

TIME TABLE

TIME	Monday September 5	Tuesday September 6	Wednesday September 7	Thursday September 8	Friday September 9
09.00 - 09.45	Registration	Cruz	Cruz	Cozzani	Bursi
09.45 - 10.30	Cruz	Cruz	Cruz	Cozzani	Bursi
11.00 - 11.45	Nascimbene	Krausmann	Paolacci	Bursi	Paolacci
11.45 - 12.30	Nascimbene	Krausmann	Paolacci	Bursi	Paolacci
14.00 - 14.45	Krausmann	Nascimbene	Cozzani	Cozzani	
14.45 - 15.30	Krausmann	Nascimbene	Cozzani	Cozzani	
16.00 - 16.45	Nascimbene	Krausmann	Paolacci	Bursi	
16.45 - 17.30	Nascimbene	Krausmann	Paolacci	Bursi	
18.00	Welcome aperitif				

ADMISSION AND ACCOMMODATION

The course is offered in a hybrid format giving the possibility to attend the course also by remote (on Microsoft Teams platform). On-site places are limited and assigned on first come first served basis.

The registration fees are:

- On-site participation, 600.00 Euro + VAT*

This fee includes a complimentary bag, five fixed menu buffet lunches, hot beverages, downloadable lecture notes.

Deadline for on-site application is August 5, 2022.

- Online participation, 250.00 Euro + VAT*

This fee includes downloadable lecture notes.

Deadline for online application is August 25, 2022.

Application forms should be sent on-line through the following web site: <http://www.cism.it>

A message of confirmation will be sent to accepted participants.

Upon request a limited number of on-site participants can be accommodated at CISM Guest House at the price of 30 Euro per person/night (mail to: foresteria@cism.it).

** where applicable (bank charges are not included)
Italian VAT is 22%.*

CANCELLATION POLICY

Applicants may cancel their registration and receive a full refund by notifying CISM Secretariat in writing (by email) no later than:

- August 5, 2022 for on-site participants (no refund after the deadline);
 - August 25, 2022 for online participants (no refund after the deadline).
- Cancellation requests received after these deadlines will be charged a 50.00 Euro handling fee. Incorrect payments are subject to Euro 50,00 handling fee.

GRANTS

A limited number of participants from universities and research centres who are not supported by their own institutions can request the waive of the registration fee and/or free lodging.

Requests should be sent to CISM Secretariat by **July 5, 2022** along with the applicant's curriculum and a letter of recommendation by the head of the department or a supervisor confirming that the institute cannot provide funding. Preference will be given to applicants from countries that sponsor CISM.

For further information please contact:

CISM

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Centre International des Sciences Mécaniques
International Centre for Mechanical Sciences



ACADEMIC YEAR 2022
The Magnus Session

NATECH RISK: MANAGEMENT STRATEGIES AND RESILIENCE TOWARDS TECHNOLOGICAL ACCIDENTS CAUSED BY NATURAL EVENTS

Advanced Professional Training
coordinated by

Valerio Cozzani
University of Bologna, Italy

Fabrizio Paolacci
Roma Tre University, Rome, Italy

Udine September 5 - 9 2022

NATECH RISK: MANAGEMENT STRATEGIES AND RESILIENCE TOWARDS TECHNOLOGICAL ACCIDENTS CAUSED BY NATURAL EVENTS

The relevance and the potentially tremendous impact of technological accidents triggered by natural events, such as earthquakes, tsunamis, floods, etc., referred to as natural-technological (NaTech) events, was demonstrated, for instance by the 2011 Tohoku earthquake and the following Fukushima nuclear disaster in Japan or by the 2015 winter floods in UK which topped £5bn. NaTech scenarios may have severe direct consequences and long-term effects due to the release of hazardous chemicals or fuels, and/or of Chemical, Biological, Radiological, Nuclear and high yield Explosives (CBRNE) substances. The control and management of risk due to Natech events is among the requirements of the Seveso-III Directive (2012/18/EU), which regulates the control of major accident hazards involving dangerous substances. This course aims to offer to students, scholars, and practitioners a clear overview of the problems and the available solutions for the

prevention and mitigation of Natech events, addressing both the control and management of risk and the enhancement of system resilience. The course will be a unique occasion to familiarize with this hot topic and to be in contact with the risk and resilience community. Six learning units will be delivered. The first introduces the specific Natech hazards and the features of Natech scenarios in the process industry, providing a clear analysis of the current state of the art and of future challenges. The second unit is focused on the vulnerability of industrial equipment to natural hazards. This important ingredient of Natech risk assessment is here analysed in depth, identifying possible damages caused by natural disasters to critical units and release modes of hazardous materials that may be triggered. Fragility analysis methods for industrial equipment are formulated and applied to specific examples. The third unit is devoted to Natech risk assessment in process and chemical plants. Existing approaches

(qualitative and quantitative) are discussed, and the role of the main ingredients (hazard, vulnerability, consequences) identified. Critical aspects, (e.g. cascading events) related to the consequence of damages caused by natural events (e.g. earthquake), are also discussed and examples pertaining to the process and energy industry are studied and discussed. The mitigations strategies currently available to reduce Natech risk are analyzed in the fourth unit. More specifically, a cutting-edge technology is introduced, which is based on the concept of metamaterial. In particular, metamaterial-based technologies are presented in the light of the large advantages that this new technology offers. Examples of the new concept of meta-foundations are presented and a smart mitigation strategy to reduce the seismic risk of storage tanks containing hazardous material is discussed. In the fifth unit, resilience concepts are formulated and applied to industrial plants, addressing

specifically Natech events. A new general method for the quantification of resilience indexes, as economic losses and business continuity, is introduced and applied to case-studies addressing the process industry when impacted by severe natural events. The last unit is dedicated to the role of safety barriers in Natech scenarios. The possible loss of integrity of safety barriers in Natech events is discussed. The role of utilities in assuring the availability of control, safety and emergency systems during intense natural events will also be addressed. The assessment of safety barrier performance will be analyzed in the light of the available key enabling models for Natech risk quantification and of methodologies currently available for the evaluation barrier performance. The role of safety barriers in protecting asset integrity and promoting system resilience will also be discussed.

LECTURERS

Oreste S. Bursi - University of Trento, Italy
6 lectures on: Phononic periodic materials and finite lattice resonant metamaterials; main issues of random vibrations; seismic input modelling; system modelling and reduction of a foundation-tank system including nonlinear components; seismic input model; optimization procedures both in frequency domain; numerical spectral dispersion relationships for uncoupled periodic resonant metamaterials traced by means of spectro-spatial analysis; issues with the vertical component of earthquakes.

Valerio Cozzani - University of Bologna, Italy
6 lectures on: Quantitative risk assessment of Natech events. Cascading events in Natech scenarios and domino effects. Integrity of utilities and of safety barriers. Safety barriers performance in Natech events.

Ana Maria Cruz - Kyoto University, Japan
5 lectures on: Understanding Natech events. Features of Natech accidents. Examples and case-studies. Promoting awareness and resilience to Natech events.

Elisabeth Krausmann - Joint Research Center, Ispra, Italy
6 lectures on: Natech hazard and risk assessment in process and energy systems. Methods for the screening of Natech hazard. The Rapid-N tool. Natech within the Sendai framework. The EU regulatory framework.

Roberto Nascimbene - IUSS, Pavia, Italy
6 lectures on: Vulnerability of industrial plant equipment to natural hazards. Seismic analysis of rigid and flexible tanks (steel, rc, fiber-glass); equivalent mechanical model and some basis of advanced finite element; soil tank interaction; piping vulnerability and non structural components; design and verification of silos and tanks using codes and guidelines (EC8, NZ, API, AWWA, ACI); examples and case studies.

Fabrizio Paolacci - Roma Tre University, Italy
6 lectures on: Resilience of process plants under Natech events: Introduction to Resilience Concept and metrics, Deterministic and probabilistic approaches in resilience calculation, Methodologies for Resilience quantification of process plants in seismic areas under Natech events, future perspectives.

LECTURES

All lectures will be given in English. Lecture notes can be downloaded from the CISM web site. Instructions will be sent to accepted participants.

PRELIMINARY SUGGESTED READINGS

Krausmann, E., Cruz, A.M., Salzano, E., 2016. Natech Risk Assessment and Management: Reducing the Risk of Natural-Hazard Impact on Hazardous Installations. Elsevier.

Bursi, O.S., Basone, F. and Wenzel, M., 2021. Stochastic analysis of locally resonant linear and hysteretic metamaterials for seismic isolation of process equipment", Journal of Sound and Vibration, 510, 116263.

Misuri, A., Cozzani, V., 2021. A paradigm shift in the assessment of Natech scenarios in chemical

and process facilities. Process Safety Env. Protection, 2021, 152, 338–351.

Franchini, A., Bursi, O.S., Basone, F. and Sun, F., 2020. Finite locally resonant metafoundations for the protection of slender storage tanks against vertical ground accelerations, Smart Materials and Structures, 29(5), 055017.

Kalemi B., Caputo A., Corritore D., Paolacci F., 2020. Computing Resilience of Process Plants under Natech Events: Methodology and Application to Seismic Loading Scenarios, Reliability Engineering

and System Safety, 195, 106685.

D. Brunesi E., Nascimbene R., Pagani M., Bellic, 2015. Seismic performance of storage steel tanks during the May 2012 Emilia, Italy, Earthquakes. J. Performance Constructed Facilities, 29.

Ozsarac V., Brunesi E., Nascimbene R., 2021. Earthquake-induced nonlinear sloshing response of above-ground steel tanks with damped or undamped floating roof. Soil Dyn. and Earth. Eng., 144, 106673.

Krausmann, E., Necci, A., 2021. Thinking the unthinkable: A

perspective on Natech risks and Black Swans. Safety Science, 139, 105255.

Suarez-Paba, M.C., Cruz, A.M., 2021. A paradigm shift in Natech risk management: Development of a rating system framework for evaluating the performance of industry. J. Loss Prev. Proc. Ind., 74, 104615.

Ricci, F., Casson Moreno, V., Cozzani, V., 2021, A Comprehensive Analysis of the Occurrence of Natech Events in the Chemical and Process Industry. Proc. Safety Env. Prot., 147, 703–713.