310025 - Structures III

Coordinating unit: 310 - EPSEB - Barcelona School of Building Construction
Teaching unit: 753 - TA - Department of Architectural Technology
Academic year: 2018
Degree: BACHELOR'S DEGREE IN ARCHITECTURAL TECHNOLOGY AND BUILDING CONSTRUCTION (Syllabus 2015). (Teaching unit Compulsory)
BACHELOR'S DEGREE IN BUILDING CONSTRUCTION SCIENCE AND TECHNOLOGY (Syllabus 2009). (Teaching unit Compulsory)
ECTS credits: 6
Teaching languages: Catalan, Spanish

Teaching staff
Coordinator: SANDOKAN LORENTE MONLEÓN
Others: ROMÁ CRESPIERA OLLÉ - JOSÉ VILANOVA GABARRÓ - SANDOKÁN LORENTE MONLEÓN

Opening hours
Timetable: Romà Crespiera Ollé: Mondays from 10 to 11
Josep Vilanova Gabarró: Mondays from 17:30 to 18:30
Sandokán Lorente Monleón: Fridays from 11 to 12 and from 14:30 to 15:30

Prior skills
The students should be able to:
- Calculate the sectional stresses of isostatic rod structures.
- Measure and check rods depending on the stresses acting, both in steel and reinforced concrete.
- Design and calculate column-beam unions and column bases for steel structures.
- Calculate beam deformations, for steel and reinforced concrete beams.
- Use appropriately the momentum formulas of fixed end momentums.
- Know the physical properties of the soils.

Requirements
Is recommended to have passed the subjects Estructures I and Estructures II.

Degree competences to which the subject contributes

Specific:
1. FE-15 Aptitude for the pre-measuring, design, calculation and verification of structures and manage its materials execution.

Transversal:
2. EFFICIENT ORAL AND WRITTEN COMMUNICATION - Level 3. Communicating clearly and efficiently in oral and written presentations. Adapting to audiences and communication aims by using suitable strategies and means.
3. SELF-DIRECTED LEARNING - Level 3. Applying the knowledge gained in completing a task according to its relevance and importance. Deciding how to carry out a task, the amount of time to be devoted to it and the most suitable information sources.
Teaching methodology

The directed learning hours consist on:
- Exposition-participative classes (big group):
The faculty does a brief exposition for introducing the general learning objectives related with the basic concepts of the subject and explains the theoretical contents. By means of practical exercises tries to motivate and involve the students so that they can participate in their learning.

It is used support material in detailed teaching plan by ATENEA: learning objectives by contents, concepts, examples, evaluation activities and directed learning schedules and bibliography.

Generally, at the end of each session there will be proposed exercises to solve out of class which can be worked individually or in groups and are part of the directed and autonomous learning.

- Practical classes - Workshop (medium group):
A practical exercise is proposed, which is related with the weekly contents and the students solve it during the class. The professor directs the students in the resolution, answers their doubts and start a debate for analyzing the results obtained.

The autonomous learning hours consist on:
- Bibliography readings.
- Study of the theoretical concepts.
- Resolution of the application exercises which complement the study of the theoretical concepts.

Learning objectives of the subject

At the end of the course, students should be able to:
- List and explain the different structural analysis types.
- Apply the matrix deformation method to solve an analysis of flat bars structures.
- Determine the actions that take part in a structure; to establish the loads state and the combinations of actions in order to verify the fulfillment of the limit states.
- Define the analysis model of a structure and determine the loads that are applied on it.
- Apply design criteria to solve the resistant diagram of a building structure and justify the adopted solution.
- Calculate the different elements that compose the building structure.

Study load

<table>
<thead>
<tr>
<th>Total learning time: 150h</th>
<th>Hours large group:</th>
<th>Hours medium group:</th>
<th>Hours small group:</th>
<th>Guided activities:</th>
<th>Self study:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>45h</td>
<td>15h</td>
<td>0h</td>
<td>0h</td>
<td>90h</td>
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<tr>
<td></td>
<td>30.00%</td>
<td>10.00%</td>
<td>0.00%</td>
<td>0.00%</td>
<td>60.00%</td>
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</tbody>
</table>
## C1 STRUCTURAL ANALYSIS

### Learning time: 60h
- Theory classes: 18h
- Practical classes: 6h
- Self study: 36h

### Description:
In this content the students work:
- Structural analysis definition.
- Types of analysis.
- Analysis methods.
- Matrix deformations method applied to the flat rods structures.

### Related activities:
There will be done the activities 1, 2, 5 and 6 which correspond to 1 in-person evaluable practice, 1 evaluation exam, resolution of workshop exercises and the final exam.

### Specific objectives:
- Explain the different types of structural analysis.
- Differenciate the stresses method and the deformations method.
- Solve simple exercises with the stresses method and the deformations method.
- Describe the phases of the matrix deformation method.
- Define the local axis, general axis and the degrees of freedom of a structure.
- Deduce the stiffness matrix of a rod and explain the meaning of each sub-matrix of the rod.
- Deduce the rotation matrix of a rod.
- Calculate the stiffness matrix of a rod of a structure according to the general axis of the structure.
- Set up the stiffness matrix of a structure.
- Calculate the equivalent actions vector about the nodes of a structure, according to the general axis.
- Calculate the final stresses in the extreme of the rod based on the movements in the structure nodes.
- Interpret the value and direction of the final stresses in the extreme of the rod.
- Draw the corresponding stresses diagrams.
- Identify the value and the direction of the structure reactions.
### C2 DESIGN AND STRUCTURAL SECURITY

**Learning time:** 10h  
Theory classes: 3h  
Practical classes: 1h  
Self study : 6h

**Description:**
In this content the students work:
- Classification and values of the actions (construction).
- Limit state method: Effect of the actions.
- Situations of calculus. Combination of actions.

**Related activities:**
There will be done the activities 2, 5 and 6 which correspond to 1 evaluation exam, resolution of workshop exercises and the final exam.

**Specific objectives:**
- Identify, classify and determine the value of the actions which act in a particular building.
- Define the concepts of favourable and non-favourable actions.
- Define the concepts of eigenvalue, representative value and calculation value of an action.
C3 STRUCTURAL ELEMENTS

Learning time: 50h
Theory classes: 15h
Practical classes: 5h
Self study: 30h

Description:
In this content the students work:
- Analysis and Design of:
  - Lightweight roof structures: truss, straps.
  - Slabs: unidirectional and bidirectional.

Related activities:
There will be done the activities 3, 5 and 6 which correspond to 1 in-person evaluable practice, resolution of workshop exercises and the final exam.

Specific objectives:
- Identify the different components of the structure of a lightweight roof.
- Define the suitable model of analysis for each component which form the resistance structure of a lightweight roof.
- Establish the simple hypothesis and the combination of actions for checking both the Ultimate Limit States and the Serviceability Limit States in each one of the components which form a lightweight roof.
- Solve the structural analysis of the components which form a lightweight roof.
- Apply the knowledge acquired in the previous subjects to pre-measure and check the different components which form a lightweight roof structure.
- Measure the edge of a slab and justify the taken value.
- Test and justify the analysis model suitable depending on the slab type.
- Establish the simple hypothesis and the combination of actions for checking both the Ultimate Limit States and the Serviceability Limit States of an unidirectional slab.
- Solve the structural analysis of an unidirectional slab (linear analysis, analysis with limited redistribution).
- Define the components which configure a reticulated slab (abacus, rebars, perimeter beams).
- Apply the virtual arcades method to determine the calculation stresses of the different components which form a reticular slab.
- Apply the acquired knowledge in the previous subjects to calculate the necessary reinforced of the different components which form a reticular slab.
## C4 Elements of Foundation and Contention

**Learning time:** 30h  
- Theory classes: 9h  
- Practical classes: 3h  
- Self study: 18h

### Description:
In this content the students work:
- Criteria for choosing the foundation type.  
- Design, analysis, and measuring of foundation components (shallow foundation, piles and pile caps).

### Related activities:
There will be done the activities 5 and 6 which correspond to resolution of workshop exercises and the final exam.

### Specific objectives:
- Identify the different components which form the foundations of a building, depending on the foundation type.  
- Deduce the features and mechanical properties of the land based on the geotechnical report.  
- Deduce the actions which serve in a foundation element, based on the results of the analysis of the structure.  
- Measure the foundation element and check its Ultimate Limit State of equilibrium.  
- Apply the connecting rod method or the acquired knowledge in the previous subjects for measuring the reinforcement of the element.
### Planning of activities

<table>
<thead>
<tr>
<th>A1 - PRACTICE 1 (CONTENT 1 )</th>
<th>Hours: 7h</th>
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</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Practical classes: 1h</td>
</tr>
<tr>
<td>Theoretical-practical exercise which includes all the knowledge related with the content 1, which has been worked till the day of the practice.</td>
<td>Self study: 6h</td>
</tr>
<tr>
<td>Individual fulfilment in the workshop schedule, in-person.</td>
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<tr>
<td>Time available: 50 minutes.</td>
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<tr>
<td><strong>Support materials:</strong></td>
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<tr>
<td>Practice wording.</td>
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<tr>
<td>Calculator.</td>
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<tr>
<td>Summary of the topic available in ATENEA and basic bibliography corresponding to the content 1.</td>
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<tr>
<td>Wordings of the exercises to solve (autonomous work).</td>
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</tr>
<tr>
<td><strong>Descriptions of the assignments due and their relation to the assessment:</strong></td>
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</tr>
<tr>
<td>Solved practice.</td>
<td></td>
</tr>
<tr>
<td>This activity has a worth of 10% in the final mark of the course.</td>
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<tr>
<td><strong>Specific objectives:</strong></td>
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<tr>
<td>At the end of the activity the students should be able to:</td>
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<tr>
<td>- Explain the different types of structural analysis.</td>
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<tr>
<td>- Differenciate the stresses method and the deformations method.</td>
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<tr>
<td>- Define the local axis, general axis and the degrees of freedom of a structure.</td>
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<tr>
<td>- Deduce the stiffness matrix of a rod and explain the meaning of each sub-matrix of the rod.</td>
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<tr>
<td>- Deduce the rotation matrix of a rod.</td>
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<tr>
<td>- Calculate the stiffness matrix of a rod of a structure according to the general axis of the structure.</td>
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<tr>
<td>- Set up the stiffness matrix of a structure.</td>
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<tr>
<td>- Calculate the final stresses in the extreme of the rod based on the movements in the structure nodes.</td>
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<table>
<thead>
<tr>
<th>A2 - EXAM (CONTENT 1 - 2)</th>
<th>Hours: 8h</th>
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</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Theory classes: 2h</td>
</tr>
<tr>
<td>Individually and in-person exam.</td>
<td>Self study: 6h</td>
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<tr>
<td>Theoretical-practical exercise which includes all the learning objectives of the content 1 and 2.</td>
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<tr>
<td>Maximum time: 2 hours.</td>
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<tr>
<td><strong>Support materials:</strong></td>
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<tr>
<td>Exam wording.</td>
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<tr>
<td>Non-programmable calculator</td>
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<tr>
<td>For preparing the exam:</td>
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</tr>
<tr>
<td>Summary of the topic available in ATENEA and basic bibliography corresponding to the content 1 and 2.</td>
<td></td>
</tr>
<tr>
<td><strong>Descriptions of the assignments due and their relation to the assessment:</strong></td>
<td></td>
</tr>
<tr>
<td>Resolution of the exam.</td>
<td></td>
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<tr>
<td>This activity has a worth of 20% in the final mark of the course.</td>
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</tbody>
</table>
Specific objectives:
At the end of the activity, the students should be able to:
- Deduce the rotation matrix of a rod.
- Calculate the stiffness matrix of a rod of a structure according to the general axis of the structure.
- Set up the stiffness matrix of a structure.
- Calculate the equivalent actions vector about the nodes of a structure, according to the general axis.
- Calculate the final stresses in the extreme of the rod based on the movements in the structure nodes.
- Interpret the value and direction of the final stresses in the extreme of the rod.
- Draw the corresponding stresses diagrams.
- Identify the value and the direction of the structure reactions.
- Solve the analysis of a flat rod structure with loads applied on the rods, imposed movements and elastic supports.

A3 - PRACTICE 2 (CONTENTS 3)  
Hours: 7h  
Practical classes: 1h  
Self study: 6h

Description:  
Theoretical-practical exercise which includes the knowledge related with the contents 3, which have been worked till the day of the practice.  
Individual fulfilment during the workshop schedule, in-person.  
Time available: 50 minutes.

Support materials:  
Practice wording.  
Calculator.  
Summary of the topic available in ATENEA and basic bibliography corresponding to the contents 3.  
Wordings of the exercises to solve (autonomous work).

Descriptions of the assignments due and their relation to the assessment:  
Solved practice.  
This activity has a worth of 10% in the final mark of the subject.

Specific objectives:
At the end of the activity the students should be able to:
- Identify, classify and determine the value of the actions which act in a particular building.
- Define the concepts of favourable and non-favourable actions.
- Define the concepts of eigenvalue, representative value and calculation value of an action.
- Identify the different components of the structure of a lightweight roof.
- Define the suitable model of analysis for each component which form the resistance structure of a lightweight roof.
- Establish the simple hypothesis and the combination of actions for checking both the Ultimate Limit States and the Serviceability Limit States in each one of the components which form a lightweight roof.
- Solve the structural analysis of the components which form a lightweight roof.
- Apply the knowledge acquired in the previous subjects to pre-measure and check the different components which form a lightweight roof structure.
- Measure the edge of a slab and justify the taken value.
- Test and justify the analysis model suitable depending on the slab type.
- Establish the simple hypothesis and the combination of actions for checking both the Ultimate Limit States and the Serviceability Limit States of an unidirectional slab.
- Solve the structural analysis of an unidirectional slab (linear analysis, analysis with limited redistribution).
- Apply the virtual arcades method to solve a bidirectional slab.
### A4 - WORKSHOP CONTEST MODEL (CONTENT 1-4)

<table>
<thead>
<tr>
<th>Description:</th>
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<tbody>
<tr>
<td>Workshop contest model. Carried out in group. Delivery and exposition</td>
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<table>
<thead>
<tr>
<th>Support materials:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bases contest model in ATENEA</td>
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</table>

<table>
<thead>
<tr>
<th>Descriptions of the assignments due and their relation to the assessment:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model. Delivery and exposition 19 december</td>
</tr>
<tr>
<td>This activity is worth a 10% in the final mark of the course.</td>
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</table>

**Specific objectives:**
- Work in group
- Application of the structural knowledge of design and construction of a model in scale.

<table>
<thead>
<tr>
<th>Hours: 7h</th>
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<tbody>
<tr>
<td>Practical classes: 1h</td>
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<tr>
<td>Self study: 6h</td>
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### A5 - CLASSROOM PRACTICES - (CONTENTS 1, 2, 3 and 4)

<table>
<thead>
<tr>
<th>Description:</th>
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<tbody>
<tr>
<td>This activity is developed in 10 in-person sessions of 1 hour, distributed throughout the course, deducting the non-school days, according to the settled schedule (workshops). It is necessary that the students have studied the contents worked at class (on Mondays) and have solved the self-evaluation exercises proposed (out of class and during the week). In every workshop session, a new exercise is proposed, which the students solve with the support of the faculty.</td>
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<table>
<thead>
<tr>
<th>Support materials:</th>
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<tbody>
<tr>
<td>Wordings of the exercises to solve.</td>
</tr>
<tr>
<td>Basic bibliography corresponding to the contents related with the exercises.</td>
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<tr>
<td>Class with blackboard, computer and projector.</td>
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<table>
<thead>
<tr>
<th>Specific objectives:</th>
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</thead>
<tbody>
<tr>
<td>At the end of the activity the students should be able to:</td>
</tr>
<tr>
<td>- Enumerate and explain the different types of structural analysis.</td>
</tr>
<tr>
<td>- Apply the matrix deformations method to solve the analysis of flat rod structures.</td>
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<tr>
<td>- Determine the actions working on a structure; establish the load stage and the combinations of actions to verify the compliance of the Limit States.</td>
</tr>
<tr>
<td>- Define the analysis model of a structure and determine the working loads.</td>
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<tr>
<td>- Apply the design criteria to solve the resistant scheme of the structure of a building and prove the chosen solution.</td>
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<tr>
<td>- Calculate the different elements which form a building structure.</td>
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<table>
<thead>
<tr>
<th>Hours: 70h</th>
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</thead>
<tbody>
<tr>
<td>Practical classes: 10h</td>
</tr>
<tr>
<td>Self study: 60h</td>
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### A6 - FINAL EXAM

<table>
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<tr>
<th>Hours: 9h</th>
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<tbody>
<tr>
<td>Theory classes: 3h</td>
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<tr>
<td>Self study: 6h</td>
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</tbody>
</table>
The final mark is the arithmetic mean of the partial marks, according to this expression:

\[ N_{\text{final}} = 0.1 \, A_1 + 0.2 \, A_2 + 0.1 \, A_3 + 0.1 \, A_4 + 0.5 \, A_6 \]

The scheduled dates for the realisation of each activity are:

- **A1:** (Evaluable practice, individual and in-person): Week 5 (October 14th)
- **A2:** (Evaluation exam, individual and in-person): Week 8 (November 4th, according to the EPSEB schedule).
- **A3:** (Evaluable practice, individual and in-person): Week 11 (November 25th)
- **A4:** (Evaluable practice, individual and in-person): Week 15 (December 19th)
- **A6:** (Final exam, group and in-person): January 11th of 2017 (according to EPSEB schedule).

The student who does not attend the Final Exam will be marked as NP (Non-Presented).

**Qualification system**

The final mark is the arithmetic mean of the partial marks, according to this expression:

\[ N_{\text{final}} = 0.1 \, A_1 + 0.2 \, A_2 + 0.1 \, A_3 + 0.1 \, A_4 + 0.5 \, A_6 \]

**Description:**
Individual in-person exam.
Theoretical-practical exercise which includes the learning objectives of all the subject contents, with diverse parts which include both practical application aspects and aspects related with the comprehension of the theoretical concepts.
Maximum time: 3 hours.

**Support materials:**
- Exam wording.
- Calculator.
- Notes, bibliography and formulary that the students bring.

**Descriptions of the assignments due and their relation to the assessment:**
Resolution of the exam.
This activity has a worth of 50% in the final mark of the course.

**Specific objectives:**
At the end of the activity the students should be able to:
- Enumerate and explain the different types of structural analysis.
- Apply the matrix deformations method to solve the analysis of flat rod structures.
- Determine the actions working on a structure; establish the load stage and the combinations of actions to verify the compliance of the Limit States.
- Define the analysis model of a structure and determine the working loads.
- Apply the design criteria to solve the resistant scheme of the structure of a building and prove the chosen solution.
- Calculate the different elements which form a building structure.

**Regulations for carrying out activities**

If some of the evaluation activities is not done, it will be considered as non-marked.
310025 - Structures III

Bibliography

Basic:


Complementary: