

Invited Paper

Structural Design in the Work of Gaudí

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Abstract: The work of Gaudí embraces all the facets of architectural design. The present paper studies the analysis and design of masonry arches, vaults and buildings. It is well known that Gaudí used hanging models and graphical methods as design tools. These methods can be traced back to the end of the 17th Century. In addition, it was not original the use of equilibrated, catenarian forms. What was completely original was the idea of basing all the structural design in considerations of equilibrium. Gaudí also employed unusual geometrical forms for some of his vaults and ruled surfaces, showing a deep structural insight. Finally, he designed tree-forms of equilibrium for the supports of the vaults in the Sagrada Família. In the present paper Gaudí's equilibrium methods are studied with some detail, stressing their validity within the frame of Limit Analysis.

Keywords: Structural design; Gaudí; Masonry arches; Vaults; Catenarian forms; Equilibrium methods; Limit analysis

Introduction

Antoni Gaudí (1852–1926) was a Master Builder. His work covers all aspects of architecture: layout, ornamentation and stability. He also incorporates other arts: sculpture (particularly), painting, and photography. Any study of Gaudí's work must embrace this global concept of the project. This article considers only one of the aspects of Gaudí's work: the design and calculation of structures. For Gaudí, structural design was an integral part of architectural design from its initial stages. It was not restricted, as was the usual case in those days, to a mere stability check. This paper will go through the different structural elements, studying the detail of Gaudí's design and calculation process and attempt to place his activity in a historical context.

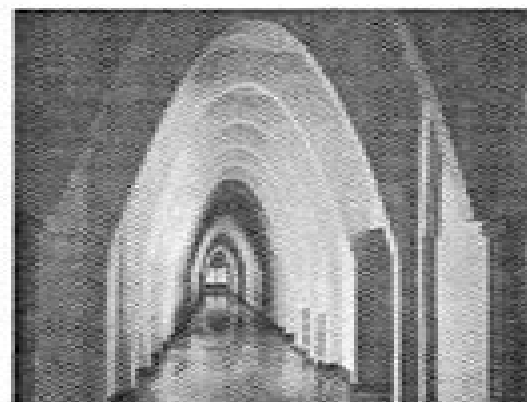
Catenary Arches

From his first projects, Gaudí showed his originality and independence. In particular, he began to use systematically a type of arch not common in the western architectural tradition. Instead of using arches with a shape derived from

the circle (roman, pointed, basket-handle, etc.), he used arches with non-circular shapes: parabolic or "catenary." These arches are already present in Gaudí's first buildings, seen in Figures 1 and 2.



(a)



(b)

Figure 1. Catenary arches: (a) Entrance to the Palaciu Güell (Rafel 1929); (b) corridor in the School of the Teresianas (Tarragó 1991).

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reached its centennial anniversary the NBS NIST reflects on and celebrates its first century with this book describing some of its seminal contributions to science and technology Within these pages are 102 vignettes that describe some of the Institute's classic publications Each vignette relates the context in which the publication appeared its impact on science technology and the general public and brief details about the lives and work of the authors The groundbreaking works depicted include A breakthrough paper on laser cooling of atoms below the Doppler limit which led to the award of the 1997 Nobel Prize for Physics to William D Phillips The official report on the development of the radio proximity fuse one of the most important new weapons of World War II The 1932 paper reporting the discovery of deuterium in experiments that led to Harold Urey's 1934 Nobel Prize for Chemistry A review of the development of the SEAC the first digital computer to employ stored programs and the first to process images in digital form The first paper demonstrating that parity is not conserved in nuclear physics a result that shattered a fundamental concept of theoretical physics and led to a Nobel Prize for T D Lee and C Y Yang Observation of Bose Einstein Condensation in a Dilute Atomic Vapor a 1995 paper that has already opened vast new areas of research A landmark contribution to the field of protein crystallography by Wlodawer and coworkers on the use of joint x ray and neutron diffraction to determine the structure of proteins

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Safety at Natural-gasoline Plants G. B. Shea, 1929

Human-Computer Interaction. Multimodal and Natural Interaction Masaaki Kurosu, 2020-07-10 The three volume set LNCS 12181 12182 and 12183 constitutes the refereed proceedings of the Human Computer Interaction thematic area of the 22nd International Conference on Human Computer Interaction HCII 2020 which took place in Copenhagen Denmark in July 2020 A total of 1439 papers and 238 posters have been accepted for publication in the HCII 2020 proceedings from a total of 6326 submissions The 145 papers included in these HCI 2020 proceedings were organized in topical sections as follows Part I design theory methods and practice in HCI understanding users usability user experience and quality and images visualization and aesthetics in HCI Part II gesture based interaction speech voice conversation and emotions multimodal interaction and human robot interaction Part III HCI for well being and Eudaimonia

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Life-Cycle of Structures and Infrastructure Systems Fabio Biondini, Dan M. Frangopol, 2023-06-28 Life Cycle of Structures and Infrastructure Systems collects the lectures and papers presented at IALCCE 2023 The Eighth International Symposium on Life Cycle Civil Engineering held at Politecnico di Milano Milan Italy 26 July 2023 This Open Access Book contains the full papers of 514 contributions including the Fazlur R Khan Plenary Lecture nine Keynote Lectures and 504 technical papers from 45 countries The papers cover recent advances and cutting edge research in the field of life cycle civil engineering including emerging concepts and innovative applications related to life cycle design assessment inspection monitoring repair maintenance rehabilitation and management of structures and infrastructure systems under uncertainty Major topics covered include life cycle safety reliability risk resilience and sustainability life cycle damaging processes life cycle design and assessment life cycle inspection and monitoring life cycle maintenance and management life cycle performance of special structures life cycle cost of structures and infrastructure systems and life cycle oriented computational tools among others This Open Access Book provides an up to date overview of the field of life cycle civil engineering and significant contributions to the process of making more rational decisions to mitigate the life cycle risk and improve the life cycle reliability resilience and sustainability of structures and infrastructure systems exposed to multiple natural and human made hazards in a changing climate It will serve as a valuable reference to all concerned with life cycle of civil engineering systems including students researchers practitioners consultants contractors decision makers and representatives of managing bodies and public authorities from all branches of civil engineering

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