The Story of Eugène Freyssinet

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Eugène Freyssinet.

Eugène Freyssinet has been proclaimed one of the most complete engineers of the twentieth century and one of the greatest builders in history. Yet his story is not well known because he was intensely modest and private, and did not write about his work. Only three books have been written about his life and work.

Freyssinet often stated, "I was born a builder." He would go on to build five world-record span length bridges, in addition to being the acknowledged inventor of "prestressed concrete" including pretensioning, the development and use of flat jacks, and post-tensioning.

Freyssinet was born in the countryside near Objat in 1879 and started his career in 1905 in Moulins. He built numerous bridges in the region, including the Praireal-sur-Besbre Bridge in 1907, a three-hinged arch having a span length of 85 ft. This was the first bridge in the world to have the formwork of the arch removed by creating forces using jacks at the crown hinge.

World-Record Span Length Arch Bridges

Freyssinet and the contractor Mercier Limousin designed and built concrete arch bridges, which successively broke his own world record for span length. They are :

- 1912, Veurdre Bridge (238-ft span)
- 1920, Villeneuve-sur-Lot Bridge (315-ft span)
- 1923, Saint-Pierre-du-Vauvray Bridge (430-ft span)
- 1930, Plougastel Bridge (610-ft span)

The main problem during construction of the Veurdre Bridge was the decentering of the three large arches that were subjected to creep and shrinkage. This was mitigated by using jacking thrusts following the procedure first used on the Praireal-sur-Besbre Bridge.

The initial bliss after construction was complete was soon followed by dreadful agony as disconcerting deformations (due to creep and shrinkage) started appearing, first slowly and then more rapidly until there was no possible outcome imaginable other than collapse.

Freyssinet took four reliable men, placed the decentering jacks back in the crown hinge, and began to raise all three arches at once, until the bridge regained its original shape. On future bridges, he eliminated the crown hinge and continued to study the problem of "deferred deformation," a phenomenon that the administrative authorities obstinately denied the existence of, and the official laboratories neglected or refused to measure over sufficiently long periods of time.

Invention of Prestressed Concrete

In 1928, Freyssinet patented the first of his three inventions for applying compression to concrete by "pre-tension and bonded wires," which was the birth of prestressing. His other two methods were his 1938 invention of

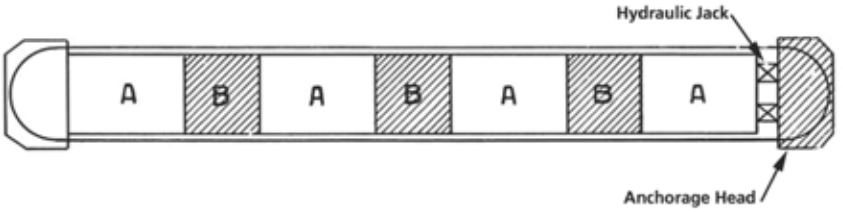
Veurdre Bridge with 238-ft span.

Villeneuve-sur-Lot Bridge with 315-ft span.

Saint-Pierre-du-Vauvray Bridge with 430-ft span.

Plougastel Bridge with 610-ft span.

World-record span length arch bridges designed by Eugène Freyssinet.



Plan view of the footings of the Maritime Station in Le Havre showing the new footings "B" between existing footings "A." Parallel prestressing wires were wrapped around reinforced concrete end anchorages, one of which was jacked away from the others, prestressing the entire composite structure.

the flat jack and his 1939 invention of the concrete anchorage, which was the birth of post-tensioning.

At the time of the October 1928 patent, the scientific community did not believe in prestressing. Freyssinet thus became an industrialist and began producing electricity poles at the Forclum plant at Montargis. The result was a complete technical success, but a commercial failure, due to the depression of 1929.

Freyssinet perfected grinding the fineness of cement, improved on his previous invention for mechanical vibration of concrete, invented steam curing to accelerate the rate of concrete hardening and rate of production, and perfected the industrial precasting process for precast concrete elements. However, over this 5-year period, he willingly spent the entire fortune accumulated during the previous part of his career. Finally, it was his spectacular rescue of the Le Havre Maritime Station in 1934, as described below, that allowed prestressing to become a reality.

Freyssinet next devised the flat jack in 1936 for compressing the raft of the Portes de Fer Dam in Algeria and for raising the height of the Beni Badhel Dam in Algeria by 23 ft to bring it up to 220 ft. The patent for the flat jack was validated in August 1939.

Freyssinet then invented the concrete anchorage. The system consists of twelve 5-mm-diameter parallel steel wires locked in a concrete anchorage cone by a tensioning jack. In August 1939, he applied for the patent that was issued and published in 1947, delayed due to World War II.

Rescue of the Le Havre Maritime Station

The Maritime Station in Le Havre, completed in 1933 for the ocean liner Normandie, was sinking 1 in. per month into a deep layer of clay and collapse seemed to be inevitable. Freyssinet proposed a solution that was immediately adopted.

The solution consisted of adding new footings between the existing footings to make the entire footing unit a monolithic, horizontal element, which was prestressed with parallel wires turned around two reinforced concrete end anchorages. One anchorage was displaced by hydraulic jacks, and the link between the old and new was assured by the general compression of the whole. Then 700 piles were installed through formed sockets of the new footings to sound layers of soil.

The result was both spectacular and convincing, and at once earned Freyssinet a worldwide reputation. This started the collaboration between Eugène Freyssinet and Edme Campenon in 1934 on the entire range of construction projects of the Campenon Bernard group.

Invention of Precast Concrete Segmental Construction

The Luzancy Bridge over the Marne River was started in 1941 and completed after the war in 1946. It was the first precast segmental bridge designed and constructed by Freyssinet. It has a span of 180 ft, a world record at the time. The bridge is a portal frame comprised of three concrete box girders that were precast in segments and assembled on site in sections. It was erected by launching equipment consisting of masts and stay cables.

The bridge was post-tensioned longitudinally and transversely with twelve 5-mm-diameter wires, and pretensioned vertically with tendons consisting of 5-mm-diameter wires. Flat jacks located in the bottom flange at the ends of the bridge allowed for adjustment to compensate for the effects of creep and shrinkage. All three of Freyssinet's inventions for prestressing were used.

The great success of the Luzancy Bridge allowed Freyssinet to build five similar bridges having spans of 243 ft over the Marne River between 1947 and 1951.

On these bridges, a thin layer of dry concrete mortar was placed between segments and compacted. Some 20 years later, his disciple Jean Muller would introduce match-cast epoxy-coated joints on the Choisy-le-Roi Bridge.

Later Years

Freyssinet continued to design and build until his death. Included in his later structures were the three arch bridges of the Caracas Viaduct from 1951-1953 (with Jean Muller on site), the Underground Basilica at Lourdes from 1956 to 1958, the Orly Airport Bridge from 1957 to 1959, and the Saint-Michel Bridge at Toulouse from 1959 to 1962. The Saint-Michel Bridge opened in 1962, 3 months before Freyssinet's death at the age of 82.

Erection of the partially assembled segments of the Luzancy Bridge in 1946.

EDITOR'S NOTE

Many more details of the life and work of Eugène Freyssinet can be found in a paper presented by the author at the 3rd fib International Congress, June 2010, Washington, D.C. The paper can be downloaded from the ASPIRE™ *website: www.aspirebridge.org, click on "Resources" and select "Referenced Papers."*