Timber Covering Structures of Churches Built in Naples during Angevin Domination

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ABSTRACT: This research goes trough historical phases of the most ancient churches built during Angevin domination in Naples Kingdom, (thirteenth - fifteenth centuries), and specifically of their covering structures. Between those churches, only St. Mary of Donnaregina and St. Peter from Majella preserve their ancient covering systems, on which a deep study has been done, also tracing the history of the most relevant transformations, partly due to decay, partly due to "remedies" contrasting deformation effects induced by the addition of the ceilings. The efficiency of those interventions has been verified comparing the static analysis on the original schemes with that on the modified ones. The historical research has been extended to the other main Angevin churches in Naples, even if they haven't preserved their ancient timber covering systems, and it has shown that the most widespread covering system was that constituted of simple king post trusses, with slope of about 30°. The only differing one is that of St. Claire church.

THE ANGEVIN ECCLESIAL BUILDING IN NAPLES

The conquest of Naples and of the Kingdom of the two Sicilies by Charles from Anjou, brother of the king of France Luis IX, is connected with the contrast between the Pope and the Emperor's supporters who governed in the Neapolitan Region, Frederic from Swabia first and then his son Manfred. In 1266, after the battle of Benevento and Manfred's death, Charles I came in Naples, receiving a triumphal welcome. The City was assumed as capital of the new kingdom and the ecclesial building, encouraged by Charles, had a great development, giving to Naples a singular aspect for the large amount of churches and monasteries.
The religious fervour of the heirs of Charles I, Charles II (1289-1309) and Robert (1309-1343), was even higher and great was the economical commitment in finishing and new building of churches, even if it produced a large debt with Tuscan bankers. That political approach gave to Naples, the possibility of competition in terms of monumental and artistic richness with Palermo, the town which, when it was the Capital of the Kingdom, the Norman Dynasty enriched with monuments, giving it great prestige in Europe. The Angevin kings supported monastic institutions: Charles II showed great devotion to Dominican Order, also enlarging Inquisition power and setting in the Church of St. Dominic Major the centre of anticlerical action; Robert, instead, was devoted to the Franciscan Order, and allowed the building of their largest temple, the Church of St. Claire.
Following Charles I, artisans, architects and goldsmiths came from Anjou to work to the building embellishment of the town. Between those people there were two famous French masters: Pierre de Chaul and Pierre d'Angicourt, who, in some cases, were responsible of the radical transformation of the existing Romanesque architectures. In the Anjou region, in the south of France, gothic architecture showed remarkable differences from the dominant gothic style of the Ile de France, defining a particular version, named "Plantagenet Gothic" o more simply Angevin Gothic, (Blomme 1998). On the contrary, the covering system above the vaults did not differ substantially from that used in the Ile de France, Fig.1, which was characterized by a drastic reduction of the mutual space between the trusses, with the consequent elimination of the purlins, and the possibility of having the slated roof directly lying above the rafters. This kind of covering system usually showed a large slope, about 60°, to allow the use of the attic while building the masonry vaults.

The influence of the Angevin Gothic on the architecture of the churches built in Naples in this period, noticed by many researchers, can't be seen in the timber covering systems. In fact in Naples the classical typological schemes, already widespread in Italy from the Roman period and still used in building churches in every part of the peninsula, especially in Dominican and Franciscan monasteries, have been employed instead of the French gothic ones.
Amongst the most remarkable churches of this period, the only ones which preserve the ancient timber structures are the churches of St. Mary of Donnaregina, and of St. Peter from Majella. The two medieval churches have a covering structure constituted of king post simple trusses, which originally were visible, as it was usual in monastic churches, before being hidden by ceilings in the Baroque era. On both the timber covering structures an in-depth study has been done, with in situ inspections, as well as archive researches. Those historical analysis have been also extended to the other main Angevin churches, as St. Eligio Major, St. Laurence Major, the Cathedral and St. Claire, even if all those churches haven't preserved the ancient timber covering structures, damaged by earthquakes and wars.

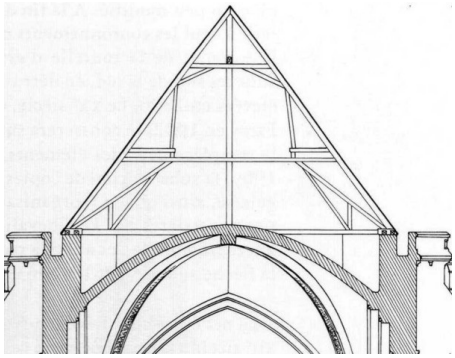

Figure 1: Covering truss of the Cathedral in Angers, capital of Anjou

ST. MARY OF DONNAREGINA

Historical notes

The church and the Clarisse nunnery of Donnaregina were built for the will of Mary from Hungary, wife of Charles II, starting from 1293. The church was finished only in 1316, thanks to the role of supervisor of building works given to Friar Umbertino from Cremona. The medieval church had a single nave, with the covering structure visible, Fig.2, and its originality was due to the solution envisaged for the choir: for the reduced dimensions of the plan, the choir was realized on a mezzanine, covering a portion of the nave, sustained by cross vaults on a double row of octagonal columns, (Chierici 1934).

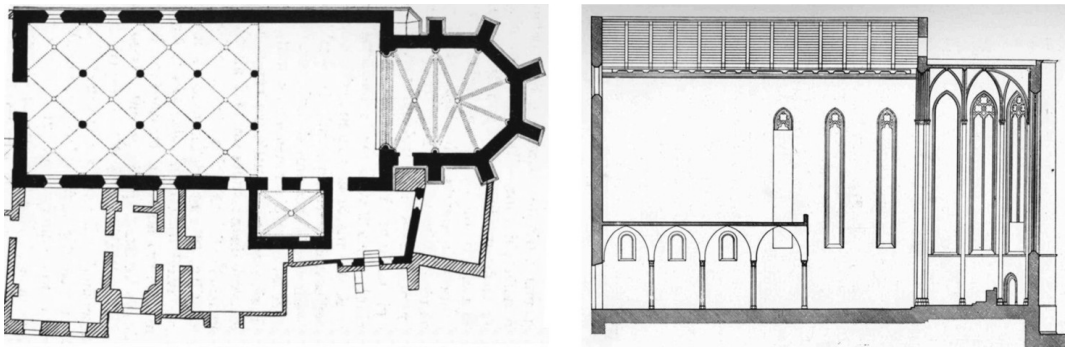

Figure 2: Plan and longitudinal section of the church of St. Mary of Donnaregina after Chierici's restoration

As happened to quite all the Angevin churches in Naples, during the period of Counter-Reformation, the trusses were hidden by a timber ceiling. In fact in the middle of sixteenth century, a timber lacunar ceiling was commissioned to master Peter Belverte from Bergamo; this ceiling, disposed beneath the corbels supporting the trusses, covered the terminal frieze of the thirteenth century frescoes. In 1617, due to the new liturgical necessities, a new church, consecrated in 1669, was built aside the old one. As a consequence, the oldest apse was partially demolished and the mezzanine was extended on the whole nave, and used as a chapel of the new church. The ground floor of the oldest church became a storehouse. The abolition of monastic orders in 1861 and the municipal administration caused large tampering, due to new destinations. In 1928 restoring works began, which finished in 1934, guided by Arch. Chierici, and gave to the church the current look. The most relevant part of Chierici's intervention was the partial rebuilding of the ancient church apse, carrying back the end wall of the new church and reducing the mezzanine floor to the original size.

In the archive documents of the Monuments Office there are notes about works on the covering system in different periods: at the end of sixties the covering mantle was substituted, together with the secondary structure; after the earthquake in 1980, Public Work Superintendence made a complete revision of the timber structures, with substitution of some damaged elements, and metallic tie-rod were disposed, in addition to the timber existing struts, to hang the ceiling to the ancient trusses. In 1996 a more complex project has involved the whole covering system, with the removing of the damaged extremities of rafters and tie-beams, where they lean above the masonry walls.

Description of the covering structure

The existing covering structure is that dating back to the end of fourteenth century and is constituted of twelve silver fir trusses of king post simple kind with timber blocking elements under the connection between inclined struts and rafters. The covering mantle is made of flat and bent tiles, leaning just upon the purlins at a mutual distance of 0.30 m. Trusses clear span is of 12.20 m, with a mutual distance of 2.20 m, and the slope is of about 29°. The lacunar ceiling is hanging from a transversal secondary structure, lying upon the tie-beams of the trusses, by means of timber as well as metallic tie-rods. Before the last restoring intervention in 1996, in all the trusses there were iron elements, testifying a past structural improvement, which had the clear intent of stiffening the structure, probably showing the beginning of yielding in the end connections. To this aim, there were also timber wedges, inserted between the ends of tie-beam and rafters, Figs. 3, 4. In the most recent works, made by the Pouchain firm, those truss extremities which showed a large decay in the connection between tie-beam and rafter, as located in the west side exposed to the moist wind coming from the sea, have been substituted by prosthesis made of resin conglomerate connected by steel threaded rods. To grant stress transferring, steel plates have been disposed on each side of the substituted structural elements.

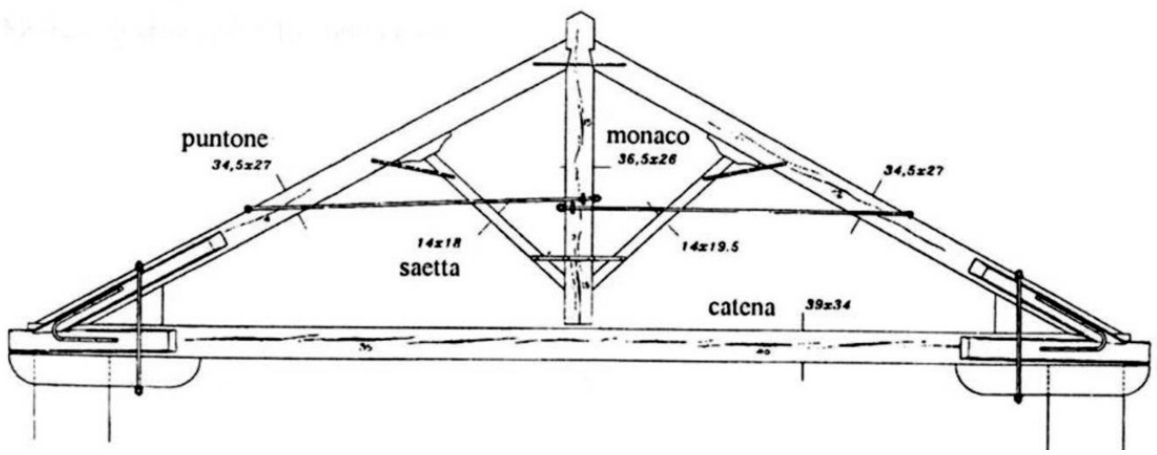

Figure 3: Frontal view of the truss before the last intervention

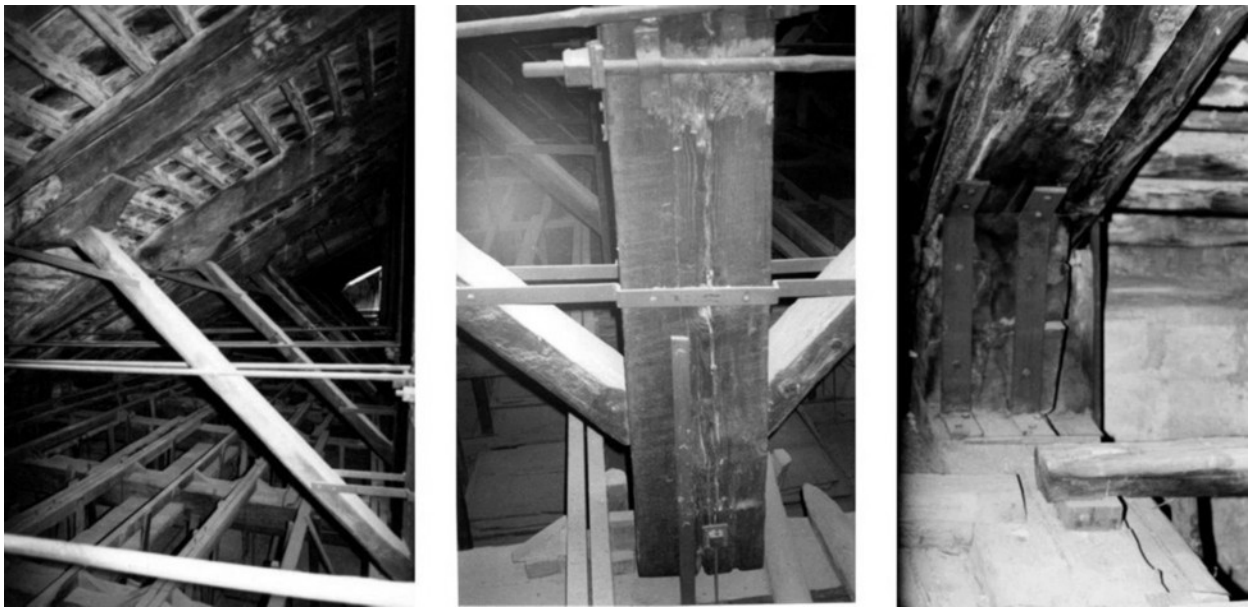

Figure 4: Details of joints

Static behaviour

The drawing of the covering structure at the time of Chierici's restoring design is shown in Fig. 5, in which the simple truss, originally visible, adorned with decorated corbels, as the Florentine examples of the same period, has been modified due to the addition of the ceiling. Timber wedges, fastened by iron strips embracing also the corbels, have been inserted in the connection between tie-beam and rafters, while the king post has been connected to the tie-beam by a metallic tie.

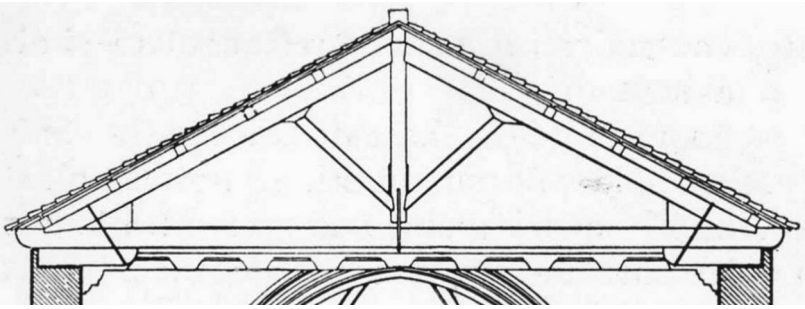

Figure 5: Detail of the cross section

Evaluation of efficiency of those remedies has been done comparing stress distribution in the structural scheme reproducing the situation of Fig. 5 with a theoretical one in which the presence of overloading due to the ceiling has been supposed on the original scheme. So it has been shown, aside the obvious supporting action of connecting tie-beam and king post, the role of the stiffening inserted in the joint between tie-beam and rafters, with the consequent reduction of bending stress in the rafters, Fig. 6.

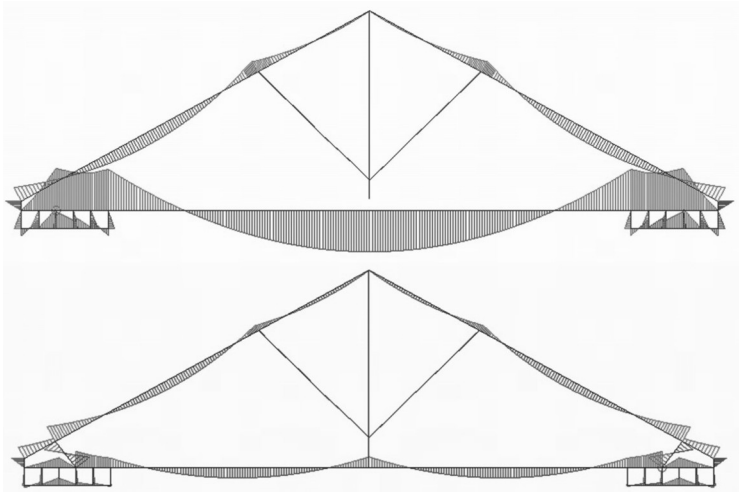

Figure 6: Diagrams of Bending moments in the two different schemes

ST. PETER FROM MAJELLA

Historical notes

The church was built at the beginning of 1300, dedicated to Peter from Morrone, become Pope Celestin V; originally it had the nave and the transept covered by timber trusses visible while the side aisles had rib vaults. Then, between 1493 and 1508, the plan was enlarged carrying ahead the façade and having five lateral chapels on each side, Fig. 7. The building lost its medieval look when, for the will of Abbot Campana, between 1651 and 1667, the timber ceiling with golden mouldings, enriched by the paintings of Mattia Preti, was built. At the same time the windows were remodelled and Baroque stucco decorations were added.
At the end of eighteenth century, eng. Rega made a restoration design which aim was bringing in light the original Angevin look, only preserving the most remarkable signs of the historical stratification, like the ceiling. Restoring works ended in 1933. Relevant repairing works on the timber covering structures were made in 1840, (Filangieri 1884). Examining the rich documentation, it can be inferred that at that time the trusses were still the original ones and the new intervention, aside involving the substitution of the damaged elements, with a large amount of decay, had the target of a global stiffening of the structure, by the insertion of secondary rafters in all the trusses, and also of inclined embracing struts in those of the nave. In the report of arch. Angelini, charged of the restoring design of the covering system, (A. S. N. 1839), its quoted that the nave was covered by fourteen fir trusses, with the ends leaning upon oak corbels, dating back to the first building of the church; the transept, instead, had chestnut trusses, cut with less accuracy, presumably dating back to the sixteenth

century. Angelini proposed a reinforcement made by the insertion of secondary rafters, bolted and locked at their lower end, thanks to indenting cut in the tie-beams, and at the upper end, thanks to inclined struts, also envisaging iron strips to secure both upper and lower joints.
Monuments Office of Naples preserves documents attesting that in 1944 the covering mantle, made of tiles, and timber boards lying on purlins, was substituted by a flat tiles self-bearing floor, still existing. Evidence of other works on the covering structure hasn't been found. So it can be deduced that the existing trusses, showing a simple scheme with king post and inclined struts, and the additions made in eighteenth century, are still the ancient ones.

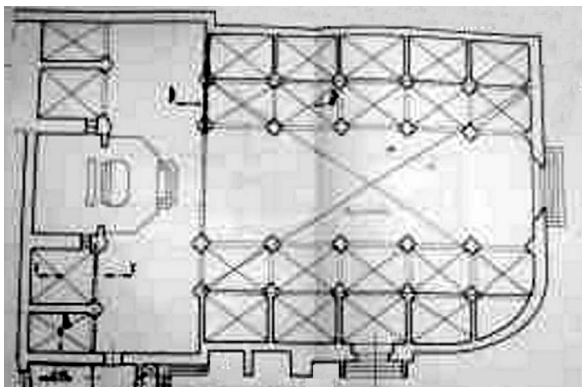

Figure 7: Plan of the church of St. Peter from Majella

Description of the covering structure

The fourteen trusses of the transept cover a clear span of about 8.60 m with a slope of 28°, Fig. 8 left. From direct analysis, it can be noticed that quite all tie-beams are made of two jointed elements, formed with round off angles. Joints are made with tooth indentation, in some case dovetail joint, reinforced by iron strips. Tie-beams are 10.00 m long, which isn't a length difficult to reach, or to supply; so it can be inferred that jointing comes out from the necessity of substituting decayed extremities, and this circumstance is also quoted in archive documents. Connection between tie-beam and principal rafter, as well as that with secondary rafter, is a half-lap joint; principal and secondary rafters are connected by iron strips and nails; the joint between the inclined struts and king post is made with a notch cut about 0.10 m from the end of the timber element.
The fourteen trusses of the nave differ from those of the transept for the clear span, the slope and the larger dimensions of the cross section. In fact the clear span is of about 10.00 m, and the slope is 30°. The tie-beams are about 11.90 m long and are made of two or three elements, with round off angles, dovetail jointed. Timber embracing inclined struts can be seen, stiffening the connection between principal and secondary rafters with the tie-beam. Other double timber elements joint the king post to the tie-beam, Fig. 8 right.

Figure 8:View of the transept (left) and of the nave (right) trusses

Static behaviour

The nave trusses, which in part are still the original ones, have been reinforced in 1840 adding the secondary rafters, the double inclined struts embracing the connection of rafters with tie-beam and the timber elements jointing the king post with the tie-beam. Evaluation of the efficiency of those remedies has been studied comparing stress distribution in the scheme modelling the actual situation, with that in a theoretical one in which the overloading due to the ceiling has been introduced in the original static scheme, Fig. 9. As the dimensions of their cross section are quite small, 0,16x0,10 m, the secondary rafters bear a reduced amount of stress, but their opposing action to the flexural deformation of the principal rafters is quite noticeable, and so is also the stiffening action of the double inclined struts jointed to the rafter and the tie –beam.

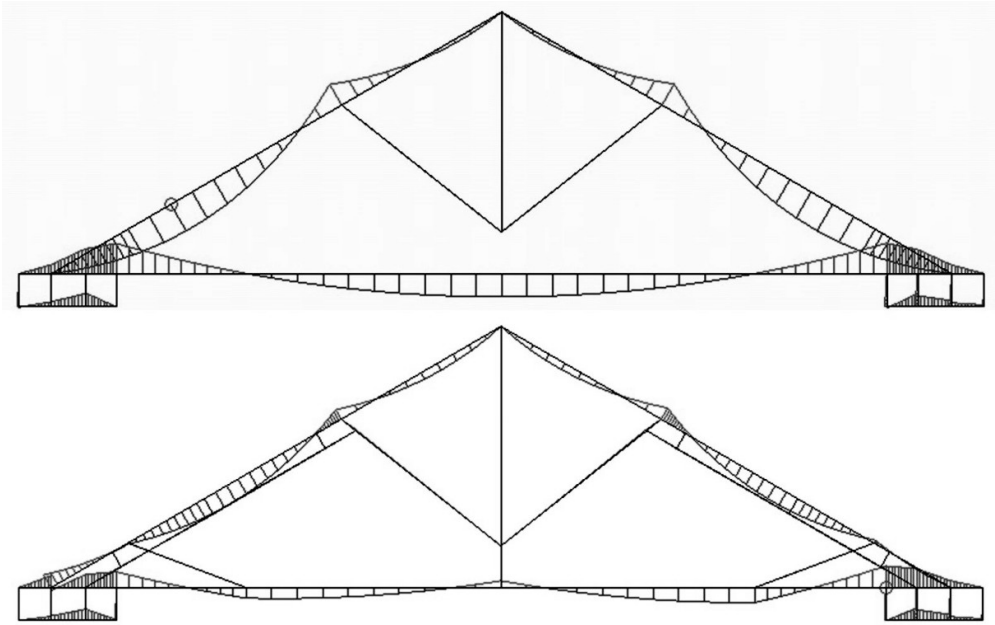

Figure 9: Diagrams of Bending moments in the two different schemes

THE OTHERS ANGEVIN CHURCES IN NAPLES

St. Eligio Major

The church of St. Eligio Major was built during the rein of Charles I. The building, whose original design have probably to be ascribed to one of the French architect come with the retinue of the king, originally had a three aisles plan, with transept and a tripartite choir. The central nave and the transept were covered by timber trusses visible, while the side aisles had rib vaults. The polygonal apse and the choir were built only in 1360. The French design will be left apart during the construction, as will be the case of the church of St. Laurence too, coeval of St. Eligio, (Venditti 1969). In 1490, the nave trusses were hidden by a lacunar ceiling, designed by Giovanni from Majano. At the beginning of the sixteenth century dates the adding of a fourth side aisle. In 1836 the church underwent large restoring works, designed by the architect Angelini, which involved a complete obliteration of any trace of the original shape and decoration. In March 1943, the building was quite destroyed by air bombing, and only at the end of eighties it has been fully restored by the Monument Office of Naples. In this restoration, the ancient gothic shapes have been brought to light, Fig. 10, and a new covering system has been constructed, with timber trusses of about 8.00 m of clear span and slope of about 31°, reproducing the simple king post scheme, supposed to be the original one.

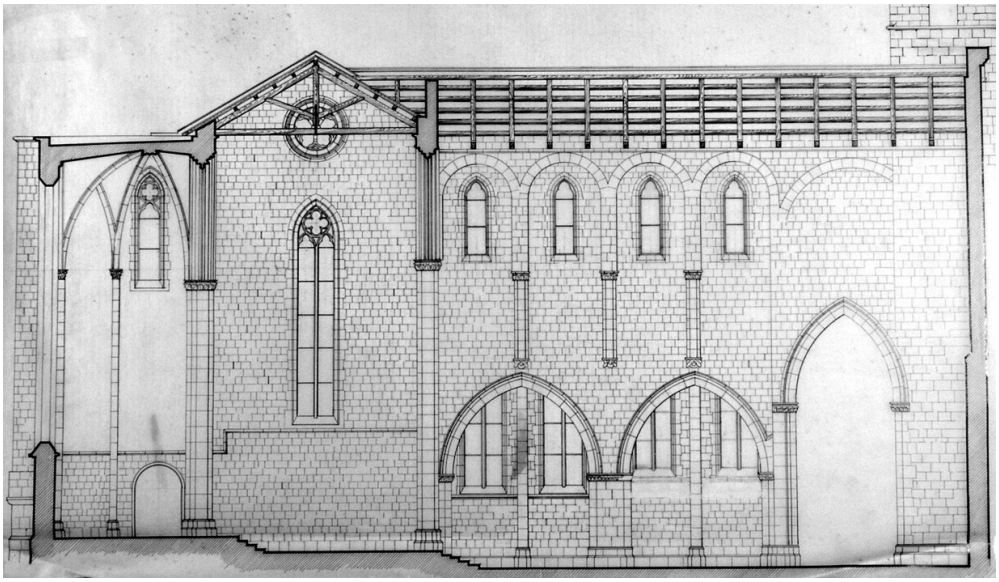

Figure 10: Longitudinal section of the church of ST. Eligio Major

St. Laurence Major

The building of the church began in the first years of the reign of Charles I, in the place of a previous existing early-Christian basilica, but was finished only during the reign of Robert, in the first half of the fourteenth century. Venditti wrote "In the case of St. Laurence, we are in presence of a work extremely significant of the ideological contrast, detectable in the formal choices, between the northern French architects, devoted to a completely structuralist architecture, that of the choir, and the southern masters, who worked in the transept and in the nave" (Venditti 1969). In fact, Fig. 11left, while the choir develops like the most common French gothic system, with rib cross vaults on ogive arches, poly-style pilasters, flying buttress, the large nave, built in the reign of Charles II, is designed as an hall covered by timber trusses visible, with a span of about 10.00 m. Between 1635 and 1670, the building, which was largely damaged and in decay, was completely transformed; it took a Baroque look, with also the adding of a lacunar ceiling. In 1926, the chief of the Monument Office, Arch. Chierici, started radical restoring works, with the aim of recovering the original gothic look, distorted by the subsequent events. After the Second World War, difficult consolidating works were made, removing all the Baroque additions. Those intervention involved building of a structure made of reinforced concrete frames, incorporated into the ancient masonry walls, and connected, at the top, by reinforced concrete trusses, painted as false timber.

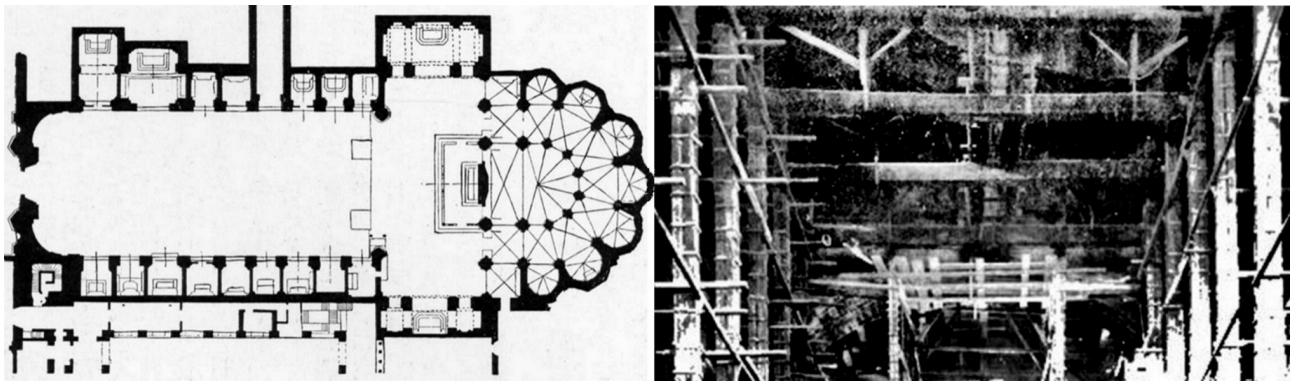

Figure 11: Plan of St. Laurence (left)and view of the seventeenth century trusses before demolition (right)

Relating to the covering structures, the historian Filangieri, (Filangieri 1883) quotes a document about the convent dormitory, coming from the papers of a notary, C. Malfitano, in which is written that the dormitory trusses ought to be built as those of the church, that is with a simple king post scheme, and also that the original church trusses have been left working until the second half of the seventeenth century. So it can be inferred that the Palladian composite scheme trusses, come in sight when the ceiling was removed to make the reinforced concrete trusses, Fig. 11 right, were built when the ceiling was realized, in substitution of the ancient king post ones. The actual pre-stressed reinforced concrete trusses reproduce the scheme of those of the seventeenth century.

The Cathedral

The Cathedral was built in1294 by will of Charles II, where there were already the church of the Saviour dating back to the sixth century, completely demolished, and the Constantine Basilica, after church of St. Restituta, which was deprived of two of its original five aisles. The plan of the Cathedral shows three aisles, a transept and a polygonal apse. During the centuries the Cathedral went through many restorations, as after the earthquake of 1456. In the first years of seventeenth century, Cardinal Carafa gave great impulse to the transformation of the building, contributing in giving a new Baroque look to the Cathedral. So in 1621 the covering structures of central nave and transept, which were made of timber trusses visible, were hidden by a wonderful timber ceiling. Large damages were produced by the earthquakes of 1688 and 1732, so that, starting from 1735, Cardinal Spinelli had to begin a large restoring of the Cathedral. Still an earthquake, in 1805, made necessary new interventions, which involved also the repairing of the covering structures. In the first half of eighteenth century, the Cathedral was newly restored following the rules of stylish restoring approach, taking a false gothic-like look. Even the facade, never built before, was constructed in neo-gothic shapes at the beginning of nineteenth century. The last restoring works took place between 1969 and 1972, giving to the Cathedral the actual look, and involving the complete substitution of the ancient covering structure, (Di Stefano 1975). The documents concerning this intervention testify that the original timber trusses showed a simple king post scheme, as in the others Angevin churches, but with a larger clear span, about 17.00 m, and a slope of 28°. The ceiling was suspended to the tie-beams by means of timber struts.
The new steel structures are characterized by the separation of the covering function from that of supporting the ceiling: the first is assigned to steel grid trusses, while the second is accomplished by steel grid beams, made independent from the trusses, and disposed in an alternate way, to which the ceiling is hung by brass rods with turnbuckles, Fig. 12.

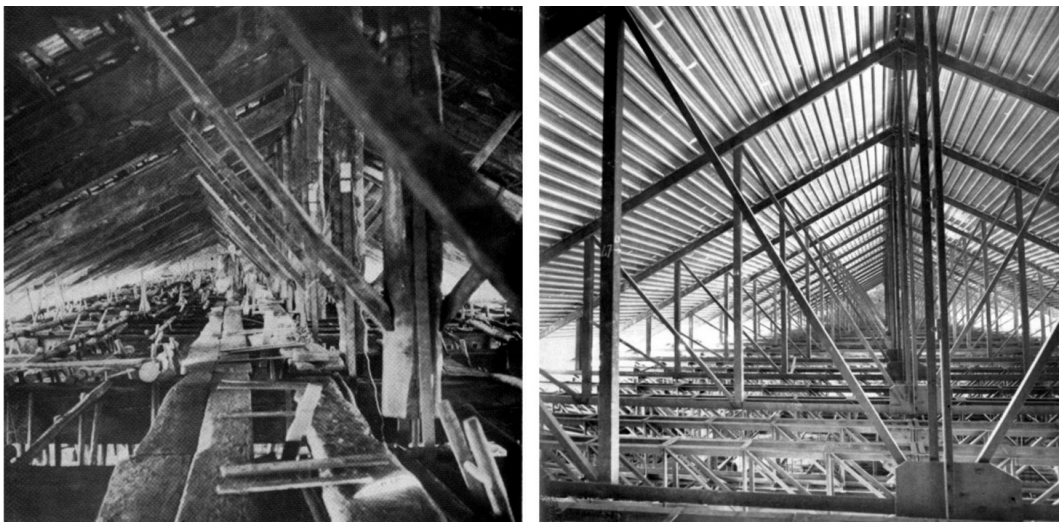

Figure 12: Cathedral covering structures before (left) and after (right) restoration of '70

St. Claire

The church of St. Claire, which first stone was laid in 1310, seems to have been already finished in 1330, but was consecrated only in 1340. It was built by will of king Robert and his wife Sancia, by the Neapolitan architects Gagliardo Primario and Leonardo di Vito. The building is constituted of a single nave with timber trusses visible and nine side chapels without transept. In 1744 the nuns commissioned the design of a global transformation to adequate the church to the coeval dominant style, which together with ornamental stuccos envisaged a false vault ceiling. The art historian Mormone, (Mormone 1959) quotes the description of the design of the false vault made by Domenico Vaccaro and Gaetano Buonocore: the two engineers took the trouble of checking the conservation conditions of the trusses before hanging to them, at a distance of about 0.40 m, the false vault, made of timber centrings, canes and stuccos. During the Second World War, an air bombing in 1943 caused a devastating fire which besides destroying all the Baroque apparatus, so uncovering the original gothic structure, also burned the whole timber covering system. The reconstruction design envisaged the restitution of the gothic original shape and consequently the reproducing of the visible trusses with the original scheme of the timber medieval ones: this layout was made of rafters, tie-beam, side posts, constituted of double elements, and a collar beam, made of a single element. The clear span is about 29.00 m and the slope is about 37°. As finding proper timber elements was difficult, the new trusses were built in reinforced concrete following the original scheme, Fig. 13. The relieves of the trusses, made in 1920 by arch. A. De Rinaldis and in 1926 by arch. M. Zampino for the Monument Office, allow to compare the measurements taken on the existing timber elements with those of the timber orders quoted in the Angevin registers. This comparison proves that even after the Baroque transformation, the trusses were still the medieval ones. In fact, in his report De Rinaldis describes a system constituted by trusses made of coupled elements, with tie-beams of length 29,00 m and cross section 0.46x0.60 m, and underlines that the timber elements of the main structure as well as those of the secondary one were accurately worked. In 1320 and in 1326, as quoted in the Angevin registers, (Tomaso; Gallino 1963), there were large orders of squared fir timber beams which ought to be employed for the church roof. In 1336, another order of timber for the same roof, (Dell'Aja 1980), still concerned square timbers for making the single collar-beams and the doubled rafters and posts. Gallino also makes reference to a document dated 1726 from which it can be inferred that at the beginning of the eighteenth century, the covering structure was still the original gothic one.

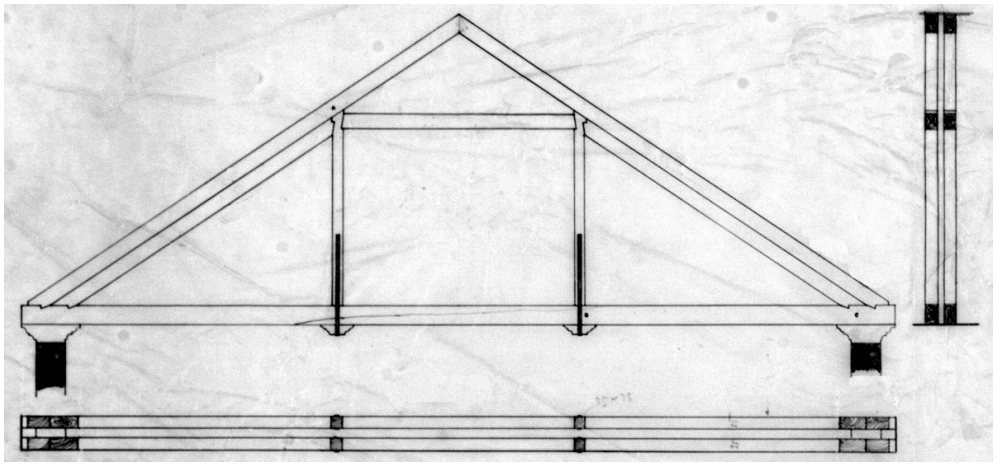

Figure 13: Scheme of the trusses of St. Claire church

CONCLUSIONS

The analysis of the most ancient and relevant churches built in Naples during the Angevin domination testifies the almost exclusive employment of a covering typology with simple king post trusses, left visible. None of the French gothic characteristics has been noticed in the studied trusses. This is not strange as in the same period in Italy a peculiar kind of gothic architecture was developing: the imported gothic style was affected by the influence of the Romanesque style, deep-rooted in the peninsula, and of the architecture of Franciscan, as well as Dominican Orders, which were the most active propagators of the gothic style in Italian regions. The typical covering system employed in the churches was constituted of classical trusses, simple king post scheme, left visible, which local masters were able to built without problems, thanks to a consolidated building tradition. Only the scheme of the St. Claire church trusses differs, certainly due to the larger clear span to be covered. Those trusses show great resemblance with those of the early-Christian church of St. Paul outside the walls in Rome where, in the fifth century a.C., on a clear span of 24.50 m, was built a system of trusses made of double elements, enclosing single king post and collar beam. The study of the two existing structures, those of St. Mary of Donnaregina and St. Peter from Majella, has evidenced the over-dimensioning of the original structures, for the actual dimensioning methods, as usual for ancient timber structures. Obviously when the overload on the tie-beam, due to the ceiling, is taken into account, the need of the connection between tie-beam and king post can be noticed. The different stiffening remedies of the joint between tie-beam and rafter, timber wedge fastened by metallic strips in the trusses of Donnaregina, embracing inclined struts in those of St. Peter, are intervention techniques quite widespread in the traditional building practice, whose efficiency is once again testified by the static analysis made here.

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