



The parabola of the parabolic arch

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Summary

Parabolic shapes did not enjoy a place in architectural history until the late 19th century, when they were extensively used by Antoni Gaudí. The influence of Gaudí, together with the Rationalist theories of Viollet-le-Duc, can be traced first in the continuing attempts to evolve a new form of Gothic architecture, where the parabolic arch played a central role. Later engineer-architects, including Pier Luigi Nervi, Felix Candela, and Santiago Calatrava, attached a symbolic meaning to parabolic structures as the realization of the rational architecture sought after by Viollet-le-Duc, continuing the legacy of Gaudí's revolutionary work.

Keywords: parabolic arch; Viollet-le-Duc; Antoni Gaudí; Pier Luigi Nervi; Felix Candela; Santiago Calatrava.

Introduction

This paper investigates how the parabola became part of the language of modern architecture, by tracing its engineering use and the symbolic meaning attached to this structural form. It shows how the parabola is part of the realization of ideas, formulated over a century ago, about the creation of an architecture expressive of the modern age, which are still permeating the way architects and engineers talk about their approach to structural design.

Parabolic arches made their debut in bridge design only as late as the 1870s with Gustave Eiffel's bridge on the Douro, Portugal, 1875-77, followed by the Garabit bridge in France, 1880-84. Concrete parabolic arch bridges were designed in Switzerland in the early 20th century by Robert Maillart, Emil Morsch, and Eduard Züblin. However it was hard for the parabolic shape to gain acceptance, even in bridge design, because of its unconventional aesthetics in the context of an architectural culture still heavily influenced by the Beaux Arts school.

1. Rationalism, Gothic and the parabola



The first appearance of the parabolic arch in architecture is in the Palau Güell (1885-89), by Antoni Gaudí (Fig. 1), and in the completion of the Sagrada Família, Barcelona. Gaudí associated the parabola with natural, organic forms, and this is best expressed in the rustic masonry vaults of Parc Güell, begun in 1900. Gaudí combined a rationalist methodology with a deep religiosity, which made him see the structures of nature as a direct reflection of the divine mind. The parabola, in particular, because of its elegant structural efficiency, became an emblem for the sacred.

The Sagrada Família was based on 13th and 14th century Gothic prototypes, and Gaudí followed an ambition of evolving a Catalan architectural style based on a rational evolution of the Gothic. In this respect he was influenced, as many architects in the 1880s, by the theories of the French architect Eugène-Emmanuel Viollet-le-Duc, for whom French Gothic architecture of the 13th century contained the principles that

Fig. 1: Palau Güell, Barcelona, Spain, 1889. Antoni Gaudí.

could lead to a new architecture expressive of the industrial age. The association of the parabola with Gothic and national traditions led to the widespread use in Germany and Holland of parabolic arches and vaults in churches and civic halls built during the first decades of the 20th century [1].

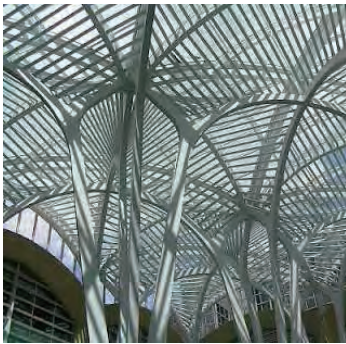
2. The rise of the Modern Gothic

The permanence of Viollet-le-Duc's rationalism in modern architecture is most evident in the work of 20th century architect-engineers, such as Pier Luigi Nervi, the Italian engineer who became famous for his airplane hangar designs of the 1930s. In 1955 Nervi wrote that by "building structural organisms shaped by laws of statics" we could "return toward an architectural truth [2]." The realization of these principles can be found already in the Orbetello and Orvieto hangars of 1935-41. The concrete ribs, supported by parabolic arches, form a diagrid called "geodesic" by Nervi, and appear as Gothic arches when intersecting at the corners.



The use of the parabola as a "natural" form, which makes also reference to Gothic architecture, connects Gaudí, Felix Candela, and Santiago Calatrava, all born and trained in Spain. Candela's church of the Medalla Milagrosa, built between 1953 and 1955, in Navarte, Mexico City (Fig. 2), has been compared to the work of Antonio Gaudí. The idea for this church came to Candela from a French engineering text, where he saw a structure formed by four paraboloids. In these he saw "an ascending tendency which is really Gothic and it is what is esteemed as Western religious architecture [3]."

The echo of these ideas can be found today in Santiago Calatrava's preference for the parabola as a form associated with an organic idea. Calatrava made a conscious connection with Gaudí's Sagrada Família in the competition for the Cathedral of St. John the Divine, New York, 1991. In discussing his design process, Calatrava claims to strive for an architecture "in which the whole structure and shape is the result of the pure expression of the material needs of construction," admitting however that "my approach to certain formal aspects may even recall my icons of architecture, like Gaudí [4]."



The organic quality which is common in the inspirational sources of the work of Calatrava, Candela and Gaudí is an additional link to the functionalism of Viollet-le-Duc, who explored the analogy between natural organisms and structural systems. We can recognize in several works, such as the BCE Place (Fig. 3), Toronto, and the Oriente Station, Lisbon, Portugal, the expression of organic form together with an abstract symbolic verticality. The BCE Place and the Oriente Station structures are tree metaphors, which suggest a reinterpretation of the tracery of the Gothic stone skeleton.

Fig. 2: Church of the Medalla Milagrosa, Navarte, Mexico City, 1953-1955. Felix Candela

Fig. 3: BCE Place, Toronto, Canada, 1987-1992. Santiago Calatrava

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