MASTER STUDY PROGRAMME, SECOND BOLOGNA CYCLE
SUSTAINABLE BUILT ENVIRONMENTS
COURSE DESCRIPTIONS

COMPULSORY COURSES OF THE 1ST YEAR

MATHEMATICS
Number of ECTS credits: **6**

Content:

Applications of derivate: scalar fields, directional derivatives, partial derivatives, extremal problems, direct optimization, conditional optimization, connections with physics, approximations, basic ideas of numerical analysis.

Multiple Integrals and their applications:multiple integrals, integrals in polar, cylindrical and sferical coordinates, applications of multiple integrals.

Vector Analysis: curves in space, vector fields, gradient, divergence, curl, line integrals,surface integrals, Gauss' divergence theorem, Green's Theorem, Stokes' theorem

BUILDING PHYSICS
Number of ECTS credits: **6**

Content:

The goal is to offer the students in-depth knowledge of the phenomena relevant in the field of construction: heat transfer, humidity and materials, and sound and noise protection.

- Students will acquire specific knowledge of heat transfer and transport of water in building materials. They will understand basic sound phenomena in buildings.
- The ability to formulate a problem in a physical-mathematical form, and the ability to select the appropriate mathematical tool to achieve quantitative results.
- To master mathematical methods for solving diffusion and vaweform equations.
- Temperature distribution, and heat transfer through matter and radiative heat transfer.
- Basic methods for diffusion equation solving, boundary and starting conditions.
- Relative and absolute humidity, humidity measurements, moisture in building materials, humidity and water vapour transport in porous materials, moisture influence on mechanical and thermal characteristics of building materials.
- Sources of sound and sound diffusion in space, reverberation, sensing and measurement of sound intensity, characterisation and control of noise in buildings.

CONSTRUCTION MATERIALS

Number of ECTS credits: **6**

Content:

- The fundamentals of the composition/structure/properties relationships of basic types of materials (ceramics, metals and their alloys, polymers and composites)
- Overview of materials through the history (current and historic construction materials)
- Factors affecting choice of materials
- Mechanical properties (strength, hardness, toughness, elasticity, etc.) and non-mechanical properties (physical properties, durability)
- Test methods for materials characterization (mechanical tests, scratch test, density, porosity and specific surface area, colour values, gloss, contact angle, microscopy, x-ray diffraction, microtomography, accelerated aging tests, etc.)
- The fundamentals of standardization and treating materials according to valid regulation
- Individual building materials (manufacturing, properties, applications in construction):
  - Metallic materials: steel, iron, non-ferrous metals and alloys
  - Stone, aggregates, brick, glass, mineral binders, mortars, renders
  - Polymers: thermosetting polymers, thermoplastic polymers, elastomers
  - Composites: concrete, asphalt, fiber composites, polymer composites, natural composites
- Durability of building materials
  - Degradation processes
  - Combination of different materials / Details
  - Methods for assessment of type and rate of degradation processes
  - Techniques for protection of various materials
  - Composites: concrete, asphalt, fiber composites, polymer composites, natural composites
- Relation between materials and their applications in buildings / Case studies
- Durability of structures / Critical sites and elements / Assessment of type and amount of damage / Case studies
- Techniques for repair / rehabilitation of structures / Case studies

WOOD SCIENCE AND TECHNOLOGY

Number of ECTS credits: **6**

Content:

- Wood anatomy: Microscopic and macroscopic identification of wood
- Wood technology: Wood moisture content and density; Mechanical properties of wood; Viscoelastic properties of wood
- Wood use

RENEWABLE AND WOOD-BASED MATERIALS IN CONSTRUCTION

Number of ECTS credits: **6**

Content:

This course will discuss all plant- (lignocellulosic) based materials used in construction, their properties, origin and use. Both structural and non load-bearing applications will be discussed. The material discussed are, for example: wood, hemp, flax, sisal, and other agricultural fibers.

- Definition of organic construction materials.
- Ecological aspects of renewable resources (GWP. ODP, grey energy, radiative forcing, etc).
- Properties of organic, plant-based materials in construction.
- Wood and wood-based materials, natural-fiber based insulation materials.
- Environmental parameters in evaluation of materials.
- Mechanical and physical properties of fiber-based construction materials.

STATISTICS

Number of ECTS credits: **6**

Content:

- Introduction: data, cases, variable types and level of measurement
- Descriptive statistics: measures of central tendency, measures of dispersion, normal curve
- Inferential statistics: hypothesis testing for one-sample case, hypothesis testing for two-sample case, ANOVA, Chi square test
- Bivariate measures of association: association between nominal variables, association between ordinal and interval-ratio variables
- Multivariate techniques: bivariate regression, multivariate regression, control variables, spurious and intervening relationships, partial correlations, multivariate regression models, non-linearity

WOOD COMPOSITES

Number of ECTS credits: **6**

Content:

- Wood adhesives
- Adhesive bonding of wood: wetability, surface tension, adhesive penetration; bonding quality
- Particle and fiber based wood panels – types, manufacturing, properties and uses
- Solid wood composites - types, manufacturing, properties and uses
- Standards relevant to wood composites

FOREST PRODUCTS VALUE CHAIN

Number of ECTS credits: **6**

Content:

Value chains of forest products and furniture, other forest products and ecosystem services:

- Industrial organization and market structures
- Distribution of value added in forest products and service chains
- Market, institution and governance of value chains
- Value chain participants and different stakeholders
- Certification, technical, quality and other aspects of forest products / services

BUILDING ENERGY SIMULATION

Number of ECTS credits: **6**

Content:

- Building energy performance simulation
- Overview of building simulation tools
- Creating building geometry
- Building zoning
- Construction
- Openings and glazing
- Lighting
- Internal loads
- HVAC
- Running a simulation
- Analyzing simulation results
- Effect of building form/architectural design on energy consumption
- Daylighting and shading
- Natural ventilation
- Passive and active solar heating

COMPULSORY COURSES OF THE 2ND YEAR

ENERGY EFFICIENT BUILDING DESIGN

Number of ECTS credits: **6**

Content:

1. Principles and objectives of energy efficient construction
   - Legislation framework
   - Indicators of building energy performance

- Classification of buildings according to energy efficiency

2. Energy sources
3. Energy flows in buildings
4. Living comfort in buildings
   - Thermal comfort
   - Air quality
   - Natural illumination
   - Subjective perspectives of living comfort
5. Climatic influences and Building site
6. Basic design parameters
   - Building shape
   - Orientation
   - Zoning of interior
   - Building components
7. Design of Passive Strategies
   - Passive heating
   - Passive cooling
   - Natural ventilation
   - Daylighting
   - Innovative hybrid concepts
   - Water supply
8. Active technical systems
   - Heating
   - Cooling
   - Ventilation
   - Lighting
   - Energy generation (PV systems)
9. Best practice examples – energy efficient residential buildings
10. Project – design of smaller residential or public building

WOOD DESIGN AND STRUCTURAL ANALYSIS

Number of ECTS credits: **6**

Content:

- Basic and advanced concepts in wood properties and design;
- Design and analysis of wood beams, columns, and shear walls;
- Design of specialty wood connectors;
- Common failure mechanism and forensic engineering concepts;
- Design for Durability.

SUSTAINABLE AND RESTORATIVE ENVIRONMENTS

Number of ECTS credits: **6**

Content:

- Sustainability with Respect to Building Materials: Environmental Impacts; Servise life;
- Sustainable Buildings: Building Rating Systems; Green building certification systems; Environmental Impacts of Buildings;
- Restorative environmental design: Biophilic design; Sustainable design; Restorative environmental design.

MASTER'S THESIS

Number of ECTS credits: **30**

Content:

Master's thesis provides a comprehensive treatment of the subject areas of sustainable built environment selected in the second cycle study program and/or interdisciplinary linkage with other subject areas.

Students choose a theme according to their interests and in consultation with the supervisor, and depending on the subject area of sustainable built environment with which they wish to deal in more detail. The theme can be theoretical or professional, whereby they must use appropriate research methods.

The length and structure of the theme is exactly defined in the instructions for writing a thesis.

ELECTIVE COURSES

ENERGY REFURBISHMENT OF BUILDINGS

Number of ECTS credits: **6**

Content:

1. Classification of existing energy-inefficient buildings according energy demand.
2. State of the existing building stock
   - residential buildings
   - public buildings
   - commercial buildings
   - sport and recreation facilities
   - culture facilities
   - protected historical buildings
3. Correlation between building type, year of construction and energy demand.
4. Concepts of energy-efficient renovation:

4.a Basic tools:
- improvement of the thermal building envelope,
- replacement of glazing, increasing glazing surfaces..
- installation of active ventilation systems, heating systems, photovoltaics.
- upgrading buildings with single or multi-level construction.

4.b Complex methods:
- possible combinations and reasonableness of individual concepts of energy renovation,
- determination of the optimal energy renovation concept for a given building.

5. Best practice examples
6. Project - complex building refurbishment

ERGONOMICS AND BUILT ENVIRONMENT

Number of ECTS credits: **6**

Content:

Introduction to ergonomy:
- Definition of the field ergonomy
- Ergonomy sub-fields (physical, cognitive, psychological, etc.) and historical development
- Ergonomy of the built environment: macro level (urbanism) in micro level (indoor – living/work space)
- Aim: health preservation/maintenance, comfort, better worker productivity, lower cost
- Opposing concepts: to make work »easier« (i.e. prevention of injuries) – to make work »harder« (maintenance/increase of strength)

Environmental influences on humans (environmental physiology and regulation):
- light and vision
- sound and hearing
- climate (temperature, elevation, humidity)
- pollution (air, water, food – allergies, cancerogenic foodstuffs)
- mechanical (gravity, vibration, mechanical properties of floors, seating and work surfaces)
- social (environmental sociology)
- integration of influences, sensing and processing of information from the environment (environmental psychology)

Triple envelope – skin, clothing (secondary »skin«), building (tertiary »skin«):
- Skin – protection from bacterial and viral infection
- Clothing – protection from solar radiation, flame, mechanical abrasion, enhances heat retention, etc. (advanced materials, work and sports clothing)
- Building – tempearature and humidity control, protection from predators, property protection, etc.

Understanding of the human body – foundation of ergonomy:

- Anatomy, physiology, biomechanics
- Antropometry, motion range, highest muscle strength range, highest injury risk range
- Injury genesis: single high load, recurring low load, or long-term low load
- Physiological boundaries for health preservation/maintenance
- Excessive loads: physical risk factors for cumulatively-caused skeletal-muscular injury (bending, rotations, vibrations, static positions, etc.)
- Excessively low loads: inactive lifestyle – risk factor for cardio-metabolic pathology (inactivity-linked ilness, activity recommendations) and inadequate fitness

Ergonomy of the living/work space:

- Building physics (openings in the building envelope, daylight, humidity and condensation, temperature, radiant characteristics of materials, noise control and soundproofing, etc.)
- Bioclimatic design (geographic and climatic characteristics of a location), installation technologies, definition of »healthy building«
- Ergonomic principles: neutral position of joints, individual adjustment of work surfaces, active/passive breaks, keeping most frequently used utensils within reach, etc.
- Properties of ergonomically designed furniture elements (chair, table/desk, recliner, closet/cupboard/cabinet, etc.)
- Elements' distribution in living spaces (kitchen, utility, children's room/nursery)
- Elements' distribution in work space (best practice cases)
- Utilisation of ergonomic tools/utensils in the activities that are risk factors (lifting and moving heavy loads, repetitive motions, etc.)
- Architecture/design which stimulate mobility (best practice cases: attractive stairwell, positioning printers away from work desks, »motion corners«)
- Regulative framework (architecture/design norms, minimal standards)

Ergonomics in urbanism:

- Markets and pedestrian areas - ground movement of modern man
- Ensuring safety (fall prevention, accidents on the road and the importance of signage, surface texture changes, separation of pedestrians from motor vehicles, ...)
- Promoting movement - infrastructure for active transportation (walking trails, bike trails, public transport), sports recreation areas, attractive interventions and examples of best practice

For people with special needs:

- Children, the elderly, pregnant women
- Blind, deaf, physically disabled
- Adjusted living / working spaces
- Mobility, access, handles, railing
- Signalling
- Modified floor textures

NON-DESTRUCTIVE TESTING

Number of ECTS credits: **3**

Content:

- Significance, classification, and history of non-destructive testing
- Basic wood properties (e.g. mechanical, electrical, acoustic, thermal, aesthetic, chemical), physical priciples, and measurable properties.
- Acoustic Methods - Ultrasonic and stress wave propagation method. Basics and principles. Stress wave transmission time, velocity, and attenuation
- Movement Detection – acceleromters, tensometers, and extonsometers.
- Internal Structure Analysis – X-ray computed tomography, neutron imaging
- Optical Methods – history and classification; digital image correlation (DIC) and its appications
- Non-destructive testing (NDT) applications. NDT techniques for: production facilities, laboratories, in-situ testing, historic structures
- Lumber Grading - machine stress rating, ultrasonic grading of veneer, MOE by static bending tests.

MODERN HISTORY OF SUSTAINABLE ARCHITECTURE

Number of ECTS credits: **6**

Content:

- Environmental design in 19th century
- Gandhi's environmental vision
- Modern architecture and environmental design
- Post-war energy consumption
- The toxic environment
- Sick building syndrome
- Obesity and the built environment
- OPEC energy crises
- The autonomous house
- Buckminster Fuller: Dymaxion house and geodesic dome
- Counterculture communes: Drop City and Auroville
- Minimalism in sustainability
- Appropriate technology
- Bioclimatic architecture in the United States
- The Brundtland report and sustainability
- The Rio summit
- Sustainability: a philosophy of adaptive ecosystem management
- Cradle to cradle
- Biomimicry
- Bioshelters
- Ecological architecture
- Buildings as ecological systems
- Environmental assessment methods

- Ecotopias
- Sustainable green buildings
- Hassan Fathy, Egypt and Laurie Baker, India
- Tropical architecture in Africa: Drew and Fry
- Vernacular architecture meets hi-tech: Renzo Piano - Tjibaou cultural center and Arup - Druk white lotus school
- Ken Yeang: Green skyscrapers
- European approach to sustainable architecture: Thomas Herzog, Norman Foster, Petzinka, Benisch, Ingenhoven Overdiek, Meyer and Van Schooten, Michael Hopkins, Richard Rogers, Bill Dunster, West 8, Mecanoo
- Sustainable development and urban planning issues in Ecolonia, Vauban and BedZED

FOREST PRODUCT MARKETING

Number of ECTS credits: **3**

Content:

The course will deliver skills necessary to apply basic concepts of marketing in the forest products industry. Application will be highlighted through concrete examples and case studies relating coursework to the day-to-day work in forest products business.

- Globalization, Industry Issues & Trends
- Information Environment
- Finding Market Information
- Marketing Basics
- Corporate Strategy
- Corporate Social Responsibility
- Marketing Strategy
- Marketing Management & Channels
- Marketing Communication

THE INDUSTRIAL ECOLOGY OF TIMBER

Number of ECTS credits: **6**

Content:

The course will begin with an introduction to the history and concepts of industrial ecology. Viewing industrial systems within society from the point of view of ecosystems. Examples will be given – e.g. Kalundborg in Denmark and it will also be discussed why there a comparatively few true industrial ecosystems in practice. The production, use and disposal of timber will then be discussed from an industrial ecological perspective and it will be shown that this is one of the few industrial sectors that can be truly embedded within natural materials flows and cycles. The course will then go onto explaining how the methodology of life cycle assessment (LCA) is based upon the principles of industrial ecology and thermodynamics and examples of LCAs will be given for different timber products. The importance of life extension and ensuring properly planned end of life options will be discussed and it will be shown how these can impact on the results of LCA.

The course will also look at options for life extension of timber products and the impact of these.

PRINCIPLES OF INNOVATION AND CREATIVITY

Number of ECTS credits: **3**

Content:

The course will deliver skills useful in developing and commercializing innovations. Application will be highlighted through examples and group work. General topics include:

- Adoption/diffusion theory
- Organizational culture and innovativeness
- Innovation systems
- Tools for innovation and creativity
- Adaptive behaviours
- Associative thinking
- Networking
- Rapid prototyping
- Lead user concepts

ADVANCED CONSTRUCTION PRODUCTS

Number of ECTS credits: **6**

Content:

- The correlation between chemical structure and properties,
- Polymer materials with a high thermal stability and resistance to UV radiation
- Protection against overheating of polymeric materials: thermotropic and thermochromic coatings, coatings with low thermal emissivity,
- Coatings with adaptable absorption, "cold" colors, radiant cooling
- Coatings and nanocomposite coatings with multifunctional properties (antisoiling, self-cleaning), "Hard" nanocomposite coatings.
- Use in the renovation of buildings and for the protection of cultural heritage
- Optical permeable polymeric materials (PTFE, Mylar)
- Protection against corrosion of metal by nanocomposites (corrosion processes, decay measurements, spectroscopy, etc.)
- Thermal storage (phase change materials - PCM)
- Overview of test methods for determining the stability of the materials (accelerated aging tests)
- green roofs
- Carbon footprint, global warming potential (GWP)
- Foundations on thermal insulations
- Construction pathology
- Photovoltaic, Photothermics
- Ventilated panels

STRUCTURAL TIMBER BUILDING SYSTEMS

Number of ECTS credits: **6**

Content:

- History and distribution of timber building around the world.
- Structural, physical and mechanical characteristics of solid and glued timber, timber products and their classification.
- Basic structural classifications of residential timber building.
- Massive timber structural building systems (log construction and prefabricated massive-panel construction).
- Skeleton structure systems.
- Classic framing systems (baloon-frame and platform-frame construction).
- Structural panel prefabricated construction.
- Hybrid structural systems, combination timber-concrete, timber-brick, timber-glass, timber-glass panels as bracing wall elements.
- Special construction details in timber building.

SUSTAINABLE GEOTECHNICS

Number of ECTS credits: **6**

Content:

- Basics of geotechnical design, geotechnical standards
- Soil improvements (preloading, draining, consolidation, chemical and mechanical improvements)
- Sustainable embankments and earthworks
- Design with geosynthetics
- Reinforced soil
- Erosion protection
- Climate change effects on infrastructure
- Geothermal geotechnics
- Geotechnical monitoring

RECYCLED WASTE IN CONSTRUCTION

Number of ECTS credits: **6**

Content:

- Resource efficiency – globally and locally
- Waste as raw material.
- Types of waste, classification, legislation.
- Transformation of waste into building product, legislation (standard, technical approval).
- Utilization of waste as aggregate.

- Utilization of waste as binders in green concrete.
- Utilization of waste in the field of geotechnics.
- Environmental aspect: immobilization of toxic components.
- Recyclability of materials.
- Life cycle assessment (LCA).

FIRE SCIENCE LABORATORY

Number of ECTS credits: **6**

Content:

1. Bomb Calorimeter

The calorific value of various materials will be determined using a bomb calorimeter to provide insight into the relevance of this value for the energy content of a material and its Heat Release Rate.

2. Burning Rate

The evolution of the burning rate and fire dynamics of fire plumes as a function of different parameters will be established, using open pool fires. Empirical and analytical formulations will be validated for various fire sizes with respect to characteristic parameters, i.e.:

- Centreline temperatures
- Entrainment rate

The effects of confining the fire within a compartment will also be examined and interpreted in relation to simple fire models.

3. Reaction-to-fire behaviour of solids

In this laboratory, the cone calorimeter apparatus is used to examine the reaction-to-fire behaviour of solid fuels under different heat exposures, with specific attention to:

- Ignition time
- Subsequent energy release rate

From the measurements, the following parameters will be determined:

- Ignition temperature
- Thermal inertia

4. Flame spread

The physical mechanisms controlling flame spread will be described on the basis of an SBI test. It will emphasize the following aspects:

- Materials properties: influence of a material thermal and chemical properties on the rate of spread (liquid:solid, high density:low density, charring: non-charring, melting:non-melting)
- Orientation: upward, downward, horizontal, lateral.
- External heat flux
- Fuel thickness: thick:thin materials.

5. Spontaneous ignition

This laboratory illustrates the different processes leading to ignition of combustible materials and is intended to provide insight on the ignition phenomenon.

- Application of ignition theory
- Piloted, Auto and Spontaneous ignition

BIOINSPIRED MATERIAL DESIGN

Number of ECTS credits: **6**

Content:

1. What is biomimicry? How does nature work?
2. The three levels of inspiration of biomimicry
3. Evaluation of the structure–functional relation of the biological materials
4. Analysis and evaluation of living organisms' adaptation strategies (both static strategies and dynamic mechanisms) to their environment in different climate zones
5. Biomimicry for materials development - smart materials
6. Biomimicry for materials development - surface modification
7. Biomimicry for materials development – materials architecture
8. Bioinspiration in design and architecture
9. Engineered living materials
10. Conclusions, challenges, and outlook