MS2
Mechanics of Sustainable Materials and Structures

Triple-Master's degree in **Civil Engineering**
"Mechanics of Sustainable Materials and Structures"

technische universität dortmund

UNIVERSITÀ DI TRENTO

CENTRALE NANTES

Co-funded by the European Union

December 16, 2025

Mechanics of Sustainable Materials and Structures – MS^2

Why this program?

Building constructions and operations show a high environmental footprint, with 36% of global energy consumption and 39% of CO_2 emissions, superior to transportation (33%) and industrial activities (29%). The latest report of the United Nations Environment Program shows that a significant part of this intense exploitation of resources (28%) finds its roots in the use of materials and that the demand for buildings and floor area is growing and expected to double by 2060. Within this framework, innovative building technologies employing low-carbon materials and proposing novel low-impact structural solutions are of paramount importance in embodied carbon reduction, with the aim to reduce construction-related CO_2 emissions through:

- *improved design of buildings and structures*
- *lifetime extension and vulnerability reduction*
- *low-impact structural design*
- *building material optimization and waste reduction through reuse and recycling*
- *sustainable management of renewable energy resources*

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Mechanics of Sustainable Materials and Structures – MS^2

Program's objectives

This program is designed to train a new generation of civil engineers as future leaders in the development of innovative solutions for sustainability and performance in the built environment by fostering creative and independent thinking and promoting low-impact oriented problem-solving. This is done by providing a solid background in fundamental mechanics, coupled with cutting-edge research in innovative materials and structures, and a research and development environment in the private sector.

This cocktail of solid fundamental skills, innovative research and link to the private sector is the perfect environment to train engineers capable to provide innovative solutions to the global today's challenges.

The program qualifies graduates for research-related and technical professional activities in the areas of

» *Advanced Mechanics for Innovative Materials and Structures*

» *Materials and Structures under Extreme Conditions*

» *Materials and Structures in their Environment*

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Mechanics of Sustainable Materials and Structures – MS^2

Prospective students

The main target group are international students from EU and non-EU countries, with a high degree of mobility and a willingness to study in an intercultural dimension.

The main skills of the students trained under this program will be in the **mechanical modeling and simulation of materials and structures**.

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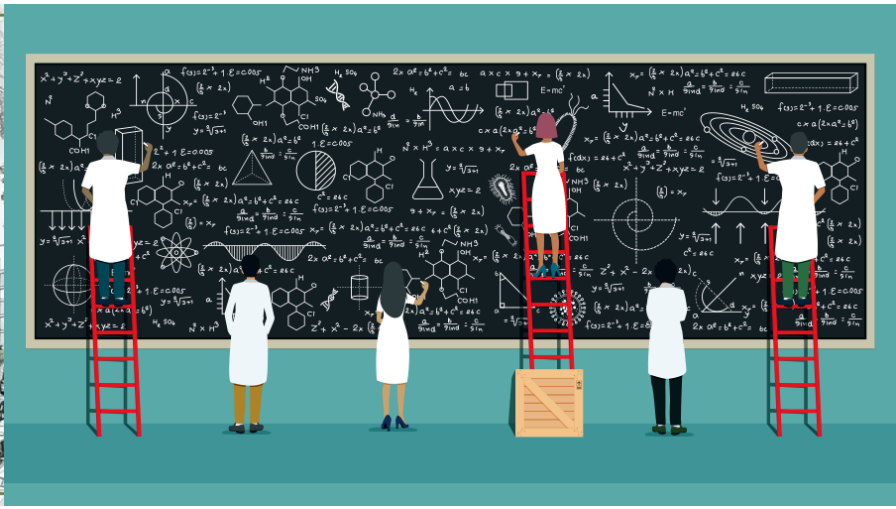
Mechanics of Sustainable Materials and Structures – MS^2

The MS^2 graduate will be part of a new generation of engineers and civil engineers with a high level of expertise specialised, trained to achieve an open sensitivity towards sustainable solutions.

Working perspectives

International contexts and in large frontier industrial realities pursuing new strategies of design and realisation of civil constructions

Small companies focused on specific and innovative applications, based on a deep understanding of mechanics



Enrolling to PhD courses in the Mechanics of Materials and Structures to pursue an academic career, as well as working in research centers

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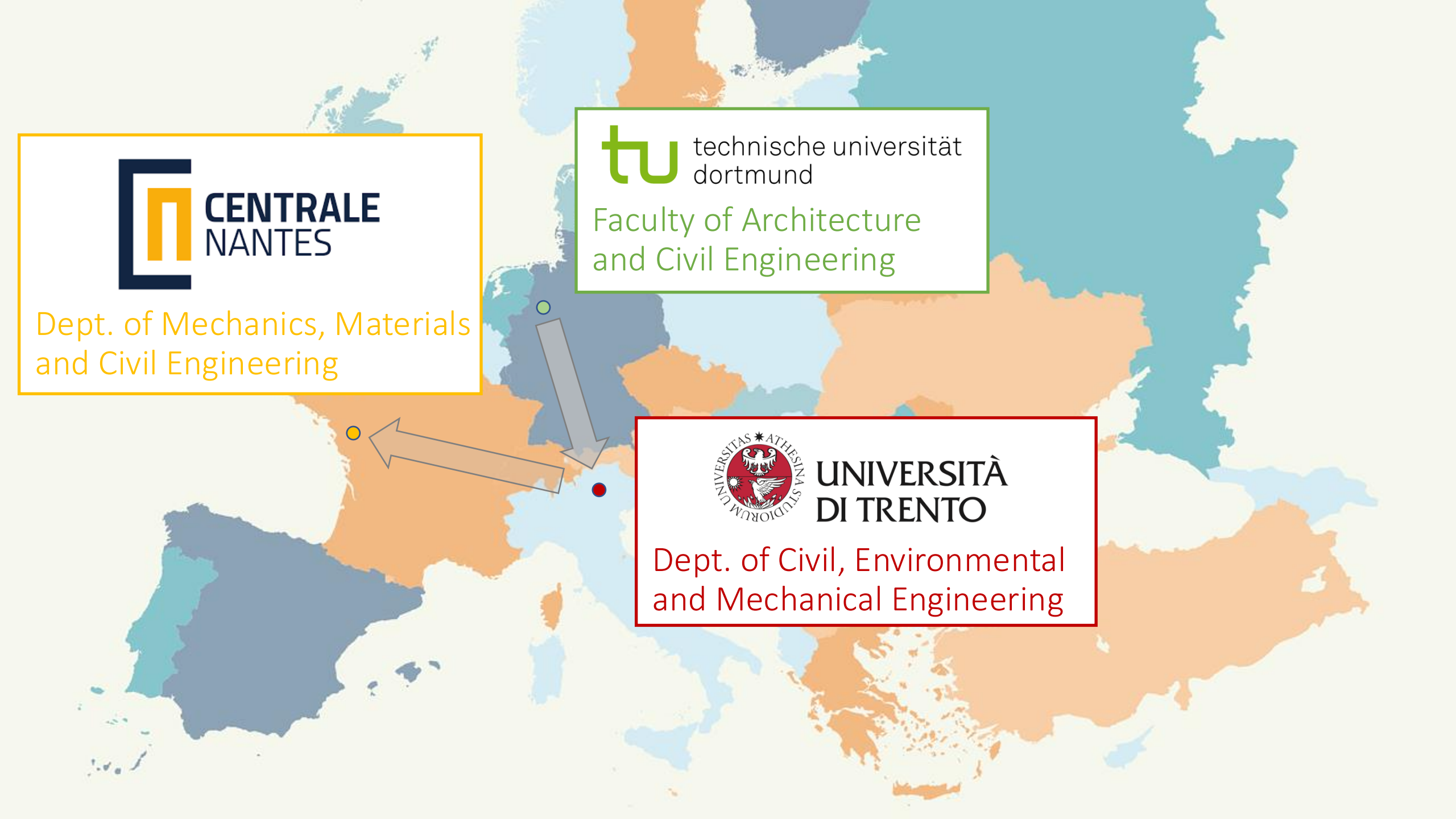
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UNIVERSITÀ DI TRENTO
Dept. of Civil, Environmental and Mechanical Engineering

Mechanics of Sustainable Materials and Structures – MS^2

Program's structure

technische universität dortmund

1st Semester

30 ECTS (Courses)

Sept 14 – Dec 22, 2026

UNIVERSITÀ DI TRENTO

2nd Semester

30 ECTS (Courses)

Feb 16 – May 26, 2027

CENTRALE NANTES

3rd Semester

30 ECTS (Courses)

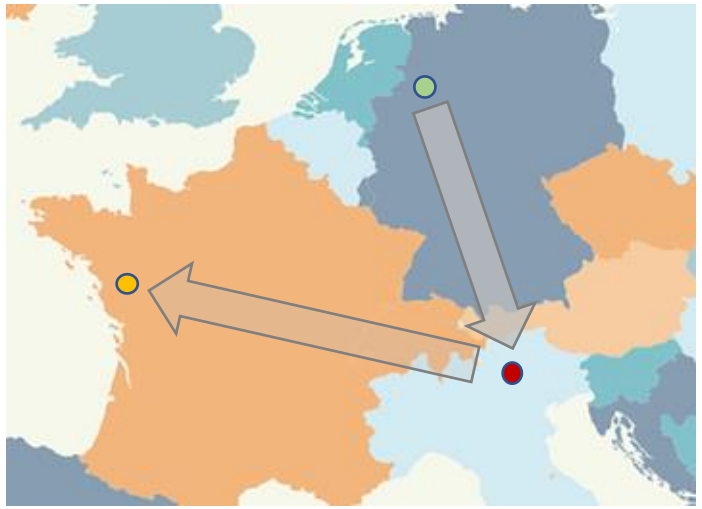
Sept 1, 2027 – Jan 15, 2028

Location selected by the student

4th Semester

30 ECTS (Master Thesis)

Apr 1 – Sept 30, 2028



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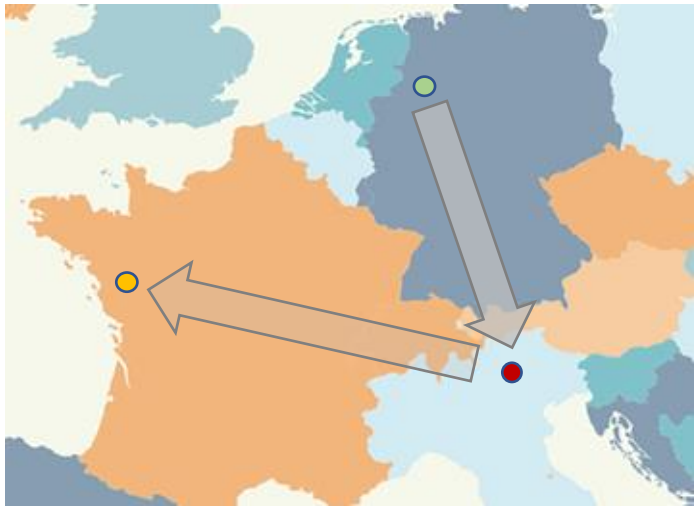
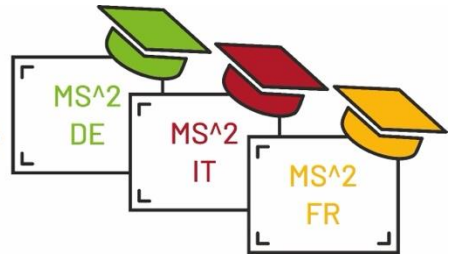


SEMESTER 1	SEMESTER 2	SEMESTER 3	SEMESTER 4
Advanced Mechanics for Innovative Materials and Structures	Materials and Structures under Extreme Conditions	Materials and Structures in their Environment	Master Thesis
TU Dortmund [DE]	UniTrento [IT]	EC Nantes [FR]	World



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Mandatory Courses (4)	ECTS
Engineering mathematics	5
Advanced continuum mechanics	8
Enriched continua and metamaterials	5
Nonlinear structural analysis	6

Elective Courses (2 among 4)	ECTS
Construction with trees in practice	3
«How sustainable can building materials be?»	3
Structural systems in engineering practice	3
Organic design and structures	3

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Mandatory Courses (4)	ECTS
Stability of structures	6
Modeling and simulation of structures	6
Mechanics of solids and structures under extreme conditions	6
Machine learning for wireless structural health monitoring	6

Elective Courses (1 among 2)	ECTS
Metastructures	6
Risk analysis and structural reliability	6

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Materials and Structures in their Environment

Mandatory Courses (6)	ECTS
Mechanics of porous media	5
Homogenization methods for materials and structures	5
Coupled problems in mechanics: from mathematical formulation to numerical methods	6
Design and behavior of modern concrete	5
Modern language	2
Summer school	2

Elective Courses (1 among 2)	ECTS
Durability and Structural Maintenance	5
Earthquake engineering	5

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The Master's thesis can be completed at

- TU Dortmund University
- UniTrento
- EC Nantes

or at one among the MS^2 associate academic and industrial partners in the world…

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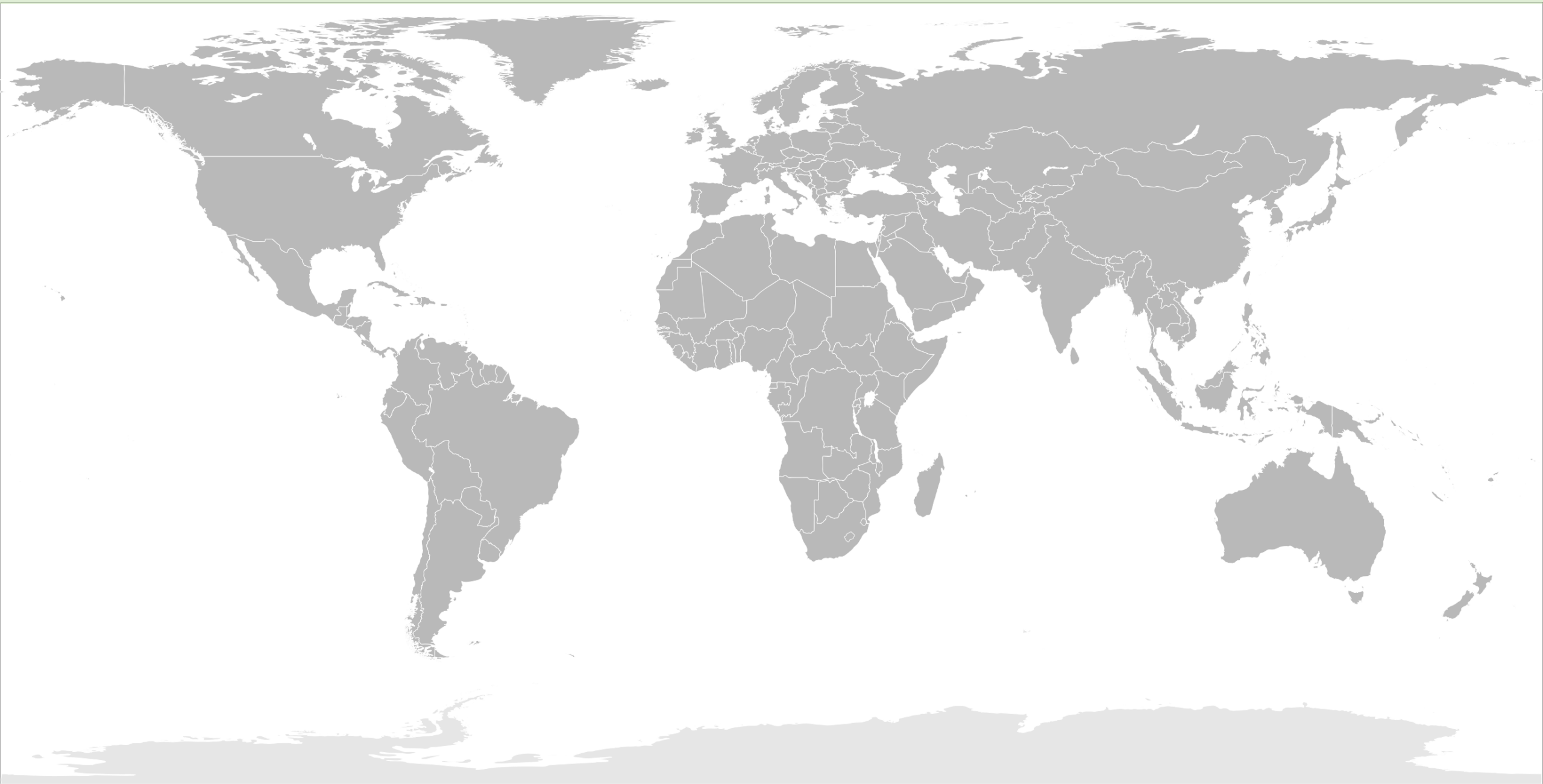


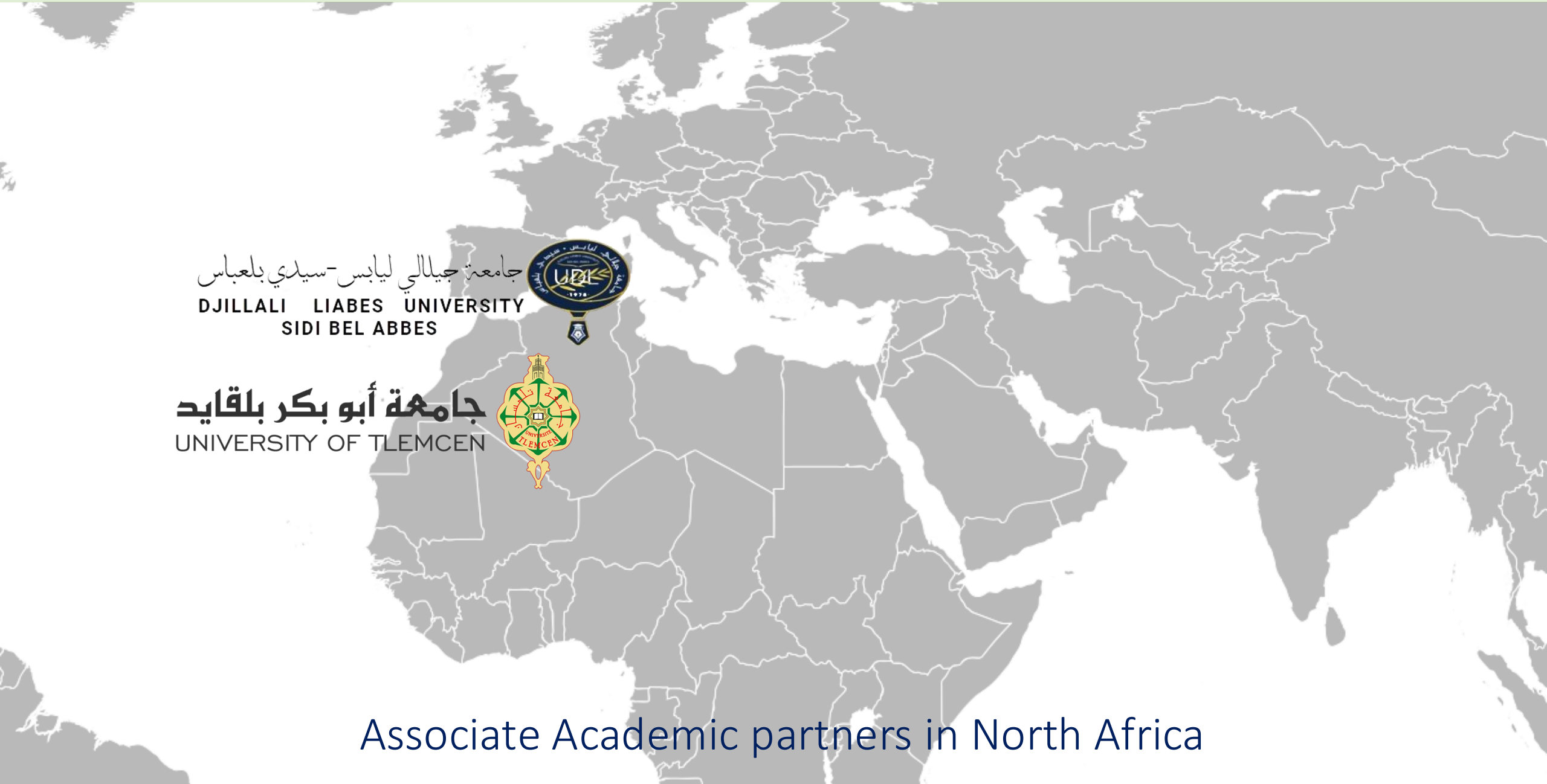
Mechanics of Sustainable Materials and Structures – MS^2

Associate Academic partners in Europe

Mechanics of Sustainable Materials and Structures – MS^2

Associate Industrial/Public partners in Europe

Mechanics of Sustainable Materials and Structures – MS^2



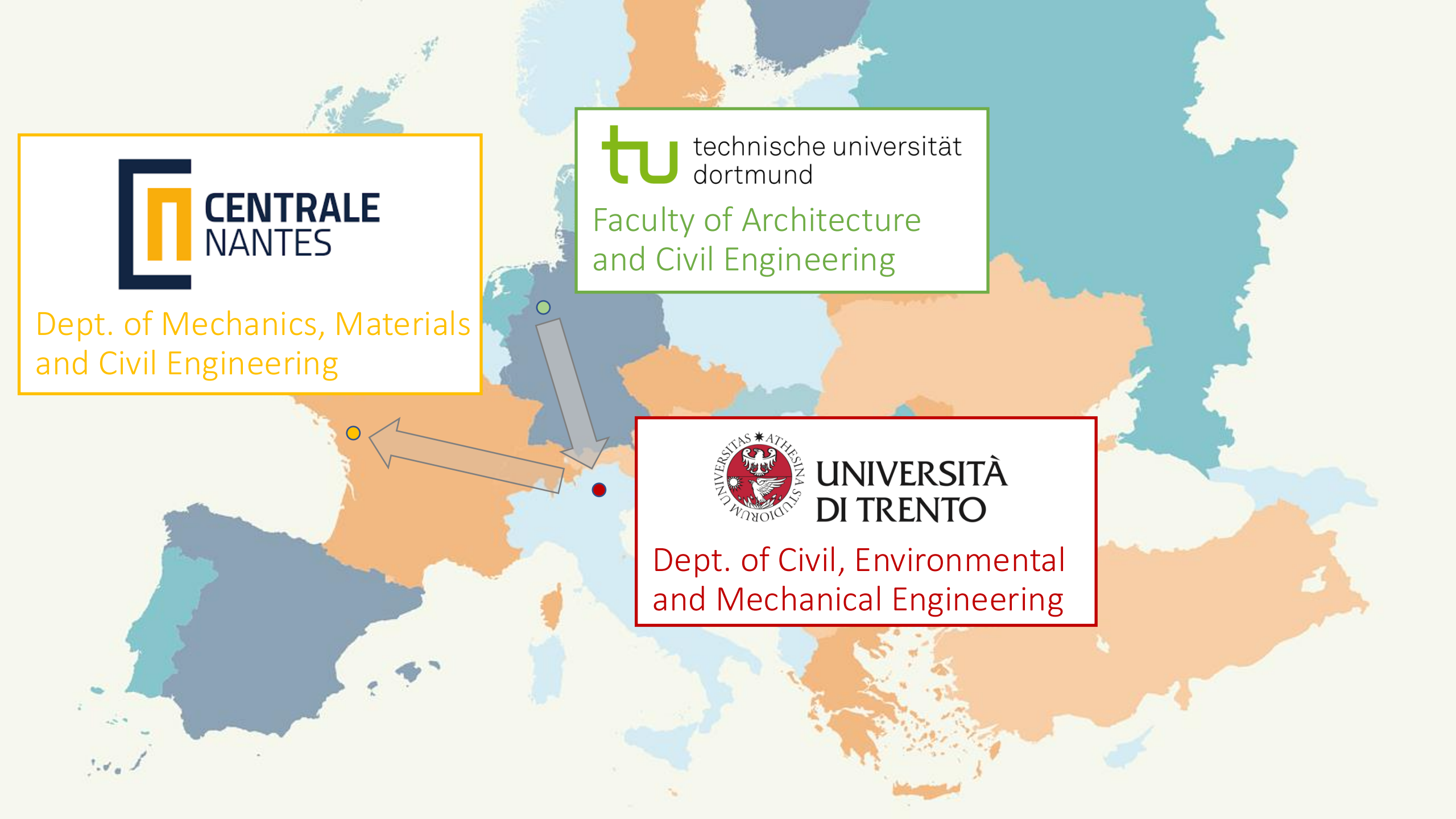
Associate Academic partners in North Africa

Mechanics of Sustainable Materials and Structures – MS^2

Associate Academic partners in North America

Mechanics of Sustainable Materials and Structures – MS^2

Associate Academic partners in Asia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Faculty of Architecture and Civil Engineering

Prof. A. Madeo

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Dept. of Mechanics, Materials and Civil Engineering

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Mechanics of Sustainable Materials and Structures – MS^2

technische universität dortmund

- Dortmund, the largest city in the Ruhr area
- 10 Million inhabitants in the surrounding Rhine-Ruhr Metropolitan Region

Distance	[km]
Essen	31
Düsseldorf	57
Köln	72
Frankfurt	175
Amsterdam	200
Berlin	422

Mechanics of Sustainable Materials and Structures – MS^2

TU Dortmund University

- Founded in 1968
- Over 30,000 students with over 5,350 international students
- Member of the UA Ruhr

- Free access to libraries
- Free public transport through the whole of Germany
- 230 different courses in 80 different sports, indoor and outdoor

Department of Architecture and Civil Engineering

- Founded in 1974
- 1995 students enrolled in the faculty with over 100 teaching staff
- Architects and Civil Engineers are trained together in the Dortmunder Model

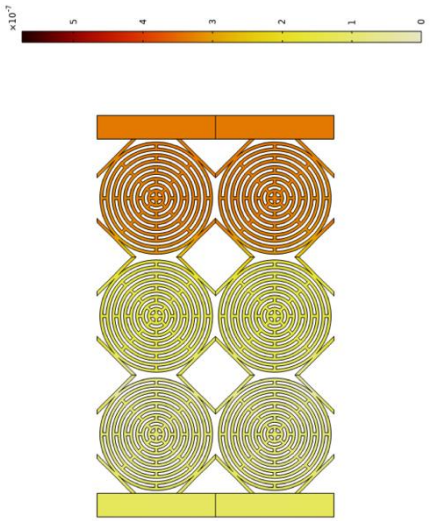
Mechanics of Sustainable Materials and Structures – MS^2

Institute of Structural Mechanics, Statics and Dynamics

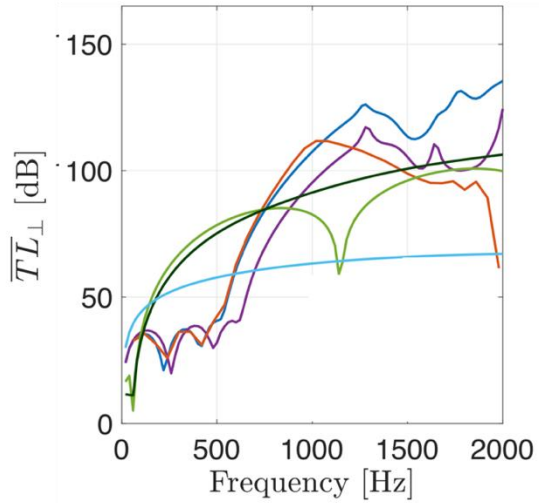
baumechanik statik dynamik

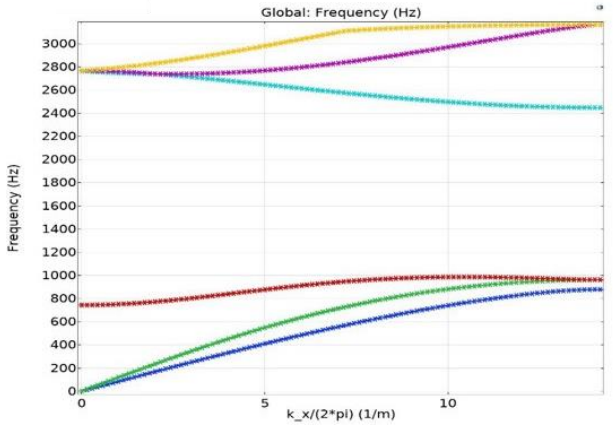
technische universität dortmund

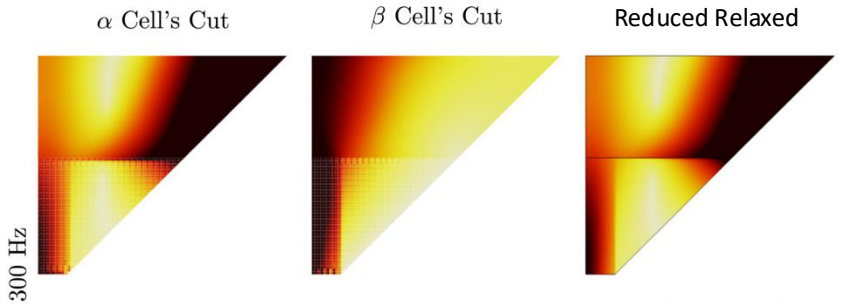
- META-LEGO ERC-Grant
- Finite-size metamaterial modeling



Transmission loss

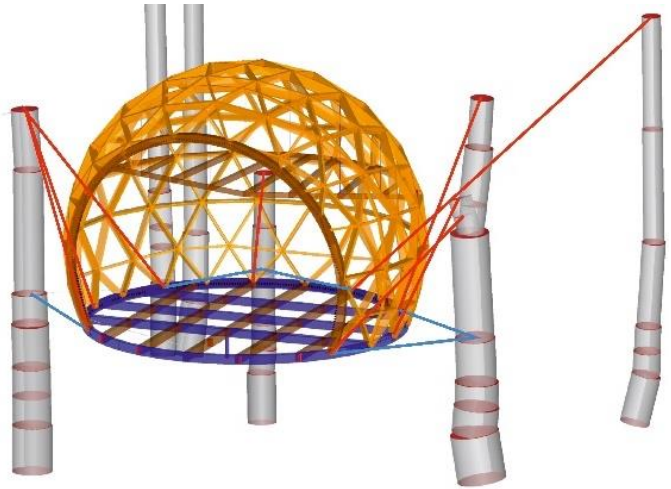






- Dispersion and Band-gap description through enriched continua
- Surface forces and non-coherent interfaces

- Sustainable Building with Trees



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Prof. F. Dal Corso

Mechanics of Sustainable Materials and Structures – MS^2

Trento is a small city (121,000 inhabitants) located in Northern Italy and due to its position it is a natural meeting point between Italian and Central European culture.

Distances from Trento to:

- Verona 98 km
- Venice 157km
- Innsbruck (Austria) 173 km
- Milan 226 km
- Florence 319 km
- Rome 592 km

UNIVERSITÀ DI TRENTO

Mechanics of Sustainable Materials and Structures – MS^2

Trento is a roman town, rich in art and history

Piazza Duomo

Buonconsiglio Castle

Garda Lake

Dolomites

Located in the river Adige valley, on the Brenner axis, it is surrounded by beautiful mountains, such as the Dolomites, and alpine lakes

Mechanics of Sustainable Materials and Structures – MS^2

- Always among the top 3 medium-sized Italian universities (1st CENSIS 2023-24)
- High internationalization
- Favoured study environment thanks to its human-scale dimensions and high level of services
- Quality of life (1st according to ItaliaOggi 2022)

Mechanics of Sustainable Materials and Structures – MS^2

5 Libraries

Monday to Saturday 8-24

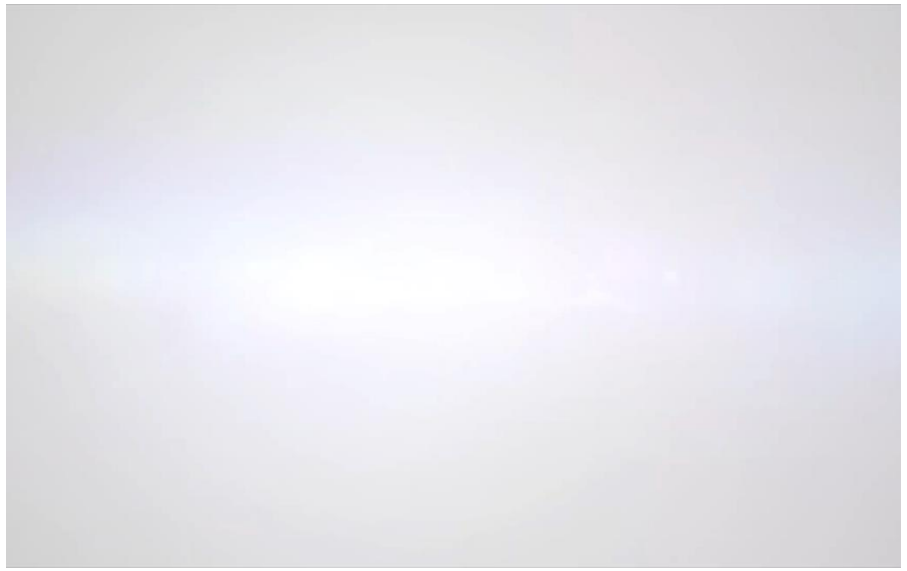
Sunday 14-21

UNITRENTO SpOrt

Free circulation card

annual subscription to the transport network of the province of Trento (€70)

Mechanics of Sustainable Materials and Structures – MS^2



- Excellent Italian Department of Civil Engineering

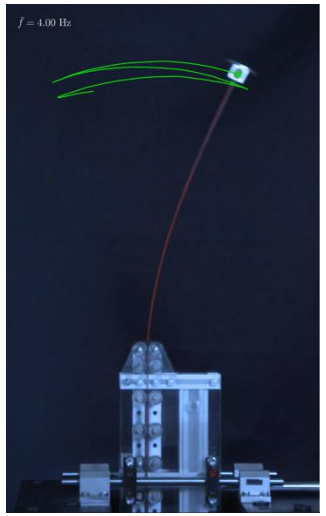
2018-2022 DIPARTIMENTO DI ECCELLENZA MIUR

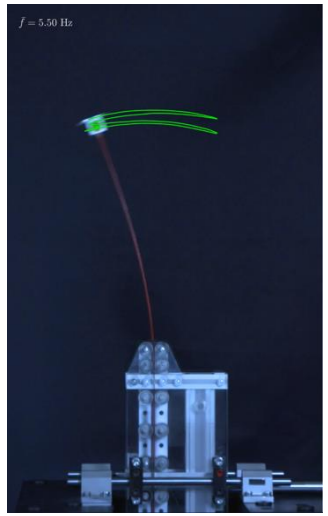
2023-2027 DIPARTIMENTO DI ECCELLENZA MUR

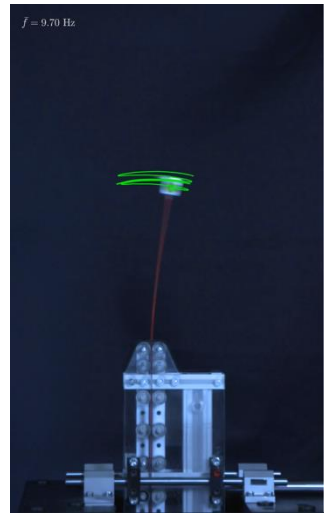
UNIVERSITÀ DI TRENTO

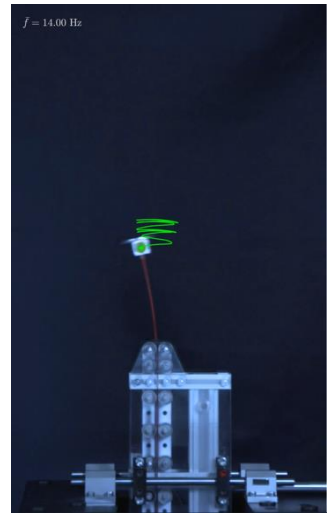
Dept. of Civil, Environmental and Mechanical Engineering

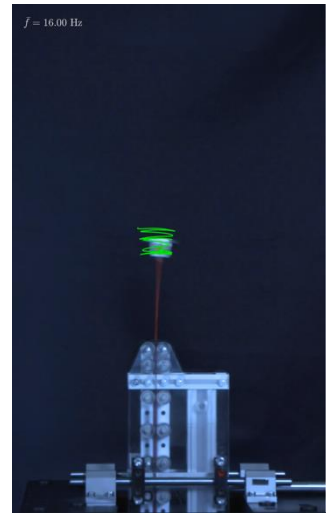
- Coordination of/participation in several of the world's most prestigious European projects (multiple ERC winners, FET, Marie Curie, etc.)
- High faculty to student ratio (200 faculty and staff: 2000 students)
- Europe's largest Materials and Structures Testing Laboratory











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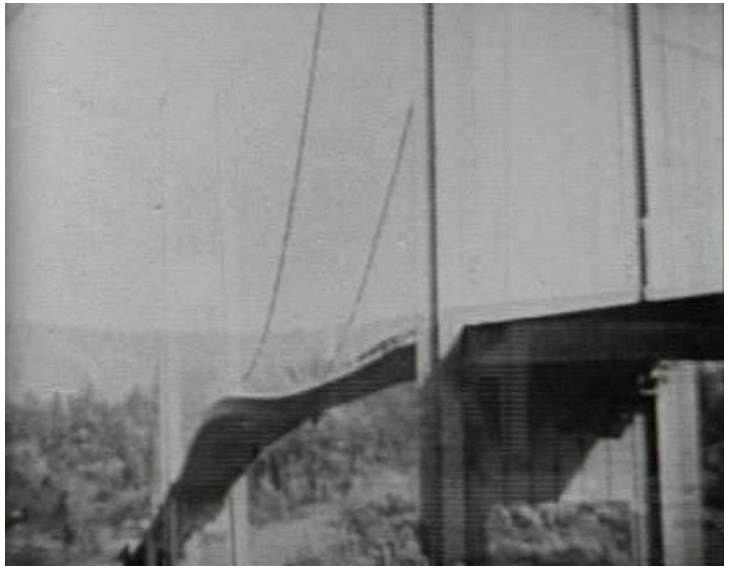
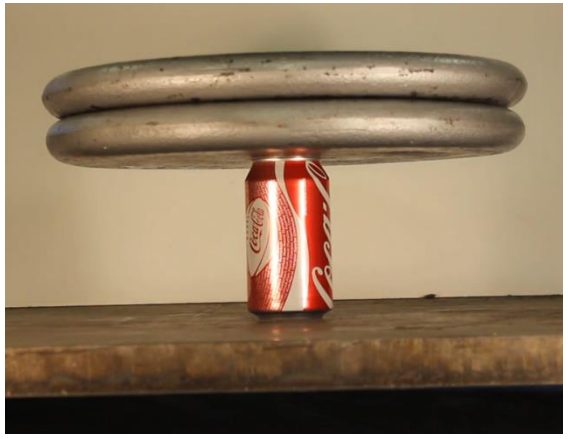
Stability of Structures

Proff. Francesco Dal Corso, Andrea Piccolroaz

The course focuses on various instability phenomena that may involve both isolated structural elements and structures as a whole:

- Discrete and continuous conservative systems
- Non-conservative systems (flutter via follower loadings, parametric resonance for non-stationary loadings)
- Coupled flexural/torsional instability
- Lateral instability of beams
- Basics of the “elastica”
- Buckling collapse of frames
- Numerical methods



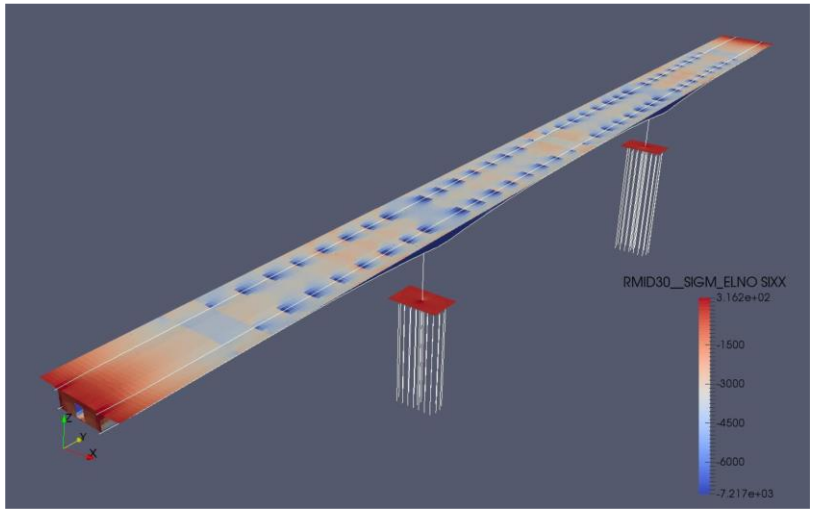


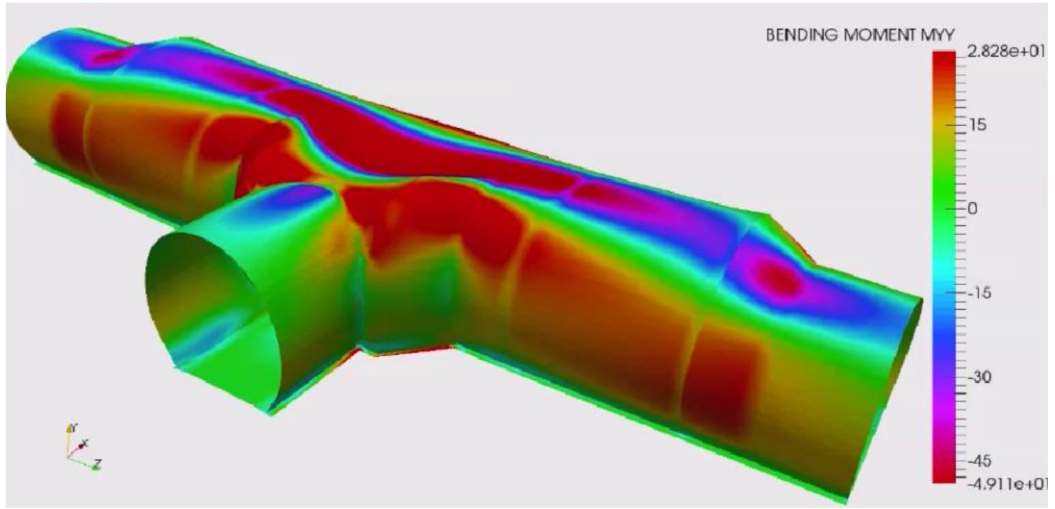
Mechanics of Sustainable Materials and Structures – MS^2

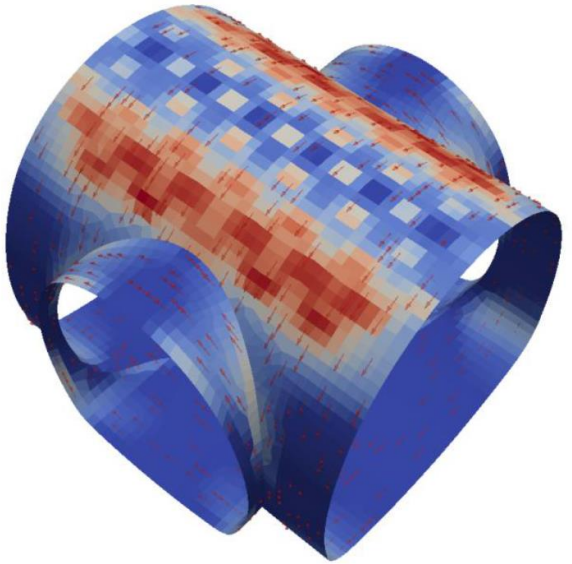
Modeling and simulation of structure

Prof. Andrea Piccolroaz

The course aims to provide students with the methodological basis and practical knowledge to deal with the numerical analysis of structural and field problems in the presence of linear and non-linear behaviors and with reference to complex structures and problems.







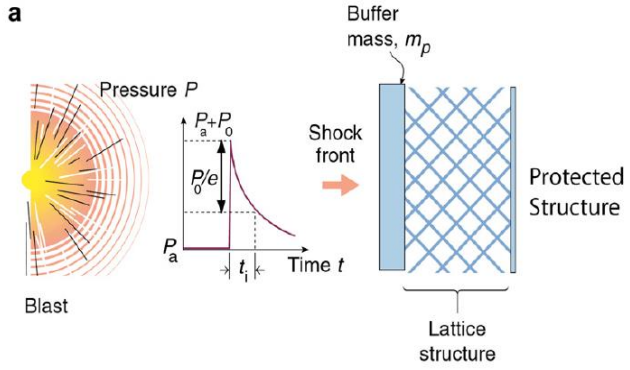
Mechanics of Sustainable Materials and Structures – MS^2

Mechanics of Solids and Structures under Extreme Conditions

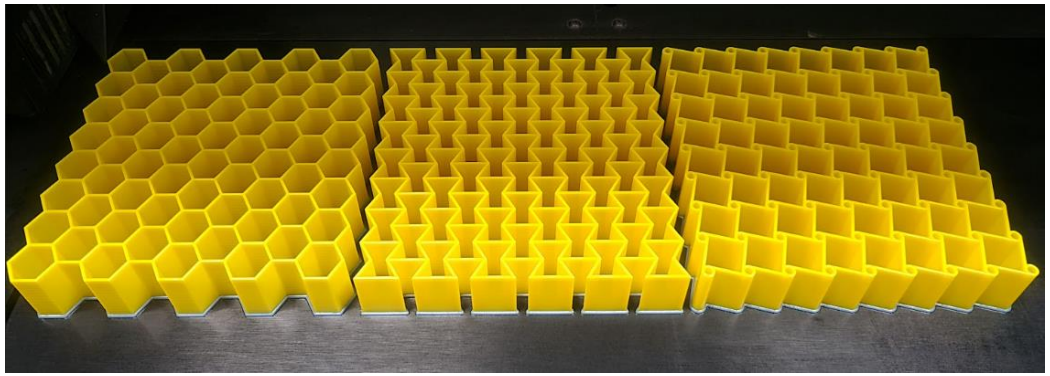
Prof. Luca Deseri

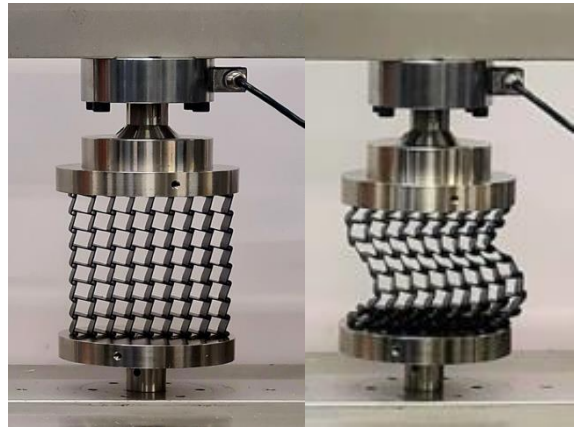
The course focuses on the concept and design of novel cellular/metamaterials-based devices shielding solids and structures subject to extreme loading conditions:

- Mechanics of Cellular Materials for the Mitigation of Extreme Loads: Bio-inspired cellular solids obtained through 3D printing/additive manufacturing;
- Mechanical Responses to small, medium, and extreme deformations;
- Mechanics of Hexagonal Structures (honeycombs), foams, & "architected" materials;
- Metamaterials for the Mitigation of the effects of Extreme Loads;
- Fracture Mechanics of Cellular Solids;
- Instability and Elastoplasticity of Cellular Structures for impact mitigation: impacts at medium and high deformation rates;
- Protection against Blasts through Cellular Claddings: basic analysis & conceptual design



In-house 3D printed traditional, auxetic, and polar polymeric honeycombs





Mechanics of Sustainable Materials and Structures – MS^2

Machine Learning for Wireless Structural Health Monitoring

Prof. Marco Salucci

Objectives:

- Provide fundamental knowledge of Machine Learning (ML)
- Offer practical training through software exercises
- Introduce the application of ML to wireless structural health monitoring (SHM)

Learning Outcomes:

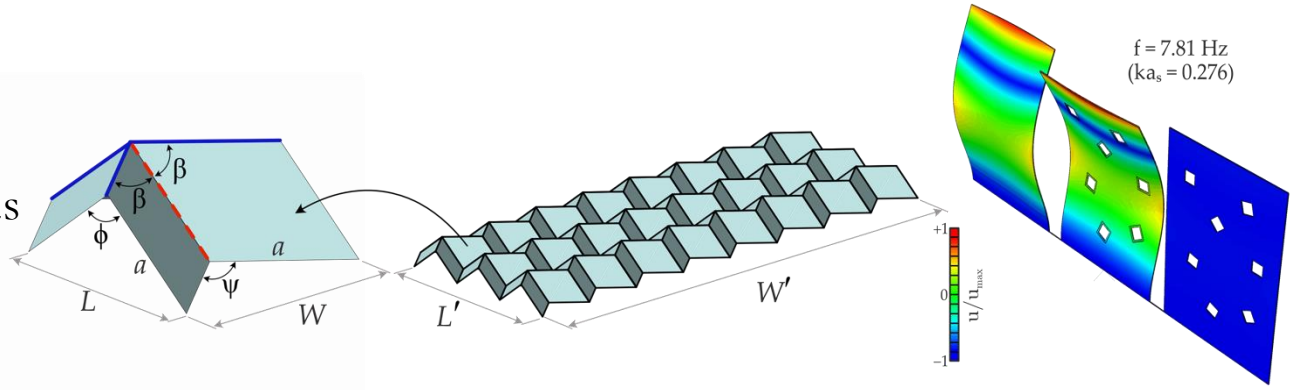
- Acquire **basic knowledge** of ML algorithms for SHM
- Understand the **role of ML** in enhancing the management and safety of civil structures
- **Apply ML techniques** to solve problems in SHM

Mechanics of Sustainable Materials and Structures – MS^2

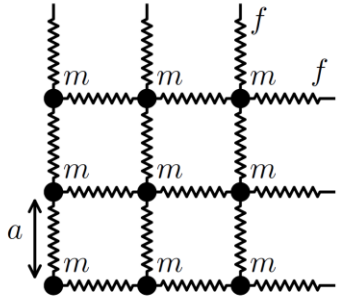
Metastructures

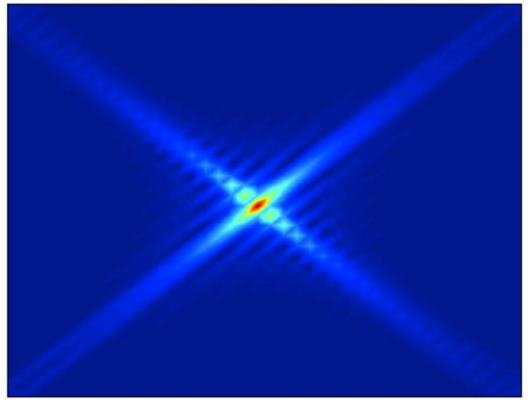
Proff. Oreste S. Bursi, Diego Misseroni, Francesco Dal Corso, Giacomo Oliveri

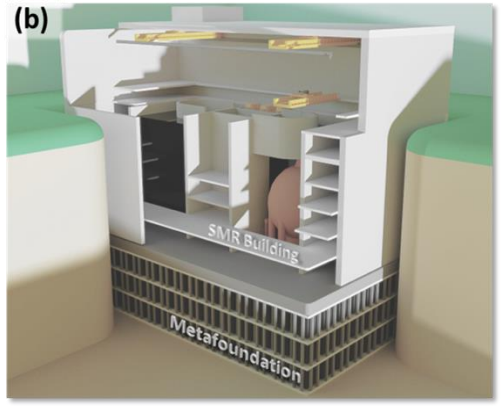
1. Basic properties of mechanical and electromagnetic waves and design principles of metastructures.
2. Multifunctional properties of mechanical metamaterials, such as vibration attenuation, bandgap features and impact energy absorption.
3. Bloch waves in origami metamaterials and cloaking transformation in elastic plates, scattering reduction of flexural waves propagation
4. Passive control, linear and nonlinear metastructures
5. Life cycle assessment and sustainable metastructures



M3 LABORATORY FOR MULTIFUNCTIONAL METAMATERIALS AND METASTRUCTURES







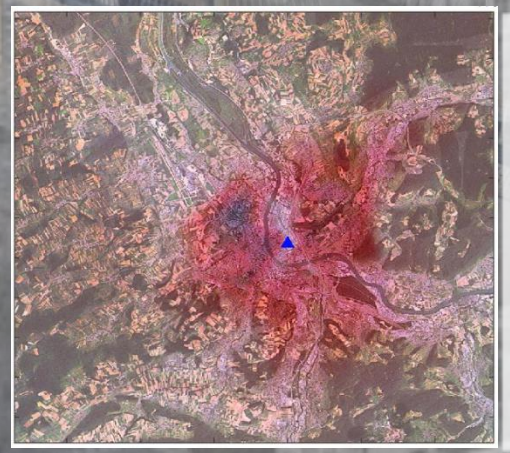
Mechanics of Sustainable Materials and Structures – MS^2

Risk Analysis & Structural Reliability

Prof. Marco Broccardo

Learning Objectives

1. Understand the fundamental principles **of risk analysis** and **structural reliability**, which form the foundation for **Natural Hazard & Risk analysis** (specific emphasis in given on **seismic risk analysis**).
2. Develop proficiency in advanced methodologies such as **Monte Carlo Methods** for evaluating the safety and reliability of complex civil engineering systems.
3. Analyze sustainable solutions for the **management and maintenance of existing infrastructure** and the development of new infrastructure



Learning Results

1. Demonstrated ability to assess and quantify the safety and reliability of both new and existing systems using advanced analytical techniques.
2. Practical application of risk analysis tools to evaluate and optimize infrastructure solutions for sustainability and long-term performance.
3. Enhanced capability to address challenges in aging infrastructure and increasing demands in the built environment through informed decision-making based on structural reliability analysis.

CENTRALE NANTES

Dept. of Mechanics, Materials and Civil Engineering

Prof. G. Sciarra

technische universität dortmund

Faculty of Architecture and Civil Engineering

UNIVERSITÀ DI TRENTO

Dept. of Civil, Environmental and Mechanical Engineering

Mechanics of Sustainable Materials and Structures – MS^2

NANTES

- **2 hours** away from Paris by train
- Easily **accessible** (airport, train, bus, tramway)
- +100 parks and gardens
- Nantes, historically an **industrial** pool
- City of **Arts**, **History** and Innovation
- European Capital of **innovation** (2019)

CENTRALE NANTES

6th largest city in France
Home to 65,000 students

Mechanics of Sustainable Materials and Structures – MS^2

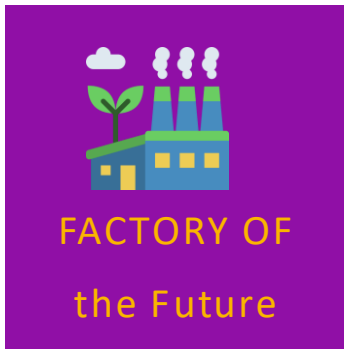
- Proximity with large industrial groups (Airbus, Naval Group, or STX Shipyard)
- European Green Capital in 2013
- Elected 3rd best city for students in 2020

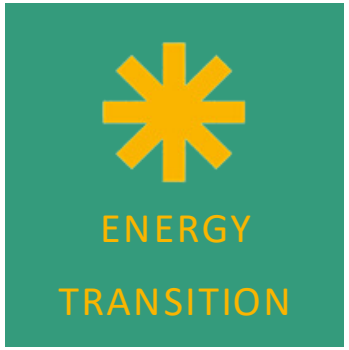
Mechanics of Sustainable Materials and Structures – MS^2

CENTRALE NANTES

- World-class engineering training in science and technology
- A major focus on sustainable development, energy transition, factory of the future and engineering for health
- Extensive collaboration with industrial partners
- International outreach (academic and research)
- Internationally recognized faculty
- A dynamic economic model that is unique in France (more than 50% of the budget comes from research income)

CENTRALE NANTES



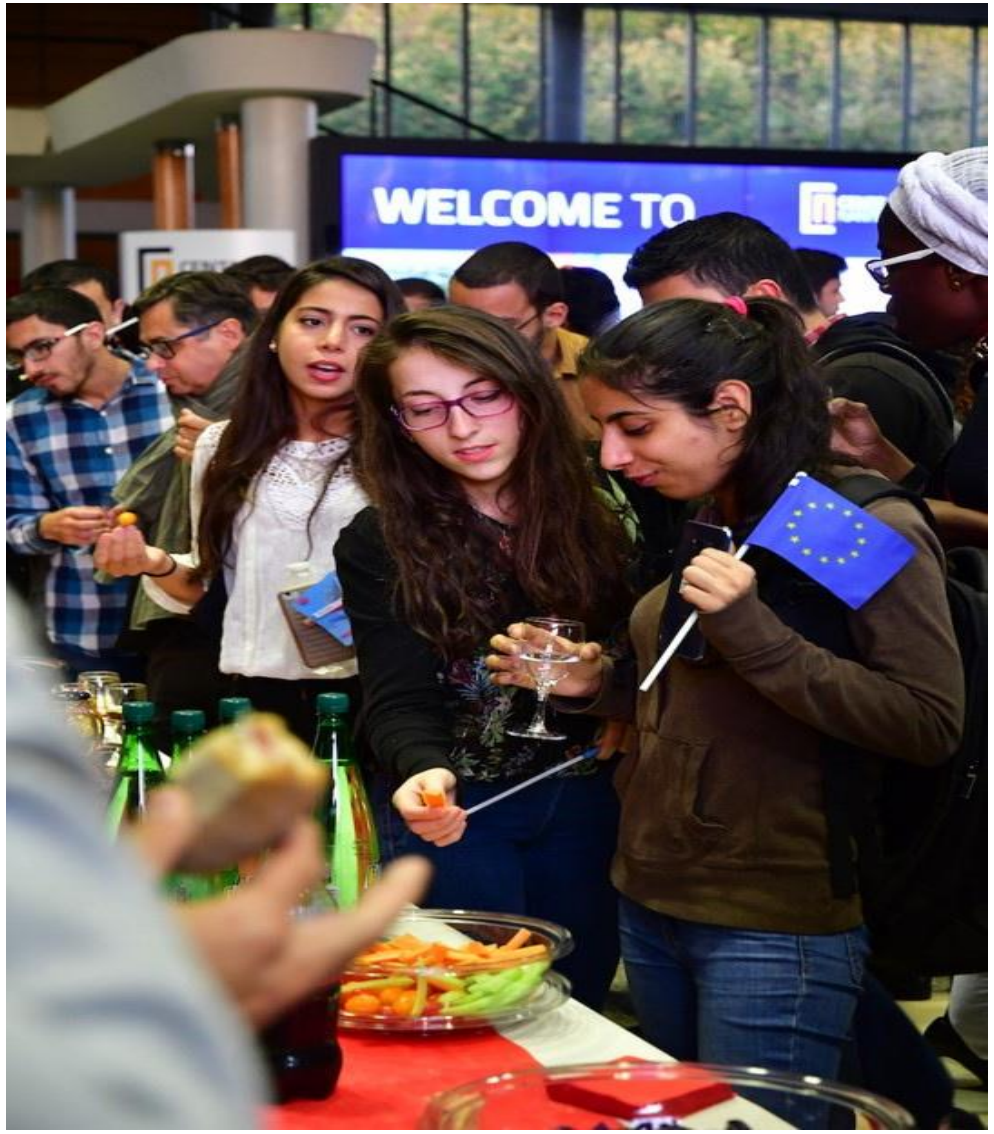


LIFE ON CAMPUS

- Excellent sports facilities: artificial pitch, squash courts, dojo, gym

- Over 80 student clubs and associations on campus: jazz, chess, theatre, cinema, dance, sailing, rugby, football, basketball, martial arts, robotics, cooking, ….

Mechanics of Sustainable Materials and Structures – MS^2

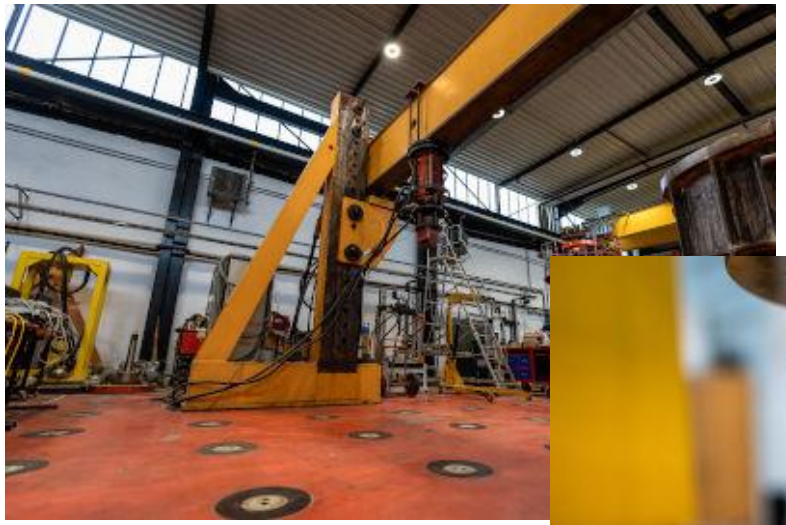


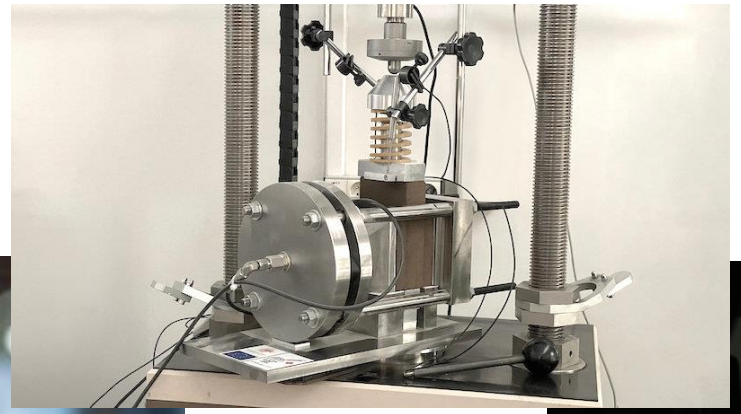
- Accommodation booking
- Airport / Train station Pick Up by our Welcome Team
- Welcome week
- Buddy programme
- Welcome support from the International office
- Help with administrative procedures such as health insurance, visa renewal…

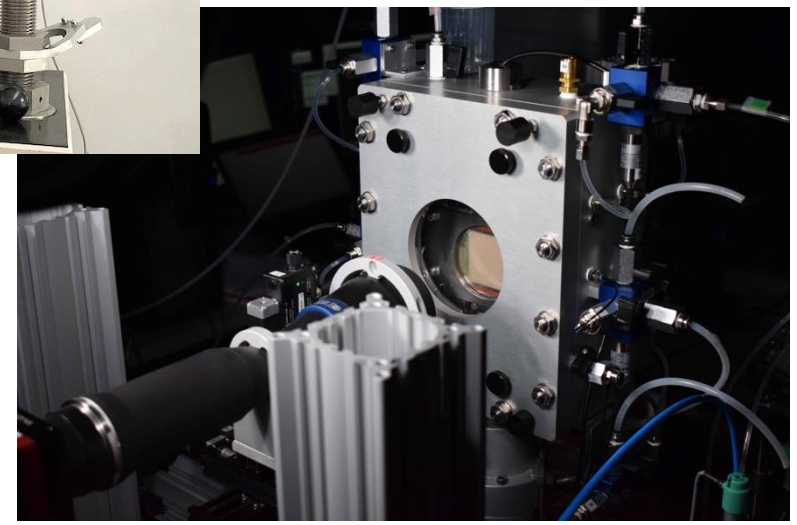
Mechanics of Sustainable Materials and Structures – MS^2

Institut de recherche en Génie Civil et Mécanique GeM

Research at GeM is balanced between advanced and applied research. The research unit is characterised by its significant and differentiating testing resources, with several technological platforms. Projects are conducted in close collaboration with industry and companies specialising in mechanical and civil engineering, in the framework of French and European programmes and networks.







Mechanics of Sustainable Materials and Structures – MS^2

Program's structure

technische universität dortmund

1st Semester

30 ECTS (Courses)

Sept 14 – Dec 22, 2026

UNIVERSITÀ DI TRENTO

2nd Semester

30 ECTS (Courses)

Feb 16 – May 26, 2027

CENTRALE NANTES

3rd Semester

30 ECTS (Courses)

Sept 1, 2027 – Jan 15, 2028

Location selected by the student

4th Semester

30 ECTS (Master Thesis)

Apr 1 – Sept 30, 2028

Materials and Structures in their Environment

Mandatory Courses (6)	ECTS
Mechanics of porous media	5
Homogenization methods for materials and structures	5
Coupled problems in mechanics: from mathematical formulation to numerical methods	6
Design and behavior of modern concrete	5
Modern language	2
Summer school	2

Elective Courses (1 among 2)	ECTS
Durability and Structural Maintenance	5
Earthquake engineering	5

Mechanics of Sustainable Materials and Structures – MS^2

- Admission requirements
- Tuition fees
- Funding opportunities
- Scholarships Selection Procedure
- Timeline

Dr. J. Voss

technische universität dortmund

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Mechanics of Sustainable Materials and Structures – MS^2

Admission Requirements

Academic Merit

- Bachelor's degree qualification in the field of Civil Engineering or equivalent
- Final Grade better or equal to
  - B according to ECTS grading (best 35%)
  - **2.8** on the German grading scale (from 1.0 to 4.0)
- English language with **official B2** proficiency certificate

Enrolment

- With a letter of admission, you enroll at TU Dortmund first link
- Start of study: 14th September 2026

The program's admission application is submitted in parallel to a possible scholarship opportunity via:

uni-assists (non-EU/EEA) or
TU Dortmund University (EU/EEA)

- Applicants without EU/EEA citizenship with a foreign university degree obtained in a country outside the EU/EAA. link

  01.01.2026 to 15.05.2026

- Applicants with EU/EEA citizenship or a university degree obtained in a country part of the EU/EAA. link

  01.01.2026 to 15.10.2026

Mechanics of Sustainable Materials and Structures – MS^2

Tuition Fees
(possible slight changes before the application process opens)

		Consortium Scholarship We will select **15** students per year based on merit who have their tuition fees partially waived
Applicants without EU/EEA citizenship	3400€ per semester x 4 = 13600€ for entire program	1900€ per semester x 4 = 7600€ for entire program
Applicants with EU/EEA citizenship or who have obtained their Bachelor's degree in EU/EEA	1900€ per semester x 4 = 7600€ for entire program	1150€ per semester x 4 = 4600€ for entire program

Mechanics of Sustainable Materials and Structures – MS^2

Funding opportunities

Mobility allowance

- Mobility bonus from Italy to France
- **2000 € / student**
- About 5 students (per cohort)

UNIVERSITÉ FRANCO ITALIENNE
UNIVERSITÀ ITALO FRANCESE

Scholarship

- 2 years of funding for selected students
- **1400 € / month / student**
- About 15 students (per cohort)
- No tuition fees for scholarship holders

European Commission

Mechanics of Sustainable Materials and Structures – MS^2

Scholarships Selection Procedure

In parallel with the program's admission application

Step 1:
- Application Form
- The same documents as the program's admission application

Step 2:
- Online test (written)

Check emails!

Step 3:
- Colloquium (online)

Interview

Scholarship can only be confirmed upon the completion of the program's admission application

The Selection is based on the following criteria:

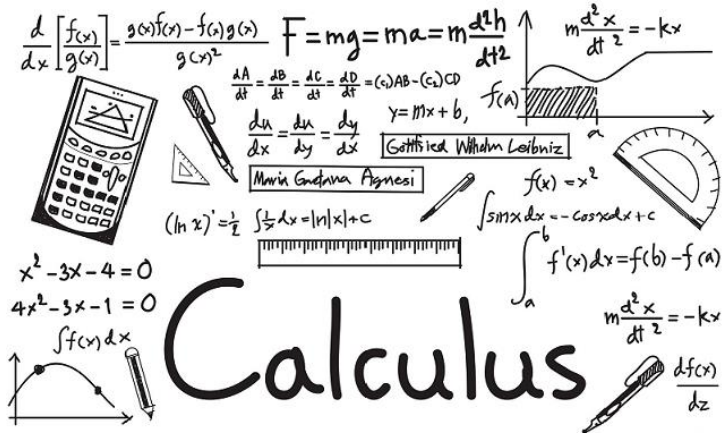
- **Interview** (written test + oral colloquium): more details after submitting the scholarship application form ⟶ 50 points
- **Academic grades**: final bachelor's degree grade or, if the applicant still needs to graduate, the average mark ⟶ 25 points
- **Two reference letters**: we will ask for a letter of recommendation (in English/pdf) from your proposed referees, including letterheads of the author's Institution and a signature ⟶ 15 points
- **Motivation letter**: CV and a two-page letter that describes why you are the perfect candidate for the EMJM scholarship ⟶ 10 points

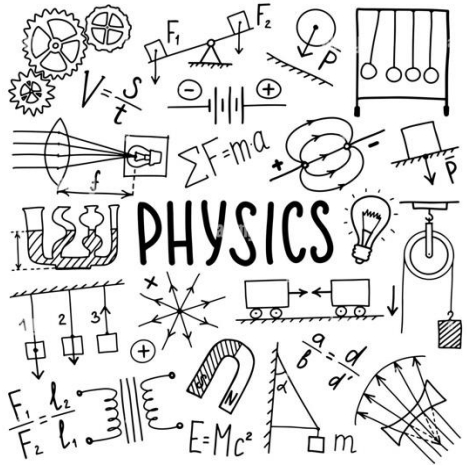
Applications are submitted via our website link

01.01.2026 to 15.03.2026

Mechanics of Sustainable Materials and Structures – MS^2

Content of entrance test

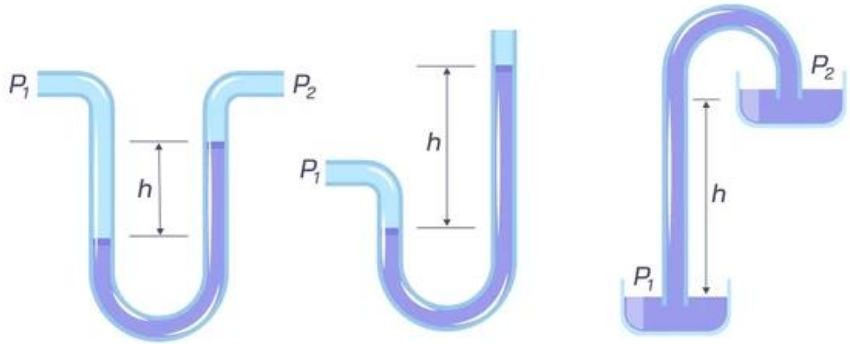




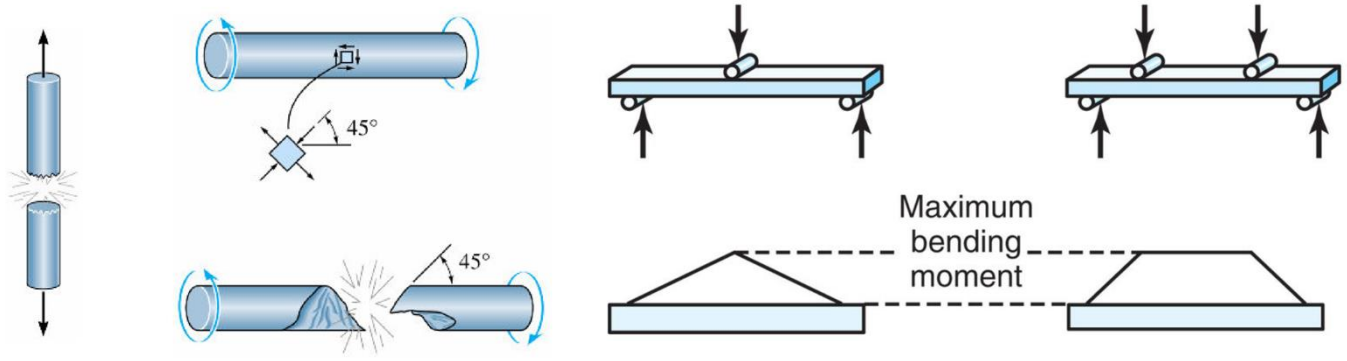
Linear Algebra

$$\underbrace{\begin{bmatrix} a_0 & b_0 & c_0 & 0 & 0 & 0 & \cdots \\ d_0 & e_0 & f_0 & 0 & 0 & 0 & \cdots \\ g_0 & h_0 & i_0 & 0 & 0 & 0 & \cdots \\ 0 & 0 & 0 & a_1 & b_1 & c_1 & \cdots \\ 0 & 0 & 0 & d_1 & e_1 & f_1 & \cdots \\ 0 & 0 & 0 & g_1 & h_1 & i_1 & \cdots \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \ddots \end{bmatrix}}_{3n\times 3n} \times \underbrace{\begin{bmatrix} x_0 & 0 & \cdots & 0 \\ y_0 & 0 & \cdots & 0 \\ z_0 & 0 & \cdots & 0 \\ 0 & x_1 & \cdots & 0 \\ 0 & y_1 & \cdots & 0 \\ 0 & z_1 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \end{bmatrix}}_{3n\times n} = \underbrace{\begin{bmatrix} x_0' & 0 & \cdots & 0 \\ y_0' & 0 & \cdots & 0 \\ z_0' & 0 & \cdots & 0 \\ 0 & x_1' & \cdots & 0 \\ 0 & y_1' & \cdots & 0 \\ 0 & z_1' & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \end{bmatrix}}_{3n\times n}$$

(a bit of) Fluid mechanics

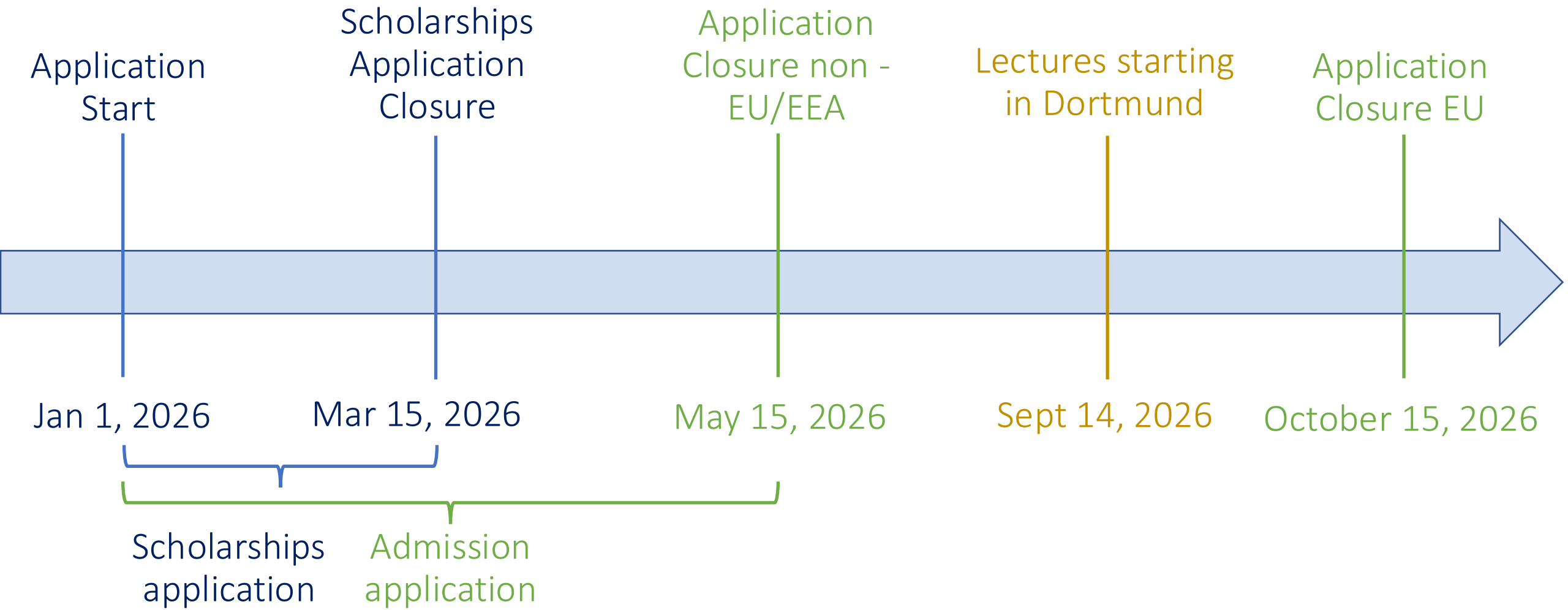


Mechanics of Solids and Structures



Mechanics of Sustainable Materials and Structures – MS^2

Timeline



MS^2
Mechanics of Sustainable Materials and Structures

Mechanics of Sustainable Materials and Structures – MS^2

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Thank you for your attention!!