

## **BUILDING WITH BOOKCASES. AN ARCHIVE DEPOT IN IRON (ANTWERP, 1851)**

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### **Keywords**

Iron book stack, building in cast and wrought iron, archive depot, engineer Théodore Lebens

### **Abstract**

In 1851 engineer Théodore Lebens, working at the *Corps des Ponts et Chaussées* in the Province of Antwerp in Belgium, designed an archive depot with iron stack to house the provincial archives. This impressive iron structure which integrates modular iron bookcases within an iron frame was highly innovative at the time. From a structural point of view, this archive depot can be seen as the predecessor of fireproof stacks such as the Congressional Library of the United States Capitol, conceived in 1852 by architect T.U. Walter or the iron stack of the Bibliothèque Sainte-Geneviève in Paris built by Henri Labrouste in 1859-68. Yet, no reference has ever been made in historical literature to the Antwerp provincial archive depot; neither is it recognized in Belgium as a pioneer in the development of Belgian iron architecture.

By means of the study of the correspondence of the *ingénieurs en chef* of the *Corps des Ponts et Chaussées* in Antwerp, the original drawings and onsite analysis of the still existing building, the design, building process and its construction are analyzed.

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Building with bookcases. An archive depot in iron (Antwerp, 1851)



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Figure 1: The Archive Depot in Antwerp, designed in 1851, consists of an iron stack. **1:** Front façade - **2:** Central iron staircase connecting the five floors of the stack - **3:** Iron bookcases and floor grids - **4:** Connection between floor grid and lower bookshelves - **5:** The cast iron bookshelves are supported via bars which are screwed into the wrought iron column - **6:** The wrought iron column fits within the cast iron beam - **7:** The roof consists of slender wrought iron bars - **8:** The columns are connected to the lowest bar of the roof - **9:** The ground level which houses the heater is covered with brick vaults.

## INTRODUCTION

In 1851 a public tender was announced to extend the governmental hotel with a depot to house the archives of the province of Antwerp in Belgium. Although it concerned a relatively small extension with a footprint of 6m by 10m and six stories high, we believe the construction was innovative for its time. The masonry loadbearing walls embrace a slender modular iron structure, consisting of open cast iron grids, supported by slender iron beams and columns.

Although structural work had been built in iron before, the integration of a modular grid of iron bookcases with iron shelves in an iron structural frame was highly innovative. Indeed, iron had already been applied to span the roof of libraries. As such, architect Robert Smirke applied disguised cast iron girders in 1823-27 to span the roof of the King's Library in London (Sutherland 1997) and architect Henry Labrouste integrated cast iron in his design to support the roof of the reading room of the Bibliothèque Sainte-Geneviève in Paris in 1843-1851. Although iron was applied in the latter libraries, their bookcases were still in timber.

The book stacks and libraries, which integrate iron bookcases in an iron frame, as is the case in the Archive Depot in Antwerp, all seem to be designed and constructed after 1851. The first design we came across in literature dates back to 1852. In that year the American architect T.U. Walter submitted plans for the refitting and extension of the Congressional library of the United States Capitol, which had been destroyed by fire on December 24, 1851. Walter submitted plans for a nonflammable library in January 1852, entirely built in iron, including structural work, bookcases and bookshelves. (Brown 2007) The two vertical sections of the plans entitled 'Design for Library of Congress', signed in 1852, show a central corridor with two tiers of galleries from which opened book alcoves. In 1852 the iron works were contracted to Beebe & Co in New York. The Western hall of the Old Congressional Library was completed in 1853 (Wermiel 2001), the North and South wings of the extensions followed in 1866. (Brown 2007)

In 1854, the construction of the Reading Room of the British Museum in London started. Architect Sydney Smirke, the younger brother of Robert Smirke, turned the sketches of librarian Antonio Panizzi into a building. He designed a cast iron dome with three levels of iron bookcases in between the cast iron ribs of the dome. The stacks were load-bearing cast-iron shelving with wide aisles of open grillework to allow the light from the glass roof to penetrate to the lower levels. (Campbell 2013) Later projects as Henri Labrouste's iron stack for the Magasin Central in the Bibliothèque Sainte-Geneviève in Paris, built in 1859-1868 and the in 1876 developed self-supporting iron stack system for the Harvard College Library are well known (Campbell 2013).

The Congressional Library, which was designed in 1852 and thus one year after the Antwerp project, is referred to in literature as the first iron fireproof library including iron bookcases and bookshelves. Henceforth, it is evident to question which references or contemporary practices could have inspired the engineers of the *Corps des Ponts et Chaussées* for the Antwerp project. Today, no final answer can be formulated, but clear insight in the design and construction process of the Antwerp Archive Depot will definitely help to define similarities and differences between the early archive and library designs.

## THE ARCHIVE DEPOT

In the mid of the nineteenth century there was an urgent need to build a depot to preserve the provincial archives of Antwerp in Belgium. Hence, on May 26, 1851, a public tender was published for the 'construction of a building to stock the archives of the Antwerp provincial government'. According to this public tender, the plans and building specifications of the archive

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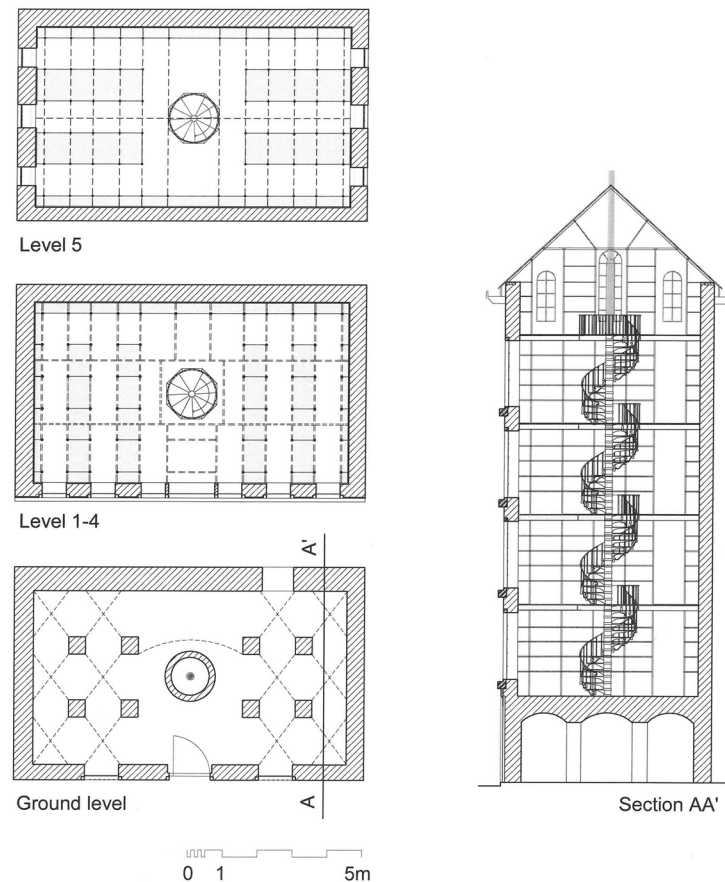


Figure 2: Ground floor (top left), typical lay-out of archive floor level 1-4 (middle left) and top floor (bottom left) Section (right) of the Archive Depot in Antwerp (original drawing of M. Tondeur, modified by authors)

depot could be consulted at the office of the *Ingénieur en Chef, Directeur des Ponts et Chaussées*. (State Archive Antwerp 1399) Up till now the aforementioned building specifications were not retrieved, but four out of seven original plans could be traced back in the State Archives: *Détails relatifs à la construction de la façade, de la porte d'entrée et des chassiss de fenêtres - Détails relatifs aux parquets et aux rayons - Détails relatifs à l'escalier - Détails relatifs au calorifère*, or respectively, the plan of the facade, windows and front door, the plan of the floor grid and book stack, the plan of the staircase and the plan of the heating system. Details of the general lay-out of the building, the floors and the roof are missing.

The original plans were drawn on March 15, 1851 by Théodore Lebens, engineer at the *Corps des Ponts et Chaussées* in Antwerp and approved by subsequently the head of the department, *l'ingénieur en chef* Ulrich Nicolas Kümmer, and by the minister of Public works, Emile Van Hoorebeke, on May 9, 1851. Despite the excessive publicity in newspapers and journals only four contractors bid on June 13, 1851. Although the cost of the building was estimated at 29.000 francs by the administration, the prices of the contractors varied between 32.900 and 36.900 francs. The correspondence of the administration of the *Corps des Ponts and Chaussées* reveals that the minister finally agreed to spend the amount of 32.900 francs as the estimation was based on the pre-design which was drafted one year earlier, on July 28, 1850. (State Archive Antwerp 1399) The lowest tender, Smeur-Durieux, a contractor of public works in Antwerp who

was at the time performing works to increase the fire safety of the *Entrepot General de Commerce* in Antwerp, was appointed the job. According to the building specification the contractor had to deliver the building in less than 5 months (by November 1<sup>st</sup>, 1851). (Van Langhendonck 1992)

Although Théodore Lebens was connected to the *Corps des Ponts et Chaussées* since 1838, he only worked in the province of Antwerp as *ingénieur de deuxième classe* since 1850, after a short interlude in France. His background and career are not well documented. Nor Lebens nor his chef Kümmer can be linked to important public buildings in iron, so the question rises who designed the innovative iron stack?

The contractor can play an important and innovative role during construction. However, in this case, contractor Smeur-Durieux was only appointed after the plans were drawn. Moreover, no modifications were made during erection; the building was constructed as designed. Even if some drawn theoretical details were hardly to fabricate in practice, deviations were not allowed. Correspondence of the administration of the *Corps des Ponts et Chaussées* reveals that casting the fine grid elements of the iron stack was extremely difficult. The contractor Smeur-Durieux first worked with a foundry in Antwerp and then moved to a foundry in Liege as a lot of the cast iron grids were rejected. (State Archive Antwerp 1399) Only after several trials the Galler foundry succeeded to fabricate the cast iron grid plates for the floors and bookshelves. (State Archive Antwerp 1399) Indeed, as the grid plates were relatively large (91 by 65cm), but only 0.6cm in thickness, the plates would warp and crack during cooling and shrinkage. Due to these problems the contractor Smeur-Durieux got several times the permission to postpone the delivery of the building, which was completed in the course of 1852 and for sure in use in 1853. (State Archive Antwerp 1399)

The archive depot was used for its original purpose until 1944, when a V2 bomb destroyed the surrounding buildings. The abandoned depot was protected as a monument in 1981 and refurbished in the 1990's. Since a decade, the archive depot houses a prominent wine shop. In the course of time an additional volume was added at the back of the archive, containing a staircase and elevator. The roof covering was replaced and four additional steel trusses were added to support the roof. Some parts of the cast iron staircase were replaced, but the complete iron structure with its cast iron grids, as well as the heating system are still intact, serving now as a witness of ingenious nineteenth-century engineering.

## CONSTRUCTION

As the protection against fire was a major issue at the time, lot of attention was paid to the fire safety of the archive depot. First, the new building was isolated from the neighboring buildings by a narrow lane to prevent fire spreading. Second, only incombustible materials were applied: brick, stone, cast iron, wrought iron and slates. Third, the window openings could be closed with iron shutters. And finally, the fire risk was reduced by placing the heating system on a separate floor. The fact that the entrance to the archive was positioned at a higher level and that it could only be reached via the governmental hotel and the office of the archivist, contributed to the general safety and to protection against theft.

The archive depot had to be positioned on a small building plot, which came available after demolition of a private house in the side street Geefstraat. To create a capacity of 1100m of bookshelves for the archive, several floors had to be built. The buildings adjacent to the depot were four levels high. Thanks to the ingenious iron structure and its reduced floor thickness of only 17cm, six levels, could be built within the same gabarit.



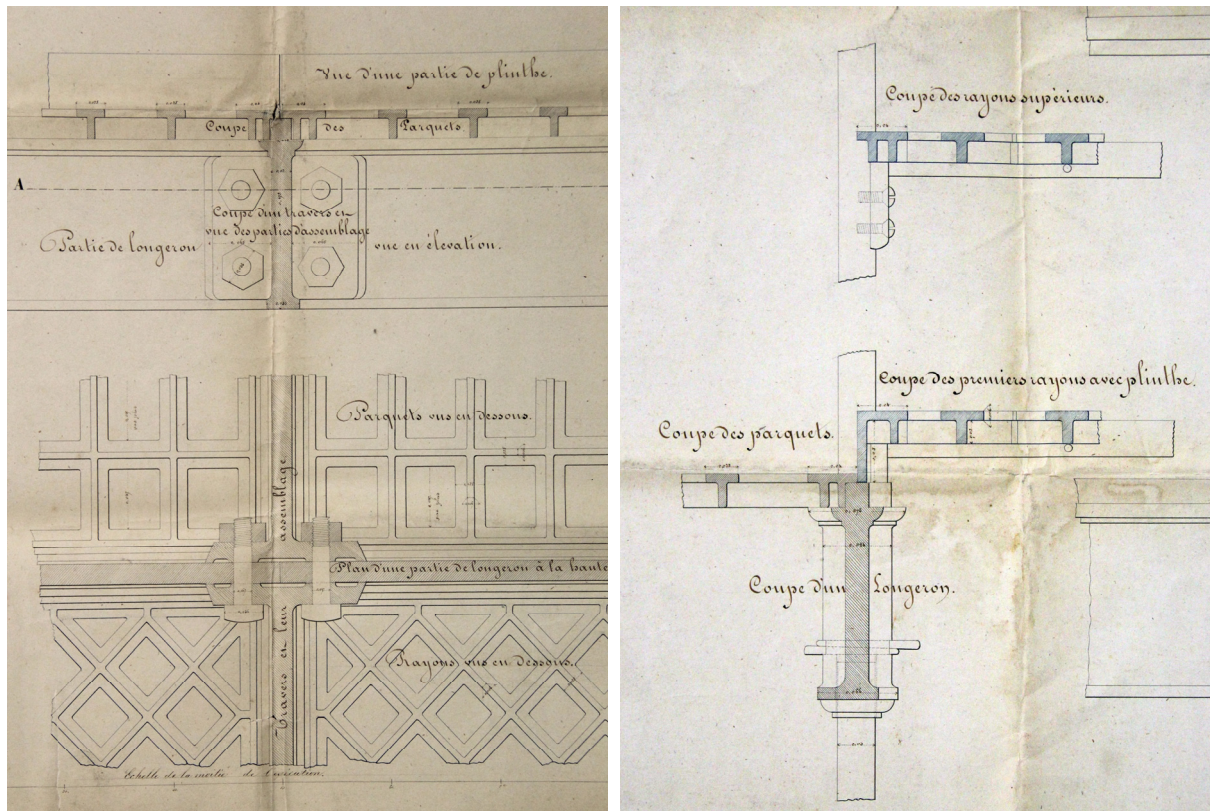


Figure 3: Two extracts from the original plan, drawn by engineer Théodore Lebens in 1851, explaining the construction of the iron stack. 1: Connection cast iron girder-joist, 2: Connection bookshelf-column (top) connection column-girder-grids (bottom) (State Archive Antwerp 6993)

### Heating system

It was a wise design decision to entirely separate the heating system from the valuable documents. Consequently, the heat had to be transported indirectly to the archive room. This was realized via a ‘calorifère’. This heating system consisted of a stove, which heats fresh incoming air indirectly via radiation. This fresh hot air is then transported to the archive room via iron shafts. The shafts end in outlets with movable grids, positioned in the four corners on the first floor. The movable grid enabled to control the amount of hot air entering the archive. In summer, the same shafts could provide fresh cool air via natural ventilation, when hot air escaped from the roof. The hot burning gasses of the stove were evacuated vertically, via a double walled shaft built in the central spire of the iron staircase. Via an iron door, positioned at the street, coal, which served as fuel, could be entered and stocked in this room.

The load bearing structure of this ground level is different from the upper levels. The heating room is covered by masonry vaults, spanning about 2m. As such, the upper archive room is separated from the dusty fireplace on the ground level.

### Book stack

The archive room counts five levels, which are connected via one central spiral staircase. (Figure 2) As the construction of the bookcases is integrated in the construction of the book stack, this room evokes an intense architectural and spatial experience. The fact that similar perforated grids are applied for bookshelves as well as for floor grids contributes to the overall ho-

mogeneity. The floors and the bookshelves are designed as a building system. To explain their built-up, we will first go into the individual components of the modular system.

The more than 300 wrought iron columns are all identical and consist of a round plain bar, 3cm in diameter and 248cm in height. On every level, ten ornamented cast iron girders, 17cm in height, span 520cm between the outer walls. As their position is determined by the module of a bookcase, the structural grid is dense, alternating between 65 and 75cm. Each girder consists of three smaller pieces which are connected with four bolts where they meet the cast iron joists. The girders fix the position of the columns as they slide about 3cm over the columns. Two iron wedges fixed the column.

Columns are transformed into bookcases by screwing horizontal bars onto the columns on pre-defined positions, at a height of respectively 5, 105, 145 and 185cm. Next, the bookshelves are placed on top of these horizontal bars. The bookshelves consist of diagonally perforated cast iron grids, which were not only put forward to improve fire safety, but also to permit good ventilation of the stocked documents, which was not the case with closed shelves. (Petroski 2000) The floor is covered with similar cast iron grids which are supported by the girders and joists. The transparency of the perforated floor grids allows natural light to be distributed and fresh air to circulate within the stack. The roof trusses follow the same structural grid. They consist of rectangular wrought iron bars (5cm by 1cm) and round compression elements (2cm in diameter).

As the stack relies entirely on daylight, the position of the bookcases depends on the window position. The lower levels have only windows at the street façade (east). Therefore, the bookshelves are positioned perpendicular to this façade to optimize the diffusion of natural daylight, needed when registrars are active in the building. However, daylight will mostly have been avoided to protect the valuable documents by closing the interior window shutters. The upper floor has only windows in its side walls. As a consequence the bookshelves are positioned in the opposite direction. On all levels smaller bookshelves are positioned against the outer walls. The book stack consists thus of a limited number of prefabricated iron elements, which can be assembled at the building site.

### **Structural work**

After the description of the structure, questions on the overall structural behavior of the stack remain. Did the designers conceive the structure as a self-supporting frame where loads are transferred via the columns from the 5<sup>th</sup> to the 1<sup>st</sup> floor? Do we have to interpret the structure as separate levels where the beams take up the load and transfer them to the outer brick walls? Or, are the bookcases hanging from the roof, which then acts as main structural element? This last option can be excluded, as the connection between roof and columns can't take up any tension. (Figure 1:7) If the first assumption would be valid, one would expect the diameter of the slender columns to increase going downwards, which is not the case. So, this brings us to the second assumption, raising the question whether or not the beams are strong enough to take up the loads and transfer them to the walls. If the cast iron girders would be fabricated in one piece, tensile stresses would mount to 60 MPa. Although this tensile stress is rather high to be taken up by cast iron, we also question the efficiency of the two bolted connections. Henceforth, the analysis of the structural components and their connections does not provide clear answers. However, studying the deformations of elements in the existing building adds to the understanding of the actual behavior.

Although the building is in overall good condition, some deformations and defects were observed. The deformation of the wrought iron columns on the first level indicates that stresses have been too high in these lower columns. Moreover, a defect girder-joist connection, with

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three missing bolts, implies that loads do not always pass through the main girder. Therefore, although we can't retrieve the original design intention of the engineer, observations of the current structural situation lead to the conclusion, that today, both columns and beams contribute to the load-bearing capacity of the iron book stack.

## CONCLUSION

From structural point of view, the provincial archive depot in Antwerp built in 1851-52, which integrates modular iron bookcases in an iron frame, can be seen as the predecessor of later fireproof stacks and libraries such as the Congressional Library of the United States Capitol or the National Library in Paris. Yet, in Belgium and beyond no traceable reference has ever been made in historical literature to the Antwerp archive depot. Was it because there was no famous architect involved in the design, because of its moderate shape or because of the fact it was a hidden gem, which was not open to the public? Either way, as several designers in various countries were developing similar systems, it proves that there was not only a need but also the knowledge and craftsmanship to develop those iron stack systems.

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