Course guides
250322 - CIENTECMAT - Materials Science and Technology

Last modified: 12/12/2019

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

Degree: **Academic year:** 2019 **ECTS Credits:** 4.5
Languages: Catalan, Spanish

LECTURER

Coordinating lecturer: SUSANA VALLS DEL BARRIO

Others: SUSANA VALLS DEL BARRIO

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
4037. Quality control of the materials used
4058. Ability to become familiar with, understand and use the principles and technologies of materials

Transversal:
591. EFFICIENT ORAL AND WRITTEN COMMUNICATION - Level 1. Planning oral communication, answering questions properly and writing straightforward texts that are spelt correctly and are grammatically coherent.
598. EFFECTIVE USE OF INFORMATI0N RESOURCES - Level 2. Designing and executing a good strategy for advanced searches using specialized information resources, once the various parts of an academic document have been identified and bibliographical references provided. Choosing suitable information based on its relevance and quality.
601. SELF-DIRECTED LEARNING - Level 2: Completing set tasks based on the guidelines set by lecturers. Devoting the time needed to complete each task, including personal contributions and expanding on the recommended information sources.

TEACHING METHODOLOGY

The course consists of 1.4 hours per week of classroom activity (large size group) and 0.7 hours weekly with half the students (medium size group).

The 1.4 hours in the large size groups are devoted to theoretical lectures, in which the teacher presents the basic concepts and topics of the subject, shows examples and solves exercises.

The 0.7 hours in the medium size groups is devoted to solving practical problems with greater interaction with the students. The objective of these practical exercises is to consolidate the general and specific learning objectives.

The rest of weekly hours devoted to laboratory practice.

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.

LEARNING OBJECTIVES OF THE SUBJECT

Students will acquire an understanding of chemistry and the behaviour and durability of materials and learn how these disciplines apply to scientific and technical problems and to geological engineering in general.

Upon completion of the course, students will be able to: 1. Understand the choice of construction materials on the basis of their mechanical and physical properties and the specific structural requirements of the project in question;
2. Plan and organise in situ and laboratory analyses of the properties of materials used in general engineering works;
3. Conduct energy and life-cycle analyses of construction materials.

Introduction to Materials: Introduction to the use of materials in Engineering: General properties; Agglomerates; Chemical properties of lime, gypsum and Portland cement; Other cements; Regulations and applications of cements; The nature of water; Rocks; concrete aggregates; Environmental impact of the use of rocks as concrete aggregates and other geomaterials; Waste materials as concrete aggregates; Concrete; Metallic materials; Steel phase diagrams; Ceramic materials: Manufacturing, raw materials and behaviour; Polymers; Bituminous and asphalt materials

Currently, the course seeks to establish the foundations for the future engineer develops especially skills for the selection and use of all materials. Proper selection of materials determines the competitiveness of any product. This function is based on knowledge of the relationships between the properties, internal microstructure and the composition and chemical reactivity and processing of the material on them. Knowing and understanding relationships be different from one material to another are the main objective of this course.

To acquire basic scientific knowledge for understanding the behavior of building materials used in performing the works of public utility.

- Know what materials are available and which are best suited for each type of professional application of Geological Engineering.

- Study the properties that determine the application of the materials and methods that allow for empirical measurement.
- Understand and establish the relationship between material properties and their composition and structure, from the synthesis of scientific and empirical knowledge.

- Know the forms of use of each material and its influence on their behavior.

- Expose the existing rules for each construction material ensuring that a level of quality in use.

STUDY LOAD

Type	Hours	Percentage
Hours large group	30,0	26.67
Hours small group	8,0	7.11
Guided activities	4,5	4.00
Self study	63,0	56.00
Hours medium group	7,0	6.22

Total learning time: 112.5 h

CONTENTS

Item 1.

Description:
Chemical composition.
Manufacture and hydratation process
Standard and applications
Manufactures aeria lime and hydraulic lime
Hydratations process
Standard and applications
Manufacture Portland cement
Portland Clinker
Hydratation and microestructure hydrated cement paste
Other cement: Additions
Standard and applications
Durability of hydratation cement paste
Manufactured CAC/R cement
Hydrated process
Applications
Clinker phases determinated: Eq. Bogue
Exercises of cement durability.

Visit. Performance of work in progress

Specific objectives:
Characterization of gypsum and its different forms, depending on the degree of hydration, calcium sulfate dihydrate, hemihydrate and anhydrous, with its various allotropic forms. It also analyzes the process of setting and hardening. In the process of curing kinetics were studied (initial and final setting.) Additionally, we show the chemical additives that modify the properties of gypsum, such as the setting speed, rheology and plasticity. It concludes the study, discussing the action that produces the cast on other building materials such as Portland cement
In this issue we study the chemical reactions experienced by air and hydraulic binders. After defining the concept of binder shows the chemical process for obtaining pure lime, calcium carbonate by calcination and subsequent "off"to generate calcium hydroxide, to continue the process of hardening of the same, by reaction with atmospheric carbon dioxide. Also study their properties and main applications.
With respect to hydraulic limes are raw materials (limestone and clay) and the calcined process and the chemical composition of the finished product (acidic species, basic hydraulic and index), the characteristics of hydration reactions and their applications Definition of cement and its chemical composition. We analyze the process of Portland cement, from raw materials, limestone and clay, called clinkerization, and specially the chemical, physical and mineralogical occurring in obtaining the calcined products, using the nomenclature most commonly used . Practical problems is determined by the percentage composition of Portland cement, according to the method BOGUE.

Next, we study the cement hydration process, with its heat of hydration and compounds that are obtained. Detailed description of the microstructure obtained by the hydration process and finally the rate of hydration and hardening. Description aluminous cement, compared with Portland cement, from its chemical composition and hydration reactions.

Then we analyze the properties of the additions (pozzolans, fly ash, slag, silica fume, limestone filler, etc) and the amendments that introduce these additions on the behavior of the hydration and hardening of Portland cement.

And finally, widely known testing and current legislation of the different cements and in which environments should aplicar. Kind of cement as RC-98 and UNE. Nomenclature and specifications. Physical testing. Chemical analysis of cements. Applications and contraindications of different types of cements.

Description CAC/R cement, compared with Portland cement, from its chemical composition and hydration reactions.

Practical problems is determined by the percentage composition of Portland cement, according to the method BOGUE. Usually raise issues of reasoning about the application of different types of cement in certain environments. As well, questions about the process of hydration of clinker and the pozzolanic reaction and the modification of the properties. And finally, are made numerical problems (BOGUE method) to determine the composition of a clinker from a cement.

Full-or-part-time: 21h 36m
Theory classes: 7h
Practical classes: 2h
Self study : 12h 36m

Item 2. The rocks: aggregates concrete

Description:
Definition and origins
Classification
Standard

Origin and definition of the rocks. Types of construction applications. Research, development and extraction of stones. Main properties: density, porosity, hardness, permeability, abrasion, mineral behavior (stability and reactivity to the environment).

Knowing the nature and mineralogical characteristics of aggregates, provides the classifications and characteristics of technical interest specified in the regulations and describes the relevant tests. And he describes the methods for sieve analysis.

Session two practices of aggregates - physical properties - particle size

Specific objectives:
Importance of studying the rocks as raw material for the development of a construction material or as aggregate in concrete. Here we describe the test methods to define the quality of the rocks and validity. And a brief overview of the process of prospecting, extraction and processing of a natural resource (rocks). In the extraction section defines the various fronts from operations .
The use of natural stone has decreased to be replaced by other materials (concrete, slag, etc).

Full-or-part-time: 7h 11m
Theory classes: 1h
Laboratory classes: 2h
Self study : 4h 11m

Item 3: Metals materials

Description:
Bynaris diagram:
Iron- carbon diagram
Ductibility- fragility
Bynaris systems: problems

Specific objectives:
Compression of the different types of phase diagrams, which will be fundamental for the interpretation of many processes in industrial chemistry and especially in metals, ceramics and cement.
Types of steels specified by the regulations

Application of the concepts of phase and constituent to some technologically important alloys (brass, bronze, etc.).
Relate the variables temperature and composition of the alloys with their properties.
Knowledge of the different crystalline structures that the iron presents, depending on the temperature, as well as the solubility of carbon in each one of them.
Recognition and determination of the phases and constituents that appear in steels and foundries.
Study of the characteristic points of the iron - carbon diagram between 0 and 6.67% C.

Full-or-part-time: 7h 11m
Theory classes: 2h
Practical classes: 1h
Self study : 4h 11m

Item 4: Introduction construction materials properties

Description:
Materials and Engineering. Science and Engineering of Materials. Types of materials. Relationship between structure and properties. Criteria for the choice of materials

Mechanical properties

Resolts and not resolts exercices

Specific objectives:
Relationship between structure and properties. Criteria for the choice of materials.

Addresses the close relationship between materials and engineering, noting that any change in the properties of a material has a new application in the field of engineering.

Full-or-part-time: 7h 11m
Theory classes: 2h
Practical classes: 1h
Self study : 4h 11m

Item 5: Concrete

Description:
Fresh concrete: workability, methods, slump.
Concept of fresh concrete. Workability, consistency and workability. Methods of testing and measuring properties. Segregation and bleeding. Specific gravity.

For this item is available a video on the fresh concrete.

Classification additives
Characteristics and properties of additives.
Standard
General characteristics and classification: Water reducers (superplasticizers). Superplasticizers. Accelerators and retarders. Air-entraining agents. Corrosion inhibitors. Other additives.

Making a practice is on fresh concrete: influence of the addition of a water-reducing admixture.
i
Manufacturing: mixtures. Transport and commissioning work: Formwork, discharge forms and compaction. Cured: type. Influence of atmospheric conditions. Technology special centrifuge, vacuum, injection, projection and dry compaction.

Structure of hardened concrete.
Compressive strength: control trials.
Tensile and flexural. Stress - strain and modulus of elasticity. Creep. Fatigue
Concept of durability and permeability. Surface wear. Salt crystallization. Action of cold (cycles of freeze - thaw). Action of fire and high temperatures.
Dissolution reactions. Expansion reactions. Reinforcement corrosion in concrete and tension. Action of seawater. Alkali - aggregate. Protective measures and conclusions.
Granulometry
Fuller and Bolomey methods
Granulometry method
wet and additive corrections
Resolts and no resolts exercices
A laboratory practice session to make a dosing
- Consistency or slump: Abrams cone
- Influence of the addition of a superplasticizer
- compression strentgth and a Brazilian
Submit a report of the practice session and corresponds 5% of the final grade.

Specific objectives:
The nature and properties of fresh concrete tests are studied before acquiring the knowledge of nature and the effects they produce the main types of additives on the properties of concrete.

Effects that the main types of additives on the properties of fresh and hardened concrete.

Knowledge of the various stages of production of concrete

Structure and properties of hardened concrete.

The study of the structure and properties of hardened concrete is done together with the description of the tests used to characterize.

Knowledge of different factors, physical and chemical, that adversely affect the durability of concrete and the study of what can be done to counteract its action.

Dosification methods (Fuller, Bolomey)

Calculation methods for the determination of concrete

Making a practice is on fresh concrete: influence of the addition of a water-reducing or superplasticizer admixture and on standard tests to determine the mechanical properties of hardened concrete.

Full-or-part-time: 33h 36m
Theory classes: 9h
Practical classes: 2h
Laboratory classes: 3h
Self study : 19h 36m

Item 6:

Description:
Organic Chemistry
Definition and types of bituminous binders
Characteristics and properties of bituminous binders

Classification of different asphalt binders, according to Spanish regulations. PG-3.

Classification of aggregates. Importance and influence of filler in bituminous mixtures. Adherence, bitumen-filler system. Testing and characterization of the filler aggregates: Los Angeles, CPA, etc. ..

Structure and Mixtures.
dosage
Measurement methods
Marshall Test
Dosage according to Marshall test method.
Asphalt Plants
Transportation
Extension

Second practice of asphalt mixtures, corresponding to 5% of the final grade. Submit a report:

- manufacture asphalt mixture
- Marshall

Specific objectives:
Introduction to organic chemistry: nomenclature. Define the different bituminous binders, their properties and tests.

Classification of different bituminous binders. Knowledge PG-3 (road standard).

Definition and testing of aggregates and filler in bituminous mixtures.

Knowledge of different types of bituminous mixtures, mixtures criteria, their manufacture and testing . Finally, aspects related to the durability of these materials.

View of the manufacturing process of a hot mix.
Criterion dosage.
Test control: Penetration and Marshall

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

Item 7: Ceramic materials

Description:
Raw materials. Clays. Degreasing and flux. Ceramic pastes. Manufacture of ceramic products. Technical properties: porosity, water absorption, mechanical strength and modulus of elasticity. Durability.

Specific objectives:
This information item will go to the main features, applications and durability,

- Knowledge of raw materials of ceramic material. Mineralogical description of the group forming clays, phyllosilicates.
* Manufacturing process of ceramic products.
* Key properties to be considered a ceramic material.

Full-or-part-time: 2h 24m
Theory classes: 1h
Self study : 1h 24m

Item 8: Sustainable building materials

Description:
Case study of the use of waste materials or from geological risks as building materials
Exhibition of the importance of using waste material from geological hazards in construction engineering

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

Syntesis activity 1 (substracts 1,2,3,4)

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

Synthetic activity 2: concrete / bituminous / ceramic / Sustainability

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

GRADING SYSTEM

The qualification of the subject is obtained based on the continuous evaluation qualifications and the corresponding laboratory and / or computer classroom.

The continuous assessment consists in doing different activities, both individual and group, of a formative nature, carried out during the course (inside and outside the classroom).

The qualification of teaching in the laboratory is the average of such activities.

Evaluation tests consist of a part with questions about concepts associated with the learning objectives of the subject in terms of knowledge or understanding, and a set of application exercises.

For the subject of SCIENCE AND TECHNOLOGY OF MATERIALS evaluation criteria:
1 exams: 70%
1.1. Test 1: E1 (subject ties, metals, general properties and aggregates) 35%
1.2. Test 2: E2 (concrete, bituminous mixtures, ceramics and Sustainability) 35%

2- Assessable exercises in class and / or self-study (group and individual): 30%
2.1. Visit report manufacturing cement and cement (group)
2.2. Realization of a abstract, scientific work (individual)
2.3. Questionnaire resolution in the classroom based on a video (individual): fresh concrete, construction work and rupture.
2.4. Resolution of questionnaires for review of each topic block in the classroom (not programmed in the calendar).
2.5. Comment and resolution of questions from a scientific work (group): sustainability in materials
3- There will be two sessions of laboratory practices: 10% within 30% of follow-up activities and evaluable inside and outside the classroom
3.1. Properties and regulations of aggregates: deliver report
3.2. Fresh and hardened concrete: deliver report

To the final mark: (E1 + E2 / 2) 0.70+ ((Assessable activities in the individual and / or group classroom) 20% + (practical) 10%) 0.30.

Qualification and admission criteria for reassessment: Students suspended to the ordinary assessment that have been submitted regularly to the evaluation tests of the subject suspended will have the option to perform a reassessment test during the period set in the Academic calendar Students who have already passed the qualification as not yet presented may not be submitted to the re-evaluation test of a subject. The maximum qualification in the case of submitting to the re-assessment exam will be five (5.0). The non-attendance of a student summoned to the test of re-evaluation, celebrated in the fixed period will not be able to give rise to the accomplishment of another test with later date. Extraordinary assessments will be made for students who have not been able to carry out any of the continuous assessment tests because of their proven force majeure.

These tests must be authorized by the corresponding head of studies, at the request of the professor responsible for the subject, and will be carried out within the corresponding teaching period.

EXAMINATION RULES.

If one of the activities of laboratory or continuous assessment is not carried out in the programmed period, it will be considered as a zero score.

For the subject of SCIENCE AND TECHNOLOGY OF MATERIALS evaluation criteria:

To the final grade: (E1 + E2 / 2) 0.70+ ((Assessable activities in the individual and / or group classroom) 20% + (practical) 10%) 0.30.

BIBLIOGRAPHY

Basic:

- Smith, W.F.; Hashemi, J. Fundamentos de la ciencia e ingeniería de materiales [on line]. 5a ed. México: McGraw-Hill, 2014 [Consultation: 10/05/2020]. Available on: http://www.ingebook.com/ib/NPcd/IB_BooksVis?cod_primaria=1000187&codigo_libro=5732. ISBN 9701056388.
- Callister, W.D. Introducción a la ciencia e ingeniería de los materiales. 2a ed. México, D.F: Limusa Wiley, 2009. ISBN 9786075000251.
- Arredondo, F. Cales. 2a ed. Madrid: Instituto Técnico de Construcción y Cemento, 1961.
- Arredondo, F. El yeso. 2a ed. Madrid: Instituto Técnico de Construcción y Cemento, 1961.
- Arredondo, F. Conglomerantes hidráulicos. Madrid: Instituto Técnico de Construcción y Cemento, 1961.
- Mehta, P.K.; Monteiro, P.J.M. Concrete: microstructure, properties, and materials. 3rd ed. New York: McGraw-Hill, 2006. ISBN 0071462899.
- Taylor, H.F.W. Cement chemistry. 2nd ed. London: Thomas Telford, 1997. ISBN 0727725920.
- Fernández Canovas, M.. Hormigón. 3a ed. Madrid: Colegio de Ingenieros de Caminos, Canales y Puertos, 1993. ISBN 8474931258.
- López Jimeno, C. Manual de áridos : prospección, explotación y aplicaciones. Madrid: U.D. Proyectos E.T.S.I. Minas, 2003. ISBN 8496140067.
- Smith, M.R.; Collis, L. (eds.). Aridos: áridos naturales y de machaqueo para la construcción. 2a ed. Madrid: Colegio Oficial de Geólogos de España, 1994. ISBN 8492009705.
- Domone, P.; Illston, J.M. Construction materials: their nature and behaviour. 4th ed. London ; New York: Spon, 2010. ISBN 9780415465151.
- Neville, A.M. Properties of concrete. 5th ed. Harlow: Pearson, 2011. ISBN 9780273755807.
- Callister, W.D. Introducción a la ciencia e ingeniería de los materiales. 2a ed. México: Limusa Wiley, 2009. ISBN 9786075000251.
- Jackson, N.; Dhir, R.K. Civil engineering materials. 5th ed. Basingstoke ; London: Macmillan, 1996. ISBN 033363683X.
- Collepardi, M.; Collepardi, S.; Troli, R. Concrete mix design. Villorba: Grafiche Tintoretto, 2007. ISBN 8890146982.
- Kraemer, C.; Morilla, I.; del Val, M.A. Carreteras II: explanaciones, firmes, drenaje, pavimentos. 1999. Madrid: Colegio de Ingenieros de Caminos, Canales y Puertos, 1999. ISBN 84-380-0149-1.

Complementary:

- Bermejo Nualart, F. Guia per a l'ús de la instrucció EHE : materials, execució, control. Espanya: ITEC, 1999. ISBN 8478533605.
- Grimshaw R.W. The Chemistry and physics of clays and allied ceramic materials. 4th ed rev. New York: John Wiley, 1971. ISBN 0471327808.
- Chinchón, S.; Sanjuán, M.A. El cemento de Aluminato de calcio y sus prefabricados. Alecant: Universidad de Alicante, 2008. ISBN 978-84-7908-968-9.
- Sanjuán, M.A; Chinchón, S. El cemento Portland. Fabricación y Expedición. Alicante: Universidad de Alicante., 2004. ISBN 84-7908-806-0.