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AN ARCHITECTURAL APPROACH COMBINING 3D SCANNING AND UNPUBLISHED ARCHIVES TO THE ANALYSIS OF A 19TH-CENTURY ENGINEERING STRUCTURE: CASE STUDY OF THE CHIFFA RAILWAY VIADUCT ALGERIA

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ABSTRACT

The engineering structure we are about to analyse is the result of several successive phases .The reasons for its current form will find their justification in the history of this structure ,which is undeniably linked to a railway renewal that Algeria experienced during the colonial period.The focus is on the twentieth-century restoration (renovation) of the railway bridge that spans the Chiffa River. This bridge was originally built in the nineteenth century as part of the Algiers-Oran railway line. The purpose of this exploratory paper is to trace the history of this structure since its construction and to document an experiment conducted in 1930 involving the revewal of metal railway structures on the mentioned line. One aspect of the study focuses on the design of old metal structures, while another looks into the technical aspects of reinforcing these structures with reinforced concrete. This reinforcement was required because of the use of reinforced concrete during the railway renewal, which modernized techniques. Furthermore, it addresses the latter’s doubling specifically in terms of its scientific and technological contributions at the time. The experiment was carried out using field surveys, 3D scanning, and analysis of archived materials from the National Society of Rail Transport archives (SNTF).

KEYWORDS

Engineering Structures, Railway Renewal, 3D Scanning , Archived Materials , Cast Iron-Reinforced Concrete, 19th and 20th Centuries

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1. Introduction

Currently, Algeria is a focal point for the continuous expansion of railway infrastructure. To address the needs of the present time, it is imperative to ascertain the future of various railway structures from the colonial era. This exploratory paper aims to document an approach for addressing an existing heritage, specifically an experiment conducted in 1930 to rehabilitate a cast iron railway structure on the Chiffa viaduct in Algeria (Figure 1).

Fig. 1. Current state of cast-iron bridge (a), Current state of second reinforced concrete. bridge (b)

Situated along the Algiers-Oran railway line (Location: 36°27'56. 1 "N 2°45'13. 9 "E), this viaduct was constructed in 1869 by the Creusot Schneider workshops. In the 1930s, significant reinforcement using reinforced concrete was carried out to strengthen its structure. This work provides a valuable understanding of this legacy.

In an approach that repositions the bridge as the quintessential architectural object, we attempt to proceed gradually in order to understand the current form of this heritage standing before us.

The investigation focuses first on the original design of the old structure, then on the techniques used to reinforce it, and finally on the unique features of this railway renovation, both in terms of doubling and reinforcement.

A thorough examination of the SNTF archives in Algiers was carried out. The research was enhanced by studying specialized publications from that time and by examining the Chiffa viaduct on-site with 3D scanning . Utilizing primarily unpublished documentation, this study aims to meticulously trace the history of the Chiffa viaduct and place it within the context of the development of iron and concrete techniques. By doing so, it seeks to illuminate the connection between the construction site and the industrial and colonial interests associated with the building of engineering structures. If the hypothesis that the circulation of knowledge and know-how, along with its adaptation to the local context, is responsible for the development of new technical processes, it is necessary to examine the Chiffa viaduct not only in terms of its interactions with the surrounding environment and its production context but also in terms of the role played by the companies involved, particularly the Boussiron company, as a significant participant in the construction and management of this site.

2. Method

To enhance comprehension of the project's processes, the study will commence by presenting a chronological account of the Algiers-Oran line renewal and its subsequent outcomes, detailing the different phases of the renewal work. Firstly, we address the viaduct during its construction in 1869.Furthermore, this analysis will assess the construction players involved and the efforts made in Evaluation of the existing structure prior to its rehabilitation and to strengthen the Chiffa viaduct, taking into account the historical development of techniques during the twentieth century, as well as the dissemination of knowledge and expertise. The multitude of graphic files, correspondence and reports obtained from the archives yielded invaluable insights into the design intricacies. Using these archives, known for their high documentary and scientific value, provided valuable documentary evidence and aided in the execution of a comprehensive synthesis project. It completed our description of the structures' current state and complexity, as well as providing information on the modifications made. Furthermore, fieldwork and the use of technology 3D SCAN allowed us to consolidate all of the results of the archival research. Furthermore, by combining archive, technological, and field data, we were able to justify the structure's current appearance and provide volumetric reconstructions of the major phases through which the viaduct passed, particularly before and after its non-reinforced state.

3. Results and Discussion

3.1 A brief history of rail renewal on the Algiers-Oran line in the 20th century

Initially, it is imperative to establish a clear and concise definition of rail renewal. The latter involves the substitution, enhancement, or restoration of the current railway infrastructure, such as tracks and bridges (Guler, 2013). To ensure clarity in the subsequent discussion, it was deemed more advantageous to conduct an objective examination of the 1930 renovation strategy, employing a historical analysis that incorporates three parameters. The text discusses three main aspects: the factors that caused its development, the process of its implementation and its overall effects, particularly on viaducts, and its focus on assessing existing structures before and after the railway renewal project. In the colonial era, the implementation of favorable circumstances led to substantial alterations in the administration of Algerian railways (LARTILLEUX, 1949). The acquisition of railway lines operated by different concessionaires persisted until they were separated into two networks, with one being overseen by the Paris-Lyon-Méditerranée company (Lamming, 2016).

Furthermore, alongside the management conditions, there has been a substantial rise in the number of passengers due to the growing competition from road transport. Subsequently, it has been recognized as crucial to create programs for new railway lines and enhance the operational circumstances of existing lines. The objective of this development was to modernize the railway techniques that have been successfully and effectively implemented in mainland France. Indeed, it was determined to assume control of the existing network, considering the challenges of managing it due to the diverse range of track gauges (Poggi, 1931). The PLM (Paris-Lyon-Méditerranée) railway company implemented a restructuring program with the aim of standardizing the operating conditions of its lines and enhancing its capabilities. The project was intricate, encompassing the strengthening of the track and engineering structures, Furthermore, any faulty alignments were corrected in both the horizontal and vertical planes, specific segments were expanded to accommodate two tracks, and the train fleet underwent upgrades to incorporate modern technology. (LARTILLEUX, 1949). This renewal is a result of the widespread adoption of reinforced concrete, driven by its significant advantages, especially in terms of rapid construction, cost-effectiveness, and efficiency (Marrey, 1995). Several civil engineering projects were initiated. These structures were either replicated or replaced to accommodate larger convoys, as stated by (Lamming, 2016). The project to renew the viaduct over the Chiffa river will provide a valuable opportunity to gain knowledge and expertise in this field.

3.2 Construction of the Chiffa viaduct in 1869

The Chiffa viaduct is situated in the wilaya of Blida along the Algiers-Oran railway line and was previously managed by the PLM (Paris-Lyon-Méditerranée) company (Bernard, 1913). This viaduct was reinforced and then doubled in the 1930s with the construction of a second reinforced concrete structure. The structure was initially constructed in 1869 by the Creusot Schneider workshops (Schneider et Cie, s. d.). The company had already gained a strong reputation during the Second Empire for its expertise in structural steelwork and metal bridges (D'Angio, 1995). The bridge was designed by the engineer Georges Martin (G.MARTIN, 1865), who was well-known for his numerous cast-iron creations (PLM, 1933). The Chiffa viaduct was constructed as part of the continuous effort to enhance the durability of cast-iron bridges, which involved conducting numerous experiments in mainland France since the early 19th century (Desnoyers, 1885).

The Chiffa experiment, which was highly praised by the media at the time, allowed for significant increases in range and a reduction in the number of support points. This resulted in substantial cost savings (Desnoyers, 1885). Cast iron also provided the benefit of quick implementation at a considerably reduced expense compared to masonry(Schueremans et al., 2018). Cast-iron structures were aesthetically pleasing and offered excellent durability, making them well-suited for long-term use (Desnoyers, 1885).

First, we describe the viaduct in its original state in 1869,The viaduct has a total opening length of 200 m and four cast iron arches that rest on masonry piers and abutments. Each arch consists of two cast-iron arches joined by struts and topped with spandrels, with a total of eleven voussoirs per arch. All the metalwork, except for the bridge parts, is composed of cast iron (Figure 2)

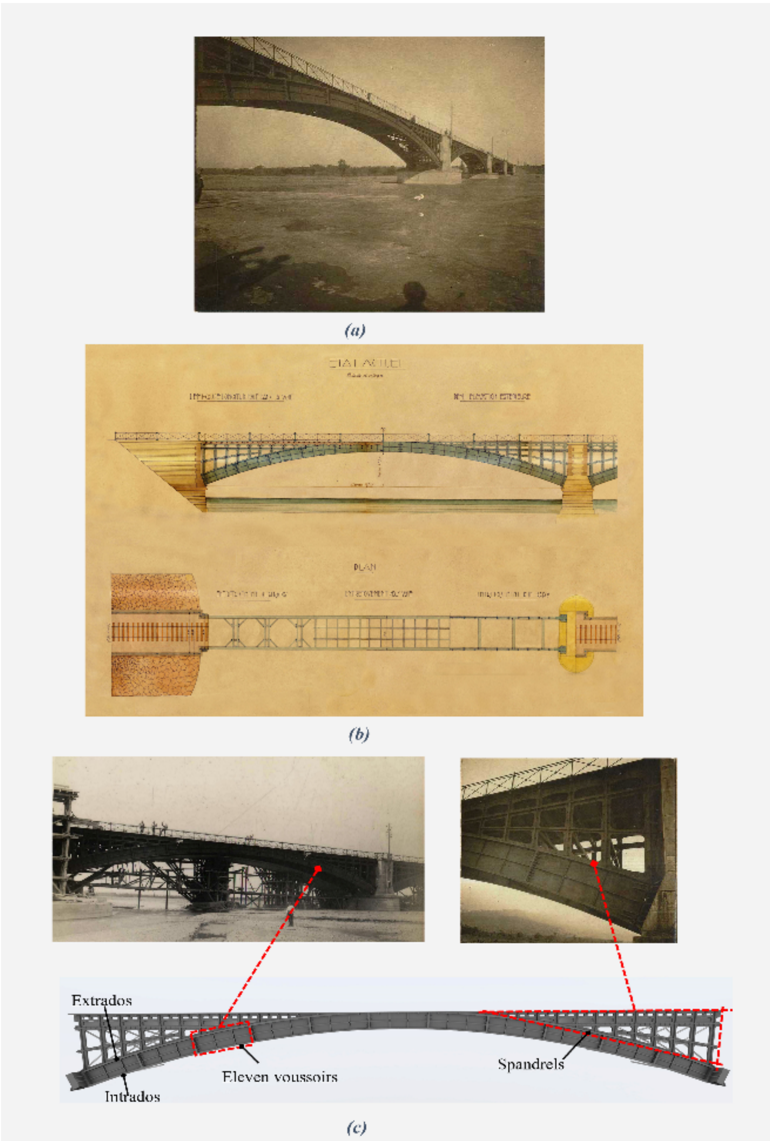


Fig. 2. View of the cast-iron viaduct (1931) (Archives SNTF,Hussein Dey, Alger, Box 357) (a), Original document of an elevation of a span (1868) (Archives SNTF,Hussein Dey, Alger, Box 96) (b), Architectural elements of the bridge spotted on a span with rare archive illustrations (1931) (Archives SNTF,Hussein Dey, Alger, Box 357) (c).

There are several types of bolted assembly. Firstly, a bracing system comprising St. André crosses is used in the transverse direction to ensure the stability of the spandrels and their interconnection. Additionally, we can see an assembly of struts on the spandrels through a sheet metal fur riveted to the struts and bolted to the spandrels' ribs. Furthermore, there is under-track bracing, a connection between the spandrel panels. We attempted to identify (Figure 3) and, where possible, restore the condition of the interior of this structure prior to any modification, focusing on the various types of bracing, which we were able to do using archival documents and fieldwork (Figure 4). There is a connection between the arch-voussoirs among themselves. Finally, the spandrels connect to the arches.

The technical drawings in the archives shed light on the various struts that are no longer visible due to concrete reinforcement, specifically the struts on the arch's extrados and intrados.

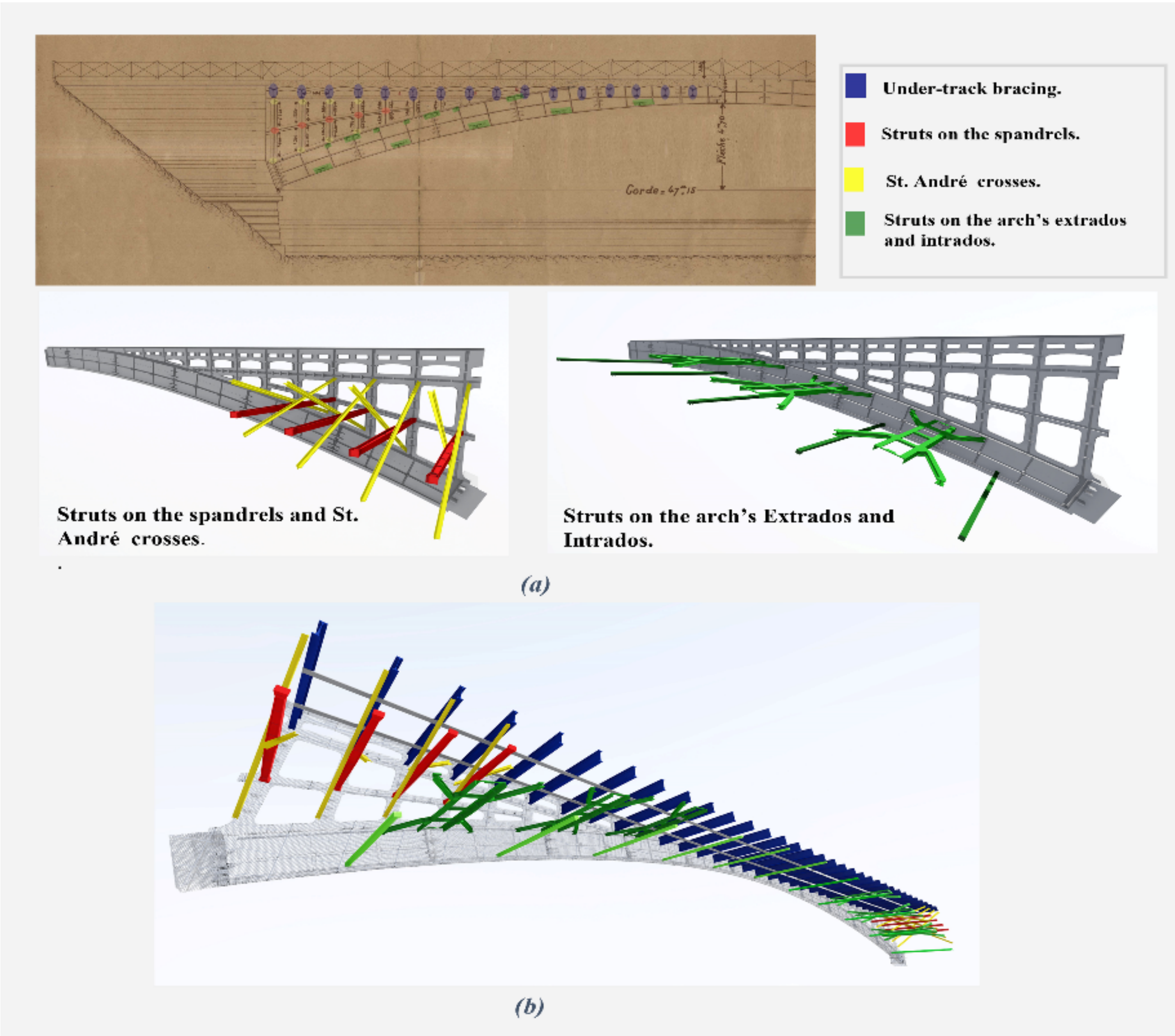


Fig. 3. Volumetry and identification of struts on part of an archive plan (Archives SNTF, Hussein Dey, Alger, Box 352, Hussein Dey) (a), volumetric restitution tests of struts on a span following our field investigations and the archives (b).

Fig. 4. *Volumetric restoration tests of the state of the struts before reinforcement (a), Current state of the struts (Authors 2024) (b).*

3.3 Evaluation of the existing structure prior to its rehabilitation

As stated in the methodology section, we will highlight the approach undertaken before the renovation, which concerns the evaluation of the existing structure prior to its rehabilitation.

The following information is extracted from an archival document titled "*Rapport des visites annuelles, et quinquennales de l'ouvrage*" conducted by the PLM company (PLM, 1933). The report provides a comprehensive account of the viaduct's history, from its original construction to its rehabilitation in 1932. It presents detailed information about the different types of damage that have occurred to the structure over time . "Unfortunately, these details are not accompanied by an illustration showing the damage in 1932." As well as the company's decision-making process in determining the methods used to reinforce it. The primary structural issues involve the loosening and absence of bolts and rivets, as well as multiple fractures in the struts between the spandrels, bracing crosses, arch voussoirs, spandrels and arches, and spandrel panels.

The report (PLM, 1933) identifies the main issue not as fractures, which do not deteriorate over time and do not impact the stability of the structure if the stresses remain constant, but rather as the challenges arising from the anticipated increase in locomotive power and weight. This would result in multiple fractures in the struts and spandrels, thereby weakening the structure even if repairs are conducted with utmost precision. To prevent the need for expensive replacement of the metal components in these structures, PLM according to his report (PLM, 1932c) decided to extend the lifespan of the viaduct over the Chiffa by reinforcing the cast-iron arches with reinforced concrete, thus adapting it to meet the new requirements. An innovative experiment was introduced, showcasing a novel technique called encasing cast-iron structures in concrete.

3.4 Viaduct renewal work in 1932

During the 1930s, this viaduct underwent rehabilitation involving both reinforcement and doubling, with the addition of a second reinforced concrete structure of the same length (200 m) parallel to the existing viaduct. It is worth noting that the most important operation associated with this doubling is the uncentring of the arches, which we will go over in greater detail later in this section (3. 6. 1). The bridge's final appearance after reinforcement and doubling is visible in its current state, which piqued our interest in reflecting on this work. We attempted to illustrate this final appearance as much as possible by using 3D scanning of the accessible parts of the site ,some parts were difficult to scan, as some bays were inaccessible even from the outside.

This scanning technique, combined with archival documents, allowed us to restore the bridge following the railway renewal operation at the time and analyze its current condition. Our approach, which draws parallels between archives and scans, has allowed us to synthesize the details of the processes used during the various phases of the work (Figure 5 and Figure 1).

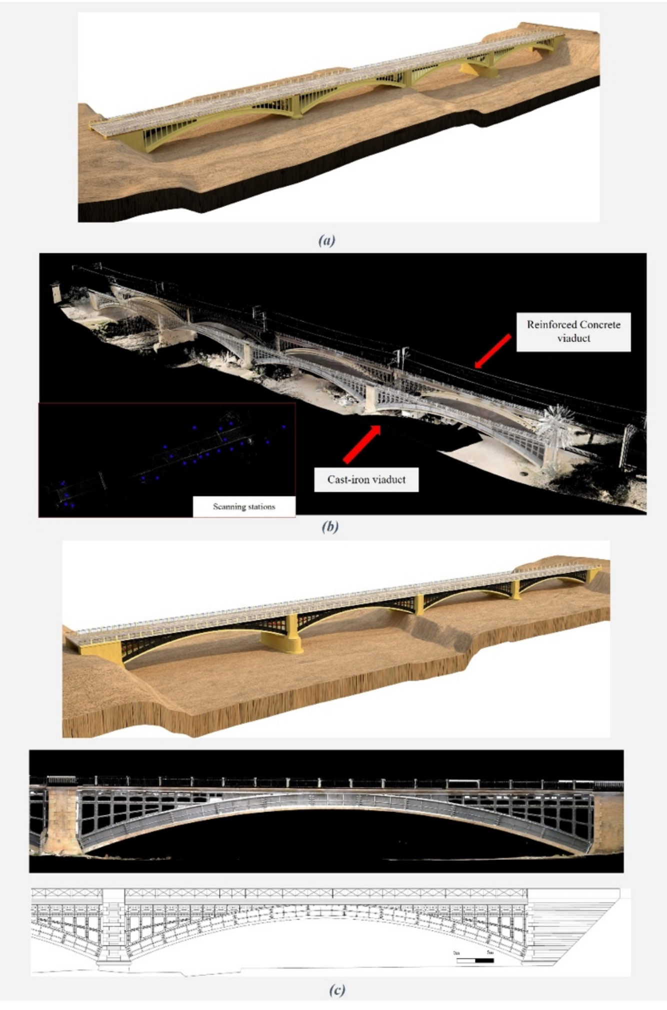
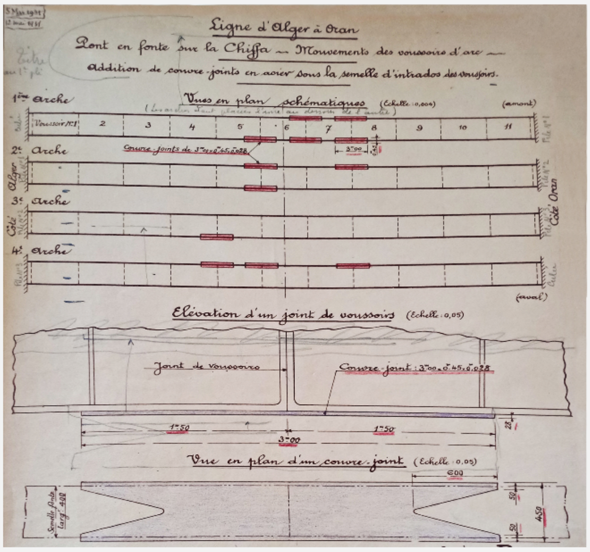


Fig. 5. Volumetry of the current state of the second reinforced concrete bridge after doubling the cast-iron viaduct (a), current state of the entire viaduct illustrated through the 3D Scan point cloud assembly (2024) (b), volumetry of the current state of the cast-iron viaduct, an ortho photo, a span elevation and photos taken in 2021(c).

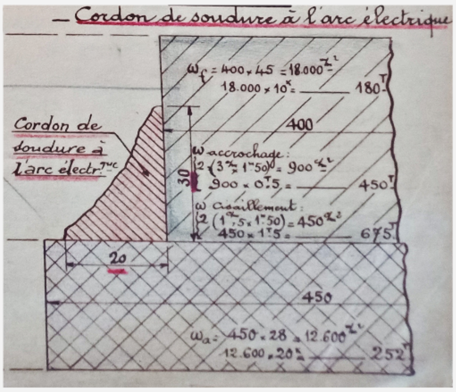
In this paper, we will look at the first reinforcement of an old cast-iron viaduct and the techniques used to implement it. This reinforcement includes innovative measures such as the installation of steel footings, the construction of reinforced concrete slabs, and the encapsulation of the spandrels' transverse bracing. The work began with the installation of steel footings to reinforce and maintain the continuity of the lower part of the cast-iron arches (Figure 6(a)). These footings not only increased strength but also corrected the tendency of certain joints to open up when trains passed over them before reinforcing cast-iron arches with reinforced concrete (PLM, 1932b). The lower part of the arches, along with certain voussoir joints, were joined by electric arc welding beneath the intrados of the defective joints. Each base plate was first welded to one of the two cast-iron voussoirs over its half-length (approx. 1.50 m) and on both sides, then, at an interval of around one hour between the passage of two trains, welded to the other segment over a length of approx. 0.75 m and on both sides from the segment joint. The remaining part of the two weld seams (approx. 0.75 m) was not completed until it had been established that the weld already made had withstood the passage of several trains.

Repairing these joints necessitated a highly skilled workforce and the use of specialized equipment not available in Algeria. It was carried out by La Soudure Autogène Française, a mainland French company (PLM, 1931) (Figure 6(b)).

Electric arc welding had made significant advancements in the field of metal bridges as a contemporary technique, particularly valuable during a period when repurposing existing materials was highly valued. This process also allowed bridges to remain in operation during construction, ensuring the highest level of safety and preserving the original appearance of the structure ("LE GÉNIE CIVIL. REVUE GÉNÉRALE DES INDUSTRIES FRANÇAISES ET ETRANGÈRES... "1941).



(a)



(b)

Fig. 6. Part of an original document illustrating a schematic view of added steel footings, elevation of a voussoir joint (a), part of the same document illustrating the electric arc welding diagram (1932) (PLM, "Renforcement par des semelles en acier" (Box 352), Archive SNTF, Hussein Dey, Algeria) (b).

A slab was placed underneath the arches to connect the arches securely and allow for convenient inspection of the entire bridge. Additionally, there was an upper surface slab that extended from the start of the arches to the kidneys. Lastly, there was a slab beneath the track that was reinforced with longitudinal and transverse ribs. This slab was laid to replace the cast-iron floor plates that supported the ballast. This final slab, which is much wider near the shoulders, greatly improves the arches' transverse stability. Furthermore, the increased thickness of the ballast mattress on which the track rests reduces structural vibration and the effects of shocks.

To reinforce and solidify the spandrels, the uprights were encased in reinforced concrete, resulting in a highly rigid transverse bracing (Figure 7). To ensure a good bond between the concrete and the metal surfaces, all of the metal parts to be encapsulated were stripped first with compressed air and a sandblaster. Using data collected in the field and the archives, we have attempted to create a volumetry to demonstrate the overall logic of the introduction of concrete into this structure (Figure 8).

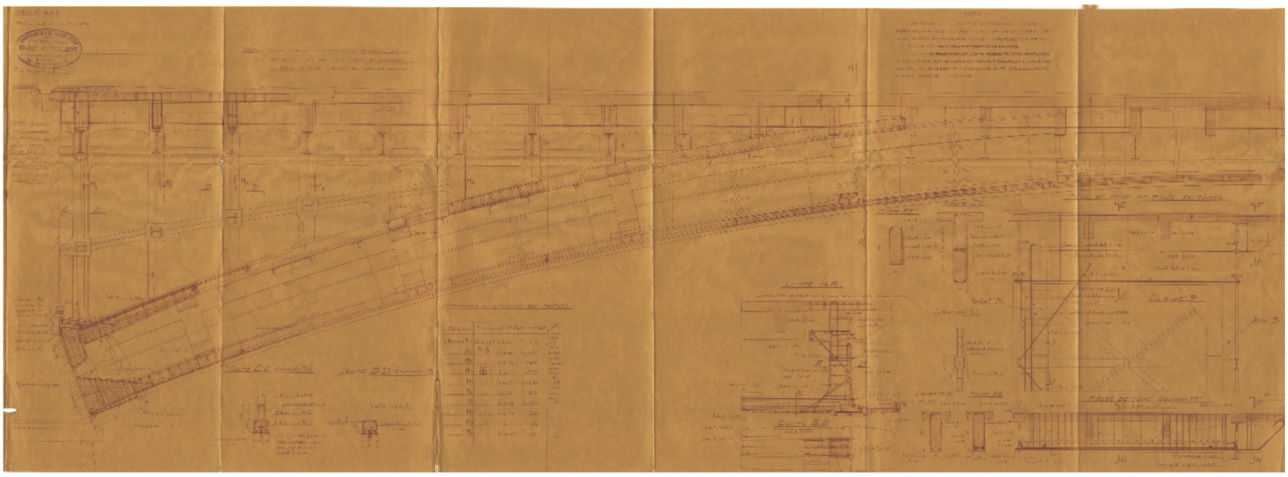


Fig. 7. An original plan showing details of the viaduct reinforcements. (PLM, « Remaniement et renforcement du viaduc sur la Chiffa,1/2 coupe longitudinale», (1932) (Box 96), Archive SNTF, Hussein Dey.

3.5 Boussirons: a major player

According to archived documents (PLM, 1932c), the Boussiron company was credited with modifying this viaduct. The company specializes in strengthening and expanding old cast-iron bridges. In addition, during that period, the company was experiencing a significant increase in the use of reinforced concrete in existing infrastructure, driven by the growing speed of convoys (Marrey, 1995). Deboulogne, the head engineer in the PLM steel construction department, was responsible for strengthening the Chiffa viaduct. In 1922, Deboulogne conducted an initial experiment to strengthen the cast-iron arches of the Voulte-sur-Rhône ,this viaduct was reinforced in 1922 . viaduct in mainland France. This process quickly became common on multiple viaducts in the PLM network, including the Chiffa viaduct.

Several reinforced viaducts are currently in use, such as the Saint Rambert d'Alban viaduct on the Rhône, commonly referred to as the Peyraud railway bridge, It was reinforced in 1929, and the Montmélian bridge on the Isère, also known as the Savoie tourist bridge It was reinforced in 1927.

The viaduct over the Chiffa river has been in use for nearly a century and is still functional . It demonstrates the technical expertise of the 19th and 20th centuries. The metropolitan experiments conducted by the Boussiron company demonstrated a significant level of scientific expertise during their work on the Chiffa viaduct. They successfully addressed various technical challenges, such as making corrections and compensations during the arch uncentering of the arches, as described in the (PLM, 1932a) report.

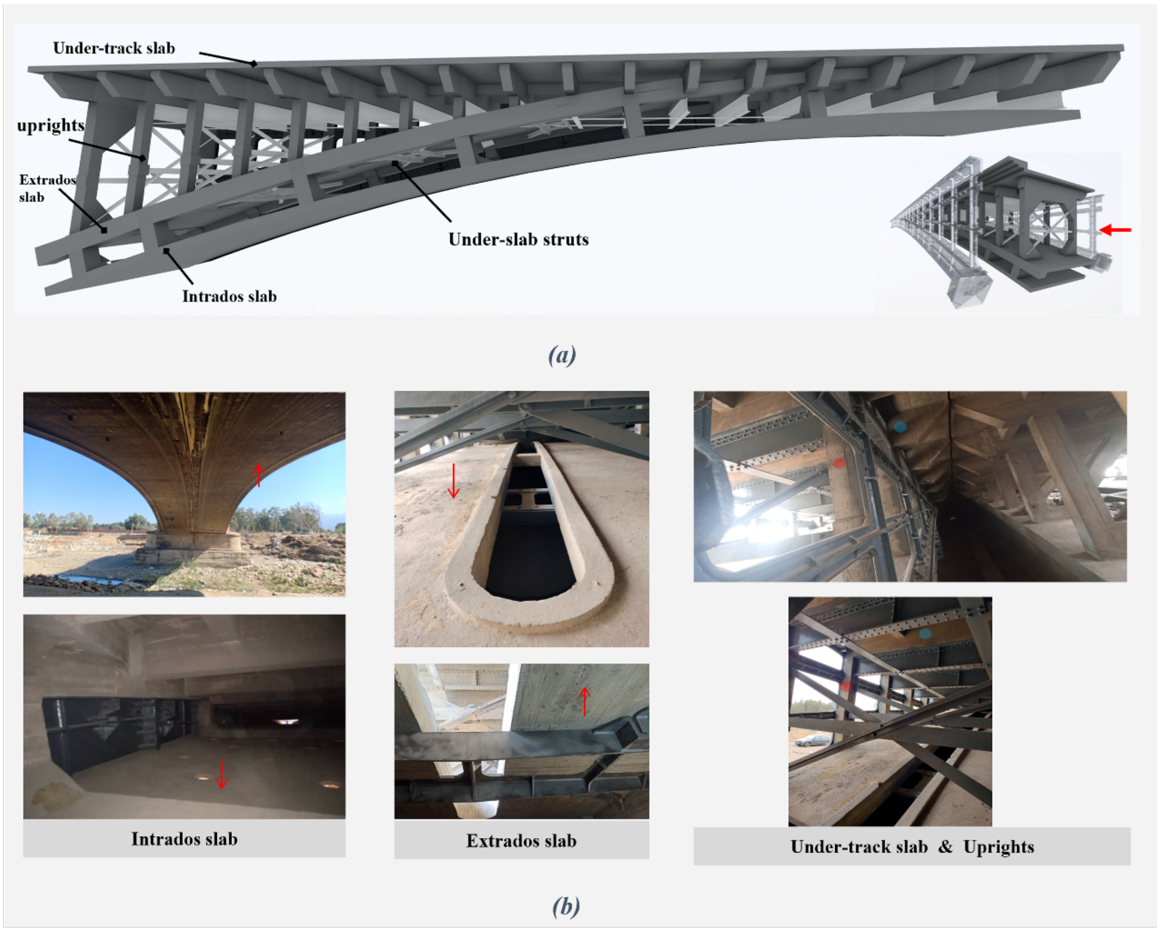


Fig. 8. Volumetry detailing the general appearance of reinforcement with reinforced concrete (a), Various illustrations of reinforcements (2024).

3.6 Boussiron and the technical challenges of the Chiffa site

The specific technical characteristics of this tested reinforced concrete reinforcement warrant special attention. The methods employed to guarantee the resistance to extremely high thresholds and the procedures for the uncentering of the arches were extensively featured in various magazines of the era, such as *"Le Génie civil: revue générale des industries françaises et étrangères" 1935)* (Boussiron et al., 1935). Boussiron stated: "For corrections, it is essential to know the value of the average coefficient of elasticity E of the reinforced concrete at the time of the operation, and to adopt a particular technique that we had the opportunity to establish definitively in February 1932 for the normal-gauge railway bridge on the Algiers to Oran line over the Oued Chiffa." (translated from French by the Authors)

The archival sources from the PLM track department (PLM service de la voie, 1932) provide clear explanations that emphasize the importance of carefully controlling the granulometry of the materials used to achieve concrete with desirable results in terms of strength. This was achieved by using different types of cement that met the specific requirements for enhancing strength.

To attain optimal strength, the concrete required rigorous compaction through vibratory techniques, resulting in exceptional density and enhanced strength. Furthermore, to guarantee an impeccable coating of the metal components, the concrete was shielded for eight days using burlap bags, tarpaulins, or straw mats. These coverings were consistently kept humid to ensure the excellent solidification of the concrete. Ultimately, the concrete was smoothly and continuously poured from the foundation to the top, with minimal disruptions to the workflow.

3.6.1 The arch uncentering operation: a scientific process prior to the arches' commissioning

Engineer Deboulongne wrote a calculation note for this delicate operation, indicating the corrections and compensations required at the time of arch uncentering :(the process of removing the hanger from under the arch after the concrete has reached the desired strength. It is designed to bring the arch into compression, after the loads previously exerted on the hanger by the concrete have been transferred) (Baes, 1929) (Perronet, 1777).

This second significant undertaking at the Chiffa viaduct site, which involved the use of jacks at the pivotal point, was initially conceived by Eugène Freyssinet : (The uncentering method was developed by Eugene Freyssinet in 1908. Instead of lowering the hanger beneath the arches, which was a complicated process that caused them to collapse, he came up with the concept of raising the arches above the hanger. This was achieved by moving the half-arches on either side of the key apart, using hydraulic cylinders that acted horizontally. These cylinders were powerful enough to generate a force that exceeded the thrust of the arches, which would have occurred during the normal process of decrementing. This is commonly known as the arch loading system.*(Le Génie civil, 1921).*

The Boussiron company was able to establish a conclusive scientific and technical compensation procedure prior to commencing the construction of arches for its different projects (Boussiron et al., 1935). The calculation of railway loads was determined by ministerial regulations published in May 1927 (Chambre syndicale des constructeurs en ciment armé de France Éditeur scientifique, 1928), which amended and updated the circulars of October 20, 1906, and January 8, 1915. The train load is equivalent to 8T/ML. Considering the dynamic impact of the train, this load is amplified and reaches a value of 8. 80 T/ML or 9 T/ML (Figure 9).

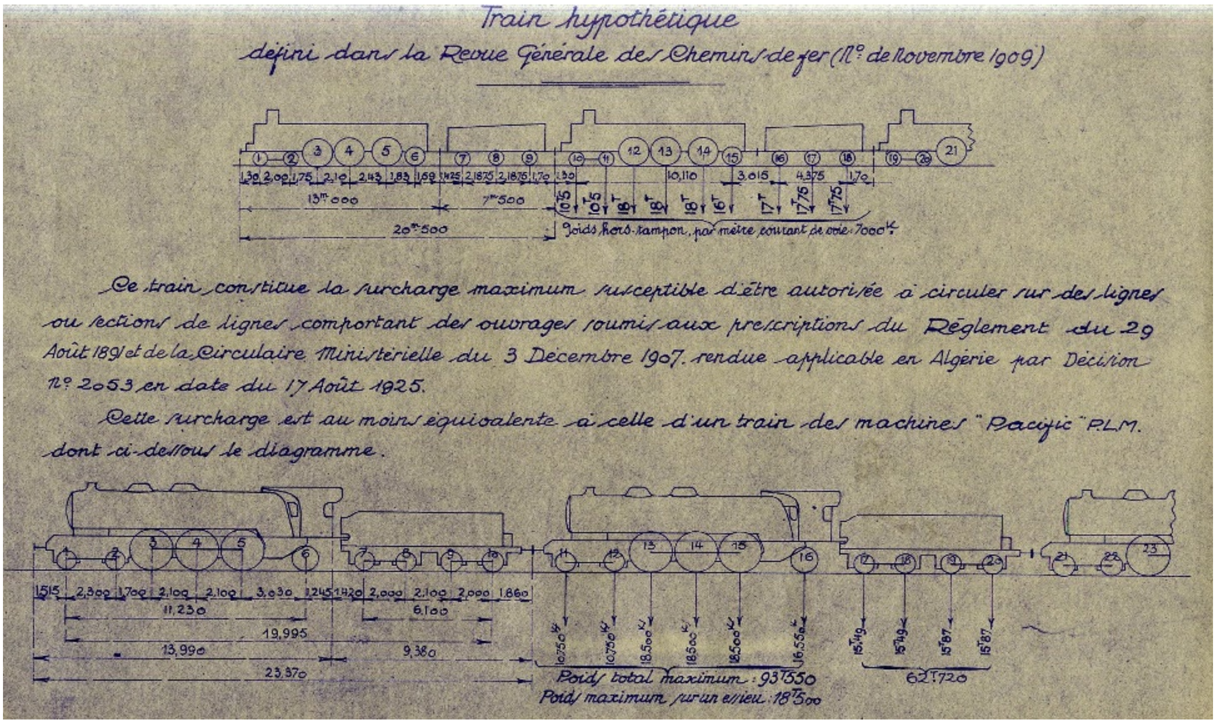


Fig. 9. Hypothetical maximum overloads (PLM, "Train hypothétique", 1932, Archive SNTF, (Box 24-AO -DA 304 -TIGUEZEL)

Before commencing the construction operation of the new reinforced concrete bridge, the reinforced concrete arch must be supported to preserve its original position. The weight of the RC uprights and this of the RC slab, which is constructed on the extrados of the arch, creates a new state of stress, which is adapted to the effects of temperature and concrete shrinkage. In order to ensure the contribution of the reinforced concrete slab to the arch's strength, the latter must be elevated to its original position before deformation. To perform this operation, hydraulic actuators must be used to apply a compressive force at the arch key. Nine (09) hydraulic actuators with a capacity of 100 tons each are used, as shown in Figure 10.

Fig. 10. Plan view of the key cut, and the rulers measuring horizontal displacements (a), view taken under the cast-iron bridge, showing the jacks in elevation in the key cut, in front of the ruler measuring vertical displacements (b), Wood shoring of the arch of the structure (c). (Established by Boussiron, "Décintrement des arcs pont sur l'oued Chiffa", 1932, Box 169A, Hussein Dey.)

When this operation is executed, the arch is released from the temporary wooden support. Reinforced concrete rules of the time specified that this operation should begin when the concrete had reached a sufficient degree of strength to support the future loads in safe conditions, as reported in (*Revue du génie militaire*, 1913). The application of actuator forces is gradual and is also controlled by measuring displacements at the key of the arch. To prevent the creation of an unfavorable rotational force, the point of the resultant of the actuator forces must coincide with the theoretical position of the arc's neutral axis. By applying force gradually, we can determine the concrete's coefficient of elasticity.

The measured data suggests that a joint opening of 1 mm necessitates a vertical displacement of 1. 715 mm at the key arch. The modulus of elasticity of the concrete in arches 1 and 2 was determined to have an average value of $E_v = 2.\ 1 \times 10^{10}$ N/m^2. The modulus of elasticity is then used to evaluate displacements resulting from the thermal and shrinkage effects of concrete. At every stage, it is necessary to verify the correlation between the opening of the joint and the vertical displacement of the arch. If there is no correspondence, we must identify the problem. If a match is found, keep running the actuators until the desired ΔL_{final} opening is reached. The ΔL_{final} opening is the sum of three terms, according to Eq. (1) (*Projet de* *règlement sur les constructions en béton armé, établi par la commission d'études techniques de la Chambre syndicale. 1928.*, s. d.):

$$\Delta L_{final} = \Delta_{LQ} + \Delta_{L\,T} + \Delta_{LR} \qquad (1)$$

where, Δ_{LQ}, $\Delta_{L\,T}$, and Δ_{LR} represent openings due to additional permanent loads, temperature variation and concrete shrinkage, respectively.

To calculate the size of openings caused by changes in temperature, a coefficient of thermal expansion α is used, with a value of α=1. 1 10^{-05}. The value mentioned is still utilized in current design codes for reinforced concrete elements (Legrand et al., 1993) (*Eurocode 2 - calcul des structures en beton*, s. d.). The temperature fluctuation recorded is presented in the graph of Figure 11.

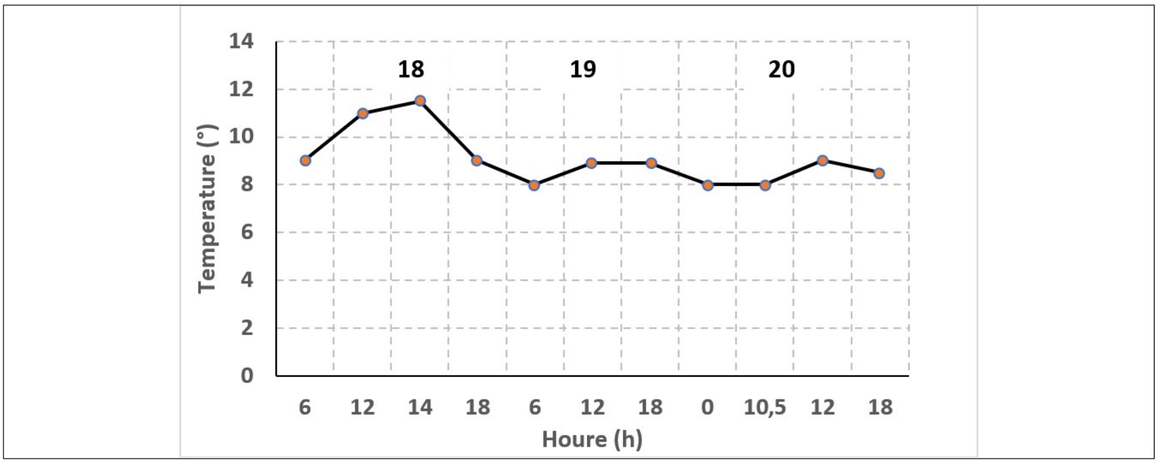


Fig. 11. Temperature variation taken from archive document (PLM 1932c) report.

The calculations indicate that the force needed to achieve the final total displacement ΔL_{final} is approximately 440 T. After this stage, the safety nuts are locked, and we fill the gap between the two keys using concrete with a ratio of 500 kg of cement per 1 m^3 of concrete. As per the guidelines outlined in the ministerial circular of October 20, 1906, the concrete must have a minimum crushing strength of 250 kg/cm² after 90 days of curing (Lévy, 1907). Cements 20/25 at 7 and 28 days satisfy this condition. The necessary steps for the reinforcement of the bridge are illustrated in **(Figure 12).**

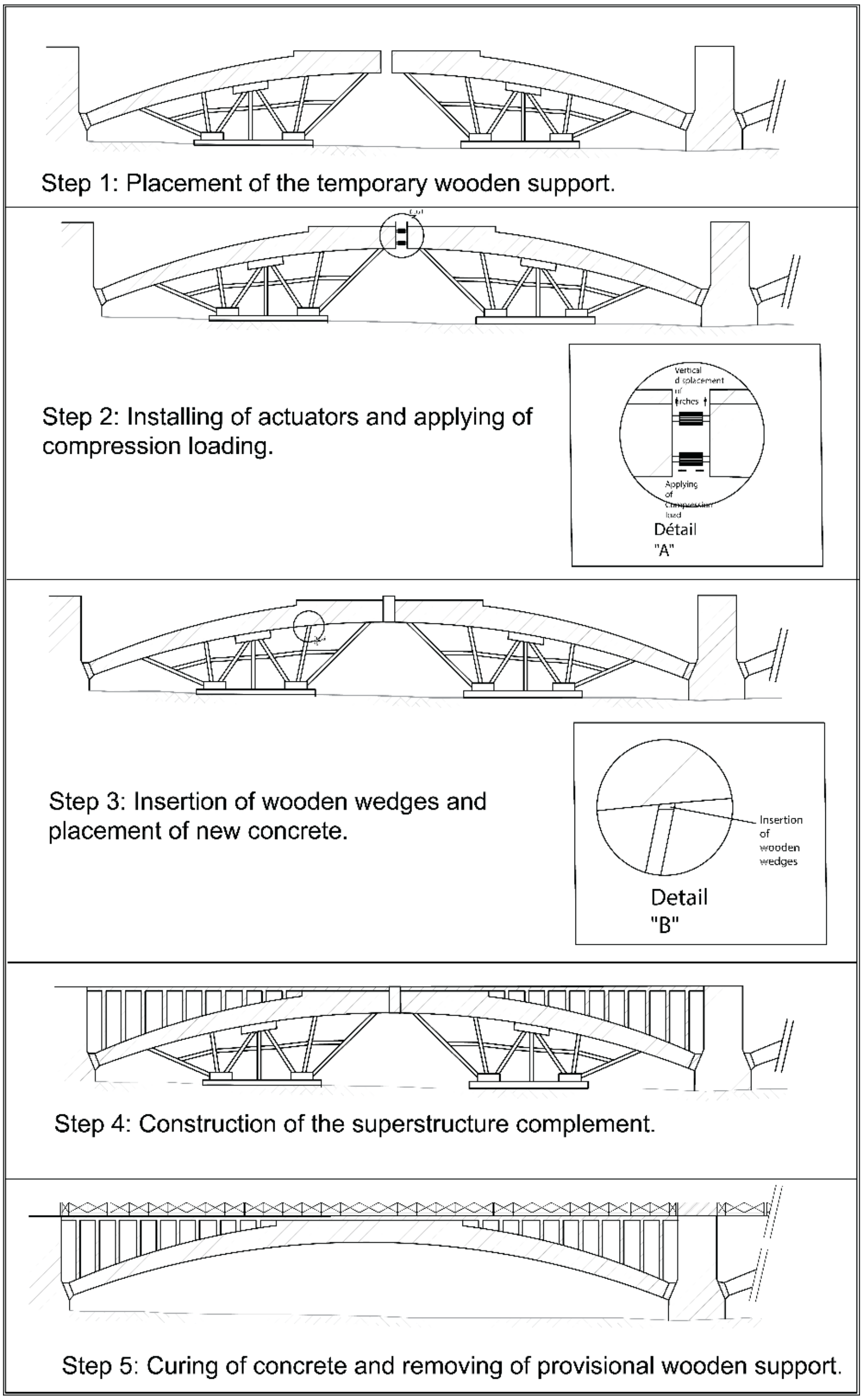


Fig. 12. Steps of the bridge arch operation.

4. Conclusions

The use of the abundant resources available in the SNTF archives in Algiers, combined with our unique approach to the subject, has enabled us to shed light on a restoration course for a historic viaduct in the 20^{e} century. This restoration involved reinforcing and adapting the viaduct to its new uses while respecting the principles of sustainability through the cohabitation of various typologies belonging to different eras. The question of the circulation of techniques and know-how was then examined through the implementation of methods and techniques that had been successfully used in France. While this paper confirms the hypothesis that Algeria served as a testing ground for new construction techniques, it also emphasizes the importance of archival sources. Indeed, the latter reveals the many facets of the roles played by various players in the construction industry, as well as the methods used to disseminate railway-specific knowledge and know-how.

The reinforced concrete reinforcement work on the Chiffa viaduct revealed the implementation, mastery, and perfection of procedures for reinforcing engineering structures at the Chiffa site during the 1930s. Combining cast-iron and concrete techniques, this achievement highlighted the site's connection to the technical and scientific issues at hand. Above all, it emphasizes the importance of expanding the history of technology beyond Europe's borders, particularly by taking a fresh, decentralized look at non-Western sites and identifying key events that are all too often overlooked or neglected. By investigating the Algerian scene of the 1930s in light of these observations, this work has made it possible to revisit the commonly accepted practice of technical history in light of unpublished archival documents, which today lift the veil on situations that have remained understudied. The SNTF's archive center, whose interest in this research we were able to gauge, paves the way for a large-scale project in this field.

This study, which also aimed to identify 19th and 20th-century engineering structures, examined how we can make the most of this heritage, which is currently being undermined by modernization and standardization. While the major rail modernization program currently underway across the country opens up new opportunities for transportation and economic development, the same cannot be said for many structures that are in danger of disappearing. The disuse of engineering structures and certain stations exacerbates the vulnerability of this heritage, which is no longer a priority for heritage preservation.

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Disclosure statement

The authors report that there are no competing interests to declare.

Data availability statement

The authors declare that the archive items associated with this paper are all available, without exception, at the SNTF archive Center, Hussein Dey Alger, under the reference numbers already declared with each figure and each archive item used. They may be consulted with official authorization.

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