

# FROM THE *ÉCOLE DE PONTS ET CHAUSSÉES* TO PORTUGUESE RAILWAYS: THE TRANSFER OF TECHNOLOGICAL KNOWLEDGE AND PRACTICES IN THE SECOND HALF OF THE 19TH CENTURY

ANA CARDOSO DE MATOS | CIDEHUS – UNIVERSIDADE DE ÉVORA

MARIA PAULA DIOGO | CIUMCT/DCSA, FCT – UNIVERSIDADE NOVA DE LISBOA

Conquering time and space was at the core of the European 19<sup>th</sup> century agenda. To build roads and railway lines, to link the world through an extensive telegraph network, to use new technologies of power, became the driving force of progress and the pillar of political and economical world dominance.

First in the European "centres", then in the European "peripheries" and eventually in the colonies, public works – and particularly a growing network of railroads – became central to the concept of modern state<sup>1</sup>.

In a peripheral country such as Portugal the pursuit of new and updated technological knowledge relied deeply on the efficiency of a network of formal and informal channels, which acted as vehicle for learning and spreading new skills, new machines and new expertise. Studying and travelling abroad, going regularly to international meetings, visiting the World Exhibitions, exchanging journals, was part of this overall strategy aiming to appropriate foreign knowledge and to adapt it to local needs and expectations<sup>2</sup>.

From the mid nineteenth century onwards, Portugal elected to build an extensive railroad network, which was considered the main incentive for the industrialization of the country. The need of a growing expertise in public works and particularly in

<sup>1</sup> Gavroglu; Papanelopoulou; Simões; Carneiro; Diogo; Sánchez; Belmar; Nieto-Galan (2008); Misa, Schot (2005).

<sup>2</sup> Simões; Carneiro; Diogo (ed.) (2003); Matos (2006); Matos e Diogo (2007).

railways led the Portuguese government to support the training of Portuguese engineers abroad. The *École des Ponts et Chaussées* was the paradigm of public works efficiency, the centre of what has been described as the “Ponts et Chaussées Europe”, a transnational space where technical knowledge and managing and administrative models circulated, creating a new political-technocratic elite<sup>3</sup>.

In this article we present two examples of this movement of technological transfer between France and Portugal: the cases of João Evangelista de Abreu (1827-1869) and of Cândido Xavier Cordeiro (1842-1904), both engineers deeply engaged in the railway network.

#### A PERFECT PAIR: RAILWAYS AND ENGINEERS

During the Portuguese second half of the 19<sup>th</sup> century, the concept of modernization is closely related to the construction of the railway network. In this context, in 1842, Costa Cabral suggested building two railway lines (Lisbon-Oporto and Lisbon-Badajoz), a proposal that was denounced by his opponents as the “lunacy of a seer”<sup>4</sup>. In 1844, Benjamim de Oliveira, a Portuguese citizen living in England (where the first railway had opened in 1825) proposed to the Count of Tojal, the Treasury Minister, that a railway line be built between Lisbon and Oporto, passing through Santarém, Leiria, Coimbra and Aveiro, “an idea that showed no possible benefit”<sup>5</sup>. In 1845 the Count of Tomar charged the *Companhia das Obras Públicas de Portugal* (Portuguese Public Works Company) with “building a railway along the bank of the Tagus river, linking Lisbon to the frontier with Spain”<sup>6</sup>, appointing the Belgian engineer Dupré to supervise the project. However, the project was suspended because of political instability and the company was wound up in 1848.

From 1850 onwards the *Regeneração* and particularly the *fontismo* brought to the forefront of Portuguese economy the development of roads and railways<sup>7</sup>. The construction of a transport network based mainly on the railways played a decisive role in the development of the country’s leading economic areas as well as in the

<sup>3</sup> Described by I. Gouzevitch and K. Chatzis in «Présentation» of the International Meeting Bettancourt: Les Ponts et Chaussées et l’Europe, XVIII<sup>e</sup>-XIX<sup>e</sup> siècles, Marne-la-Vallée (Paris), 17-19 June 2008.

<sup>4</sup> Martins (1979: p. 135).

<sup>5</sup> Abragão (1956: pp. 120-124).

<sup>6</sup> Abragão (1956: p. 124).

<sup>7</sup> Portuguese historiography dates the *Regeneração* to the period 1850-1877. Its spirit, however, was carried on into the rest of the 19<sup>th</sup> century and the early 20<sup>th</sup> century. Fontes Pereira de Melo, a prominent engineer and politician (he served several times as Minister and Prime Minister) was the main mentor of this new agenda, often labelled as *fontismo*.

differing paces of regional growth, thrusting Portugal into the international web of modern economic relationships and creating new economic, financial, legal, demographic, cultural and technological perspectives.

From 1850 to 1880 the Portuguese government was easily able to raise foreign funds for building national infrastructures, supported by its own credibility (Portugal was part of a selected group of countries using gold as its monetary standard) and by the interest of British capitalists in investing their money in “material structures”. These foreign companies were invited to participate in the Regeneration project by applying both their capital and technical expertise. As these companies used their own technological know-how, management models, and engineers, Portuguese engineers were, at the beginning, only used to suggest minor changes and to approve the plans which were presented to the Ministry of Public Works, Trade and Industry<sup>8</sup>.

In 1852 the Portuguese government announced that proposals for the construction of a railway line between Lisbon and Santarém and, in a second stage, from Santarém to the border with Spain, were welcomed. The winning proposal was presented by the *Companhia Central e Peninsular dos Caminhos de Ferro* (Central and Peninsular Railway Company), a railway company headed by Harry Hislop. The project was supervised by an English engineer, Thomas Rumball, whose plans were subsequently reviewed and slightly altered by two Portuguese engineers, João Crisóstomo de Abreu e Sousa and Joaquim Tomás Lobo d’Ávila, both members of the *Conselho de Obras Públicas e Minas* (Public Works and Mining Board).

The line between Lisbon and Carregado was opened on the 28<sup>th</sup> October 1856<sup>9</sup>. The development of the railway network continued, gathering pace in the 1880s and covering a total of 2,358 km by the end of the century<sup>10</sup>.

The focus on railways fostered the development of a specialised professional community engaged in technical activities. The new technologically driven agenda of the *Regeneração*, based on public works and particularly on railways, led to a growing status of engineers as a professional group, and to the rise of civil engineering. At the same time, as leading protagonists of modernity, Portuguese

<sup>8</sup> Pinheiro (2000).

<sup>9</sup> The railway line was at first perceived as a dangerous technology. The Medical Academy, of Baviera warned of the risks to public health (diseases of the brain, pleurisy, catarrh, etc.) from steam-powered trains, affecting both passengers and the general public. Eça de Queirós, a major Portuguese writer, wrote in his novel *Os Maias*: “Vilaça had travelled by train from Carregado. ‘Isn’t it terrifying?’ asked the priest, his spoon suspended in front of his mouth. ... ‘It does make you shudder a bit’. Vilaça commented on his experience. ‘They can say what they like, but it does make you shudder!’”

<sup>10</sup> When Fontes Pereira de Melo died in 1887, a total of 1,600 km of railway were in operation, about 45% of the network that existed in 1956, a century after the opening of the first line.

engineers had to face the power of European engineering in a double folded relationship: European engineering was accepted as the main reference concerning know-how and expertise; being praised by European fellow engineers meant to be recognized as members of a wider community. This close contact with foreign technological communities and, above all, the opportunity to apply their skills and expertise on equal terms with their European peers made it possible for Portuguese engineers to perceive themselves as professionals.

The training of these men involved specialising in civil engineering and a consequent mastery of practical know-how on a par with their foreign counterparts. However, although civil engineering was clearly the most promising working area for Portuguese engineers, most of them were hardly familiar with it. Most of them had only been trained as military engineers at the *Escola do Exército* (Army School) and just a very small group had been sent abroad to study theory and practice, namely to the *École des Ponts et Chaussées* in Paris<sup>11</sup>.

During the second half of the 19<sup>th</sup> century, 27 Portuguese engineers, both senior engineers and promising students, enrolled in courses at the *École des Ponts et Chaussées*<sup>12</sup>. Some of the senior engineers went to Paris at their own expenses, but most of them applied for a grant from the Ministry of Public Works<sup>13</sup>. This Ministry was also bound to send at least three students per year to study abroad. When returning to the motherland, all of them would present a detailed report and would dedicate themselves to public works, that is to say, to the modernization of Portugal, thus "paying back" the government investment.

By 1881, around 11% of the Portuguese engineers affiliated at the *Associação dos Engenheiros Civis Portugueses* (Portuguese Association of Civil Engineers) were trained abroad. France was the favourite choice, reaching almost 70% of the preferences of the students; 41% of those who went to France chose the *École des Ponts et Chaussées*<sup>14</sup>. Among these graduate and undergraduate students we will focus on explore two case studies: João Evangelista de Abreu and Cândido Xavier Cordeiro.

<sup>11</sup> Between 1825 and 1851, 19 Portuguese students attended the *École des Ponts et Chaussées* as "auditeurs". See Picon (1992: pp. 405-406).

<sup>12</sup> Matos (2009a).

<sup>13</sup> Law dated from 17 July 1855, Article 30.

<sup>14</sup> «Relação dos Sócios em 2 de Abril de 1881», in *Revista de Obras Públicas e Minas*, XII, ns.135/136, March/April 1881, pp. 46-58. For further data see Diogo (1996) and Diogo (2009).

## FROM LISBON TO PARIS

João Evangelista de Abreu was selected to go to the *École de Ponts et Chaussées* in 1856<sup>15</sup> and Cândido Xavier Cordeiro in 1864<sup>16</sup>. Both of them had a specific training in engineering and had a few years practice both in public works and in teaching.

João Evangelista de Abreu, held a bachelor's degree in Mathematics from the University of Coimbra (1850) and a degree in Military Engineering from the Army School (1854). From 1852 to 1853 he taught Geometry and Mechanics applied to the Arts [i.e., industry] and Professions, at the Liceu Nacional de Lisboa (Lisbon National High School); from 1854 to 1856 he was responsible for a set of disciplines on roads and railways at the Army School<sup>17</sup>. These disciplines were available for students interested in civil engineering and who wanted to complete their military education with a more extensive training on civil engineering.

In 1855 the Portuguese government established three grants to support Portuguese engineers who wanted to complete their training abroad. For those who wanted to dedicated themselves to public works the *École de Ponts et Chaussées* was the natural choice. João Evangelista applied for a grant in 1855 and a year later he was already in Paris. At the *École*, Evangelista immediately stood out from his colleagues as a brilliant student both concerning theoretical and practical matters<sup>18</sup>.

Cândido Celestino Xavier Cordeiro held also a bachelor's degree in Mathematics from the University of Coimbra (1861). Between 1861 and 1893 he studied at the Army School where he enrolled the disciplines related to civil engineering. After concluding his degree, Cândido Xavier began his professional career at the Public Works division of Castelo Branco (center inner part of Portugal)<sup>19</sup>. In 1864 he successfully applied for a grant to study at the *École de Ponts et Chaussées*.

Cândido Xavier easily stood out from his colleagues, among whom one could find Alfred Picard (later known as *Picard the Great*), Guillaïn, future Minister of the Colonies, Agnellet future Chief-Engineer of Public Works in Northern France, Eustachio Thomaz Skrochowski, Zaleski, Safranski, all from Austria and the Turk Margosoff. Xavier was particularly good in Mathematics thus becoming quite renowned among colleagues and teachers.

<sup>15</sup> Pedro d'Alcântara Gomes Fontoura and José Joaquim de Castro were also selected. Since the last gave up the idea of studying in Paris, he was replaced by Valentim Evaristo do Rego.

<sup>16</sup> Sixteen engineers applied for this grant. Cândido Xavier Cordeiro, Augusto Luciano Simões de Carvalho e João Veríssimo Mendes (do Castanheirinho) were chosen.

<sup>17</sup> AHMOPCI, João Evangelista de Abreu's file.

<sup>18</sup> Carvalho (1907).

<sup>19</sup> AHMOPCI, Cândido Xavier Cordeiro's file. See also Matos (2009b).

At the *École de Ponts et Chaussées* both João Evangelista de Abreu e Cândido Xavier were trained by some of the best French engineers – Reynaud, Bresse, Mangon, Bayle, Garnier –, who taught their students the most updated engineering methods.

Together with the more conventional classes, the *École* encouraged its students to have a close contact with the main engineering works in France, promoting fieldwork trips.

In 1857, after having completed his first year at the *École de Ponts et Chaussées*, João Evangelista de Abreu went to Bayonne, Pau and Marseille to study roads, railways and harbours.

At Bayonne, Evangelista was particularly interested in the similarities between the Adour harbour and the Douro harbour (northern part of Portugal) and between the small harbour of Saint Jean de Luz and that of Leixões (also in northern Portugal). During the month he spent at Bayonne, João Evangelista became familiar with the so-called “Napolitano system” developed by the French engineer Dagueneu.

After Bayonne, the Portuguese engineer went to Pau to study the road system along the French-Spanish Border. After having briefly returned to Bayonne, João Evangelista travelled to Marseille where he joined his fellow countrymen, Pedro d’Alcântara Gomes Fontoura and Valentim Evaristo Rego, to study the local harbour.

At the end of his fieldwork trip Evangelista wrote his report in which he praised this kind of training. In fact, before leaving to their fieldwork assignment, the students received a set of letters of recommendation that opened them the doors for the “real” world of public works<sup>20</sup>:

“Thanks to the letters of recommendation it was easy for us to contact with different engineers who welcomed us warmly. Drawings, memoirs, reports and documents of every kind were made available to us.”

Just two examples: concerning the bridge over the Adour, they received “all the documents, both drawings and texts, as well as notes concerning the details”; in Marseille, where they studied the harbour under construction and the railway to Toulon, they were allowed to examine in detail different types of bridges<sup>21</sup>.

At the end of his second year, João Evangelista de Abreu went on a fieldwork trip to Bordeaux and, once again, to Marseille and Toulon. His aim was to study the Gironde estuary, the new iron bridge over the Garonne that linked the two railway

<sup>20</sup> Abreu, Fontoura e Rego (1858: pp. 360-380). See also Matos (2009a).

<sup>21</sup> *Ibidem*.

lines of Orléans and the Midi, the procedures for fixing dunes and its economic results, and the network of water distribution<sup>22</sup>. He was also interested in comparing the Bordeaux and the Marseille harbours with the Lisbon harbour. Commenting on the warm reception he had at the bridge builder's yard he wrote:

"I have twenty-three large drawings on the design of this important work; in addition, thanks to the warm welcome by M. Régault, engineer of bridges and roads, and both the designer and the chief engineer of this project, I was allowed to participate in the definitive estimates of the project."<sup>23</sup>

The report presented by Evangelista after this fieldwork trip was unanimously praised by his teachers and at the end of his course he received not only the regular diploma but also a special mention to the quality of his work.

Before leaving France, João Evangelista went on a last fieldwork trip to study the construction of the Kehl bridge, in the Strasbourg railway line, which linked France to Germany.

Cândido Xavier Cordeiro wanted to go to Grenoble or to Savoy for his first year fieldwork. However as the former was offered to Picard, he took on the latter. In his second year he went

— "to Bercy, with Jaqmin, to visit the Paris-Lyon-Méditerranée railway workshops; to Creil and to Epone, with Bayle, on a geological trip that included the famous foundries at Montataire; to Auteil, with Morandière, to see both the works on the railway line around the city and the building site of the viaduct on the top of the bridge at the Point du Jour."<sup>24</sup>

At the end of the second year, Cordeiro went to Marseille with Agnellet and Mendes Guerreiro.

Furthermore, in 1867, Cândido Xavier Cordeiro was charged by the Portuguese government of collecting information on the "state of the art" concerning railways at the Paris World Exhibition<sup>25</sup>. The visits to the venue of World Exhibition were complemented by a set of visits to several railway yards, workshops and stations.

In his third year, Xavier Cordeiro went, together with Luciano de Carvalho, on a fieldwork trip to Bretagne, in order to study

"the harbours of Nantes, Saint-Nazaire, Lorient, Brest, Saint-Brieux and Saint Malo and the railway lines of Rennes and Nantes, renowned by both their viaducts at Gouet, Morlaix, and Chateaulin, and their sinuous mountain paths very similar to the Portuguese ones."<sup>26</sup>

<sup>22</sup> Abreu (1860: p 112).

<sup>23</sup> Abreu (1860: p. 117).

<sup>24</sup> Carvalho (1906: p. 547).

<sup>25</sup> Whenever exhibitions were held in Paris, the Portuguese government instructed those holding the scholarship at that time to study the technology being displayed. See Matos (2004).

<sup>26</sup> Cordeiro (1870a: p. 3).

During its railway travel to Saint-Brieu, Cândido Xavier stopped a few times to visit and study several on going public works, such as the Le Mans train station with its metal covering, and the harbours at Sables d'Ollonne and at Saint-Nazaire. At Saint-Nazaire, the Portuguese engineer toured what he considered to be a "first class harbour yard"<sup>27</sup> in company with the local engineer M. Revol, studying the main engineering works at the Penhouet dock.

He then travelled to Alli, where he visited the viaduct over the Aulne river, considered as a benchmark for stone made viaducts; from Alli, Cordeiro sailed to Brest and from there he reached Saint-Brieu, where he stayed for a few days to study, under the supervision of the French engineer M. Christophe, the western railway line. He finally returned to Paris, via Saint-Malo, where he visited the harbour.

Already in Paris, Cândido Xavier was appointed to go with the Portuguese engineer João Joaquim de Mattos to London in order to study the docks, the new Westminster harbour and the Metropolitan Railway

Back to Paris, Xavier immediately began studying the French railway network, visiting the railway yards at Bercy, la Villette, la Chapelle, Giouin et Cail. These fieldtrips, together with the information collected at the World Exhibition, convinced Cândido Xavier Cordeiro that the French and the German railways were the best example for the Portuguese railway network as they provided a set of efficient solutions to overcome the Portuguese northern and northeast mountainous countryside<sup>28</sup>.

In this context he asked the Portuguese Minister of Public Works permission to extend its training abroad in order to visit the German railway network. The permission was granted and, in April 1864, Cândido Xavier and his colleague Mendes Guerreiro went to Strasburg to visit the Kehl bridge and the Graffenstaden plants, renowned manufacturers of locomotives and industrial machinery who had won a gold medal at the Paris Exhibition. The winning locomotive presented at the Word Exhibition was considered by the Portuguese engineer as "*extremely suitable for the steep slopes of some of the Portuguese railway lines.*"<sup>29</sup>

From Strasburg, Cordeiro went to Mulhouse where he visited André Koechlini's factories, which he considered superior to the Graffenstaden plants. He then travelled to Munich where he met some German colleagues, namely Von Dick, Head of the German railways, who shared with him information on the Baviera

<sup>27</sup> Cordeiro (1870b: p. 83).

<sup>28</sup> Cordeiro (1870a: p.8).

<sup>29</sup> Cordeiro (1870a: pp. 75 -77). See also Matos (2009b).



railways, and Zenetti, who accompanied the Portuguese engineer to the Krauss & C<sup>a</sup> factory. Xavier was especially interested in this factory because they had also presented at the Paris Exhibition an “intriguing” locomotive, which was awarded with the gold medal<sup>30</sup>.

From Munique, Cordeiro went to Italy. Before visiting several engineering works at Milan and Venice (channels, sewerage, the arsenal), he stopped at Insbruck and Brenner where he examined the railway lines. He continued travelling by train to Vienna and, later on, to Hungary. In both countries he collected a significant amount of information on railways. Between Vienna and Berlin he had the opportunity to visit the “magnificent railway line of Bondenbach-Dresden”<sup>31</sup>, and the Borsig factory, in Berlin, which were considered the most important German factory at that time.

Travelling back to Paris, Cândido Xavier Cordeiro stopped at Köln, where he visited the Rein railway line, directed by the German engineer Emil Hartwich. From this visit, Xavier highlighted the solution used to cross the Rein at Rheinhausen, developed by Hartwich himself, considering that “maybe some of the technical problems which arise from trying to link the Portuguese southern and northern railway lines, near Lisbon, could be solved by using this fantastic system”<sup>32</sup>.

Back to Portugal, both João Evangelista de Abreu e Cândido Xavier engaged in the Portuguese new political and economical agenda of the *Regeneração*, based on the growing importance of public works and particularly of railways. The time had arrived for them to apply the knowledge they had acquired by studying at the *École de Ponts et Chaussées* to Portugal.

#### FROM PARIS TO LISBON

When they returned to Portugal the engineers trained at the *École des Ponts et Chaussées* joined the technical staff of the Ministry of Public Works. Throughout the second half of the 19<sup>th</sup> century they played an important role as leaders of the railway network and of public works all over the country and also as experts in technical committees.

The training these engineers had received abroad on “the sciences and arts of construction”<sup>33</sup> was the core of a corps of technicians able to free the country from

<sup>30</sup> Cordeiro (1870a: p.81).

<sup>31</sup> *Ibidem*.

<sup>32</sup> Cordeiro (1870a: p. 38).

<sup>33</sup> *Boletim* do MOPCI, 1 de Janeiro de 1861, p. 12.

reliance on foreigners to plan or carry out every project in civil engineering.

When João Evangelista de Abreu returned to Portugal he was appointed as Head of the 2<sup>nd</sup> inspection division for the railways; from 2 October 1866 he also took on the task of directing the railway studies south of the River Tagus<sup>34</sup>. When D. Eusébio de Page (the successor of D. José de Salamanca, the famous Spanish engineer who directed the Northern and Eastern railway lines in Portugal) decided to appoint two engineers to direct the works in the Northern railway line and in the Eastern railway line, he chose Adolfo Ibarreta for the first one and he asked the dean of the *École des Ponts et Chaussées* to choose another highly competent engineer for the second one. João Evangelista de Abreu was the dean's choice. After just one year he was already in charge of directing both lines<sup>35</sup>. Although he had to face a significant number of technical problems in both lines, Evangelista never gave up his plans and, by 1864, he was ready to inaugurate the two railway lines.

In 1865 he returned to the Army School and to the Ministry of Public Works where he was appointed to lead a study on the railway line south to the river Tagus. However, due to political and economic reasons, this study remained as a theoretical proposal. Evangelista, who was a man of action, was strongly disappointed and was happy to embrace the new project to improve the Lisbon arsenal. It was a project in which he could fully apply the technical knowledge had brought from the *École des Ponts et Chaussées*. João Evangelista had already studied the Lisbon harbour and the project for improving the arsenal was part of this wider study. Once again economic reasons didn't allow the full project to be executed, leading Evangelista to despair. His psychological balance became increasingly fragile. In 1869 he died in an asylum.

On his return to Portugal, Cândido Xavier Cordeiro joined the Board for Sanitary Improvements, but soon he was appointed to work, under the supervision of João Joaquim de Matos, in the construction of the railway line of Minho (northern Portugal). Xavier was responsible for the section between the right bank of the river Ave and the Braga branch. It was a tough task, namely due to the shortness of materials needed to built the line and of specialized workers<sup>36</sup>.

The Minho railway line also included two important works of art: the Durães Viaduct, 180 metres long and 22 metres high, and the Bridge over the River Lima, with ten huge sections each 60 metres long, "which pillars had in their foundations, for the first time in our country, compressed air in massive iron caissons"<sup>37</sup>, thus

<sup>34</sup> *Boletim* do MOPCI, 11 de Novembro de 1866, p. 330.

<sup>35</sup> *Abragão* (1956: pp. 244-247).

<sup>36</sup> (1906b: p. 35).

using the system Cândido Xavier had studied at the Kehl bridge during one of his fieldtrips at the *École de Ponts et Chaussées*.

In 1878 Cândido Xavier was once again sent to the World Exhibition in Paris to “study the narrow-gauge railway system, both concerning the use of locomotives and carriages and the use of steam in roads with or without rails”<sup>38</sup>.

Soon after his return (1879) he was appointed as Portuguese representative at the construction of the Indian railway line between Mormugão and New Hubi. Both the railway line and the works of improvement of the harbour of Mormugão would be conducted by a British firm contracted by the Portuguese government. Cândido Xavier, considered as an expert in railways, was asked to supervise the plans and the proposals and to collect further technical, statistical and economic information on the line and the harbour. Once the general proposal was accepted, Xavier was sent to India during four years (1881-1885) to supervise the ongoing works.

Back to Lisbon he was invited to join the technical staff of the Portuguese Royal Railway Company, where he developed a vivid professional career until 1902. Among his technical works during this period one should highlight the bridge over the Mondego River (centre of Portugal) and, near Lisbon, the Oeiras viaduct and the Rossio tunnel that was praised and presented as a perfect example of the “technical proficiency of our [Portuguese] engineers.”<sup>39</sup>

During his professional life, Cândido Xavier was appointed to serve in numerous technical commissions (for instance the one which tested the D. Maria bridge (Oporto); and evaluation panels (for instance the proposals for building the D. Luís bridge (Oporto)). Moreover his renowned expertise in engineering led to frequent invitations to serve as consultant both in Portugal and in Spain.

In 1902 Xavier left the Portuguese Royal Railway Company and joined the Board of Public Works and Mines.

During his career, Cândido Xavier published several theoretical articles, particularly at the *Revista de Obra Públicas e Minas (Journal of Public Works and Mines)*. He was a founding member of the Associação dos Engenheiros Civis Portugueses (Portuguese Association of Civil Engineers) and one of its presidents. In 1904 he was elected member of the Royal Academy of Science of Lisbon, a sign of recognition of the high standards of his work in the field of mechanics, namely the memoirs presented at the 6<sup>th</sup> International Railway Meeting (1900).

<sup>37</sup> Carvalho (1906: p. 558).

<sup>38</sup> Carvalho, (1906: p. 362).

<sup>39</sup> «Caminhos de Ferro Portuguezes. Inauguração do Tunnel do Rocio», *O Occidente*, XII, 372, 21 de Abril de 1889, p. 91.

## CONCLUDING REMARKS

Despite frequent but minor changes concerning the *curricula* of the courses, civil engineering continued to be considered during the 19<sup>th</sup> century as part of military training, having no autonomous status. Thus, public works kept being carried out by military engineers, who were part of the whole embracing “technical services”, which were in charge of “the defence of the country, civil works, roads, geological and other surveys, draining, improvement of ports and the supervision and management of arsenals.”<sup>40</sup>

However, this hybrid profile was increasingly inadequate to the country's needs. In the Portuguese modernization agenda, which was largely based on public works (in particular railways, roads, sanitation and hygiene, and ports), civil engineers embodied the idea of progress, thus playing a decisive role in the “new” Portugal. Soon civil engineers were able to lobby in order to create the Corps of Civil Engineers and Assistant Engineers (1864) and later the Portuguese Association of Civil Engineers, (1869).

Oddly enough the question of how to train civil engineers remained an unsolved business. In 1848, Albino de Figueiredo, an engineer who worked at the Minister of Public Works, emphasised the importance of civil engineering, considered as a powerful weapon to “consolidate a corpus of knowledge specific to civil engineers, a professional group without which any nation is deprived of its public works.”<sup>41</sup>

In 1854, Júlio Máximo de Oliveira Pimentel, a well known chemist and teacher at the Polytechnic School as well as a member of the Parliament, submitted a project that aimed at converting part of the military training institutions into Scientific and Technical Professional Schools, namely by creating a Public Works School (for civil engineers, builders, architects, geographical and hydraulics engineers and mining engineers) and an Industrial School (for mechanical, chemical and metallurgy engineers and foremen). This highly controversial project, especially regarding the poor role played by polytechnic schools was not approved.<sup>42</sup>

<sup>40</sup> *Diário do Governo*, nº 251, 1859, p. 1361

<sup>41</sup> *A Epoca*, I, 1848, p. 397

<sup>42</sup> The proposal of closing down the Polytechnic Academy of Oporto and other schools and the minor role ascribed to the Lisbon Polytechnic generated strong opposition, in particular from the teaching staff of the Oporto Polytechnic, which addressed a petition to the Members of Parliament. This petition was later published in the *Jornal da Associação Industrial Portuense* 19, pp. 296-304, 20, pp. 312-320 and 21, pp. 330-336, with the title *Breve Memória sobre a Instrução Pública Superior no Porto e nas Províncias do Norte, oferecida aos Senhores Deputados da Nação Portuguesa pelos Lentos da Academia Polytechnica*.

In 1859, the Parliament resumed the debate on the training of Portuguese engineers. The obvious lack of schools was, once again, the keystone of the discussion. However the solution which was considered the most suitable was not to create new schools in Portugal but to send abroad our best students. The Ministry of Public Works was bound to send at least three students per year to study abroad. The *École des Ponts et Chaussées*, the *École des Mines* and the engineering schools at Gand, Freiberg and Liège were considered the top schools at the time, and thus the ideal scientific and pedagogical milieu to complete their engineering training. After being abroad students were expected to return to the motherland "with the training required to fulfil the noble functions of an engineer and through useful work payback Portugal what the country had invested."<sup>43</sup>

Both João Evangelista de Abreu and Cândido Xavier Cordeiro epitomize this kind of policy. They were diligent students at the *École des Ponts et Chaussées* and their skills as engineers were often praised. At the *École* they had the opportunity to improve both their theoretical and practical training. After they returned to Portugal they used their training and experience to improve Portuguese engineering and to participate actively in the modernization agenda of the *fontismo*.

Although the choice of "buying" foreign scientific and technological knowledge in the European market-place had evident costs to Portugal, namely by delaying the implementation of national centres for developing expertise and skills, the role played by Portuguese engineers that went abroad to attend foreign schools was crucial to the modernization agenda of the 19<sup>th</sup> century.

To study at the *École des Ponts et Chaussées* was as important piece in a wider puzzle leading to Portuguese modernity. Portuguese engineers were thus leading actors of this complex play, bringing back home, both to the mainland and to the colonies, the new trends of technological knowledge and practise.

#### BIBLIOGRAPHY

ABRAGÃO, F (1956), *Caminhos de Ferro Portugueses - Esboço de uma história*, Lisbon, Companhia dos Caminhos de Ferro.

ABREU, João Evangelista de (1860), «Relatório sobre o emprego do Tempo de missão feita no fim do segundo ano do curso de Pontes e Calçadas pelo aluno João Evangelista de Abreu, dirigido ao excelentíssimo Senhor Visconde de Paiva, Ministro de sua Magestade Fidelíssima em Paris», *Boletim do Ministério das Obras Públicas, Comércio e Indústria*, 8 de Agosto, p. 112.

ABREU, João Evangelista de, FONTOURA, Pedro d'Alcântara Gomes; REGO, Valentim Evaristo (1858), «Relatório...», *Boletim do Ministério das Obras Públicas, Comércio e Indústria*, 3 de Março, pp. 360-380.

<sup>43</sup> *Diário do Governo*, nº251, 1859, p. 1361

CARVALHO, A. Luciano de (1906), «Elogio Histórico de Cândido Xavier Cordeiro», *Revista de Obras Públicas e Minas*, tomo XXXVII, n.ºs 442-444, Outubro/Dezembro.

CARVALHO, A. Luciano de (1907), *Cândido Xavier Cordeiro. Elogio Histórico*, Lisboa, Imprensa Nacional.

CARVALHO, A. Luciano de (1905), *João Evangelista de Abreu. Elogio Histórico*, Lisboa, Imprensa Nacional.

CORDEIRO, Cândido Xavier (1870a), «Estudos feitos em França e Alemanha», *Revista de Obras Públicas e Minas*.

CORDEIRO, Cândido Xavier (1870b), «Excursão à Vendaia e à Bretanha», *Revista de Obras Públicas e Minas*, n.º 1.

DIOGO, Maria Paula (1996), «In search of a professional identity – the *Associação dos Engenheiros Cívicos Portuguezes*», *ICON*, 2, pp. 123-127.

DIOGO, Maria Paula (2009), *A Construção de uma Identidade Profissional – A Associação dos Engenheiros Cívicos Portuguezes*, Lisbon, Colibri.

GAVROGLU, K.; PAPANELOPOULOU, F.; SIMÕES, A.; CARNEIRO, A.; DIOGO, M. P.; SÁNCHEZ, J. R.; BELMAR, A.; NIETO-Galan, A. (2008) «Science and Technology in the European Periphery», *History of Science*, 46, 152/2, pp. 153-175.

MARTINS, A. Oliveira (1979), *Portugal Contemporâneo*, Lisbon, Guimarães & Ca. (2ª edição).

MATOS, Ana Cardoso de (2004), «World exhibitions of the second half of the 19<sup>th</sup> century: a means of updating engineering and highlighting its importance», *Quaderns d'Història de l'Enginyeria*, VI, pp. 225-235.

MATOS, Ana Cardoso de (2006), «Industria e Maquinismo en Portugal: transferencia y adopción de Tecnología entre finales del siglo XVIII y principios del siglo XX» in LAFUENTE, António, CARDOSO de MATOS, Ana; SARAIVA, Tiago, (ed), *Maquinismo Ibérico*, Madrid, Doce Calles, pp. 229-234.

MATOS, Ana Cardoso de (2009a), «Asserting the Portuguese Civil engineering identity: the role played by the *École des Ponts et Chaussées*» in MATOS, Ana Cardoso de; DIOGO, Maria Paula; GOUZEVITCH, Irina; GRELON, André (eds.), *The Quest for a Professional Identity: Engineers between Training and Action/Les enjeux identitaires des ingénieurs: entre la formation et l'action/Jogos de identidade: os engenheiros, a formação e a acção*, Lisbon, Colibri, pp. 177-208.

MATOS, Ana Cardoso de (2009b), «Etudier en France, travailler au Portugal: le cas de l'ingénieur Cândido Xavier Cordeiro (seconde moitié du XIX<sup>e</sup> siècle)», in *Premier congrès francophone d'histoire de la construction* (editing).

MATOS, Ana Cardoso de; DIOGO, Maria Paula (2007), «Bringing it all back home: Portuguese engineers and their travels of learning (1850-1900)», *HOST–Journal of History of Science and Technology*, 1, pp. 155-182. [<http://www.johost.eu/>].

MISA, Tom; SCHOT, J. (2005), «Inventing Europe: Technology and the Hidden Integration of Europe», *History of Technology*, 21, 1, pp. 1-19.

PICON, Antoine (1992), *L'invention de l'ingénieur moderne: L'École des Ponts et Chaussées 1747-1851*, Paris, Presses de l'École Nationale des Ponts et Chaussées.

PINHEIRO, Magda (2000), «Os engenheiros portugueses e a construção ferroviária no século XIX», paper presented at the XX APHES Meeting.

SIMÕES, Ana; CARNEIRO, Ana; DIOGO, Maria Paula, (ed.) (2003), *Travels of Learning*, Dordrecht/Boston, London, Kluwer Academic Publishers.