# Course guide
# 2500046 - GECEDIPREF - Building Construction and Prefabrication

**Last modified:** 01/10/2023

**Unit in charge:** Barcelona School of Civil Engineering
**Teaching unit:** 751 - DECA - Department of Civil and Environmental Engineering.

**Degree:** BACHELOR'S DEGREE IN CIVIL ENGINEERING (Syllabus 2020). (Optional subject).

**Academic year:** 2023 **ECTS Credits:** 7.5 **Languages:** Catalan

## LECTURER

**Coordinating lecturer:** PEDRO ROCA FABREGAT

**Others:** DANIEL ALARCÓN FERNÁNDEZ, GIORGIO ANITORI, PEDRO ROCA FABREGAT

## DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

**Specific:**
14410. Knowledge of the typology and calculation bases of prefabricated elements and their application in manufacturing processes. (Specific technology module: Civil Construction)
14411. Knowledge about the project, calculation, construction and maintenance of building works in terms of structure, finishes, facilities and own equipment. (Specific technology module: Civil Construction)

**Generical:**
14380. Scientific-technical training for the exercise of the profession of Technical Engineer of Public Works and knowledge of the functions of advice, analysis, design, calculation, project, construction, maintenance, conservation and exploitation.
14383. Ability to project, inspect and direct works, in their field.
14386. Capacity for maintenance, conservation and exploitation of infrastructure, in its field.
14389. Knowledge of the history of civil engineering and training to analyze and assess public works in particular and construction in general.
14390. Identify, formulate and solve engineering problems. Pose and solve construction engineering problems with initiative, decision-making skills and creativity. Develop a systematic and creative method of analysis and problem solving. (Additional school competition).
14391. Conceive, project, manage and maintain systems in the field of construction engineering. Cover the entire life cycle of an infrastructure or system or service in the field of construction engineering. (Additional school competition).

## TEACHING METHODOLOGY

The course consists of 5 hours per week of presential teaching. This hours are devoted to:
(1) Lecturing on theorical subjects, wher the teacher presents the concepts and materials of the course. This aspect represents about 65% of the classroom time.
(2) Detailed presentation and discussion of practical exercises (20% of time)
(3) Evaluation including tests and practical exercices to be solved by the student (15% of time).
In addition, the student has to develop a certain number of practical assignments on different subjects of the course.
A tecnical visit concerning the contents of the course is also envisaged.
Support material in the form of a detailed teaching plan is provided using the virtual campus ATENEA: content, program of learning and assessment activities conducted and literature.

Although most of the sessions will be given in the language indicated, sessions supported by other occasional guest experts may be held in other languages.

## LEARNING OBJECTIVES OF THE SUBJECT

Concept of building (Elements and systems of a building. Functions and conditions. Global analysis and interaction between systems. General considerations regarding sustainability and life cycle analysis of buildings. Building physics. The inner environment. Thermal and hygrometric conditions. Saving energy. Acoustic insulation. Fire protection). The building's enclosure: facades and roofs. Installations: Electrical, hydraulic, sanitation, climate and vertical transport. Building structure (Basic load-bearing elements: one-way or two-way concrete framing systems, walls, superficial and deep foundations. Structural systems based on walls and framed systems. Systems based on walls and cores. Behaviour of the different structural systems facing horizontal actions. Industrialization and pre-fabrication in construction (Considerations on manufacturing, transport and assembly. Main elements and techniques. Applications of the prefabrication in civil works and building construction).

1 Ability to establish the bases of calculation in the design of structures, based on the regulations of existing actions, calculation and execution.
2 Capacity for designing and/or verifying structures in complex cases: plate analysis, rupture methods, introduction to elasticity and finite element method.
3 Capacity for dynamic and seismic analysis of simple cases. 3.4 Knowledge of the design, calculation, construction and maintenance of building works in regard to their structure, finishes, installations and equipment.

Elements and systems of a building. Building concept. Functions and conditions; subsystems. Introduction to the protective system (closings and finishes). Introduction to the facilities and equipment system. Introduction to the structural system. Global analysis and interaction between subsystems.
General considerations on sustainability and life cycle analysis of buildings. Building physics. The indoor and outdoor environment. Thermal and hygrometric conditioning factors. Energy saving. Acoustic isolation. Light conditioning factors. Natural light. Protection against fire. Building protection. General considerations about the exterior of a building. Facades Covers. Other elements. Installations. Electric. Artificial lighting. Hydraulic installations, sanitation, rainwater and seawage disposal. Climate control. Other facilities. Building structure I: Load-bearing elements; Dead loads in buildings; General typology of slabs for buildings; One-way concrete slabs; Bidirectional concrete slabs; Metal and mixed framing systems; Load bearing masonry walls; Foundations of a building. Building structure II: Stability and lateral stiffening; Characteristics of the horizontal actions and incidence in the Building; Behavior of the basic constructive types under horizontal actions; Lateral stiffness by means of walls and cores; Special solutions for high-rise buildings; Techniques for the analysis of buildings before horizontal actions. Building structure III: General details of construction; Details of construction in special elements and areas; Formation of construction joints, expansion joints and settlement; Special cases: very tall buildings, highly illuminated buildings, buildings in areas of seismic activity.

## STUDY LOAD

| Type | Hours | Percentage |
|---|---|---|
| Self study | 105,0 | 56.00 |
| Guided activities | 7,5 | 4.00 |
| Hours medium group | 37,5 | 20.00 |
| Hours large group | 37,5 | 20.00 |

**Total learning time:** 187.5 h

## CONTENTS

### THE SUBSYSTEMS OF THE BUILDING AND THEIR INTERACTION

**Description:**
Building functions related to stability, protection and conditioning. Subsystem analysis. Relationship between subsystems and functions. Introduction to the protective system. Elements of the closures of the building (facades and roofs) and specific functions. The compartmentalization of interior spaces. Renderings. Devices for regulation.

**Specific objectives:**
Knowledge of the functions, elements and systems that make up the building. Analysis of the problems derived from the interaction between the different subsystems (enclosures, installations and structure) and of the main arrangements that allow the optimization of their superposition in the building.

**Full-or-part-time:** 12h
Theory classes: 5h
Self study : 7h

### BUILDING PHYSICS

**Description:**
The indoor environment. Characteristics and usual values of the environmental parameters in the interior of buildings. Effect and seasonal variation of external actions (climatic agents). Thermal and hygrometric conditioning. Economic importance of thermal conditioning and energy saving. Approach to the problem of heat flow in the cold season. Approach to the same problem in hot season. Basic concepts of heat transmission theory. Calculation of the thermal resistance of different enclosures. Materials used for thermal insulation. Problems arising from the condensation of water vapor in the enclosures. Basic concepts of air psychrometry and the theory of vapor diffusion. Psychrometric abacus. Dew temperature and saturation pressure. Analysis of the formation of surface and interstitial condensations in enclosures. Steam barriers. Permeability of the enclosures to the air passage.
Practical exercise on the verification of the thermal behavior and on the possible condensation of water vapor in an interior space.
Nature and effects of the action of fire. Levels of action in the event of fires. Characterization of the "fire" action and the response of the Buildings and their elements. Effects and response to fire of different materials and structural elements. Approach to fire protection. General and simplified methods for checking the fire resistance of structures. Treatment and prescriptions established in current regulations. Flame retardant coatings.
Practical exercise related to the analysis of the fire resistance of a reinforced concrete structure
Incidence of noise on comfort and need for sound conditioning. Basic concepts of acoustics. Isophonic curves. Sources of emission and intensity. Aspects involved in the acoustic behavior of buildings: absorption, resonance, reverberation, impacts. Insulating capacity of the constructive elements. Law of mass. Match frequency. Influence of adjacent construction elements. Treatment and prescriptions on sound insulation in current regulations: general guidelines relating to urban planning and the design of buildings and facilities. Minimum insulation required for the different structural elements of the building. Recommendations regarding immission levels and reverberation times. Insulating materials and acoustic resonators.

**Specific objectives:**
Knowledge of the characteristics and parameters of the interior environment of buildings. Analysis of the thermal conditions and the operation of the thermal insulation of the building. Presentation of thermally insulating materials and elements.
Practical implementation of the concepts and theoretical formulation related to the verification of thermal conditions and condensation of water vapor.
Knowledge of the effects of fires on buildings and the levels and solutions that are applicable to their protection. Knowledge of the resistant behavior of various structural materials in the face of fire. Approach to the basic methods of analysis of buildings against fire.
Practical application of the concepts acquired in relation to the verification of the fire resistance of buildings
Knowledge of the acoustic behavior of buildings and solutions for improving levels of insulation and comfort. Approaching the problem from the physical point of view. Compliance with current regulations and familiarization with improvement solutions.

**Full-or-part-time:** 28h 47m
Theory classes: 8h
Practical classes: 4h
Self study : 16h 47m

## THE PROTECTIVE SYSTEM

**Description:**
General considerations on the external envelope of the Building. Morphology and functions of the outer envelope. Order and contact between the resistant, thermal and watertight enclosures. Problems related to the contact between the envelopes: thermal incompatibility and formation of thermal bridges.

**Specific objectives:**
Understanding of the problems that result from the contact between the structural and protective layers. Presentation of the problems of the conventional solutions and proposal of optimal solutions. Presentation of the main types of solutions for facades, roofs and partitions, with their corresponding advantages and disadvantages.

**Full-or-part-time:** 7h 11m
Theory classes: 3h
Self study : 4h 11m

## STRUCTURAL ELEMENTS (1)

**Description:**
Nature of the various gravitational actions. Nature and characteristics of the different live loads and their associated uses.
Fundamental types of ceramic, wood, reinforced or prestressed concrete, in situ or prefabricated concrete, steel and composite slabs. Devices used to enhance the monolithism connection o load bearing elements (compression layer, perimeter beams and intermediate nerves).
One-way concrete slabs. Fundamental types. Analysis of the resistant characteristics along with the constructive aspects, specific types and most common uses. Elements of the slab and conditions that must be met. Slab formation and required geometric conditions. Methods based on the plastic redistribution of moments. Concept of active deflection and verification of the deformability. Constructive details for the formation of supports on various types of bearing elements. General slab reinforcement detailing.
Detailed presentation in class of the practical process related to the complete design and verification of a one-way slab.
General types and range of use depending on the span and overload. Approach to the virtual gantry method. Edge beams: importance, functions and sizing criteria. General criteria for the reinforcement of two-way slabs. Punching verification: description of the breaking and checking mechanism. Sizing of steel capitals and abacuses.
Detailed presentation of the practical process related to the design and verification of a two-way slab.
Constructive and resistant advantages of the use of the postensioned slabs. Types of postensioned slabs. Specific technology for post-tensioning. Specific construction solutions and details. Introduction to the design and verification.
Composite floor slabs consisring of a steel profiled deck and concrete: elements, formation and fundamental characteristics. Types. Structural possibilities and main applications. Details for improving acoustic and fire behavior. Basic calculation criteria. Construction details.

**Specific objectives:**
Assessment of actions that may act on buildings
Knowledge of the various types of slabs and the devices used to guarantee the necessary slab monolithism and the appropriate connection with the vertical structure of the building.
Knowledge of the types of unidirectional slabs of reinforced or prestressed concrete. Familiarization with the criteria and the calculation process in service and in ultimate conditions. Knowledge of construction details.
Practical demonstration of the design process and resistant verification of a one-wayl slab.
Knowledge of the types of two-way reinforced concrete slabs. Presentation of the criteria and the verification process in service and in ultimate conditions. Knowledge of construction details. Analysis of the resistance to punching on pillars and presentation of specific reinforcement details.
Practical demonstration of the design process and strength verification of a two-way floor slab.
Knowledge of the advantages of post-tensioning in the formation of slabs for buildings. Presentation of specific constructive and technological aspects.
Knowledge of the main characteristics and applications of the composite slabs consisting of a steel profiled deck and concrete.

**Full-or-part-time:** 36h
Theory classes: 10h
Practical classes: 5h
Self study : 21h

## STRUCTURAL ELEMENTS (2)

**Description:**
Masonry component materials. Masonry typology and textures. Description of the basic resistant mechanisms of masonry composite specimens under normal and tangential stresses. Behavior of walls subject to vertical and horizontal forces. Buckling failure. Behavior of buildings consisting of masonry structural walls under vertical and horizontal actions. Resistant verification of load-bearing and shear walls in accordance with current regulations.
Exercise related to the practical application of the methods for the resistant verification of a structural system consisting on masory load-bearing walls.
Introduction to shallow foundations for buildings. Main elements and structural types. Design of footings and mat foundations. Use and design of centering and tie beams for shallow foundations. Use and design of basement walls. Specific construction details.
Detailed presentation of the practical application of the criteria and methods for the design and resistant verification of shallow foundations for buildings.
Introduction to deep foundations for buildings. Main elements and structural types. Use and design of piles, pile-caps and tie beams. Specific construction details.
Practical application of the criteria and methods for the design and resistant verification of deep foundations for buildings.

**Specific objectives:**
Presentation of the types of masonry walls and the characteristics of the component materials. Knowledge of the basic resistant mechanisms and possible modes of failure at the level of small composite specimens, structural element (wall) and buildings consisting of structural walls.
Practical implementation of the concepts and methods for the resistant verification of a structural system consisring of masonry load-bearing walls.
Knowledge of the specific construction elements and types of shallow foundations for buildings.
Practical demonstration on the design and resistant verification of a shallow foundation for a building.
Practical application of the criteria and methods for the design and resistant verification of deep foundations for buildings.
Practical demonstration on the design and resistant verification of a deep foundation for a building.

**Full-or-part-time:** 33h 36m
Theory classes: 8h
Practical classes: 6h
Self study : 19h 36m

## GLOBAL CONSTRUCTION DETAILS

**Description:**
Need for construction, contraction, expansion and settlement joints. Influence of climatic, geometric and resistant parameters. Distances, optimal position and formation. Special devices.

**Specific objectives:**
Discussion on the function and formation of different types of joints in the structure of buildings.

**Full-or-part-time:** 4h 48m
Theory classes: 2h
Self study : 2h 48m

## PREFABRICATION

**Description:**
Industrialization and prefabrication in buildings and engineering works. Precast concrete as a material and as a construction technique. Considerations on manufacturing, transport and assembly. Main elements and techniques.
Applications of prefabrication to civil works. Applications for the formation of structures, foundations, retaining walls, pipes and others. Application of prefabrication to buildings. Construction elements for buildings. Skeletal structural systems, systems based on large panels and systems based on three-dimensional cells. Joints between elements.
Practical development of the design process of a precast concrete element.

**Specific objectives:**
Presentation of precast concrete as a building material and construction technique. Discussion of the main technological aspects. Discussion of the main applications of precast concrete for the construction of structures of public works and buildings. In each case, presentation of the main elements and systems.
Practical application of the criteria and procedures allowing the design a precast concrete element.

**Full-or-part-time:** 24h
Theory classes: 8h
Practical classes: 2h
Self study : 14h

## FACILITIES

**Description:**
Air conditioning installations. Indoor climate control. Physical principles and systems.
Sanitary facilities. Wastewater and stormwater drainage. Elements and operation of the sanitation network. Design. Vertical transport. Types of transportation facilities. Elevators: systems and elements. Adherence and hydraulic elevators. Design.
Practical design of a installation for a building.

**Specific objectives:**
Description of the essential aspects of different types of facilities. The session mainly focuses on facilities that can significantly impact on the structure of the building.
Knowledge of the procedure for the design of an installation for a building.

**Full-or-part-time:** 12h
Theory classes: 4h
Practical classes: 1h
Self study : 7h

## OTHER ACTIVITIES

**Description:**
Technical visit to a prefabrication facility

**Specific objectives:**
Knowledge of the elements and procedures used in the prefabrication of elements for civil works and buildings through a technical visit of a prefabrication facility.

**Full-or-part-time:** 21h 36m
Practical classes: 5h
Laboratory classes: 4h
Self study : 12h 36m

## GRADING SYSTEM

The course grade is obtained through continuous assessment within the classroom by evaluation tests, plus a number of assignments to be developed outside the classroom.
The evaluation tests include a series of questions on concepts associated to the learning objectives of the course, both in terms of knowledge and understanding. These tests may also include application exercises. The tests are developed throughout the course and refer to its various topics or units.
A number of 2 tests of this type are envisaged. These tests consists of a series of questions about concepts related to the various topics of the course.
Furthermore, the student must solve and deliver a number of exercises related to the practical application of concepts on different subjects of the course. These exercises are part of the evaluable activities to be performed outside the classroom. It is expected that the student will have to solve and deliver about 4 assignments of this type. The delivery of these exercises is mandatory.
The grade of the course (N) results from the following calculation:
N = 0.3 A + 0.7 E
where
A is the average rating of the assignments to perform outside the classroom.
E is the grade obtained in final global test
N, A and E are graded in a 0 to 10 scale. The student will pass the subject if the final grade N is equal or larger than 5.0

Criteria for re-evaluation qualification and eligibility: Students that failed the ordinary evaluation and have regularly attended all evaluation tests will have the opportunity of carrying out a re-evaluation test during the period specified in the academic calendar. Students who have already passed the test or were qualified as non-attending will not be admitted to the re-evaluation test. The maximum mark for the re-evaluation exam will be five over ten (5.0). The non-attendance of a student to the re-evaluation test, in the date specified will not grant access to further re-evaluation tests. Students unable to attend any of the continuous assessment tests due to certifiable force majeure will be ensured extraordinary evaluation periods.

These tests must be authorized by the corresponding Head of Studies, at the request of the professor responsible for the course, and will be carried out within the corresponding academic period.

## EXAMINATION RULES.

Failure to perform a continuous assessment activity in the scheduled period will result in a mark of zero in that activity.
The activities or assignments to be performed outside the classroom are mandatory and need to be delivered so that the student can be graded from the course.

## BIBLIOGRAPHY

**Basic:**
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- Paricio, I. La construcción en la arquitectura. 4a ed. Barcelona: Institut de Tecnologia de la Construcció, 1999. ISBN 8478533753.
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**Complementary:**
- Regalado, F. Los forjados reticulares: manual práctico. Barcelona: CYPE Ingenieros, 1991. ISBN 8440491743.
- Tomlinson, M.J.; Boorman, R. Foundation design and construction. 7th ed. Harlow, England: Pearson Education, 2001. ISBN 9780130311801.
- Rodríguez Ortiz, J.M.; Serra Gesta, J.; Oteo Mazo, C. Curso aplicado de cimentaciones. 7a ed. corr. Madrid: Colegio Oficial de Arquitectos de Madrid, 1996. ISBN 84-8557-237-8.
- Ambrose, J.; Tripeny, P. Building structures [on line]. 3a ed. Hoboken, NJ: John Wiley & Sons, Incorporated, 2011 [Consultation: 28/10/2020]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=693226. ISBN 9780470542606.