From static history to restoration issues: The Gesù Nuovo church in Naples (Italy)

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ABSTRACT: The Gesù Nuovo church – the seat of the Society of Jesus in the capital of the Spanish viceroyalty – presents the opportunity for a significant case-study related to the connections existing between static history and present problems in the structural field. Archival documentation allows the reconstruction of the various hypotheses being made, starting from the 17th century, in relation to the stability of the building. The research highlights a historical structural “weakness”, referring, in particular, to one of the pillars in the crossing and to the arches weighing onto it. Making a close study of the interpretations, given from the 18th century, by royal engineers until recent years, the study aims at correlating the hypotheses expressed in the past with the present structural conditions of the church. The “historical” issue of the cross damages is studied carefully in the conclusions in order to emphasize the necessity of a well-considered integration between the analysis of present conditions and a complex system of multidisciplinary skills, aiming at a full comprehension of the causes of architecture instability.

1 INTRODUCTION

1.1 Ancient and new structural interventions in the Gesù Nuovo church

One of the restorer’s main tasks is to make a close investigation of the various phases of a building’s construction and transformation. The knowledge of all the previous consolidation or “embellishment” interventions, permits the planning of a restoration project as compatible as possible with the conservation of an artefact.

This research has been carried out on a monument of considerable importance, the Gesù Nuovo church in Naples. It aims not only at illustrating its history but also at assessing the damage, caused by operations conducted during the past centuries, to which, in different ways and using the technological skills of the various ages, there has been an attempt to find a remedy.

Even in this specific case the research has confirmed the conviction that each building’s consolidation is absolutely not separate from the more complex operation of restoration. This operation is based on historical knowledge and uses all possible technical investigations to reach a correct diagnosis of the building damage and to preserve, as much as possible, the material with which it is constructed. Moreover, considering the static model as a testimony of a civilization and a historical document, any project must be based on a precise understanding of it.

The local Soprintendenza [regional board of the Ministry of cultural and environmental heritage] recently restored the four pillars, the tambour and the arches of the church’s crossing. It is interesting to notice that, over the centuries, crushes and damages have been interpreted using the best technicians of each age. The first dome’s double calotte collapsed after the 1688 earthquake and afterwards some hypotheses were made about the characteristics of the crush. The dome was then rebuilt with the plan of the architect Arcangelo Guglielmelli with its weight discharging onto the four 16th century pillars under the tambour. In particular, the first pillar on the left showed, over the centuries, serious symptoms of instability. Also on this occasion, the specialists, who were the most qualified in each period, were engaged in a debate about the causes of the damage.

Luigi Vanvitelli, leading the debate, hypothesized that the cause of the damage to the left pillar and of the complex cracking pattern of the church’s crossing was due to the hurried repair of building damage after the 1688 earthquake.

In conclusion, during the 18th century, two technical fronts were formed: one believed that damage was due to the weight of Guglielmelli’s dome, the others that they were due to the covering pressure on the vertical walls.

The remedy consisted in the replacement of the masonry dome with a light lathwork vault supported by wooden trusses. Nevertheless, considering the issue
with a view that ignores the historical perspective, if such a drastic solution, implying the destruction of a significant constructive element of the monument, is to be censured, the subsequent substitution can be judged much more seriously. In 1973, the Genio Civile (Ministry of Public Works) replaced the light lathwork vault with a reinforced concrete one, weighing on the masonry structures below.

In the period after World War II the use of reinforced concrete became more and more frequent, especially in structures that were disguised; this happened in the Gesù Nuovo church where the inside of the concrete cap had been coated with stucco. Nevertheless, in this case, with great probability, the remedy has been the cause of further disruptions for which, in recent years, there has been an attempt to find a solution. Fortunately, today the instruments allow technicians to make diagnoses, which are also supported by numerical calculations, that are much more precise than in the past; still, as in this case, the attention and sensitivity of the restorers must ensure that the proposed solutions do not involve any more drastic substitution of parts. The solutions should instead imply operations for structural improvement with the addition of elements which are compatible with the ancient structures.

2 THE BUILDING OVER TIME.
CONSTRUCTION AND RESTORATIONS BETWEEN THE 16TH AND 18TH CENTURIES

2.1 The building site and the pre-existing structures

The study of events of the construction of the Gesù Nuovo church provides significant grounds for reflection referred to multiple topics which are related to the construction and to the transformation of architecture since the 16th century. The analysis of historical sources suggests an articulated combination of interpretations of damage and, consequently, of methods of consolidation proposed during past centuries. At the same time, the examination of the planning choices which have been adopted in the substitution of parts – the dome in the crossing, particularly – highlights how the integration of lacking parts has been developed during each historical phase with a sincere expression of the contemporary “state of technique” and the culture of planning.

Since its establishment, the church of the seat of the Society of Jesus in the capital of the Spanish vicereign was planned in correspondence with the pre-existing architecture of the 15th century palace of the prince of Sanseverino (De Frede 2000).

External facades were re-used in Giuseppe Valeriano’s project along three sides of the building for economic reasons and, moreover, for the recognition of its urban significance and role. The vertical perimetric structures of the palace were preserved and underfounded (Pirri 1970, p. 116, p. 121, note 58) while the excavation of the four crossing pillars started in 1584, probably with the center of the crossing planned in correspondence to the palace courtyard (Schinosi 1706–1711, lib. V, cap. VI, p. 464).

The reconstruction of the building phases is facilitated by information given by the Jesuit chronicler Giovan Francesco Araldo at the end of the 16th century (Divenuto 1998), together with historical data provided by documentary sources preserved in the Jesuit archive in Rome (Pirri 1970; Bösel 1985, vol. I, pp. 416–419). Through Araldo’s narration it is possible to understand that the foundations of the four pillars were realised between November 1584 and March 1585, reaching the “monte, et ferma pietra”, that is the tuff in the subsoil (Divenuto 1998, p. 238). Reading the Jesuit chronicler, we learn that the four pillars on which the dome had to be placed were built in only three months, from March to June 1585 (Divenuto 1998, p. 240 and p. 243), covering their tuff basement with piperno blocks. An interruption of approximately ten years in the building of the church followed the establishment of the pillars so that the construction was started again only in 1594 with work in the tribune and in its side chapels (Divenuto 1998, p. 372); construction times slowed down again in 1596 because a serious blaze burned in the church and because of the death of Valeriano in July. The construction of the crossing was started again only when the tribune was completed. The erection of the four arches discharging on the pillars – built about ten years before – and, finally, of the bottom ledge of the tambour concluded this building phase.

The church of Gesù Nuovo was inaugurated in October 1601 (Errichetti 1963, p. 183, note 2) without its central dome: about thirty years passed from the inauguration to the beginning of the construction of the Jesuit dome in 1629 (Errichetti 1963, p. 177).

2.2 The domes of the Gesù Nuovo church in the seventeenth century

Although it is scarce, useful information about the construction of the dome can be deduced from the seventeenth century cartography and, moreover, from the description of the structure and of its dimensions given by the Neapolitan guide Carlo Celano in 1692. The first dome of the Gesù Nuovo church had a tambour that was marked externally with buttresses with volutes (Figs 1 and 2). Two calotteos weighed on the tambour and they were separated by an interspace about seven metres high in correspondence with their keystone; in addition, a staircase leading to the lantern on top was constructed between the two vaults (Celano 1692, p. 44). The lantern, consisting of a cylinder of masonry surrounded by eight grey tuff columns,
balustrades and vessels, produced a significant weight on the lower calottoes; as we learn from Celano, the lantern was the first element to crack shortly after its completion so that it required the replacement of a stone column with a brick one.

According to the above mentioned seventeenth century author, this intervention caused a “weak point” which was at the origin of the collapse of the Jesuit double dome, which occurred during the earthquake of 1688. Therefore, such a hypothesis, empirically tending to highlight the role played by the lantern in the collapse of the dome, had already been advanced in an “official report of damages” produced approximately one month after the earthquake; in fact, this document stressed that “the dome fell beginning to crumble from the lantern”, striking in its collapse the lateral chapels of the transept (Cantabene 2004, p. 177). Through reference to the documentary sources, it is possible to suppose that the seismic tremors caused the loss of the two vaults and that of the lantern, while they spared the seventeenth century tambour which remained largely in place. This fact is confirmed by the description of the dynamics of the collapse provided by the Neapolitan architect Giuseppe Lucchese in 1708; this technician, engaged in the analysis of crackings of the double dome of the Treasury of St. Gennaro Chapel in the cathedral of Naples in the same year (Russo 2007), refused any hypothesis of a fall “on perpendicolo” of the Gesù Nuovo dome as had been advanced by contemporary “mathematicians”; on the contrary, he emphasised the rotation suffered by the vaulted parts and by the lantern towards the west transept side. As the report of Lucchese makes clear, the four arches, the pendentives and the tambour remained “firm and intact” (ATSG, A/22, foll. 66v–67); a circumstance that would not have arisen, according to Lucchese, in case of a collapse only in a vertical direction.

The Jesuits attended to the repair of the tambour, to the construction of the transept left vault again and to closing the crackings with lime and bricks in only six months (Errichetti 1963, p. 177). Thereafter, the collapsed parts were rebuilt following the plan of the Neapolitan architect Arcangelo Guglielmelli between 1692 and 1693 (Amirante 1990, p. 247 and p. 334). As a drawing of 1769 clarifies (Sasso 1856, tav. 13; Errichetti 1963, p. 178) (Fig. 3), a single vault concluded by a smaller lantern was built in order to replace the complex double dome of the beginning of the century (Fig. 4); its weight loaded, of course, on the pillars and arches dating, as said before, back to the end of the sixteenth century.

2.3 From the interpretation of structural damage to planning choices. Debate and construction in the eighteenth century

Just over sixty years after the rebuilding of the vault and of its lantern, the dome by Guglielmelli and, in particular, the first pillar on the left required the attention of Jesuits because of a worrying cracking pattern. A monitoring of this pillar was undertaken in 1767 using “swallow tails of marble” (Carrafiello 1995, p. 358) in correspondence with the above-mentioned pillar; at the same time, a first consultation with the royal architect Luigi Vanvitelli was carried out in order to have suggestions about appropriate remedies (Di Stefano 1973, p. 232).

The expulsion of the Jesuits from the Kingdom of Naples, which occurred in the same year, and the subsequent settlement of Reformed Franciscans in the church caused an interruption in the control of progression of the crackings and in Vanvitelli’s task. Only from 1769 onward did the attention of engineers and religious focus again on the conditions of the building as the survey of 1769 by the architect Giuseppe Mauro demonstrates (Fig. 3). Beginning from 1769 the most accredited Parthenopean technicians of the second half of the eighteenth century were involved in the issues of the church. Among these, in particular, a decisive role was played in the choices by Ferdinando Fuga, who replaced Vanvitelli as the trusted technician of the Franciscans. Considering “azzardosissima” the solution of the rebuilding only the cracked pillar,
Fuga proposed in 1769 a thickening of the structures of the four pillars in the crossing, of the upper arches and, in addition, of the remaining pillars and arches of the church resorting to “sottarchi” and “contropiastri” (Errichetti 1963, pp. 178–179). This proposal would have greatly expanded the resistant sections of the construction but, at the same time, it would have altered its space and the perception of the chapels and the tribune as provided for in the design of Valeriano.

The contradiction between eurythmia and the reasoning behind firmitas led, therefore, the Franciscans and the Royal Secretariat to require the formation of a team of experts in order to solve the problem; a committee composed of the Neapolitan professional intelligentsia, with Fuga himself, and with Mario Gioffredo, Giuseppe Pollio, Giuseppe Astarita, Pasquale Monzo, Lorenzo Iaccarino, Felice Bottiglieri and Berardo Galiani, was formed in November 1769 in order to understand the causes and to propose a solution to the structural problems of the church (Errichetti 1963, pp. 178–179). During 1770 and the first half of next year, therefore, two “schools of thought” were gradually emerging through the direct examination of the conditions of the building; the first one can be considered much more “interventionist”, while the other one was characterised by a more conservative approach. As we have seen, Fuga may be considered the exponent of the first approach, so that he would even propose the demolition of the aisles of the church, justified by economic reasons, in the following years (Errichetti 1963, p 181).

With respect to the issue, the royal architect Mario Gioffredo, planner and director of the construction of the complex dome of the Spirito Santo in the same years, would stand definitely on a more moderate front. Opposing Fuga’s ideas, he supported the hypothesis of the recourse to only a partial substitution of the damaged pillar, avoiding more invasive interventions in this way. The position of Gioffredo coincided, with the appropriate distinctions, with the interpretations – in opposition to Fuga, as well – made by a young member of the technical Neapolitan class, Vincenzo Lamberti and, equally, by Berardo Galiani, author of the commented translation of Vitruvius De Architectura in 1758. The first, a young engineer who published the Voltimetria retta in 1773, ascribed the damage of the pillar and the dome to the actions of underground waters; he hypothesized an underpinning with arches near to the left pillar and a consolidation of the pillar with iron plates (Di Stefano 1973, p. 233). Lamberti,
exponent of an emerging “theory of vaults” in the Neapolitan context, showed himself to be significantly abreast of studies conducted in other parts of Europe in the report he presented on that occasion (Guerra 1967, pp. 392–393); this, in particular, was in relation to the equilibrium of vaults and arches, as the quotations from de la Hire and Belidor demonstrate. This theoretical and cultural background was not enough, however, to avoid the answer, articulate and pragmatic, that Luigi Vanvitelli presented to the Secretariat of the Royal House in 1772 (Di Stefano 1973, pp. 233–234): sharing the idea of intervention of Ferdinando Fuga and removing the issue from “mathematical” interpretations, Vanvitelli brought the problem of the Gesù Nuovo church back to the direct examination of the phenomena. The architect attributed the main causes of the pillar’s cracking and the causes of the damage still underway to the seismic tremors and to the excessive speed of past “restorations”.

The position taken on the issue by Galiani seems equally interesting: a meditated approach to the constructive and dimensional characteristics of the building emerges from the report submitted by him in 1774, especially when the technician highlighted the existence of planning “repentances” in correspondence to the cross. He reported, in particular, the existence of a system of brick arches that had been constructed higher than the four tuff arches and connected with them through masonry plugs of poor quality. Galiani, like Lamberti and Gioffredo, excluded the possibility of an excessive load transmitted from the top dome on the four pillars and he rather attributed the damage to the thrusts of coverage structures on vertical walls (Carrafiello 1995, pp. 355–373). Despite the above described opposing positions, the majority of technicians involved in the question ended up attributing the damage underway to the excessive weight of the dome of Guglielmelli and to the poor quality of the construction; so, the demolition of the tambour and the higher vault was proposed in 1774. Started only in 1786, the intervention was carried out under the direction of the royal engineer Ignazio Di Nardo and it involved the replacing of the seventeenth century structures with a lighter “incannucciata” bowl (Fig. 5), sustained by a system of upper wooden beams (Errichetti 1963, pp. 181–183).

Di Nardo’s intervention concluded, so, a significant phase in the history of the church’s domes, characterized by the progressive reduction of covering masses and, consequently, of weights.

3 THE FOURTH DOME OF THE CHURCH

3.1 Damages and interventions of consolidation

The Gesù Nuovo “dome” that today dominates the crossing of the church is the result of a substitution made in 1973 by the Ministry of Public Works, through its local office of Genio Civile (Fig. 6). The intervention was carried out to remedy the progressive deterioration, aggravated by the effects of the 1961 earthquake, of the 18th century fake lathing vault (Iapelli F.S.I. 1993). At a closer look the present dome, covered with decorative stuccoes in late-baroque taste, is a plate of reinforced concrete leaning on a circular masonry tambour whose base is inscribed in a square.
As an application of the widespread theories of that moment on the use of reinforced concrete shells, the “camouflage” solution adopted by the Genio Civile complied with both structural and formal requirements. There was a foretaste of this choice in the postwar institutional culture that looked favourably on solutions that recompose architectural elements of buildings highly compromised by war damage, – with particular regard to the replacement of wooden roofing – making use of the innovative technology of suitably disguised reinforced concrete.

In a 1949 letter the Soprintendente of Campania Monuments, Antonino Rusconi, informing the Jesuit rector of the church about the conditions of the wooden truss above the dome, calls for a review of the structure of the cover and also, for a replacement of the lathing vault with a masonry or reinforced concrete one (ASBANa, Gesù Nuovo 8/158, draft n. 5846 of the 9/12/1949). Therefore, concern about the condition of the dome is closely connected, as early as the first post-war period, to the conditions of the wooden trusses of the coverage.

At the same time, symptoms of masonry crushing begin to cause worry when Rusconi brought to the attention of the authorities to the fact that, in the accumulated delay in the repair of the war damages, the pillars of the crossing were showing a phenomenon of expulsion of marble coatings (ASBANa, 8/158, letter of 21/06/1952). The Genio Civile officer in his turn (ing. L. Persico) highlighted the necessity to uncover the pillars and, over all, to proceed to the restoration of the dome to its former condition. This “ripristino” was truly urgent, given the detachments of large plaster and stucco pieces from the present dome’s structure, which was detrimental to the public safety, and given also the progressive degradation of the wooden truss.

Although the cover replacement in 1973 has clearly increased the heaviness on the walls, in the light of recent investigations regarding the structure, which are discussed below, it has been observed that, during the earthquake of 1980, the concrete cover played a joint function of the masonry structures in response to the pressures of the undulatory waves (ASBANa, Report of ing. Ettore Minervini, 20/09/1999).

In 1987, the condition of the rotting beams and of the secondary frame of the roof above the crossing suggested the replacement of the wooden roof with a reinforced concrete one. Concrete slide walls, 25 cm thick, are projected above the cover to provide the connection between all the longitudinal stringcourse attaching at the roof’s impost. The walls are configured at the intrados according to the shape of the vault that covers the crossing and at the extrados according to the pitched roof. These walls lean on a re infomed concrete stringcourse whose section was to be, according to the plan, 130 cm × 80 cm (ASBANa, Gesù Nuovo 8/158 project). The weight reached by the new structure
(ASBANa Report No. 103 of 20/5/1998) admitted the urgency of a plan of investigations aimed at understanding the overall structural situation of the church with particular reference to the elements that showed signs of instability: the four pillars of the crossing, the dome’s pendentives and the tambour.

These surveys, consisting in horizontal and inclined logging, endoscopic investigations, non-destructive investigations on the walls using flatjacks, topographical surveys with electromagnetic waves for the spatial measurement of cracks and empty spaces, with the return of data collected using surface georadar (GRP), showed that the four pillars, despite a constructive symmetry between them, were characterized by a remarkable diversity of the composition of walls and by a lack of continuity, with special anomalies found in the south west pillar (ASBANa, Georadar report Tecnoin srl). Along with these investigations the engineer Ettore Minervini, entrusted by the local Soprintendenza, performing the necessary calculations on the structures of the crossing, determined the tensions of medium compression to which pillars are subjected:

- Total weight of the structure weighing on the four pillars: 13,398 t;
- Media-resistant surface of the pillars: A. tot $4 \times 4 \times 4 \text{mt} = 64$ square meters;
- Pressure-average = 20.9 kg/cm$^2$. (ASBANa, ing. E. Minervini report s.d.)

Combining the diagnostic results with structural calculations, engineer Minervini pointed out that the pillars, though endowed with a certain wall thickness, had a resistant surface reduced only to the outer layer of masonry, an outer peel of “tufo-pipernoide” (tuff-piperno), 50 cm thick; while the inner core of masonry bag showed a low degree of cohesion. The intervention, aimed at stemming an obvious crushing phenomenon that was underway, had become, at the end of the twentieth century, urgent.

The occasion of a project for a pedestrian crossing below the church provided the opportunity to investigate the church underground. The results of surveys conducted by the Soprintendenza were reassuring about the compactness of foundational structures and allowed the exclusion, as a concurring cause, of any possible sinking of the foundations (ASBANa, 29/09/2003 Geognostic investigations, Tecnoin srl).

The solution reached by the Soprintendenza’s technicians aimed to pursue a widespread consolidation of the building, which is now historicized as a mixed structure of masonry and concrete, at the same time improving the masonry response to the weight that the enormous coverage of the dome exercises on elevated walls. A system – of which ample use was made in other parts of the structure affected by crushing – of armed injections with mortars injected at low pressure was used in the four pillars of the crossing. The question, also raised at the ministerial level (arch. R. di Paola) of whether these injections could have the effect of burdening the nucleus of the pilaster rather than consolidating it and risking an increase in stress compression, has conducted to the use of very fluid mortars compatible with the masonry materials, also able to exclude chemical reactions with the salts present in masonry themselves and avoid harmful reactions to the marble cladding (ASBANa, 20/05/1998, Report n. 103). This first intensive work on the pillars was followed by operations aimed at consolidating the trabeation above the St. Ignatius chapel, above the nave on the side of the Moscati chapel and the tambour under the “dome” (ASBANa report n. 93, 26/05/1999). During the execution of these operations, signs of crushing have been noticed at the keys of the arches of the transept, of the aisle, of the apse together with any other secondary arches. In addition, the lower edge of the tambour, once perfectly horizontal, was now like a wavy line with the lowest points on the keys of these arches (ASBANa Report n. 38 3/4/2000). Therefore, in the further static intervention of consolidation, on the basis of what has already been done on the pillars, executive priority has been given to saturation of cracks as a preparatory operation.

3.2 The conservation of existing constructive systems between innovation and tradition

Currently, the work of the Soprintendenza is focusing on the saturation of cracks that span the entire vault on the main aisle. In this case the operation has been preceded by a consolidation of the wooden roof (ASBANa Report n. 109, 14/06/1995) which shows how, in recent years, the attitude is to prioritize the permanence of traditional structural systems through consolidation. This aims at the preservation of the role of structural components of the architectural building.

It is worthwhile to point out that the intervention carried out on the coverage correspondent to the choir also goes in the direction of the conservation of pre-existing constructive systems. The constructive system produced up to now, while showing clear signs of a worrying history of damage, is material proof of a local building tradition that is also rich in historical significance. The planned coverage is made up of a sequence of parallel walls shaped according to the trend of the pithed roof. Each septum is composed of a masonry arch that is slender compared to the larger mass of the triangular wall itself, which, departing from the underlying barrel vault, discharges its weight on the raising walls and partially on the same vault’s buttresses.

Due to a arch shaped central opening on the top of the central triangle, laid upon the arch below, worrying cracks and disconnections have showed at the top and on the sides walls. In order to ease the burden of
the cover above these walls, which are about 20 metres apart, and to help the relative stability avoiding traumatic interventions, supporting structures have been projected. In particular, two Polonceau metal profiles in contact with the opposite sides of each of the triangular walls, properly connected, will be burdened with the coverage weight and they will support the cemented points of the same walls as well. These metal structures will unload the entire weight on two string-courses in reinforced concrete, shaped so as to assist the masonry structures and to contain a channel for the disposal of rainwater. The mechanical properties of the steel profiles made this solution acceptable, because they are relatively thin with respect to the high mass of wall that they support, with the function they serve in full view (ASBANa Report n. 134 del 21/10/1996).

The interventions that this review briefly describes constitute the testimony of how, over the last 15 years, thanks to experiences that have shown their ineffectiveness over time, the path to improving the preexistent structural condition has been undertaken, trying to avoid the wishful thinking of radical substitutions. At a time when the architectural heritage is subject to a close evaluation in terms of seismic vulnerability we expect to submit these choices to a safety assessment, as required by the recent “Guidelines for the evaluation and reduction of seismic risk to cultural heritage” approved in Rome on June 15, 2007.

4 CONCLUSIONS

Through the examination of past and recent interventions on a complex architecture, the authors aim at focusing on present conservation issues of the Gesù Nuovo church in Naples. Whereas in past centuries the solution to structural problems tended toward the massive substitution or elimination of parts, questions of consolidation must take into consideration today a “constructive requirement”; this means the necessity of preserving a diachronic architectural system must be taken into consideration. As described in the paper, traditional and “modern” solutions contribute to the mentioned requirement in a unique way.

REFERENCES


ABBREVIATIONS:

ANSI: Archivio Napoletano Societatis Jesu.
ASBANa: Archivio Soprintendenza ai Beni Architettonici e ambientali di Napoli e Provincia;
ATSG: Archivio Cappella del Tesoro di San Gennaro, Napoli.

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