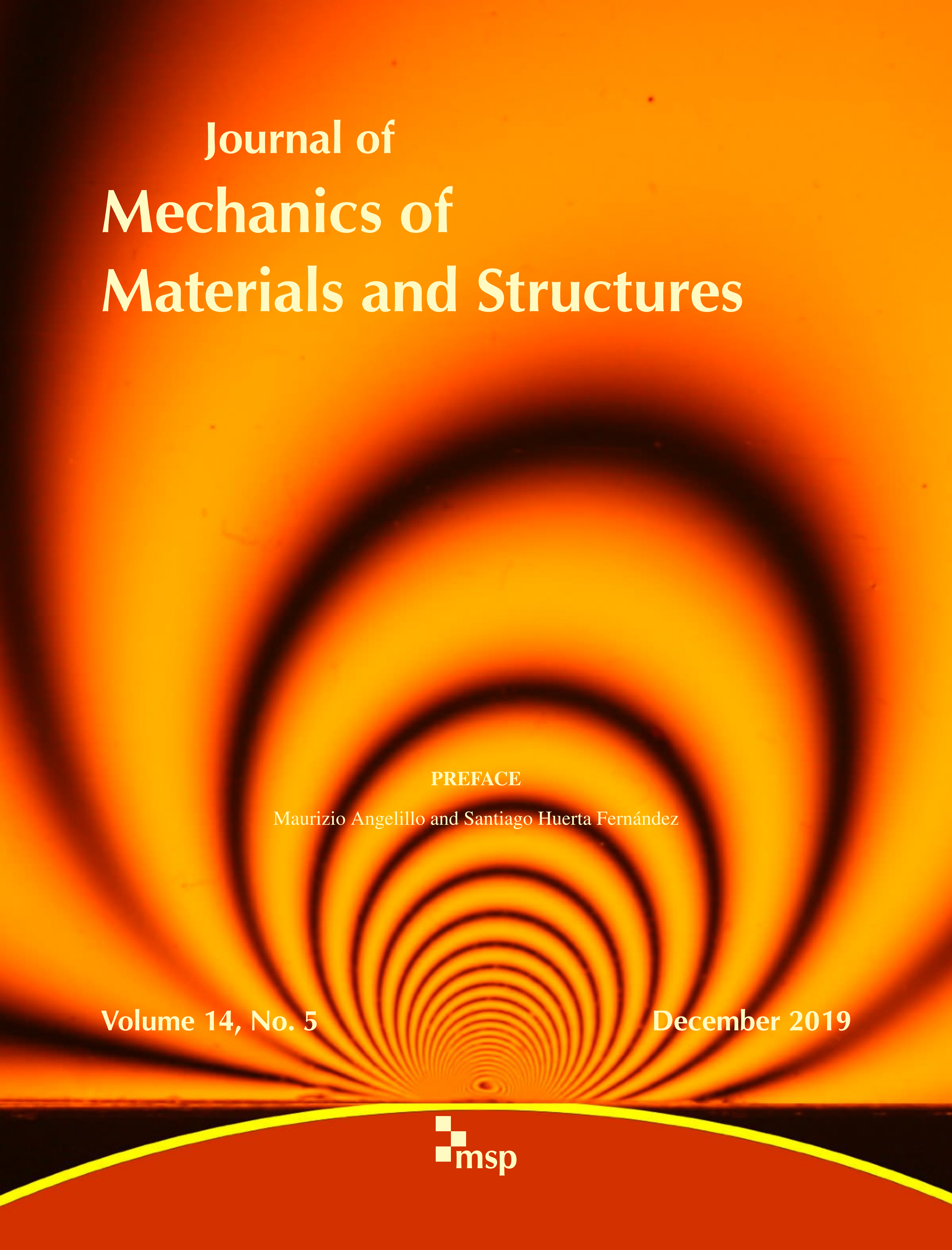

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PREFACE

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PREFACE

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The theory of arches and masonry vaults originated at the end of the seventeenth century: Robert Hooke had the brilliant intuition to analyse arches as inverted hanging chains and this allowed the analysis to be incorporated within the science of statics. In France, La Hire published at the beginning of the eighteenth century the first article on the collapse of arches, intending to calculate their thrust. Both the equilibrium and collapse approaches were developed further during the eighteenth century. Since the beginning of the nineteenthth century, large masonry bridges have been calculated almost routinely using either of the two approaches. In the middle of that century, the diffusion of the concept of lines of thrust was a crucial step in advancing the analysis of arches and masonry vaults, as it allowed one to understand both collapse and equilibrium.

However, this coincided with a pronounced decline in the interest in the theory of masonry construction. The second half of the nineteenthth century concentrated on the development of elastic theory, which is more suited to wrought iron and steel structures. The notion took hold that masonry arches, too, should be calculated as an elastic continuum, contradicting both common sense (masonry is essentially discrete at the macroscale) and the observed collapse of arches. This was a huge step backwards in the understanding of arches and vaults; however, from a practical point of view, engineers and architects continued to use equilibrium graphical methods.

By 1900 the theory of masonry structures had stagnated and articles on masonry structures practically disappeared from specialized journals. The so-called Modern Architecture of Bauhaus dramatically broke with the millenary tradition of vaulted construction: arches and vaults were considered old-fashioned and largely disappeared from architecture (though they were still being built; traditions do not die suddenly). Towards the 1930s the increase in the weight of road vehicles made it necessary to reconsider the safety of many old masonry bridges. Nineteenthth-century tests on voussoir arches were repeated and it was noted that the appearance of cracks substantially modified the results of elastic analysis. In the 1960s photoelastic methods and, above all, the appearance of computers, which could handle linear elastic equations easily, revived interest in the use of elastic models of masonry structures, ignoring the evidence of century-old voussoir arch tests and the cracked state of actual masonry structures.

It was within this confusing framework that the figure of Professor Jacques Heyman of Cambridge emerged, almost miraculously. Having contributed decisively to the final development of the plastic calculation of steel frames within Baker's Cambridge team, he realised that the whole field of masonry structures could be included within the wider field of limit analysis if the material met certain conditions: high compressive strength, no tensile strength and a construction which precludes sliding. Precisely these conditions were the hypotheses used in the calculation of masonry arches throughout the nineteenth

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century. In his paper “The stone skeleton”, published in 1966, Professor Heyman took this crucial step, rigorously explaining the theory and applying it to the Gothic structure. In the following five decades he has continued to improve the understanding of masonry construction, combining popularization with specialized articles on the most important structural types such as bridge arches, cross and fan vaults, domes, towers and spires, rose windows, and stairs, not only explaining their structural behaviour, but also giving, for the first time, a rational interpretation of their cracks and movements, inherent in this type of constructions.

It would be difficult to imagine the current field of masonry structures without Professor Heyman’s seminal contributions. It was he who first realized that the main corollary of the Safe Theorem is the equilibrium approach. Indeed, far from having to make adventurous hypotheses about boundary conditions (essentially ephemeral), Professor Heyman has shown that masonry buildings can be analysed simply by looking for that equilibrium solution, among the infinitely many possible, that respects the compressive nature of the material — its yield condition.

Thus, after 100 years it turns out that the so-called old theory of vaults, used throughout the nineteenth century, was proved to be valid within the more general framework of modern limit analysis. This explains why the calculations made by nineteenth-century engineers on large masonry bridges were essentially correct. So too were equilibrium analyses on masonry vaulted buildings carried out by some architects and engineers in the late nineteenthth and early twentiethth centuries (Planat, Wittmann, Mohrmann). Finally, Gaudí’s genius led him to use the equilibrium approach to generate his complex structures using funicular models.

The work by Professor Heyman over the last fifty years allows us not only to analyse masonry structures, but also to understand the complete framework of the evolution of these constructions that go back more than 6000 years in the Near East. Certainly, as he pointed out, limit analysis leads to geometric statements: the safety of a masonry structure depends essentially on its shape, regardless of size. The old structural rules that have come down to us are indeed geometric, and collect and synthesize the critical experience of the great master builders.

We want this issue of the *Journal of Mechanics of Materials and Structures* to stand in recognition and tribute to the work of Professor Jacques Heyman, which has helped and continues to help us understand masonry structures, illuminating this wide structural field that forms the core of our monumental heritage.

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