

The Hennebique Company: An Early Industrialization for the Reinforced Concrete (1880-1914)*

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Abstract

Recent years, various problems concerning reinforced concrete (RC) structures have happened in Japan, and various discussions are being taken. To consider such problems, it seems to be important to improve an appearance and a development of the RC. For that, this study focuses the Hennebique Company, the first RC company in the world. In our study, an initial RC technology in the world would be clarified according to the original materials of the company kept in France. As a primary part of the study, this paper overviews an establishment and a development of the company through a growth of an organization.

1. Introduction

Around early 1890s, François Hennebique (1842-1921) (photo-1) started one of the earliest great international firms for the building and bridge construction by the way of reinforced concrete. He succeeded to set up the use of the new material as a usual method both for the constructors and for some active architects as partisans. First he developed his activity in Belgium and France, where he set up the central bureau of the firm in 1893. Parallel to that, he quickly developed his system in France, European countries and colonies. The Hennebique archives were transferred to the IFA (Institute for the French Architecture) at the end of 1980s¹⁾.

The main periods of the history of the Hennebique firm could be presented as:

- 1) The technical research times of François Hennebique started in Brussels around 1880 and pursued in France. It ended by the crucial patentees of 1892-93 setting up the “Hennebique system” of construction. The opening of the Hennebique Company was 1892²⁾.
- 2) The firm increased its activities very quickly among France, others European countries and colonies. Furthermore the technical qualities of the “Hennebique System”, its success was mainly based upon an original, dynamic commercial organization. At its top, 1905, the firm got around 20% of the reinforced concrete world market³⁾.
- 3) The golden times of the Hennebique Co was followed by a more competitive period where he must firmly defend his top position. The progressive end of the patentee protection, the setting up of the European governmental control upon

construction as the French prescriptions of 1906, and the growing of a strong competition between specialized firms ruled such a period.

- 4) The World War I (1914-18) and few years after the death of François Hennebique marked the end of the originality of the Hennebique Company among the construction firms. It lost a significant part of its international markets and its research department became more ordinary. It came back to the group of current concrete firms till the end of the Company name, 1967⁴⁾.



photo-1 François Hennebique

2. From research for incombustible floor to the “Hennebique system”

Born in the northern part of France, François Hennebique was mainly a self-taught man. He started his career as a foreman for different workplaces in Belgium and Paris. At the end of the 1870s, he could get some contracts in the Brussels region as a little independent contractor. Aware of the needs of the building construction and curious of technical

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innovation, he focused his attention upon the question of incombustible floors. The iron girders were not so good against fire.

In 1886, he got its first patentee for "tubular floors" made with concrete reinforced by iron bars inside the structure, certainly without real experiments in reinforced concrete. Sometime, François Hennebique claimed that he started its first experiments around 1880⁵⁾. Nevertheless, its first significant constructions using reinforced concrete floors for some private villas in Belgium were identified at the end of 1880s⁶⁾. Trough a later brochure, the Hennebique Co. indicated its first attempts for the year 1888: François Hennebique poured reinforced concrete for a first prototype floor inside the yard of the firm place. He made some attempts with concrete girders reinforced with low and high, round iron bars linked with regular, flat iron pieces. Getting exceptional strength tests, he decided to use the solution for the Madoux villa at Lombardzeye, Belgium⁷⁾.

Obviously, it was not the first reinforced concrete attempt despite the brochure too rapid assertion. F. Hennebique itself had made some references to the Monier researches in reinforced concrete as a source for his first inspiration for such a solution⁸⁾.

François Hennebique was especially aware of the cost of iron and for the difficulties to find round iron bars. He also paid attention to simplify the implementation process at the workplace. His research for getting the most efficient system for concrete floors evolved to different directions. One attempt was for a lower iron sheet process both to be the concrete cofferdam and to be a permanent reinforcement. One other was a crossed beams system but the most significant improvement was getting by the simplification of the reinforced bars inside the concrete material. He kept only the lower horizontal bar for the main tension strength upon the girder. Short, flat iron bars completed such a bar. They were regularly set up in vertical position toward the upper side of the concrete. The empiric manner researching both the good structures for the simplest implementation was the surest guide of Hennebique.

The different solutions led him to get Belgian and French patentees in 1892 and 1893. That bore the Hennebique technical system defended by a pool of patentees. The reinforced beams system was completed by concrete pillars directly linked with it. That made a continuous and apparent fine skeleton for concrete construction, as vertical and horizontal ribs. Such a system was based upon the "étrier" method for the iron network and the continuous monolith concept⁹⁾.

Certainly, Hennebique was not the first to propose a "system" involving the monolith concept with an efficient iron structure inside the concrete. Such ideas were also present inside other construction systems as Coignet¹⁰⁾ or Cottancin did in France or Wayss and Freytag¹¹⁾ in Germany and Austria. However Hennebique had a deep sense of the workplace context and his system was certainly one of the most simple to implement without many specialized workers. He had the sense of the minimal use of metal inside the structure by the choice of its most efficient place. It was also one of the cheapest systems for a standard technical result if the Hennebique guideline was correctly followed by the

builders.

Such a system dealing with an economic approach of the workplace bore a good sound for customers. It suggests one of the reasons of the extremely quick Hennebique's success. Another general aspect must be underlined to understand why the reinforced concrete process got a strong early success in France. Among the major industrial countries of the 1880s, France suffered of the highest cost for irons because its iron ores and coal mines resources were the most limited¹²⁾. New technology limiting the iron bars use was welcome. On the other hand, the resources for limes, even hydraulic limes, were good and largely scattered among the French regions, with an ancient tradition in understanding and use of the cement and concrete methods. Pavin de Lafarge, Louis Vicat and Marc Seguin brightly illustrated such an old tradition among the French civil engineers from the early 19th Century¹³⁾.

3. The early times and the first successes of the Hennebique Co.

Hennebique linked the beginning of its Company with the getting of patentees, as a planed strategy. First step showed an association with the Belgian industrialist J.J. Septon, in 1892 in Brussels. G. Delhumeau asked the question to know if Septon, a fine accountant who managed the first months of the firm in Brussels, initiated the Hennebique organization. As early than 1893, Hennebique could reach its complete independence and he soon opened a Parisian bureau¹⁴⁾.

The amount of contracts rapidly increased during the years 1893-1894 with some important industrial buildings in the Northern France. The most featured constructions of this period were the grain silos and flour mill of Brébières, a weaving factory at Armentière, a textile warehouse and a woolen factory in Tourcoing, the Bernard sugar factory in Lille.

The rightness of the initial Hennebique's purpose for incombustible floors and his active lobbying among the textile managerial bourgeoisie of Northern France, his born country, bore its immediate success for the industrial building construction. Such a solution was well fitted in a specific country with an old tradition for the textile industry and important fire risks. But it is not the alone reason of success. We must also note the supple adaptation of the Hennebique process to the variable industrial contexts. The interest for some new solutions allowed by the reinforced concrete was also great, as the shed roof for getting lighter inside the factory, the large and clear span for the concrete girders or the thinness of walls and structures. Hennebique organization offered also short delays for studying plans and technical solutions by the efficiency of the Hennebique's research office. However, the involvement of local contractors by the system of the concessionaire companies bore a local touch and trust. The well-controlled delays and cost of construction completed the feeling of a good affair. Furthermore, the first development of the Hennebique system showed some important qualities to serve the functionalist concept of industrial architecture.

Quickly the firm got some other important contracts in Paris' industrial suburbs with the sugar factory of Saint-Ouen

(1894) and the large flourmill of Nantes (1894). These two workplaces were exceptionally important for the Hennebique Co, as references for its capacity to manage big projects leading to large workplaces for short delays. During this early period, the Company also opened foreign agencies in Switzerland, Spain and England, getting early an international touch.

To explain the Hennebique success for a so short time there were also an exceptional organization with many innovative managerial aspects.

4. The Hennebique technical and economical organization

The principle of the Hennebique organization were settled immediately at the starting time of the firm in Brussels in 1892-93, parallel to the patentees strategy and the commercial information for incombustible floors. Delhumeau speaks about the "Hennebique offensive"¹⁵⁾. The firm itself summarized its organization purposes as:

"From all preceding [examples], it seems to result clearly that the reinforced concrete is the absolute construction material, from which use is offering all the advantages both for the owner and for the architect, under the condition it was studied by a competent specialized engineer and executed by capable contractor. The Hennebique Co. organization trends towards this couple of goals."¹⁶⁾

The organization of the firm concerned the technical management of the projects and a very new decentralized approach. It involved both the construction technical relationships and the workplace management. It based upon three structures and must be understood as a dynamic relationship from center to border and reciprocally, as the life of the firm. It could be preferable to talk about an industrial group within a strong management between identified partners than a real integrated company.

The three structures of the Hennebique management were: the central research office quickly transferred to Paris, the local entrepreneurs getting the license of the "Hennebique system" for reinforced concrete construction, and the regional agents as a key intermediate structure. That corresponded with the three classes of collaborators defined by François Hennebique:

"1) My agents assuming the direction of the regional or foreign technical offices, and able to set up the pilot study and the detailed estimate for a project."

"2) The contractors – concessionaires under license of one of my patentees, as executives for the workplaces."

"3) The engineers and technical drawers employed inside my offices"¹⁷⁾.

Note the F. Hennebique difference of style between *my agents* and *the contractors*. The first was a trusty collaborator representing the firm, the second a partner under agreement.

After 1893-94, Hennebique was not an entrepreneur by itself but the owner of a bloc of patentees offering a complete and adaptable system for construction with the reinforced concrete. He looked for some local or regional contractors able to manage the workplace under his technical control by the making up of the project studies and plans. Well known entrepreneurs among a region were the best, as Dumesnil was for Paris. Furthermore, commercial and administrative crucial features surrounded the construction itself before the final agreement and during the workplace time.

The concession of the license was ruled by a simple standard agreement between Hennebique and the entrepreneur. The central research office studied deeply the project submitted by the entrepreneur or the regional firm agent. It must follow all the technical steps of the project, producing the preparatory studies for getting the affair, drawing the complete plans and the complete safety calculations. The central office also sent some specialized technician at the workplace to give advice and to follow the good application of the Hennebique process. During the early times, it was frequently François Hennebique himself who did the field task of advisor, teaching the reinforced concrete workplace to the contractor and workers. The Company was co-responsible with the contractor for the construction¹⁸⁾.

The engineers and technical drawers, as the global technical staff of the firm started modestly at two in 1892, as direct assistants of François Hennebique during the Brussels first step. Quickly it reached 14 in 1894, 56 in 1897, close to 100 in 1900 and around 380 at the top before the First World War. This global staff was shared between the central office in Paris, settled at n°1, Danton Street, after 1901 and the regional agencies. The Parisian staff had some fine engineers mainly from the "Ecole Centrale" and could get the help of some well-known architects as Boileau. The central Parisian staff reached around 100 engineers and technicians in 1905¹⁹⁾.

The contractors could use the name of Hennebique process concessionaire and looking for new projects behalf the company. In counterpart he had to pay 10% from each affair agreement to the Hennebique Co. He also must reach a total amount of affairs under license each year. The subtlety of the Hennebique attitude toward its concessionaires consists of to give a license to one contractor for a region but without any monopolistic situation. The contractor was attached to a regional agent with others contractors under license. It was a regional group of entrepreneurs with possibilities of internal

Table 1: Hennebique Co. organization and activities during 1890s²¹⁾

Year	Agencies	Contractors under patentee	Studied projects	Effective constructions	Affair amount(FF)
1893	2	6	174	41	900 000
1895	7	21	304	127	2 000 000
1897	17	55	1 542	473	8 200 000
1899	26	141	2 789	1 235	21 300 000

concurrence. For specific workplaces, Hennebique could allow some outside contractors to get agreement. The quick development of the reinforced concrete market, the diversity of projects from ordinary buildings to specialized civil engineering, and the needs of several enterprises allowed such an attitude for the largest workplaces. I.e.: five contractors under the Hennebique license acted for the Paris world exhibition of 1900 for six constructions contracts²⁰⁾.

5. The Hennebique agents and the geographic firm organization

Agents for French region and foreign countries become quickly an essential step between the central office making the deep studies and the local context of affairs, particularly the relationships with architects. The first task of the agent was to manage the technical research office for its region, studying pilot projects and estimating the proposals for owners and architects.

“The architect will found in the Hennebique firm a devoted collaboration to prepare free of charges all the projects he have to undertake; he have simply to ask for, and whatever the country, the closest agent will at its disposal and he will indicate the specific advantages the reinforced concrete borne to the project he is studying.”²²⁾

During the early 1910s, agencies with research office reached close to 60 for around 40 foreign countries²³⁾. Then, engineers and drawers were around 280 for the agencies and 100 for the central office of Paris. For that period, it was certainly the most important technical research office for construction and civil engineering in the World. However, quality of detailed studies, quantity of files studied and generally short delays offered a strong specificity for the Hennebique firm. It reached its top efficiency mainly before the French prescriptions of 1906 for the use of reinforced concrete²⁴⁾.

Almost simultaneously all the European countries adopted such guidelines bearing new rules to the practice of reinforced concrete. On the other hand, many patentees of

concrete pioneers felt in the public domain. The technical offices from Hennebique and others reoriented their activities, following the decreasing for deep and detailed studies. As Delhumeau asserts: it was the transition time from “system” to “material”²⁵⁾. That means from the application of a controlled construction process under patentees from Hennebique or others to an almost ordinary and free use of a construction material. Then, such a use followed official guidelines for practical application and scientific methods for the material strength calculation.

Furthermore, the Hennebique agent must assume diversified and crucial tasks for the Company. He must set up a large network of personal relationships to get contacts for affairs, to be an active representative of the firm among regional and foreign elite making the yes or no of business. He had also to perform the administrative approaches and to integrate the official construction guideline into the firm proposal, as the construction prescriptions and final control tests. Furthermore, the agent assume a coordinator role with the contractor to supply the workplace at the low best cost by the local or allied suppliers for cement, iron bars, raw materials, etc. The agent had to make a permanent and active survey for the building market and for the construction policy of the authorities.

6. Circulation of technical ideas: a new and efficient management tool

The Hennebique Central office also organized the presence of specialized consultants at the workplace site. They have the mission to survey the most important workplaces and to give advice to the contractor and the foremen. That guaranteed the most efficient practices for the reinforced concrete uses, following the “Hennebique system”. They assumed a living links between actors of the group and also the technical diffusion of the main practical ideas for the general success of reinforced concrete for the 1890s to the World War I²⁸⁾.

François Hennebique and the central bureau made very pedagogical plans with clear explanations and specific guidelines for the implementation of every projects studied by the Central research office for the concessionaires. That

Table 2: The geographical Hennebique organization in December 1905^{26), 27)}

	Agencies :	Agencies and sub-agencies total :
France	Paris, Lille, Lyon, Nancy, Nantes (2 sub-agencies), Bordeaux, Chalons-sur-Marne, Granville, Rouen, Marseille, Perpignan, Clermont-Ferrand, Toulouse, Dijon	15
Europe	Germany (+ Austria), England, Belgium, Denmark, Spain (2 agencies), Greece, Holland ¹⁾ , Hungary, Italy (7), Portugal, Russia (2), Finland, Poland, Sweden, Switzerland (2)	20 (+ 4) countries : 16
Asia and Middle East	Japan, Vietnam, Turkey, Turkestan	2 (+ 2) countries : 4
Africa	Egypt, Tunisia, Algeria, Morocco, South-Africa	3 (+ 2) countries : 5
America	Canada, USA (5 agencies), Argentine, Uruguay, Brazil, Equator, El Salvador, Guatemala (+ Honduras, Nicaragua & Costa-Rica), Mexico, Panama (+Colombia), Venezuela	12 (+ 3) countries : 15

happened with many details during the first period of the firm, from 1893 to the middle of 1900s. After the early times, that remained as a touch of the Hennebique studies associated for a long time to the legal technical responsibility shared between the central office and each contractor for every construction.

The specialized workers and technicians sent to the main workplaces acted beyond plans and manuscript guideline. They had to help the contractor for the implementation and the management of the workplaces. François Hennebique himself performed such field expert missions during the early time of the firm. In his mind, it was a crucial and pedagogical aspect of the concessionaire organization. They formed quickly a diversified human group merging expert foremen and engineers, all them aware of the practical questions for the reinforced concrete. They followed the workplaces and contractor needs, specially for the early times, dispensing practical knowledge about the workplace plants, cofferdams, making up the iron net and explaining how to do and to pour the concrete, etc.

When the agencies system started, it was typically one of the management roles of the agency engineers between the concessionaires in charge of realizations and the Central office in charge of technical studies. There were not rigid distinctions and not permanent functions for such a job. Experts came from the every part of the Hennebique organization and from all level, but mainly from the Central office. The expert assignment balanced between personal capacities and available technicians.

Quickly, such individual links with concessionaires and exchange of experimental knowledge seems too limited for François Hennebique and his staff. He decided to reinforce the sense of the group and the feeling of contractors to be members of a technical elite. The first collective manifestation was a banquet organized for the celebration of the 1000th studied project by the firm, on first May 1896. It was decided to make firm banquets for every new 1000 new studied projects. They regularly happened: two in 1897, two in 1898²⁹⁾.

But that seemed quickly not enough and a too limited manifestation. The firm wished to bring more pride from the Technology to all its members: contractors, agents and engineers. For that, technology bore itself the central feature for the individual identification to the group. Technology meant of course there the “Hennebique System”. The Company decided to organize an every year congress for the reinforced concrete.

During the beginning of year 1897, the first congress happened, linked with the opening of the new Parisian bureaus. Practically, it was mainly devoted to the Hennebique realizations, but it have some public manifestations and invited personalities as “Ponts et Chaussées” engineers, famous architects, etc. It appears as a putting on stage for the reinforced concrete technology and as a collective celebration with official speeches, technical talks, exhibition of photos for workplaces and masterpieces, banquets, visit of Parisian workplaces, etc. The second one happened for February 1898, the third for January 1899³⁰⁾.

The rapid development of the Hennebique firm and its immediate international dimension needed a more structured

link for the exchange of technical ideas and the diffusion of the group realization and capacities. The edition of a monthly periodical devoted to the reinforced concrete was decided at the second congress of February 1898. Hennebique gathered an editorial staff settled in the Central office, directly linked with the Documentation and archive service. Named “Le béton armé”, the first issue was published on 1st June 1898, a twelve page journal. The editorial was devoted to the originality of the Hennebique technical system and to its social purposes. The first journal goal was the regular diffusion of the information among the group, for the customers and for the partners as architects or engineers. Accounts of workplaces, accounts of reception tests, photos of masterpieces immediately displayed a central role inside the journal³¹⁾.

Photos take quickly an important place as a visual symbol of the Hennebique success story, and as an evidence for the architectonic role of the reinforced concrete and its diversified fields of use. Specific plates fully devoted to photo reports appeared for the 8th issue with the monumental and aesthetic construction of the three span bridge of Chatellerault³²⁾ (photo-2).

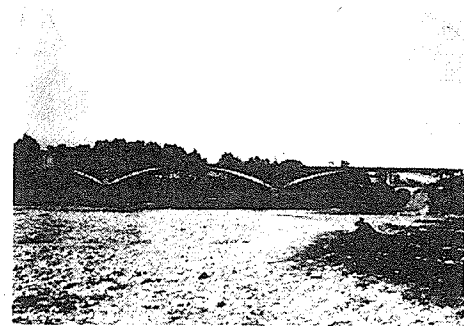


photo-2 The Chatellerault Bridge

7. Conclusion

The efficiency of the “Hennebique system” relied upon two main complementary items. First item was the global efficiency of the technical Hennebique proposals by its simplicity and for one of the lowest cost inside the market competition. Second one was its group organization based upon the first attempt in civil engineering and building construction for the concessionaire system, ruled by a very dynamic social structure.

Using such methods, the group immediately reached an international dimension getting some important agreements, first in Northern and Western France, Belgium and quickly in Italy, England, Switzerland, Spain or Egypt. The concessionaire structure avoiding regional monopolies and the agent system well supported a so fast increasing of affairs and geographical zone.

The strong Central research office fuelled by young and capable engineers mainly educated at the famous Parisian “Ecole centrale” allowed the firm to deep and quick numerous studies in the every fields of the building construction and civil engineering. Such studies were done on

the free charge principle, till during the 1930, where the number of 100 000 studies was overcome by the Hennebique Co.³³⁾

Organization of congresses and publication of the periodical "le béton armé" obviously were an interested manifestation and a professional edition under its total control, fueling the Hennebique affairs and reinforcing its structures as well as its reputation. Furthermore, such initiatives deeply contributed to the diffusion and the popularization of the reinforced concrete technology among Europe and many others countries.

Notes

- 1) The Hennebique's Archives were first presented at the IFA meeting: "Archives industrielles, archives d'architecture", IFA, Paris, December 1989.
- 2) Gwenaél DELHUMEAU, *L'invention du béton armé. Hennebique 1890-1914*, I.F.A. (Institut Français d'Architecture) & Norma ed., Paris 1999. She bears a decisive thesis to the understanding of the Hennebique Co. The more today complete Hennebique study.
- 3) Antoine PICON, *L'art de l'ingénieur*, Centre Georges Pompidou, Paris 1997, p. 223.
- 4) Michel COTTE, "Hennebique François", in Michel RAGON, *Dictionnaire des architectes*, Encyclopaedia Universalis & Albin Michel, Paris 1999, p. 308-310.
- 5) *Le béton armé*, n° 1, June 1898, p. 1-2. "Le béton armé" means "The Reinforced Concrete" in French. Hennebique is the first regular user of such term in French.
- 6) G. DELHUMEAU, *op. mentioned*, p. 40-44.
- 7) HENNEBIQUE Co., *Le béton armé Hennebique*, Paris [1929], brochure of 61 p., p. 5.
- 8) [François HENNEBIQUE], *Le béton armé*, n° 1, 1st June 1898, p. 1-2. It is the editorial of the first issue of the Hennebique Co. Periodical, certainly by F. Hennebique itself.
- 9) *Le béton armé*, n° 28, September 1900, p.4. For this crucial period, Hennebique got two Belgian patentees in February 1892 and July 1892, and three French patentees in August 1892, August 1893 and December 1897.
- 10) First attempts for using the iron reinforced concrete was made in France by Joseph-Louis Lambot (1848), Joseph Monier (1849) and François Coignet (1852) who was probably the first to propose a "system" for buildings applied mainly by his son Edmond after 1890.
- 11) Antoine PICON, *op. mentioned*, p. 543. The firms Freytag and Wayss bought the Monier's patentee in the middle of 1880s. They merged in 1893 and got a large success in civil engineering with the reinforced concrete method inside Germany, Austria and Central Europe.
- 12) The 1870 German – French war reduced drastically the mineral French resources by the occupation of a part of Lorraine rich for iron ores and the French part of the Sarre coal field.
- 13) Ichiro KOBAYASHI and Michel COTTE, "On the foundation works of the Tain-Tournon bridge designed by Marc Seguin", *Historical Studies in Civil Engineering*, Japan Soc. of Civil Engineers, n° 15, 1995, p. 175-186.
- 14) G. DELHUMEAU, *op. mentioned*, p. 104-105.

- 15) G. DELHUMEAU, *op. mentioned*, p. 104-105.
- 16) [HENNEBIQUE Co.], *op. mentioned*, [1929], p. 57.
- 17) *Le béton armé*, n° 28, September 1899, p. 7. A very interesting issue of the Hennebique periodical summarizes the Company activities for the 1890s.
- 18) G. DELHUMEAU, *op. mentioned*, p. 112-147.
- 19) *Le béton armé*, n° 28, September 1900, p. 7-8; Antoine PICON, *article mentioned*.
- 20) *Le béton armé*, n° 28, September 1900, p. 6.
- 21) *Le béton armé*, n° 28, September 1900, p.8.
- 22) HENNEBIQUE Co., *op. mentioned*, [1929], p. 57.
- 23) *Le béton armé*, printed regularly the detailed list of agents, bureaux and contractors under license classified by French region or by foreign countries.
- 24) MINISTÈRE DES TRAVAUX PUBLICS, *Commission du ciment armé: expériences, rapports et propositions, instructions ministérielles relatives à l'emploi du béton armé*, Paris 1907.
- 25) DELHUMEAU, *op. mentioned*, p. 263.
- 26) *Le béton armé*, n°91, December 1905.
- 27) In Italics: concessionaire or sub-agency or individual engineer acting as representative of the Hennebique firm but without permanent research office.
- 28) G. DELHUMEAU, *op. mentioned*, p. 119-123.
- 29) *Le béton armé*, n° 7, December 1898.
- 30) *Le béton armé*, n° 9, February 1899.
- 31) *Le béton armé*, n° 1, June 1898.
- 32) *Le béton armé*, n° 8, January 1899.
- 33) HENNEBIQUE Co., *op. mentioned*, [1929], p. 57.

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