Course unit title	***DESIGN OF SUSTAINABLE CONSTRUCTIONS***
Course unit code	1C1
Type of course unit	Compulsory
Semester	1
Number of ECTS credits allocated	6
Name of lecturer(s)	Hájek / Netušil (CTU); Luís Simões da Silva / Helena Gervásio / Paulo Santos (UC); Lecturer (UPT); Barbara Rossi (ULg); Lecturer (LTU); Lecturer(Associate 1); Lecturer (Associate2).
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 exteriments.
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