generation of highly qualified researchers and engineers, able to support and implement all aspects of the pioneering concepts introduced in this project.

In the timeframe of the four years of the project, Training Schools will cover all the fundamental scientific and technological developments in the fields of geotechnical engineering, structural analysis, and noise and vibration engineering relevant to all aspects of structure protection.

Taking place 8 months after the 1st Training School, where introductory design and modelling principles were established, the 2nd event will focus on advanced technological topics related to seismic wave propagation, inelastic structural response, and anti-vibration protection.

The program includes a total of fourteen lectures by renowned academics from partner institutions and valued guests.

COVID-19 Mitigation Measures

To enable participation of ESRs, partners, and external participants from outside Italy who would not be able or do not wish to travel, during such difficult circumstances, the organizers will adopt a blended mode combining physical attendance, for those that can be in Italy, with web-participation.

Given today's restrictions, a maximum number of 12 people can be physically present in the room. It goes without saying that physically participating attendees will strictly adhere to health and safety protocols, in agreement with directions by the European Research Agency and the World Health Organization.

A total number of 40 participants will be permitted and registration requests will be judged/approved by the organizers based on a strict priority list and the relevance of the attendee with the INSPIRE concepts.

Contents

For information contact:
info@itn-inspire.eu

Agenda of the 2nd Training School

Tuesday, 01 December – Thursday, 03 December

A three-day long Training School will take place in Trento, Italy from 1st to 3rd of December 2020. The event will follow the Development Workshop (30/11/2020) but is organized independently, by the University of Trento with support from the INSPIRE project administrator.

The Agenda includes:

- Advanced and applied analysis of structures Hazard assessment and risk assessment analysis
- Non-linear modelling of wave propagation
- Stability, plasticity, buckling and coupled problems in engineering
- Project organization and management
- Experimental approaches in earthquake engineering and seismic protection
- Advanced Lectures on meta-materials

Registrations requests should be submitted online via the INSPIRE website: itn-inspire.eu/2nd-training-school

For more details and registration visit: https://itn-inspire.eu

The INSPIRE consortium is thankful to the University of Trento for the organization of the event and especially to the organizers:

Professor Oreste S. Bursi, Professor Francesco Dal Corso, Fabrizio Aloschi (ESR10), and Ms. Lorena galante

Mountain views from the campus of the University of Trento.
Photo: Fabrizio Aloschi (ESR10)

Time	Tuesday 01/12	Wednesday 02/12	Thursday 03/12
09:00 – 10:30	“Stability and buckling in structural mechanics” by **F. Dal Corso**	“Vibraton-based identification of structures” by **A. Palermo**	“An introduction to nonlinear metamaterials” by **V. Dertimanis**
10:30 – 11:00	**Coffee Break**		
11:00 – 12:30	“Project organization and management in geotechnical engineering and erection of structures” by **C. Vrettos** and **S. Meissner**	“Guided waves-based identification of structures” by **A. Marzani**	“Fundamentals of acoustics and noise insulation” by **A. Paradeisiotis**
12:30 – 14:00	**Lunch Break**		
14:00 – 15:30	“Associative and nonassociative elastoplasticity and stability” by **D. Bigoni**	“Control of mechanic and thermal energy by advanced artificial materials” by **D. Torrent** “Seismic quantitative risk assessment of an LNG storage plant” by **O. S. Bursi**	“Experimental approaches for seismic protection of structures and infrastructures” by **G. Tsionis**
15:30 – 16:00	**Coffee Break**		
16:00 – 16:45	“Performance-based earthquake engineering for seismic risk” by **O. S. Bursi**	“Probabilistic seismic hazard analysis and fragility functions - Hands-on tutorials” by **C. Nardin**	“Wave propagation in earthquake engineering: Case histories of disastrous events” by **G. Gazetas**
16:45 – 17:30	“Dealing with surface waves: laboratory and field experiments” by **A. Colombi**		

Stability and buckling in structural mechanics

by Francesco Dal Corso

A rising paradigm in structural design is the exploitation of (instead of avoiding) mechanical instabilities for attaining exotic behaviours towards the realization of innovative multistable devices, metamaterials, architected structures for vibration mitigation and energy harvesting. Based on simple discrete structural systems, the mechanical principles underlying trivial path restabilization, tensile buckling and buckling loads dependence on constraint's curvature will be disclosed.

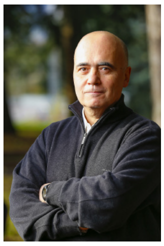
After earning a PhD in Materials and Structural Engineering at the University of Trento, Italy, Francesco Dal Corso won a postdoctoral fellowship at the Department of Applied Mathematics and Theoretical Physics, University of Cambridge. He is currently Associate Professor of Solid and Structural Mechanics at the University of Trento. His research activity is devoted to the Mechanical behaviour of Solid and Structures. He has co-authored over 40 journal papers and has co-guest edited a Special Issue of the Journal of the Mechanics and Physics of Solids in 2020.

Tuesday 1/12 | 9:00 – 10:30

Associative and non-associative elasto-plasticity and stability

by Davide Bigoni

The rate equations of nonassociative elastoplasticity will be introduced with reference to smooth yield function and plastic potential. Based on these incremental equations, stability in the van Hove sense and in the sense of ellipticity will be presented. The role of the acoustic tensor will be detailed. Results will be presented including folding of extremely deformed materials.



Davide Bigoni is a mechanician working in solid and structural mechanics and material modeling, wave propagation, fracture mechanics. His approach to research is the employment of a broad vision of mechanics, with a combination of mathematical modelling, numerical simulation, and experimental validation. From 2001 Davide Bigoni holds a professor position at the University of Trento, where he is leading a group of excellent researchers in the field of Solid and Structural Mechanics. He has authored or co-authored more than 100 journal papers and has published a book on nonlinear Solid Mechanics.

Tuesday 1/12 | 14:00 – 15:30

Suggestions for preliminary Reading

- D. Zaccaria, D. Bigoni, G. Noselli and D. Misseroni Structures buckling under tensile dead load. Proceedings of the Royal Society A, 2011, 467, 1686-1700.
- D. Bigoni, D. Misseroni, G. Noselli and D. Zaccaria Effects of the constraint's curvature on structural instability: tensile buckling and multiple bifurcations. Proceedings of the Royal Society A, 2012, 468, 2191-2209
- Bigoni, D., Bosi, F., Dal Corso, F. and Misseroni, D. (2014). Instability of a penetrating blade. Journal of the Mechanics and Physics of Solids, 64, 411-425.
- Bosi, F., Misseroni, D., Dal Corso, F., Neukirch, S., Bigoni, D. (2016). Asymptotic self-restabilization of a continuous elastic structure. Physical Review E, 94 (6), 063005.
- D. Bigoni (2012) Nonlinear Solid Mechanics Cambridge University Press.

Vibration-based identification of structures

by Antonio Palermo

Vibration responses can be used to characterize and monitor the behavior of civil engineering structures and mechanical components. They are used to estimate the modal parameters, e.g., mode shapes, frequencies, damping ratios, of a structure and thus characterize its dynamic behavior. When the vibration responses are collected with the records of the applied input force/displacement (Input and Output records), one can make use of Experimental Modal Analysis techniques to identify modal parameters. Unfortunately, application of a measurable excitation is often impractical for civil engineering structures. In these scenarios, modal testing procedures based on the vibration response of the structure, known as Operational Modal Analysis (OMA) techniques, are pursued.

After briefly reviewing the fundamentals of structural dynamics and revising some basics techniques of signal processing we will discuss the use of the most common Input-Output and Output-only identification techniques, formulated both in the frequency and time-domain.

Antonio Palermo is a Postdoctoral Fellow in the Department of Civil, Chemical, Environmental and Materials Engineering at the University of Bologna. He received his Civil Engineering degree from the University of Bologna (2011), a MSc in Earthquake Engineering from Imperial College (2013), UK, and a Ph.D in Structural Engineering from the University of Bologna (2017). In 2018, he joined the Department of Mechanical and Civil Engineering at the California Institute of Technology as a “Cecil and Sally Drinkward Postdoctoral Fellow”. His research interests lie at the intersection between solid mechanics, applied physics, and civil engineering with the aim of designing novel materials and structures for elastic wave propagation control.

Wednesday 2/12 | 9:00 – 10:30

Guided waves-based identification of structures

by Alessandro Marzani

Mechanical guided waves can be proficiently used for the diagnostic and monitoring of elongated structures or waveguides. The key aspects of guided waves in this context is their capability to operate long distance reaching thus difficult or inaccessible spots. Among the advantages of guided waves are their increased sensitivity to defects, due to many parameters involved (amplitude, frequency, mode, phase/group velocity), their capability to insonifying the whole volume of the waveguide and thus to detect both internal or external defects, their sensitivity to material properties and waveguide geometric characteristics which allow to use them in inverse approaches for structural identification.

After reviewing the peculiar characteristics of guided waves the lecture will focus on their use in inspection strategies, discussing transductions systems, processing techniques and some applications. In the proposed applications links to concepts investigated nowadays in the framework of metamaterials (dispersion, bragg scattering, mode conversion, negative refraction) will be highlighted.

Alessandro Marzani is Associate Professor of Structural Mechanics and Coordinator of the PhD Program in “Engineering and Information Technology for Structural and Environmental Monitoring and Risk Management - EIT4SEMM” of the University of Bologna. His academic degrees include a PhD from the University of Calabria, a MSc from the University of California San Diego, and a Civil Engineering Diploma from the University of Bologna. His research interests include non-destructive evaluation and health monitoring of materials and structures, guided wave propagation, structured materials for wave propagation control, optimization techniques and structural identification strategies. Dr. Marzani holds three international patents on real time monitoring and system diagnosis specifically dedicated to plate-like systems and pipe system networks.

Wednesday 2/12 | 11:00 – 12:30

Suggestions for preliminary Reading

- Karl F. Graff, Wave Motion in Elastic Solids, Oxford University Press, 1975.
- Joseph L. Rose, Ultrasonic guided waves in solid media, Cambridge University Press, 2014.
- M.J.S. Lowe, D.N. Alleyne, P. Cawley, Defect detection in pipes using guided waves, Ultrasonics, Volume 36, Issues 1–5, 147-154, 1998.
- F.D. Philippe, T.W. Murray, C. Prada, Focusing on Plates: Controlling Guided Waves using Negative Refraction, Scientific Reports, 5, Article number: 11112, 2015.
- M. Paz, Y. H. Kim, Structural Dynamics, Springer 2018
- C. Rainieri, G. Fabbrocino, Operational Modal Analysis of Civil Engineering Structures, Springer 2014
- R. Brincker, C. E. Ventura, Introduction to Operational Modal Analysis, Wiley 2015

Project organization & management in geotechnical engineering and erection of structures

by Christos Vrettos & Simon Meissner

The management of construction projects is mission-oriented, and a holistic approach is required to provide economic planning and construction. The first part of the lecture will summarize basic ingredients for a project management work during the early project phases. Typical issues pertaining to the geotechnical design as part of the integral building design will be addressed.

The project organization and management in geotechnical engineering and erection of large-scale geotechnical structures are important parts for a successful development of projects. Part II of this lecture will be devoted to project examples of deep excavations and foundations of high-rise buildings in urban areas. Special features in planning phase, with i.e. numerical methods, and execution phase will be presented.

Dr. Christos Vrettos holds Dipl.-Ing. and Dr.-Ing. degrees from the University of Karlsruhe, and a habilitation from the Technical University of Berlin. He spent several years in the construction industry and geotechnical consulting. His expertise covers soil mechanics and foundation engineering, soil dynamics and geotechnical earthquake engineering, vibration protection, numerical methods in geomechanics, extra-terrestrial soil mechanics, and terra mechanics. He is member of several code committees, author of numerous publications.

Simon Meissner studied Civil Engineering at the Technical University (TU) of Darmstadt, Germany and the Royal Institute of Technology in Stockholm, Sweden. He received his doctoral degree from the TU Darmstadt in 2014. He is a publicly appointed and sworn expert in geotechnical engineering, foundation engineering/ design and rock construction. He has contributed to the development of numerical methods for a variety of foundation systems, especially of combined piled-raft foundations for high-rise buildings, and is author of numerous publications. He is appointed lecturer at the TU Kaiserslautern and TU Darmstadt.

Tuesday 1/12 | 11:00 – 12:30

Seismic quantitative risk assessment of an LNG storage plant

by Oreste S. Bursi

Refrigerated liquefied gas (RLG) terminals that are part of lifeline facilities must be able to withstand extreme earthquakes. A liquefied natural gas (LNG, ethylene) terminal consists of a series of process facilities connected by pipelines of various sizes. In this lecture, the seismic performance of pipes, elbows and bolted flanges is analysed and seismic fragility functions are presented within the performance-based earthquake engineering framework. More precisely, particular attention is paid to component resistance to leakage and loss of containment even though several different limit states were investigated. The LNG tank, support structures and pipework, including elbows and flanges, were analysed with a detailed 3D finite element model. For this purpose, we developed a mechanical model of bolted flange joints, able to predict the leakage limit state, based on experimental data. A significant effort was also devoted to identification of a leakage limit state for piping elbows, and we found the level of hoop plastic strain to be an indicator. Given the complexity of the FE model of the LNG plant, we selected the Cloud method for probabilistic seismic demand analysis. Then, using a series of nonlinear time history analyses, we studied the behaviour of critical components such as elbows and bolted flange joints. In order to develop fragility curves, we selected a set of 36 ground motions from a database of historic earthquake accelerations. To evaluate the extension of a cloud due to explosion in an elbow,, coupled fluid-dynamic simulations were carried out. Finally, the average rate of fatalities per year was computed and a classification of risk level based on the EN 1473 was performed.

Oreste S. Bursi
University of Trento, Italy

Oreste S. Bursi graduated in Mechanical Engineering at the University of Padua in 1984, and achieved his PhD. in Mechanical Engineering at the University of Bristol. He is full Professor of Structural Dynamics and Control at the University of Trento since 2001. He has always been interested in complex dynamical non-linear systems consisting of structural and mechanical components as well as control devices. Devices have been used both to control in real time or test dynamical systems subjected to natural hazards based on computer hardware and software. Thus, through the analysis and design of such complex systems that require both advanced modelling and simulation and experimental techniques, Oreste S. Bursi has built up his scientific background tailored to multidisciplinary problems. As a result, he became a leading researcher in Europe in the area of heterogeneous dynamic substructure coupling. Recently, he addressed his research interests towards quantitative risk assessment of critical petrochemical facilities subjected to technological accidents triggered by natural disasters; and relevant vibration mitigation of process plant components/systems by means of linear and non-linear finite lattices (metamaterials). http://r.unitn.it/en/dicam/nhmsdc
http://me.unitn.it/oreste-bursi/

Tuesday 1/12 |16:00 – 16:45 &
Wednesday 2/12 |14:45 – 15:30

Probabilistic seismic hazard analysis and fragility functions - Hands-on tutorials

by Chiara Nardin

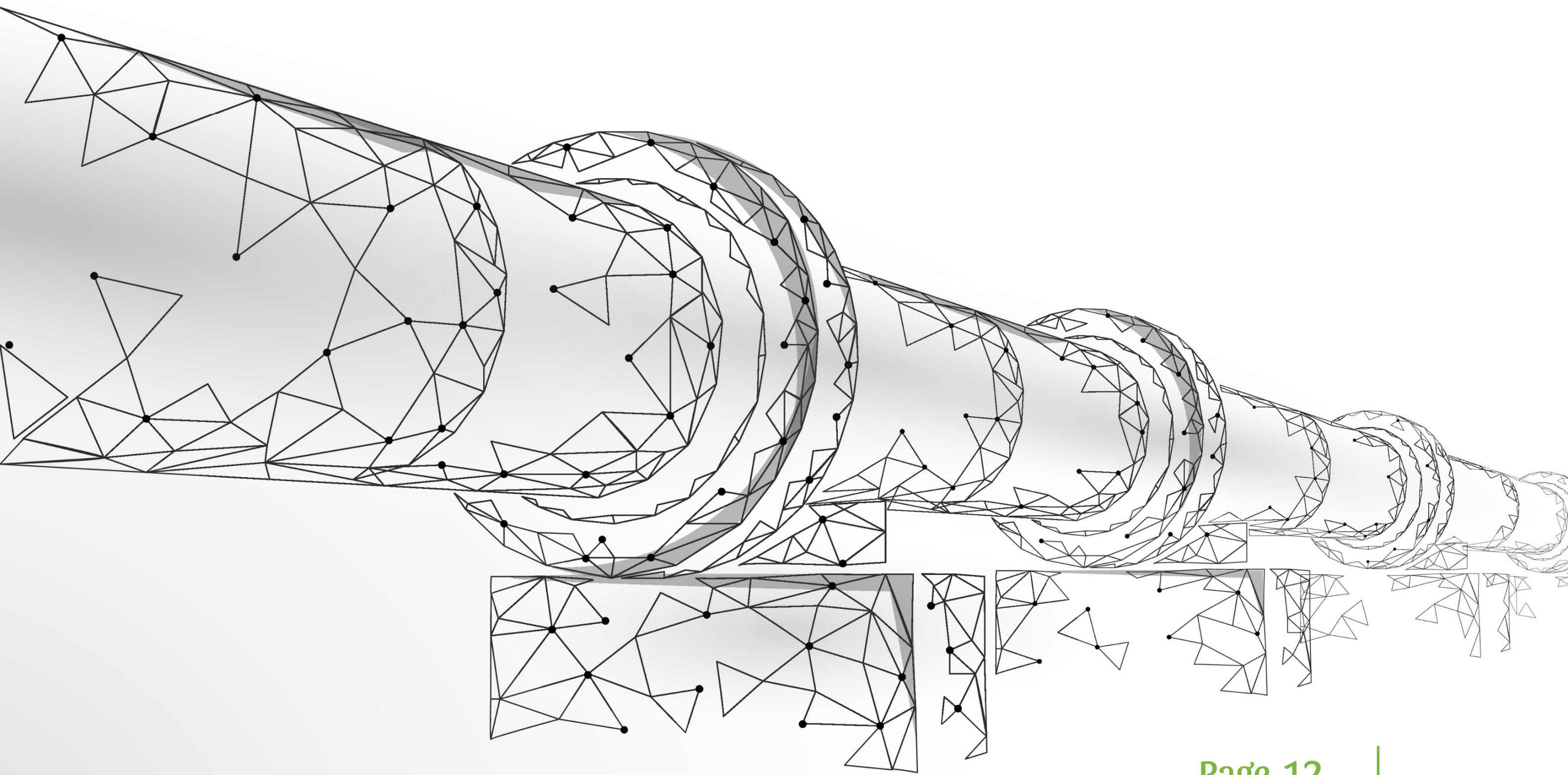
During the last decades, effects and consequences of several and catastrophic seismic events produced a change of perspective on design and build structures' processes. In these perspective, also technical codes have enhanced and changed from a prescriptive to a performance approach. Along this vein, the PEER framework of Performance Based on the total probability theorem, PBEE's goal is to assess performance of systems in terms of different decision variables such as monetary losses, downtime, fatalities etc. by integrating four distinct stages: (i) hazard, (ii) structural/fragility, (iii) damage and (iv) loss analysis. In these lectures, a focus on the first two steps of PBEE's framework is carried on. In a greater detail, in order to perform hazard and fragility analysis for a real case-studio application, integrated MATLAB procedures are illustrated.

Chiara Nardin is Civil engineer fulfilling a Ph.D. programme in Modelling and Simulation at the Department of Civil, Environmental and Mechanical Engineering of the University of Trento. She received her M.Sc. degree with summa cum laude in 2019, discussing a thesis on Evaluation of fragility functions of structural systems for risk analysis based on Markovian processes. She positively attended APESS 2019 - Asia-Pacific-Euro Summer School on Smart Structures Technology ranking first in the challenging competition on data analysis and development of advanced sensor technologies for structural health monitoring systems (SHM). Her research interests rely on risk analysis and fragility assessment of civil and process plant infrastructures, with a special attention to industrial facilities under severe seismic events. She is passionate about design of complex systems that require both mathematical and advanced FE modelling, validated through experimental tests. Recently, she is actively involved, inside the European SERA SPIF's Project, in experimental campaign's design phases and in the development of a suitable ground motion model for shaking table tests of a real-scale steel moment resisting frame structure equipped with complex process components. As a result, she is currently authoring and publishing several Journal papers on the aforementioned activities.

Wednesday 2/12 |16:00 – 17:30

Suggestions for preliminary Reading

- Natech Risk Assessment and Management - Reducing the Risk of Natural-Hazard Impact on Hazardous Installations, E. Krausmann, A. M. Cruz, E. Salzano, Editors, Elsevier, 2017.
- Bursi, O. S., di Filippo R., La Salandra, V., Pedot, M. Reza, Md S., "Probabilistic seismic analysis of an LNG subplant", Journal of Loss Prevention in the Process Industries, Special Issue on Risk Analysis in the Process Industries: State of the Art and the Future, Vol. 53, 2018, 45-60.
- Caputo, A., C., Paolacci, F., Bursi, O.S., Giannini, R., " Problems and perspectives in seismic Quantitative Risk Analysis of chemical process plants", Journal of Pressure Vessel Technology, 2019, 141(1):010901-010901-15. PVT-17-1245, doi: 10.1115/1.4040804.
- Baker J. W. (2008). An Introduction to Probabilistic Seismic Hazard Analysis (PSHA), White Paper, Version 1.3.
- Cornell, C.A. (1968). Engineering seismic risk analysis, Bull. Seism. Soc. Am., 58, 1583-1606.
- Porter, Keith. (2003). An Overview of PEER's Performance-Based Earthquake Engineering Methodology. Proc. Ninth International Conference on Applications of Statistics and Probability in Civil Engineering (ICASP9).



Dealing with surface waves: laboratory and field experiments

by Andrea Colombi

Surface waves can be responsible for significant seismic-related damages as carrier of groundborne vibrations.

In this lecture a few examples from previous and current research projects dealing with surface waves, metamaterials and structures will be presented and discussed. After introducing, from a seismological perspective Rayleigh and Loves waves, we will explore under what conditions closely spaced buildings may interact when excited by seismic surface waves. Using the results from the “metaforest experiment”, where trees have been used as local resonators to mimic a large-scale metamaterial, we will see how array methods (e.g. beam forming, cross-correlation, frequency wavenumber representation) can be used to extract the intimate details of the wave propagation in a complex scenario. Finally, we will discuss a few laboratory experiments and numerical simulations that have been particularly successful in reproducing surface waves and metamaterials in scaled set-ups.

After 5 years spent at the Institute des Sciences de la Terre at the Universite Grenoble-Alpes (France) and at Imperial College London (UK), I returned to ETH Zurich, the university where I earned a doctoral degree in 2013. Although my undergraduate studies are in engineering, I am both a seismologist and a numerical scientist with a keen interest for dynamics problems, in particular multiscale ones difficult to reproduce experimentally. My research projects span from the micro to the geophysical scale involving time and frequency domain simulations, analytical modelling, laboratory and field experiments. Currently I run a research group funded by the Swiss Science National Foundation and the EU on structured- and meta- materials. With the help of a team of PhD students and postdocs here at ETH, and a network of international collaborators, I develop numerically and experimentally new materials and mechanical structures able to control the propagation of elastic waves. During my 10 years in science, I have received a number of prestigious fellowship and grants including the Marie Sklodowska Curie fellowship, the Ambizione fellowship and a FET-Proactive.

Tuesday 1/12 | 16:45 – 17:30

Suggestions for preliminary Reading

- https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2000RG000100
- https://www.researchgate.net/publication/311716859_Experimental_and_Numerical_Evidence_of_the_Clustering_Effect_of_Structures_on_Their_Response_during_an_Earthquake_A_Case_Study_of_Three_Identical_Towers_in_the_City_of_Grenoble_France
- https://www.researchgate.net/publication/340111260_Locally_Resonant_Metasurfaces_for_Shear_Waves_in_Granular_Media
- https://www.researchgate.net/publication/337759005_Evidence_of_metamaterial_physics_at_the_geophysics_scale_the_METAFORET_experiment

Experimental approaches for seismic protection of structures and infrastructures

by Georgios Tsionis

Large-scale testing is essential to understand the response of physical infrastructures and their components when subjected to earthquake actions. The European Laboratory for Structural Assessment (ELSA) operates a reaction wall of unique dimensions and capabilities for mono- or bi-directional testing of real-size multi-storey buildings and of critical elements of even larger structures, such as bridges. The lecture will build on the long experience of ELSA in the development of experimental methods and practices (control, measurement techniques, etc.). It will present examples of recent large-scale testing campaigns at the ELSA reaction wall as well as their contribution to codes and standards for the seismic design of structures. The lecture will also present a database for storing and sharing experimental data from earthquake engineering research infrastructures.

Georgios Tsionis is a scientific officer at the European Commission's Joint Research Centre. He holds a Diploma in Civil Engineering from the University of Patras and a PhD in Earthquake Engineering from the Technical University of Milan. He has 20 years experience in research in the field of earthquake engineering and in standards for the construction sector. His research interests include large-scale experimental testing, numerical modelling and fragility analysis of reinforced concrete structures under seismic loading, risk and resilience assessment of the built environment. Since 2014, he coordinates the activities for access to the ELSA Reaction Wall and HopLab research infrastructures of the Joint Research Centre and for networking of research infrastructures. Currently, he contributes as well to a pilot project on integrated techniques for the seismic strengthening and energy efficiency of the European building stock.

Thursday 3/12 | 14:00 – 15:30

Wave propagation in earthquake engineering: Case histories of disastrous events

by George Gazetas

A phenomenon of major importance in earthquake engineering stems from the passage of seismic waves through the soil layers under a structure. Depending on their frequencies, the amplitude of these waves may be enhanced or reduced, resulting in ground shaking that differs from site to site as a function of the soil characteristics. The term "soil amplification" has been used to describe the often disastrous consequences of such wave effects.

The lecture, after briefly outlining the fundamentals of soil amplification, presents a number of case histories illuminating the phenomenon in some notorious earthquakes. The focus is on the Mexico City recorded motions ("accelerograms") and distribution of damage during the earthquakes of 1985 and 2017 which are analysed in depth. It is shown how vertically incident shear waves, propagating one-dimensionally through the soft and deep clay deposit, can explain most of the observed effects ; but also that Rayleigh and Love waves originating at the edges of the Mexico City basin could offer some explanation of the recorded huge duration of the motions in the form of several low frequency "beating" cycles. The effect of the vibration of structures on the recorded motions in the free field (called "soil-structure-soil" interaction) may also have an effect. Other historic earthquake events are analysed involving both detrimental and beneficial effect of soil "amplification".

Suggestions for preliminary Reading

- E Garini, G Gazetas, K Ziotopoulou,"Inelastic soil amplification in three sites during the Tokachi-oki MJMA 8.0 earthquake", Soil Dynamics and Earthquake Engineering 110, 300-317 2018.
- E Garini, G Gazetas, I Anastasopoulos, Evidence of significant forward rupture directivity aggravated by soil response in an Mw6 earthquake and the effects on monuments," Earthquake Engineering & Structural Dynamics 46 (13), 2103-2120 2017.
- Gelagoti F., Kourkoulis R., Anastasopoulos I., Gazetas G., "Nonlinear Dimensional Analysis of Trapezoidal Valleys Subjected to Vertically Propagating SV Waves", Bulletin of Seismological Society of America, Vol. 102 (3), 199-1017, 2012.

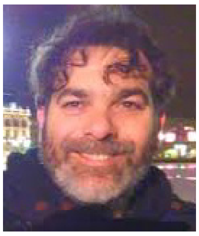
Professor of Geotechnical Engineering at the National Technical University of Athens (Greece) for 30 years, following an academic career in the US, where he taught at SUNY-Buffalo, Rensselaer (RPI), and Case Western Reserve University. His main research interests have focused on Soil Dynamics and Soil-Structure Interaction. Much of his research has been inspired by observations after destructive earthquakes. An active writer and teacher, he has been a consultant on a variety of (mainly dynamic) geotechnical problems. He is recipient of many awards, including the James Croes Medal, the Alfred Noble Prize, and the Walter Huber Civil Engineering Research Prize from the American Society of Civil Engineers (ASCE). He has given several prestigious lectures sponsored by international geotechnical societies, including the 2009 "Coulomb", the 2013 "Ishihara", and the 2019 "Maugeri" Lectures . In 2015 he received the "Excellence in University Teaching" award from the Institute of Science and Technology of Greece, and in March 2019 he delivered the 59th Rankine Lecture in London.

Thursday 3/12 | 16:00– 17:30

Control of mechanic and thermal energy by advanced artificial materials

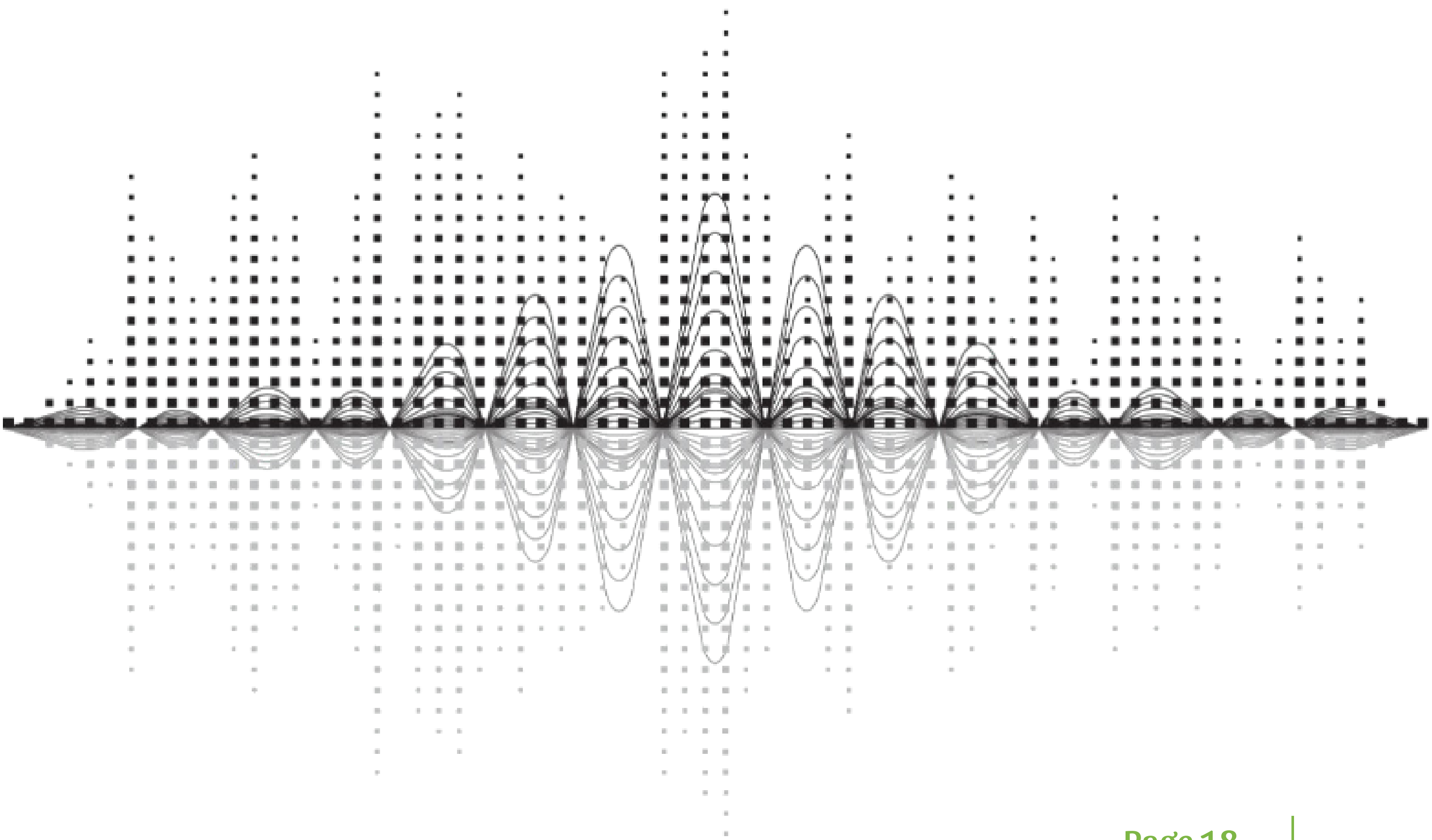
by Daniel Torrent

The control of acoustic and thermal energy is a challenging problem with a broad range of applications. In this talk we will review mechanisms to achieve this control by means of artificial structures specially designed for this purpose. It will be shown that a spatio-temporal modulation of the thermal properties of a material can induce non-reciprocity on it, and numerical simulations will be presented to illustrate this behavior, as well as several proposals for their realization. Later on, it will be shown how engineered gratings can be used to modulate the flow of acoustic and elastic energy towards specific directions, and a very efficient inverse design method will be presented. Some applications will be summarized, and the experimental realization of an acoustic carpet cloak based on these structures will be presented.



Daniel Torrent was born in Castellón de la Plana (Spain), in May 19th, 1979. He studied physics at the University of Valencia and obtained his PhD in the Electronics Engineering Department of the Polytechnic University of Valencia, in 2008. During his career he has contributed to the development of both theoretical and experimental tools to understand the propagation of acoustic, elastic and electromagnetic waves in complex media. After four years of research stays in the University of Lille (France) and the University of Bordeaux – CNRS (France), he has been awarded by the "Ramón y Cajal" Fellowship, and currently is working as a researcher at the "Univeritat Jaume I" in Castellón de la Plana.

Wednesday 2/12 | 14:00 – 14:45



Suggestions for preliminary Reading

- Nayfeh, A.L., and Mook, D.T., Nonlinear Oscillations, John Wiley & Sons, Inc., Weinheim, 1995.
- Vakakis, A.F., Gendelman, O.V., Bergman, L.A., McFarland, D.M., Kerschen, G. and Lee, Y.S., Nonlinear Targeted Energy Transfer in Mechanical and Structural Systems, Vol. I & II, Springer, New York, 2008.
- Fermi, E., Pasta, J., and Ulam, S., 1955, Studies of nonlinear problems, Los Alamos Scientific Lab. report LA-1940.
- Chakraborty, G. and Mallik, A.K., 2001, Dynamics of a weakly non-linear periodic chain, International Journal of Non-Linear Mechanics, 36(2), 375 - 389.
- Lazarov, B.S. and Jensen, J.S., 2007, Low-frequency band-gaps in chains with attached with non-linear oscillators, International Journal of Non-linear Mechanics, 42(10), 1186-1193.
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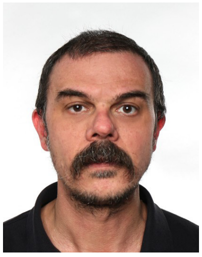
- Vigran, T. E. (2008). Building Acoustics. CRC Press.
- Cox, T. J. and D'antonio, P. (2009) Acoustic absorbers and diffusers: theory, design and application. Crc Press.
- Springer Handbook of Acoustics (2014) Springer Handbook of Acoustics. Springer New York. doi: 10.1007/978-1-4939-0755-7.
- I.A. Antoniadis, A. Paradeisiotis, Acoustic Meta-materials Incorporating the KDamper Concept for Low Frequency Acoustic Isolation, Acta Acustica United with Acustica, Vol. 104, Iss.1 (2018).

An introduction to nonlinear metamaterials

by Vasilis Dertimanis

A new concept for passive vibration mitigation has emerged by the exploration of metamaterials. The latter comprise a special class of periodic structures, characterized by fascinating filtering effects: when the frequency of the incoming excitation falls into their "blind" zone, the propagation of motion is arrested in any direction, thus forming a "band-gap". An associated challenge, however, lies in the size of the band-gap, as well as in the arbitrary selection of the low-frequency threshold, which is critical in many engineering applications. A solution to this problem is the introduction of nonlinearities into the metamaterial. In this short course, we will review the recent advances on the field, after introducing the fundamentals of nonlinear dynamics.



Vasilis Dertimanis received a Diploma in Mechanical Engineering from the University of Patras, Greece, and the Ph.D. Degree from the National Technical University of Athens (NTUA), Greece, in the area of modeling and identification of faults in mechanical and structural systems. His research interests lie in the areas of structural identification and health monitoring, linear and nonlinear state estimation, active and passive structural control, hybrid testing and optimization. Vasilis has served as a senior researcher in the NTUA Vehicles Laboratory, Machine Design Laboratory and Laboratory for Earthquake Engineering. He has also participated as a Marie Curie experienced researcher to the EU funded SmartEN ITN project. For more than a decade, he has been in parallel self-employed as a freelancer engineer and inspector, as instructor in training seminars on transportation of dangerous goods by road/rail, as well as a measurement engineer and structural vibration analyst. Since January 2014, Vasilis has been a member of the Chair of Structural Mechanics and Monitoring in ETH Zurich and as of May 2017, he is Senior Assistant and Lecturer.

Thursday 3/12 | 9:00 – 10:30

Fundamentals of acoustics and noise insulation

by Andreas Paradeisiotis

Engineering Acoustics - Challenges: Noise isolation and absorption in rooms, buildings, transportation media and outdoor areas. Physics and perception of sound: Sound pressure, frequency bands and sound measurements. Sound propagation: 1D propagation, point and spherical sources, propagation in the presence of impedance mismatch, bending waves in solids. Sound absorbers and diffusers: Porous materials, membranes, cavities. Room acoustics: Reverberation, modal density, and technical standards. Noise transmission: Single and double leaf walls, Sound Transmission Loss, modelling and analysis, road noise. Structure-borne noise: Radiation of structural elements and mitigation procedures.

Dr Andreas Paradeisiotis, Research Assistant, National Technical University of Athens (NTUA), Greece. Graduated as a Mechanical Engineer from the NTUA in 2014 where he also earned his PhD in Mechanical Engineering in 2019. He is currently Research Assistant at the Dynamics & Structures Laboratory (DSL), Department of Mechanical Design & Automatic Control in the School of Mechanical Engineering at the NTUA. He has participated in two national and two European research projects and also the COST Action: Designs for Noise Reducing Materials and Structures (DENORMS). He assists in the teaching of undergraduate courses and he is the co-author of academic course notes on Flight Dynamics & Control, Machine Dynamics, Mechanisms & Machine Theory and one academic e-book on Flight Dynamics & Control. He has published over ten papers in peer-reviewed international journals and conferences. His research interests and expertise include vibration control, energy harvesting from ambient excitation, acoustic metamaterials, and passive and active noise control with emphasis in transportation media and building acoustics.

Thursday 3/12 | 11:00 – 12:30

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