VOL. 9, NO. 2 (2023)

KNOWLEDGE AND SCIENCE ON BUILDING TECHNOLOGIES. MEANS, INSTRUMENTS AND MODELS

TEMA
Technologies
Engineering
Materials
Architecture

e-ISSN 2421-4574
DOI: 10.30682/tema0902

Journal Director: R. Gulli

Assistant Editors: R. Albatici, A. Ferrante, G. Margani

Cover illustration: Stereotomic helical staircase in Villa D'Este, Tivoli, Italy.

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e-ISSN 2421-4574
ISBN online 979-12-5477-367-3
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Vol. 9, No. 2 (2023)
Year 2023 (Issues per year: 2)

Publisher:
Ar.Tec. Associazione Scientifica per la Promozione dei Rapporti tra Architettura e Tecniche per l'Edilizia
c/o DICATECH - Dipartimento di Ingegneria Civile, Ambientale, del Territorio, Edile e di Chimica - Politecnico di Bari
Via Edoardo Orabona, 4
70125 Bari - Italy
Phone: +39 080 5963564
E-mail: info@artecweb.org - tema@artecweb.org

Publisher Partner:
Fondazione Bologna University Press
Via Saragozza 10
40123 Bologna - Italy
Phone: +39 051 232882
www.buponline.com

TEMA: Technologies Engineering Materials Architecture
Vol. 9, No. 2 (2023)
e-ISSN 2421-4574

AUTARKY METAL ROOFING AT THE MECENATE PAPER MILL IN TIVOLI: AN UNSEEN APPLICATION OF GINO COVRE'S PATENTS

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DOI: 10.30682/tema090007

TEMA Technologies Engineering Materials Architecture

e-ISSN 2421-4574

Vol. 9, No. 2 - (2023)

This contribution has been peer-reviewed.

Abstract

In 1887, the Papermill Mecenate settled at the Sanctuary of Hercules the Victor in Tivoli, thanks to the construction of the Canevari Canal. The papermill represented, for decades, the largest industrial plant placed on the former religious site, which had already housed various manufacturing functions. The phases of greatest overlap occurred in the 1930s and 1950s by engineer Emo Salvati, who designed many reinforced concrete structures. In 1938, he and Marco Segrè, the factory owner, approached Gino Covre to make lightweight metal roofing. Arrived in Rome in 1935, Covre was already working steadily with the Antonio Badoni firm in Lecco. In Rome, he registered many patents, including the one for "Vaulted arch, composed or constituted with frame elements" (1936). The paper presents the historical-constructional investigation, supported by digital information modeling, of two unpublished applications made by Covre that were lost in the late 20th century. Covre's Rome period is under-explored, and the case study raises important questions about those early years. The loss of vaults gives greater emphasis to existing traces-photographic, documentary-that can provide insights into the lost built object. Gino Covre's experimentation in the autarkic phase with metal structures by means of a significantly reduced use of material appears to be an exceptional issue, and the application of Tivoli tests the system later used at the Palace of Congress at E42 designed by Adalberto Libera.

Keywords

Metal vaults, Metal structure, Lost Heritage, Autarchy, Industrial archaeology.

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1. INTRODUCTION

This contribution represents an excerpt of a broad program of investigations on the ancient industrial area in the monumental complex of the Sanctuary of Hercules the Victor of Tivoli (Fig. 1). The specific thematic areas of research concern the knowledge of the prolonged production vicissitudes, the related architectural bod-

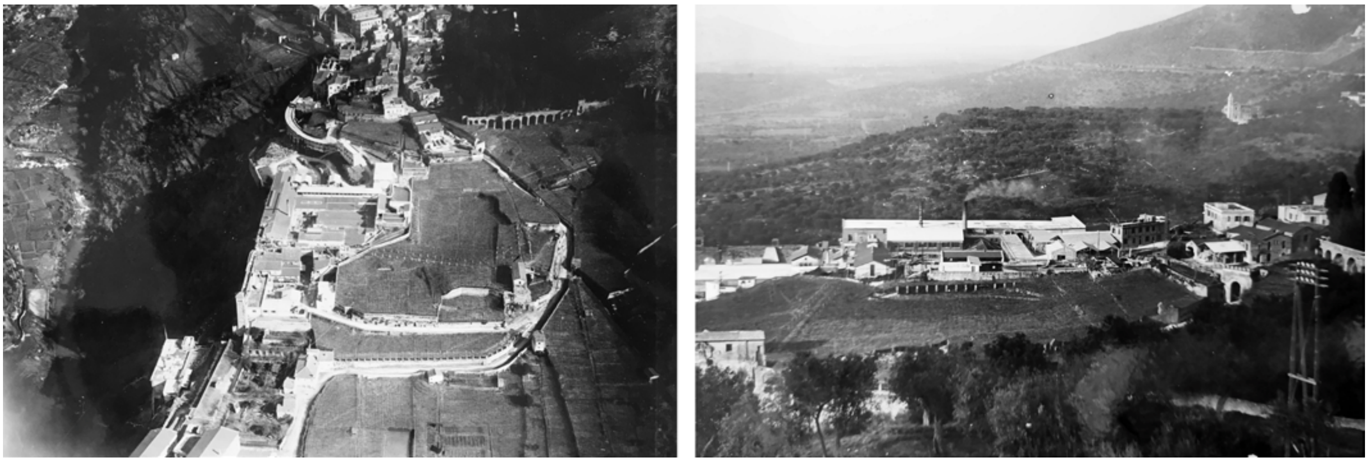


Fig. 1. *Two aerial views of the Segré Paper Mill before and after the interventions coordinated by Emo Salvati. 1926, left, and late 1930s, right © ASR.*

ies and the urban outcome, as well as the identification of design tools for the management and enhancement of the archaeological-industrial palimpsest. The latter, in Tivoli, particularly at the Sanctuary site, consists of evidence of at least five centuries of productive activity, from manufacturing to industry [1–3]. It confirms Tivoli as an exemplary case of the Italian way toward industrial heritage [4, 5]. In a rich sequence of uses, the industrial production of paper and electricity began in the late 19th century, as well as, among many others, a pasta factory, thanks mainly to the opening of the canal, known as Canevari, through the sanctuary structures in 1886. The aims of the research are broad, and therefore, they ask for different disciplinary competencies, from the architectural area to the historical and economic ones. The activities of the main research unit in Rome, skilled in historical-architectural engineering, have been devoted to the survey of historic building organism and architectural restoration tools. In parallel, the research groups at the universities of Evora and Seville deal more specifically with community awareness and intangible heritage. An early sharing of results took place at the Second General States of the Industrial Heritage of Rome in 2022, in the specific session held in Tivoli at the Antiquarium of the Sanctuary [6–8].

The paper focuses on the story of the Mecenate – or Segrè – Paper Mill of the Tiburtine Paper Mill Society [9] at a significant historical moment: autarky. Due to the sanctions imposed by the League of Nations after the invasion of Abyssinia by Italy (1935), the fascist regime encouraged policies aimed at self-sufficiency, imposing the use of local products with specific laws (i.e., RDL n. 216 of 01/07/1926, Law n. 189 of 01/09/1939, RDL n. 1326 of 10/07/1939). In this context, the use of metallic materials in building construction was rigorously limited, influencing both reinforced concrete and iron construction processes.

The research brought to light that engineer Gino Covre worked for the paper mill in the construction of several metal roofs and that in one of them, in particular, he pioneered his first patent for the construction of metal vaults with a very low use of material [10]. This patent, recalled by scholars in the few publications to date, is the basis of the construction solutions adopted by Covre the following year for the realization of the large cross vault wanted by Adalberto Libera in his project for the E42 Palace of Congresses. Thus, the Tivoli case proved worthy of attention, although limited to a functional use and related to a demolished building. The presence of many reuses, especially productive reuses, at a religious site and the subsequent, intentional loss of the material object have raised more than one question and forced extensive research both on the theoretical front, addressed by colleagues at the Universities of Evora, Seville, and Rome with the working group "De Ora a Labora" (from "Pray" to "Work"), and on the technological front, aimed at the application of digital tools for the representation, fruition, and data sharing of now an intangible heritage.

2. METHODOLOGY

The methodology integrates current investigation tools typical of construction history and industrial archaeology with the opportunities offered by the approach of ArchaeoHBIM [11].

As early as the first Congress of Construction History in Madrid in 2003 was an opportunity to take stock of the purpose, method, and field of studies. Among the many participants, Werner Lorenz pointed out that one of the main motivations for pursuing these studies is the invaluable resource they could offer to face the crisis in engineering [12]. The case presented in this paper offers an opportunity to define the outlines of the missing part of a building organism, rediscovering it as objectively as possible through the support of the plans and the evidence of building site photographs, archive documents, and architectural-constructional survey of the remaining building. The systematization of the documentation was done through the support of digital tools in the BIM environment, and an essential role is played by the restitutive survey of the original state, according to Poretti [13]. Thanks to the potential of a 4-dimensional HBIM, the survey of the original state could be complemented by the reconstructions of multiple states of the configuration of the work: before, during, and after the life cycle of the studied work (Fig. 2).

Thus, the research took up the challenge of declining the ArchaeoHBIM, of which it captures the experiences of applying it to the legacies of antiquity for objects and systems of industrial archaeology. As reported in a previous methodological contribution, digital tools enable the organization of the complexity of layered data in a system characterized by multiple archaeologies to increase the possibility of cognitive synthesis for the various disciplines involved [14]. Documentary, archival, and architectural survey research has been associated with the generation of an information model that, on the one hand, has the standard elements of cultural heritage applications (integrated surveys, scan-to-BIM process, multi-scalarity and automation of semantic recognition processes of geometric elements), while on the other hand, it has experimented with those specifically characterizing industrial heritage: sanitary and environmental engineering; presence-absence of machines; industrial construction experimentation; and the links between production organization, functional layout, and spatial form.

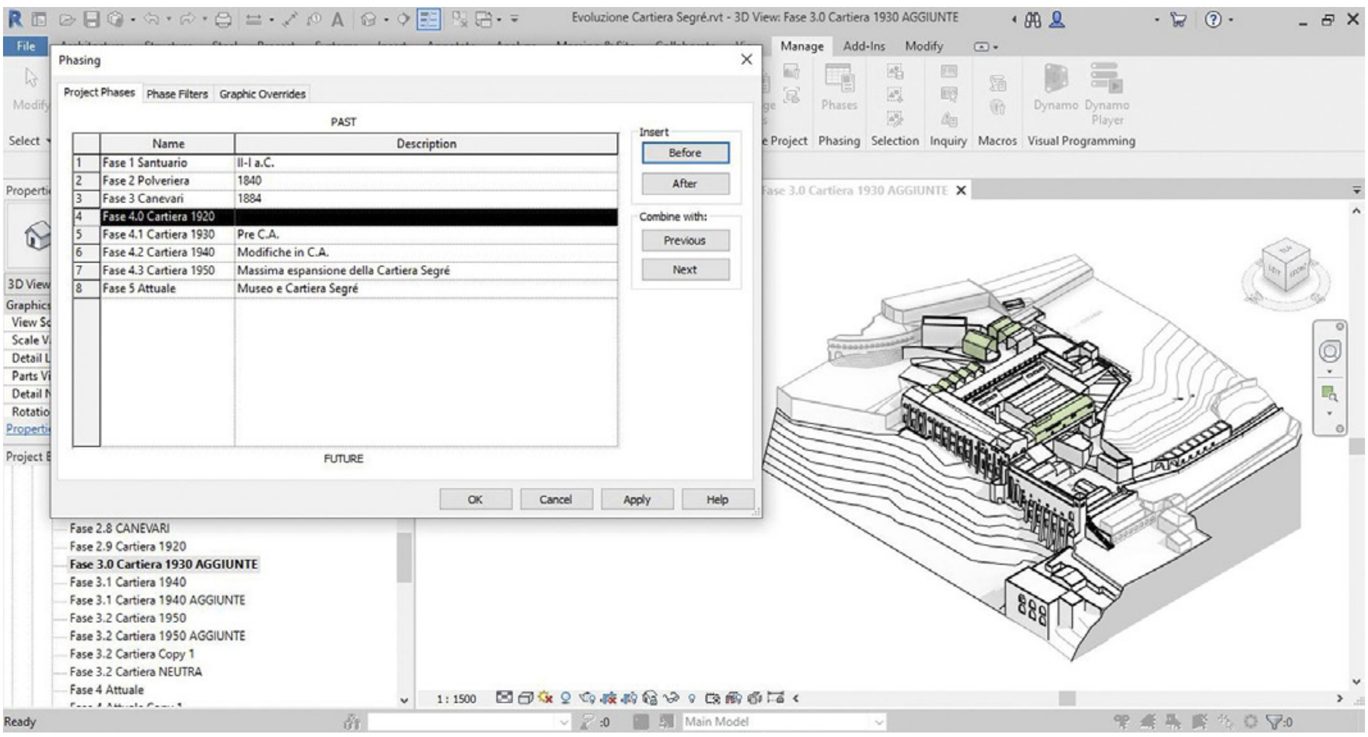
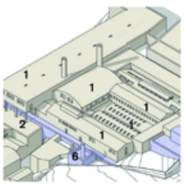
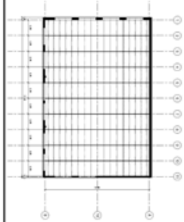
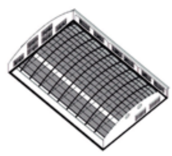
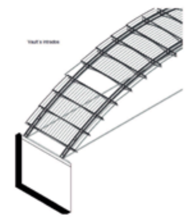
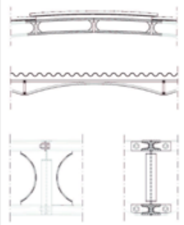


Fig. 2. *Definition of the phases for the diachronic BIM of the former Segrè Papermill within the BIM Authoring Autodesk Revit - AR.*

The Cartesian and temporal referencing on the component of a digital model was also very useful because of the breadth of archives consulted (Fig. 3). Among the main ones were the State Archives of Rome, the Municipal Historical Archives of Tivoli, and the Badoni Archives at the Politecnico di Milano. The representation of the case study through a BIM exploited the typical construction potential by families and instances. In fact, the use of industrialized components, found in components manufactured off-site in the mechanical workshops, matches the construction logic of BIM models and the standardization of components. However, this is a favorable case because experimental technical solutions, such as the one found, may often lack comprehensive historical-documentary information.

The information modeling aspects of the BIM process are entrusted to the definition of the LOD (Level of Detail). Although discordant in formalization in different countries' standards, the LOD is defined by progressively more detailed stage scales and by the subdivision of two concepts: the geometric component (in Italy defined LOG, Level of Geometry) and the information component (in Italy defined LOI, Level of Information). The applications of the BIM process to industrial heritage share the same principle with those of archaeological heritage, particularly for production machines that are often in a state of severe degradation or are even completely absent. This complexity is also reflected in the definition of LOD for lost elements [REF Paper sustainability] and for construction elements referred to specific patents, far from large-scale standardization logics such as industrialized constructions, and for which it is complex to frame the elements of the BIM model in an exact LOD scale, such as that of the analyzed case study. Nonetheless, the issue required a specification elaborated in Tab. 1, where the authors linked the horizontal elements (HE) modeled and the Italian LOD scale, specifying where they are reconstructions of the original configurations.

Finally, a further aspect is gratified by the realization of the information/model and concerns the spatial configuration of the buildings in relation to the production layout. The definition of the complete information model of the previous stages effectively supported an understanding of the geometric complexity and the reconstruction of the production process that defined its

LOD A	LOD B	LOD C	LOD D	LOD E	LOD F	LOD G
						
Geometry Representative 3D volume **Object** 3D solid, barrel vault **Characteristic** Rough dimensions of the building	**Geometry** Generic 3D model **Object** 3D solid of walls, roof and openings **Characteristic** Rough dimensions of the building and approximate position in its contest	**Geometry** 3D model with definite grid and proportions **Object** correct 3D geometry of vertical and horizontal elements **Characteristic** Floor plan with correct dimensions and thickness of walls, openings and roof	**Geometry** 3D model of structural and architectural elements **Object** 3D geometry of the construction system **Characteristic** Primary and secundary structural elements, building skin	**Geometry** Detailed 3D model of structural elements **Object** 3D geometry of the forming parts of the curved trusses and the secundary joists **Characteristic** Primary and secundary components	**Geometry** Detailed 3D model of structural elements and structural connections **Object** 3D geometry of the main structural connections **Characteristic** Correct size of composite truss elements	**Geometry** Detailed 3D model of structural components and connections **Object** 3D geometry of all the components **Characteristic** Correct size of composite truss elements, material properties

Tab. 1. *Definition of the constructive detail of the lost light metal vault to the deepest possible LOD.*

On the other hand, concerning the surviving ancient archaeological structures, it was necessary to proceed by integrating the methods of laser photogrammetry and imaging methods. In the lost metal vaults, the original presence of modular components has been an advantage in modeling and defining parametric elements for various properties, including virtual reconstruction of what is lost, as in the present case. Furthermore, preserving building components also permits defining performance characteristics or assigning a decay status [15]. For example, in reinforced concrete structures built with lightweight technologies to cover large factory spaces, such as for the vaults of the halls for the Hollander machines, it is methodologically possible to combine geometric surveying with automatic identification of major pathologies.

shape and space. Therefore, the paper focuses on the integrated result of the historical-documentary research, construction survey, restitutive drawing, and 4D modeling of the lost metal elements of the Segrè paper mill. Then follows the detailed description to which it is associated, as a complement, also the considerations on the impact that such loss due to voluntary demolition has not only on the understanding of the factory but of the same ancient sacred building in its millennial history.

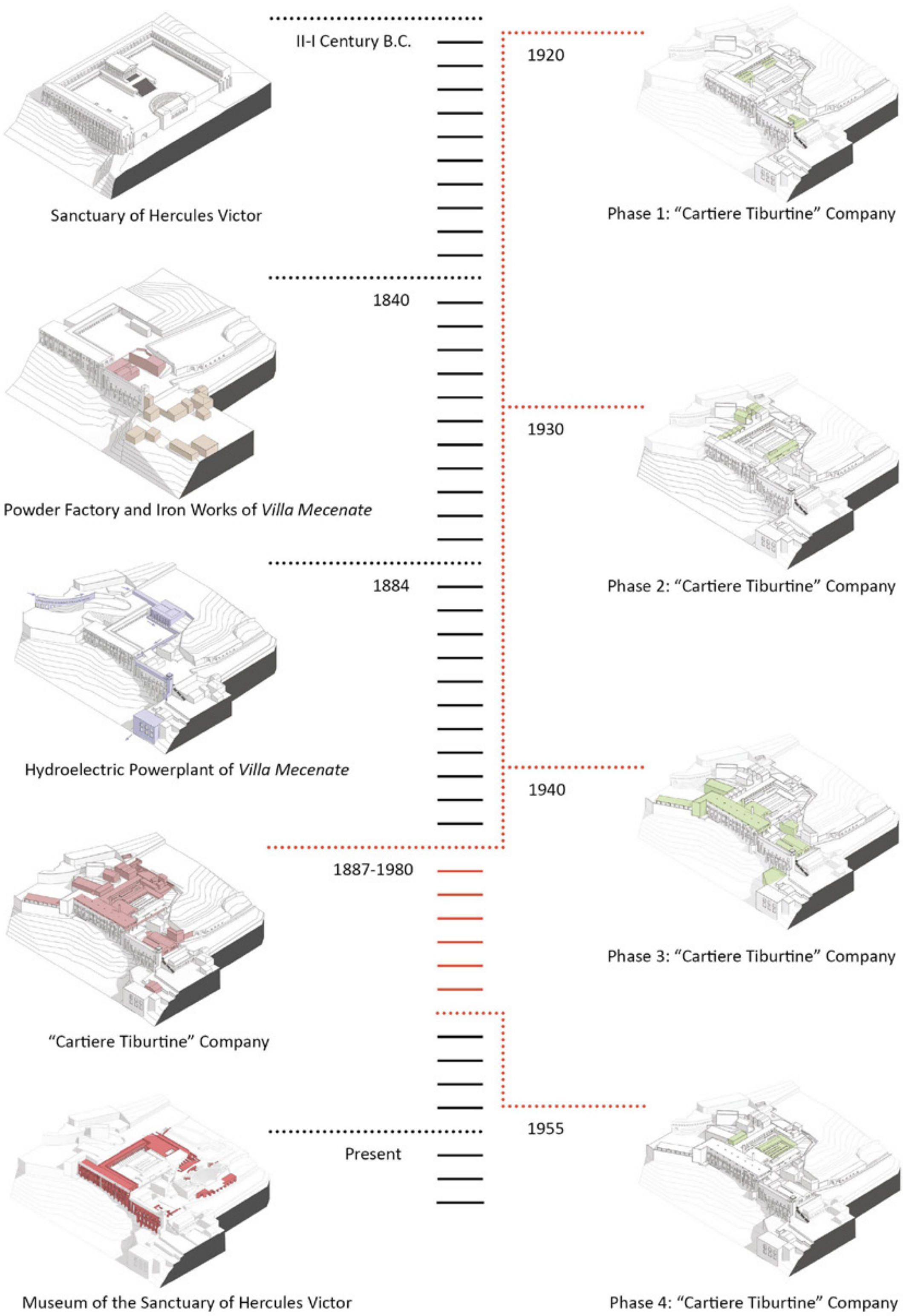


Fig. 3. *Case study evolution stages in contemporary age in the BIM model - AR.*

3. THE MODERNIZATION OF THE MECENATE PAPER MILL IN THE THIRTIES OF THE TWENTIETH CENTURY

From its founding in 1887, the mill had many expansions required by the evolution of production techniques, the use of different forms of energy within the mill, and the need to quantitatively increase production. Thus, it would be going to occupy more space in the Sanctuary and overlap with growing new structures. At the peak of autarky, the Segrè family's paper mills in Tivoli went through a season of crucial industrial renewal and growth in the quality and quantity of production. The fortune of the Segrè, in particular, is related to their main production site, the Cartiera Tiburtina, also known as the Mecenate or Segrè paper mill, located in the ancient structures of the Sanctuary of Hercules the Vintor. The latter site was historically traversed by water, enriched in the 16th century by the significant amounts of water diverted for the monumental fountain system of Villa d'Este, designed by Pirro Ligorio. As written above, the city has a long tradition of productive activities, including paper and woolen mills, ironworks, and oil presses propelled by many conduits derived from the river Aniene. In the structures of the Sanctuary, productive uses can be traced at least from the beginning of the seventeenth century with the installation of ironworks [1] by the Camera Apostolica and precisely for the exploitation of those flows conducted for the pleasure of the cardinal Este [8]. The sequence of subsequent uses is only partially defined. Starting in 1887, with the construction of the Canevari Canal, the site was at the center of the city's rapid industrialization. Taking advantage of the energy produced thanks to the power plant fed by the canal, the Tiburtina Paper Mill was installed, which at the turn of the century: «is lit by electric light, has 2 steam boilers for heating, of the total strength of 45 horsepower, and 2 rotating autoclaves for boiling rags and straw. It produces paper of various qualities, including very thin paper for letter copying, citrus wrapping, and similar, also making large exports of it». It is the most advanced of the 7 plants operating in Tivoli, employing a total of 381 workers, 5 paper machines, and 9 drum machines [17].

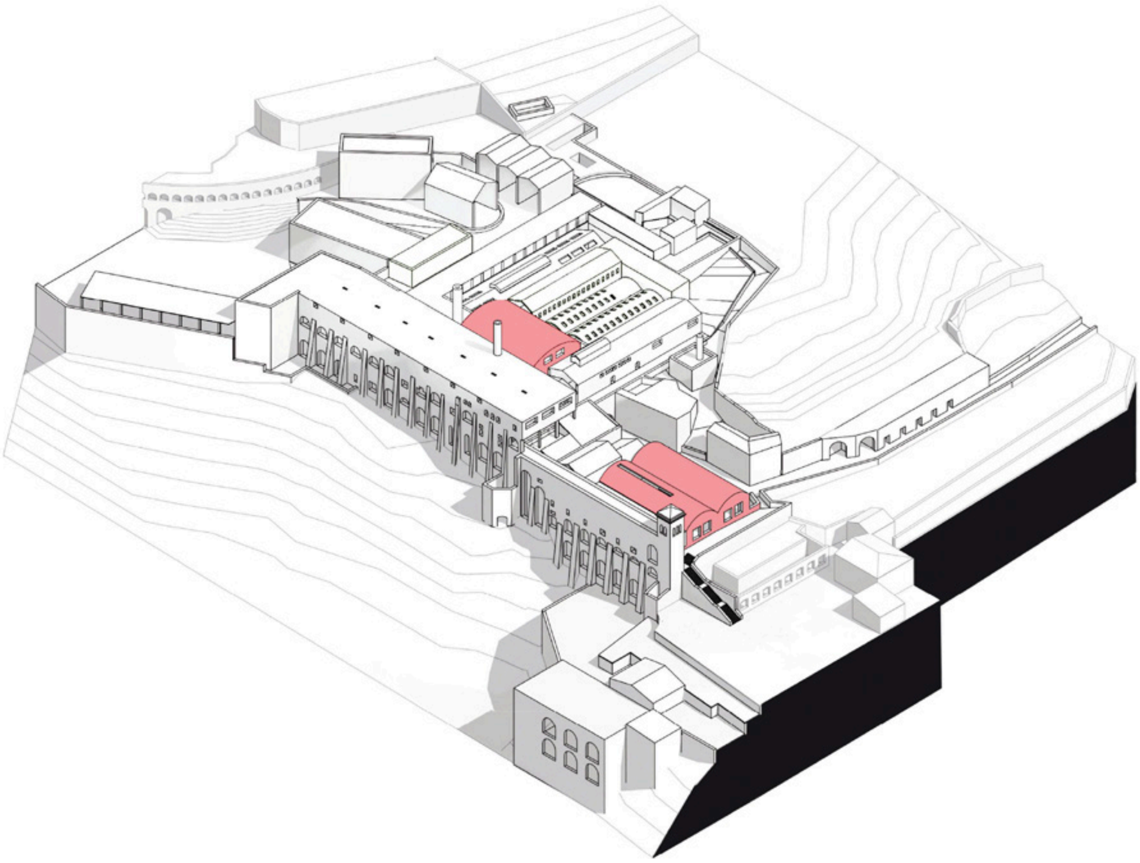


Fig. 4. *Configuration phase of the paper mill in late 1938. In pink are Gino Covre's metal vaults - AR.*

Later, when the company is about to celebrate its 50th anniversary, the site is affected by a massive building activity supervised and coordinated by engineer Emo Salvati on a commission from Marco Segrè. Production is rationalized, new and powerful machines are installed, a small power plant is built, and a new thermal power plant provides steam for the turbo alternators that power the three paper machines, numerous Hollander beaters, and refiners. In 1937, the work was completed in time to celebrate the factory's 50th anniversary in the largely renovated paper mill in the presence of the authorities, workers, technicians, and their respective families. The interventions of the 1930s are, therefore those that make the maximum overlap between the factory and the ancient site, covering with elevations every extension of the ancient artifact, and also using as much as possible the outdoor or underground spaces of the "Via Tecta".

Notably, the main structures built by Salvati, starting in 1936, all in reinforced concrete, were: the new paper sorting department, in the courtyard of the third continuous machine, corresponding to the old sacred area of the Sanctuary; the new warehouse for outgoing paper and wastepaper, adjacent to the north side of the triporticus; he also renovated the north building of the rag shop, inserting reinforced concrete frames; and he rebuilt the west room of the rag shop, located on the last level of the substructures and now gone. As part of these works, Salvati and Segrè turned to lightweight metal vaulting for some large-scale roofs. They, therefore, first approached the firm Anonima Costruzioni Italiana, which, on March 25, 1938, proposed a metal solution based on Cametti's patent for metal lamellar vaults, and, only later, contacted Gino Covre, who had arrived in Rome in 1935 when his professional relationship with the Badoni firm of Lecco [18], a historic mechanical company, was already well established. The sequence of operations carried out in this epoch, referenced in the BIM model, is shown in the figure (Fig. 4).

4. METAL VAULTS OF GINO COVRE

4.1. THE LOST VAULTS AT THE MECENATE PAPER MILL

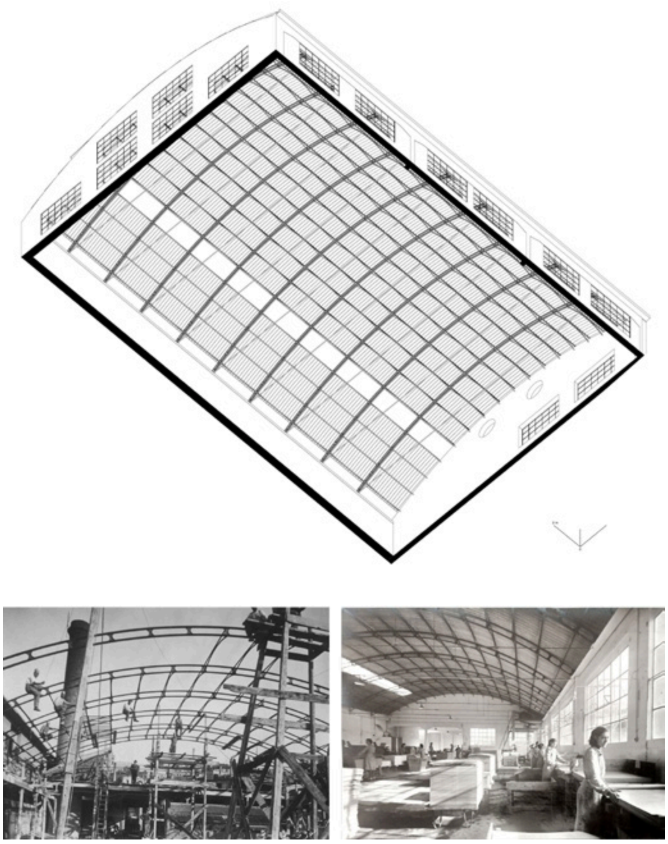


Fig. 5. *Left: Restitutive model of the original configuration of the metal vault of the Paper Selection Room.*

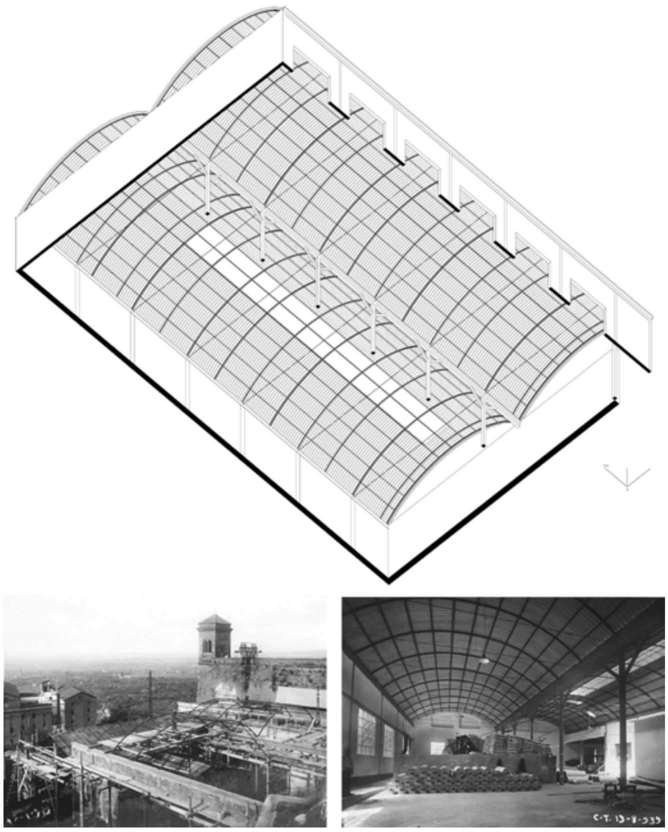


Fig. 6. *Right: Restitutive model of the original configuration of the metal vaults of the Courtyard First Paper Machine.*

Following a conversation with Marco Segrè and Emo Salvati on May 16, 1938, Covre proceeded to design the roofing of two halls with wide vaults of metal components. On July 5, 1938, he delivered the executive design for the whole thing. The first roof consists of a vault with plan dimensions of 18.40x27.40 m, made to cover the upper floor of the new concrete slab in what was the courtyard of the third continuous machine adjacent to the triporticus, in the west sacred area (Fig. 5). The room is intended for paper selection and served by a freight elevator that connects it with the floor of continuous machine, of the finish hall, and further down directly with the "Via Tecta". The need for a light and non-pushing roof is understandable since the elevation structures intended to support it consist of: on the east side by the masonry wall of the west rag house, built as a superelevation of the entablature and attic of the east triporticus, and on the west side by a reinforced concrete frame made partially embedded in the masonry of the pre-existing Hollander Beaters Hall (Fig. 7). Covre devised a solution consisting of ribs and transoms that applied what he had registered in Patent No. 343079 of September 10, 1936, "Vaulted arch, composed or constituted with frame elements" (Fig. 9). Ribs and transoms form a curved frame in which the elements cooperate with each other for the stability of the whole. The ribs have a height of 290 mm and consist of the upper and lower wings, given by pairs of "U NP 4"-normal 40-mm profile-welded with a pitch of 115.5 cm to uprights made from 200-mm-wide, 4-mm-thick plates (Fig. 8). The pitch of the struts is halved near the supports to provide greater resistance to shear stress. The struts are composed and stiffened at the transverse warp by the incision of two crescents to which are welded calendered plates sect. mm 40x4. The individual struts, which constitute for discrete pieces the core of the rib, are welded to the profiles of the ribs, both on the outside (with a bead at the intrados and extrados of the rib on the edges of the "U NP 4"), and on the inside, again on the edges of the "U NP 4". Therefore, searching for maximum optimization of the amount of steel Covre does not follow the usual strategy of the lattice beam but rather that of lightened arch beams.

With a view to greater stability, the secondary joists are designed not to rest on the structure but to be solidified to both rib wings. They are made of 40-mm "T NP 4" profiles bolted in situ by means of plates previously welded into the core of the "U NP 4" bridges of the ribs. The upper chord is straight; the lower one is arched calendered; the joists are therefore configured as arched beams, a fact that later will be easy to find in Covre's works. The nodes between ribs and the chords of the secondary joists, as they are configured, are similar to a hinge behavior, which can ensure the absence of additional stresses generated, for example, by the thermal deformations of large arches. The vault is very low, with a radius of curvature of about 16 meters, and the ratio of rise to span is 2.95/18.40, which is less than 1 to 6, and this, combined with the nature of the constraints, makes the presence for each rib of tied rods intended to unload the thrust essential completely. In the design phase, two Φ 24 mm are provided for each rib, while in the construction phase, only one of greater diameter was placed. The use of material, therefore, is kept to a minimum, compensated by great care in increasing the strengths by shape as far as in the individual components, such as in the stiffened crescents of the struts or the arched lower chords of the joists. The ribs were not assembled or welded in place, as they were from the design intended to be joined in situ by bolting in two sections. A valid supposition may lead to believe that they were made by the firm Antonio Badoni, since on July 6, 1938, Covre, as soon as the project was delivered, wrote to engineer Giuseppe Riccardo Badoni inviting him to carry out the work even though he feared that: «the small amount of workmanship makes you a little perplexed or may affect prices», but insisting that the «Cartiere Tiburtine are planning other works […] far more important than this one». A search for confirmation of Covre's wishes is still underway at the Badoni Archives and the Segrè Fund.

The second intervention consists of two metal vaults to cover the courtyard of the 1st paper machine (Fig. 6). The purpose is to make a new newsprint depot. It is unique how the solution proposed by Covre is for this building completely different, in the view of an approach, which can be called tailoring, to the design conditions. The courtyard has a plan dimension of m 22.60x33.10 and is divided into two bays by a reinforced concrete frame with six pillars of sect. 20x20 cm, parallel to the existing boundary walls. The individual bays, therefore, measure 11.30x33.10 m and are covered with a low-arched metal vault. A modest span is thus obtained for which he proposes a much simpler metalwork than the one adopted for the chosen paper room. The two vaults are made with ribs and joists based on the use of U-shaped metal elements in the section of just 58x32x4 mm.

With this extreme simplification, the rib is made with a double "U" juxtaposed on the core side with a plate of 4 mm thickness in between, while the secondary joists are made with a single "U". The ribs are composed by welding into a single component, while the joists are bolted in place to the ribs with hinge constraint. The presence of constrained tie rods eliminates horizontal trust, plunged into the concrete beams of the edge. Tied rods are provided by design for each joist every 5 meters, but during construction, twice as many are laid in place, fixing them at all the ribs, located with an axial distance of 2.5 meters. For the sake of completeness, we report that before turning to Covre, Salvati had drawn up a design hypothesis delivered in August 1937, which was later canceled (it is not known whether Salvati had also drawn up a roofing hypothesis for the chosen paper hall, but it is likely to be considered consistent with his mandate on all the works of the paper mill). Salvati's design for the paper newspaper room already presents the elevation structures that were later built and would support the Covre vaults. However, metal roofing was preferred to the initially planned wooden roofing. Before Covre's proposal, an outline design and estimate were requested from the company ACI - Anonima Costruzioni Industriali, which had, for this purpose, sent its offer with a solution based on the CAM patent of engineer Cametti and brought as a curricular example the steel "lamellar" vaults and canopies made in only 29 days for the new Ostiense Station. On a comparative analysis, the structures proposed by ACI presented more joists (+35%) made with "U" profiles about 150 mm high. Probably, given the prohibitive cost of steel during the autarky, the offer of the ACI company was not approved and we turned to engineer Covre to have a solution, thanks to his patent, with a significantly lower use of material (for the ribs alone there is the use of less than half of the steel).

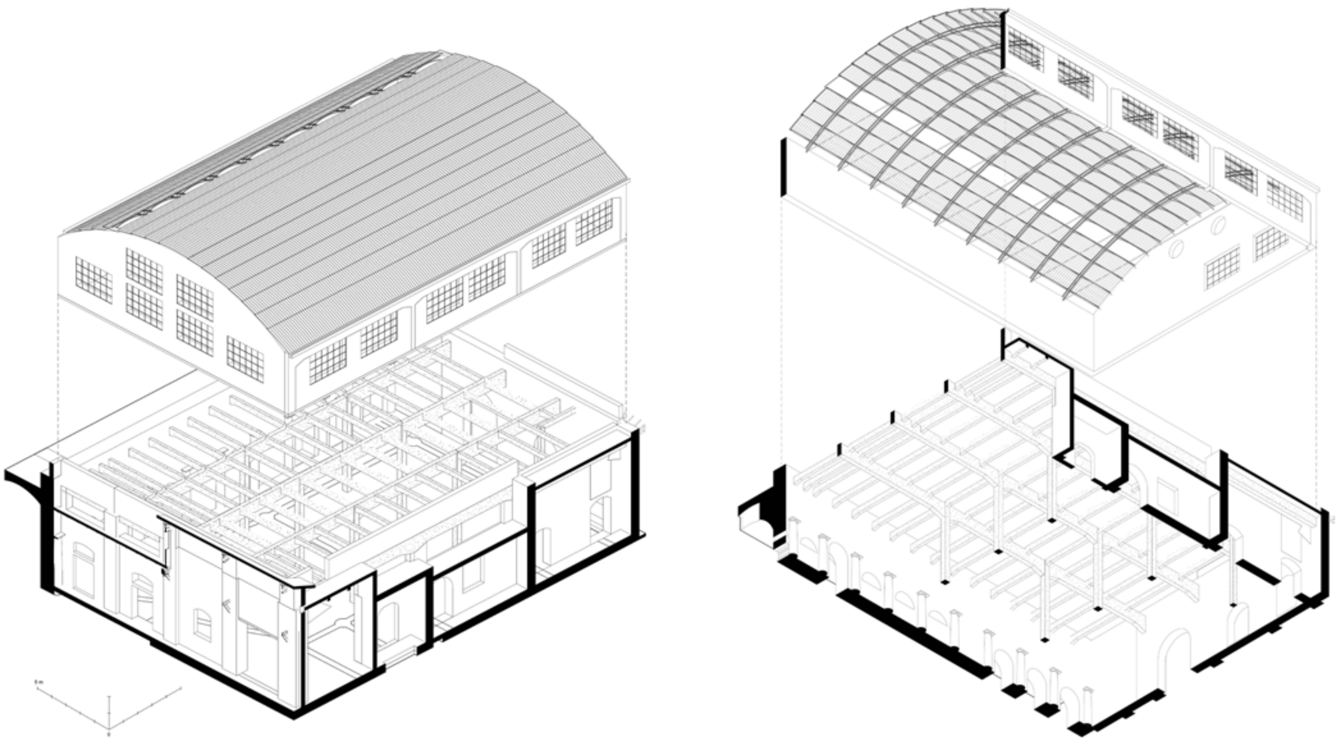


Fig. 7. *Exploded axonometric view of the paper selection room and the processed paper store in the sanctuary structures.*

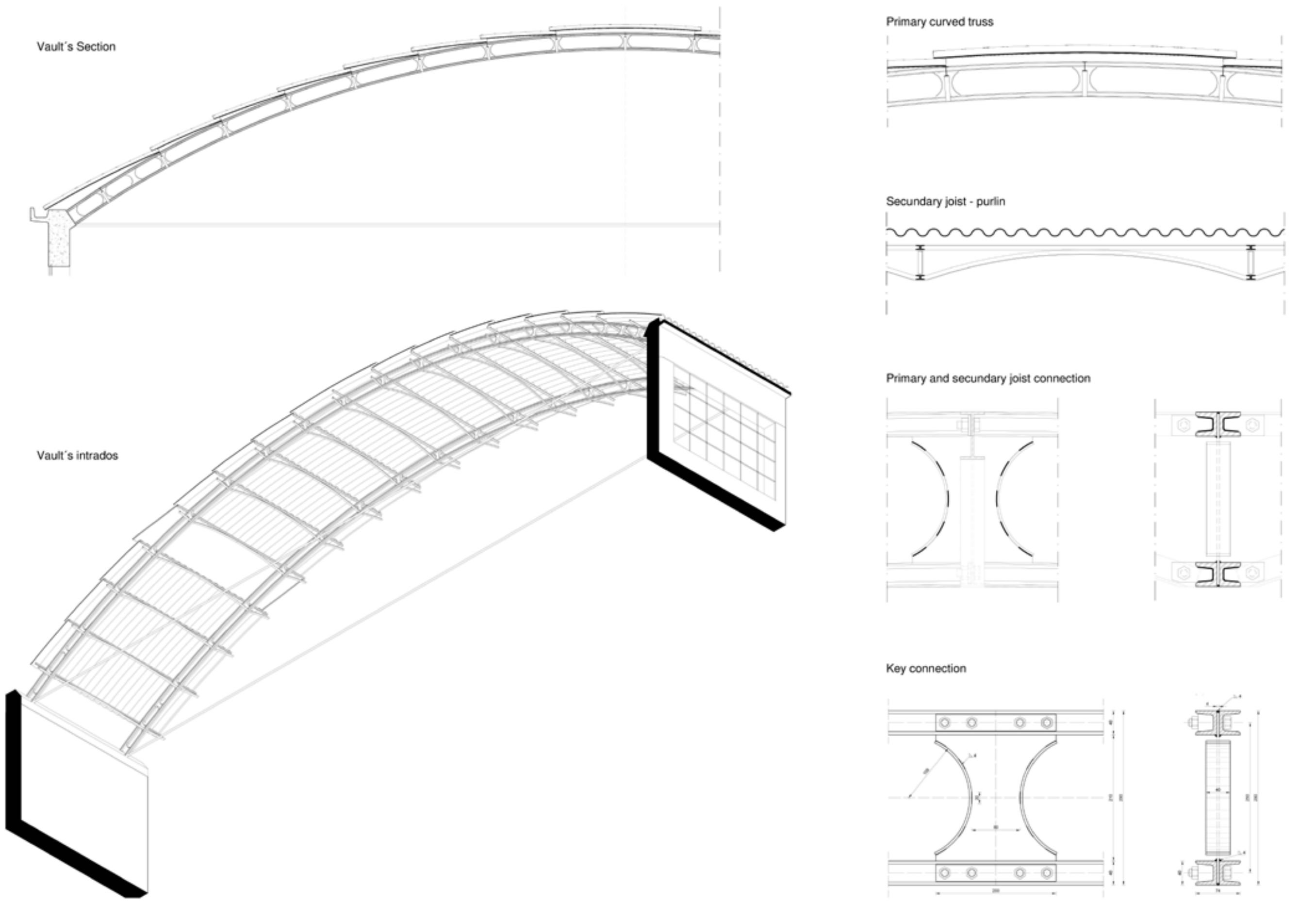


Fig. 8. *Construction details of the metal vault of the paper selection room.*

4.2. APPLICATION AND DISSEMINATION OF THE BUILDING SYSTEM

Behind such successes is the enduring partnership between engineer Badoni and the designer. It was from 1930 that the latter worked steadily with the historic Antonio Badoni firm, which was headed by Giuseppe Riccardo Badoni. For the Badoni firm in 1934-37, he dealt, among other things, with the metal structures to be built for the Feltrinelli House designed by Lodovico and Alberico Barbiano, confronting more closely with the themes of the new architecture to which he would later make his notable contribution [19]. In addition, Badoni had established «permanent connections with Rome, where his correspondent is Eng. Adelchi Cirella, who takes care of relations with the various ministries». It was to Cirella that Covre was addressed when, in 1935, he moved to Rome [20]. The association strengthened over the years, so much so that «in 1946, an office of the Badoni Company was established at the office of Eng. Gino Covre to coordinate and develop the technical-commercial work resulting from Eng. Covre's expertise and the use of his patent for the welding of steels applied to large infrastructures» [18]. Giovannardi also notes that Covre's biography [21] is still far from complete, and this small case study can contribute, with the questions it raises, to open a window on the early years of the Roman period, which, with good reason, can be considered those of the designer's establishment in great engineering and thanks to which the fruitful and lasting association with Pierluigi Nervi and many other engineers less familiar with metal construction will also be born. It is worth mentioning at least one other outstanding example, the metal solution for the arch of E42 worked out by Covre with Badoni, for which full-scale samples were also built.

As the Badoni firm itself stated a few years later, the works for light industries, or exhibitions, «are the prac-

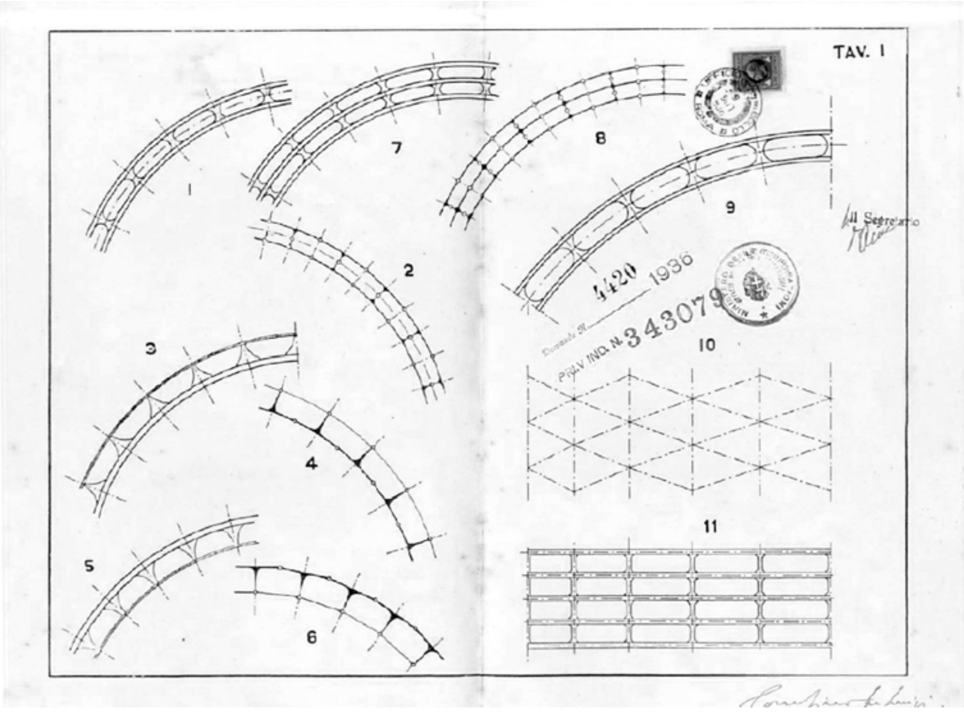


Fig. 9. *Patent n. 343079 / September 10. 1936 «Vaulted arch, composed or constituted with framed components» by Gino Covre, son of Luigi © ACS.*

tical application of the brilliant results obtained from a profound study of engineer Gino Covre on the theory of solid-element structures […]. The Covre-type structures are all electrically welded and bolted together at assembly […] these structures, given their characteristics, are easily assembled and disassembled, allowing the integral recovery of the structure itself and its subsequent reuse» [18].

The construction solutions of the original patent are finally applied in the construction of the great cross vault of the Palace of Congress at E42. They were not only an initial start of later design research; when convenient, the designer adopted them again for many years. They are found, for example, used in the construction of three pavilions for the 1951 Milan Expo, each measuring 20x72 m in plan, plus a projecting canopy of 3 m. For a total covered area of each pavilion of 1,600 square meters, a quantity of only 36 tons of steel was used, and the three halls were also built in only 50 days (Fig. 10).

Fig. 10. *Left: the cross vault of the Palace of Congresses and Banquets of Rome E42 under construction © 1939 ACS. Right: the Agriculture Pavilion, Milan International Exhibition © 1951 Badoni Archive - Polimi.*

5. SACRED PLACE AND SUBSEQUENT REUSES: DEMOLITION AS LOSS OF HISTORY AND IDENTITY

The research also compels some further considerations. With the secularization of religious property in the Napoleonic era and following the Unification of Italy, many new productive functions came to settle in many sacred places, churches, and convents, among other reuses. After the requisitions, many examples of religious typologies were subject to major changes in use, and all of this is an emerging theme of relevant interest for understanding our built environment and the relationships that innervate the historic territory. The presented case study comes from a longer historical event in time, but in its palimpsest, there are traces of numerous transitions through productive uses and religious centralities. Originally settled as a sanctuary, it provided countless functions inside it, making it a territorial centrality [22]. With decadence, it had several processes of reuse, parceling, reduction of the area used, and partial renaturalization. It housed monastic communities and churches, an important part of the sacred area became a fine vineyard, and, within it, more and more productive and industrial initiatives took place, thanks to the waters that never stopped flowing through it and, indeed, from the construction of Villa d'Este onwards increased considerably.

It is also undeniable that the Sanctuary's structures, especially the ornamental ones and those in elevation above the imposing substructures, are now lost, and the remaining ones are significantly compromised by the many events. In this condition, they have formed an organism with the items of the various structures that have been superimposed on it that have opened up new meanings, paths, and relationships with people, the city, and the land. Today, the area is fenced as an archaeological site of cultural interest, scientific research, and public enjoyment. The co-presence of the signs of ancient and modern sacred events, as well as of ancient and modern productive ones, requires the utmost caution with respect to the removal of non-antique elements; indeed, it demands a careful reading of them, on a par with those of the Roman age, as only from this can arise an understanding of the processes that have taken place and the changes in the original organism. The alternative is a cultural and social impoverishment of the "city of water, electricity, paper, and landscape". Such impoverishment would, however, be associated with the objective difficulty of understanding the archaeological ruin if entirely stripped of the traces of its successive uses. Moreover, the presence of an industrial and architectural history made up of firsts and excellences is in itself a reason for cultural recognition, and the comprehensiveness of different values can only make the site even more unique.

6. CONCLUSIONS

The specific study, which emerged as part of an all-round investigation of the archaeological-industrial object, required the involvement of many skills. The whole activities, research, architectural survey, construction investigation, and HBIM process (which allowed the systematization of archival data, literature, history, and direct comparison with material data) made it possible, in general, to place the lost Covre's works in Tivoli, in the broader unfolding of the local or global architectural and construction issues [23]. This is a case of heritage loss due to a choice made at the end of the 20th century because of a value selection based on principles that do not respect the different eras of the landscape and industrial objects. In fact, the pavilion's roof survived until the late twentieth century; the Superintendence authority demolished it as part of a larger demolition plan that affected many vestiges of the factory. The study was also an opportunity to see how Covre's patent was used as an alternative to another relevant, little-investigated autarchy patent for lamellar vaults, the Cametti. This one, used, for example, for the vaults of the Ostiense station in Rome, is based on metal-slat/lamellae, in direct reference with Hugo Junkers' patent used from the hall of his 1929 Kaloriferwerk.

Unfortunately, the haste of demolition of Covre's works was not accompanied by an industrial archaeological or construction history study, resulting in two levels of misunderstanding. On the one hand, the non-disclosure of the general value of the phases of construction and use makes places like this sacred and productive, a special reservoir of information about the centuries-old history of the community, the settlement, and the site. On the other, the value of the object itself [14]. Research and modeling tools make it possible to bridge part of this historical gap and carry forward a cultural memory of dual value that would otherwise be completely lost. The absence gives new importance to all the existing traces – photographic, documentary, construction site – that could provide, in an investigation at this point focused on a lost heritage, the valuable elements to understand the built object and place it in what appears to be an exceptional affair: Gino Covre's experimentation in the autarkic phase with vaulted metal structures for large spans, by means of a significantly reduced use of material [20]. From what has emerged, the work deserves such a study, as it does not appear in the studies so far [20, 21, 24]. At the same time, it seems to constitute a pioneering use of the system patented by Covre in 1936, and, finally, because it was precisely on the basis of the same system that he proceeded to design some large works in metal construction just a year later, such as the roofs for the new pavilions of the Innocenti company, but especially the roof of the E42 congress building by Adalberto Libera (1939-41). Perhaps also belonging to this group of works, to what may constitute a "heritage series", there is a hangar built for the Littorio airport also in 1938, currently under study by the authors.

A distinctive trait of the most influential events in the history of construction is precisely that of starting from the experimentation of a new insight found in individual cases, completed works and research, and then arriving, after many and repeated trials, at the elaboration of an overall vision to be subjected to the scrutiny of the present and future times. Thanks in part to the work conducted on the occasion of the "Archivio in-vita" exhibition, desired by the heirs, the Milan Polytechnic, and the Municipality of Lecco, on the Antonio Badoni archive, the time is ripe for a widespread investigation of Covre's works, for whom questions are opening up about a prolific and brilliant career as a designer-inventor attentive to the needs of industry and architecture, from the Milanese season to that of Rome, to that of the postwar period, from his association with Badoni to his collaborations with Nervi, and with many other architects of his time [25]. Issues not only of the science and technique of building but of architectural authorship as a whole and of a major contribution to the renewal of the spatial qualities of his time.

Acknowledgments

Scientific collaboration agreement on "Industrial Archaeologies of Tivoli" between Dicea-Sapienza University of Rome, Aipai-Italian Association for Industrial Archaeological Heritage, and Institute of Villa Adriana - Villa d'Este Ministry of Culture. P.I.: E. Currà, S. Del Ferro, L. Bernardi.

Authors contribution

Conceptualization, E.C..; methodology, E.C.; historical research, E.C., A.D.P., R.R., general supervision, E.C.; survey, A.D.P., R.R., M.A., E.C.; digital model supervision, M.A., A.D.A., M.R.; digital model elaboration, A.D.P., R.R.; drawings, A.D.P., R.R.; writing, E.C. § 1,2,3,4,5,6; A.C.D., V.S.S. § 5, 6; A.D.P., R.R., M.R., A.D.A. § 6; reviewing, M.R., A.D.A.

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