Geometry of Gaudí Arches: Why Parabolic and Catenary Shapes?

Francisco Salazar Mendoza, Braulio Bracamontes, Carlos Gámez,
Fernando Sepúlveda, and Vladik Kreinovich
Department of Computer Science, University of Texas at El Paso, 500 W. University
El Paso, Texas 79968, USA, fsalazarmendo@miners.utep.edu,
babracamonte@miners.utep.edu, cagmezhernndez@miners.utep.edu,
fasepulveda@miners.utep.edu, vladik@utep.edu

Abstract. It is known that the famous Catalan architect Antoni Gaudí had arches in many of his buildings. A recent book has shown that practically all his arches have one of the following two shapes; they are either parabolic arches, in which the y-coordinate is a quadratic function of x, or so-called catenary arches. In this paper, we provide a possible mathematical explanation of why Gaudí used only these two types of arches.

Empirical fact. It is known that the famous Catalan architect Antoni Gaudí (1852–1926) had arches in many of his buildings. A recent book [1] has shown that practically all his arches have one of the following two shapes; they are:

- either *parabolic* arches, in which the y-coordinate is a quadratic function of x; Gaudí used these arches in Nau Gaudi in Mataró, Collegi de les Tresianes, Palau Gëll, stables at the Finca Güell, and Celler Güell;
- or so-called *catenary* arches, described by the formula

$$y = c \cdot \cosh\left(\frac{x}{c}\right) = \frac{c}{2} \cdot (e^{x/c} + e^{-x/c}); \tag{1}$$

  Gaudí used these arches in Pavellons de la Finca Güell, Els Pavellons de la Finca Güell, Cas Battló, Casa Milá, and in Celler Güell.

A natural question: how can we explain why Gaudí used only these two types of arches?

There are some explanations, but the problem largely remains. One explanation provided in [1] is that the parabolic arches have limited support ability. So, from the mechanical viewpoint, when more support is needed, it is better to use catenary arches.

This explains why not all Gaudí arches are parabolic, but it does not explain why namely catenary arches are used – since other shapes could also provide additional stability.

What we do in this talk. In this talk, we provide a possible explanation of why these two types of arches were selected.

Our main idea. Our main idea is to take into account that all arch forms are smooth, so the corresponding equations can be described by Taylor series $y = a_0 + a_1 \cdot x + a_2 \cdot x^2 + \ldots + a_n \cdot x^n + \ldots$

References

[1] C. Alsina and R. B. Nelsen, *The Genius of Gaudí: Geometry and Architecture*, Mathematical Association of America (MAA) Press, an Imprint of the American Mathematical Society (AMS), Providence, Rhode Island, 2025.