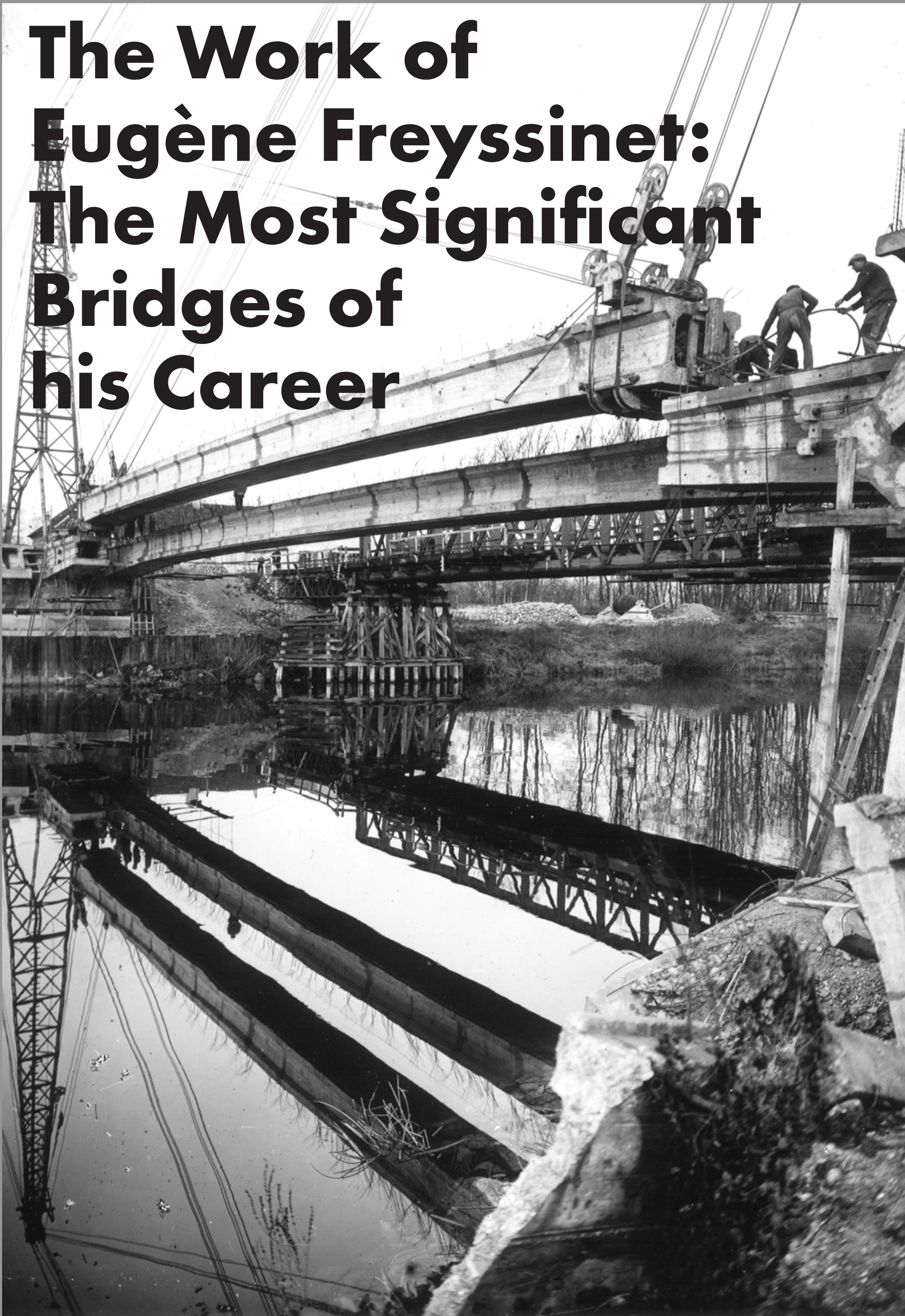
The Work of Eugène Freyssinet: The Most Significant Bridges of his Career



FROM 1904, when his career began, until 1962, when he died, Eugène Freyssinet did not stop building or advising on all aspects related with his work. To give an idea of his interest in the field of bridges, we selected the following: the Veurdre and Plougastel bridges as reinforced concrete examples and the Luzancy, the Marne and the Caracas La Guaira highway bridges as prestressed concrete works. In these brief descriptions, rather than the technical nature of the design, we have focused on intuition and innovation which made these works models and which inspired many engineers to continue working respecting quality.

By Pierre Jartoux

"I AM a natural-born builder!" expressed Eugène Freyssinet in the late 40s, when he remembered the successes of his career while lecturing or writing articles. His roots from Corrèze, his studies at the *École des Ponts et Chaussées* (School of Civil Engineering)—where he was taught everything that Séjourné had developed making magnificent stone vaults—became an intellectual heritage that predisposed him to this profession. His engineering career began in the early 20th century—Portland cement had been invented by Vicat more than a century before, mortar had been used by Monier[1] to erect light constructions replacing wood, and in the late 19th century, Hennebique realized the first real concrete structures and Coignet built a bridge over the Seine, the *Viaduc de la Vanne*. This new material, the mechanical properties of which were barely known except for its ability to set and harden over time and that it could replace stone, captivated the young engineer during his first job for the public works in Vichy. What attracted him was the moldability, the simplicity of its fabrication and its low cost. His origins from Auvergne—origins usually linked in France to extol the virtues of economy and even of avarice—could not fail to point out this quality. He used this material from a builder's point of view—he made some small bridges over the Bourbonnais streams—but especially from a scientific point of view. In 1903, while visiting the consoles of the *Rue de Rome* in Paris over the *Gare St. Lazare*, built by his master Rabut, he had become aware of one of concrete's significant insufficiencies: the cracking in the strained parts of a structure. Being a practical engineer, he drew two conclusions which underlie his long career. The first one was that concrete should not be used other than in structural forms, undergoing only compressive stresses, something that he systematically did using the vault form until 1930 and getting the most out of it—successively beating world records and making structures such as the Veurdre Bridge on the Allier River (1911) and the Plougastel Bridge, officially Albert Louppe Bridge (1930). The second conclusion was the determination to control and eliminate cracking which became possible with the invention of prestressed concrete, a new material which would "revolutionize the Art of Building." He built numerous bridges with prestressed concrete among which we have chosen the most striking ones: the Luzancy Bridge on the Marne River (1942–46), the bridges over the Marne (1947–51), and finally the three bridges on the Caracas–La Guaira Highway (1951–53).

< The installation of the central preassembled beam on the on-site prefabrication grounds. Luzancy Bridge by **Eugène Freyssinet**.

The Veurdre Bridge

> *From 1907 to 1911, the Veurdre Bridge had occupied my mind almost constantly. I had always loved it more than any other of my bridges, and from all of those that the war destroyed it was the only one that caused me real grief. What I can say about it is similar to what Mistral said about Mireille in his Epistle to Lamartine:* "It's my heart and soul. It is the flower of my years."

After such a confession, more than 40 years after its construction, it was important to begin our article with the saga of this work. It was an adventure in which one of two players was the entrepreneur François Mercier. When the need to replace the existing three-section suspension bridge appeared, the Administration prepared a masonry project. Mercier discovered in Freyssinet's office a similar work for the site of Boutiron, upstream of Vichy, a simple exercise that had been made without the prejudices of the daily tasks of the *Service Vicinal* Engineer. After thinking for a few minutes he declared "I like this project and I want you to carry it out in full freedom and at your own risk. It's easy to arrange: I offer the Department the reconstruction of its three bridges—Boutiron, Châtel-de-Neuvre and Veurdre—according to your project for which I am responsible together with the needs for studies and construction. For each bridge, I request a lump sum equal to one third of the amount provided for the sole Veurdre Bridge, payable at once if the tests are satisfactory. If unsuccessful, I will rebuild each bridge according to the draft prepared by the Administration; the

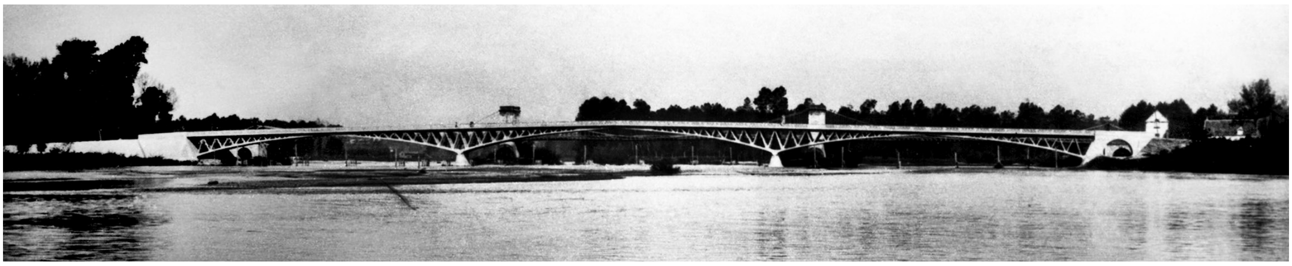


Figure 1. General view of the Veurdre Bridge.

Department cannot refuse such an offer." And indeed, it did not refuse the offer allowing him to build the three bridges for the sum of 630.000 francs, planned to only carry out the Veurdre Bridge. A century later, which architect, engineer, would not want to face such a challenge, with such a sponsor? It was an enormous responsibility and risk-taking task for this young engineer just in his 30s. Referring to this moment he would further on say, "At least three times in my life I faced a bold push to the extreme, ignoring the greatest risks."

During the 3 years before this adventure, Freyssinet had already had the intuition that this famous concrete, so simple to use, had some hidden properties which reserved a few unpleasant surprises to an audacious user such as him: shrinkage and creep under load over time. Regulation at that time did not give specific information about these phenomena and how to take them into account. Freyssinet discovered—it is one of his great merits—that concrete was not an elastic material but an elastic-plastic one and the designer had to take this into account in his calculations. Before starting the project's preliminary studies and in order to understand these phenomena, he demanded to make a test. And what a test!

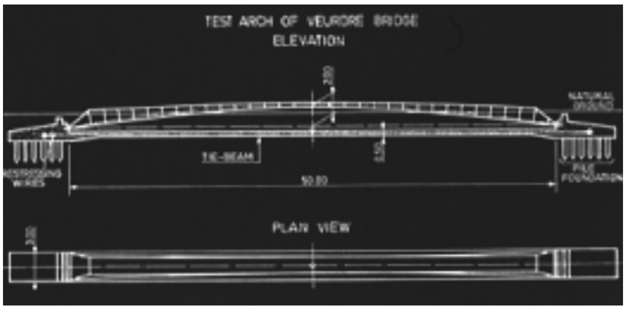


Figure 2. Test Arch. Elevation.

Figure 3. Test Arch expertise.

Figure 4. The prestressed bars

A 50-metre-span, 2-metre-high segmental arch, a true work of art that can be loaded with a small narrow-gauge train traveling in the vicinity: it is the Test Arch of the Veurdre Bridge. It has remained preserved almost miraculously, in the ground where it was built, now a vegetable garden along the RN7 at Moulins. Why are we giving the details of this test? Because it contains the seeds of many of Freyssinet's achievements developed during the remainder of his long career:

- Creep in concrete
- Improvement of concrete strength by increasing the smoothness of cement grinding
- Construction using prefabricated elements
- Concrete prestress with post-tension!

Measuring the value of the loaded concrete creep shrinking was obviously the main reason for building this huge test. The measures taken in 1908 were not sufficient to avoid the disappointments that occurred a few months later on the bridge itself, as we will explain later on.

He sensed the importance of the grain size role in cement; both to fill gaps in the structure aggregates—sand—and to improve the rheology of fresh concrete in order to completely core fill on-site and make it more durable. With additional crushing he improved the grinding fineness before mixing. From that moment onwards he obtained "remarkably easy-to-handle concrete without an excess of water and with a regular 90-days strength of 400 kg/cm^2 (40 MPa), having the capacity to considerably elongate before breaking due to yield strength."

By building this arch he was able to experiment with prefabricated construction, saving on-site time and enabling the structure to be very quickly loaded during the testing program. This was actually done, "but the execution proved that this idea was ahead of the possibilities of the time." He was only able to use this method at the Luzancy Bridge in 1942. Today we are aware of the success of this construction method.

Finally, the first production of a prestressed concrete beam using post-tension arrived. "for many years [...] I was obsessed with the idea of prestress: I used it to connect the two abutments with a concrete cable of approximately 150 dm^2, precompressed between the two abutments [...] under a permanent load of about 2500T." In fact it is the first prestressed beam built well before the patent registration in 1928. In 1993 an expertise proved that the prestress was still active.

The urgency of the fulfillment did not allow him to use decentering jacks acting at the middle hinge of each arch. "In the Test Arch I replaced them with steel corners sunk into the mass [...] With the set of corners I was able to raise the arch over the curve, freely begin to buckle to the left and to the right, and finally restore the straightness of the axis."

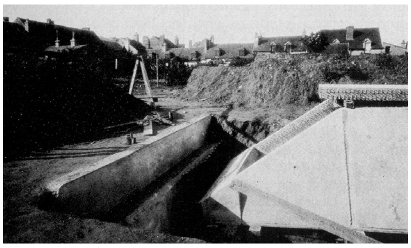


Figure 5. The end of the arch and one of the prefabricated elements before being placed.

Figure 6. The articulation during its excavation in 1993.

The construction of the Veurdre Bridge had begun at the same time. In 1910 it was finished and ready to support the load tests. Given the very specific conditions of the tender, the construction had raised a great controversy supported by the local press. It was the first time that Freyssinet's innovations caught people's interest, backed by journalists keen to fill their columns with the story of a disaster: "The tests were a triumph. A hill overlooking the bridge on the right bank was occupied by thousands of spectators, waiting since dawn to witness the fall of the work which had been announced by a daily paper from Nevers under the orders of an unwise competitor. Their hopes were disappointed [...] and nothing but the planned deflection [occurred]."

Figure 7. The Veurdre Bridge immediately after its construction.

Destroyed in 1944, we have no detailed documents of its construction. Fortunately, the Boutiron Bridge, its younger brother completed a year later, is still in use and in very good shape as the pictures testify.

Figure 8. The Boutiron Bridge today.

Like the Veurdre Bridge, this work has three spans of about 72.50 m, with the arch lowered to 1/15; note that the Alexandre III Bridge in Paris, made of steel, with a similar span and built a few years earlier, has the same profile which gives a good idea of the achievement! The photos show the perfection of its execution and the attention put into the detail such as in the fillet area between beams. By then, Freyssinet had not yet invented the mechanical vibration of the formworks in order to compact the concrete and, of course, poker vibrators did not exist.

Figure 9. Detail of original railings and a concrete section of 6x6cm intact after 100 years. What a lesson!

To complete this description of the Veurdre Bridge, it is essential to discuss the incident that took place a few months after the brilliant reception of the work mentioned before. Freyssinet explained it with so much suspense that it is necessary to read the full version. Thus begins the story: "At the end of spring 1911, more than 13 cm of deformation appeared at the middle hinge of each arch [...]" After one of Freyssinet's secret rapid tests, he understood the phenomenon and decided to act immediately without telling the administrations and scientific boards, as the bridge threatened to collapse due to a huge decrease in concrete's elastic modulus caused by creep. With the help of four men on which he relied—and without interrupting the traffic—he installed his decentering jacks in the middle hinge of each arch, above the normal position, in order to cause compression in the arch moving it in the direction opposite to which gravity pulled, jacking up the bridge to its original position and blocking the third articulation of the arch, something imposed by the regulations of the time! The bridge performed perfectly until it was destroyed by war. Boutiron is there to show the relevance of the analysis of this incident.

We have described at length Freyssinet's first major bridge because it contains the seeds of many of the ideas with which he would continue beating record after record, and which "would revolutionize the art of building" for nearly half a century, as he stated later.

The Plougastel Bridge officially called *Pont Albert Louppe*

This is the last work designed by Freyssinet in the *Béton Armé* (Reinforced Concrete) period of his career. The project was done between 1923 and 1930 and during these years Freyssinet registered a patent for the prestress method (1928)—until his death in 1962 he would focus on developing applications of this new construction system. Again, his innovative and cheap proposal faced strong opposition from steel manufacturers. The Committee had already endorsed the project but Albert Louppe, Board member and Chairman of the General Council of Finistère, demanded that each of the designers should defend their project in front of the Council. Freyssinet intervened and would later say, "My words were clear, I had no trouble tearing to pieces the false arguments from those who opposed to my project and I obtained the almost unanimous approval of the Commission." His project was built and it bore the name of Albert Louppe.

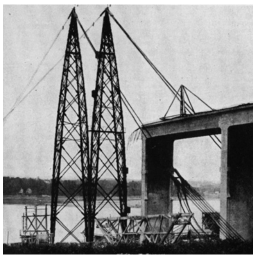
The General Council was aware of the need of this project since 1882 because the inhabitants of the Brest region who needed to cross the estuary of the Elorn to go from north to south of the department had to make a 30 km detour. A 900-metre-long bridge was necessary and in 1923 the decision to build it was taken. The last major concrete bridge is a highlight in Freyssinet's career. Not only its three 186-metre-long spans constituted a new world record, but its construction methods fascinate us as technicians.

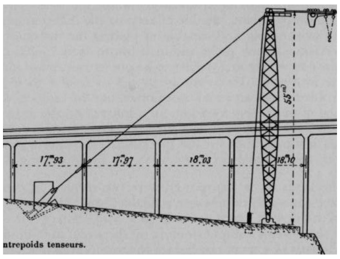
After the problems with Veurdre, knowledge on the effects of creep was not yet sufficient. To make sure the right values had been taken into account in the calculations, Freyssinet began making new tests.

A floating reusable wood-nailed-centering underpinned by a steel cable—a real work of art itself with its 150-metre-span—was built and set up in place taking advantage of the high tide and taking the formwork away when the tide was low.

Figure 10. The formwork being moved to the second span.

The supply of concrete for the structure was achieved with a blondin designed by Freyssinet because no manufacturer had accepted the challenge of making such a device. Something also remarkable was the 55-metre-high wooden derricks with two articulations which supported the wire cable carrier. Undisputed master of concrete construction, Freyssinet had no equal when building in wood, sometimes combining it with concrete when there was the need to transfer a high concentration of forces.





Figures 11, 12. The 55-metres-high wooden derricks.

Inaugurated on September 10, 1930 by the President of the French Republic, Gaston Doumergue, it was blessed on Sunday October 12, 1930 by Bishop Adolphe Duparc. A crowd estimated between 40,000 and 50,000 people had invaded the bridge and its surroundings to celebrate the event.

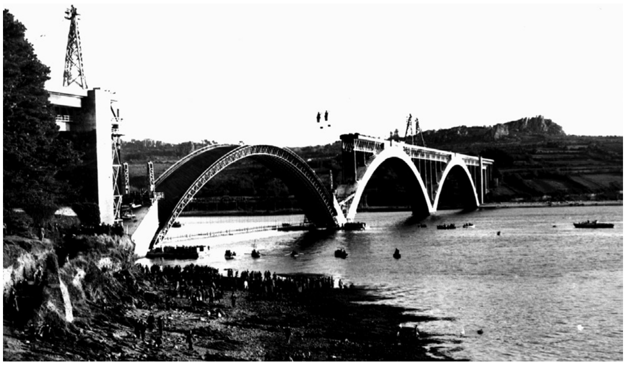


Figure 13. The bridge being rebuilt.

Unfortunately the bridge was decommissioned in August 1944 once the Germans had destroyed the first span on the Brest side. Post-war economy and the cost of repair meant that the bridge was not opened again until 1949. Twenty years after the initial construction, no other technique appeared to be better than the one developed by Freyssinet. However, the original two-way deck turned to be insufficient to the increasing traffic and in 1961 the width was extended to 12 m to allow three lanes with two 1-metre-wide sidewalks. This new organization also proved inadequate and very quickly, in the late 80s, the decision to build the Elorn cable-stayed bridge was taken. Authorities wishing to retain the imposing work, part of the landscape of the Bay of Elorn, decided to keep it. Unfortunately its presence together with the westerly winds of the estuary area formed Karmann vortices in the bridge's area, putting its stability into risk. It was necessary to streamline the three spans of the bridge making a not nice aesthetic effect but allowing the bridge to survive. The Albert Louppe Bridge is now reserved for pedestrians and agricultural machinery.

After the opening of the Plougastel Bridge, Eugène Freyssinet wrote a few sentences which can be considered unexpected for a builder:

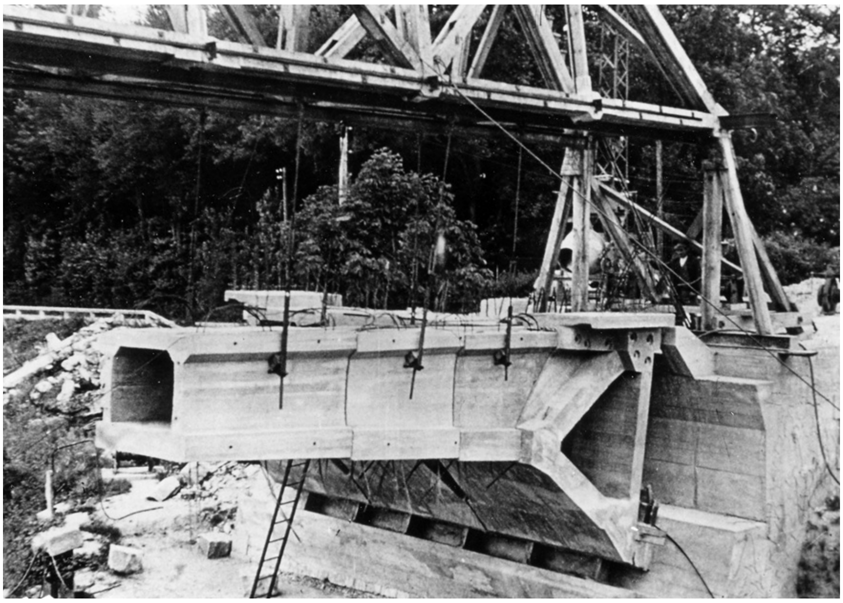
> *In Brittany, the light is a fairy who always plays covering nature with changing coats; sometimes lead, sometimes silver or pearl or something intangible and bright. In the evenings, when making the tests for the Louppe Albert Bridge, light lay on the bay's most magnificent treasures. And each line of the bridge turned into a long string of unreal light, adding more beauty to the whole wonderful work, proving that the fairy of the harbor had already adopted the child that men had imposed, and knew how to weave clothes which were beautiful enough to hide all the shortcomings of the work.*

The structure that can be seen under the deck was intended for the train although it was never used. On top of the central part of the first span we can see the suppression of the railings, an improved aerodynamic element which in the western side consists of a fairing which facilitates the flow of air around the central point.

The Luzancy Bridge

A series of works which use the spectacular new bases introduced by prestress begin with this bridge. The modest work with a span of only 55 m and a width of 8 m is of exceptional elegance. It also deals with a series of new techniques which slowly evolved since 1928 when the patent *Procédé de fabrication de pièces en béton armé* (Method to produce reinforced concrete pieces) was registered, today's description of "prestress". These new techniques had already been tried in the consolidation of the Le Havre maritime terminal and by the *Entreprises Campenon Bernard* works in Algeria. Started in 1942, works were interrupted by the war and the construction would not resume until 1945. Freyssinet utilized this stop to refine the construction method.

The banks of the Marne which are not very resistant seemed rather unfavorable to handle the load of an arch-shaped bridge. Freyssinet, aware of this situation, anticipated adjustable abutments using flat jacks—bags made of steel sheets that could be inflated with a liquid pressure to 15MPa. This was perhaps the most wonderful tool he invented.



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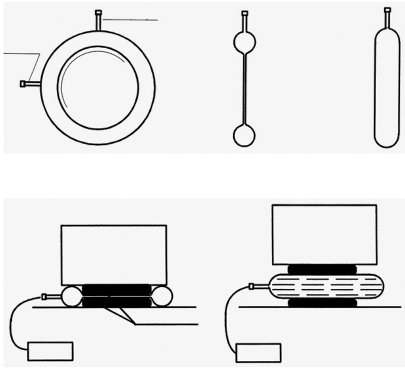

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Figure 14. Abutment with active interposition of flat jacks in support of the crutch.

Figure 15. The beam was set using a wood centering with concrete nodes. Installation of a cantilevered segment on one of the bridge's ends.

Figure 16. Flat cylinder. The diagrams show the design and how it is used to lift a load.

Figure 17. The installation of the central preassembled beam on the on-site prefabrication grounds.

Figures 18, 19. Precast segments at the working grounds. Note the concrete "candles"–used to lay the segments before preload-assembling–which reproduce exactly the longitudinal profile.

Figure 20. Recent view of the Luzancy Bridge. Note the excellent preservation of the railing and the transverse prestress anchor bosses.

Before the project was stopped, he imagined using a centering made out of a wooden beam with concrete nodes to set the precast segments. This piece of wood broke after the first uses and he abandoned this approach and developed another system using derricks and carrier cables. Reminiscent of Plougastel, it used the same wooden derricks due to the lack of steel for such applications at the end of the war. Note however that the beam system was taken up again in steel construction, 25 years later, by Jean Muller, his youngest student.

The bridge was prefabricated using several segments in which each cell underwent very powerful vibration that compacted the concrete to such a point that it allowed the mold to be removed 24 hours later. Since 1934, with the exception of the Le Havre passenger terminal, the building of posts or pipes in Algeria became a perfectly well-controlled technique.

Figures 14 and 15 show how Freyssinet, in 1941, envisioned the use of the beam setting—allowing both the installation of the segments and their suspension before their fixing—using prestressed cables. After abandoning this system, figure 17 shows how, once the work was taken up again in 1945, Freyssinet used carrier cables and a preassembled beam.

Figures 18 and 19 show two areas of the on-site prefabrication grounds with precast segments and a preassembled central beam. The assembly is done by introducing a final prestress more or less centered and fit in the four holes that can be seen in figure 19.

This first work which used precast segments could not assure the perfect combination of two consecutive segments as can be done today. The on-site preassembly required to ensure a caulk joint combination which needed a high-dose mortar (800 kg/m^3), without much water (moist soil texture), around 2-centimeters-thick and strongly compacted using a hammer. This allowed applying the prestress force immediately. The five bridges over the Marne, built some years later with more industrialized systems, used this same technique.

Structurally, Freyssinet wanted this work to be a real exercise that would demonstrate all possible prestress contributions to the stability and durability of a bridge. The bridge was prestressed in the three directions. During construction, the segments were given a prestressed grip using 3 mm diameter wires stretched on the formwork prior to pouring the concrete. Both ends of the cantilevered beams sitting on the abutments were held in place by a temporary external prestress. The central part was prestressed on-site with twelve 5 mm diameter cables strung through the holes waiting for concreting. When all the segments were set up, the overall stability cables were positioned from the top deck at the ends of the bridge continuing obliquely through the sloping holes in the segments and finally weaving under the bridge in order to place them in grooves which were covered with mortar after tension was introduced. After all these operations had been done, the transverse prestressing on the upper and lower sides took place—the anchor bosses visible on both sides show the presence of prestress. Finally, prefabricated pavement pieces with railings were set tightly against each other using flat jacks inserted in a few joints to ensure perfect continuity. These sidewalk elements were then tightened to the structure using vertical prestress which gave as a result a structural solidarity considered in the longitudinal bending strength of the bridge. The result of this real corsetage of the bridge is a great over time conservation as evidenced by recent photos. Although nearly perfect, there are still two criticisms that can be done after half a century. The first is that the prestress system used is so complex that the labor cost would be impossible today and those who conceived the bridges over the Marne took it into account only some years later. The second concerns the protection of prestress cables. Studying all the constructions carried out by Freyssinet or under his control, it is difficult to take it as an execution quality defect, but with regard to the cable protection we must acknowledge that he failed and underestimated the problem. This only concerned very few of his early works thus his young students and future employees persuaded him to improve the protection of the cables. In the 70s the Luzancy Bridge's cables under the deck corroded and it was necessary to replace the prestress with new cables which flow freely through the beams and were very adequately protected against corrosion. We can be certain now that the bridge is promised a long life.

The Five Bridges on the Marne

These five bridges are called Anet, Trilbardou, Esbly, Ussy and Changis-Saint-Jean. If Freyssinet defined the scheme inspired by that of Luzancy, it was actually Jean Chaudesaigues, then Director of Studies at Campenon Bernard, who spearheaded the studies. The completion of these bridges, substantially identical, was industrialized in a prefabrication factory in the vicinity of Esbly and the prefabricated elements were transported to the construction site using barges on the Marne. The project was simplified and instead of a box girder he used six I-beams stiffened transversely with six prestressed transverse struts. The deck was transversely prestressed only on the upper slab with 2 cables made of twelve 5mm-diameter-strands every 1.25 m. The bridges have a 74-metre-span and an 8-metre-wide deck with two 1-meter-sidewalks.

As in Luzancy, the deck is made of beams on crutches

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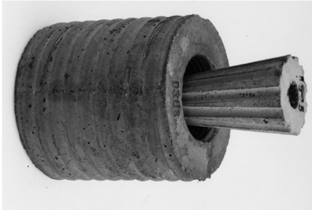

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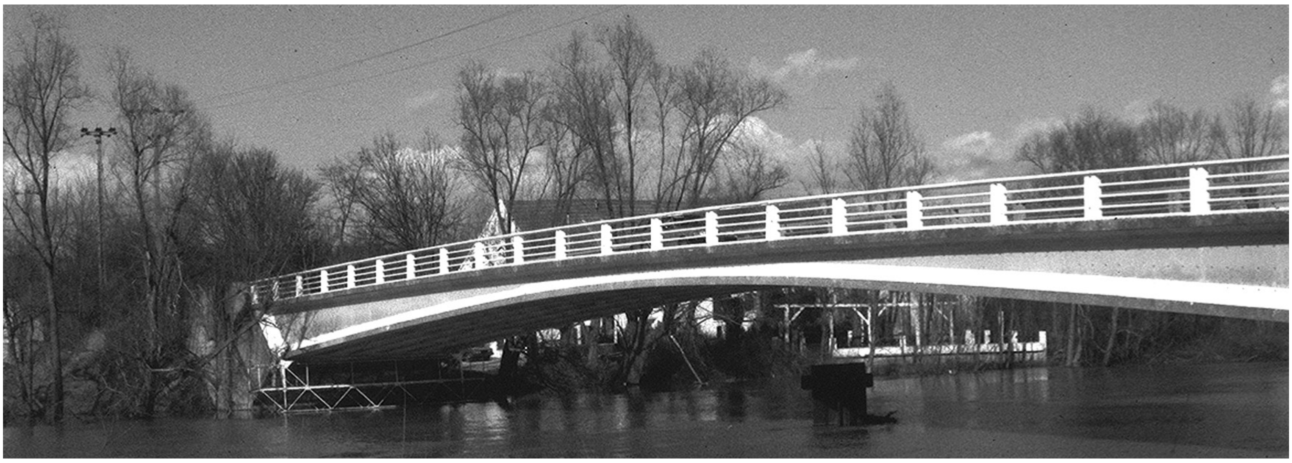
Figure 21. Esbly Bridge. Detail of an edge beam web showing the smooth surface of the concrete and on the left, the trace of a struck joint.

Figure 22. The concrete anchor 12Ø5, outer cylinder h=100 mm, Ø96mm, outer cylinder l=74mm, Ø40mm, permanent prestress force=250kN.

Figure 23. Anet Bridge.

Figure 24. Trilbardou Bridge.



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producing a major pressure on the abutments. The abutments of the old bridges had been strengthened to resist the horizontal thrust of about 1800T. Flat jacks were also interposed between the crutch supports and the abutments to compensate any possible land movements.

What is very new compared to Luzancy, are the arrangements for the production of the beam segments. There were about 20 times more pieces, which meant a series of industrial process involving multiple molds and especially a need to reduce the time to reach sufficient strength before they were released. The method developed for the posts in 1930, resumed in Algeria for the pipes of the Oued Fodda, was repeated: concreting with intense vibration, compression and drying with steam. A 250 kg/cm^2 resistance was achieved 90 minutes after casting.

Another important innovation was the introduction of vertical prestress on the beams' web. The deck of the beam (top part) and the heel were first cast separately on the vertical mold—the vertical steel stirrups were in place at the right length, and anchored in the two parts while being concreted. After curing, the web was concreted

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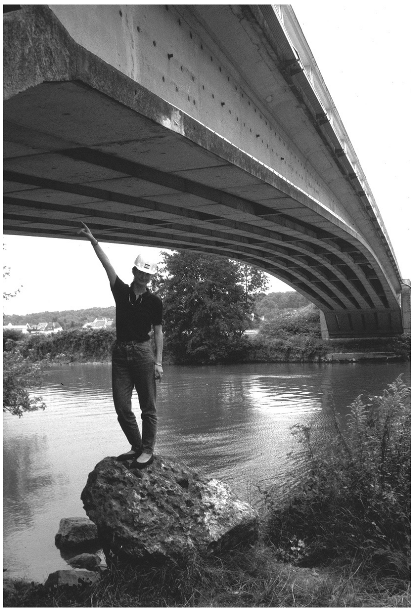

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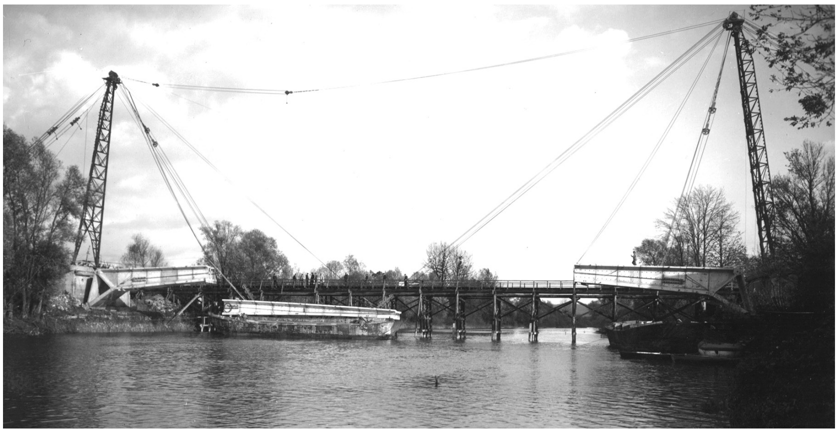

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Figure 25. Esbly over the Marne Bridge.

Figure 26. Esbly Bridge. Positioning of an element with the help of a cable transporter.

Figure 27. Changis-Saint-Jean over the Marne Bridge.

Figure 28. Ussy over the Marne Bridge.

All photos of these works were taken on bridges which are older than 50 years. Note their conservation which is the result of a careful implementation and compression effect given by prestress.

after separating the top and bottom parts with a jack system that tensed the abutments. The web forms were prepared and it was concreted with great care as it was only 10 cm thick and 2.5 m high!

The following steps were similar to what had been done in Luzancy. First the two beam ends were assembled using external provisional prestress, then the central part was assembled on-site and the caulk joints were done before introducing the longitudinal prestress. The whole piece was then placed on barges lead to the bridge site and installed with the carrier cable developed for Luzancy. The photos, which have been taken recently, show that these works are in an excellent state of preservation. Initially, the road did not have a sealing layer and one of them, located near a gravel quarry, endured heavy traffic which the designers had not counted with.

The Three Bridges of the La Guaira — Caracas Highway

These are the last important works built by Campenon Bernard in which Freyssinet was personally involved. He was more than 70 years old but still had the tenacity and strength that enabled him, throughout his life, to passionately defend a project he was convinced was feasible both regarding quality and economy. On a very long drawing board he designed to the largest possible scale the arches and their construction method of the bridges so no detail escaped the sagacity of his thinking. Up to his last works, he remained faithful to the principle he had set in his early career stage "I drew the work in great detail, convinced that a work is good or bad depending on its details."

He designed these works but again it was one of his students—the youngest—John Muller, who was responsible for the implementation studies. The bridge consists of a concrete arch and a deck made of prestressed beams—a synthesis of a builder who dedicated his life to innovative structural typologies and their construction methods. These three bridges are no exception, and the 60-metre-deep gorges which had to be crossed precluded the construction of a full centering. Finally the end of the cable-stayed arch formwork was built from the two large viaduct piles. The construction of the arches was then begun with a first cable-stayed centering but, in order to restrict the weight, only the lower slab and the segments' web were built. This disposition was enough to convey the compression forces to the supports—these compression forces appear from the central centering element and the final concreting. The same method was used with a new piece of cable-stayed centering bearing the progress of the arch to 25% of the length on both sides of the articulation of the two starting points of the arch.

Figure 29. Two of the bridges with a 150-metre-long span upon finishing the highway.

Thus began the last and most spectacular phase of the construction, the construction of the central arch with a nearly 75-metre-span, built in the lower part of the gorge using the nailed wood technique that had been used to reconstruct the destroyed Plougastel span. Similarly, the centering was underpinned by a cable, making it a relatively light structure, although the weight is about 200T and it had to be raised about fifty meters to its final position.

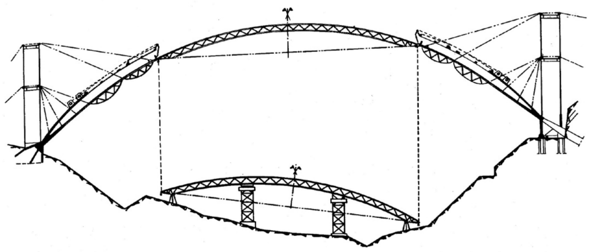

Figure 30. Scheme of the centering.

Figure 32 does not show the crowd of incredulous journalists scoop searching that, it seems, gathered at the bottom of the gorge during the first operation, hoping to capture the disaster that might accompany this phase, deemed risky even if it had been meticulously prepared. No doubt that day Freyssinet must have remembered the disaster that could have taken place due to the decentering of Veurdre! The innovative techniques developed by Freyssinet and then by his followers continued being surprising because of their audacity. After the decentering of the roof of the velodrome built for the Montreal 1976 Olympic Games—designed by Taillebert and studied by Freyssinet International—doubts on success had again gathered many journalists which were more than skeptical regarding the accuracy of engineering calculations.

These three bridges performed very well since their construction. However, one of the three was demolished after a landslide which affected one of the abutments, making the arch buckle. These kind of tectonic movements completely escape preliminary soil tests done prior to the construction of a large bridge like this one. This accident does not change the relevance of foreseeing methods adopted by innovative designers who must always be aware of their responsibility vis-à-vis the users. Freyssinet was one of them, one who brought these values to the highest level of performance: "Using the community's resources in the best way is not the builder's simplest way to gain fame or fortune or elegance of mind. It is an absolute obligation."

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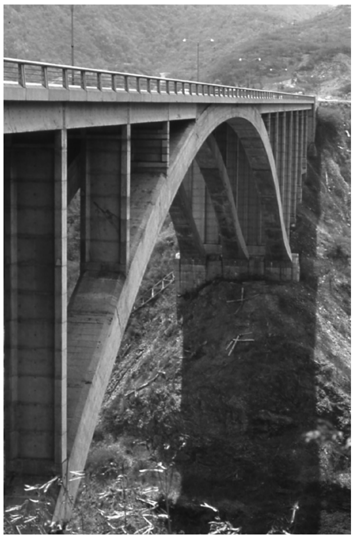

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Figure 31. The middle centering ready to be lifted. The built part shows the segment webs without the upper slab.
Figure 32. The middle centering being lifted.
Figure 33. One of the 3 bridges of the La Guaira–Caracas highway.

Figure 34. **Eugène Freyssinet** (1879-1962).

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Born in 1937, he is a mechanical engineer graduated at the *École des Arts et Métiers*, civil engineer, graduated from the *Centre des Hautes Études de la Construction*. His career has been connected to the Freyssinet Group: civil engineering studies office; testing on material prestressing section; material manufacturing factory; and research department on new materials (prestressing anchors and braces). Since his retirement, he became involved in the activities of the Association Freyssinet and currently serves on the *Conseil d'Administration*.