Course guide
310789 - 310789 - Fire Engineering: Simulation, Design, and Experimentation

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Unit in charge: Barcelona School of Building Construction
Teaching unit: 753 - TA - Department of Architectural Technology.

Degree: BACHELOR'S DEGREE IN ARCHITECTURAL TECHNOLOGY AND BUILDING CONSTRUCTION (Syllabus 2019). (Optional subject).

Academic year: 2026 **ECTS Credits:** 3.0 **Languages:** Catalan, Spanish, English

LECTURER

Coordinating lecturer: Lacasta Palacio, Ana Maria

Others: Haurie Ibarra, Laia
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TEACHING METHODOLOGY

Different learning methods will be combined:
- Delivery of theoretical content through lectures.
- Practical laboratory work.
- Practical work using computer-based tools.
- Resolution of practical case studies.
- Independent study.

LEARNING OBJECTIVES OF THE SUBJECT

Fire safety is one of the major challenges in modern engineering and architecture, as it influences the design, construction, operation, and maintenance of buildings and infrastructure. This course introduces students to the fundamental principles of fire engineering and provides the knowledge and tools required to analyse fire behaviour, assess fire-related risks, and design effective fire protection solutions.

Throughout the course, theoretical foundations are combined with practical activities involving simulation, experimentation, and engineering design. Using analytical tools and real-world case studies, students will explore fire spread, material behaviour under fire conditions, occupant evacuation, and fire protection systems. The aim is to provide students with a comprehensive understanding of fire safety and to enable them to apply their knowledge to engineering projects and informed decision-making in fire safety engineering.

STUDY LOAD

Type	Hours	Percentage
Hours medium group	10,0	13.33
Hours large group	20,0	26.67
Self study	45,0	60.00

Total learning time: 75 h

CONTENTS

Physical-chemical phenomena of combustion and mechanisms of fire propagation

Description:
This block introduces the physical and chemical foundations of fire and thermodynamics applied to combustion. The chemistry of combustion is analyzed using the model of the fire tetrahedron. The three mechanisms of heat transfer are examined: conduction, convection and radiation, as main vectors of the evolution and initial development of a fire.

Specific objectives:
- Understand the model of the fire tetrahedron and the physico-chemical phenomena that govern the combustion reaction.
- Identify the different heat transfer mechanisms involved in the initial development of a fire.
- To know the basic parameters involved in the fuel ignition process.

Related activities:
- Small-scale laboratory tests for the study of the ignition and behavior of the flame.

Full-or-part-time: 6h
Theory classes: 2h
Laboratory classes: 2h
Self study : 2h

Fire behavior of materials and construction systems

Description:
In this block, the behavior of materials and construction systems when they are exposed to the action of fire is analyzed. The concepts of reaction and resistance to fire are introduced, deepening in the standardized test methods and the regulatory frameworks that regulate their classification. Likewise, the role and influence of the different families of construction materials on the initial development and evolution of a fire is evaluated.

Specific objectives:
- Distinguish between the concepts of reaction to fire and fire resistance.
- Understand the procedures of standardised fire tests and interpret the current fire classification systems.
- Evaluate the influence and behaviour of different construction materials on fire development and fire spread.

Related activities:
- Laboratory practice where the reaction to fire of different construction materials will be evaluated.
- Analysis and interpretation of technical sheets and classification reports of construction products.

Full-or-part-time: 11h
Theory classes: 2h
Laboratory classes: 2h
Self study : 7h

Fire Spread in Buildings: Modelling and Digital Simulation

Description:
This module examines the behaviour and development of fires in buildings, considering both fire growth within indoor spaces and fire spread through building façades. The main factors influencing fire development are analysed, including building geometry and architectural layout, fire load, material properties, ventilation conditions, and the interaction between these factors. The module also introduces the main computational modelling and simulation tools used in fire engineering to analyse fire behaviour and support the design of performance-based fire safety solutions.

Specific objectives:
- Understand the physical mechanisms governing fire spread in buildings, both within indoor spaces and through building façades.
- Identify the main factors influencing fire development and spread, and assess their impact on building fire safety.
- Understand the fundamental principles of computational fire modelling and simulation.
- Develop basic skills in the use of fire simulation tools to analyse fire scenarios and support the design of fire safety solutions.
- Apply computational simulation tools to both the analysis of real fire incidents and the performance-based assessment of fire safety engineering projects.

Related activities:
- Analysis of real fire case studies.
- Modelling and simulation of fire scenarios using specialised computational tools.
- Interpretation and discussion of simulation results.

Full-or-part-time: 18h
Theory classes: 4h
Practical classes: 2h
Self study : 12h

Fire Evacuation: Human Behaviour, Modelling and Simulation

Description:
This module explores the principles of occupant evacuation during fire emergencies, focusing on the factors that influence human behaviour and their impact on life safety. Fundamental concepts related to occupant movement, evacuation times, and the capacity of means of egress are examined, together with the key parameters involved in the design of safe evacuation routes.

The module also introduces the computational modelling and simulation tools used to analyse evacuation processes. Through the simulation of different fire scenarios, students will learn how to evaluate the effects of variables such as the number and distribution of exits, the width of corridors and stairways, occupant density, and occupant characteristics. These analyses will be used to assess and optimise building safety within the framework of performance-based fire safety design.

Specific objectives:
- Understand the fundamental concepts related to evacuation time, occupant movement, and the capacity of means of egress.
- Understand the principles of computational modelling and simulation of evacuation processes.
- Develop basic skills in the use of evacuation simulation tools to analyse different emergency scenarios.
- Evaluate the influence of building layout and occupancy characteristics (e.g. number of exits, corridor and stair widths, occupant distribution, etc.) on evacuation time and overall fire safety.
- Apply evacuation simulation tools to support the design and assessment of performance-based fire safety solutions.

Related activities:
- Modelling and simulation of evacuation scenarios using specialised computational tools.
- Comparison of alternative evacuation route designs through simulation.
- Interpretation and discussion of simulation results.

Full-or-part-time: 12h
Theory classes: 2h
Practical classes: 2h
Self study : 8h

Implementation of active and passive protection systems

Description:
In this block, the criteria of selection, design and application of fire protection measures in the building are studied, both from the perspective of passive protection (sectorization, firewall elements, reaction of the finishes) and of the active one (detection systems, alarm, automatic extinction or smoke control). The interaction of these systems in the global safety design is analyzed and the vision of the professional sector of fire safety is introduced through case studies.

Specific objectives:
- Distinguish between active and passive fire protection systems and evaluate their suitability for different applications.
- Identify the most appropriate fire protection systems for different fire safety scenarios.
- Understand the design, installation, and maintenance requirements for fire protection systems in accordance with the applicable regulations.

Related activities:
- Analysis of practical cases of design and dimensioning of protection systems in building projects.

Full-or-part-time: 6h
Theory classes: 4h
Self study : 2h

Regulatory Framework for Fire Safety

Description:
This module introduces the regulatory framework governing fire safety in buildings, with particular emphasis on the Fire Safety Basic Document (DB SI) of the Spanish Technical Building Code (Código Técnico de la Edificación, CTE). The module examines the regulatory criteria established to limit fire ignition and fire spread, facilitate occupant evacuation, support emergency response, and minimise the consequences of fire.

Specific objectives:
- Understand the structure and objectives of the regulatory framework applicable to fire safety in buildings.
- Understand the principles and fundamental requirements of the Fire Safety Basic Document (DB SI) of the Spanish Technical Building Code (CTE).
- Interpret and apply regulatory requirements according to the characteristics and intended use of a building.
- Relate regulatory requirements to the principles of fire engineering, fire protection systems, and evacuation design.
- Develop the ability to analyse and justify fire safety solutions based on the applicable regulations.
- Recognise the limitations of prescriptive approaches and introduce the concept of performance-based fire safety design as a complementary approach.

Related activities:
Analysis and interpretation of case studies involving the application of the DB SI.

Full-or-part-time: 8h
Theory classes: 4h
Self study : 4h

Integration of Fire Safety Systems and Strategies

Description:
This module integrates the knowledge acquired throughout the course to develop comprehensive fire safety strategies for buildings. Building on an understanding of fire behaviour, material properties, fire protection systems, evacuation processes, and the applicable regulatory framework, students will analyse and define the measures required to ensure occupant safety, limit the consequences of fire, and facilitate emergency response.

The module focuses on integrating the different fire protection systems and strategies into a coherent fire safety design, combining regulatory requirements with engineering principles, analytical and simulation tools, and a performance-based approach. It also addresses emergency planning, including emergency response plans and self-protection plans, as well as the importance of managing, implementing, and maintaining fire safety measures throughout the service life of buildings.

Specific objectives:
- Integrate knowledge of fire behaviour, fire protection systems, evacuation processes, and the regulatory framework in the development of comprehensive fire safety strategies.
- Apply the requirements of the applicable regulatory framework to the development and evaluation of fire safety engineering projects.
- Understand the decision-making process involved in designing fire safety solutions by integrating regulatory, technical, and functional criteria.
- Apply analytical and simulation tools to justify and optimise fire safety strategies, particularly within the framework of performance-based fire safety design.
- Understand the structure, content, and purpose of emergency response plans and self-protection plans.
- Recognise the importance of managing, maintaining, and updating fire safety systems and strategies throughout the service life of buildings.
- Develop a comprehensive and integrated understanding of fire safety, considering technical, regulatory, organisational, and operational aspects.

Related activities:
- Critical analysis of fire safety projects and self-protection plans.
- Development and discussion of evacuation and emergency response strategies.

Full-or-part-time: 14h
Theory classes: 2h
Practical classes: 2h
Self study : 10h

GRADING SYSTEM

The final grade will be obtained from the different assignments, the midterm exam, and the final exam. The weighting of each assessment component is as follows:
- Laboratory practical: 15%.
- Fire evolution simulation assignment: 15%.
- Fire evacuation assignment: 15%.
- Fire safety project: 15%.
- Midterm exam: 15%.
.-Final exam: 25%.

BIBLIOGRAPHY

Basic:
- Drysdale, Dougal. An Introduction to fire dynamics . 3rd ed. Chichester : Wiley, 2011. ISBN 9780470319031.
- Alvear, Daniel. Modelado y simulación computacional de incendios en la edificación . Madrid : Díaz de Santos, cop. 2007. ISBN 9788479788322.
- Fernández Núñez, Rafael. Protección contra incendios . Madrid : Cie Dossat 2000, cop. 2004. ISBN 848965669X.