



Structural Engineering is Much More than Formulas: Introducing a New Course on Philosophy of Structures

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Summary

This paper presents the objectives, contents and teaching methodologies used in a new course on Philosophy of Structures developed at the School of Civil Engineering of the Universitat Politècnica de Valencia in Spain. The course combines the analysis of engineers' writings, selected case studies, visual analysis of structures, graphic statics and field trips with the writing of a paper about a particular structure. In their paper, the students must comment on the technical data of the structure and on its authors, but they also have to delve into the links between structure, society, aesthetics and architecture. Results show that the course develops students' structural intuition and creativity and fosters a passion for engineering.

Keywords: Philosophy of Structures, structural criticism, Structural Art, graphic statics, education, creativity, field trips, Construction History.

1. Introduction

In 1957 Eduardo Torroja published the book "*Razón y Ser de los Tipos Estructurales*" [1] (translated to English as "Philosophy of structures"). Its main goal was to explain how to choose the more adequate and economical structural system to solve a construction problem considering that the construction had to meet some requirements (safety, aesthetics, function...) and had to be built with the construction materials and techniques available in a certain context. In the first chapter, Torroja insisted in the idea that structural analysis was a mere tool to check if the forms and dimensions of a structure were suitable to bear the loads acting on a structure and that the extraordinary development of structural mechanics during the 19th and 20th centuries had resulted in not paying the proper attention to the "ontological study" of the structural systems. This was undesirable because, as Torroja pointed out, any designer who disregards this kind of study might be "in danger of serious failures". Torroja explained his ideas on the conceptual design of structures in a course called "*Tipología Estructural*" ("Philosophy of structures") taught at the School of Civil Engineering of Madrid, at the time the only civil engineering school in Spain.

After Torroja, other authors have also pointed out the importance of simplified analysis methods and conceptual design in engineering education and practice. For example, the shell designer Félix Candela wrote "*all calculations, no matter how sophisticated and complex, cannot be more than rough approximations of the natural phenomenon they try to represent*" [2] and more recently Mike Schlaich has explained in detail the role of conceptual and structural design in the education of the engineer [3]. Other authors have explained how creativity can be a part of the engineers' education (Bögle, [4]) or how case studies can be used to develop structural criticism and structural intuition (Payá-Zaforteza, [5]).

Within this general context, this paper presents the main ideas, teaching methodologies and learning results behind a new course on philosophy of structures taught by the authors at the Universitat Politècnica de València (Spain). The course is an elective course within the fourth year of a bachelor degree in Civil Engineering and was first taught during the academic year 2013-14. Thirty-one students took the course, four of them coming from foreign countries. All the lectures were in Spanish. The paper is structured as follows: Section 2 explains the main objectives of the course, s