250235 - INFTRANSP - Transport Infrastructures

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 PUBLIC WORKS ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)
ECTS credits: 7,5
Teaching languages: Catalan, Spanish, English

Teaching staff
Coordinator: ADRIANA HAYDEE MARTINEZ REGUERO
Others: ADRINA BACHILLER SAÑA, EDUARDO FERNANDEZ DE VILLALTA FERRER-DALMAU, ADRIANA HAYDEE MARTINEZ REGUERO

Degree competences to which the subject contributes

Specific:

3082. Ability to construct, conserve, dimension and design roads and the items comprising basic road provision

3083. Ability to construct and conserve railway lines with knowledge of the application of the specific technical regulations, differentiating the characteristics of the rolling stock

3091. Ability to construct, conserve, dimension and design roads and the items comprising basic road provision

3092. Ability to construct and conserve railway lines with knowledge of the application of the specific technical regulations, differentiating the characteristics of the rolling stock

General:

3105. 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.

3111. 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 5 hours per week of classroom activity.

The 3 hours are devoted to theoretical lectures, in which the teacher presents the basic concepts and topics of the subject, and the 1.5 hours are devoted to show examples and solves exercises (average).

The rest of weekly hours devoted to tests.

Support material in the form of a detailed teaching plan is provided using the virtual campus ATENEA: content, program of assessment activities and conducted learning, literature.

Learning objectives of the subject

Students will acquire an understanding of highway construction, preservation, design and planning, as well as the various basic roadway elements. They will acquire an understanding of railway construction and preservation, and also learn to apply specific technical regulations and to distinguish between different types of rolling stock.

Upon completion of the course, students will have acquired the ability to: 1. Design a road according to traffic and other conditioning factors. 2. Design the horizontal layout and vertical profile of transport infrastructure. 3. Carry out a railway infrastructure project, including the layout and design of the elements that make up the section.

Horizontal layout and vertical profile of highways, and coordination between the two aspects; Design of highway cross sections; Traffic; Movement of vehicles; Traffic flow and capacity; Earthworks, including surface and subsurface drainage; Design and sizing of roads; Characteristics of railway infrastructure; Stiffness and deformability of roadways; Basic characteristics of railway vehicles; Layout of railways; Mixed traffic and tilting vehicles; Stress on roadways; Mechanical behaviour of a roadway under vertical stress; Incorporation of transverse stress; Design of roadway infrastructure and
superstructure; High-speed railways; ICT-assisted analysis of highway and railway demand, transport operations and services, financing, and pricing of tolls and tickets

<table>
<thead>
<tr>
<th>Study load</th>
<th>44h 30m</th>
<th>22h 30m</th>
<th>8h</th>
<th>7h 30m</th>
<th>105h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total learning time</td>
<td>23.73%</td>
<td>12.00%</td>
<td>4.27%</td>
<td>4.00%</td>
<td>56.00%</td>
</tr>
<tr>
<td>Theory classes</td>
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<tr>
<td>Practical classes</td>
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<tr>
<td>Laboratory classes</td>
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<tr>
<td>Guided activities</td>
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<tr>
<td>Self study</td>
<td></td>
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</table>
## Content

<table>
<thead>
<tr>
<th><strong>0. Presentation</strong></th>
<th><strong>Learning time:</strong> 2h 24m</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Theory classes: 1h</td>
</tr>
<tr>
<td></td>
<td>Self study: 1h 24m</td>
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</tbody>
</table>

**Specific objectives:**
Presentation of the course: objectives, faculty, calendar, system evaluation, bibliography.

<table>
<thead>
<tr>
<th><strong>1. ROADS. Construction of earthworks</strong></th>
<th><strong>Learning time:</strong> 12h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Theory classes: 3h</td>
</tr>
<tr>
<td></td>
<td>Practical classes: 2h</td>
</tr>
<tr>
<td></td>
<td>Self study: 7h</td>
</tr>
</tbody>
</table>

**Description:**
Soil classification problems.
Factors affecting the process of compaction, moisture, compaction type and energy, soil type. Proctor test.
Moisture and density measurement.
Soil compaction problems
Previous operations to earthmoving. Removal, loading and transport. Embankment construction.

<table>
<thead>
<tr>
<th><strong>2. Subgrades</strong></th>
<th><strong>Learning time:</strong> 4h 48m</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Theory classes: 1h</td>
</tr>
<tr>
<td></td>
<td>Practical classes: 1h</td>
</tr>
<tr>
<td></td>
<td>Self study: 2h 48m</td>
</tr>
</tbody>
</table>

**Description:**
Bearing capacity and subgrade design problems.

<table>
<thead>
<tr>
<th><strong>3. Drainage</strong></th>
<th><strong>Learning time:</strong> 2h 24m</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Practical classes: 1h</td>
</tr>
<tr>
<td></td>
<td>Self study: 1h 24m</td>
</tr>
</tbody>
</table>

**Description:**
### 4. Pavements

| Description: |

| Learning time: |
| 4h 48m |
| Theory classes: 1h |
| Practical classes: 1h |
| Self study: 2h 48m |

### 5. Basic materials.

| Description: |

| Learning time: |
| 7h 11m |
| Theory classes: 1h |
| Laboratory classes: 2h |
| Self study: 4h 11m |

### 6. Work units

| Description: |

| Learning time: |
| 21h 36m |
| Theory classes: 2h |
| Practical classes: 2h 30m |
| Laboratory classes: 4h 30m |
| Self study: 12h 36m |
### 7. Circulation

**Description:**
- Traffic Variables
- Relationships between traffic variables

**Learning time:** 4h 48m
- Theory classes: 2h
- Self study : 2h 48m

### 8. Traffic studies

**Description:**
- Traffic forecasting
- Traffic studies "in situ"

**Learning time:** 4h 48m
- Theory classes: 2h
- Self study : 2h 48m

### 9. Capacity and levels of services

**Description:**
- Definitions and conditions
- Level of service (L.O.S.) in freeways.
- L.O.S. in 2-way roads
- Exercises

**Learning time:** 9h 36m
- Theory classes: 3h
- Practical classes: 1h
- Self study : 5h 36m
## 10. Introduction of geometric design

**Description:**
- Administration managing road infrastructures.
- Coding the road networks.
- Context of the geometric design within the scope of the sector.
- Geometric design standards: international context.
- La Instrucción 3.1-IC: approach and presentation.
  - Horizontal alignment.
  - Vertical alignment.
  - Cross section.
  - Speed Reference.
  - Visibility.
  - Terrain.
  - Coordination horizontal-vertical alignment.

**Learning time:** 4h 48m
- Theory classes: 2h
- Self study: 2h 48m

## 11. Horizontal alignment

**Description:**
- Straight alignments.
- Circular curves.
- Transition curves.
- Relationship between radius and superelevations.
- Shape and characteristic parameters.
- Minimum length.
- Alignments
  - Straight - Circular
  - Reverse curve (S-shaped curve)
  - C curve (spiral connecting two circular curves with different radius)
  - Combination of two spirals

**Learning time:** 14h 23m
- Theory classes: 2h
- Practical classes: 4h
- Self study: 8h 23m
## 12. Vertical alignment

**Learning time:** 9h 36m  
Theory classes: 1h  
Practical classes: 3h  
Self study : 5h 36m

**Description:**  
- Calculation axis.  
- Grade inclination.  
- Ramps and slopes  
- The parabola.  
- Minimum parameters of the agreements.

Sag vertical curve.  
Crest vertical curve

Exercise to improve the vertical alignment design  
Vertical alignment with fixed-elevation points.

## 13. Cross section

**Learning time:** 4h 48m  
Theory classes: 1h  
Practical classes: 1h  
Self study : 2h 48m

**Description:**  
- Number of lanes of reference section.  
- Cross section on the ground.  
- Superelevation transition.

Superelevation laws

## 14. RAILWAYS. Track and material

**Learning time:** 9h 36m  
Theory classes: 4h  
Self study : 5h 36m

**Description:**  
Rail networks and operational difficulties  
Main features of a road  
Type of railway track
<table>
<thead>
<tr>
<th>Topic</th>
<th>Learning time</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>15. Circulation and increased cornering speed</strong></td>
<td>16h 48m</td>
<td>Uncompensated acceleration and cant deficiency. Transition curves. Systems to increase velocity.</td>
</tr>
<tr>
<td><strong>16. Geometric quality</strong></td>
<td>2h 24m</td>
<td>Parameters that define the geometric quality of the track. UIC criteria.</td>
</tr>
<tr>
<td><strong>17. Vertical forces and track design</strong></td>
<td>12h</td>
<td>Evaluation of vertical forces exerted by the vehicles. Mechanical analysis of the behavior of a railway track in front of vertical forces. Design of track components.</td>
</tr>
<tr>
<td><strong>18. Turnouts</strong></td>
<td>7h 11m</td>
<td>Equation of lateral displacement of the track. Derailment of a vehicle.</td>
</tr>
</tbody>
</table>
| **19. Turnouts** | **Learning time:** 2h 24m  
Theory classes: 1h  
Self study: 1h 24m |
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Turnouts.</td>
</tr>
</tbody>
</table>

| **20. Bridges and tunnels** | **Learning time:** 2h 24m  
Theory classes: 1h  
Self study: 1h 24m |
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Bridges and tunnels</td>
</tr>
</tbody>
</table>

| **Control** | **Learning time:** 19h 12m  
Laboratory classes: 8h  
Self study: 11h 12m |
| --- | --- |
For assessment purpose, the course consists of three parts: Traffic and Geometric Design (TT), Earthworks and Pavements (EF), and Railways (FC).

The Mark of the course will be the arithmetic mean of the mark of each of these three parts if the student has got a mark equal to or higher than 4.0 in each one of them:

\[ \text{Mark of the course} = \frac{(\text{Mark TT}) + (\text{Mark EF}) + (\text{Mark FC})}{3} \]

Otherwise, the Mark will be the harmonic mean of the mark obtained in each of the three parts:

\[ \text{Mark of the course} = \frac{3}{\left(\frac{1}{\text{Mark TT}} + \frac{1}{\text{Mark EF}} + \frac{1}{\text{Mark FC}}\right)} \]

To pass the course, the student’s course Mark must be equal to or higher than 5.0.

The mark of each part will be obtained as described below.

In the case of the part Traffic and Geometric Design (TT) there will be some assessable activities in the topic Geometric Design. The mark of Traffic and Geometric Design (TT) will be the weighted mean of the exam of Traffic (38%) and the mark obtained in Geometric Design (62%). This last mark (Geometric Design mark) will be obtained by weighting the corresponding exam (80%) and assessable activities (20%):

\[ \text{Mark TT} = 0.38 \times \text{Traffic Exam} + 0.62 \times \text{Geometric Design Mark} (0.80 \times \text{Geometric Design Exam} + 0.20 \times \text{Geometric Design Activities}) \]

The mark of the part Earthworks and Pavements (EF), as well as that of Railways (FC), will be the weighted mean obtained in the corresponding exam and the assessable activities that will be developed during the course, so the exam will be weighted as 80% and the assessable activities as 20%:

\[ \text{Mark EF} = 0.80 \times \text{EF Exam} + 0.20 \times \text{Activities} \]
\[ \text{Mark FC} = 0.80 \times \text{FC Exam} + 0.20 \times \text{Activities} \]

The Mark will be NP when the student does not attend any of the three exams described above and there will be no mark for the student.

Furthermore, at the end of the course, there will be a retaking exam exclusively for the students that, having a numerical Mark, this is not equal to or higher than 5.0.

Once this retaking exam has been taken the mark of each part will be the highest one obtained either in the course or in the retaking exam only if one of them is higher than 4.0. Otherwise, the mark considered will be the one obtained in the retaking exam.

The retaking exam will be compulsory for the students that have one or more of the partial marks lower than 4.0 and the Mark of the course also lower than 4.0. The Mark will be NP when being compulsory the attendance at one of the retaking exams, the student does not attend it.

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**

The Mark will be NP when the student does not attend any of the three exams described above and there will be no mark for the student.

The Mark will be NP when being compulsory the attendance at one of the retaking exams, the student does not attend it.

**Bibliography**

**Basic:**

**Complementary:**