

The Forth Bridge's Human Cantilever: Engineering, Photography and Representation

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Abstract: During the Victorian Age, when the results of ambitious engineering radically transformed the principles of construction, photography proved to be a faithful and indispensable witness. This is plainly seen in the magnificent enterprise to build the railway bridge over the Forth River, accurately captured by the lens of the photographer and engineer Evelyn George Carey, whose excellent work to record those events is without equal. His almost daily annotations were free from symbolic meaning and monumental tendencies: it was the bridge itself that held the most important role. In the form of an experiment it was decided to illustrate the principle of the cantilever at the Royal Institution in 1887. It was during that particular circumstance that Carey produced the famous photographic image of the Human Cantilever. Carey presents to the observer an encyclopaedic array of representations and helps to truly visualise engineering.

Key words: Bridge engineering, cantilever technology, photography, nineteenth century architecture.

1. Introduction

The railway bridge that crosses the estuary of the Forth River in Scotland is considered to be one of the masterpieces of nineteenth century engineering, the largest ever built and the first to have a superstructure made of steel: one of its two designers, Benjamin Baker, defined it “a romantic chapter from a fairy tale of science” [1].

During the Victorian Age, the rules of the past for the art of construction were broken by the bold inventions of famous engineers the likes of Joseph Paxton, Isambard Kingdom Brunel, Robert Stephenson, John Fowler, and Gustave Eiffel, although they seemed to be unaware of the consequence of their proposals, nor did they seem to be at all anxious to change the shape of the outside world. Theirs was a light and aerial vision of the structures they built, and with great intuition they chose photography as a faithful witness to this radical transformation. The invention of photography had played an essential role in the field of

engineering, suggesting a new way of exploiting the constructed object: the photographic image had become the medium between reality and image, establishing new relations and creating further possibilities for a reading of the structure and for its “scientific” interpretation. As the engineer and architecture historian Sigfried Giedion once said: “Only photographs remain as witness that the overcoming of gravity in apparently floating constructions was achieved in magnificent form during the nineteenth century” [2].

No wonder, then, that all the stages in the building of the Forth Bridge were observed through numerous photographic sessions, which were to become one of the most exciting collections of images in the history of photography.

2. An Engineer Photographer

The official photographer at the Forth Bridge building site was the engineer Evelyn George Carey, who was also an assistant engineer on the project. Only rarely do photographers fully and from a professional point of view understand the buildings they take pictures of, and the aims of their creators the way Carey

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did. Carey's goal was to record as accurately as possible and on glass negatives the progress of construction as the railway bridge rose above the firth of Forth, and to do this with technical know-how and painstaking precision. Despite the considerable efforts required to handle his cumbersome camera equipment as he moved about the caissons and the maze of unfinished steel beams, Carey succeeded in recording the passing of time in a story told through images at an engaging pace, and with a vision that was crystal-clear and perfectly in focus. Plainly expressing through his art what modern industrial civilization was capable of achieving, the photographer did not just reveal the widespread fascination with the new steel technology, but he also chose to photograph the men who laboured at the site, his analysis an intense and original one, which seemed to penetrate the human side of the day-to-day events he witnessed. For Carey's camera lens, the bridge played a dual role: it was both a monument under construction and a workplace. Carey's series of photos for the Forth Bridge (Fig. 1) was one of the first critical and historiographical assessments by an engineer photographer, and it was

widely acclaimed; the photos provided an accurate recording of this notable happening, from the inauguration of the site, to the laying of the three large columns; from the first images of the small island of Inchgarvie located in the middle of the river and used as a foundation for one of the imposing cantilevers, to the work carried out to complete the railroad track crossing the bridge. What especially stood out in some of the photos was the metal framework itself, whether it was the large steel tubes riveted and then carefully checked over in the workshop, or the trusses that were employed in the laying of the foundations; still today, the memory of the photo lens conveys an extraordinary message, telling the story about a project based on willpower and commitment, and progress at the height of its creative expression. While the bridge was being built, between 1883 and 1890, there was bitter controversy within the scientific community, resulting from the anxiety that continued to linger long after the collapse of the Tay Bridge. The memory of the 75 victims of the disaster that had taken place in 1879 while the train was crossing the bridge was still a very vivid one. For this reason Fowler and Baker took



Fig. 1 Evelyn George Carey, Forth Bridge nearly completed from the Hawes Pier on 15 April 1889 (*National Archives Scotland—Neg.n.323*).

numerous precautions, applying rules for safety that were so restrictive that their project appeared to be risk-free. This bridge, assured the engineer Wilhelm Westhofen, supervisor of the project and author of the first important book on Forth Bridge, would “by its freedom from vibration gain the confidence of the public, and enjoy the reputation of being not only the biggest and the strongest, but also the stiffest bridge in the world” [3].

The public watched in amazement as, from 1882, tremendous quantities of materials began to arrive by sea and rail on both shores of the Forth River. The building sites stretched out into the sea-side towns, bringing with them their gigantic masonry pillars to support the railway viaduct, so gigantic that houses and ships and people suddenly appeared to be catapulted into the Lilliputian dimensions narrated by Jonathan Swift. Surprisingly, the bridge was actually built twice: each section of the structure was assembled on land and then dismantled before being moved out to the bridge site for its final assembly.

Carey's photography was particularly extraordinary when combined with Westhofen's book entitled *The Forth Bridge*, published in 1890 on the occasion of the project's completion [4]. The author could still remember the noise of the steel hitting the steel, of hammers, riveters, hydraulic spades and generators; he could recall the men working on the shores, and the makeshift workshops. The book included the vastest and most detailed account of all of the stages in the construction of the bridge, alongside photos that had been taken with great care and printed with what at that time was a new technique in photography, the gelatin-silver process; the book proved to be successful with its readers, particularly when the images were accompanied by Westhofen's narrative.

3. Critics and Engineering Challenges

Never before, in all of the United Kingdom, had there been so much faith in engineering. A whole generation of engineers would learn from the

experience of its predecessors, and create a style that would soon claim to offer universal solutions. Fowler and Baker's solutions indeed ended up changing the physiognomy of nearly everything that was going on in engineering during those years: design and era were entwined. Despite this, within a few years, the bridge became the target of critics and experts who vehemently found fault with the idea of accepting “the aesthetics of a work of engineering with the absence of all ornament” [3]. Amongst those who energetically refused the solutions that the construction of the bridge proposed were John Ruskin and William Morris, the latter of whom, during the annual meeting of the National Association for the Advancement of Art and its Application to Industry held in Edinburgh in 1889, indicated the Forth Bridge, at that time nearly complete, as being “that supreme expression of ugliness” [5]. Morris' point of view was, of course, not shared by Underwood and Underwood, the famous international company that published stereoscopic views, and that at the end of the nineteenth century, in one of the most famous 3D views of Scotland, produced the image whose caption read “Scotland's Pride—the great Forth Bridge and the Highland Kilt.” This celebration of the national costume alongside a modern symbol for the Scottish landscape ultimately determined the inspiring role played by Fowler and Baker's impressive structure. The Forth Bridge likewise attracted the interest of the art historian Kenneth Clark. In *Civilisation*, published in 1969, the scholar declared that the bridge was the most imposing construction to stem from the skill of two designers who had renewed the Gothic experience in building” [6]. Curiously, a panoramic view from the top of a beam, boldly realized in the sixties by the architecture photographer Eric de Maré, was chosen for the back cover of the book. The artist de Maré's creative research, which was characterized by shots from a strong perspective often interpreting the bridge as a game of geometrical shapes, recalled the dynamics of Carey's own technique.

4. The Human Cantilever

The issue at the heart of nineteenth-century debate, which was a seeking out of new forms of architecture that could form an alliance between scientific progress and art and, as a result, the resources for alternatives to the traditional canons of aesthetics, perceived the poetics of iron as the best opportunity to express a new concept of formal beauty. This way of thinking was perhaps more accurately expressed in the comparative wall diagram drawn by Professor Charles Robert Cockerell for the South Kensington Museum, where the outline of a cantilever from the Forth Bridge was compared with works like the Great Pyramid of Giza, the Pantheon and the Basilica of Saint Peter in Rome, the Leaning Tower of Pisa, Saint Paul's Cathedral in London and the Central Transept at Crystal Palace. Carey's decision to photograph this lecture diagram

was seen as something quite unique and it became the object of the curiosity and interest of the halls of academia. A similar study, in the form of an experiment, was conducted by Baker when he decided to illustrate the principle of the cantilever while giving a talk at the Royal Institution in 1887. It was during that particular circumstance that Carey produced the famous photographic image of the Human Cantilever (Fig. 2).

The "Chambers's Journal of Popular Literature, Science and Art" (1 September 1888) published the following description of the living model: "Two men sitting on chairs extend their arms and support the same by grasping sticks which are butted against the chairs. There are thus two complete piers, as represented in the outline drawing above their heads. The centre girder is represented by a stick suspended or slung from the two inner hands of the men, while the anchorage provided

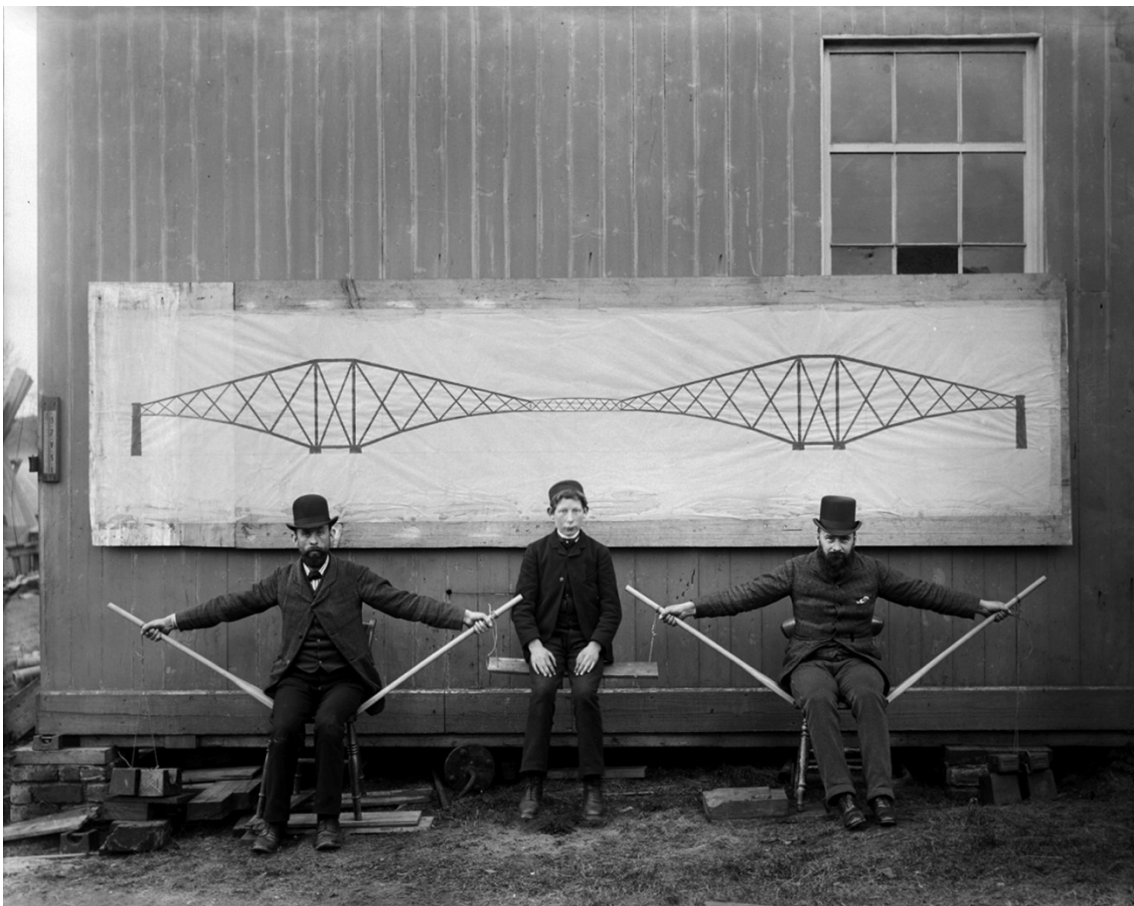


Fig. 2 Evelyn George Carey, Forth Bridge Human Cantilever "Youth on swing between two man"—1887c (*National Archives Scotland*—Neg.n.171).

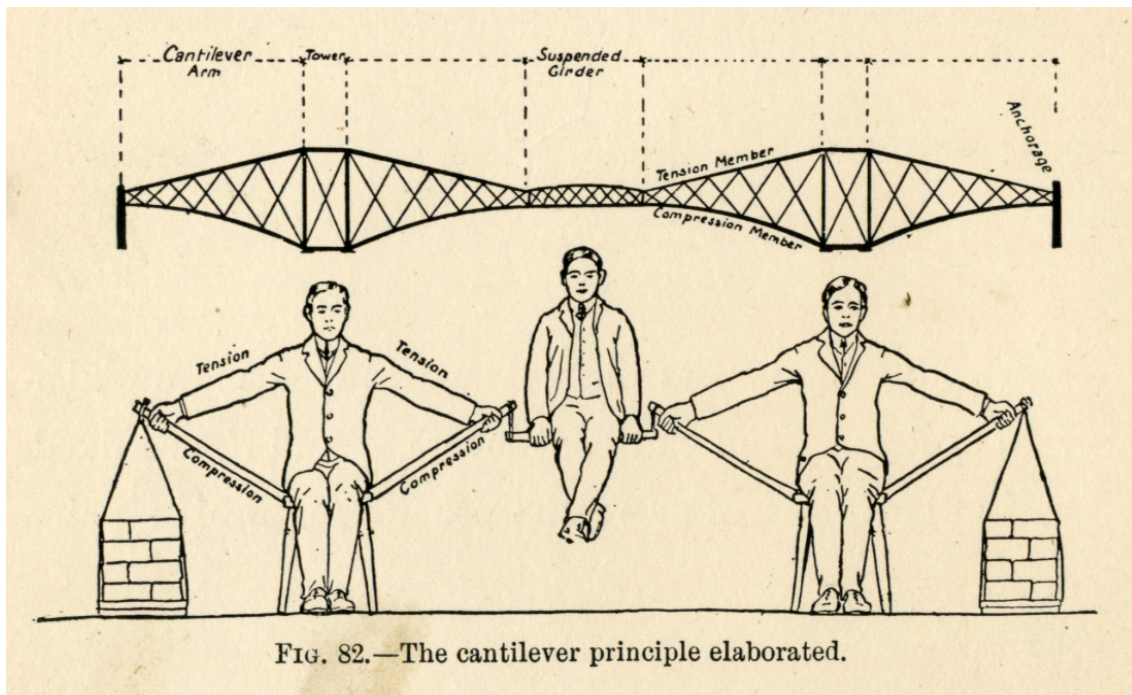


Fig. 3 The cantilever principle elaborated with Watanabe as a living model [7].

by the counterpoise in the cantilever end piers is represented here by a pile of bricks at each end. When a load is put on a central girder by a person sitting on it, the men's arms and the anchorage ropes come into tension, and the men's bodies from the shoulders downwards and the sticks come into compression. The chairs are representative of the circular granite piers. Imagine the chairs one-third of a mile apart and the men's heads as high as the cross of Saint Paul's, their arms represented by huge lattice steel girders and the sticks by tubes 12 feet in diameter at the base, and a very good notion of the structure is obtained" [8].

The other man at the centre of the composition was Kaishi Watanabe (Fig. 3), one of the first generation of Japanese engineers to travel West so that he could ultimately imitate the innovations in technique that had been developed in the Forth Bridge building site. A student of Fowler and Baker, Watanabe was invited to participate in the "living model" of the Human Cantilever to remind audiences of the debt its designers owed to the Far East where the cantilever principle had first been invented and applied.

5. Conclusions

It was this very photograph that revealed just how revolutionary the design for the Forth Bridge really was. The unprecedented dimensions of the linking girder arms, the comparison with Baker's design in the background, and the "tableau vivant" in the foreground, would significantly enrich the spatial perception and vision of the project, contributing to the more practical professional training of future engineers. Of the many photographers who, at the end of the nineteenth century, carefully observed the changes that were the result of the Industrial Revolution, Evelyn George Cary's vision was the most analytic, careful and mindful of the results achieved by science and technology. At the basis of his photographic interpretation of the Human Cantilever was the conviction that the Forth Bridge constituted an icon of the supremacy of humankind. This suggestive and highly spectacular image represented everything that was behind the design for the bridge, one of the most ambitious challenges in engineering and in the culture of that time.

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