REINFORCED CONCRETE STRUCTURES DESIGN FOR ARCHITECTURE DEGREES: A PROBLEM-BASED LEARNING PROPOSAL

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Abstract

Regarding the global design of buildings, despite that nowadays their appearance is very important, their adequate structural design is essential. For that reason, it is necessary that the Architecture degree students are trained to acquire different skills related to the structural design of a building. Between the different types of structures, those made using reinforced concrete are very usual in Europe, especially in Spain.

On the other hand, many important changes in the learning and teaching methodologies have been introduced due to the new scenario created by the Bologna Declaration and the European Higher Education Area. The Architecture degrees have not been exempt from these important changes, which have affected the planning of their subjects. In the present new methodologies, the paper of the students in the learning and teaching process is fundamental, and the final objective is to prepare them for the globalized labour market, in which the students can carry out a high amount of different tasks during their professional career.

In this work, it is described a problem-based learning proposal for initiating the Architecture degree students in the design of reinforced concrete elements and structures. This proposal has been based on the experience and the results obtained during several academic years in the theoretical and practical classes of the subject “Structures 3” of 4th course of Architecture degree at University of Alicante (Spain). This subject has a total of 6 ECTS.

In general terms, the proposal consists in the progressive learning of how reinforced concrete structures perform through the process of designing a beam and a column. During this process the students will learn concepts like durability, ultimate and serviceability limit states, idealisation of the structure and characteristics of materials.

Keywords: Architecture, structures, reinforced concrete, European Higher Education Area, problem-based learning.

1 INTRODUCTION

The introduction of the European Higher Education Area in engineering degrees has meant important changes in the learning and teaching methodologies and in the planning of the subjects [1]. The Architecture degrees have not been exempt from these changes. Within the European Higher Education Area, the practical knowledge plays an important role. In relation to the global design of buildings, despite that nowadays their appearance is very important, their adequate structural design is essential. For that reason, it is necessary that the Architecture degree students are trained to acquire different skills related to the practical structural design of a building.

Furthermore, the acquisition of these practical skills could be also useful for the students in their future job, because the globalized labour market of engineers brings with it the possibility that the students can carry out a high amount of different tasks during their professional career. In the particular case of Spain, the reinforced concrete structures are very common, so it is necessary that the students adequately acquire the knowledge related to the different steps involved in the design of the structural elements made with this material.

The Architecture degree at University of Alicante (Spain) started during the academic year 1996-97, which is a relatively long experience. However, the new Architecture degree designed and planned according to the guidelines of European Higher Education Area started at University of Alicante during the academic year 2010-11. This has supposed the introduction of new learning and teaching methodologies, which has constituted a challenge for students and teaching staff.
In this work, it is described a problem-based learning proposal for initiating the Architecture degree students in the design of reinforced concrete elements and structures. This proposal has been based on the experience and the results obtained during several academic years in the theoretical and practical classes of the subject “Structures 3” of 4th course of Architecture degree at University of Alicante (Spain).

2 PRESENTATION OF THE SUBJECT “STRUCTURES 3”

The subject “Structures 3” of 4th course of Architecture degree at University of Alicante has a total of 6 credits ECTS. Each credit ECTS corresponds to 25 hours of student work. The 40% of these hours are in-person class and the rest corresponds to the personal work of the student. As a consequence, the subject “Structures 3” has 60 hours of in-person class, which are divided in 30 hours of theory classes and 30 hours of practical classes.

The syllabus of the subject is made up of four units, which are shown in Table 1.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Title</th>
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<tbody>
<tr>
<td>1</td>
<td>Introduction to the reinforced concrete technology</td>
</tr>
<tr>
<td>2</td>
<td>Ultimate limit states</td>
</tr>
<tr>
<td>3</td>
<td>Serviceability limit states</td>
</tr>
<tr>
<td>4</td>
<td>Reinforced concrete walls and foundations</td>
</tr>
</tbody>
</table>

Regarding the current academic year 2016-17, the number of registered students at the subject was 110. The students were given out in two groups of theory classes and four different groups of practical classes.

3 PROPOSAL OF PROBLEM-BASED LEARNING METHODOLOGY AND PRELIMINARY RESULTS OBTAINED DURING THE ACADEMIC YEAR 2016-17

In general terms, the proposal consists in the progressive learning of how reinforced concrete structures perform through the process of designing a beam and a column. During this process the students will learn concepts like durability, ultimate and serviceability limit states, idealisation of the structure and characteristics of materials. Now, it will be individually described the works of column and beam design and after that the preliminary results obtained during this academic year 2016-17 will be mentioned.

3.1 Work 1: Reinforced concrete column design

Previously to this work, it is explained to the students many concepts related to the durability of the reinforced concrete elements and to the ultimate serviceability limit states [2,3,4]. Moreover, a brief introduction to the SAP2000 software [5] is explained.

The objective of this first practical work is to design completely a concrete column, which belongs to a building structure. In Fig. 1 it can be observed a capture of the work wording. The different steps that the students should develop in the work are:

- Determination of the actions and stresses in the structure.
- Requirements to consider for guaranteeing an adequate durability of the structure.
- Longitudinal reinforcement determination and instability limit state verification:
  - Mechanical slenderness.
  - Lower slenderness limit.
Total eccentricity determination.
- Final stresses to consider for calculating the longitudinal reinforcement of the column.
- Determination of the longitudinal reinforcement which is necessary to dispose in the section of the column.
- Checking if the reinforcement solution previously determined accomplishes the requirements of minimum amount of reinforcement.
- Checking if the reinforcement solution accomplishes the space requirements between bars.

Shear reinforcement determination:
- Verification of failure due to diagonal compression in the web.
- Verification of failure due to tension in the web.
- Checking the arrangements for reinforcements.

Graphical representation of the reinforcement solution obtained for the column.

3.2 Work 2: Reinforced concrete beam design

Before this work, it is explained to the students the ultimate serviceability limit states concepts related to the reinforced concrete beams design [2,3,4].

The goal of this second practical work is to design completely a reinforced concrete beam. In Fig. 2 it can be observed an image of the work wording.

The different steps that the students should develop in the work are:

- Determination of the actions and stresses in the beam.
- Requirements to consider for guaranteeing an adequate durability of the beam.
- Longitudinal reinforcement determination:
  - Mechanical capacity of the reinforcement steel required in the section of the maximum positive bending stress in the left bay of the beam.
  - Mechanical capacity of the reinforcement steel required in the section of the maximum negative bending stress in the beam.
Mechanical capacity of the reinforcement steel required in the section of the maximum positive bending stress in the right bay of the beam.

Requirements of minimum amount of reinforcement.

Election of the longitudinal reinforcement of the beam.

Determination of the anchorage length of the reinforcement bars.

Graphical representation of the longitudinal reinforcement solution obtained for the beam.

- Shear reinforcement determination:
  - Verification of failure due to diagonal compression in the web in the beam sections with the highest shear stresses.
  - Verification of failure due to tension in the web in the beam sections with the highest shear stresses.
  - Checking the arrangements for reinforcements.
  - Election of an adequate proposal for the shear reinforcement of the beam.

3.3 Results

Both works previously described in this paper have been put into practice during the academic year 2016-17. They were solved in groups of two students. In general, it has been observed very good results and all the students passed the evaluation of these work, and many of them obtained a high grade. Furthermore, they showed a high interest during the sessions dedicated to solve questions and to discuss the work. Finally, the feedback received of this methodology has been very good.

4 CONCLUSIONS

The guidelines related to learning and teaching methodology established by the new European Higher Education Area has supposed a challenge for students and teaching staff, especially in the cases of Architecture degrees. Between the different topics of these degrees, the study of reinforced concrete structures plays an important role. Besides, the complexity of these structures makes necessary to introduce adequately the students to their performance. In this paper, it has been described a problem-based learning proposal for initiating the Architecture degree students in the design of reinforced concrete elements and structures. This proposal has been put into practice at the subject.
“Structures 3” of Architecture degree at University of Alicante (Spain) during the academic year 2016-17, and it has been obtained very good results

REFERENCES


