Jacques Heyman

ROYAL ACADEMY OF ENGINEERING

From plastic theory to magnificent cathedrals, Jacques Heyman has had a long and varied career. **Helena Russell** maps the highlights.

CAREER MILESTONES

1941	Began reading maths at University of Cambridge
1942	Switched to engineering
1944	Graduated from Cambridge Joined Shell to work on jet engines
1946	Returned to Cambridge as research assistant to John Baker
1949	Gained PhD and went to Brown University in USA for postdoctoral study
1955	Elected to fellowship at Peterhouse, Cambridge
1956	Volume 2 of Baker's book, *The Steel Skeleton*, published, with Heyman and Michael Horne as co-authors
1966	'The Stone Skeleton' article published
1971	Appointed professor of engineering at Cambridge
1983	Appointed head of engineering department at Cambridge
1992	Retired
1995	*The Stone Skeleton* published
2022	Awarded Sir Frank Whittle Medal by Royal Academy of Engineering
2026	Second edition of *The Stone Skeleton* published

Reaching a century is always cause for celebration; to still be publishing books at such an age is surely rare, and something few would contemplate. Not so Jacques Heyman, whose classic text on the structural engineering of masonry, *The Stone Skeleton*, has just been revised and published in a second edition (see **page 33** for Helen Rogers' review).

Heyman, who celebrated his 100th birthday last year, admits that he had to be persuaded a new edition was necessary, and reveals that his eldest daughter played a major role in the process. 'My feeling was that I'd done with all that,' he says, 'but she is a powerful woman and generally I do what she says!'

Despite his light-hearted take, the latest edition of Heyman's book has serious intent. In their foreword to the second edition, Madrid Polytechnic University's Professor Santiago Huerta and Professor John Ochsendorf of Massachusetts Institute of Technology state that today the book is 'more necessary than ever' due to the increasing reliance on the numerical capabilities of computers and the potential misunderstanding of a masonry structure's true state that can arise from this.

'If a structure has stood for centuries, and an engineer claims that the structure is no longer safe, this book provides a path for checking the claim,' says the foreword. It can also be used to challenge 'expensive and damaging interventions' that may be proposed because of misconceptions about how masonry structures work.

What's more, the continued relevance of Heyman's work is demonstrated by references such as the case study on thrust-line masonry design for the towers on Barcelona's Sagrada Família, published in *The Structural Engineer* in March 2026.

Acknowledged as one of the world's leading experts in cathedral and church engineering, Heyman spent a great deal of his professional life studying masonry structures, working on high-profile restoration projects at Ely Cathedral and Westminster Abbey, among others, while a professor at Cambridge University. But he did not come to the subject until he was well established in his career, having focused on steel design and the plastic theory in the early days.

Engineering: a practical necessity

Heyman got off to a flying start as a young man, showing a talent for mathematics and being fast-tracked through school in south London two years ahead of his cohort. He started in the sixth form aged 13 and two years later had passed his Higher School Certificate and was being prepared for the Oxbridge entrance exams.

Mathematics was a natural choice for him, he says, being the subject in which he demonstrated the greatest ability. He did not do well enough in the entrance exam to get a scholarship to King's College, but was accepted into Peterhouse at the start of 1942 after his father intervened on his behalf.

Heyman's age worked in his favour, as he was too young to be conscripted and was allowed to continue his studies while others were called up to fight. He was even elected as President of the Junior Common Room by dint of being the only candidate of his cohort still in the college.

But although maths was his strongest subject, he soon realised he could not make a career in it. 'I was not good enough to be a mathematician,' he says, 'and so I changed to engineering.' The move was also the result of pressure from his father, who wanted him to pursue a more practical profession. At the time, it was known as the Mechanical Sciences Tripos; students received a general engineering education with the opportunity to specialise in the third year.

WWII was still raging when Heyman graduated in 1944, but now it was his engineering expertise that saved him from being called up – he was recruited to work for Shell on jet engine design. He had some knowledge of German – his Romanian father being multilingual – and this was also put to good use in translating documents.

Steel and plastic theory

After the war, Heyman returned to Cambridge to do a doctorate under John Baker, who had been appointed head of the engineering department in 1943 and was in the process of transforming it.

Baker was not only a reforming force in the educational sphere, he was also seeking to develop plastic theory and its application to structural engineering. A lot of steel-framed buildings were being erected and, for the first time, stresses were being measured on site. They bore little resemblance to those predicted by the calculation methods accepted at the time, and on which the designs were based. Baker wanted to develop a code of practice that established the role and application of plastic theory in this field, and Heyman found himself in the thick of it.

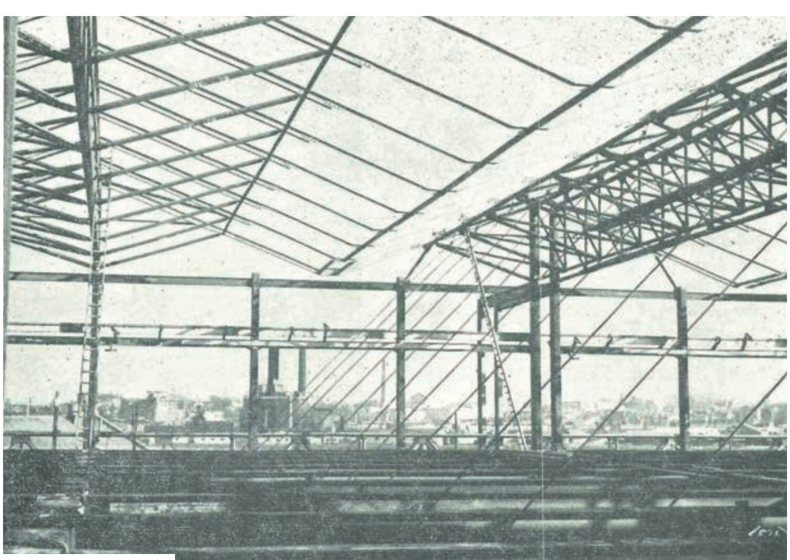
Heyman's familiarity with the emerging theories led Baker to employ him as a tutor, to teach other engineers about plastic analysis on a new, nine-month course. This was done on the proviso that Heyman spend each summer working in industry to gain practical knowledge.

During this time, he was employed by consulting firm Scott & Wilson on the design of a steel warehouse at Southampton Docks. The structure – Shed 102 – was built as a terminal for cruise passengers arriving at the docks by train, and Scott & Wilson wanted to proportion the girders using the new plastic theory. By his third summer, Heyman was working as a junior site engineer, and the experience he gained enabled him to subsequently become a chartered engineer.

Construction of Shed 102 **(Figure 1)** was completed while Heyman was in Southampton. It was the first plastic design of such heavy steelwork, and the main members were proof tested by applying the full design loads. Around 390t of scrap steel was used in the procedure, being hung from the girders in cradles.

The knowledge Heyman had gained put him in pole position when Baker was seeking assistance with a new book on steel structures. Although Baker had taken sabbatical leave to write *The Steel Skeleton*, he had only managed to complete the first volume covering elastic behaviour and design, and needed assistance to draft the second volume on plastic behaviour. Heyman and fellow academic Michael Horne, who became IStructE president in 1980, collaborated on the second volume, which was published in 1956; the following year Heyman published his first book on how to use plastic theory to design simple factory buildings.

a) Plastically designed girders for first-floor level



b) Main roof steelwork

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FIGURE 1: Shed 102 – a warehouse at Southampton Docks – was an early introduction to plastic design of heavy steelwork for Heyman

Masonry and cathedrals

The origin of his subsequent segue into masonry is less clear, even to Heyman himself. 'Why masonry? I have thought very hard about it, but I can't recall why I initially considered applying plastic theory to masonry,' Heyman says. 'Brown University [in the USA where Heyman had spent some time] had already done work on it, but I really don't know why I chose to pursue it.'

His first challenge was to find out about masonry structures and their design, and in the 1960s this meant detailed research in the library. 'I found it very difficult to make a start,' he recalls. 'The year 1964 was well before the days of Google, and I was not used to the mechanics of library searches. It took a long time, but eventually I found a book by John Fitchen: *The construction of Gothic cathedrals*. The book … has over 300 pages with lavish illustrations, and is a work of major scholarship,' Heyman says.

In 1966 Heyman's first paper on the action of structural masonry was published – unashamedly picking up Baker's lead with his title, 'The Stone Skeleton', and bringing together his knowledge of plastic theory with his research into masonry construction.

'The paper gave a broad, and necessarily shallow, view of, for example, Gothic quadripartite vaults and flying buttresses, Byzantine domes, and the overall structural action of a great cathedral,' explains Heyman in his 2014 'technical autobiography' *Skeletons*, which is published on the IStructE website (https://bit.ly/skeletons-heyman).

'General principles were also flamboyantly stated – that the cracked state is in fact the natural state of masonry, and that cracks indicate merely that the building has acted in a way to find a comfortable state in response to small unpredictable movements imposed by the environment.'

Within a few years of the article's publication, Heyman found his advice being sought by Donovan Purcell, the Surveyor to the Fabric of Ely Cathedral, who had seen Heyman's articles and wanted engineering input for a crucial project to repair and restore the cathedral's great West Tower **(Figure 2)**.

Somewhat daunted by the prospect of being considered an expert, Heyman nevertheless found a way to pursue the opportunity. 'I knew nothing about masonry. I had done some mathematics to establish a basis for understanding the action of stone blocks piled on each other, and I had become interested in the history of the engineering analysis of this action,' he says. 'If I were to act, effectively, as the engineer in charge of a major restoration, I did not have the staff and office capacity to provide surveys, drawings, reports and so on.' Fortunately, he had kept in touch with RT James & Partners, the engineering firm that he had worked with on the Baker Building at Cambridge University, and he brought them on board for the project.

Heyman recalls the weekly visits he made to the cathedral during the two-year project, and how he disliked the journey across the Fens during the exceptionally cold winters. 'My spirits recovered at about halfway, when the cathedral could be seen in the distance, and I realised that the tower was still standing,' he says. 'I had not yet grasped fully the implications of my theoretical work; my trivial interventions into the fabric of the tower could never compromise the essential stability of the whole construction.'

His work at Ely, and introduction to the Cathedral Architects Association, was the launchpad for his involvement in 'about a dozen cathedrals and perhaps 50 churches' over the subsequent 40 years. 'Because of my obsession with the safe theorem, whose fundamental conclusion is to leave well alone, my interventions were usually on a small scale, and my advice was often, acceptably, to do nothing,' he says.

One of the most high-profile establishments that Heyman served was Westminster Abbey, in the first instance being commissioned to report on the condition of the remaining medieval roofs, and propose how they should be made safe. He assisted with a major restoration of the Henry VII Chapel **(Figure 3)**, where he had ample opportunity to study and analyse masonry construction, and his wider work led to a detailed examination of the structural behaviour of architectural features such as fan vaults, rose windows and cantilevered staircases. These and the other findings he made in the course of his work are the core around which *The Stone Skeleton* is built.

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FIGURE 2: Heyman's developing expertise in structural masonry led to work on many cathedrals, beginning with restoration of the West Tower at Ely Cathedral (pictured, left)

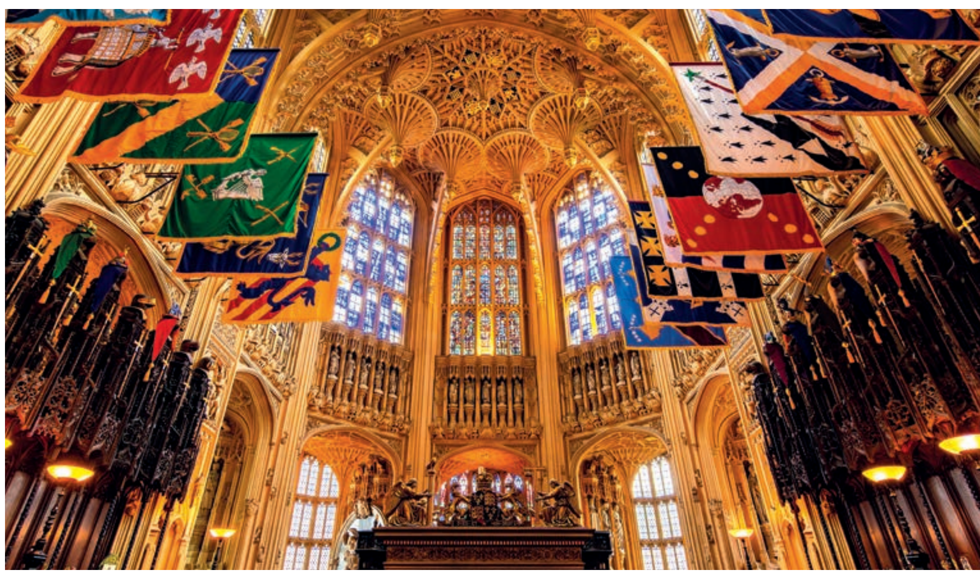

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FIGURE 3: Heyman's involvement with Westminster Abbey included restoration of the Henry VII chapel, which allowed further opportunity to study and analyse masonry construction

International renown

Heyman remained at Cambridge University for the rest of his career, becoming head of the engineering department 'by accident' in 1983. It was not exactly an accident, given that he was one of the two final candidates, but the post was recruited from the existing pool of professors, so he was automatically in the running. The recruitment committee chose the younger candidate, a decision that Heyman supported; ironically, the unfortunate head died within two months and Heyman was elected by default, to a post he held for nine years.

His international renown as a masonry expert was boosted by a chance meeting with Spanish architect Santiago Huerta, who had read his work and proposed to translate 28 of Heyman's papers into Spanish and publish them as a single book. Huerta set about the monumental task with great energy and *Estructuras de fábrica* appeared in print in 1995, a year before the English version, *Arches, vaults and buttresses*. The Spanish work became a two-volume publication after a further 27 papers were translated, and Huerta has also translated half a dozen of Heyman's books, all of which outsold the English editions.