Changing Cultures

European Perspectives on the History of Portland Cement and Reinforced Concrete, 19th and 20th Centuries

Edited by
João Mascarenhas-Mateus

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The construction practices we employ in our daily life in European societies today were shaped by major changes in the past, such as the introduction and dissemination of Portland cement and reinforced concrete, a development that constitutes a fundamental chapter in the history of construction in the 19th and 20th centuries. Such changes were boosted by several innovations in the fields of applied mathematics, chemistry and physics. They involved patents licensing, optimization of materials production and machinery. There were new legislative frameworks, a specific knowledge transfer within a network of actors and the transformation of hierarchical frameworks.

Written by international specialists, this two-part book is centred on case studies from the UK, Germany, Switzerland, France, Belgium, Portugal, Spain and Italy. The first part explores the mutual international influence between these countries and their intrinsic characteristics in this field, resulting from each nation's particular economic, social, political, cultural and technological conditions. The second part focuses on the history of public works companies. Capable of carrying out both private works and major infrastructures, these players exemplify the technological and business advances that the construction sector has experienced over the last two centuries. This book is a must-read for researchers on contemporary construction history in Europe.

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In 2010 and 2015, he organized the First and Second Portuguese Conferences on the History of Construction in Portugal. He was one of the coordinators of the Organizing Committee of the First and Second International Congresses on Luso-Brazilian Construction History (2013 and 2016) and the founder (since 2015), former president (2018–2021), and present vice-president of the Portuguese Society for Construction History Studies (SPEHC). He is a member of the editorial committee of the *International Journal of the Construction History Society*. He was the chairman of the Organizing Committee of the 7th International Congress on Construction History (7ICCH, Lisbon 2021).

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Jelle Angillis is a historian with a broad interest in the history of architecture and construction in combination with social and cultural history. Angillis was initially active in the building industry itself. At the University of Antwerp, his doctoral research on building practice in post-war Belgium combines his practical experience of the building industry with insights from historical research. In his research, Angillis mainly focuses on the fact that, besides concrete design, social interaction, labour and many hands have also shaped Belgium's built environment. According to his findings, the design is inseparable from the execution, the materials and people who materialized the drawn line. His publications have focused on the history of public works contractors and Antwerp's post-Second World War construction culture.

Inge Bertels is a Belgium historian and Master in Conservation. Her personal research focuses on the intersection of 19th and 20th century construction history, architectural and urban history. From 2000 to 2006 she was linked to the R. Lemaire International Centre for Conservation and the Architectural History research group of the Department of Architecture, Urbanism and Planning of the Katholieke Universiteit Leuven, where, in April 2008 she successfully defended her PhD "Building the City, Antwerp 1819–1890". Later she worked as a postdoctoral fellow of the Fonds Wetenschappelijk Onderzoek at the Centre of Urban History of the Universiteit Antwerpen, and as a lecturer and researcher at the Department Architectural Engineering of the Vrije Universiteit Brussel. Since February 2018 she has held a full-time position as Full Professor of Architectural History and Building Culture at the Faculteit

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Mike Chrimes is a former Director of Engineering Policy and Innovation at the Institution of Civil Engineers (ICE), United Kingdom. Having been responsible for major public works projects, he has a vast knowledge of management in civil engineering with a particular interest in the use of digital media to provide a global information service to the ICE. He has written and lectured extensively on information services for civil engineers and the history of civil engineering. One of his many subjects of interest is the history of engineering and the work of British engineers in South Asia during the British Raj. He has published many books about his investigations, namely *The Civil Engineers: The Story of the Institution of Civil Engineers and the People Who Made It* and the three-book series published by ICE, London: *The Civil Engineers* (2011), *The Contractors* (2013) and *The Consulting Engineers* (2020), co-authored with Hugh Ferguson.

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(2015), former president (2018–2021), and present Vice-President of the Portuguese Society for Construction History Studies. He is a member of the editorial committee of the International Journal of the Construction History Society. He was the chairman of the Organizing Committee and Proceedings editor of the 7th International Congress on Construction History (7ICCH, Lisbon 2021). Author of several papers in scientific journals, his publications include *Técnicas tradicionais de construção de alvenarias* (Lisbon: Livros Horizonte, 2002) and coordination of the books *História da Construção em Portugal: fundações e alinhamentos* (Coimbra: Almedina, 2011) and *História da Construção em Portugal: consolidação de uma disciplina* (Lisbon: By the Book, 2018).

Michel Provost teaches construction techniques at the Université libre de Bruxelles, Belgium, both at the École polytechnique and at the Faculté d'architecture La Cambre Horta. He is also a consulting engineer in charge of structural studies for several projects in infrastructure, building and heritage. In all these activities, he has always maintained close links with the educational sphere. He has published works on underground structures, on the interaction between structure and architecture (e.g. on the pavilions of the 1958 Brussels World Fair), engineering heritage in Belgium and in the Democratic Republic of Congo during the 19th and 20th centuries. With Bernard Espion and Rika Devos, he was responsible for the highly pioneering and innovative project aimed at the preservation and study of the contractor Blaton's archives (Brussels, 2014–2016).

Gilbert Richaud is an architect and researcher at Laboratoire de Recherche Historique Rhône-Alpes UMR 5190, Lyon, France. His work is focused on the study of the history of concrete during the 18th and 19th centuries. He is author of fundamental books on Antoine Desgodets and François Cointereaux and their vital importance to the development of rammed earth constructions. Richaud has dedicated a great deal of work to the relations between the concrete of Ancient Rome and first modern concrete. He has also studied the architect Gaspard André and his pioneering work in Lyon and Genève during the second half of the 19th century. He is author of reference books on those subjects, including *Palladio and Concrete: Archaeology, Innovation, Legacy* (L'Erma di Bretschneider, 2021) with Louis Cellauro, and was the coordinator of titles such as *Les leçons de la terre: François Cointeraux (1740–1830), professeur d'architecture rurale* (Paris: INHA/ Les Éditions des Cendres, 2016) with Laurent Baridon and Jean-Philippe Garric.

Mario Rinke is a Professor at the Faculteit Ontwerpwetenschappen, University of Antwerp, Belgium. He teaches and researches in the fields of technology and architecture. Genuinely interested in transformation processes between areas of knowledge, materials and institutions, as well as structural thinking, he has specialized in hybrid material concepts, early reinforced concrete and early industrial timber (glulam), but also historical and contemporary concepts of adaptable structures. Trained as a structural engineer, he worked as a design engineer for major offices in London and Zurich and ran his own practice in Zurich for several years. Mario Rinke holds a Diploma-Degree in Civil Engineering from the Bauhaus University Weimar and a PhD from Eidgenössische Technische Hochschule (ETH), in Zurich. He was senior researcher and lecturer at the architecture department of ETH and senior lecturer at the Lucerne University of Applied Sciences and Arts. Currently, parallel to his teaching activity he serves as a member of scientific committees, and as a reviewer for different scientific journals. He is a founding member of the International Association of Structures and Architecture (IASA) and is currently a member of its management board. Apart from the many articles he has produced for scientific journals and book chapters, Mario Rinke has edited and co-edited several books, including *The Bones of Architecture: Structure and Design Practices* (Zurich: Triest Verlag, 2019).

Edwin Trout is Manager of information Services at The Concrete Society (United Kingdom) and previously at the British Cement Association. He has acted as Executive Officer of the Institute of Concrete Technology (ICT) since 2011. He has a special interest in the history of Portland cement and concrete industries. His book *Some Writers on Concrete: The Literature of Reinforced Concrete, 1897–1935* published in 2013 by Whittles Publishing, Scotland, traces the emergence and development of the specialist book on concrete, at a time when reinforced concrete was a new technology. Edwin Trout has written widely on the history of institutions and individual actors involved in the cement and concrete industries in many different scientific journals, and contributes regularly with a column to *Concrete*, the Concrete Society magazine.

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Introduction

João Mascarenhas-Mateus

In 1909, the book *Reinforced Concrete in Europe* by Albert Ladd Colby (1860–1924) was published with the aim of disseminating in the USA the advances in reinforced concrete made in each of the European countries at that time. Besides introducing the main systems, types of reinforcement bars and their applications, the work describes an intermediate phase of a paradigm shift in the constructive cultures of the Old Continent in which the institutions capable of establishing consensual rules of use for the new construction culture became recognized and – importantly – the first national codes on reinforced concrete construction and the introduction of Portland cement were produced. Since the publication of that essay, several fundamental works have been published on the history of Portland cement and reinforced concrete in the fields of architectural history, art history or history of technology, such as *Concrete: The Vision of a New Architecture* (1959) by Peter Collins (1920–1981); *Le Béton, Histoire d'un Matériau. Économie, Technique, Architecture* (2005) by Cyrille Simonnet (1952–); *Concrete from Archeology to Invention (1700–1769)* published in 2013 by Roberto Gargiani (1956–); or more recently, *German Concrete. The Science of Cement from Trass to Portland, 1819–1877* by Salvatore Aprea, published in 2016.

Today, at a time when reinforced concrete already firmly belongs to a globalized construction tradition, it seems pertinent to focus on the ontology of this culture in Europe, broadening the discussion beyond the authors of inventions, patent owners, structural theorists and rationalist architects from France, Great Britain and Germany, who were revered in the aforementioned books. How did the advent of reinforced concrete manage to diminish the use of millenary cultures of masonry, carpentry and rammed earth to such reduced proportions? What were its origins, and why was this new culture adopted by European countries? The main objective of this book is to reflect on these questions and contribute to answering them. Specialists from different European countries besides Portugal (Spain, France, UK, Belgium, Switzerland, Germany and Italy) were invited to take part in the endeavour to produce a critical reading of this shift paradigm in their own countries. This exercise in critical analysis is framed not in architectural history or the history of technology but within the study of the history of construction, understood as the history of building cultures – in other words, the history of everyday life in communities in relation to the activity of building.

The ways in which we build today in Europe and around the globe result from a cultural paradigm shift initiated with scientific innovations that proliferated during the Enlightenment, accelerated by the dynamics of the industrial revolution, the advent of steam power and steel in construction, and the study, application, testing, refinement and regulation of Portland cement. This process was articulated within a network of actors, which was not limited to patent inventors, academics, engineers and architects; rather, individual and collective contractors,

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construction materials manufacturing and resale companies, and public administration institutions also made a fundamental contribution to this change. For this reason, to address more deeply the intricate relationships that were established between networks of actors, this book is divided into two parts.

In the first part, the transformations of the construction cultures of each country are studied from different perspectives: patent registration; administrative policies; knowledge transfer, and in particular the training of engineers and architects; machinery; corporate organization of actors; dissemination aimed at the general public and specialized publications for academics and technicians; and local, regional and national legislative regulations.

The second part analyses the historical paths of different public works construction companies that contributed to the reception, development and projection of reinforced concrete in the UK and Ireland, Portugal, Belgium and Italy as well as in many of the regions under the colonial administration of these countries, extending the geographical scope of the influence of the new construction culture to other countries, especially on the African continent. These national actors, who often had impressive international profiles, have thus far been little studied. Yet they were fundamental to the consolidation and dissemination of new ways of building, starting with early models emerging in France and the UK.

The book begins and ends with texts on the case of Portugal, a peripheral nation situated on the western edge of the European continent with an intermittent capacity for technological updating (due to its geostrategic position and the transformations in its political regimes) that has nevertheless received, processed and adapted reinforced concrete in its daily constructive activity.

Thus, Chapter 1.1, by João Mascarenhas-Mateus, gives a broad overview of the cultural, commercial, economic, academic, legislative and institutional spheres that reflected this paradigm shift in Portugal. The period of study starts in the second half of the 19th century, with the first national activity to produce artificial hydraulic limes and natural cements and the importation of Portland cement. The analysis takes in the discussion in specialized journals and monographs on the limits and the advantages of the new construction process to understand how an excellent consensual reputation for reinforced concrete was created. It concludes with the year 1935, when the second national reinforced concrete code was published, reflecting the consolidation of a new culture that would be used effectively by the new authoritarian regime of the Estado Novo.

The following text, Chapter1.2, by Edwin Trout, reviews successive steps in Britain's dissemination of Joseph Aspdin's 1824 Portland cement patent and the efforts made to catch up with the reinforced concrete that had had its first commercial success in France and was the subject of theoretical studies and codification in Germany. It describes the institutional constraints initially faced by the first patented systems and licensed contractors. For example, Louis Gustave Mouchel, Hennebique's patent agent, struggled to be accepted by official building regulations, while other actors sought to achieve freedom of design. The study follows this whole process up until the full exploitation and promotion of reinforced concrete was permitted by different regulations, influential texts and the publication of the 1934 UK Code of Practice.

Gilbert Richaud dedicates Chapter 1.3 to France. He begins by underlining the importance of François Cointereaux's studies at the end of the 18th century in revisiting the ancient *structura caementicia* and looking to the creation of a new constructive system of concrete moulding by optimizing the millenary process of *pisé*. This new system was made possible by the development and theorization of high-strength mortars by researchers such as Louis-Joseph Vicat. The author then describes the genesis and great international dissemination of the works carried out in *béton aggloméré* by François Coignet, as well as the large-scale uses of his system of new monolithic masonries. The text goes on to discuss the early works of Gaspard André and Tony Garnier to explain how their pioneering works made it possible to theorize on the use of plain concrete in the construction of walls to create an aesthetic made up of simple volumes with rectilinear lines and reinforced concrete for the construction of floors and roofs.

The following text, Chapter 1.4, by Mario Rinke, looks at the study of the dynamics that were established in Germany and Switzerland for the creation not only of the first guidelines and codes on reinforced concrete in 1904 and 1909 respectively but also of the first calculation methods for reinforced concrete structures. These dynamics involved contractors, industrialists, engineers and architects, institutions and academics confronted with the collapse of some structures and the determination of the authorities to control the whole construction process. Influenced by the testing of the resistance of materials promoted by national laboratories, Swiss and German attitudes differed. In Germany, designs based on proposed calculation methods had to be approved by the authorities. In contrast, the emphasis in Switzerland was on sound knowledge of the building practice and individual responsibility. Alongside the creation of the first legislation, Rinke analyses in detail the knowledge transfer necessary for the emergence in Germany of the first calculation theories by Wilhelm Ritter, Mathias Koenen and Emil Moersch, and their relationship with construction companies such as Wayss & Freytag and cement industry associations. In the case of Switzerland, the author discusses the importance of Robert Maillart and his beamless slabs, and of empiricism in the creation of new calculation theories.

From construction and calculation methods codification in Germany and Switzerland, we move on to the study of the construction history role of cement and reinforced concrete patents registered in Spain between 1884 and 1906 in Chapter 1.5 by Francisco Domouso de Alba. After describing the importance of pioneers like José Eugenio Ribera, Manuel Busto or Juan Manuel de Zafra, Domouso shows how foreign and Spanish patents were used to cover the costs of a material which was supported by little theoretical evidence and how these also provided a means of marketing the material. The text provides an in-depth analysis of the different applications of patent registration in Spain: the creation of specialized new building companies, the productions of new derivative products, the introduction of new methods for prefabrication and industrialization and improved knowledge of the structural behaviour of reinforced concrete.

From Spain, the narrative moves on to Belgium with a text by Bernard Espion, Chapter 1.6, which reviews the contribution of four fundamental figures in the history of construction of particular importance to the dissemination of reinforced concrete in Europe. The first is the Frenchman François Hennebique, who started to establish his great design office in Belgium in the 1890s. Next is the Belgian engineer Paul Christophe, who in 1902 wrote the first book on the different systems of reinforced concrete – a milestone for the definition of the calculation methods used all over the world during a great part of the 20th century. The author then discusses the Franki de Liège company, which made a vital contribution to foundation techniques in reinforced concrete. Finally, the collaboration between Gustave Magnel of Ghent University and the Brussels-based Blaton-Aubert company in the pioneering development of prestressed concrete is analysed.

To conclude our journey through the national dynamics of the introduction of reinforced concrete in Europe, in Chapter 1.7, Tullia Iori examines the case of Italy in four well-defined periods: 1850–1900, 1900–1915, 1915–1935 and 1935–1943. The first period is characterized by the importance of registering national patents on the basis of the results of international patent trials, leading to the creation of new Italian companies that started to offer variations of tried-and-tested foreign systems. The second period discusses the 1908 earthquake in Messina and

Reggio Calabria and the importance of the structural calculations of the Risorgimento bridge in Rome in 1911 in affirming the anti-seismic capabilities of the new building system. After 1915, reinforced concrete was no longer the exclusive domain of patents and small firms, and as of 1929 it was protected by new corporative Fascist legislation. Reinforced concrete began to define a new architectural language. Supply problems due to the First World War improved research into the limits of the new building system.

The second part of the book opens with a case study of the first great British contractors engaged in the new iron and steel constructions designed to connect many regions of the globe by means of railroads, contractors that to a certain extent provided a model for companies from other countries with colonial possessions. Chapter 2.1 by Mike Chrimes studies the mechanisms of emergence of the first well-capitalized national contractors in the UK and Ireland. During the period between 1800 and 1914, these companies not only closely followed the technological transformations in the construction field, but also quickly spread them globally, first through the first canal constructions and then with the construction of the railroads. Examples include the company Waring Brothers, which specialized in railway structures, and Thomas Brassey, who expanded his activity to the manufacture of construction materials and the construction of tramways, sanitation, gas and electricity supplies.

Written by Bernard Espion, Rika Devos and Michel Provost, Chapter 2.2 is dedicated to Blaton, the influential Belgian construction company, from its foundation in 1865 to 1954. Having started out in the trade in building materials – in particular artificial cement – the company would begin executing reinforced concrete constructions in 1897. From 1927 onwards, the third generation of managers diversified the company's activities with the successive creation of several companies specializing in Vibro piles, prestressed structures and real estate operations, leading to its expansion into France and the former Belgian Congo.

Chapter 2.3, by Simonetta Ciranna, explores the activity of the German-born engineer and contractor Rodolfo Stoelcker and his construction company founded in Italy in 1913, from that year up until the post-war period. Since his early work in Germany for Wayss & Freytag, followed by Ferrobeton in Italy, Stoelcker's specialization in reinforced concrete had been a constant. The construction works executed by Stoelcker in collaboration with some of the greatest Italian architects of the Fascist period display the use of the most up-to-date methods of the new construction culture. The study serves to revisit the role of Italian contractors in depth during a controversial period that marked Europe in the 20th century.

Belgium comes into focus once again in Chapter 2.4, by Inge Bertels and Jelle Angillis. The chapter opens with the city of Antwerp in the 19th and 20th centuries to tell the construction history in terms of the activity of construction companies and their relation to steel and reinforced concrete. The system of public tendering and its influence on the creation of new construction companies, the development of their professional status, the first attempts to form modern trade associations and their relationship with the institutions of public administration are studied in the first of these centuries. Then, this relationship among politics, economics, technology and public works is analysed in more detail for the period 1945–1985, using the company Frans Verachtert NV as a case study.

This set of case studies is particularly illustrative of the vital role of public works companies in the implementation and development of construction cultures in contemporary times. Ending in Portugal, the country of departure on this long tour in the history of construction in Europe, Chapter 2.5, by João Mascarenhas-Mateus, Manuel Marques Caiado and Ivo Veiga, examines the activity of 13 public works contractors during the Estado Novo regime (1933–1974). The chapter contributes an analysis of the relationships of each company with firm founders, engineers and architects, other contractors, materials producers and vendors as well as public institutions. The structural solutions, machines, equipment and materials used in different infrastructures are described and used to identify different technological periods depending on infrastructure types.

Many different readings can be made of this book. As with the history of the implantation of concrete construction culture, the story of its contractors can also be taken as a starting point to examine the history of construction in the 19th and 20th centuries. All European countries directly and indirectly mentioned in the following pages have contributed in their own way to shaping our present building culture. In the period from the Enlightenment to the aftermath of the Second World War, there was a shift in the way Europeans build, during a period of two centuries when a strong belief in scientific and economic progress coincided with neoclassical ideals that took antiquity as a model, the construction of modern nations and the great catastrophes of the two world wars. This process and the attendant radical changes in the construction sector were made possible by an effective transfer of theory and applied knowledge among not only the European countries studied here but also others, including Russia and the Soviet Union, as well as between Europe and the USA. Amid the struggle for the more favourable geostrategic results, these transformations expanded to other regions of the globe under European colonial administration.

The editor wishes to express their immense gratitude to the authors and co-authors for all their efforts, patience and support. This work would not exist but for the time, knowledge and generosity they invested in a special word of recognition to Manuel Marques Caiado. Sincere thanks also go out to Kate Major Patience for proofreading every chapter, and to the team at Taylor & Francis (the Netherlands), in particular Janjapp Blom, Kaustav Ghosh, Jahnavi Vaid and Balaji Karuppanan.

We wish you a fruitful read of this collection of essays written within the framework of construction history in which we endeavour to contribute to a solid understanding of contemporary cultures of building.

Chapter 2.3

Rodolfo Stoelcker

A German Engineer-Contractor in Italy in the First Half of the 20th Century

Simonetta Ciranna

Introduction

Rodolfo Stoelcker arrived in Rome in October 1912, at the age of 32. Soon after, on 22 January 1913, an industrial patent for a "reinforced concrete pipe joint with internal pressure" with a duration of three years was registered in his name (Ministero di Agricoltura, Industria e Commercio 1915: 8). It was in October 1914, however, that he registered his own *Impresa per costruzioni d'ingegneria d'ogni genere, specialmente cemento armato, fondazioni, ponti, iniezioni di cemento, opere idrauliche, ecc*. (enterprise for engineering constructions of all kinds, especially reinforced concrete, foundations, bridges, cement injections, hydraulic works, etc.) with the Rome Chamber of Commerce.[1]

Originally from Ettenheim in Baden-Württemberg, Germany,[2] Stoelcker had already been in Italy since 1906, working in Genoa as an engineer for Wayss & Freytag of Neustadt an der Haardt (today Neustadt an der Weinstrasse),[3] an important company in Germany and owner since 1893 of the patent of Joseph Monier (1823–1906) filed in 1880, which helped transform Monier's ferro-cement into reinforced concrete thanks to the skill and continuous experimentation of its technicians.[4]

It was in Genoa that, in April 1908, Stoelcker and Swiss engineer Oscar Huber (1875–1945)[5] found themselves among the founders of the Società Ferrobeton Anonima Italiana sistema Wayss & Freytag,[6] a subsidiary that aimed to strengthen the presence in Italy of the aforementioned German company after the Ministry of Public Works had issued the first regulations dedicated to the execution of public works in reinforced concrete in January 1907 (Ministero dei Lavori Publici 1907).[7]

Thus, it was within the framework of Wayss & Freytag (Figure 2.3.1) that Stoelcker acquired a solid professional competence and experimental capacity, favoured also by his acquaintance and relations with Emil Mörsch (1872–1950), who, from 1901, was the technical director of the aforementioned company as well as professor of Reinforced Concrete Construction at the Eidgenössische Technische Hochschule (ETH) in Zurich and the University of Stuttgart and one of the founders of the theory of reinforced concrete construction.[8] Stoelcker's theoretical knowledge and interests in applied research are also endorsed by two articles he published in 1906 focusing on the calculation of reinforced concrete plates and the differences with those without reinforcement (Stölcker 1906a, 1906b).

As an employee of Wayss & Freytag, in 1907–1908, Stoelcker and Huber oversaw the construction of two reinforced concrete bridges to be built with the systems patented by company, one over the Padrongianus stream and the other over the Posada River in the province of Sassari. However, after having "prepared, founded and directed the Ferrobeton company until the

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Figure 2.3.1 Ferrobeton advertisements from 1909 (top) and 1912 (bottom). Top: only the city of Genoa is indicated as the location of the company's head office. Bottom: Milan, Rome, Naples and Messina also appear, and the capital is indicated as the office of the international company.

Source: Annuario genovese. Guida Amministrativa, Commerciale e Industriale di Genova, Provincia e Liguria, 1909 and 1919.

autumn of 1912, designing and executing many engineering works, mainly in reinforced concrete, in every region of Italy, from Sardinia to Dalmatia, from Sicily to Piedmont", Stoelcker left this company "because of irremediable political disagreement with the German capitalists", and began to work independently from 1913.[9]

However, the restart of his activity in Rome was hindered precisely by his German origins. These were the years that heralded Italy's entry into the First World War, and Stoelcker faced first hostility and later being forbidden to practise in the first person. That happened soon after he gained his first important assignment in Rome, that of building the Simplex pile foundations for the Ministry of the Navy, and during the course of construction he was obliged to appoint his brother-in-law as the company's contact person.[10] Nevertheless, the construction site documents for this imposing building designed by the architect Giulio Magni (1859–1930) on the Lungotevere delle Navi highlight Stoelcker's central role in the management of an innovative foundation system, Simplex piles.[11] In this work (Figures 2.3.2 and 2.3.3), the execution of the piles became gradually more difficult due to the discovery of numerous archaeological remains in the subsoil, which led to the breaking of the piles. Added to this problem were other factors that heavily conditioned the works: the scarcity of metal materials (e.g. cast-iron spikes for the piles), delayed deliveries (of iron as well as of pile drivers from Germany) and the shortage of skilled labour called up to war and sent to the front.

To enable the use of the Simplex pile foundation system and the execution of hydraulic works, Stoelcker invested in the acquisition of the necessary equipment (e.g. pile drivers) and created a specialized competence that allowed him to participate and often prevail – as in the Ministry of the Navy – in numerous tenders, in which he competed with leading Italian and international companies in the field of reinforced concrete construction.

Bridges

The use of patents and technologies linked to Germany and, in a broader sense, to the most advanced research on the use of reinforced concrete on an international scale is also evidenced in Stoelcker's involvement in the construction of the Tazio Bridge in Rome, built over the Aniene River to connect via Nomentana with the new Montesacro district, on a project from 1920 carried out by the company Filippo Zanetti under the guidance of architect Gustavo Giovannoni (1874–1947) (Benedetti 2012). In 1923, Stoelcker was commissioned to consolidate the foundations of the abutment and abutment-pile, which had been inadequately built on sagging ground, and set up a slab-on-grade foundation with piles patented by August Wolfshotz Preszzementbau.[12]

Stoelcker's involvement in this work continued in 1938–1939 with a total reconstruction of the central arch of that bridge (Figure 2.3.4), which led to the replacement of the existing unreinforced concrete arch with a three-hinged reinforced concrete arch, with a higher profile and lower horizontal thrust at the abutments.

Finally, in November 1944, Stoelcker, by then an Italian citizen since 1923, was asked as the original designer of that bridge to direct the works needed to repair the damage caused by the sabotage of the German troops who dynamited it in their retreat from Rome.[13]

The construction of bridges, of different scales, functions, relevance (urban, territorial and "political") is, indeed, a constant in the 50 or so years of Stoelcker's Italian activity. In this field, the repeated involvement in bridge construction, such as the Tazio or Nomentana bridges even after the WWII, exemplifies Stoelcker's professional solidity and "resilience" to changing political regimes.

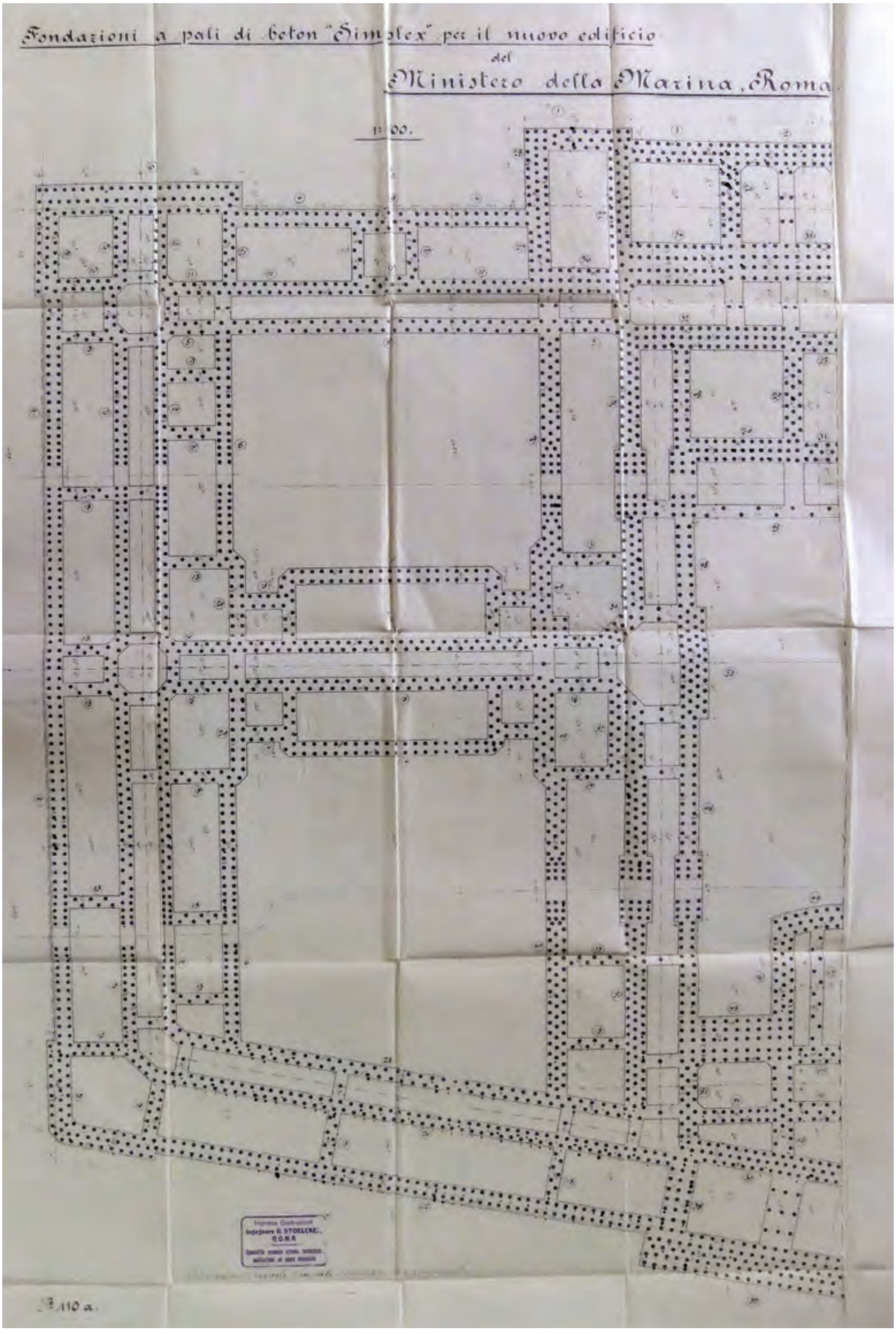

Figure 2.3.2 Rome, Ministry of the Navy, planimetry of the foundations with Simplex concrete piles on a scale of 1:100 representing half of the building.

Source: State Archives of Rome, Roman Civil Engineering Office, file no. 915.

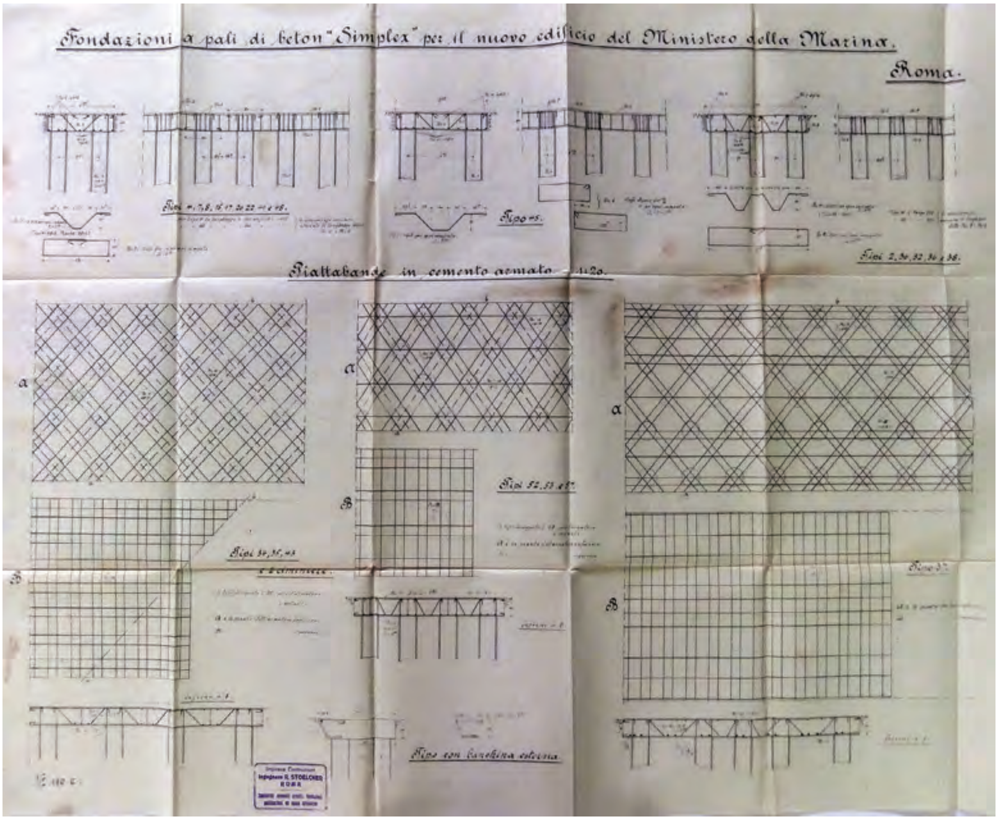

Figure 2.3.3 Rome, Ministry of the Navy, Simplex concrete piles; details related to the reinforced bars.

Source: State Archives of Rome, Roman Civil Engineering Office, file no. 915.

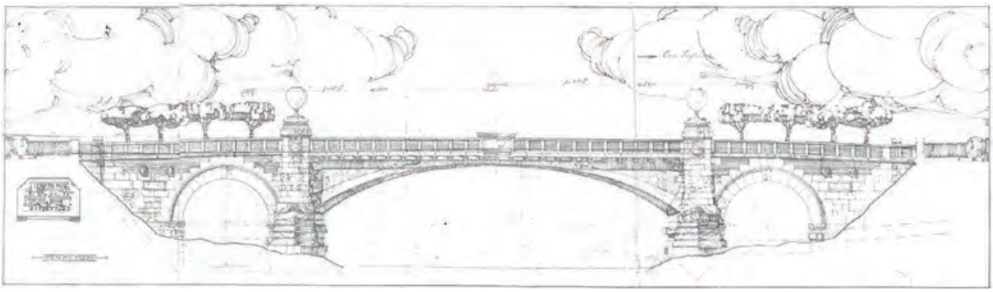

Figure 2.3.4 Ponte Nomentano, Rome, upstream elevation, 1938.

Source: Rome, *Dipartimento Sviluppo Infrastrutture e Manutenzione Urbana*, *Ufficio Ponti*, Ponte Tazio.

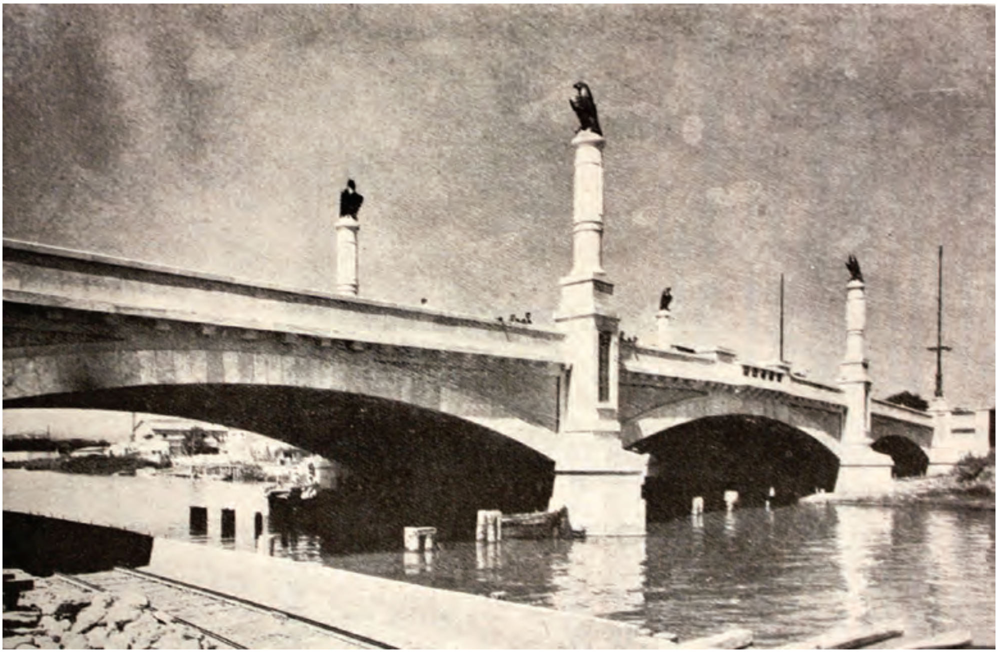

Figure 2.3.5 Pescara, Ponte Littorio over the river Pescara: photo just after work was completed.

Source: Fago (1935).

These contexts and changes led him to respond to different needs, as well as to deal with designers whose own training and language combinations produced heterogeneous results, some of which, moreover, were wiped out by the wartime destruction of the Second World War.

The latter include the bridge over the Aventino river in the municipality of Casoli (Chieti, Abruzzo) built between 1923 and 1925 and destroyed in 1943[14]; the bridge over the via Appia in Minturno (Latina, Lazio) built in 1927, destroyed by the Gustav Line bombing in 1944 and rebuilt two years later[15]; and the imposing Ponte Littorio bridge over the Pescara River built between 1930 and 1933, destroyed in 1944 and rebuilt after the war under the new name of Ponte Risorgimento (Figure 2.3.5).

Much more than its predecessors, the last of these bridges had a strong monumental vocation, connecting the two municipalities of Castellammare Adriatico and Pescara, which since January 1927, at the proposal of Benito Mussolini – encouraged by the Pescara poet Gabriele d'Annunzio (1863–1938), among others – had been merged in the single municipality of Pescara.

To emphasize this territorial and administrative change, the Ministry of Public Works called on the Roman architect Cesare Bazzani (1873–1939), who was inclined to a courtly classicism pleasing to the Fascist regime, to design it. Structurally, the bridge consisted of seven continuous longitudinal beams on four piers with varying moments of inertia, with a load-bearing structure made of reinforced concrete made of high-strength 350-kg cement. All the structural elements, such as piers, abutments, *armillae* and cornices, were clad in Ascoli travertine, while the decorative parts such as parapets, lictor columns, plinths and balconies were in Trani limestone and the kerbs of the pavements in Sardinian granite (Figure 2.3.6). The gables of the arches and the

Figure 2.3.6 Invitation to the inauguration ceremony of the Ponte Littorio by the *Podestà* printed by Nicola D'Arcangelo's typography.

Source: Millevolte (2019: 47).

intrados were executed with cement mortar plaster imitating travertine.[16] The lightness of the stones used was then enhanced with the decorative elements of the bronze eagles by sculptor Renato Brozzi (1885–1963) and the two statues by sculptor Nicola d'Antino (1880–1966) were installed during the summer of 1935.[17]

Documenting the company's range of action in the construction of bridges are Stoelcker's works in 1930: in October, alongside the Directorate of the Road Service of the Municipality of Rome, the widening of the Salario Bridge in Rome,[18] and in November the executive project for the bridge over the Greve stream in the locality of Casellina for the variant of the state road 67 Florence-Ponte Elsa, under a concession delivered by the Azienda Autonoma Statale della Strada.[19]

In the early 1930s, Stoelcker's interests in Tuscany are attested by the opening of one firm branch in Florence, located in via Calimala in the city centre, which was mentioned several times in local bulletins and yearbooks.[20] Remaining on the subject of bridges, in August 1933 Stoelcker takes also part in the call for tenders issued by the municipality of Prato for the construction of a reinforced concrete footbridge over the Bisenzio river, linking via S. Antonio with via XXIII Marzo. In the tender won by Ferrobeton of Rome, among other companies, the Roman company Nervi & Bartoli (Guanci 2008: 183–195)[21] participated with an elegant architectural static solution.

Among the documents enclosed with his application for this tender, Stoelcker included two portfolio lists, one relating to works that his company was in the process of completing on

1 October 1932 and the other to those already completed on that date. Limited to reinforced concrete bridges, in the first inventory he listed, in addition to the monumental bridge over the Pescara River,[22] other bridges over the Bisenzio for the Ministry of Public Works, 15 "small bridges" in various locations in the Piscinara Reclamation Area for the *Consortio* and the bridge over the Bruna in Gavorrano (Grosseto, Tuscany). In the second list, he included bridges in Casoli (Chieti, Abruzzo), Arli (Ascoli Piceno, Marche), Amatrice (L'Aquila, Abruzzo) and in Cittaducale (Rieti, Lazio) for public administrations; in the Maremma Toscana for the Genio Civile and the Province of Grosseto; over the Garigliano and the Alveo della Piana canal for the Genio Civile of Caserta; in the Padule di Fucecchio (Florence, Tuscany) for the Ministry of Public Works; on the Brizzi near Sapri for the Caserta Public Works Superintendency; on the Elsa river near Marsiliana for the Azienda Autonoma Statale della Strada, as well as the repair of a number of bridges on the via del Mare (Rome-Ostia motorway), and the aforementioned work to widen the Salario bridge over the Aniene for the Province of Rome and the bridge over the Greve.

This significant activity continued over the years with at least three other major bridges built, the first in Rome under a contract of 1939 and the other two in Abruzzo during the years of post-war reconstruction, one in the municipality of Salle between 1949 and 1951 and the other in the municipality of Aprati between 1952 and 1953. In fact, even during the brief interlude brought about by the bankruptcy of the company, declared in 1935 and concluded with the approval of a composition with creditors in May 1937,[23] Stoelcker had consent to continue the construction of the Casilino flyover road in Rome over the State railway tracks at via Gallarate and via Aquila, the contract for which had already been signed with the Province in December 1933.[24] The contract for the construction of the new bridge over the Tiber at San Giovanni dei Fiorentini dates back to November 1939, following a call for tenders dated from 28 April of the same year. The bridge was to be built at the mouth of the new tunnel under the Janiculum Hill between the Ponte Vittorio Emanuele bridge and the Ponte Sospeso.[25] The latter, known as the "de fero" (iron) bridge, was one of the four suspension bridges entrusted by the Reverenda Camera Apostolica to the Società dei Ponti in Ferro in the 1840s[26]; Stoelcker was also entrusted with its demolition, undertaking to re-use the resulting materials. Named after Prince Amedeo di Savoia Duke of Aosta (1898–1942), the new bridge was built between 1941 and 1942 with a design by architect Giuseppe Bronzetti (1904–1944).[27] It had three arches in brickwork, piers of masonry and travertine on compressed air foundations and abutments consisting of the retaining walls "adapted and reinforced with piling and cement concrete blocks" (Figure 2.3.7).[28]

In the same period, in 1943, the Government of Rome also commissioned Stoelcker with the special maintenance works of the Ponte del Risorgimento inaugurated in May 1911 on the occasion of the 50th anniversary of the Unità Nazionale. Known for the boldness of its single span, a low arch with a span of 100 m and 10 m rise, this bridge was the first to be built in reinforced concrete in Rome, by the company of engineer Giovanni Antonio Porcheddu (1860–1937), the only concessionaire in Italy of the François Hennebique (1842–1921) patent. Regarding the subject of the contract awarded to Stoelcker, the maintenance work specified "the repair of damage in the walls of the longitudinal diaphragms and abutments of the bridge by means of pressure injections".[29]

If the design and execution of the Principe Amedeo di Savoia Aosta Bridge appear to be "autarkic" expressions of the Fascist regime, the two bridges built in Abruzzo in the early 1950s for the Cassa del Mezzogiorno (Grassini et al. 1962: 164–166) are quite different in terms of structural and architectural experimentalism. Among these, the bridge over the Orta River in the commune of Salle stands out for its formal and structural synthesis (Figure 2.3.8). It was

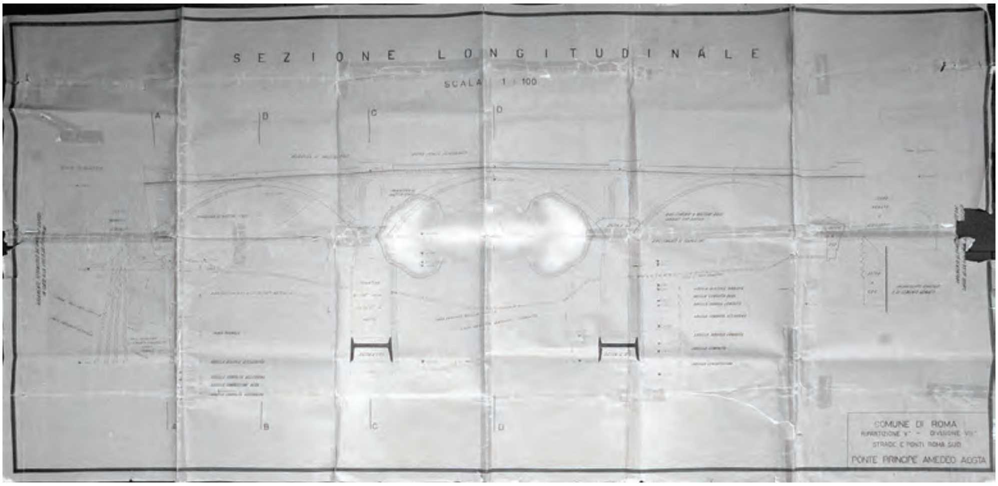

Figure 2.3.7 Ponte Principe Amedeo di Savoia Duca d'Aosta near San Giovanni dei Fiorentini, Rome.

Source: *Dipartimento Sviluppo Infrastrutture e Manutenzione Urbana-Centrale Unica Lavori Pubblici* (SIMU), folder no. 21 Fiorentini.

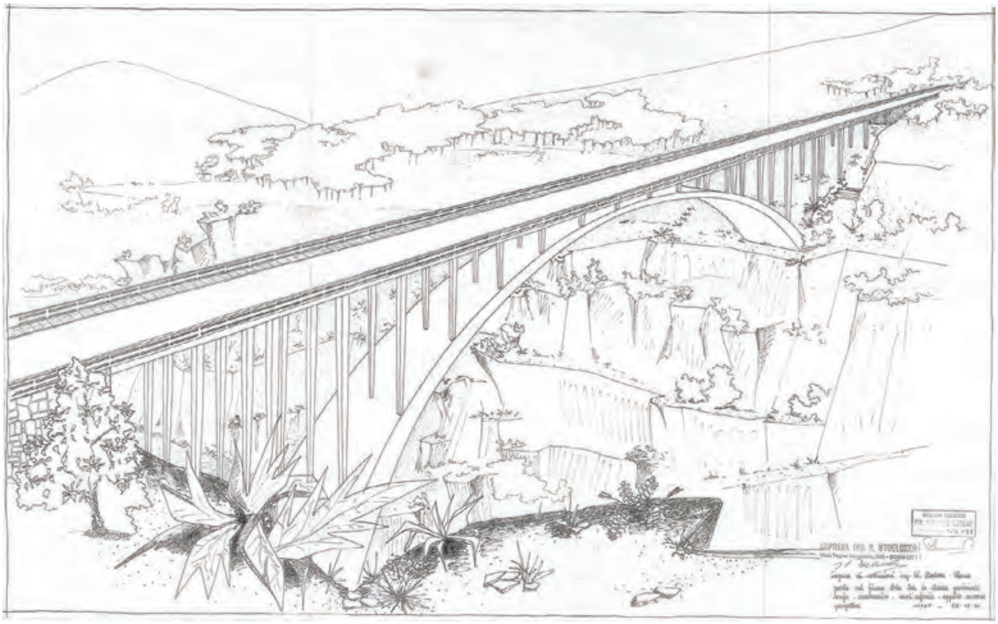

Figure 2.3.8 Salle, bridge over the Orta River, 22 December 1951, perspective of the project engineer Riccardo Morandi and engineer-contractor Rodolfo Stoelcker.

Source: Historical Archive Provincial Administration of Pescara, file no. 1, fasc. 1.

built between 1952 and 1955 by the Stoelcker company together with the engineer Riccardo Morandi (1902–1989), whose notoriety and design rigour in those years combined with decisive research, in particular, on prestressed reinforced concrete.

This work was the result of a long bureaucratic and planning process, which can exemplify the transformations in the field of engineering and the emergence of the use of reinforced concrete. Starting in 1926 with a design for a viaduct with several arches in rubble masonry lined with freestone, arches in concrete and frontal *armillae* in freestone, the final call for tenders in 1951 included the possibility of using prestressed reinforced concrete. The call for tenders was based on an outline project by the Technical Office of the Province of Pescara for a reinforced concrete bridge consisting of an interlocking arch completed with pilasters, located just upstream of the Orta outlet of the Arigastia stream. This work was done in a context of great landscape impact, having on the left a high, almost vertical rocky bank and, on the right, a spur jutting out towards the riverbed (Figure 2.3.9).

In the final solution, the bridge was executed with a single arch measuring 202.70 m in length, with a Ligowski's catenoid profile. Strassner's tables were used for the definition of the influence lines and drawn from the tapered downward profile (Ciranna 2019a: 37–42).[30]

The second bridge in Abruzzo was built between 1952 and 1953 in the Teramo area over the Vomano River, on the Cervaro-Aprati road (Figures 2.3.10 and 2.3.11). In this case, Stoelcker acted in the dual role of designer and contractor. The bridge, which is smaller in size and formally less "dynamic" than the previous one, is also located in an orographic and landscape context of particular beauty.[31]

Figure 2.3.9 The Salle bridge over the Orta River in a period postcard.

Source: Ciranna (2019a).

Figure 2.3.10 Bridge over the Vomano River, 1952–1953 photo during construction.
Source: Uffici Amministrazione Provinciale di Teramo.

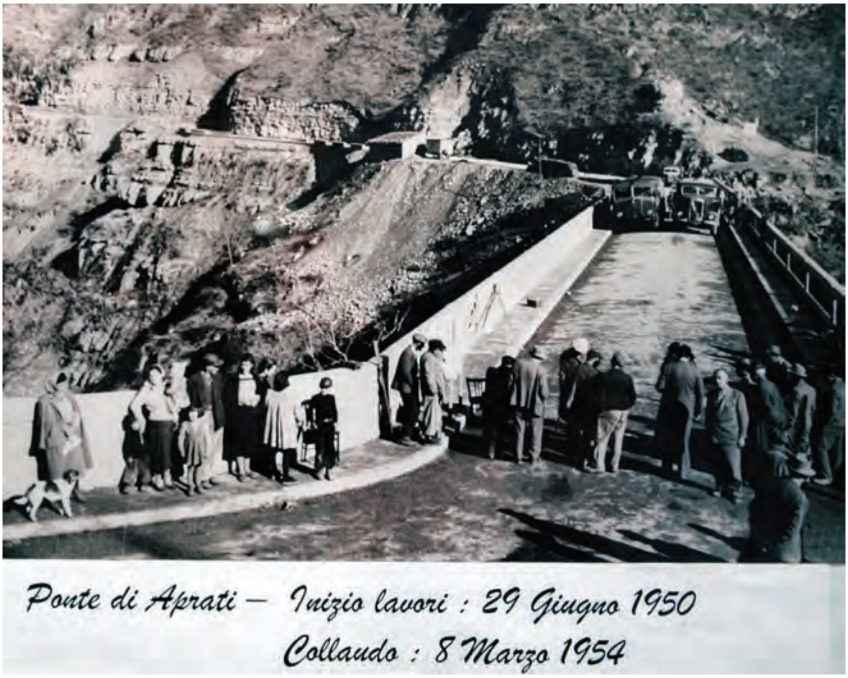

Figure 2.3.11 Bridge over the Vomano River, proof load test on 8 March 1954.
Source: Uffici Amministrazione Provinciale di Teramo.

Thirty Years of Engineering and Architecture

The concise and non-exhaustive account of the company's activities limited to bridges only gives an idea of Stoelcker's much broader presence in the field of public works – works in which he adopted, where possible, innovative technologies and patents for reinforced concrete.

Simplex piles certainly constituted one of the company's prerogatives from its earliest Roman beginnings, and perhaps one of the main reasons for its bankruptcy in 1935 must also be attributed to them in a crisis that hit after a decade of very successful and diversified professional activity, the most important lines and construction sites of which are outlined below. Rome was a young capital city that, after the political and financial crisis of the collapse of the Banca Romana at the end of the 19th century and a slow recovery in the early years of the 20th century, had an interwar building sector characterized both by technological backwardness and resistance to new craftsmanship from building sites and workers, as well as by conflicts between the needs of the central government and the interests of the municipality. Constraints sometimes tied to political choices curbed the use, the expressiveness and the structural results of reinforced concrete (Ciucci 1989: 77).

In the second half of the 1920s, at least two works brought Stoelcker to the attention of an international audience, also thanks to his own self-marketing activity. In September 1930, he took part as a representative of major Italian companies in the 1st First International Congress for Concrete and Reinforced Concrete, held in Liège, Belgium[32]; on this occasion, he presented a report in which he illustrated in detail two of his works in Piazza Verdi in Rome: the new Officina Carte Valori dello Stato – Poligrafico (1926–1928) and the Casa dell'Automobile (1928–1929). In the former, the engineer worked on a mighty building, part of which had already been constructed to be used as the seat of the Court of Auditors (begun in 1911–1914), designed to be built in masonry. Although he had to use the existing foundations, Stoelcker managed through the use of reinforced concrete to provide the building with bright and spacious rooms, statically capable of accommodating the heavy machinery of the workshops and bearing the dynamic loads generated by their operation (Stoelcker 1931).[33]

The formally "hybrid" result of the building, that is an architecture characterized on the outside by the monumental eclecticism of a "European capital" and a functional interior, free from partition walls, punctuated by regular rows of pillars supporting the main and secondary trusses, was also replicated in the *ex-novo* construction of the Casa dell'Automobile, named after the joint-stock company founded by FIAT in 1925 with the support of the Italo-American Petroleum Company (Figure 2.3.12).

Built based on a design by architect Enrico Bacchetti, and demolished in the 1960s, the building destined for a private multi-storey car park at the forefront in Europe in terms of size and interior technology, presented itself as a huge block building modelled – albeit in simplified tones – by arcade fronts marked by a giant order (the main tripartite order) on an ashlar base and upper attic. These latter features led art critic and journalist Pier Maria Bardi (1900–1999) to place the building among the *passatist* works in the so-called *Tavolo degli Orrori* (*Table of Horrors*), a collage exhibited at the Second Italian Exhibition of Rational Architecture held in Rome in 1931.

The innovative character of its architecture, one of the largest car parks in the world, capable of accommodating over 900 cars on its ten floors (one underground and the last occupying only the inner part of the building), lay in its excellent use of the free solutions of the planimetric layout determined by the reinforced concrete structure – with the exception of the foundations in tuff stone, lime mortar and pozzolan – as well as those of the technological services (Figures 2.3.13 and 2.3.14). The static solution adopted by architect Bacchetti completely concealed

Figure 2.3.12 La Casa dell'Automobile, façade on Piazza Verdi, Rome.
Source: Stoelcker (1929).

the daring functionality of the interior space and, in particular, the dynamism imparted by the double-helix ramp allowing the cars access to the floors. These were elements which Stoelcker had already carefully discussed in the article published in 1929 in *L'Ingegnere. Rivista tecnica del sindacato nazionale fascista ingegneri e dei circoli di cultura degli ingegneri* (Stoelcker 1929; Ciranna 2021b), as well as in the aforementioned report.

The double-helix ramp, inspired as much by the Pozzo di San Patrizio in Orvieto as by the Château de Chambord near Blois or the multi-storey garage patent of the Turinese engineer Emilio Giay (1876–1951) of August 1925 (Olmo 1994: 12), was an element that attracted a great deal of interest in publications and exhibitions such as the I Mostra Nazionale dell'Ingegneria held in Rome in 1931 (Ferrario 1931). It was an architectural solution whose synthesis of structure and form showed a marked spatial quality, the result of Stoelcker's youthful formative experiences at the side of Mörsch, thus in the sphere of German engineering, more interested in the Monier structural system, consisting of two-dimensional elements – plates and vaults, rather than linear Hennebique – pillars and beams (Pogacnik 2006).

An ability to control and apply reinforced concrete in different circumstances found expression here in the elevations, just as it did in the contemporary or slightly later applications of the patented Zeiss-Dywidag (Z-D) system for thin, cylindrically shaped vaulted roofs, which the German construction company Dywidag – Dyckerhoff & Widmann – granted to Stoelcker in 1928 (Petry 1932: 280–281, 286; May 2015). Stoelcker adopted them for the roofs of two Roman garages: the first in 1928 for the taxi company Società Trasporti Automobilistici (STA)

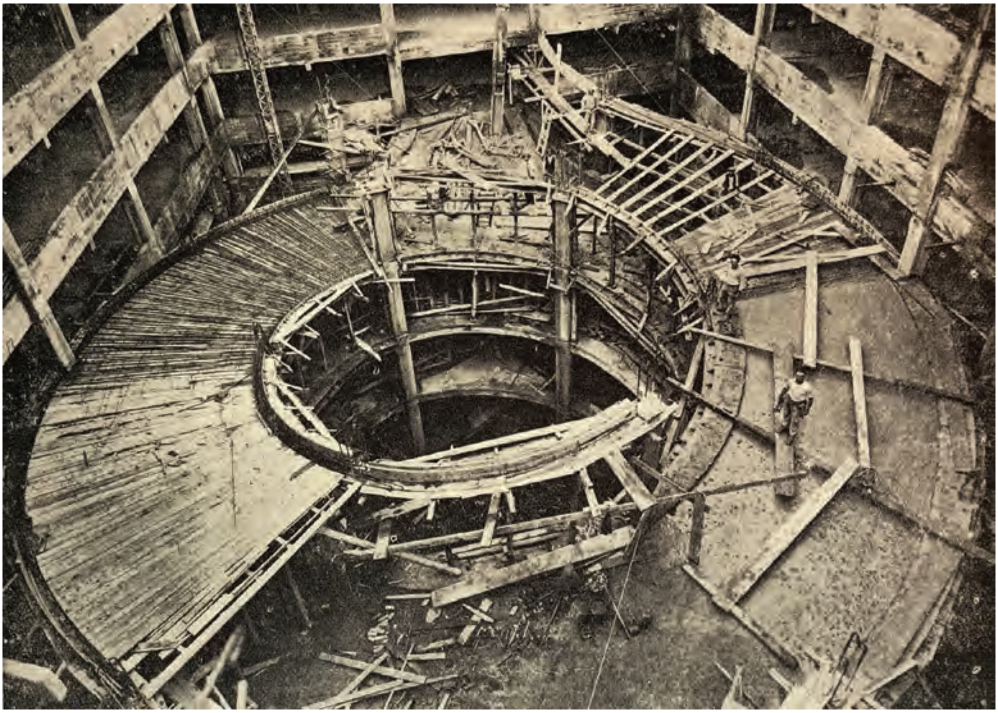

Figure 2.3.13 La Casa dell'Automobile in Piazza Verdi, Rome. The distribution ramp under construction.

Source: Stoelcker (1929).

in Piazza Ragusa, where he executed an 8-cm thin vaulted roof with 25-m span and an intrados with no visible beams (Figure 2.3.15) and the second in 1931 for the *Azienda delle Tramvie e Autobus del Governatorato di Roma* (ATAG) public transport depot in Trastevere.

The latter consisted of a two-storey structure covered with four thin vaults with a span of 14 m and a length of 41 m, each with skylights in the key along a length of 14 m (Russo 2017; Di Castelnuovo 1932: 158–160, 173–175).

The application of foreign patents and daring reinforced concrete solutions was not, therefore, limited to hidden structures, although in this respect, the paradigmatic construction of the water reservoir on via Eleniana near the Basilica of Santa Croce in Gerusalemme, intended for watering the streets and gardens of the Appio Latino, Tuscolano and Tiburtino neighbourhoods (Figure 2.3.16), is noteworthy.

Although the first planning and construction phases date back to the years 1884–1885, it was not until the late 1920s that it was actually built. As in the contemporary Piazza Verdi building site, the architecture of the exterior – a sort of monumental tetrapylon designed by architect Raffaele De Vico (1881–1969) – in tuff with brick courses (plinths) and architraves, crowning bands and travertine tympanums, concealed the four cylindrical chambers (with a total capacity of 2,000 m^3) built in reinforced concrete by Stoelcker, winner of the 1929 competition (Figure 2.3.17). In October 1933, his company also signed the contract for the completion works, consisting of both the reinforced concrete structures to connect the existing ones with

Figure 2.3.14 La Casa dell'Automobile in Piazza, Rome. The distribution ramp complete from the top.

Source: De Cupis (1929, pl. X).

Figure 2.3.15 *Officine della STA* in Piazza Ragusa, Rome.
Source: Russo (2017).

the framework of the perimeter walls, and the perimeter stone walls and structures, that is the traditional "Roman-style" masonry (Ciranna 2018, 2021a).

The solution adopted, including the expensive hidden system, and the use of Simplex piles for the foundations decisively accelerated the company's bankruptcy in 1935: it was the bankruptcy administrator himself who found the cause of the crisis in the stoppage of the Avezzano cathedral building site.[34] In 1929, Stoelcker was commissioned to build the foundations of the new cathedral in the Abruzzi town, which had been destroyed by the earthquake that hit the Marsica area in 1915. But his proposal to use Simplex piles due to the marshy terrain was met with firm opposition from the designer and director of works, engineer Sebastiano Bultrini (1867–1936). This resistance was then supported by the client, which led to Stoelcker's ousting from the commission and the termination of the contract, actions that were not followed up with the settlement of the sums committed by the company.

Figure 2.3.16 The water reservoir on via Eleniana standing out against the city walls, here coinciding with the Claudian aqueduct, Rome.

Source: The author.

Figure 2.3.17 Interior of the water reservoir on via Eleniana, Rome. The water tanks' profiles near the perimeter wall.

Source: The author.

And yet, the company's expertise in foundations in the presence of water was well known (even in Abruzzo): just consider, in addition to the bridges already mentioned, the dams on the Liri River (Figure 2.3.18) and, in particular, the one built in Sant'Eleuterio near Ceprano for the Società Mediterranea di Elettricità's hydroelectric plant. The work was completed in 1929 and inaugurated with great fanfare in the presence of the authorities in May of that year, an event filmed and documented by the Giornale Luce.[35] Stoelcker himself used it the following year to promote the company, including its photo in advertisements that appeared in specialized magazines such as *Il cemento armato* of 1930.[36]

Further proof of esteem for the company's technical expertise can be found in the assignments given to Stoelcker between 1932 and 1933 by Marcello Piacentini (1881–1960), chief architect on the building site for the new University City of Rome. In July 1932, Piacentini commissioned the Stoelcker firm to conduct tests on the geotechnical engineering properties of the subsoil to determine the type of foundations. Test results revealed a very irregular soil, which prompted Piacentini's decision to use a concrete pile system to be cast on site, an assignment to be entrusted to specialized companies with patents and suitable machinery.[37] The companies Stoelcker and Ferrobeton, both qualified in the use of Simplex piles, were the winners of the competition and divided up the six buildings envisaged by the tender, with Stoelcker taking Lot A (the Rectorate, Law and Humanities buildings) (Figure 2.3.19) and Ferrobeton Lot B (Mathematics, the Institute of Hygiene and the Institute of Physics).

Figure 2.3.18 Dam on the Liri river at Sant'Eleuterio near Ceprano in the advertisement for the Impresa Stoelcker.

Source: *Il cemento armato*, XXVII, 2, February 1930: 20.

Figure 2.3.19 Pile driving structure used by Stoelcker for the construction site of the University City of Rome.

Source: Cover of *L'organizzazione scientifica del lavoro* magazine (year VIII, fascicule V, May 1933).

Widespread rumours about Stoelcker's financial fragility and the whiff of bankruptcy were probably among the reasons that prevented the company from acquiring further orders for the elevated university buildings.

As already mentioned, Stoelcker resumed his activity after 1937 and continued it until the end of the war with important assignments. He also participated together with other Italian companies in the construction of one of the three complexes that formed the Auschwitz concentration and extermination camp – to be precise, the camp founded in October 1942 in the town of Monowice in Poland, located near the Buna-Werke synthetic rubber plant, owned by I. G. Farben, to which the deportees were destined (Mantelli 1992: 274).[38]

After an apparent post-war lull, company activity resumed with important contracts – in addition to those already mentioned for bridges – signed in the mid-1950s with the Municipality of Rome. The first in 1954 concerned the new Forte Antenne transformation and distribution centre located in Acqua Acetosa; the second in 1955 was the construction of artefacts for Azienda Comunale Elettricità e Acque (ACEA) for a second steel pipeline to cross the Tiber Valley with the Peschiera Aqueduct.[39]

Additionally, in 1956, the company was involved in the construction of the Autostrada del Sud in the section between Pompei and Catellammare,[40] a work that finally consolidated not only Stoelcker's commitment but also his professional life in an Italy that was then in the midst of an economic boom.

Notes

1 Historical Archives of the Rome Chamber of Commerce, *Ditta Rodolfo Stoelcker*, *Company Register,* folder no. 3437, Registration Certificate of 20 October 1914.

2 Known in Italy as Rodolfo Stoelcker, Rudolf Stölcker was born on 22 February 1880 to Carlo and Teresa Wehrle. This is recorded in the Criminal Records Certificate issued by the Court of Rome to Stoelcker on 14 September 1935, in the State Archives of Rome, *Tribunale fallimentare*, file no. 1192 bis.

3 The city in which he probably met his future wife Antonietta Maranghi, a native of that city, as well as his brother-in-law, the accountant Carlo Maranghi, known in Rome as a player as of 1912 at the Lazio football club, who would be instrumental in the years of the First World War for his first important Roman commission, the foundations of the Ministry of the Navy.

4 On the spread of reinforced concrete in Italy, see Iori (2001: 16–20, 51).

5 The engineer Oscar Huber was a specialist in structures and a pupil of Emil Mörsch, who had employed him at Wayss & Freytag in 1906; he carried out his entire career in the Italian subsidiary which moved from Genoa to Rome in 1912 and in 1914 became independent, at least in name, from the parent company, becoming Ferrobeton Società Anonima Italiana. A brief profile is outlined in his obituary (Straub 1951: 733).

6 See, among others, Di Pietro (2018: 564–565).

7 The regulations remained in force until April 1922, when new ones were proposed and converted into law in 1925.

8 Theory supported by his work *Der Betoneisenbau* of 1902, widely disseminated and translated into several languages. For the Italian translation, see Mörsch (1910).

9 The quotations are taken from *Istanza di concordato preventivo a seguito di fallimento of 18 September 1935*, in the State Archives of Rome, *Tribunale fallimentare*, file no. 1192bis, f. 14880, vol. 1.

10 On the opposition to Stoelcker and the attacks in newspapers on both Ferrobeton and Stoelcker, see also the bibliography in Ciranna (2017) and Ead. (2021b), in particular pp. 368–369.

11 Prescribed in the competition notice of 18 December 1913.

12 On the different phases of construction and reconstruction of the bridge, see in particular Ciranna (2016: 300–301).

13 *Archivio Storico Capitolino* (ASC), *Contratti*, *contratto d'appalto del 18 novembre 1944* rep. no. 27596, Contract for work to repair the Tito Tazio bridge over the Aniene river entrusted to Mr. Rodolfo Stoelcker by the Municipality of Rome. In the power of attorney dated 6 August 1943, it is specified that Stoelcker is an Italian citizen resident in Viale Regina Margherita 262. In this power of attorney,

Mrs Antonietta Maranghi di Giuseppe in Stoelcker, born in Genoa and domiciled in Rome viale Regina Margherita 263, and Maria Geraci fu Decimo, domiciled in Rome, who administer his property, are appointed as Stoelcker's attorney general. The contract was awarded by private treaty for £300,000 Italian lire following resolution no. 792 of 23 October 1944. From the special tender specifications, we learn that the repair work following the mine explosion included:

> the demolition of the damaged structures of the bridge and their reconstruction, the reinforcement of some members by injecting cement under pressure, the demolition and relative reconstruction of part of the parapets of the bridge, the resurfacing of the road surface in the damaged part, the supply of various materials, as well as timber and labour, etc.

14 A collection of photos and a few news items is available at www.casoli.info/casoli/cartoline (accessed 19 September 2022).

15 Some news is available at: www.cdsconlus.it/; www.costantinojadecola.com and http://old.comune.minturno.lt.it/museo (accessed 19 September 2022).

16 For the bibliography and archival sources cited in reconstructing the different phases of the bridge construction, see in particular Ciranna (2019a: 36–37).

17 The bridge was solemnly inaugurated in the summer of 1933. Cf. Archivio Istituto Luce, Giornale Luce B0322, 1933 – "Ricco di archi e colonne, il nuovo Ponte del Littorio sul Pescara sostituisce l'insufficiente ponte in ferro ora demolito. Il ministro dei lavori pubblici lo ha solennemente inaugurato" available at: https://patrimonio.archivioluce.com/luce-web (accessed 12 December 2022).

18 The text by Cecchelli, C. (1931) consists of a brief technical description with photos of the construction site. In 1930, Impresa Stoelcker was awarded two contracts for embankment works in Vallerano, namely the first for the "Raising of the carriageway and modification of the parapets of the bridge over the Vallerano ditch at Tor di Valle to protect the Via del Mare from the Tiber floods" (22 April) and the other for the "Reinforcement of the carriageway and modification of the parapets on the Malafede ditch" (15 July), in the State Archives of Rome, *Ufficio Speciale per il Tevere e l'Agro Romano, Sistemazione sponde*, file no. 210 (1930–1936) Vallerano, Malafede.

19 Florence State Archives, 011/70/I, file no. 630, ins. 1, Azienda Autonoma della Strada. Concession for the construction of a bridge over the Greve Torrent at "Casellina" for the variant of State Road no. 67. There is an earlier project dated 5 April 1930 signed by SAIS Società Anonima Imprese Stradali Roma Viale Regina Margherita 262, that is the company founded by Stoelcker on 18 January 1929 which in 1931 transferred its registered office to Milan. On the latter, see Ciranna (2021b: 381–2).

20 See, for example, Regione Toscana (1933: 227).

21 The documentation is kept in the Prato Municipality Archives, *Opere pubbliche, Strade, Passerella pedonale sul fiume Bisenzio*, file no. 969 (the folder also bears the number 88).

22 Here as in other entries that follow, Stoelcker used the plural "bridges" without specifying the exact number and location.

23 On the bankruptcy, see Ciranna (2021b: 384).

24 On 19 December 1935, a contract was drawn up between the Province of Rome and the Rodolfo Stoelcker Company in bankruptcy concerning the construction of a new overpass on the State railway at Via Casilina. In the contract, Stoelcker was represented by Dr Ettore Felici, curator of the bankruptcy of the company. Stoelcker had obtained the contract on 20 December 1933, registered in Rome on 8 January 1934 for the sum of £670,000. Following a variation requested by the Railways, a new project for the work was approved for an amount of £1,170,000. In ASC, Contratti, 20 December 1933, there was the construction of a flyover on the Ferrovie dello Stato tracks near Via Casilina and, on 19 December 1935, there was the construction of a new flyover on Via Casilina. In addition to this bridge, Stoelcker was also allowed to continue the construction of the piezometric tower for the Acquedotto Vergine in Salone, the contract for which was dated 28 June 1934.

25 ASC, *Contracts,* 5 November 1939 rep. 21895, *Contract for the construction of the new bridge over the Tiber at San Giovanni dei Fiorentini*, value of works £7,700,000. The contract was consequent to the completion of the tender of 28 April 1939.

26 On the contract for the four bridges awarded to this company, see D'Onofrio (1968); Pietrangeli (1964: 295–300). Of the four bridges planned – the Rotto bridge (to be completed in the missing section), the one at San Giovanni dei Fiorentini, at Ripetta and at Ripa Grande with access to the San Paolo road – only the first two were built. The Fiorentini bridge was completed in 1873 in a Rome that had just become the capital of Italy.

27 Architect Bronzetti had also designed the bridge over the Castelfusano Pond Canal, built by Impresa Stoelcker in 1933, see ASC, *Contratti,* 7 June 1933 rep. N. 10049, "Contratto tra il Governatorato di Roma e il Sig. Stoelcker Rodolfo". Construction of the bridge over the Stagno canal at Castel Fusano, following resolution no. 2284 of 25 April 1933, contract by private treaty for an estimated cost of £105,945.31, granted for a price per body of £63,000. See also contracts dated 9 March and 9 May 1934.

28 The quotation is taken from the Special Tender Specifications kept in the archives of the former V Department, Rome, now Dipartimento Sviluppo Infrastrutture e Manutenzione Urbana-Centrale Unica Lavori Pubblici (SIMU), folder 21 Fiorentini. Here, it is specified that the demolition of the suspension bridge would take place after the new bridge was opened to pedestrians and would include

> in addition to the dismantling of the iron structures, the demolition of the piers also in the underwater area until the normal section of the riverbed was restored, the demolition of the terminal aediculae on the banks, the complete restoration of the embankments and any other accessory work.

29 Archivio Storico Capitolino, *Contracts,* 8 October 1943, rep. no. 26747, contract between the Province of Rome and Mr. Stoelcker Rodolfo. Subject: contract for cement injections necessary for the extraordinary maintenance of Ponte Risorgimento. Amount: 99,500 Italian Lire. The contract was by private treaty following resolutions 2380 of 13 August 1943 and 2892 of 7 October 1943 and in accordance with the special specifications attached to the contract. See also there, contract of 25 September 1942 and that of 6 October 1944 for the completion of the works at Ponte Risorgimento.

30 The arch has a cellular structure consisting of a 22- to 30-cm-thick intrados slab, three 35- to 45-cm-thick vertical septa and a 22- to 30-cm-thick extrados slab – all connected by 13 stringers with a constant thickness of 20 cm.

31 See here nos. 34–35 for the bibliography and archival sources in the cited texts.

32 The companies invited, in addition to Stoelcker, included Ferrobeton, Vianini and Eternit. See A.G.B.: 1930.

33 The original project was by architect Garibaldi Burba (–1925), the conversion into workshops was followed by architect Arturo Larderel. See State Archives of Rome, Roman Civil Engineering Office*,* file nos. 32–48 and 406.

34 Bankruptcy was declared in September 1935, but the signs of the company's financial difficulties were apparent three years earlier (Ciranna 2021b: 375).

35 In Istituto Luce, Giornale Luce A/A0342, *Inauguration of Ceprano power station*, date: 05/1929 film code: A034205. Available at: https://patrimonio.archivioluce.com/inaugurazione-della-centrale-elettrica-ceprano (accessed 24 September 2022). The work is also included in the aforementioned list submitted by Stoelcker to the municipality of Prato for the invitation of tender for the footbridge over the Bisenzio, see no. 25.

36 The advertisement appeared in several issues of the year among various advertisements, see *Il cemento armato*, XXVII, 2, February 1930: 20.

37 A necessary choice, in Piacentini's opinion, both to meet the delivery time indicated by the Duce within three years and to satisfy the demands of modernity, innovation and comparison with international circles. Cf. Ciranna (2019b).

38 Concerning the agreement between the Federazione Nazionale Fascista Costruttori Edili (FNFCE) and IG Farben and HGW (Hermann Göring Werke), Mantelli mentions the contract signed on 14 March 1942 which committed a consortium of 40 Italian companies, with the supply of 8,635 construction workers as well as 21 cooks and interpreters. The contract is in print: Federazione Nazionale Fascista Costruttori Edili, *Contratto per l'esecuzione di lavori di costruzione in partecipazione con imprese germaniche, nei cantieri di Heydebreck, Blechhammer e Auscwitz*, Tipografia del Gianicolo, Rome, 1942. See also Fertilio, D. (18 March 2001), 29; http://giuseppemarazzini.blogspot.com (accessed 25 September 2022).

39 ASC, *Contracts,* one concluded on 24 February 1954 and registered on 10 April and the other on 2 March and registered on 30 March 1955.

40 The engineer Mario Neumann, born in Rijeka in 1920 (who was Stoelcker's son-in-law, having married his daughter Teresa Maria), moved with his family to the USA in 1957 and was engaged on this site. I thank his son David for providing the author with the relevant documentation.

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