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250144 - HSUPSUB - Surface and Groundwater Hydrology

Coordinating unit: 250 - ETSECCPB - Barcelona School of Civil Engineering
Teaching unit: 751 - DECA - Department of Civil and Environmental Engineering
Academic year: 2018
Degree: BACHELOR'S DEGREE IN CIVIL ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)
BACHELOR'S DEGREE IN CIVIL ENGINEERING (Syllabus 2017). (Teaching unit Compulsory)
ECTS credits: 4,5 Teaching languages: Catalan, Spanish, English

Teaching staff

Coordinator: MANUEL GOMEZ VALENTIN

Others: MANUEL GOMEZ VALENTIN, FRANCISCO JAVIER SANCHEZ VILA

Opening hours

Timetable: Prof. Manuel Gómez Friday 16 - 20 h
Prof Xavier Sanchez Vila Tuesday 16-20h

Degree competences to which the subject contributes

Specific:
3035. Knowledge of the basic concepts of surface and underground hydrology.

Generical:
3104. Students will learn to identify, formulate and solve a range of engineering problems. They will be expected to show initiative in interpreting and solving specific civil engineering problems and to demonstrate creativity and decision-making skills. Finally, students will develop creative and systematic strategies for analysing and solving problems.
3106. Students will learn to assess the complexity of the problems examined in the different subject areas, identify the key elements of the problem statement, and select the appropriate strategy for solving it. Once they have chosen a strategy, they will apply it and, if the desired solution is not reached, determine whether modifications are required. Students will use a range of methods and tools to determine whether their solution is correct or, at the very least, appropriate to the problem in question. More generally, students will be encouraged to consider the importance of creativity in science and technology.
3107. Students will learn to identify, model and analyse problems from open situations, consider alternative strategies for solving them, select the most appropriate solution on the basis of reasoned criteria, and consider a range of methods for validating their results. More generally, students will learn to work confidently with complex systems and to identify the interactions between their components.
3110. Students will learn to plan, design, manage and maintain systems suitable for use in civil engineering. They will develop a systematic approach to the complete life-cycle of a civil engineering infrastructure, system or service, which includes drafting and finalising project plans, identifying the basic materials and technologies required, making decisions, managing the different project activities, performing measurements, calculations and assessments, ensuring compliance with specifications, regulations and compulsory standards, evaluating the social and environmental impact of the processes and techniques used, and conducting economic analyses of human and material resources.
3112. Students will develop an understanding of the different functions of engineering, the processes involved in the life-cycle of a construction project, process or service, and the importance of systematising the design process. They will learn to identify and interpret the stages in preparing a product design specification (PDS), draft and optimise specifications and planning documents, and apply a systematic design process to the implementation and operation phases. Students will learn to write progress reports for a design process, use a range of project management tools and prepare final reports, and will be expected to show an awareness of the basic economic concepts associated with

the product, process or service in question.
3113. Students will learn to identify user requirements, to draft definitions and specifications of the product, process or service in question, including a product design specification (PDS) document, and to follow industry-standard design management models. Students will be expected to show advanced knowledge of the steps involved in the design, execution and operation phases and to use the knowledge and tools covered in each subject area to the design and execution of their own projects. Finally, students will assess the impact of national, European and international legislation applicable to engineering projects.

Transversal:

585. ENTREPRENEURSHIP AND INNOVATION - Level 1. Showing enterprise, acquiring basic knowledge about organizations and becoming familiar with the tools and techniques for generating ideas and managing organizations that make it possible to solve known problems and create opportunities.
586. ENTREPRENEURSHIP AND INNOVATION - Level 2. Taking initiatives that give rise to opportunities and to new products and solutions, doing so with a vision of process implementation and market understanding, and involving others in projects that have to be carried out.
589. SUSTAINABILITY AND SOCIAL COMMITMENT - Level 2. Applying sustainability criteria and professional codes of conduct in the design and assessment of technological solutions.
594. TEAMWORK - Level 3. Managing and making work groups effective. Resolving possible conflicts, valuing working with others, assessing the effectiveness of a team and presenting the final results.
584. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.

Teaching methodology

The course consists of 1.8 hours per week of classroom activity (large size group) and 0.5 hours weekly with half the students (medium size group).

The 1.8 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 0.5 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.

The final grade will be:
0.5*(0.25*HMS coursework + 0.75*(0.5*T1 + 0.5 T2)) + 0.30(0.5*T3 + 0.5*T4)+0.20(sum(ti)/n)

where T1 and T2 are the two tests on Surface hydrology, while T3, T4 are the two comprehensive tests on Groundwater, and ti are small quizzes (5-10 min) that will take place at the beginning of some of the classes from the groundwater part, with approximately weekly periodicity (i. e., n ranges between 5 and 7)

Learning objectives of the subject

Students will acquire a basic understanding of surface and groundwater hydrology and learn to apply this knowledge to engineering problems.

Upon completion of the course, students will have acquired the ability to: 1. Carry out a hydrological modelling study of a basin, including aspects of water resource quality and management. 2. Carry out a hydrological modelling study of an aquifer and contaminant transport, including aspects of water resource quality and management. 3. Carry out an integrated study of surface water and groundwater.

Description of physical processes associated with drainage basins and their quantification, using professional tools such as HEC-HMS; Basic concepts of groundwater flow and solute transport in soil, including both qualitative and quantitative aspects.

Knowledge of the basic concepts of surface and groundwater hydrology and the ability for application to engineering problems.

1. A study of a watershed hydrological modeling, as well as quality issues and management of water resources.
2. To develop a hydrogeological model of an aquifer and contaminant transport, including aspects of quality and water resources management.
3. Develop an integrated study of surface and groundwaters

Provide the ability to describe in a watershed the associated physical processes and their quantification, and using a professional type tool such as HEC-HMS.
Basic principles of groundwater flow and solute transport in the field including both qualitative and quantitative aspects

Study load

Total learning time: 112h 30m	Theory classes:	30h 30m	27.11%
	Practical classes:	6h	5.33%
	Laboratory classes:	8h 30m	7.56%
	Guided activities:	4h 30m	4.00%
	Self study:	63h	56.00%

Content

Rainfall and basin analysis	Learning time: 4h 48m Theory classes: 2h Self study : 2h 48m

Description:
Introduction to the Topic. Precipitations: types and origins. Rainfall measurements: pluviometers. Hyetograph and Pluviograph. Mean areal rainfall. Basin: concept and descriptors. Time of Concentration.

Specific objectives:
Introduce the rainfall data analysis, pluvigraphs and hyetographs. Mean area rainfall.
Basin concepts: descriptors, time of concentration

IDF curves. Método racional	Learning time: 7h 11m Theory classes: 2h Laboratory classes: 1h Self study : 4h 11m

Description:
Rainfall data. Statistics of extremes. IDF and DDF curves. Rational method. Basic concepts. Runoff coefficient.
Spanish regulation 5.2.IC
Rational method: Exemples.

Specific objectives:
Introduction to the data analysis, IDF and DDF curves as well as introduce the Rational method, according to the spanish regulation 5.2. IC Drainage
Present the application of Rational method and prevent on some mistakes usually observed in the professional practice

Design rainfalls	Learning time: 2h 24m Theory classes: 1h Self study : 1h 24m

Description:
Design storm. Alternating block method.

Specific objectives:
Introduce the design rainfall concept, associated to a return period. Alternating block procedure: examples of application

Effective rainfall and rainfall losses	Learning time: 13h 12m Theory classes: 4h 30m Practical classes: 1h Self study : 7h 42m

Description:

Excess of precipitation (Effective rainfall): Water balance. Losses: Interception
Concepts of evapotranspiration (real and potential). Estimation and measurement. Evaporimeters and Penman Monteith equation. Depression storage: influence in rural and urban basins
Infiltration: infiltration models. Horton model. Linear model. F index.
Curve number. Hypotesis and application. SCS table land uses / CN.
Curve number examples.

Specific objectives:

Present the concept of effective rainfall, and the associated losses. Interception during rain events
Present the relevance of evapotranspiration according to different time scales of the analysis, and the way to measure / estimate the values. Usual values observed in Spain
Depression Storage losses, on irregularities of the basin. Usual values
Introduce the infiltration process. Concept of model of infiltration. Models of one, two and three or more parameters for infiltration
Introduce the curve number procedure, the most usual procedure for ungauged basins. Concepts and empirical proposal. Initial abstraction. Table of CN values and previous moisture AMC effects
Apply the CN procedure for different AMC conditions, and verify ponding time and end of rainfall concepts.

Test for assessment	Learning time: 13h 12m Laboratory classes: 5h 30m Self study : 7h 42m

Rainfall - runoff process	Learning time: 9h 36m Theory classes: 3h Practical classes: 1h Self study : 5h 36m

Description:
Rainfall runoff process: Unit Hydrograph, Reservoir models and Kinematic Wave. Unit hydrograph: basic concepts. Graphic and matrix methods. UH from real data.
Unit hydrograph: applications. S diagram
Synthetic Unit hydrograph. SCS synthetic unit hydrograph. Concepts and applications.

Specific objectives:
Introduction to the rainfall - runoff analysis. Present the main different approaches: Unit hydrograph (UH), reservoir models and kinematic wave approach over terrain cells. Introduction to the UH: concept and numerical and graphical methods to be used. UH from real measurements on the basin
Exposing the application of unit hydrograph, and how to obtain the UH for rain duration
Introduction of the synthetic unit hydrograph concept.Development of the SCS case. Concepts and recommendations for practical applications

Flood routing process	Learning time: 9h 36m Theory classes: 4h Self study : 5h 36m

Description:
Flood routing. process on Reservoirs. Attenuation due to the reservoir for incoming discharge hydrographs. Spillways and bottom outlets effects
Flood routing in riverbeds. Muskingum method. Kinematic wave concepts and approach.

Specific objectives:
Introduction to the flood routing process and effects on discharge hydrographs: volume conservation, peak flow attenuation, increase of base time, etc. To understand the role of spillways and bottom outlets on peak flow reduction
Introduction to the flood routing in rivers, considering hydrologic methods: Muskingum model, coefficients and applications. Introduction to the Kinematic Wave approach (gravity and friction dominating forces). Estimation of parameters from real data

Introduction to HEC-HMS code	Learning time: 2h 24m Laboratory classes: 1h Self study : 1h 24m

Description:
Introduction to the HEC-HMS code, and to the coursework to be done

Specific objectives:
Propose to the student the use of a standard professional tool to develop a hydrological analysis in a basin

hydro-geological and hydro-geochemical concepts

Learning time: 12h

Theory classes: 5h
Self study : 7h

Description:

Movement of water in the hydrosphere
Underground reservoirs
Chemical components of groundwater.
Hydrogeological exploration.
Joint use of surface and groundwater.

Specific objectives:

Movement of water in the hydrosphere. The Hydrologic Cycle focused on the underground cycle. Water resources and reserves. Water balance
Underground reservoirs. Concept. Aquifer and aquitard. Groundwater level and groundwater level.
Chemical components of groundwater. Parameters determining the physical, chemical and physico-chemical properties of groundwater. Rock-water ratio. Origin. Process modifiers. Stiff diagram
Hydrogeological exploration. Objectives and methodology. Drilling: methods. Well design. Pipings and grids.
Joint use of surface and groundwater. Joint management. Artificial recharge. Interaction between groundwater and marine waters. Penetration of the salt wedge.

groundwater flow

Learning time: 12h

Theory classes: 3h
Practical classes: 2h
Self study : 7h

Description:

Water flow in porous media
Continuity Equation
Solutions of 1D flow in porous medium
Springs
Piezometric surface layout and flow networks

Specific objectives:

Water flow in porous media. Porosity, hydraulic conductivity. Darcy's Law. Heterogeneity and anisotropy. Transmissivity.
Continuity Equation. The coefficient of storage. Steady state and transient state. Some particular solutions.
Solutions of 1D flow in porous medium
Springs. River-aquifer interaction. Flow Networks. Definition. Path. Qualitative and quantitative interpretation. .
Piezometric surface layout and flow networks

water wells	Learning time: 9h 36m Theory classes: 2h Practical classes: 1h Laboratory classes: 1h Self study : 5h 36m

Description:
Hydraulic Basics deposits
Hydraulic transient deposits: confined aquifer, semi-confined and free.
Interpretation of pumping tests. Graphic methods.
Permeameter, probes, groundwater models / sandbox

Specific objectives:
Hydraulic Basics deposits. Hypothesis. Pumping tests: concept and preparation. Dupuit-Forcheimer hypothesis. Formulas Thiem, and Dupuit Glee.
Hydraulic transient deposits: confined aquifer, semi-confined and free. Superposition principle. Theory of images.
Interpretation of pumping tests. Graphic methods.
Show the students some of the apparatus most used in groundwater, with practical hints about applications and use

contamination of groundwater	Learning time: 7h 11m Theory classes: 2h Practical classes: 1h Self study : 4h 11m

Description:
Solute transport mechanisms.
Study and management of chemical analysis.
Aquifer contamination

Specific objectives:
Solute transport mechanisms. Reactive compounds. Characterization of solute transport. Transport equation. Elementary solutions.
Study and management of chemical analysis. Representation of chemical data. Aquifer contamination. Solving the transport equation in simple cases. Determination of transit times.
Aquifer contamination. Pollution sources: landfills, agriculture, toxic waste, and others. Accidental spills.

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hydrogeology and civil engineering	Learning time: 4h 48m Theory classes: 2h Self study : 2h 48m

Description:
Impact of public works on the flow and quality of groundwater.
Stability of slopes and dams, soils and rocks.

Specific objectives:
Impact of public works on the flow and quality of groundwater. Urban hydrology. Consolidation. Liquefaction. Stability of slopes and dams, soils and rocks. Drainage excavations. Drainage and calculation methods. Inflows to tunnels.

Qualification system

The mark of the course is obtained from the ratings of continuous assessment and their corresponding classroom computers.

Continuous assessment consist in several activities, both individually and in group, of additive and training characteristics, carried out during the year (both in and out of the classroom).

The evaluation tests consist of a part with questions about concepts associated with the learning objectives of the course with regard to knowledge or understanding, and a part with a set of application activities.

The final grade will be:
0.5*(0.25*HMS coursework + 0.75*(0.5*T1 + 0.5 T2)) + 0.2*T3 + 0.3*T4

where T1 and T2 are the two tests on Surface hydrology, T3 is a class activity regarding flow net drawing and T4 is a comprehensive test on topics related to Groundwater.

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.

Regulations for carrying out activities

Failure to perform a continuous assessment activity in the scheduled period will result in a mark of zero in that activity.

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Bibliography

Basic:

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Bedient, P.B.; Huber, W.C.; Vieux, B.E. Hydrology and floodplain analysis. 4th ed. Upper Saddle River, NJ: Prentice Hall, 2008. ISBN 9780131745896.

Chow,, V.T.; Maidment, D.R.; Mays, L.W. Applied hydrology. New York: McGraw-Hill, 1988. ISBN 0070108102.

Gómez, M. Curso de hidrología urbana. Barcelona: Escola Tècnica Superior d'Enginyers de Camins, Canals i Ports. UPC, 2008. ISBN 978-84-612-1514-0.

Comisión docente Curso Internacional de Hidrología Subterránea (ed.). Hidrogeología: conceptos básicos de hidrología subterránea. Barcelona: Fundación Centro Internacional de Hidrología Subterránea, 2009. ISBN 978-84-921469-1-8.

Complementary:

Maidment, D. Handbook of hydrology. New York: McGraw-Hill, 1993. ISBN 0070397325.

Shaw, E.M. Hydrology in practice. 4th ed. Londres: Spon Press, 2011. ISBN 9780415370424.

Custodio, E.; Llamas, M.R. (eds.). Hidrología subterránea. 2a edición corregida. Barcelona: Omega, 1983. ISBN 8428204462.

Domenico, P.A. y F.W. Schwartz. Physical and Chemical Hydrogeology. 2nd ed. New York: John Wiley and Sons, 1998. ISBN 0471597627.

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