VOL. 8, SPECIAL ISSUE (2022)

Remarkable historic timber roofs. Knowledge and conservation practice.
PART 1 - Construction history and survey of historic timber roofs

TEMA
Technologies
Engineering
Materials
Architecture

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Cover illustration: Lattice roof trusses in the nave of Jät church, Småland, Sweden, 1225–1226 by Robin Gullbrandsson. © Robin Gullbrandsson (2022)

e-ISSN 2421-4574
DOI: 10.30682/tema08SI

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e-ISSN 2421-4574
ISBN online 979-12-5477-085-6
DOI: 10.30682/tema08SI
Vol. 8, Special Issue (2022)

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Year 2022 (Issues per year: 2)

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TEMA: Technologies Engineering Materials Architecture
Vol. 8, Special Issue part 1 (2022)
e-ISSN 2421-4574

COFFERED CEILINGS IN THE CHURCHES OF ROME, FROM THE 15TH TO THE 20TH CENTURY

TEMA Technologies Engineering Materials Architecture
e-ISSN 2421-4574
Vol. 8, Special Issue part 1 - (2022)

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DOI: 10.30682/tema08SIi

Abstract

The contribution concerns the coffered ceilings in Roman churches, which were built between the mid 15th and the mid 20th century and still represent ornamental components of great value. The coffered ceilings still visible today are approximately sixty; many others have been demolished or destroyed by calamities through time.
The attention on the subject revived after the collapse inside the church of San Giuseppe dei Falegnami occurred in August 2018; the event highlighted the vulnerability of the coffered ceilings and a lack of historical and technological knowledge regarding individual cases.
By referring to the architectural treatises on the subject, this article focuses on the early 19th century texts by Jean-Baptiste Rondelet and Giuseppe Valadier, illustrating two different criteria for creating coffered ceilings.
In the first one, the coffered ceilings are directly connected to the roof trusses, providing for the lining of the tie beams.
In the second one, the coffered panels are nailed to wooden frames hanging from joists placed over the tie beams. Both construction methods can be found in the coffered ceilings of Rome, but most cases refer to the second system. Thus, the contribution delves into the construction process in detail and focuses on the arrangement of the elements, reporting the analysis of some study cases based on direct checks and surveys. In this regard, knowledge of the extrados of the ceilings is crucial for foreseeing possible conservation works, allowing to avoid the risk of inappropriate restoration or replacement of original elements.

Keywords

Ceiling, Lacunar, Coffered ceiling, Wooden structures.

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1. INTRODUCTION

On August 30, 2018, two of the four trusses of the Roman church roof of San Giuseppe dei Falegnami collapsed, and consequently, two-thirds of the carved wooden ceiling, dating back to 1612, suddenly fell off [1]. When the construction site for the restoration of the lost ceiling was set up, a lack of technical knowledge about the coffered ceilings of ecclesiastical buildings in Rome was revealed [2].

As many coffered ceilings were inserted during the Modern Age in former, ancient spaces (exceptions are some 19th-20th century churches newly designed with coffered ceilings), studies in the historical-artistic field are predominant; nonetheless, the construction criteria and structural functioning are scarcely investigated. In this regard, one key factor is the structural peculiar-

Fig. 1. *Rome, Santa Maria Maggiore all'Esquilino; the coffered ceiling of the basilica (1492-99).*

ity: coffered ceilings of Rome are wooden decorated decks hanging from above structures in different ways. Therefore, specific knowledge of both the construction technique and the structural behavior is necessary, considering their conservation and restoration status. The mentioned characteristics are strictly related to the design development, namely their artistic outcomes over time. This contribution moves in this direction and represents the first anticipation of the contents of broader research currently underway.

2. COFFERED CEILINGS SPREAD IN RELIGIOUS ARCHITECTURE AND RELATED CONSTRUCTION CRITERIA ILLUSTRATED BY TREATISES

The addition of coffered ceilings in Roman basilicas dates back to the mid 15th century. The first two churches to include such structures were San Marco in Piazza Venezia (1467) and Santa Maria Maggiore all'Esquilino (1492-99) [3] (Fig. 1). Both works were commissioned by the Pope, probably inspired by the Classical Florentine carved ceilings (a well-known example is the basilica of San Lorenzo, in Florence). Similar additions were realized between the 15th and 16th centuries.

However, the coffered ceilings had the most diffusion in Rome after the Council of Trent (1545-1563), as the consequent Reformation was calling the Catholic Church to refer to its origins, and the coffered ceiling was assumed as a reference looking to the Constantinian basilicas.

In addition to the iconographic value of that architectural solution, there was also a functional acoustic improvement coming from the coffered ceilings, which created an excellent "sound box" for listening and preaching, a crucial element of the Tridentine Reform, clarified by the *Instructiones fabricae et supellectilis ecclesiasticae* by Carlo Borromeo (1577).

Moreover, the ceiling can also be intended as a communicative religious "tabula", exhibiting elements of indoctrination by images, statues, and canvases: the ceilings changed from representing starry skies to acquiring a mystical Christian dimension [4]. The purpose of inserting statues and various elements required a more versatile composition, encouraging the spread of this kind of ceiling, characterized by coffers of various shapes, compared to the simple checkerboard configuration [5].

This evolution was followed by a new structural system, allowing the creation of more varied and complex shapes. The ceilings realized in the Roman basilicas between the second half of the 15th century and the middle of the 17th century are approximately thirty [6]. This development was interrupted for about two centuries and had a revival under the pontificate of Pope Pius IX Mastai Ferretti (1846-1878): about a dozen of new ceilings were built, and many others were restored. This trend continued during the mid 20th century: in 1939, the last newly designed coffered ceiling was built for Santa Giovanna Antida Thouret Basilica; in 1940, the former coffered ceiling destroyed by fire was replaced in San Lorenzo in Damaso.

The treatises, as well as the contemporary specialist literature, offer a wide range of knowledge on the topic, including suspended ceilings from the slab [7–9]. While investigating this kind of structure, suspended coffered ceilings must be included, considering their peculiar formal and technical characteristics and construction solutions. Regarding coffered ceilings, Renaissance sources – as most of the following ones – are focused mainly on artistic qualities. Among the first writings mentioning the coffered ceilings, there is *De re aedificatoria*, first printed ed. 1485 by Leon Battista Alberti [10], and also *Sette libri di Architettura* (1537) by Sebastiano Serlio [11]. Serlio illustrates a catalog of the figurations used in simple and complex compositions and makes some considerations on the advantages and limits of such coverings.

Similarly, 18th and 19th centuries writings deal with the theme of describing shapes, not going into their technical characteristics in more depth. Among these, *Trattato elementare di Architettura civile* by Francesco De Cesare (1827) describes four characteristics: shape (square, rectangular or rhomboid); placement of the full and empty forming the coffers related to the inner architecture of the nave; proportion, (the proportion between width and length of the coffer); decoration, inspired to ancient buildings [12]. Therefore, architectural treatises mainly refer to coffered ceilings describing their figurative characteristics and focusing on the shape that the scheme can assume in accordance with the space to be covered [13, 14]. Only two books from the early 19th century deal with the technical issue regarding coffered ceilings, describing them as false ceilings connected to trusses: *Trattato teorico e pratico dell'arte* by Jean-Baptiste Rondelet (originally French edition 1802-1817; Italian edition 1833) [15] and *L'architettura pratica* by Giuseppe Valadier (1828) [16].

Both authors refer to the existing ceiling of the Basilica of Santa Maria Maggiore, built during the pontificate of Pope Alexander VI Borgia (1492-1503). The ceiling

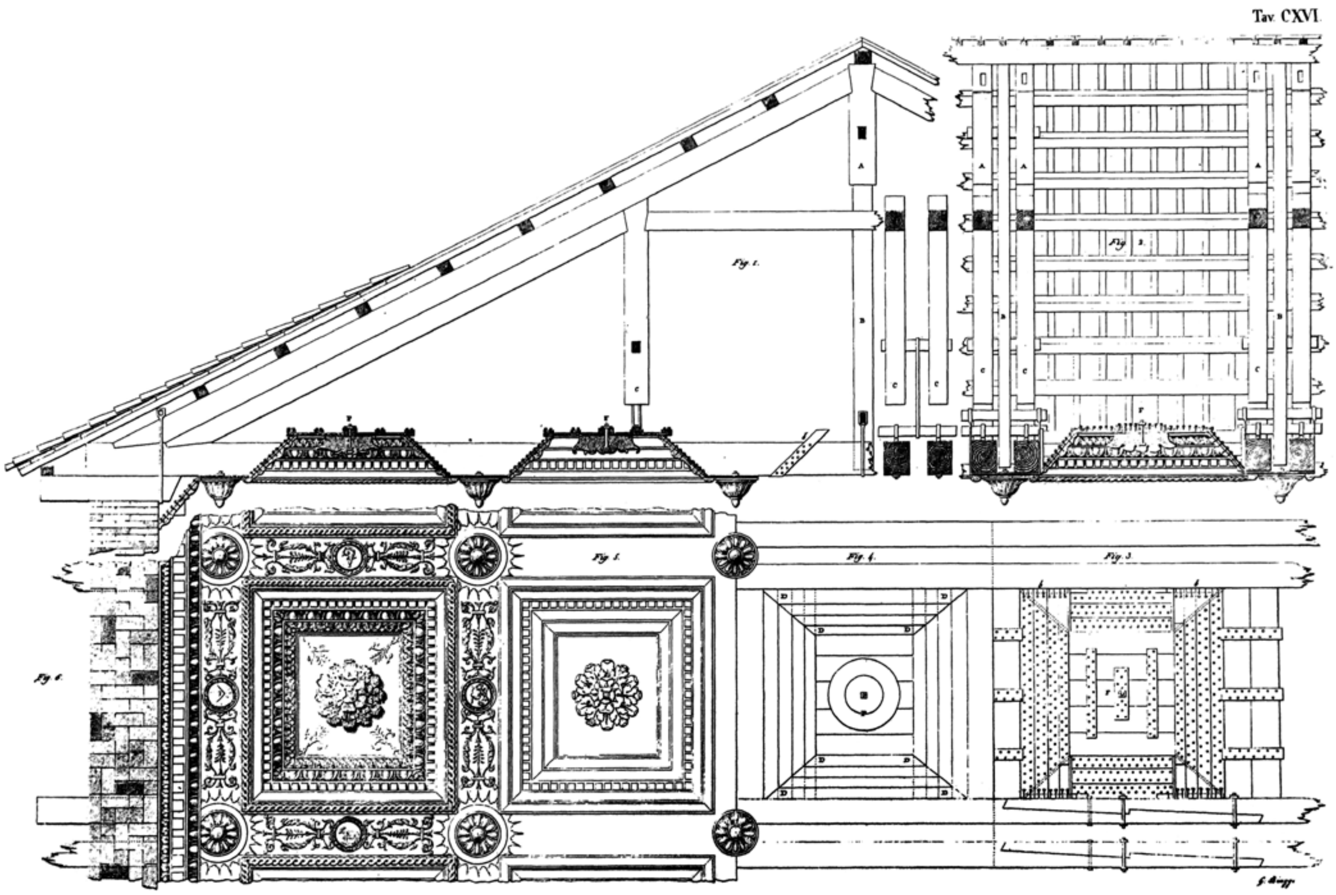

Fig. 2. *Jean-Baptiste Rondelet, Trattato teorico e pratico dell'arte di edificare, p. CXVI (first French edition 1802-1817; Italian edition 1833).*

is described through technical drawings (a plan and a detailed section) and text. However, the two authors illustrate different procedures for the construction. The drawing by Rondelet shows the tie beam of the trusses encased by the boards forming the coffers. The spacing between the trusses determines the general ceiling scheme. Moldings are then applied on the boards, supported by oblique wooden plugs nailed to the tie beam, with a span of about 15 m. The bottom of each coffer is covered by a board to which the carved rosette is fixed using a "cavicchia" (a metal connecting element used instead of a nail) (Fig. 2). Differently, the drawing by Valadier represents the section of the ceiling of Santa Maria Maggiore separated: «dalle corde delle incavallature sostenenti il tetto o il pavimento di una sala superiore perché, primo non si dà alle corde, o travi maestri un doppio peso da sostenere, e poi siccome facilissimo è il caso di rinnovare una qualche incavallatura […] Sarà dunque prudenza di un architetto di tessere sotto le incavallature […] un'altra armatura di grosse travi sostenuta [da] saettoni […] ed a quelli con legni del tutto separati affidare il soffitto» (From the tie beams of the trusses supporting the roof or the floor of an upper room because, first, the ropes or master beams are not given a double weight to support, and then, since it is very easy to renew some trusses […] Therefore, the architect will be cautious in fabricating under the trusses […] another framework of large beams supported [by] struts […] and entrust the ceiling with those with completely separated woods).

The drawing reveals that the structure illustrated by Valadier was not allowed to load the trusses but a system of horizontal beams placed parallel to the trusses on a lower level. The described structure would be able to achieve renewal operations of the roof without touching the underlying ceiling. Once the load-bearing system of beams is placed, "arcarecci" (purlins, namely minor square section beams) have to be placed; on the purlins, U-shaped frames (formed by laths) are fixed supporting the boards composing the lacunar ceiling (Fig. 3).

This scheme does not correspond to the structure of Santa Maria Maggiore, where the ceiling is made according to the criterion reported by Rondelet. Observing the extrados made it possible to certify that the existing system of the boards composing the lacunars connected to the twin trusses supporting the roof was feasible. As reported by the author, the composition boards of the coffers are nailed to the tie beams of the trusses using wooden wedges, which correspond to the transversal wooden ribs in the intrados drawing. However, according to Valadier's description, the system composed of frames hanging from a secondary truss was the most widespread procedure in the realization of the wooden ceilings of Roman churches. So, possibly Valadier was trying to illustrate a standard method, considered the best option; yet, hanging the frames on an independent system of beams – instead of trusses – does not correspond to the most common practice in Rome. Regarding the construction, two methods emerge: in the first one, the coffered ceiling is made starting from the covering of the floor beams or trusses, and in the second one, connection elements hang the beam of the trusses and coffered ceiling.

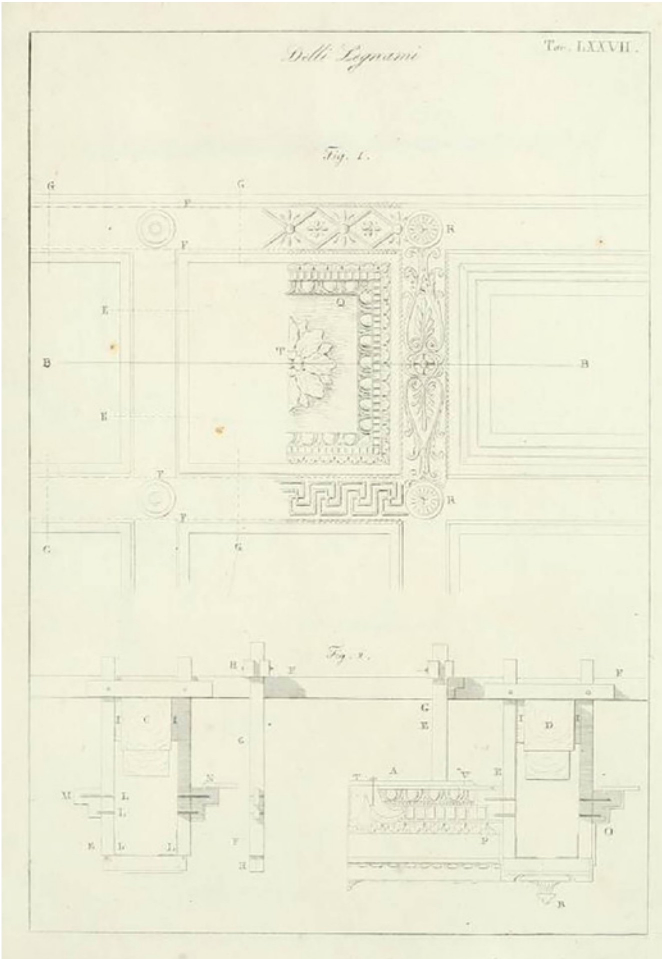

Fig. 3. *Giuseppe Valadier, L'architettura pratica (1828), p. LXXVII.*

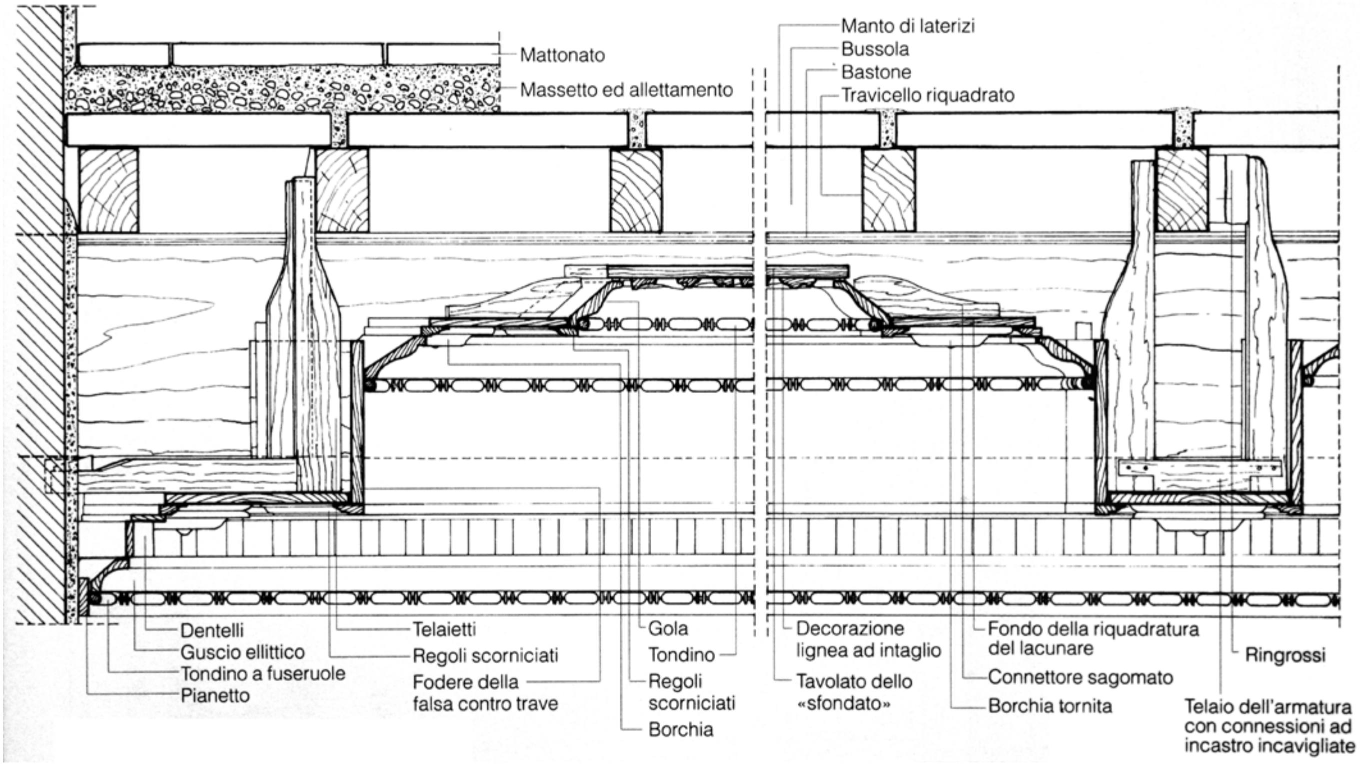

Fig. 4. *Detail of a lacunar false ceiling in Palazzo Altemps. (Image source: Manuale del Recupero del Comune di Roma, 2000, p. 193).*

The first method was realized during the 15th century in San Marco and Santa Maria Maggiore – a technique used until the second half of the 16th century when a more free design of the coffers led to hanging them from frames. This system – as Valadier claimed – made it possible to repair and maintain the roof without dismantling the coffered ceiling. The book *Manuale del Recupero del Comune di Roma* (2000) provides a technical analysis of the construction methods of the wooden ceiling, based on the examples of the second half of the 17th century existing in Palazzo Altemps [17]. The volume illustrates a coffered ceiling attached to the beam, as described by Rondelet (a regular coffered shape following the spacing between beams of the above floor), and a suspended ceiling with lacunars, inserted below a wooden floor and partially similar to the one reported by Valadier. For the latter one, detailed drawings highlight the set of elements necessary for its hanging; the coffers are supported by "panconcelli", namely small wooden uprights, allowing the total adaptability to the shapes of the suspended ceiling (Fig. 4). These elements are slimmer at the top, allowing the insertion of anchoring nails to the joists of the floor above. The represented frames are U-shaped to fix the boards forming the coffer to the beams above and L-shaped on the perimeter, inserted in the walls. Nails and half-lap joints guarantee connection stiffness among the elements. The construction process of the ceiling includes positioning the frames first, then the covering fixing forming the false beams. Then, frames and decorative elements are positioned through nailing (small elements can be glued). The description in the *Manuale* is detailed and precise; however, to further understand the construction methods of the coffered ceilings in Roman churches, it is crucial to examine the wide range of cases, looking at their state of conservation and envisioning the potential restoration works.

3. ANALYSIS OF CONSTRUCTION CRITERIA

The ceilings considered by the research are approximately sixty (including the coffer ceilings covering naves and transepts and some chapels of churches in Rome, from the 15th to 17th century and from the 19 to 20th century). Dimensions vary significantly: from modestly sized ceilings – such as San Giuseppe dei Falegnami (11.00 m x

16.00 m) to imposing ceilings – such as the one covering the central nave of San Paolo fuori le mura (24.30 m x 90.50 m).

The research is based on inspections of both internal and external elements of the ceiling, which are commonly not considered. It aims to understand their reciprocal position to identify how the compositional and ornamental aspect of the wooden coffers is related to the supporting elements.

Once the various elements were identified, a comparative analysis of the various cases was carried out, allowing a better understanding of the building procedures and verifying the presence or absence of systematic methods [18, 19].

Considering that the coffered ceilings examined were inserted in existing buildings, we can assume that the trusses supporting the roof were already present; consequently, the workers were forced to work in a given situation. So, after the architect designed the ceiling, in its general lines describing the coffers, the *faber lignarius* considered the number and spacing of the existing trusses to achieve the assembly, covering the trusses directly or hanging the ceiling from them. The covering system, commonly used in 15th century Roman churches, is also used in the ceiling of San Vitale in via Nazionale, which was built in 1934; all other coffer ceilings, whose external structures were explored, are made following the hanging system. The decoration scheme of the ceiling in San Vitale shows three longitudinal bands – the central one is the largest – in a checked pattern of rectangular coffers. In this scheme, false transverse trusses are positioned according to the spacing between the upper trusses. The boards forming the false trusses are nailed to the beams, and the bottom boards of the coffers are nailed to them, also by shims (Fig. 5).

The direct anchoring criterion, therefore, limits the design of the ceiling: uniformity and rigidity of the scheme are the direct consequence of the need to relate to the distribution of the trusses. More complex compositions, in free shapes, are realized by a system not related to the trusses' position, fixed using frames nailed to the joists placed above the beam. By positioning the joists freely, the frames can retain the "shaped skin" of the ceiling, therefore representing a somewhat flexi-

Fig. 5. *Rome, San Vitale in via Nazionale; extrados of the coffered ceilings (1933-1934).*

Fig. 6. *U-shaped frame detail. On the left, frame with a crossbar (Rome, San Bartolomeo all'Isola, 1623-24); on the right frame with two crosspieces (Ss. Cosma and Damiano, 1632).*

Fig. 7. *U frame with a crosspiece made up of several elements connected to each other in a staggered form. The picture shows the reinforcement work carried out about ten years ago, proving the insertion of a little reinforcing steel with double screw clamps for the anchorage of the bottom. In fact, the ceiling presented a marked transversal viscous deformation accompanied by localized subsidence (Rome, San Silvestro al Quirinale, 1573).*

ble system, offering more freedom in constructing the wooden roofs. On the other hand, by adding sleepers above the joists, hanging frames not in vertical correspondence with them is possible. The frames analyzed can be grouped into three classes: the first one including U-shaped devices, consisting of two uprights and one or more cross beams (Fig. 6); the second also concerning U-shaped elements, whose cross beams are made up of several jagged elements, able to hook an articulated shape of the lacunar (e. g. San Silvestro al Quirinale, Fig. 7); the third one relates to L-shaped devices, used to be clamped to the masonry, if the frames, instead of being supported by joists, are anchored to the perimeter walls (Figs. 8 and 9).

Fig. 8. *L-shaped perimeter frame anchoring the ceiling to the perimeter walls (Rome, Santa Maria in Trastevere, 1617).*

Moreover, individual panels or iron hangers can be found (see ceilings built from the second half of the 19th century or replacing wooden hangers damaged). Finally, the use of iron pins to hook modest size decorations in the interior of the ceiling is revealed (as heraldic coats of arms and reliefs). The comparison among the study cases allowed understanding some standard construction criteria. Regular seriality arranging the frames along the edge of the ceilings was constantly observed; it is based on the continuity of the perimeter frame and the constant weight to be supported along the extension.

The center-to-center distance of the frames generally does not exceed one meter. The position of the frame upright (double in the case of larger frames) determines the position of the first purlin, constant in each span. The internal part of the ceiling is differently organized, showing an uneven and varied arrangement of the frames, derived from the complex and diversified forms of the lacunars requiring a continuous change of position of the posts. Nonetheless, comparing the symmetry of lacunar frames along the longitudinal axis, an asymmetrical dislocation of the frames emerges, demonstrating that the frames are placed not following a pre-established, gen-

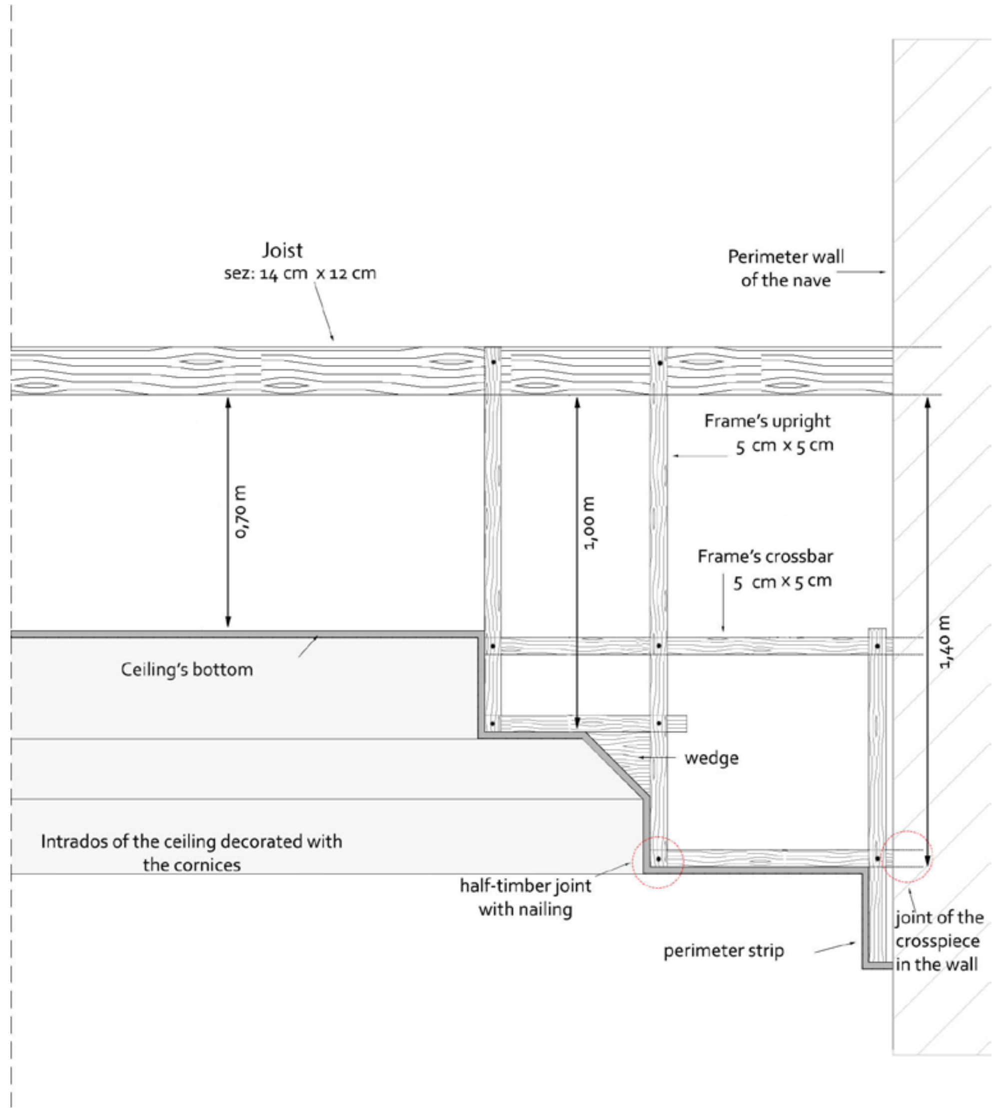

Fig. 9. *Basilica of Saints Cosmas and Damian. Detail of an L-shaped perimeter frame of the ceiling (1632).*

eral, and rigidly adopted criterion but following flexible rules, according to the organization of the construction site and workers skills. For example, the parallel sides of the same lacunar are often hung by frames placed in different positions, even if they are in the same number. Regarding their spacing, the archival research documentation proved the existence of reference parameters. The contract for the construction of Sant'Eligio dei Ferrari ceiling, arranged on May 24, 1602, between the archconfraternity of the church of Sant'Eligio and the carpenter Francesco Nicolini, reports: «Che detta soffitta sia fatta di legname d'abeto conforme al dissegno, e profilo sottoscritto da noi a tutta spesa del mastro con alcune cornice di albuccio, et intaglio di legname stagionato ben polito, e bene inchiodato con chiodi novi, e ben congiunto. Item, che le squadre che andaranno per reggere detto soffitto siano fatte di ligname di castagno bene inchiodati, e che ogni longhezza di tavola d'abeto debbia pigliare quattro squadre e non meno. Che gli alcarecci dove si devano attaccar dette squadre siano di buona grossezza al paro di travi» (That the aforesaid ceiling is made of fir wood conforming to the design, and profile signed by us at the expense of the master with some poplar frame, and carving of well polished seasoned wood, well nailed with new nails, and well joined. Item, that the teams that will go to support said ceiling are made of well-nailed chestnut wood and that each length of fir board must take four frames and no less. That the joists that these frames have to be attached to are of good thickness, like the beams).

The document clearly mentions the wood elements used (chestnut for the structural elements – joists and frames – fir for lacunar external boards, and "albuccio" or poplar for the decorative parts) and reveals that the frames (called *squadre*), are composed of at least by four boards per fir plank. The boards are vertical elements constituting the lacunar structure; the entire frame width derives from their width; the horizontal board of the frame is nailed at the crosspiece base.

In this scheme, the number of frames is adjusted to the length of the vertical boards, to be fixed to the uprights. Then, the assembly of the boards, completing the lacunar with nails or joints, and the decoration elements follow (including astragal, bead, and reel – or coats of arms and figures in relief). The frame can be made by more than one crosspiece (probably in relation to the number of "bussole" (squares constituting the height of the lacunar, defining the depth of the coffer). Together with the frames, the panels (single vertical axes) are used, often placed at the corners or supporting the boards of the coffer bottom, inserted where the double anchoring provided by the U-shaped frames is not necessary or possible. Considering the ribs of the coffers – both straight and curved – a regularity in the distribution of the frames emerges, and a center-to-center distance, also in this case, does not exceed one meter in length. However, the center-to-center distance varies with the weight that the uprights are supporting, according to the number of boards composing the lacunar and the decoration applied. Therefore, in the case of a richly decorated ceiling, the spacing is smaller; otherwise, it is larger without carved elements decorated with painted tables or canvases.

The frames, or the individual panels, determine the arrangement of the upper joists. When considering these elements, two factors are crucial, although they do not affect the quality of the ceiling: the spacing of the trusses and a walkable wooden surface above the joists. In case of a short distance between the trusses and the absence of a walkable surface, the joists have a small section (about 6 cm x 6 cm), rough in shape, not squared; moreover, their positioning is due to the need to hang the uprights below. The result is an irregular and uneven arrangement that, in some cases, is not perfectly orthogonal with respect to the tie beams of the trusses (as in Sant'Agnese fuori le mura, 1606) (Fig. 10). Moreover, a more regular arrangement of the joists emerges in trusses with a wide center-to-center distance. However, in both situations, the joists are not nailed to the beams, wrapping them, but just leaning on top. Differently, realizing a walkable surface requires a maximum distance between joists of 50 and 60 cm to nail the planks over them. Therefore, the frames for hanging the ceiling are not directly related to the joists and the insertion of crosspieces – below the beams or at the same height – is necessary to fix the hangers in the intermediate spaces (an example is the coffered ceiling of San Giuseppe dei falegnami (Fig. 11).

Fig. 10. *Ceiling without upper wooden deck with non-uniform arrangement of joists (Rome, Sant'Agnese fuori le mura, extrados of the coffered ceiling, 1606).*

Fig. 11. *Ceiling covered by a walkable floor, made by joists placed on regular distance, to which the U-shaped or L-shaped frames of the ceiling are hung by crossbeams (Rome, Extrados of the ceiling of San Giuseppe dei Falegnami, 1612).*

4. CONCLUSIONS

The study aimed to highlight the importance of the building technique of the coffered ceilings in the churches of Rome. So far, this topic has not been addressed specifically; there is a lack of a detailed illustration of the different structures built and a broad picture of the different construction typologies. Conversely, the studies of ceilings in the field of art are highly developed; studies focus mainly on diffusion – starting from the second half of the 15th century – and on the evolution of forms over time, up to the early 20th century. Furthermore, due to the particular historical and aesthetic value attributed to the coffered ceilings, special attention was paid to the state of conservation: preserving the structure of the coffered panels and the rich decorative and chromatic quality was repeatedly requiring interventions, even of considerable extension, to ensure tightness, prevent collapses (even minimal ones, and with serious risks for people), replace damaged parts, restore surfaces and reliefs [20]. However, during certain restorations, the lack of knowledge on the topic and the scarce consideration of the ancient wooden carpentry above the extrados of the ceilings led to inappropriate interventions, up to the complete replacement of the ancient technological system [21]. The complete replacement consisted of inserting a steel structure, independent from the roof trusses, namely a mesh of IPE beams with metal tie rods fixed to the coffer's wooden boards. An example is the case of the ceiling of the central nave of the Basilica of San Pancrazio where, during the restorations carried out at the beginning of the 2000s, the original hanging system was replaced by a steel one, supported by a framework of IPE beams. This substitution, useful to reinforce the structure, radically changed the overall behavior of the ceiling. In fact, wood – a hygroscopic material – is affected by environmental conditions, shrinking, and swelling due to changes in moisture content. The modification of the structural system – even if limited in size – brings new constraints, resulting in unwanted deformations. Moreover, metallic material leaning against the wood, if not treated or inserted in a way that does not allow proper ventilation of the area, could activate processes of localized biotic degradation [22, 23]. Therefore, a specific understanding of the construction methods of the lacunar ceilings in the churches of Rome, based on the importance attributed to their integral physical authenticity, both intrados, and extrados, emerges. In order to preserve the integral physical authenticity, the maximum effort – based on the historical value of the technique and on the ancient execution modality that could be valid for structural efficiency – should be made. This condition can only be verified by fully understanding the original construction features of the coffered ceilings, their requirements, their effectiveness degree, any constitutive defects, and the conditions of conservation of the materials. In this manner, works aiming at solving static and deterioration problems could be carried out in a controlled and targeted way rather than a radically innovative way.

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