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Original article

Determination of the geometric shape which best fits an architectural arch within each of the conical curve types and hyperbolic-cosine curve types: The case of Palau Güell by Antoni Gaudí

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ABSTRACT

We provide a method to objectively determine which is the geometric shape which best fits an arch of a heritage building within each of the conical curve types – ellipse, hyperbola, parabola – and hyperbolic-cosine curve types – catenary, hyperbolic cosine, Rankine –, and we also provide an objective measurement of that fit. This method does not involve mechanical, constructive or structural processes; it only involves standard geometric processes, numerical processes, computing, statistics and 3D data acquisition. Using these techniques, we generate a method, which allows an objective determination of an arch's geometry in a heritage building. For architectural and historical reasons, and also due to discrepancies regarding the arch's geometry, as an application case for this method we have chosen the arch on the façade of Palau Güell (1886–1890) in Barcelona, a heritage building designed by Antoni Gaudí.
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1. Research aims

We provide a method to objectively determine which is the geometric shape which best fits an arch of a heritage building within each of the conical curve types and hyperbolic-cosine curve types.

2. Introduction

Arches have been used in many ways and applied to different composition styles over time in architectural heritage buildings. Sometimes their geometric and constructive layout has been recorded on historical treatises or sketches, which have survived to the present day, allowing us to know the construction process used by the architect to design that structural element [1–3]. But in other cases there are no documents to objectively determine the geometry used on the arches of prominent buildings. In such cases, a – subjective and intuitive – debate is usually opened in order to define the arch geometry, leading to discrepancies or even without coming to a clear conclusion.

This paper provides a method to objectively determine which is the geometric shape, which best fits an arch of a heritage building within each of the conical curve types and hyperbolic-cosine curve types, and also provides an objective measurement of that fit. We say in advance that this method does not involve mechanical, constructive or structural processes; it only involves standard geometric processes, numerical processes, computing, statistics and 3D data acquisition.

2.1. Conceptual basis, usefulness and limitations of the method

This paper intends to put a new focus on the geometric determination of architectural arches. Our proposal is complementary to other recent papers, which are also related to this matter. Thus, for example, paper [4] from 2015 examines the catenary and parabolic curves in Gaudí's buildings. However, the authors do not provide any numerical calculations nor any geometric formulas, which are adapted to the physical reality of Gaudí's arches. On the contrary, we do provide calculation algorithms and adapted geometric formulas. Paper [5] from 2016 deals with the geometry of the Roman amphitheatre in Tarragona. Using a tachometric process, the authors of this paper obtain a cloud made up of 139 points and then find a fitting ellipse. To that effect, they first determine the 4 vertexes of the ellipse, allegedly from the cloud points. However, they do not provide any mathematical method explaining how

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