THE FOUNDING EVENTS OF PRESTRESSED CONCRETE IN BELGIUM
SEEN THROUGH THE BLATON ARCHIVES

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Abstract

The recent discovery (2013) of the archives of the Belgian contractor Blaton-Aubert who patented and developed in Belgium during the Second World War a system of prestressing concrete by post-tensioning similar to Freyssinet's has allowed assessing with a new vision the contribution of all actors involved in the early history of prestressed concrete in Belgium. The cross influences of Freyssinet, Magnel and Blaton are analysed, and a precise chronology - which was lacking - of the first prestressed concrete constructions that were realized in Belgium during the war is given. Searching through the Blaton archives has revealed:
- the extent of the partnership between the Blaton brothers and Magnel in the promotion and design of the first prestressed concrete projects;
- the crucial role of the engineering office of Blaton-Aubert in the detailed design of the projects and the industrial development of the "Sandwich" system;
- the role of the representative of Freyssinet in Belgium.

An account of the chronological development of the following important projects is given:
- roof at V. Trief Works, cement silos and gantry at A. Dapsens cement plant in Tournai, the railway bridge decks and experimental beam tested in situ at the Rue du Miroir in Brussels, a footbridge in Malheide, and a footbridge Rue de Gosselies in Brussels.

Thanks to these experimental structures designed or built in the years 1942-1944, Blaton was in excellent position from 1945 onwards to take part to competitions for the construction of buildings and bridges in prestressed concrete, not only in Belgium but also abroad, and Magnel was regarded as a leading authority on prestressed concrete worldwide.
INTRODUCTION

The early history of prestressed concrete in Belgium is invariably associated with the name of Gustave Magnel (1889-1955), professor at Ghent University, who began experimenting with prestressed concrete in 1941 (Espion 2009). He is often credited to having developed a system of post-tensioning consisting of anchorage with flat wedges and tendons known as "Sandwich" or "Blaton-Magnel" which was widely used in Belgium, and also a bit abroad, even in the USA, after the second World War and up to the beginning of the 1960s.

Up to now, the sources for studying the history of the early development of prestressed concrete in Belgium were mostly Magnel's publications and especially the 1st edition of his famous textbook (Magnel 1948a, Magnel 1948b), which was the first comprehensive treatise on prestressed concrete design. However these sources never mention the origins, the conditions and the dates of the first prestressed concrete structures built in Belgium. This means that the story of the origins of prestressed concrete structures in Belgium is largely unknown or presented unilaterally.

Very recently, important archives of the contractor Blaton-Aubert have surfaced sixty years after the dissolution of the company which was active from 1865 up to 1954. This contractor was responsible for most of the first and important applications of prestressed concrete in Belgium in the 1940s and early 1950s. The analysis of these archives allows now reconsidering more exactly the early development of prestressed concrete in Belgium.

THE BLATON-AUBERT COMPANY AND ITS ARCHIVES

The Blaton-Aubert Company (in short: Blaton) was set up in Brussels in 1865. In 1895, when the business of reinforced concrete construction began to spread, it became rapidly one of most successful contractors for private and public building in Belgium. A concise history of Blaton has been given by Hellebois (2013). Between 1927 and 1954, the brothers Armand Eugène Blaton (1897-1988) and Émile Blaton (1901-1970) managed the company together. From 1954 onwards, the original company was split into several companies for their heirs, but nowadays a granddaughter of Émile Blaton still chairs a Brussels-based construction company bearing the name "Blaton".

In the summer of 2013, about 93m³ of archives from Blaton covering mostly the construction activities of the company during the first half of the 20th Century were given to the Archives d'Architecture Moderne (AAM, Brussels) by a grandson of Armand Blaton. These archives consist mostly of photographs, drawings, blueprints and hundreds of wrapped packs corresponding each to a project studied, applied for or carried out by Blaton. The inventory of this huge amount of archival material is still under progress, but it already appears that the company did not kept the record of all its activities and that a selection was made in past times. However, for the period covering the early development of prestressed concrete, the archive appear quite untouched, and is certainly the best source available up to now to study the pioneering role of Blaton in this field. Their exploitation allows to write a different story than was presented by authors who wrote on Magnel mostly from published (secondary) sources (Taerwe 2005; Radelet De Grave 2005; Van de Voorde 2011), and will go far further than the author's own contribution which had a more limited scope (Espion 2009).
These archives provide a new commentary on the early days of prestressed concrete in Belgium. They clearly show the involvement of the contractor Blaton-Aubert in the industrial development of the system, the promotion of use with many unrealized projects and the interactions between Magnel, Blaton-Aubert, other Belgian contractors and the representative of Freyssinet in Belgium.

It is now obvious that Magnel, as well as the engineers of Blaton, were well aware of the researches, patents and applications of prestressed concrete by Freyssinet. Since 1939, the agent representative for the Freyssinet patents for Belgium and Congo was Auguste Goditiabois (1886-1946), owner of the Laboratoire de Cinématique in Brussels. Goditiabois received from Freyssinet in November 1940 the manual for the detailed design of bridges prestressed by post-tensioning issued by Freyssinet in October 1940 (Freyssinet 1940). The Blaton engineers knew that manual certainly by 1942. In the paper that Freyssinet published as text of his November 1941 famous lecture in Paris, he acknowledges that Magnel helps him to promote and develop in Belgium the applications of prestressed concrete (Freyssinet 1941, 341). This paper is fully reproduced at the request of Goditiabois in the Belgian journal Reconstruction in 1942 (Freyssinet 1942). Every issue of this journal published 1940-1944 displays a full page of advertising for the Laboratoire de Cinématique which further helps to promote prestressed concrete by having reprinted the French paper (Redonnet 1943a) that describes two of the rare applications of prestressed concrete by post-tensioning to bridges in France during the war (Redonnet 1943b).

Three months after the Freyssinet lecture, Magnel delivers on February 27, 1942 a lecture in Brussels reporting on his first experiments with prestressed concrete in his laboratory at Ghent University (Magnel 1942). This conference was attended by a hundred people, among them a significant delegation from Blaton. An echo to this conference is given in the French journal Travaux (Anon. 1942).

On March 21, 1942, the brothers Armand and Émile Blaton apply for a Belgian patent (444918) describing the principles of the "Sandwich" anchorage (Fig.1). It should be underlined that neither the name of Magnel, neither the term "Sandwich" does appear in the patent. However, it has become clear that the Blaton brothers were convinced that this patent infringed with the Freyssinet patent and also that they recognized the contribution of Magnel to the development of
The founding events of prestressed concrete in Belgium seen through the Blaton archives

the "Sandwich" system. A very interesting item found in the archives is a copy of a contract between Goditiabois (representing Freyssinet) and Magnel, dated from May 27, 1942 and valid for five years, stating that:

- there will be only six licensees of the Freyssinet patents for prestressing in Belgium, namely the contractors Pieux Franki (Liège), Société Belge des Bétons (SBB, Brussels), Strabed (Brussels), Blaton-Aubert (Brussels), François & fils (Brussels) and Delens (Ghent);
- all construction projects in prestressed concrete shall be submitted for approval to Magnel;
- the fee to be paid by a contractor to the Laboratoire de Cinématique for constructing in prestressed concrete shall be between 5 and 10% of the cost of the prestressed concrete construction;
- for rewarding the expertise of Magnel in his evaluation of the project, the Laboratoire de Cinématique shall pay to him 18% of the fee paid by the contractor to the Laboratoire de Cinématique;
- in addition, a company that builds a prestressed concrete structure shall independently pay to Magnel 10% of the fee to be paid to the Laboratoire de Cinématique, with a yearly minimum of 50,000-fr.

The contract was undersigned by Campenon-Bernard (holder of the rights of Freyssinet patents till the set up of the STUP in 1943) and by Armand Blaton in the name of the six Belgian contractors. Despite the fact that Blaton always used the "Sandwich" system, there is evidence that Blaton paid fees to the Laboratoire de Cinématique and to Magnel according to this agreement, at least till 1946, when Magnel begins to question the need to pay a fee to Freyssinet when using the Sandwich system. In general, when establishing a quotation for a prestressed concrete construction project, the Blaton management added to the construction costs (labour, material, transport...) 7 to 8 % for Freyssinet (i.e. Laboratoire de Cinématique), same amount for Magnel, same for the overhead costs of the company, and same amount as profit for Messrs. Blaton.

Magnel acted on one side as technical advisor to the Blaton Company, but also as some sort of commercial agent trying to promote the use of prestressed concrete in his circle of contacts. And definitely, assuring that Professor Magnel would supervise the project was a strong argument for Blaton to convince his clients to turn from a classic project in reinforced concrete to a bold new solution in prestressed concrete. The detailed design of the projects was carried out in the engineering office of Blaton where high caliber engineers rapidly learned to master principles and computations of prestressed concrete. The names of two of these engineers have been identified: Bjarne Olsen, an engineer graduated from Ghent University in 1909, head of the engineering office, and Samuel Chaikes (1910-1986), an engineer graduated from Ghent University in 1936. In this wartime period, two independent consulting engineers, not members of the engineering staff of Blaton, seem to have been involved in the design of some projects prepared or even carried out by Blaton: Jean Ronsse, an engineer graduated from Ghent University in 1924, and Felix Riessauw (1912-1999), an engineer graduated from Ghent University in 1935, and assistant to Magnel at the university.

During the wartime period, Blaton, thanks to the help of Magnel, pioneered the promotion of prestressed concrete and invested into the technical development of the "Sandwich" system of anchorage and cable during the years 1941-1942-1943. Since the Freyssinet products (cone anchorage and cables) were not available in Belgium during the war, the Blaton Company became eventually provider of post-tensioning devices, and sometimes subcontractor for applying pre-stressing, to competitors that had been granted the right to use the Freyssinet patent like Strabed, SBB or Delens for projects they won and which were executed from 1945 onwards.
THE WARTIME PROJECTS

The size of this paper does not allow to record all the projects in prestressed concrete of floors, roofs, girders, bridges, footbridges, industrial structures, foundation piles, pylons, railway sleepers... studied by the engineering office of Blaton during the war: there are dozens and the earliest seems to date back to May 1941. This paper will concentrate on the main projects of the wartime period studied by the engineering office of Blaton which were effectively realized, and which are all, except for one, mentioned and illustrated in Magnel's book (Magnel 1948).

Industrial constructions

Apparently, the first projects pursued by Blaton were intended to use post-tensioning as a mean to build structures with small precast concrete elements.

The very first project is the construction of a roof for Victor Trief Works at Deux-Acren (Lessines, Belgium). The business of that company was precisely concrete precasting. Blaton and Magnel, who may have been influenced by the traditional barrel form of roof for industrial buildings in reinforced concrete, proposed that the structure of the roof consists of six circular tied arches with 15m span and 4 m rise in prestressed concrete (Fig.2). The prefabricated concrete voussoirs were to be laid on centers and then tight together by post-tensioning. In this case, prestressing was not justified by considerations on the behavior in service but by the construction (erection) needs. The design of this structure began in late 1941 and was finalized in April 1942. Post-tensioning of the arches took place in June and August 1942. It should be underlined that this world première necessitated already the knowledge of losses induced by friction when tensioning the wires of a cable in a sheath along a circular line. Careful measurement of cable elongation were recorded at the tensioning of the cables and the results were compared to a previous test along an annular test structure built in the Blaton yard in Brussels either in late 1941 or early 1942. Magnel (1948) does not mention this roof for the Trief Works in his textbook.

Figure 2: Prestressed concrete circular arch of the roof at Trief Works, Summer 1942 (©Fonds Blaton, AAM)
Chronologically, the second prestressed concrete structure projected and built by Blaton is the group of four cement silos for the Alexandre Dapsens cement plant in Tournai described in detail in (Magnel 1948a, 377-379; Magnel 1948b, 193-195; Anon. 1949). The diameter of the shaft of these silos is 8m and their storage depth is 16.72m. The walls consist of small precast curved concrete blocks 18cm thick tight together by circular post-tensioning. Prestressing is here fully justified additionally by stress considerations in service under full loading. The extension of the storage capacity of cement for this client was already under study by the engineering office of Blaton in the late 1930s. By January 1942, Blaton had considered the possibility of building these silos in prestressed concrete by holding together small elements following a typical application that is illustrated in the patent submitted two months later (Fig.1). The convincing argument for the client who had to accept this world première structure was of economical nature: despite significant fees to be paid for applying prestressed concrete, the savings in construction materials (cement, steel, wood for the formwork) - which were scarce and under quotas at that time - were so important that the cost quoted by Blaton was less than in reinforced concrete, and construction in prestressed concrete was also faster. The project advanced then rapidly: detailed design ended by December 1942, acceptance of the project by the controlling office SECO in February 1943, beginning of producing the concrete blocks for the walls in February 1943 even before settling the agreement with the Laboratoire de Cinématique on the fees to be paid to Freyssinet. The construction of the silos proceeded between March and July 1943. Blaton proposed a similar method of construction in April 1943 to the Cokeries du Brabant at Vilvoorde near Brussels to build the quenching flue of the coke ovens, but the order was only placed in December 1945. Erection of this circular tower, described in (Magnel 1948a, 379-380; Magnel 1948b, 195-196; Anon. 1949), 6.4m in diameter and 21m in height, took place in 1946.

The construction of the silos at the Dapsens cement plant allowed Magnel to propose and Blaton to build another innovative structure in prestressed concrete: the gantry connecting the top of the old silos in reinforced concrete to the top of the new silos in prestressed concrete is supported by four prestressed concrete hollow girders with 18.5m span. Each of these girders was constructed on the ground by assembling with post-tensioning precast concrete voussoirs with depth 1m and length 0.5m, and then raised in place in one piece (Magnel 1948a, 185-187, 379; Magnel 1948b, 113-114, 194-195). The girders were on their final supports in December 1943. The world première lies here in leaving the prestressing cables visible inside the hollow caisson, a form of post-tensioning that will be called later "external prestressing" and which is a trade mark of several projects by Magnel and Blaton. The four silos and their gantry, although no longer in use, still survive today in Tournai and should be considered as industrial heritage.

Similar hollow girders were designed to build a roof at Karlec works (St Niklaas) in 1944 (probably not constructed) and to erect a provisional support for a pipeline across the Ghent-Terneuzen canal at Langerbruggen (Magnel 1948a, 185-187, 379; 1948b, 113-114, 194-195). The construction of this structure for the Canadian Military Corps of Engineers proceeded rapidly between February and May 1945 with the voussoirs intended initially for the Karlec roof.

**Bridges and footbridges**

The author has written previously (Espion 2009) the story of the three main projects of bridges and footbridges of that period by Magnel and Blaton. Finding their files in the archives allows now to correct some errors and to revise slightly the story.

The project for the 20m span prestressed concrete decks of the railway bridge over the Rue du Miroir in Brussels has been presented by Magnel (1948a, 348-358; 1948b, 171-175) as the
launching event for prestressed concrete in Belgium, and is still considered as such in the collective memory of Belgian engineers. The first mention of this "experimental" project dates from May 1941, but it was not known till now that the first version of the project was with the post-tensioning Freyssinet system of anchorages and cables. It was also explicitly written by Magnel that the project had to be approved by Freyssinet himself. The experimental program was presented to the technical board of SECO in July 1941. Probably already in 1942, it had been decided to adopt the Sandwich system of post-tensioning instead of the Freyssinet system. By comparison with concomitants projects by Blaton, this one proceeded more slowly. The on site test up to failure of the experimental beam with 20m span (the first ever test to failure of a large beam prestressed by post-tensioning) took place on July 14, 1943 and not in 1942 as erroneously reported by Espion (2009) who had inferred the year 1942 from several sources (e.g. Magnel 1948b, 172). Just after this test attended by a large audience, the two bridge decks in prestressed concrete were cast in November 1943, but their cables were only tensioned in 1944 (Espion 2009). These decks are still in everyday use.

As seen above, Magnel and Blaton did not wait for the results of the test to promote projects in prestressed concrete: this was also the case for the 44.5m span footbridge at Malheide (Espion 2009, Magnel 1948a, 365-366; Magnel 1948b, 184-185). The first detailed project in prestressed concrete for this footbridge by the engineering office of Blaton dates back to July 1942; a second project is established in May 1943, probably to be submitted as alternative bidding for the call to tender launched by the Authority to rebuild that footbridge. In September 1943, Blaton sent to his competitor SBB a quotation for providing all necessary elements of the prestressing system. The deadline for the call was October 1, 1943. Six bids were received for reconstructing in reinforced concrete, and three in prestressed concrete. Prestressed concrete was effectively cheaper than reinforced concrete, but what a blow for Blaton which - in this 1st public call to tender for a prestressed concrete project - ended last behind SETRA and his competitor SBB! The further story of the building of that footbridge - which still exists - can be found in (Espion 2009).

The case of the footbridge at the Rue de Gosselies in Brussels (Espion 2009, Magnel 1948a, 364-365; Magnel 1948b, 182-183) may be similar. The Authority had prepared already in April 1942 a project in reinforced concrete to reconstruct this footbridge. It may be assumed that Blaton took part to the call for tender because the engineering office of Blaton produced a drawing for a project in reinforced concrete in July 1943. But the general contractor who was awarded the contract was finally a small Brussels-based firm called "G. Clauses, Ir". After the successful test of the experimental beam in July 1943, Blaton-Aubert probably proposed to the Authority and to G. Clauses to switch to a more economical project in prestressed concrete and Blaton became subcontractor to G. Clauses for the prestressing part. It can now be stated precisely that the girders of the footbridge were cast on October 11-13, 1944 and that Blaton applied the post-tensioning on October 31, 1944. Although still in good condition, this footbridge will be dismantled and removed from its site in 2015.

CONCLUSIONS

- This research into the Blaton archives has revealed that the company began to explore the potential of prestressed concrete by post-tensioning as soon as May 1941;
- that rapid progresses were made during the years 1941-1942-1943 in developing design projects and the technology of the "Sandwich" system which was fully matured with drawings for any combination of cables in January 1944;
The founding events of prestressed concrete in Belgium seen through the Blaton archives

- that a close cooperation and even some form of partnership existed between Magnel and Blaton-Aubert;
- that during these early years Magnel and Blaton were loyal partners of Freyssinet who received royalties for the use of his patent by Blaton;
- that Magnel was also rewarded financially with the usual fee for a consulting engineer for his technical expertise and for his role as promoter of construction projects;
- that the first prestressed concrete structures in Belgium were industrial structures built in 1942 (for V. Trief) and 1943 (for A. Dapsens), and not bridges or footbridges.

REFERENCES


