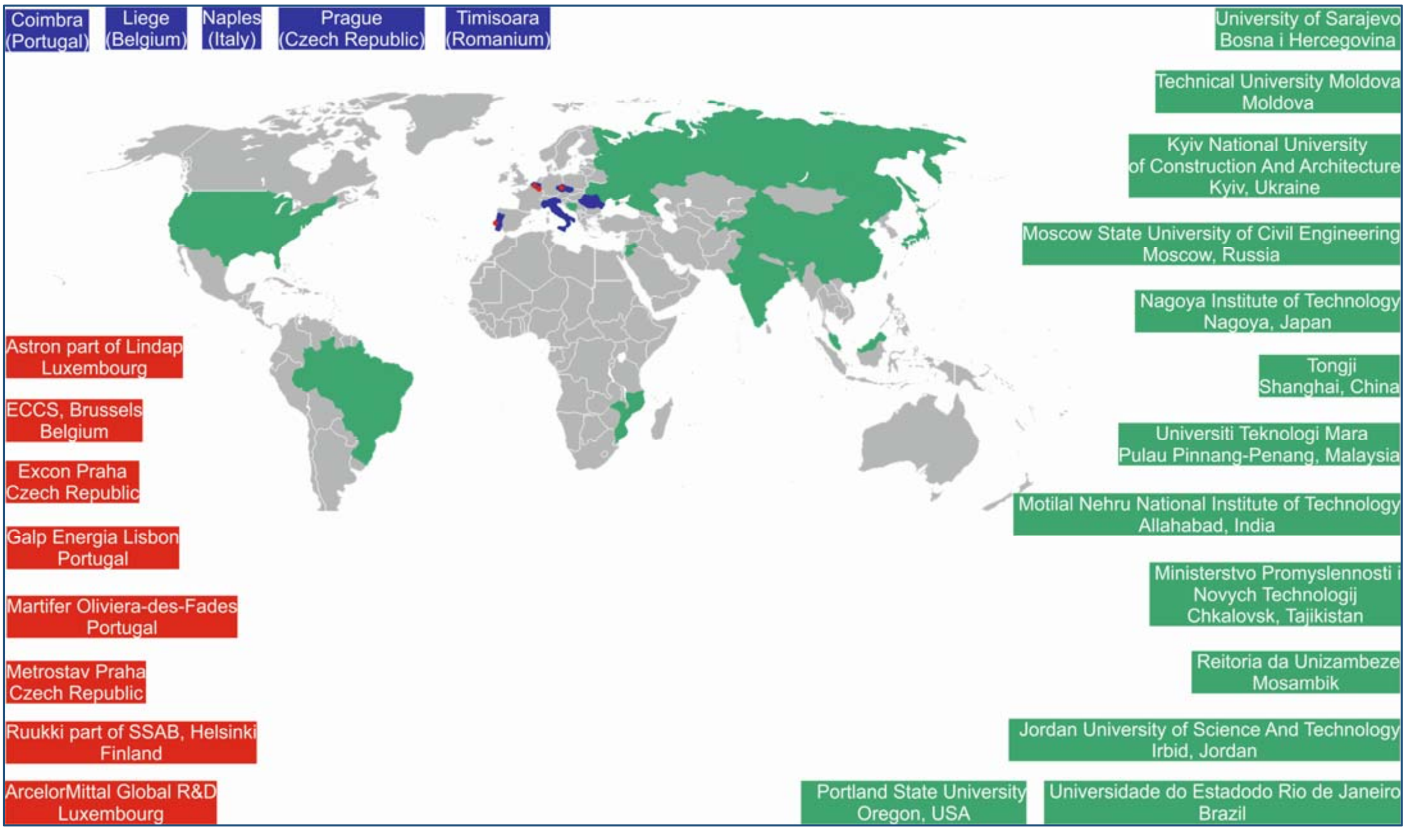
Application for

Erasmus Mundus Joint Master Degrees (EMJMD) 2016

Sustainable Constructions under Natural Hazards and Catastrophic Events

SUSCOS_M



D ANNEXES

SYLLABI OF LECTURES

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Course unit title	*DESIGN FOR SUSTAINABLE CONSTRUCTIONS*
Course unit code	
Type of course unit	Compulsory
Semester	1
Number of ECTS credits allocated	6
Name of lecturer(s)	To be completed: xxxx (UC); xxxxx (CTU); xxxxx (ULg); xxx (UNINA); xxxx (UPT).
Learning outcomes of the course unit	▪ Clear understanding of the concepts of Sustainable Development (SD) and Sustainable Construction (SC); ▪ To understand the challenge of the application of the principles of SD to the construction sector; ▪ To identify the advantages and disadvantages of steel and steel construction in the context of SC; ▪ To take advantage of steel structures in the pursuit of SC; ▪ To provide essential knowledge in relation to methodologies and tools for the assessment of sustainability; ▪ To apply these skills in the promotion of steel buildings in the context of SC.
Mode of delivery	Frontal lesson, computational work and experimental laboratory work.
Prerequisites and co-requisites	General admission requirements
Course contents	PART A – Sustainability of steel and steel structures 1. INTRODUCTION a) Sustainable development aspects, key indicators, European directives, international standards; b) Sustainable construction: basic concepts, assessment tools, life cycle concepts, lifetime analysis. 2. LIFE-CYCLE ANALYSIS a) Methodologies and tools for the assessment of sustainability (life cycle approaches, rating systems BREAM, LEED, HQE, VALIDEO, etc) b) Definition, codes such as ISO standards (functional unit, system boundaries, cradle-to-gate, cradle-to-grave, cradle-to-cradle), impacts and damages, important steps of the analysis (normalization, sensitivity analysis, end-of-life management) c) Buildings specificities (operational energy, embodied energy, compactness, etc)

d) Durability of steel structures (corrosion, fatigue, etc.) and maintenance
e) Computational tools
3. SUSTAINABILITY OF STEEL AND STEEL CONSTRUCTIONS
a) Contribution of steel buildings for the sustainability of the construction sector
b) Identifications of main barriers/drawbacks of steel construction
a) Life-cycle inventory (data sources for steel, transport, system boundaries "cradle-to-gate with end-of-life recycling credits", comparative illustrative data for steel, concrete and wood)
b) Allocation of recycling materials: How to take the recycling into account (analytical formulation)

PART B – Heat Transfer
1. MECHANISMS OF HEAT TRANSFER
a) Basic concepts of energy conservation: first law of thermodynamics
b) Heat transfer: modes, rate equations and energy balances
c) Heat transfer by conduction
d) Heat transfer by convection
e) Heat transfer by radiation
d) Thermal comfort
2. NUMERICAL SIMULATIONS OF HEAT FLOW AND HEAT TRANSFER
a) Basic concepts of numerical simulations
b) Discretization, mesh and errors
c) Exercises: use of softwares EasyCFD_G and ANSYS-CFX

PART C – Thermal Behaviour and Energy efficiency in buildings
1. ENERGY CONSUMPTION OF BUILDINGS
a) Increase of global energy demand, global primary energy consumption, the potential of renewable energies, etc;
b) Energy consumption share in buildings (Hot Water, Heating, Cooling, Illumination, Appliances).
2. TOOLS FOR PREDICTION OF ENERGY CONSUMPTION IN BUILDINGS
a) EN ISO 13790 approach: Portuguese code of practise (RCCTE)
b) Advanced dynamic approach: DesignBuilder/EnergyPlus software
3. ENERGY CONSUMPTION - KEY FACTORS
a) Climate (air Temperature, solar radiation, relative humidity, wind speed and direction, ground temperature, daylight hours);
Exercise C1: Compare weather data for three European cities using AutoDesk Ecotect Weather Tool
b) Building envelope (building shape coefficient, building orientation/exposition, opaque elements (walls, roof, etc), thermal insulation, thermal bridges, air tightness, windows, glass types, frame types, shading, overhangs, devices;
Exercise C2: Compute U-value of a light-weight steel frame wall using THERM software
c) Building services (appliances, illumination, natural daylight, efficient lamps, heating, air-conditioning, ventilation, hot water, ventilation

	heat recover); d) Human factors (schedule, utilization, internal gains). 4. ENERGY EFFICIENCY OF STEEL BUILDINGS a) High thermal inertia vs. low thermal inertia; b) Passive house characteristics; c) Measures to improve the thermal behaviour of steel buildings. Exercise C3: Parametric study using the DesignBuilder software (passive case) comparing two different solutions for each of the following four parameters: Overhangs, Windows glazing, Ventilation and Windows shading devices PART D – Sustainable assessment of a buildings: case study approach A) Design of the building based on the requirement of minimum energy consumption (DesignBuilder/EnergyPlus software); B) Life cycle assessment and optimization of the light-weight steel building considering environmental, economical and social criteria (GaBi software); C) Comparison of alternative designs (other structural solutions).
Recommended or required reading	▪ Kibert, C., "*Sustainable Construction*", John Wiley & Sons, 2005. ▪ Sarja, A., "*Integrated Life Cycle Design of Structures*", Spon Press, 2002. ▪ Santos, P., Simões da Silva L. and Ungureanu, V., *"Energy-efficiency of lightweight steel-framed buildings"*, ECCS Sustainability Design Manuals, ECCS Press, 2012. ▪ Gervásio, H., "*Sustainable design and integral life-cycle analysis of bridges",* PhD Thesis, University of Coimbra, 2010. ▪ Crawford, R.H., "*Life cycle assessment in the built environment*", Spon Press, 2011. ▪ Quaschning, V., "*Understanding renewable energy systems*", Earthscan, 2005. ▪ ISO Standards 14040 series ▪ CEN Standards TC 350
Planned learning activities and teaching methods	The frontal lectures of the course will held in two weeks, separated by one month. These lectures are organized in theoretical lectures and tutorials. In between these concentrated weeks, projects are assigned to the students as well as computational work and laboratory experiments.
Assessment methods and criteria	The assessment consists of a final exam only after having completed all the project assignments and the final project, which have to be brought at the exam. The final assignment has to be delivered within two weeks after the end of the course. All the project assignments must be approved by the tutor. Grading system. Passed or not passed.

Language of instruction	English

Course unit title	*CONCEPTUAL DESIGN OF BUILDINGS*
Course unit code	1C2
Type of course unit	Compulsory
Semester	1
Number of ECTS credits allocated	6
Name of lecturer(s)	To be completed: xxxx (UC); xxxxx (CTU); xxxxx (ULg); xxx (UNINA); xxxx (UPT).
Learning outcomes of the course unit	The students should, at the end of the unit, be able to conceptually design a building through the selection, in a wide library of structural solutions, of the most appropriate ones to be implemented. To achieve it, they will rely on their knowledge of these technical solutions, but also on their acquired ability to integrate various other conceptual aspects as the feasibility and the economy of the project and the capability to use 3D structural analysis software for this purpose.
Mode of delivery	Frontal lesson , design projects, home work
Prerequisites and co-requisites	General admission requirements
Course modules	Part A – Structural analysis To review concepts and application of nonlinear analysis in the context of 3D frame systems. To familiarise the students with the use of 3D structural analysis programs using beam elements (e.g. ROBOT), including second-order analysis and plastic analysis. Contact Hours: 10h Part B – General concepts for the design of steel structures To introduce the design philosophy and procedures of Eurocode 3. Contact Hours: 8h Part C – Design of steel members and joints To provide the theoretical background and the detailed design procedures for the design of of steel members, joints and components. Contact Hours: 20h Part D – Design of composite members and joints To provide the theoretical background and the detailed design procedures for the design of of composite members and joints. Contact Hours: 16h Part E – Integrated design of buildings Contact Hours: 18h

Course contents	**Part A – Structural analysis** L1 – Structural modelling L2 – Elastic and plastic analyses L3 – First order and second order analyses L4 – Buckling analysis L5 – Approximate methods L6 – Examples **Part B – General concepts for the design of steel structures** L7 – Introduction to the Eurocodes. L8 – Principles of conceptual design of buildings. Global structural analysis. L9 – Design of steel members: tension members, columns and beams. L10 – Design of steel members: beam-columns. Introduction to the design of joints L11 – Keynote Conference **Part C – Design of steel members and joints** L12 – Classification of cross-sections L13 – Buckling resistance of columns and beams L14 – Beam-columns L15 – Bracing systems L16 – Joint typologies and structural analyses L17 – Bolting and welding L18 – Component method L19 – Simple joints L20 – Characterization of components L21 – Examples **Part D – Design of composite members and joints** L22 – General concepts and global analysis L23 – Shear connections L24 & 25 – Composite beams L26 – Lateral torsional buckling of composite beams L27 – Composite slabs L28, 29 & 30 – Composite columns L31 – Composite joints **Part E – Integrated design of buildings** L32 – Conceptual design of industrial buildings L33 – Conceptual design of multi-storey steel buildings L34 – Principals of design and actions L35 – Design of low rise building L36 – Design of a tall building **Critical appraisal of construction techniques** 1. Beam or column elements: steel (lightweight and heavy profiles), concrete, composite, timber, rolled, built-up, with or without openings …. 2. Connections: rigid, semi-rigid, steel or composite, timber 3. Floors: concrete, composite, precast, slim floors … 4. Roofs

	5. Claddings 6. Buildings: multi-storey, industrial …
Recommended or required reading	Simões da Silva L., Simoes R., Gervásio, H.: Design of steel structures. ECCS Eurocode Design Manuals, ECCS and Ernst & Sohn, 2010, 438 p. Jaspart, J.P. and Weynand, K.: Design of joints for steel and steel-concrete stuctures, ECCS, Ernst & Sohn and Wiley, 2012. Johnson R.P.: Design of composite structures, 3rd edition. Trahair N.S., Bradford M.A., Nerthercot D.A., Gardner L.: The behaviour and design of steel structures to EC3. Taylor & Francis, 2008, 490 p. Balio G., Mazzolani F.M.: Design of steel structures, FNSpon, London, 1999
Standards	EN 1993-1-1: 2005. Design of Steel Structures. Part 1-1: General Rules and rules for buildings. EN 1993-1-8: 2005. Design of Steel Structures. Part 1-8: Design of joints. EN 1994-1-1: 2005. Design of Steel-Concrete Composite Structures. Part 1-1: General Rules and rules for buildings. EN 1090-2: 2011. Execution of Steel and Aluminium Structures. Part 2: Execution of Steel Structures.
Tools	ROBOT Structural Analysis (freely available to students) ECCS EC3 Steel Member Calculator LTBeam Semi-Comp+ COP … ACE
Planned learning activities and teaching methods	**Part A – Structural analysis** To complete a work assignement that includes the calculation of a 3D frame by various methods of analysis (linear elastic, eigenvalue, second-order elastic, plastic, non-linear second-order). Frontal lectures. **Part B – General concepts for the design of steel structures** Frontal lectures. **Part C – Design of steel members and joints** Frontal lectures. **Part D – Design of composite members and joints** Frontal lectures. **Part E – Integrated structural design of buildings** Frontal lectures. In parallel to the course modules, students have to achieve the design of a particular building on the basis of assumed realistic design requirements provided by the lecturers (1st project). A feasibility study will also be carried out. Besides that students are asked to observe existing buildings, to select one of these and to analyse it (2nd project). At the end of the module, a critical appraisal of the projects takes place, involving the lecturers and the students.

Assessment methods and criteria	The assessment includes the following evaluations: written examinations during the module and oral presentation/justification of the two above mentioned projects (the one proposed by the lecturers and the one selected by the student).
Language of instruction	English

Course unit title	*CONCEPTUAL DESIGN OF BRIDGES*
Course unit code	1C03
Type of course unit	Compulsory
Semester	1
Number of ECTS credits allocated	6
Name of lecturer(s)	To be completed: xxxx (UC); xxxxx (CTU); xxxxx (ULg); xxx (UNINA); xxxx (UPT).
Learning outcomes of the course unit	The students should, at the end of the unit, be able to conceptually design a bridge through the selection, in a wide library of structural solutions, of the most appropriate ones to be implemented. To achieve it, he will rely on his knowledge of these technical solutions, but also on his acquired ability to integrate various other conceptual aspects as the feasibility and the economy of the project.
Mode of delivery	Frontal lesson , design projects, home work
Prerequisites and co-requisites	General admission requirements
Course modules	Part A – Applied theory of plates To transmit the theoretical background on theory of plates. To familiarise the students with the use of FEM software in the context of nonlinear analysis. Contact Hours: 10.5h Part B – Design of plated structures To provide the theoretical background and the detailed design procedures for the design of plated steel members.Contact Hours: 7.5h Part C – Fatigue & fracture of steel structures To provide the theoretical background and the detailed design procedures for the fatigue design of steel bridges. Contact Hours: 7.5h Part D – Design of bridges Contact Hours: 38.5h D.1 – Overview of typical steel and composite decks in road and rail bridges. D.2 – Conceptual design of composite bridge decks in road bridges. D.3 – Quantification of actions in bridges.

	D.4 – Detailed design of composite bridge decks in road bridges. **D.5 –** Orthotropic bridge decks. **D.6 –** Foobridges **D.7 –** Rehabilitation of old iron and steel bridges **D.8 –** Design of Composite railway bridge decks.
Course contents	Part A – Applied theory of plates (10.SEP to 17.SEP) L2 – Theory of plates: in-plane loading L3 – Shear lag L4 – Numerical solution by FEM L5 – Theory of plates: transversally loaded plates; plates loaded in-plane and transversally. Large displacement theory L6 – Numerical solution by FEM L7 – Unstiffened and stiffened plates loaded in compression L8 – Numerical solution by FEM Part B – Design of plated structures L9 – Introduction to the design of slender sections. Global analysis L10 – Ultimate behaviour of unstiffened and stiffened plates L11 – Design of plated members: direct stresses L12 – Design of plated members: shear resistance L13 – Design of plated members: transverse forces, interaction and detailing of transverse and longitudinal stiffeners Part C – Fatigue & fracture of steel structures L14 – L15 – L16 – L17 – L18 – Part D – Design of bridges L1 – Keynote Conference and Bridge Awards L20 – L21 – L22 – L23 – L24 – ... The following topics are addressed: 1. Introduction 2. Generalities about conceptual design – objectives 3. History of bridges 4. Typology of bridges 5. Girder bridges 6. Trusses 7. Bridges 8. Bowstrings 9. Suspended bridges 10. Arches 11. Movable bridges

	12. Cable-stayed bridges 13. Concrete bridges 14. Steel bridges 15. Composite bridges 16. Equipments
Recommended or required reading	Beg D., Kuhlman U., Davaine L., Braun B.: Design of plated structures. ECCS Eurocode Design Manuals, ECCS, Ernst & Sohn and Wiley, 2011, 438 p. Nussbaumer A., Borges L., Davaine L.: Fatigue design of steel structures. ECCS Eurocode Design Manuals, ECCS, Ernst & Sohn and Wiley, 2011, 239 p.
Standards	EN 1990:A.1 2005. Design of Steel Structures. Part 2: Design of joints. EN 1991-2: 2005. Design of Steel Structures. Part 2: Design of joints. EN 1993-1-5: 2005. Design of Steel Structures. Part 1-1: General Rules and rules for buildings. EN 1993-1-7: 2005. Design of Steel Structures. Part 1-7: Design of joints. EN 1993-1-9: 2005. Design of Steel Structures. Part 1-9: Design of joints. EN 1993-1-10: 2005. Design of Steel Structures. Part 1-10: Design of joints. EN 1992-2: 2005. Design of Steel Structures. Part 2: Design of joints. EN 1993-2: 2005. Design of Steel Structures. Part 2: Design of joints. EN 1994-2: 2005. Design of Steel Structures. Part 2: Design of joints.
Tools	FEM software EBPlate
Planned learning activities and teaching methods	Frontal lectures are organised from the beginning. In addition, students have to achieve the conceptual design of a particular bridge on the basis of assumed realistic design requirements provided by the lecturers. A feasibility study will also be carried out. At the end of the unit, a critical appraisal of the projects takes place, involving the lecturers and the students.
Assessment methods and criteria	The assessment includes the following evaluations: oral examination on the contents of the lectures and oral presentation/justification of the above mentioned project. As part of the oral examination, students will have to comment orally photographs presenting a particular bridge selected by the lecturers.
Language of instruction	English

Course unit title	*LOCAL CULTURE AND LANGUAGE*
Course unit code	1C04
Type of course unit	Compulsory
Semester	1
Number of ECTS credits allocated	2
Name of lecturer(s)	To be completed: xxxx (UC); xxxxx (CTU); xxxxx (ULg); xxx (UNINA); xxxx (UPT).
Learning outcomes of the course unit	The course is an introduction to the Host country´ society and the political and social system governing the country. After completing the course, the student should be able to: - describe significant aspects of the Host country´s society from a geographical, social and historical perspective. - carry out comparative studies between Host country´s society and the conditions in the student´s home countries. - have a basic knowledge of the Host country´s speech and writing, to be able to communicate in "everyday" situations. - perform and present written reports within given instructions and time frames
Mode of delivery	Lectures which introduces the Host country´s society and the political system, its historical development and present organization. There will also be study visits to local sites of interest. The students will also do a project work and present that at a seminar.
Prerequisites and co-requisites	none
Course contents	The course consists of three parts. The first part introduces the Host country´s society and the political system, its historical development

	and present organization. The emphasis is on the distinguishing features of the country´s system. What is characteristic for the Host country´s way of living and its governance system? The second part consists of providing the students basic skills for communicating in the language of the Host country. The third part of the course consists of project work. The aim of the project is to pursue a comparative analysis of some aspect of the Host country´s system and the conditions in the student's home country. What are the differences and similarities between the two countries? The work result in a written report presented and discussed at a seminar.
Recommended or required reading	Information and reports from official websites. Handouts
Planned learning activities and criteria	The teaching will take the form of lectures and seminars. Study visits to local sites of interests.
Assessment methods and criteria	The course aim is examined through a report that is presented and discussed at a seminar. ECTS grading table will be used.
Language of instruction	English

Course unit title	*ADVANCED DESIGN OF CONCRETE STRUCTURES*
Course unit code	1E01
Type of course unit	Elective
Semester	1
Number of ECTS credits allocated	5
Name of lecturer(s)	To be completed: xxxx (UC); xxxxx (CTU); xxxxx (ULg); xxx (UNINA); xxxx (UPT).
Learning outcomes of the course unit	After completing the course, the student is expected to have understanding for calculation and design of the main elements in reinforced concrete structures according to current building codes. • Be able to understand the behaviour of reinforced concrete structures •carry out calculations on safety verification of reinforced concrete members. • Have skill to design r.c. structural members and components • be able to understand the behaviour of joints diagrams, normal force, shear force and bending moments • have skills in mechanics that give the basis for construction subjects • be able to describe theories and solution methods in mechanics • understand the subject's importance to other courses in the civil engineering programme
Mode of delivery	Frontal lesson , laboratory
Prerequisites and co-requisites	General admission requirements to the second semester.
Course contents	The purpose of this course is to introduce students step by step with the design of seismic resistant structures. Thirteen topics, listed below are covered in the course. Description of topics Design of RC frame structures 1.1 Verification and design rules for RC sections under axial-bending loads according to the ultimate limit state method. 1.2 Verification and design rules against shear and torsion.

1.3 Provisions by European and American Guide Lines (Eurocodes and ACI).

2. Ductility of RC structures
2.1 Moment-curvature diagrams, tri-linear and bi-linear models.
2.2 Ductility of RC sections under bending.
2.3 Plastic hinge and allowable plastic rotation for RC elements under bending, Eurocode criteria.
2.4 Influence of axial force.
2.5 Examples.
2.6 Ductility at sectional and structural scales.

3. Failure analysis of structures
3.1 Plastic hinge and maximum rotation in plastic range for steel and RC elements.
3.2 Limit analysis of frame structures,
3.3 Greenberg-Prager delimitation method,
3.4 Incremental analysis with control of required rotation for RC structures.
3.5 Calculation methods based on moment redistribution for RC structures.
3.6 Effect of axial forces.
3.7 Examples.

4. Serviceability limit states of RC beams
4.1 Evolution of cracking phenomenon for RC elements under tensile axial force.
4.2 Moment-curvature diagrams in cracked range.
4.3 Crack width and deformability of beams in cracking range.
4.4 Approximate formulas and normative requirements. Delayed deformation for concrete (shrinkage and creep). T
4.5 theory of linear viscoelasticity.
4.6 Creep and relaxation functions.
4.7 The ageing phenomenon, CEB, ACI methods, Italian codes.
4.8 Algebraic methods (EM, MS, AAEM methods).
4.9 Problems concerning structures subject to delayed deformation.
4.10 Principles of linear viscoelasticity.
4.11 Numerical examples.

5. Prestressed concrete beams:
5.1 Basic concepts.
5.2 Techniques for prestressed concrete elements.
5.3 Stress resultants in statically determined structures.
5.4 Statically-redundant structures (basics).
5.5 Pre-tensioned and bonded post-tensioned elements.
5.6 The design states and the limit conditions for bonded post-tensioned beams. Verification according to Eurocode and ACI

	Guidelines. 5.7 Loss of prestressing force. 5.8 Detailing and local verifications. 6. RC plates subject to in-plane loadings 6.1 Theory of elasticity (fundamentals), 6.2 plane stress and plane strain states. Simplified methods. 6.3 RC High beams: cracking range and failure modes, high beams with multiple supports. Design criteria and details. 6.4 Suspended loads. 7. RC plates under transverse loads 7.1 Kirchhoff plate theory: Lagrange equations and boundary conditions. 7.2 Simply-supported and clamped plates. 7.3 RC plate structures: design criteria and details. RC slabs over columns: approximate methods for calculation of internal actions, design rules and details. 7.4 Verification against punching. 8. Instability of RC structures 8.1 The model column method. 8.2 The equilibrium state method. 8.3 M-N interaction diagrams with II order effects. 8.4 The effect of delayed deformations. 8.5 The case of precast structures. 8.6 CNR 10025 Design Guidelines and International Guidelines. 8.7 Foundations for precast structures: Design criteria and construction details.
Recommended or required reading	Background material of research projects developed by the teachers Chosen chapters related to selected topics of theory of stability and connections Eurocodes ECCS recommendations Guidelines, Standards
Planned learning activities and teaching methods	The course will be held in two weeks. Each topic will be undertaken in one week. The course is organized in theoretical lectures and tutorials. Teaching is given in classes including numerical examples and exercises. Compulsory assignments are given during the course. A final assignment is given concerning the preliminary design of a r.c. building. This work should be done in group of two students.
Assessment methods and criteria	The final oral exam only after having completed all the homework and the final project, which have to be brought at the exam. The homework has to be delivered within two weeks after the assignment. The final

	assignment has to be delivered within to week after the end of the course. All the assignment must be approved by the tutor. Grading system. Passed or not passed. A certificate awarding ECCS credits after the course accomplishment may be provided upon the request.
Language of instruction	English

Course unit title	*ADVANCED DESIGN OF TIMBER STRUCTURES*
Course unit code	1E02
Type of course unit	Elective
Semester	1
Number of ECTS credits allocated	5
Name of lecturer(s)	To be completed: xxxx (UC); xxxxx (CTU); xxxxx (ULg); xxx (UNINA); xxxx (UPT).
Learning outcomes of the course unit	Aim The aim of this course is to give students the latest knowledge about the timber structures.To describe the historical development of the use of timber in building and engineering structures and to develop an awareness of significance of timber as a traditional structural material. To focus attention on the essential properties of timber which have to be considered in the design, detailing and construction of timber structures. To develop an understanding of importance of strength grading in process of converting wood, a natural raw material, into timber for structural use. To introduce new high strength wood-based materials. To describe their use and how they can be designed by following the Eurocode 5 principles. To describe the Eurocode principles for safety and serviceability and the bases of design common to all materials, together with the special rules for timber structures necessitated by, for example, the effects of load duration and moisture content. To describe the strength and stiffness of timber members and components at different loading. To give an overview of the different types connections used in timber structures. To give introduction to the design and use of planar and spatial timber structures. To describe the structural behaviour of timber frame house construction. To describe the use of timber in modern bridges. To present calculation methods for structural fire design. To present information about timber under influence of climatic conditions and durability of timber structures. Skills The course is conceived in order to give students the following skills: - Understanding of wood as a cellular and anisotropic material. - Understanding the behaviour of different timber structures. - Understanding how to calculate the design resistance of timber structures according to Eurocode 5. - Understanding how to do the best detailing. - Understanding basics of manufacturing and maintenance of

	different timber structures. - Knowledge how to do FE analysis and interpret obtained results.
Mode of delivery	Frontal lessons, seminar work and home work
Prerequisites and co-requisites	No requirements
Course contents	The purpose of this course is to introduce students step by step with the design of timber structures. Eight topics, listed below are covered in the course.
Recommended or required reading	Kuklík, P.: Design of timber structures with worked examples, CTU in Prague, 2012. Thelandersson, S. – Larsen, H.J.: Timber engineering, John Wiley& Sons Ltd., 2003. Eurocodes and European standards.
Planned learning activities and teaching methods	**1 Introduction to advanced timber structures** 1.1 - History of building construction Timber framed houses, roof and wall structures, bridges. 1.2 - Wood as a structural material Technical and non-technical characteristics, potential of timber in building sector. **2 Wood properties and wood engineering products** 2.1 - Wood properties Structure of wood (macro-, micro-, submicro-), natural features in sawn timber, shrinkage, creep, loss of strength, evaluation of structural properties. 2.2 - Structural timber and glulam Grading, mechanical properties, poles and round timber, solid timber, structural timber with special properties (KVH, DUO/TRIO). Glulam production and properties, structural use of glulam. 2.3 - Wood based panels Panels based on wood pieces (fibres, strands and veneers) and also wood boards. Detailed description of cross laminated timber - production, load- carrying behaviour, modelling and verification (plates, walls and joints). **3 Limit states design** 3.1- Structural members Reliability assessment (deterministic, semi or fully probabilistic). Design of members according to Eurocode 5 (stress in one direction, combined stresses, with varying cross-section or curved shape). Stability of members. 3.2 - Connections Connections with metal fasteners (nails, dowels, bolts, screws,

connectors, punched metal plate fasteners). Design according to Eurocode 5.

3.3 - Components, assemblies and composite structures

Glued thin-webbed or thin-flanged beams, roof and floor diaphragms, timber-concrete composite floors, strengthening of timber members.

Possible assignment

- Design of column and beam of a heavy timber frame structure.

4 Planar and spatial timber structures

4.1 - Planar structures

Beams, portal frames, arches, trusses, bracing, serviceability limit state criteria, 2nd order theory.

4.2 - Spatial structures

Space grid and shell structures.

Possible assignment

- Design of moment resisting connection.

5 Timber frame houses

5.1 - Methods of construction

Light and heavy frames. Massive structures.

5.2 - Design models

5.3 - Connections between elements

Possible assignment

- Design of timber-concrete composite floor of a multi-storey building.

6 Timber bridges

6.1- Types, sizes and structural systems

6.2 - Bridge decks

6.3 - Connections and details

6.4 - Design according to Eurocode 5

6.5 - Maintenance

7 Fire resistance of timber structures

7.1 - Behaviour of timber and wood-based materials in fire

7.2 - Fire resistance of timber members and joints

7.3 - Design according to Eurocode 5

8 Durability of timber structures

7.1 - Natural durability of timber

7.2 - Deterioration mechanisms, hazard and durability classes

7.3 - Timber structures in aggressive environments

Assessment methods and criteria	Approved assignments will be necessary to prepare at the end of the course on the work performed during the course. Grading system. Passed or not passed. A certificate awarding ECCS credits may be provided upon the request.
Language of instruction	English

Course unit title	*ADVANCED DESIGN OF GLASS STRUCTURES*
Course unit code	1E03
Type of course unit	Elective
Semester	1
Number of ECTS credits allocated	5
Name of lecturer(s)	To be completed: xxxx (UC); xxxxx (CTU); xxxxx (ULg); xxx (UNINA); xxxx (UPT).
Learning outcomes of the course unit	Aim The course is intending to introduce the students the field of structural applications of glass and to give them some specific skills for calculation and detailing of for basic glass structures: panes beams and fins, columns and walls, point-supported glass, as well as for glazing systems such as glass facades, canopies and roofs, stairs and floors. On this purpose the properties of glass as structural material will be presented in comparison with other basic building materials, together with selected examples of glass/glazing applications. Design details and connecting technology, relevant technical regulations, specification and current methods applied in design will be described. Worked examples will accompany the lectures for better understanding, and design project will help to fix specific knowledge. Skills The course is conceived in order to give students the following skills: - Understanding use of glass as structural material in specific application in buildings - Understanding the basic philosophy glass behaviour and use technical regulations and design specification for glass structure calculation and design - Understanding specific features of connecting and supporting systems, and detailing used in glazing - Applying FE analysis in structural glass design and interpretation of results.
Mode of delivery	Frontal lesson, seminars with worked examples, home works, design projects
Prerequisites and co-requisites	i.e. general admission requirements

Course contents	The course contents covers the following topics: I. Glass as a structural material II. Basis of design of structural glass III. Design of structural glass: strength and loadbearing behaviour of glass members IV. Glazing: Structural glass systems; connecting and supporting technology V. Robustness of glass structures VI. Sustainable design
Recommended or required reading	ISTRUCTE: Structural use of Glass in building, The Inst. 0f Structural Engineers, London, 1999. R. Nijsee: Glass in Structures, Birkhauser, Basel, Berlin, Boston, 2003. C. Schittich et al. Glass construction manual, Bikhauser. Basel, Boston, Berlin, 1999. Rice P., Dutton H., Structural glass , E&FN Spon m London, 1990 pr EN13474-1: Glass in building-Design of panes-Part 1:General basis of design pr EN 1374-2: Glass in building-Design of panes-Part 2: design for uniformly distributed loads ASTM-E-1300-02: Standard Practice for determining Load Resistance of Glass in Buildings
Planned learning activities and teaching methods	Course content The course is conceived for 12 weeks: 1- Structural glass applications in building 2 –Glass as structural material Types of glass; Structural and non-structural properties. Annealed glass; toughened glass; heat-strengthened glass; laminated glass. Insulated glass. Fire resistant glass. Photovoltaic Glass. 3- Basis of design Principles. Design requirements. Actions and Combinations. Design criteria for ULS and SLS, Design methods: calculation and design assisted by testing Standards and design specifications. 4- Design of structural glass members: Panes, beams and fins, columns, walls , point-supported glass 5. Connecting and supporting of glass : design detailing and technology 6 Glazing systems Glass facades, canopies and roofs, floors, stairs, bridges, glass

	balustrades. Glass in large deflection structures. 7. Robustness of glass structures Blast resistant glass; shock and bullet resistant glass; seismic action. 8 Glazing for sustainable design Applications The applications are done under the form of practical applications and project: Worked examples: - Pane calculation under different loading and supporting conditions - Beam and column design checking Project (elective): - Glass facade - Canopy - Stair
Assessment methods and criteria	Approved assignments will be necessary to prepare at the end of the course on the work performed during the course. Defence of project. Grading system. Passed or not passed. A certificate awarding ECCS credits may be provided upon the request.
Language of instruction	English

Course unit title	*ADVANCED DESIGN OF STEEL AND COMPOSITE STRUCTURES*
Course unit code	2C05
Type of course unit	Compulsory
Semester	2
Number of ECTS credits allocated	6
Name of lecturer(s)	To be completed: xxxx (UC); xxxxx (CTU); xxxxx (ULg); xxx (UNINA); xxxx (UPT).
Learning outcomes of the course unit	Aim The aim of the course is to present the structural solutions for the main categories of steel and composite steel-concrete structures applied in buildings and industrial construction. The following types of construction are concerned: - industrial buildings - tall buildings - large span structures - plated and shell structures - lightweight structures On the purpose to give students a global approach of the specific problems to given construction type, the specific lectures are organised according to the following integrated structure: - specific structural typologies and detailing - loading conditions and design criteria - analysis and design checking at ULS and SLS - specific requests for execution and erection Particular aspects related to stability problems, dynamics, fatigue and specific connecting design will be addressed where and when they are significant. Also, the use of high performance materials for steel and/or concrete or composite will be tackled. Relevant parts of EN 1993 and EN 1994 as well as of EN 1990 and EN 1991 will be employed for the calculation of such elements. The theoretical part is supplemented with practical analyses by various methods: analytical and FE analysis, design project.

	Skills The course is conceived in order to give students the following skills: - Adopting different design approaches as appropriate for the characteristic structural system - Understanding the behaviour of different steel and composite structures. - Understanding ULS and SLS conditions for different structural typologies. - Assigning best detailing according to structural system. - FE analysis, numerical design, and interpretation of results.
Mode of delivery	Frontal lesson , seminary and laboratory work, homeworks
Prerequisites and co-requisites	i.e. general admission requirements
Course contents	Analysis and design methodologies for special steel and composite steel-concrete structures will be explained and detailed. The course is devoted to cover the following main topics: I. Industrial buildings II. Tall buildings III. Large span structures IV. Plated and shell structures V. Lightweight steel constructions
Recommended or required reading	Steel and composite steel-concrete Eurocodes and normatives ECCS design recommendations Access Steel website (www.access-steel.com) Luís Simões da Silva, Rui Simões and Helena Gervásio, Design Of Steel Structures, ECCS | Ernst & Sohn ISBN (ECCS): 978-92-9147-098-3, 2010 Buckling of Steel Shells - European Design Recommendations ECCS ISBN (ECCS 92-9147-000-92, 2008 Darko Beg; Ulrike Kuhlmann; Laurence Davaine; Benjamin Braun, Design of Plated Structures, , ECCS | Ernst & Sohn ISBN (ECCS): 978-92-9147-100-3, 2010 Design of Cold-formed Steel Structures Eurocode 3: Design of Steel Structures Dan Dubina, Viorel Ungureanuand Rafaelle Landolfo Eurocode 3 Part 1-3 – Design of Cold-formed Steel Structures, ECCS, in print Richard Liew, J.Y.; Balendra, T. and Chen, W.F. “Multistory Frame Structures” Structural Engineering Handbook Ed. Chen Wai-Fah Boca Raton: CRC Press LLC, 1999 David A. Nethercot, Composite Constructions, Spon Press – Taylor and Francis, 2004
Planned learning activities and teaching methods	Course content The course is conceived for 12 weeks: 1 – Single story buildings (non-residential buildings and industrial halls): - Typology of single-story buildings

- Specific loading conditions: climatic actions, technological actions etc.
- Details and structural typologies: main frame, secondary structure, cladding and roof, connections
- Design for resistance and stability (ULS) and serviceability (SLS) criteria.

2 – Multi-story buildings:
- Design concepts and structural systems: gravity frames, bracing systems, moment-resisting frames, dual frames, steel-concrete composite systems, influence of joint behaviour.
- Specific loading conditions: permanent, imposed, lateral loads (wind, earthquake) etc.
- Composite floor systems: composite beams, composite floors, slim-floors.
- Methods for global analysis.
- Design for resistance and stability criteria (ULS). SLS conditions to vertical and horizontal loads.
- Robustness of multi-story buildings: impact, explosion, fire, use of high performance materials.

3 – Large span structures:
- Design concepts and structural systems: reticulated structures for roof systems, truss structures, suspended structures
- Specific loading conditions: heavy climatic conditions (snow, wind)
- ULS and SLS conditions: stability, dynamics.

4 – Plated and shell structures:
- Application of plated structures.
- Strength and stability of plated structures: behaviour in shear, bending, compression, combined loads.
- Application of shell structures.
- Strength and stability of shell structures: membrane theory, bending theory.

5 – Lightweight steel structures:
- Application of lightweight steel construction.
- Characteristics of cold-formed steel profiles: effective geometrical characteristics, design resistance and stability criteria, connecting design and technology
- Residential steel lightweight buildings: specific loading, conditions for design at ULS and SLS, constructive details.
- Roofing and cladding systems: diaphragm effect, constructive detailing, technological conditions.

Applications

The applications are done under the form of practical applications and

	project: Practical applications: - Stability of columns - Design of a plated girder - Design of composite columns - Design of a roof purlin (cold-formed thin-walled element) Project (elective): - Industrial hall - Multi - storey building - Residential house in cold-formed steel solution
Assessment methods and criteria	Approved assignments will be necessary to prepare at the end of the course on the work performed during the course. Grading system. Passed or not passed. A certificate awarding ECCS credits may be provided upon the request.
Language of instruction	English

Course unit title	*Robustness of structures against seismic and exceptional loadings*
Course unit code	2C06
Type of course unit	Compulsory
Semester	2
Number of ECTS credits allocated	6
Name of lecturer(s)	To be completed: xxxx (UC); xxxxx (CTU); xxxxx (ULg); xxx (UNINA); xxxx (UPT).
Learning outcomes of the course unit	After completing the course, the student is expected to: • Be able to understand the dynamic behaviour of constructions and the effect of dynamic loads. •Have skills in structural dynamics that give the basis for construction subjects • Have skill to design steel structural systems and components able to attenuate or withstand seismic actions. • Carry out calculations with the aid of finite element methods • Understanding the principles and methods of dynamic analysis • Have skills to apply the rules and verifications given by European codes • Be able to design, draw seismic resistant steel structures.
Mode of delivery	Frontal lesson Tutorials
Prerequisites and co-requisites	General admission requirements to the second semester.
Course contents	The aim of the course is to provide students with both the theoretical and constructional bases for the design of steel structures in seismic areas. Scope of the course is to provide the required background knowledge of structural dynamics and basic methodologies for the design of engineered structures in seismic zones, as well to conceive the conceptual and preliminary design of a steel seismic resistant structure. During the course students will learn the fundamental aspects of earthquake engineering, and in particular: fundamentals of engineering seismology, fundamentals of structural dynamics, definition of the seismic actions, behaviour of structures under earthquake actions -with reference to both the elastic and the inelastic behaviour-, structural design approaches according to the most important codes and

regulations. The design methods will be described using steel structures as case studies.

The purpose of this course is to introduce students step by step with the design of seismic resistant structures.
The thirteen topics covered in the course are listed as follows:

1. Fundamentals of seismology
   1.1. Brief history of earthquake engineering
   1.2. causes of earthquakes,
   1.3. theory of plate tectonics,
   1.4. definition of seismic waves,
   1.5. location of the epicentre, intensity scales, magnitude scales.

2. Fundamentals of seismic hazard
   2.1. Strong ground motion
   2.2. seismic hazard analysis
   2.3. local site effects
   2.4. definition of a design earthquake.

3. Dynamic analysis of single-degree-of-freedom systems I
   3.1. Introduction to dynamics of structures
   3.2. free vibration analysis of SDOF systems
   3.3. undamped and damped vibrations of SDOF systems
   3.4. response of SDOF systems to harmonic excitations

4. Dynamic analysis of single-degree-of-freedom systems II
   4.1. Forced vibration
   4.2. response of SDOF systems to arbitrary excitations
   4.3. numerical evaluation of the dynamic response.

5. Dynamic analysis of single-degree-of-freedom systems III
   5.1. Response of SDOF systems to earthquakes
   5.2. elastic earthquake response spectrum
   5.3. design spectrum.

6. Dynamic analysis of multi-degree-of-freedom systems
   6.1. Free vibration
   6.2. natural vibration frequencies and modes
   6.3. forced motion of MDOF systems
   6.4. modal analysis.

7. Finite element methods in structural dynamics I
   7.1. Free vibration analysis
   7.2. Rayleigh – Ritz method
   7.3. vector iteration techniques
   7.4. inverse vector iteration method
   7.5. subspace iteration method.

	8. Finite element methods in structural dynamics II 8.1. Dynamic response analysis 8.2. time-stepping procedure 8.3. central difference method 8.4. Newmark's method 8.5. stability and computational error of time integration schemes 8.6. analysis of nonlinear response 8.7. average acceleration method 8.8. HHT method. 9. Seismic analysis I 9.1. Earthquake analysis of linear and non-linear systems 9.2. multi-modal response history analysis 9.3. multi-modal response spectrum analysis. 10. Seismic analysis II 10.1. Equivalent static analysis of linear MDOF systems 10.2. ductility-modified response spectra 10.3. non-linear static analysis – pushover analysis 10.4. displacement-based seismic design. 11. Earthquake-resistant design of structures I 11.1. Principles and objectives of earthquake-resistant design 11.2. practical aspects of earthquake-resistant design 11.3. principles to ensure good seismic behaviour. 12. Earthquake-resistant design of structures II 12.1. Eurocode 8 12.2. general rules 12.3. seismic actions 12.4. general and specific rules for steel buildings and towers 13. Seismic design of steel structures 13.1. Conceptual design of buildings and towers, 13.2. design criteria, 13.3. dissipative design, 13.4. seismic design of connections
Recommended or required reading	Seismic Design of Buildings to Eurocode 8, Ahmed Elghazouli (Editor) , Taylor & Francis Chopra, A.K.: Dynamics of structures. Pearson Prentice Hall, 2007. Booth, E. and Key, D.: Earthquake design practice for buildings. Thomas Telford, 2006. Fardis, M. et al : Designers´ guide to Eurocode 8,Thomas Telford, 2005. Bruneau, M., Uang, C.M., Whittaker, A., Ductile Design of Steel Structures. McGraw-Hill Professional 1997. Mazzolani F.,M., Piluso V., Theory and design of seismic resistant steel

	frames. Spon Press 1996. Leet, K. and Uang, C.M., Fundamentals of Structural Analysis, McGraw-Hill, Inc., 2004.
Planned learning activities and teaching methods	The course will be held in 13 week. Each topic will be undertaken in one week. The course is organized in theoretical lectures and tutorials. Teaching is given in classes including numerical examples and exercises. Compulsory assignments are given during the course. A final assignment on the conceptual design of a steel building in seismic area. Drawing as well as structural report showing calculations on preliminary design is also required. This work should be done in group of two students.
Assessment methods and criteria	The final oral exam only after having completed all the homework and the final project, which have to be brought at the exam. The homework has to be delivered within two weeks after the assignment. The final assignment has to be delivered within to week after the end of the course. All the assignment must be approved by the tutor. Grading system. Passed or not passed. A certificate awarding ECCS credits after the course accomplishment may be provided upon the request.
Language of instruction	English

Course unit title	*ROBUSTNESS OF STRUCTURES EXPOSED TO FIRE AND EXPLOSION*
Course unit code	2C7
Type of course unit	Compulsory
Semester	2
Number of ECTS credits allocated	6
Name of lecturer(s)	To be completed: xxxx (UC); xxxxx (CTU); xxxxx (ULg); xxx (UNINA); xxxx (UPT).
Learning outcomes of the course unit	Aim The aim of this course is to give students an understanding of the design methods of structures at accidental situations, fire and explosion. The course is focussed on all design methods involved in fire design: prediction of fire scenario, evaluation of fire load, calculation of gas temperatures in the fire compartment and structural analysis. Special attention is paid to fire modelling when several design models is presented including nominal temperature curves, simple models and advanced models. Gas temperature in the fire compartment is considered as basis for the structural design. Methods for prediction of temperature of the structural elements are presented and mechanical properties of structural materials (steel, concrete, timber and aluminium structures) are presented. Design models for steel, concrete, steel concrete composite, timber and aluminium structural elements loaded by tension, compression and bending moment are presented. Attention is paid to protection of steel and timber structures to fire, various methods of protection are described. Smaller part of the course is focussed on explosions. Types of explosions are described together with design models. Basic principles of structural analysis are presented. Design methods are explained with focus to increase robustness of the structure. The theoretical part is supplemented with practical exercises using simple design models with aim to apply the knowledge in design of simple structural elements. Understanding of basic principles of structural analysis and design of steel, concrete and timber structures is necessary. Skills The course is conceived in order to give students following skills: - To understand the basic methods in fire engineering.

	- To be able to develop possible fire scenarios and to understand various fire models. - To predict the gas temperature in the fire compartment for the selected fire scenarios, to evaluate the fire load density and other fire parameters necessary for thermal analysis of the fire compartment. - To be able to predict temperature of unprotected and protected structural elements and to be able to select / design suitable fire protection of those elements. - To understand the specific problems related to structural analysis at fire. To be able to predict the mechanical load at fire and calculate internal forces of simple structures exposed to fire. - To understand the effect of high temperature on mechanical properties of steel, concrete, timber and aluminium alloys. To be able to design steel, concrete, steel-concrete composite, timber and aluminium structures exposed to fire. - To understand the purpose of fire testing, measurements and equipment of fire testing laboratory, large scale testing. - To understand the models for load by explosion in open and closed space, structural analysis at explosion, structural damages and repair of structures. - To understand the robustness of structures and to be able to design simple structures to ensure structural integrity.
Mode of delivery	Frontal lessons, seminar k and home work
Prerequisites and co-requisites	No requirements
Course contents	Thermal analysis of the fire compartment, including prediction of possible fire scenarios, evaluation of fire load density, rate of heat release and other parametres necessary for the analysis represent the most important part of the fire design procedure and are the main part of the course. It will be focussed on various design methods of prediction of gas temperature in the fire compartment. Simple methods (nominal and parametric fire curves) and advanced methods (localised fire, zone models) will be described in details, overview of CFD will be given. Several useful software tools for easy application of these models will be presented. Prediction of structural behaviour and mechanical load during the fire follow the thermal analysis. Students should be able to predict temperature and resistance of steel, concrete, steel concrete composite, timber and aluminium structural elements. This will be documented on simple elements such as beams and columns and

	complex structures (steel frame). The students practise the design methods according to European standards to be able to perform structural design at fire. The students should understand different types of explosion, evaluation of parametres of the explosion and dynamic analysis of the structures. Basic principles of robustness of the structure, structural design to increase robustness and to prevent progressive collapse of the structure will be explained. This will be demonstrated on some existing buildings. Practical application (evaluation of joint tying capacity) will be practised by students.
Recommended or required reading	Jean-Marc Franssen J.M., Vila Real P., Fire Design of Steel Structures, ECCS, Publication 302, ISBN 978-92-9147-099-0. Buchanan A. H., Structural Design for Fire Safety, John Wiley and Sons, Chichester 2003. ASCE Manual, Performance-Based Design of Structural Steel for Fire Conditions, American Society of Civil Engineers, 2009. Lennon T., Moore D.B., Wang Y.C., Bailey G.G., Designer's Guide to EN 1991-1-2, EN 1992-1-2, EN 1993-1-2 and EN 1994-1-2, Thomas Telford, 2006. Access Steel website (ww.access-steel.com).
Planned learning activities and teaching methods	Eleven topics, listed below are covered in the course. 1 Introduction to fire safety 1.1 - Fire safety, classification of structures, fire compartments, escape routes (general overview) 1.2 - Natural fire and its relation to design to fire safety 2 Fire load and models of fire 2.1 - Fire load density, characteristic and design load, effect of active fire measures, rate of heat release, fire scenarios 2.2 – Simple models for compartment fires, nominal fire curves, parametric temperature curve Practical calculation of fire load density for simple compartment, evaluation of temperature curve, comparison of different models, advantages and disadvantages of simple models 2.3 - Advanced fire for compartment fires, zone models, CFD models Application of software to apply zone models for thermal analysis, overview of CFD analysis 2.4 - Fire load for localised fires, modelling of localised fires 3 Structural analysis at fire 3.1 - Accidental load combination, structural analysis at fire 3.2 - Video from large scale fire test in Cardington, example of analysis of steel structure in Cardington 4 Fire resistance of steel structures

4.1 - Temperature of unprotected steel elements at fire, fire protection of steel structures, temperature of protected steel elements at fire
4.2 - Material properties of steel at high temperatures
4.3 - Resistance of element loaded in tension, compression, bending, lateral torsional stability of beams
4.4 - Design of joints
Practical application: design of simple elements exposed to fire: unprotected beam, protected column

5 Fire resistance of concrete structures
5.1 - Material properties of concrete at high temperatures
5.2 - Resistance of reinforced concrete slabs, beams and columns
Tables, simple methods, advanced methods
Practical application: design of simple elements exposed to fire: concrete beam, concrete column

6 Fire resistance of steel concrete composite structures
6.1 - Fire resistance of composite slab
6.2 - Resistance of composite beams
Tables, simple methods, software AFCB
6.3 - Resistance of composite columns
Tables, simple methods, software AFCC
Practical application: design of simple elements exposed to fire: composite beam, composite column

7 Fire resistance of timber structures
7.1 - Behaviour of timber structures exposed to fire, fire protection of timber structures
7.2 - Design method for timber structures
Method of effective cross-section, method of reduced stiffness and strength
7.3 - Design of joints
Practical application: design of simple elements exposed to fire: timber beam, timber column

8 Fire resistance of aluminium structures
8.1 - Temperature of aluminium structures exposed to fire,
8.2 - Material properties of aluminium alloys exposed to high temperatures
8.3 - Resistance of elements loaded by tension, compression and bending moment

9 Fire tests
9.1 - Introduction to testing and measurement, equipment of fire test laboratory, examples of tests, test setup
9.2 - Large scale fire tests (Cardington, Mokrsko), evaluation of test data

	10 Loading at and structural analysis at explosion 10.1 - Types of explosion, explosion in enclosed open and space, interaction with buildings, structural analysis at explosion, 10.2 - Mechanical behaviour of material at dynamic load. 10.3 - Damage to structures, protection of structures to explosion, reconstruction 11 Robustness 11.1 - Design for robustness, structural behaviour, structural integrity, ductility Project assignment Fire resistance of steel / composite / timber building - defining fire scenarios, evaluation of fire parametres, thermal analysis, temperature of structural elements and evaluation of fire resistance according to requirements, design of fire protection when necessary - various structures can be covered: office buildings, car parks, industrial buildings of various purpose, storage buildings, shopping centres, etc.
Assessment methods and criteria	Approved assignments will be necessary to prepare at the end of the course on the work performed during the course. Grading system. Passed or not passed. A certificate awarding ECCS credits may be provided upon the request.
Language of instruction	English

Course unit title	*BIM, BUSINESS ECONOMICS AND ENTREPRENEURSHIP*
Course unit code	2C08
Type of course unit	Compulsory
Semester	2
Number of ECTS credits allocated	2
Name of lecturer(s)	To be completed: xxxx (UC); xxxxx (CTU); xxxxx (ULg); xxx (UNINA); xxxx (UPT).
Learning outcomes of the course unit	▪ Clear understanding of the concepts of macro and micro economics; ▪ To identify the relevant issues from economics for application in the construction sector; ▪ To develop skills for innovation and risk taking; ▪ To understand production and operational issues in industrialised construction; ▪ To apply these skills to the construction sector.
Mode of delivery	Frontal lesson and group work.
Prerequisites and co-requisites	General admission requirements
Course contents	Strategic planning and management of construction company Introduction to construction business management, Challenges of construction industry, summary of key management problems. Business strategies Business strategies to minimize the risk of business failure, plan implementation/control strategies. Financial management strategies Financial long term planning in context of strategic objectives and assessment, short term goals, situation analysis, performance measurement, analysis of general business environment – tools and methods, implementation. Business development in construction company Marketing analysis, demand assessment, marketing policies, marketing tools, work acquisition methods and procedures. Financial analysis and management in construction company Specific requirements on accounting, financial statements and construction industry specific standards according IAS/GAAP, percentage method of revenue and profit recognition.

	Cash flow analysis Profitability, liquidity, debt and trend analysis. Cash flow analysis. Risk management in construction company RM Strategies, insurance for builders´ practice, bonding as limitation factor of company growth, bonding in construction project practice. Risk Management Systems for construction projects Classification of risk in civil engineering contracts, mitigation of risk, RM systems in industry practice. Project management systems applied in construction contracting Principles of project management for construction, project organization, methods and tools, specifics of construction company project management. Advanced systems of construction project management Procurement systems, contract types, advanced systems of construction project management. Standard contracts in civil engineering FIDIC types of standard contract, Red Book, Yellow Book and White Book. Large contracts in civil engineering Specialty of FIDIC application for large contracts, highways, bridges, plants. Production and Operation Strategy and competition; forecasting; Inventory control; Supply chain management; Push and pull production control systems; Operations scheduling; Project scheduling; Quality and assurance. Integrated Design and Production Application of total integration techniques (BIM). Entrepreneurship Definition and history; Innovation; Ethics. Entrepreneurial venture plan Opportunity assessment; Feasibility plan. Entrepreneurial issues for start-up Legal forms of entrepreneurial organizations; Legal environment; Financial sources
Recommended or required reading	▪ Schaufelberger, J., "*Construction Business Management*", Pearson, 2009. ▪ Yescombe, E.R.,: "*Principles of Project Finance*", Academic Press, San Diego, 2002. ▪ Clough R.H., Sears G.A., & Sears, S.K., "*Construction contracting: A practical guide to company management*", Hoboken, NJ: John Wiley and Sons Inc , 2005. ▪ Civitello A.M., Levy S.: Construction Operations Manual of Policies and Procedures, 4rd edition, McGraw-Hill, New York, 2005, 480 p. ▪ Langford D., Male S.: Strategic Management in Construction, 2nd Edition. Blackwell Science, 2005. ▪ Seely, I.H., "Building Economics", 4th edition, Palgrave –

	McMillan, 1996 ▪ Kuratko, D.F., Hodgetts, R.M., "*Entrepreneurship: theory, process, practice*", Thompson, 2007. ▪ Nahmias, S., "Production and Operation Analysis", 5th edition, McGraw-Hill International, 2005.
Planned learning activities and teaching methods	The frontal lectures of the course are held in modules. These lectures are organized in theoretical lectures and tutorials. In between these concentrated weeks, projects are assigned to the students as well as computational work.
Assessment methods and criteria	The assessment consists of a final oral exam only after having completed all the project assignments and the final project, which have to be brought at the exam. The final assignment has to be delivered within two weeks after the end of the course. All the project assignments must be approved by the tutor. Grading system. Passed or not passed.
Language of instruction	English

Course unit title	**_RELIABILITY AND RISK-BASED DESIGN OF INFRASTRUCTURE SYSTEMS_**
Course unit code	2E04
Type of course unit	Compulsory
Semester	2
Number of ECTS credits allocated	5
Name of lecturer(s)	To be completed: xxxx (UC); xxxxx (CTU); xxxxx (ULg); xxx (UNINA); xxxx (UPT).
Learning outcomes of the course unit	**Aim** Probabilistic reliability and risk methods are becoming more and more frequently applied in design and decision making concerning new and existing infrastructures. The course provides basic methods for design of complex technological systems consisting of structural subsystems (buildings, bridges, tunnels) and subsystems of protective elements (barriers, sprinklers, fire detectors etc.). Uncertainties in specifying system properties and expected environmental influences with return periods over decades and centuries (wind storms, severe snowfalls, floods) are described by probabilistic models. Advanced theoretical approaches including Bayesian networks are applied to assess societal, economic and other consequences of adverse events and alternative decisions. The course is based on the most recent scientific knowledge including probabilistic reliability analysis, risk assessment and optimisation. Lessons are supplemented by seminars where fundamental principles of reliability analysis and risk assessment are illustrated by a number of case studies. **Skills** Graduates of the course will gain the knowledge and abilities related to: - Quantification of uncertainties associated with structural design - Probabilistic modelling of basic variables affecting structural reliability - Prediction of extreme events based on available data - Reliability analysis of structural systems using various probabilistic methods and probabilistic basis of the partial

	factor method - Basis of risk assessment using different techniques for probability and consequence analysis - Applications of simplified cost benefit analysis, economic optimization to support decision making concerning infrastructures exposed to severe environment - Understanding and utilization of the concept of target reliability.
Mode of delivery	Lessons, seminars and home assignments.
Prerequisites and co-requisites	Knowledge of basic principles of structural analysis and design, relevant mathematics and statistics.
Course contents	Considerable uncertainties are included in complex models describing performance of infrastructures exposed to severe environmental conditions. This is why the course provides students with the basis of probabilistic methods of the theory of structural reliability, risk assessment and optimisation. Lectures include probabilistic reliability analysis (models for basic variables, structural reliability) and risk assessment (hazard identification, consequence analysis, risk evaluation and optimisation, decision making). Conditions specific to European environment are taken into account in specifying the theoretical models for basic variables. The principles of risk analysis and decision making are applicable to newly designed as well as existing infrastructures. Risk assessment is based on Bayesian networks. Economic, societal and environmental consequences of adverse events are considered for assessment of expected risk and specifying alternative decisions. The course provides students with the most recent scientific knowledge and currently used procedures for reliability and risk assessment of built infrastructures exposed to unfavourable environmental effects. The methodology is fully consistent with EN 1990 and ISO 2394. Applications of the theoretical procedures are illustrated by a number of case studies using Excel sheets and freeware products for risk analysis.
Recommended or required reading	Faber M.H. Lecture notes on risk and safety in civil engineering. ETH Zurich, 2001, http://e-collection.library.ethz.ch/eserv/eth:25307/eth-25307-01.pdf Holický M. Reliability analysis for structural design, Sun Press, 2009. Holický M. Introduction to Probability and Statistics for Engineers, Springer, 2013. JCSS. JCSS Probabilistic Model Code: Joint Committee on Structural Safety, 2015 (periodically updated, online publication). <www.jcss.byg.dtu.dk> Nielsen T. D. and Jensen F. V., Bayesian networks and decision graphs. Berlin: Springer, 2007. Melchers RE. Structural Reliability Analysis and Prediction, Chichester,

	England: John Wiley & Sons Ltd., 2001. EN 1990. Eurocode – Basis of structural design, Brussels: CEN, 2002. ISO 2394. General Principles on Reliability for Structures, Geneve, Switzerland: ISO, 2015.
Planned learning activities and teaching methods	The following topics are covered in the course: **1 Uncertainties in structural design** 1.1 – Aleatory and epistemic uncertainties 1.2 – Structural reliability 1.3 - Reliability methods **2 Probability theory in structural reliability** 2.1 - Experiment, random event, sample space Examples 2.2 – Relations between random events 2.3 - Definitions of probability 2.4 - Basic rules for the computation of probabilities 2.5 - Conditional probability, Bayesian theorem, updating of probabilities Example of proof loading **3 Probabilistic models of basic variables** 3.1 - Random variable 3.2 – Sample characteristics 3.3 – Description of material properties 3.4 – Prediction of extreme events Example – effect of statistical uncertainty **4 Fractiles of random variables** 4.1 – Characteristic and design values based on theoretical models 4.2 - Fractile estimation from samples Example of estimation of representative values of material strength and wind speed **5 Basis of reliability theory** 5.1 - Basic concepts Example of a structural member exposed to permanent actions 5.2 - Fundamental cases of one random variable 5.3 – Multivariate cases Practical application: FORM and Monte Carlo simulations 5.4 – Reliability updating 5.5 – Reliability basis of the partial factor method Practical application: Partial factors for material property and climatic action **6 Time-variant reliability** 6.1 - Time-variant actions – climatic and imposed loads 6.2 - Turkstra's rule

6.3 – Ferry Borges-Castanheta models
6.4 - Rectangular wave processes
Practical application: continued from 5.3

7 Case study – reliability of reinforced concrete structure under climatic actions
7.1 - Model structure
7.2 - Limit state function
7.3 - Reliability analysis
7.4 – Discussion of results

8 System reliability
8.1 – Introductory example
8.2 - Parallel system
8.3 - Series system
Practical application: detailed analysis of the example from 8.1

9 Risk analysis
9.1 - General procedure
9.2 - Hazard identification
9.3 - Definition and modelling of relevant scenarios
9.4 – Qualitative analysis
9.5 – Quantitative analysis - estimation of probabilities and risks, logic trees, Bayesian networks

10 Resilience and consequences
10.1 – Lessons from major accidents and structural collapses
10.2 – Resilience of infrastructure
10.3 – Economic losses (society vs. private owners)
10.4 – Societal consequences
10.5 – Environmental consequences
Practical application: risk assessment of complex technological system

11 Decision making
11.1 – Risk optimisation
11.2 – Decision under uncertainty, pre-posterior analysis
11.2 – Target reliability for structural design
11.3 – Target reliability for existing infrastructures

Project assignments
1. Estimation of representative values of material strength and climatic action
2. Reliability analysis of the fundamental case of load effect and structural resistance
3. System reliability
4. Risk analysis using Bayesian networks

Assessment methods and criteria	Assignments must be completed and approved before an exam. Grading system. Passed or not passed. A certificate awarding ECCS credits may be provided upon the request.
Language of instruction	English

Course unit title	***CLIMATE CHANGE IMPACT ON BUILT ENVIRONMENT***
Course unit code	2E05
Type of course unit	Elective
Semester	2
Number of ECTS credits allocated	5
Name of lecturer(s)	To be completed: xxxx (UC); xxxxx (CTU); xxxxx (ULg); xxx (UNINA); xxxx (UPT).
Learning outcomes of the course unit	**Aim** The aim of this course is to give students the understanding of the changes with take place in the climate across the globe, and how these changes can affect our built environment. The most visible signs of climate change can be seen through the extreme weather events taking place worldwide (heavy snow, extreme winds), more often and with more intensity, thus increasing the load effect. Other signs however are difficult to evaluate and can affect on long term the safety, durability and health of the built environment (temperature, humidity, levels of precipitation, emissions), thus reducing the resistance and durability of the material. Therefore, the data related to climate changes need to be classified and quantified to evaluate the results of the interaction hazard-vulnerability-exposure. **Skills** The course is conceived in order to give students following skills: - Understanding the effects of climate change on built environment and the need for concerned actions against climate change issue - Understanding the interaction between hazard, vulnerability and exposure and in the evaluation of climate effects - To be able to use analytical models and advanced models for quantification the climate hazards - Understanding in using simplified approaches for estimation of time-dependent properties of building materials - Understanding in modelling and analysis against natural hazards - Understanding and knowledge of life cycle assessment - To be able to understand and have orientation in developing action plans for response to climate change

	- Knowledge in how to perform and conduct design/evaluation projects for new/existing projects (eg. building, bridge) and decide for intervention measures.
Mode of delivery	Frontal lessons, seminars and homework
Prerequisites and co-requisites	No requirements
Course contents	On the purpose to give students a global view of the climate change and how it can impact different construction types, the lectures are organised according to the following structure: - Introduction to climate change, effects on built infrastructure - Evaluation, modelling and characterization of climatic hazards - Estimation of time-dependent properties of building materials - Objective Oriented Resilience Performance Based Design and Evaluation - Action plans for response to climate change - Case studies The students should understand the relation between climate change indicators (e.g. wind), climate change risk (e.g. wind-driven snow) and impacts on built environment (increased static and dynamic loading on structures, structural damage and collapse). This interaction will be demonstrated using relevant scientific knowledge related to climate changes hazards, the characterization of mechanical properties of building materials under progressive degradation induced by climate effects, and appropriate methodologies for Performance Based Evaluation and Design of constructions for progressive climate action exposures. The students should also learn how an intervention strategy should be established in order to enhance the capacity of building stock and new constructions to face climate change effects during their design lifetime.
Recommended or required reading	- Tutorial materials will be prepared in due time in format of handouts in areas of the course - Peer reviewed papers from journals - Background material of recent/ongoing research projects - Eurocodes, Guidelines, Standards - Scientific reports and different web sources: IPCC reports (www.ipcc.ch); FEMA (https://www.fema.gov/climate-change);
Planned learning activities and teaching methods	Seven topics, listed below, are covered in the course: 1. Introduction to climate change a. Scientific data related to climate changes (meteorological records, National bodies, European bodies independent organisations IPCC, past events), causes (natural, anthropogenic), signs, threats

b. Impact on built environment:
- reliability, robustness, resilience, safety
- durability, health, degradation, lifespan, reuse, heritage
- insurance rates

c. Short term actions, long term policies:
- reduction of effects of human activities
- adaptation to climate change (local, global)
- emissions, adaptive performance building technology, pre-normative research, essential requirements, construction directive, technical regulations)

2. Effects of climate change on built infrastructure
   a. Climate indicators (atmospheric moisture change, temperature change, wind, climate and pollution, climate and biological effects)
   b. Short term effects, long term effects
   c. Structural effects, non-structural effects
   d. Durability of materials vs extreme environmental effects
   e. Impact of climate change in urban areas (demand for comfort)
   f. Interaction hazard-vulnerability-exposure

3. Models, characterization and quantifying parameters for climate change actions
   a. European/national geographic matrix for climate change
   b. Evaluation, measurements, models, characterization and quantifying parameters for climate hazards (snow, ice storm, heat waves, rain, wind, temperature variation)

4. Estimation of time-dependent properties of building materials (e.g. durability of materials under progressive climate effects)
   a. Characterisation of mechanical properties and durability of building materials
   b. Reliability of constructions
   c. Residual life, rate of degradation, time-dependent, exposure
   d. Safety and health

5. Hazard Scenarios, Objective Oriented Resilience Performance Based Design and Evaluation
   a. Hazard levels: serviceability, damage control, life safe, collapse prevention
   b. Extreme events
   c. Multi-hazard scenarios, coincidental hazard events
   d. Uncertainties, reliability based evaluation
   e. Modelling and analysis against natural hazards
   f. Structural safety & resilience: performance based oriented

definition of hazard level

g. Planning of emergency response/collapse prevention
h. Response Performance Levels: functional, time scale to recover functionality
i. Life cycle modelling

6. Action plans for response to climate change

a. Emergency interventions in vulnerable buildings/infrastructures/others
   - Prevention, limitation, protection from effects of natural hazards caused by floods, landslides, etc, through repairing/retrofitting/rehabilitation of structural/nonstructural elements
   - Soil improvement/consolidation
   - Rehabilitation at related buildings and facilities
b. Long term interventions:
   - Adaptation of existing buildings/infrastructures/others to face the new climate conditions
   - Development/revision of building codes and natural hazard maps to mitigate the effects of future climate changes and extreme climate events
   - Zonation maps for complying with the impact of future climate changes (natural hazards maps for floods, landslides, extreme temperatures, …)
   - Adaptation of essential quality requirements of quality, durability and mechanical resistance of construction materials to prevent collapse/damage to building elements
c. Protection strategies and politics
   - Rehabilitation and reuse
   - New concepts and technologies
   - Integrated design (Life cycle and Life Cost based)
   - Protective measures and construction rules

7. Case studies

a. Existing building resilience against climate change impact
   - Building with essential services
   - Severe weather events
   - Climate vulnerability analysis
   - Intervention, retrofitting
b. Design for future climate
   - Building profile (location, type, features affected by climate change)
   - Climate scenarios, projections
   - Consideration of future risks/extreme events
   - Design criteria

	• Passive design/active design • Risk assessment • Adaptation strategy, cost–benefit analysis
Assessment methods and criteria	Approved compulsory assignments will be necessary to prepare a public presentation at the end of the course on the work performed during the course. Grading system. Passed or not passed. A certificate awarding ECCS credits after the course accomplishment may be provided upon the request.
Language of instruction	English

Course unit title	*DESIGN FOR RENEWABLE ENERGY SYSTEMS*
Course unit code	2E06
Type of course unit	Elective
Semester	2
Number of ECTS credits allocated	5
Name of lecturer(s)	To be completed: xxxx (UC); xxxxx (CTU); xxxxx (ULg); xxx (UNINA); xxxx (UPT).
Learning outcomes of the course unit	Aim The aim of this course is to give students an understanding of the behaviour of steel tubular towers for wind turbines, using analytical and numerical methods and to practice design calculations. In addition other lattice towers and different types of concrete towers combination will be discussed The Eurocodes are used throughout the course to calculate the structural resistance. The "International version of the codes" will be used in the course and students will have opportunity to borrow prepared compendiums which will be returned afterwards. This version of the Eurocodes is prepared by the international experts and is not nationally adjusted. The course describes different part of the tower: foundation, instability phenomena which are limiting for the resistance of a tower, different types of connections, as well as load analysis and safety strategy based on partial safety factors, tower production and maintenance. Understanding of economical and technical aspect involved in planning, design and construction of the wind farm, onshore and offshore will be provided. The aim is to have an understanding of theoretical background and engineering (design) models, and the resistance according to codes. Design concerning instability, assembling connections, foundations, design of details prone to fatigue load are based on theoretical models and design standards for win tower certification and Eurocodes. Exercises using FE method, using commercially available software, are optional and may be performed to compare analytical and numerical results. Previous experience in FE analysis is not requested but it is advantageous. Skills The course is conceived in order to give students following skills: - Understanding and quantifying difference in sustainability aspects between different electrical energy resources.

	- To be able to access costs of the tower using simplified approach and basic sustainability assessment. - Understanding of the load analysis, interaction of dynamic effects caused by the wind and mechanical performance of the turbines. - Understanding of the instability phenomena and a basic background theory. - Understanding and knowledge on how to calculate design resistance of a tower according to Eurocodes. - Understanding basics of manufacturing and maintenance of different tower types. - Understanding of behaviour and basic elements of design of best-practice details of assembling bolted joints. . - To be able to understand and have orientation in actual renewable energy economy at the world and European level. - Knowledge in how to performed FE analysis and interpret obtained results, optional skill.
Mode of delivery	Frontal lessons, seminar k and home work
Prerequisites and co-requisites	No requirements
Course contents	Seven topics, listed below are covered in the course. Design loads, including background of the approximation of external loads to design values of the cross-section forces, and resistance of the tower, including the foundation are main topics of the course. Basic theory of practical methods used to approximate cyclic loading is given. Assembling connections of the towers are considered focusing on design of bolts. One of the most important parts of structural design is to identify the engineering model and define different failure modes that may occur for a chosen design load of a tower. The design resistance is checked for each failure mode. In the compulsory assignments students practice use of the structural codes and engineering models for calculation of cross section forces, critical forces and the design resistance. Elastic stability of circular cylindrical shell, considering axial load and combination of axial load and bending moment will be given. Post-buckling behaviour of a perfect and imperfect shell will analysed to understand background of the design rules. Finite element method is used to calculate resistance of the tower for axial force and combination of axial force and bending moment, and to estimate design force in the bolts of the flange connection

	("unsymmetrical T-stub connection).
Recommended or required reading	Tutorial examples will be prepared in due time in format of handouts in following areas sustainability assessment, costs analysis, shell stability, flange connection-one half of the T-stub. Peer reviewed papers from journals and different web sources will be provided. Background material of research projects developed by the teachers Choosen chapters related to selected topics of theory of stability and connections Eurocodes ECCS recommendations Guidelines, Standards
Planned learning activities and teaching methods	1 Introduction wind power potential 1.1 - Installed capacities Installed capacity and production, by countries and regions 1.2 - Trends Position of the wind tower business, comparison of various renewable resources and conventional energy power. **1.3. –** Sustainibalty aspect of electrical energy generated from different sources. Nuclear power vs. fosil power vs. renewable power of wind, hydro and solar. 1.3 - Wind resource assessment Speed persistence, tower height, site selection Possible project assignment in area of following topics Calculation of the payoff time for a certain type of wind power plant. Calculation of the payoff time for a renewable power facility. Sustainability assessment of a certain type of wind power plant 2 Wind tower design 2.1 - How wind turbine works Rotor, nacelle 2.1 - Tower structural concepts Steel, hybrid, concrete, lattice 2.3 - Costs, preferences Comparison between different tower concepts, 2.4 - Rules, standards, recommendations, guidelines Eurocodes, GL-guidelines, DNV-guidelines, IEC-standards 3 Loads 3.1 - Safety and reliability

Structural safety, structural reliability, code calibration
3.2 - Load types,
Aerodynamic blade loads, gravity loads,
3.3 - Design load cases,
Rules of thumb,
3.4 - Design approximation of wind loads,
10-minute mean, wind shear, design tables, section loads
3.5 - Fatigue load,
Damage equivalent loads, Rainflow count, load spectra, Stress range, S-N curves, the Palmgren-Miner rule
3.6 - Applying design loads on FE models,
Linear extrapolation of tower DEL
3.7 - Seismic loading,

4 Foundation
4.1 - General about possible solutions
4.2 - Design of fundament

5 Tower connection
5.1 - Design checks,
Failure modes
5.2 - Flange connection
Use of the provided extreme load tables, cross-section forces, design of bolts
5.3 - Friction connection
Design of bolts, structural detailing, loss of the pre-tension force
5.4 - Numerical example

Possible project assignment in area of following topics,
Hand calculation part
Design of flange connections.
Design of friction connections
Various levels of complexity could be addressed by FEA, without and with the contact elements.
The flange connection, segment part in tension.
Considerations of the T-stub connection, symmetric vs. unsymmetrical T-stub.

6 Stability concepts
6.1 - Concept of elastic stability
Circular cylindrical shells (buckling of circular cylindrical shells, axial compression, combined bending and axial compression)
6.2 - Post-buckling behaviour
Perfect shell, imperfect shell
6.3 - Openings
Concentration of stresses, stiffening
6.4 - Design approach

	Design according EC3 Possible project assignment, Tower resistance FEA vs hand-calculation methods Buckling of the a tower, Axial and combination axial-bending moment Non-linear analysis Initial imperfections, axial and combination axial-bending moment Analysis of lower segments including the opening in compression. **7. Fabrication and maintenance** 7.1 - Production Description of the production process, cutting rolling, welding, tolerances 7.2 - Transport Size limits, organization, temporary stiffening 7.3 - Maintenance of the tower Inspection intervals, design for life time
Assessment methods and criteria	Approved compulsory assignments will be necessary to prepare a public presentation at the end of the course on the work performed during the course. Grading system. Passed or not passed. A certificate awarding ECCS credits after the course accomplishment may be provided upon the request.
Language of instruction	English

Course unit title	**DEGREE PROJECT**
Course unit code	3C01
Type of course unit	Compulsory
Semester	3
Number of ECTS credits allocated	30
Name of lecturer(s)	Wald (CTU); da Silva (UC); Jaspart (ULg); Landolfo (UNINA); Dubina (UPT).
Expected result	The overall objective of the Degree project is that the student practices, develops and is able to apply theory and methods to solve problems relevant to a profession as Master of Science in Engineering. This means that on completion of the project the student is able to: – Formulate relevant questions for investigation from a chosen subject within the subject area. Apply knowledge and proficiency that has been acquired during the period of study to a complex development project or a smaller research project in an independent and systematic manner. – Choose and justify the study method for an investigation. – Analyse and defend the problem formulated in a correct manner with respect to science and engineering, without complete information. – Locate and critically review information and summarise this in a scientific manner. – Plan, structure and execute a project within research, development or investigation. – Judge the scientific and practical relevance of the results obtained. – Work to a timetable. – Express them well in writing in a verbally and scientifically correct manner. – Create and execute a presentation of the results of the project, defending the conclusions.

Project content	The content of the degree project is designed in collaboration with the supervisor from host University. The degree project always contains a theoretical foundation in the form of a literature survey that highlights the area of technology and the methodology, summarised in a scientific manner.
Prerequisites and co-requisites	All exams SUSCOS_M courses need be passed.
Course contents	The content of the degree project is designed in collaboration with the supervisor from host University. The degree project always contains a theoretical foundation in the form of a literature survey that highlights the area of technology and the methodology, summarised in a scientific manner.
Execution	The student independently plans and executes the degree project; the supervisor is available for assistance. A timetable of the project is continuously reviewed.
Extent	The length round 100 p. is expected. At least one hard copy and pdf version will be delivered for review and defence based on host University internal rules. The work will consist of Recommended cover and first pages, Abstract, Keyword, List of contents, Declaration that the work was prepared independently under the guidance of the leader, List of references and host university local requirements.
Professional review of the project	Project will be thoroughly reviewed by independent professional person outside the University.
Language	English
Defence of project	Project will be defended ahead of host University jury during one hour procedure till the end of January of last year of study.