






Study on the Mechanical Capacity and Structural Relevance of a Flying Buttress Through the Analysis of a Particular Case

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ABSTRACT

A flying buttress serves an aesthetic purpose and two technical purposes. In particular, it helps to drain rainwater from the roof and also plays a structural role. The aesthetic and drainage functions can be determined visually and with the help of several bibliographical references. On the contrary, in order to assess the structural function a rigorous mechanical study must be carried out. Starting from the mechanical capacity of a flying buttress, this paper presents a method to determine its relevance and influence on the structural behaviour of the cathedral.

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1. Introduction

Along with the ribbed vault, the flying buttress is one of the most emblematic Gothic architectural elements. Theoretically, it fulfils three functions (Blas 2019; Tarrío 2015): a) it has an aesthetic purpose and a great visual impact on the outside of the building, b) it drains and channels rainwater from the roof owing to its location and inclination, and, c) it neutralises the horizontal thrusts from the ribbed vaults of the central nave and transmits them to the culées. Despite the above and the many scientific papers and analysis dealing with the functionality of this architectural element (Courtenay 1997; Kimpel and Suckale 1985; Llopis-Pulido et al. 2016; Roca et al. 2013), the fact is that some flying buttresses partially do not fulfil one of the above three functions.

The aesthetic features and the drainage and channeling function can be determined by referring to papers and analysis (Samper, Herrera, and Costa-Jover 2022; Samper, Martín-Sáiz, and Herrera 2022) on the shape of these architectural elements, and also by visually examining each element. However, assessing the structural function is not a straightforward task, as it requires a rigorous analysis of the mechanics involved. For this reason, the present paper will attempt to establish an objective method to determine the level of influence of a flying buttress on the overall structural behaviour of the cathedral. In other words, we aim to answer two questions: First, what is the mechanical capacity of a flying buttress?; and second, is this capacity relevant

to the overall structural behaviour in the cathedral context? To do so, the present analysis is applied to one of the flying buttresses located at the apse of Girona Cathedral due to its unique features.

The flying buttresses of Girona Cathedral are worthy of study for two reasons. First, these flying buttresses are aesthetically different from any other type of flying buttress, even those located in other cathedrals nearby which historically conditioned the construction process of Girona cathedral. For instance, the strong geographic, historical and constructive influence of Narbonne Cathedral on the architectural design of Girona Cathedral (Cassanelli 1995; Freigang 2002; Molina 2007) fades out when formally comparing both types of flying buttresses. The second reason is that, as shown in Figure 1, the flying buttresses in Girona Cathedral do not fulfil the function of draining rainwater away from the roof. Given the differences in aesthetics, the non-conformity to the usual shape and the absence of a rainwater drainage function, the authors were motivated to evaluate the purpose and structural function of this particular flying buttress.

In addition to providing an objective method for quantifying the mechanical function of a flying buttress, the aim of this paper is to analyse the specific case of a flying buttress in Girona Cathedral and to check whether its presence contributes to the transmission of thrusts from the vault; in other words, to ascertain whether and to what extent functional aspect c) is fulfilled.