

# **Stone bearing wall in Basilica of St. Nicholas in Bari**

## **Structural vs aesthetics reasons of materials, techniques, reinforcements, shapes and dimensions**

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### **ABSTRACT**

This paper aims to codify a set of wisdoms gained through tradition in construction to make it available today to design and to restoration in stone bearing. In particular, it focuses the constructive characters of stone wall, up to establish points of synergy between structural and aesthetic reasons.

The Basilica of St. Nicholas in Bari is assumed as ideal case studied to exemplify the Apulia Romanesque way of building.

To achieve the goals, stone wall is investigated from several point of view: material, constructive techniques, wood armour system and stone reinforcements, showing the integration of structural arrangements in the architectural forms and the correspondence between building system and architectural language.

Moreover, the dimensional increase of stone wall, linked to the great size of the Basilica, is investigated through three dimensional qualities of wall, considering them not only as numeric values but also such as form and space. In this way the study comes to the analysis of the different planimetric arrangements and shapes of the stone wall, in relation to the level of stability and robustness that they give to the building as a whole.

### **INTRODUCTION**

This study derives from a research on design and construction in stone bearing in Apulian Romanesque architecture, carried out by the author in Dipartimento ICAR (Civil engineering and architecture) of Politecnico di Bari.

Apulian Romanesque architecture expresses an organic idea of construction, connected with the use of local stone-types. The Basilica of St. Nicholas in Bari is the first experimental yard and the main behavioural model of the type-morphological process of Apulian Romanesque, both for the conquest of great dimensions with stone bearing structures and for the mix of function requested to medieval cathedral.

In the Basilica of St. Nicholas in Bari the wall is the most important element in the conception of the building, both for architectonic form and for bearing structure.

This paper aims to codify the types of wall present in Basilica of St. Nicholas in Bari, with

the purpose to find the key of the relation between technical and aesthetic forms of wall. In the walls, the stone takes part to the Vitruvian triad:

- *Firmitas*: stone is component of bearing structures
- *Utilitas*: stone determines the system of fruition in the architectural typology
- *Venustas*: stone is cut into ashlar which offer direct representation of constructive system.

The investigation overcomes the limits of the single building, because the Basilica of St. Nicholas in Bari contains the main types of stone walls present in Apulian Romanesque architecture.

## 1. The wall as architectural paradigm

In the Basilica of St. Nicholas there are organic bonds between elements, structures and systems that make up the parts of the building. Each parts of the building has its own spatial features, but also has technological and structural properties, which vary depending on the quantity, quality and organization of its components.

The wall is an intermediate level of relationship between elements of different types and levels, as it can be decomposed in terms of lower grade (masonry face, rows, blocks), but can also be aggregated in terms of higher grade (aisles, galleries, tunnels, towers).

The wall also has the fundamental characteristics of the construction in stone bearing, since assumes three-dimensional valence and has its own system of ashlar masonry.

It implies that the wall reduces to minimum terms the problems related to construction in stone and it is useful for managing the mutual congruence between elements, structures and systems: from the single ashlar to the entire building.

The architectural nature of the wall, in this sense, is the paradigm: a three-dimensional entity easily controlled by the designers, through invariant, attributes and ranges of variation of its constitutive laws.

In the Basilica of St. Nicholas, also, the wall is supporting structure and a closing element, then it absolves to the mechanical, spatial and figurative instances of architecture in a syncretic way.

## 2. Constructive characters

From the pictures of the restoration of the Basilica of St. Nicholas is clear that the walls have double stonework and a filling between them. This constructive technique provides for:

- one-ashlar-thick stonework on exterior side;
- one-ashlar-thick stonework on interior side;
- a core of rubble and waste materials of small and medium-size and inert materials, such as earth and sand, contained between them.

For the realization of external facings are used the harder rock types, such as the Stone of Trani, which are not very porous and rather resistant to weather salinity. For the realization of the facing toward the interior is frequent the use of stones the more humble and porous. The

quality of the workmanship of the ashlar is more accurate and regular in external stonework than in internal one. The two stone works present independent textures, both for the height of the rows and for the size of the each ashlar.

The clamping between the parties is generally guaranteed by the arrangement of diatones, that are laced crosswise with respect to the wall.

From the mechanical point of view, the two facings of the wall are self-supporting; they participate in the bearing capacity of the wall and form a formwork for the filling of the core.

The inner core of the wall allows you to compensate for the low resistance of the limestone used and to achieve the thickness required to the stability of the wall. In addition, the inner core provides accommodation for structures to improve the mechanical performance, such as armors and wooden dormants, which can be considered as antecedents of reinforced masonry. These elements are embedded within the wall and therefore do not interfere in its aesthetic quality.

Examples of this practice are some wooden beams having a function of tensile armor. Schettini discovered them during the restoration of the stone masonry in the north-east corner. Moreover, Schettini finds a dormant in oak wood above the triple lancet window near the left pillar of the triumphal arch. It has the function of co-operation with the masonry in the resistance to flexion [1].

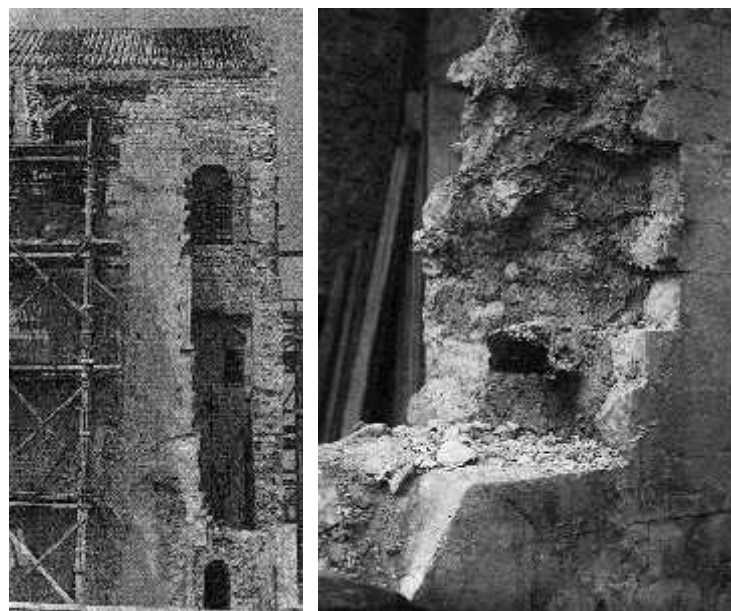


Figure 1 – Wall in the north-est corner during the restoration in XX century. (Schettini, 1967)

From the aesthetic point of view, the secondary plastic and the texture of the stonework are independent for each face, but coincide entirely on the openings who pass the wall thickness.

The inner cores are hidden from view by their nature, so they do not have aesthetic value in themselves. Their aesthetic role consists in increasing wall thickness, required by subtraction mass operations, by articulation of the facade plans, by splay and by generation of chiaroscuro.

For more, the cores are easily executed thanks to recovery of resulting materials, without affect the economy of the yard.

## 2. Design characters

From the design point of view, in the Basilica of St. Nicholas the wall has three-dimensional value. The thickness dimension transcends the physical numerical data, up to involve the articulation of space, form and structure, on the zenithal plane.

There are three types of wall:

- Wall with plane development
- Wall with multi-plane development
- Wall with outturned development

In the following sections, for each of them are highlighted invariant features and attributes that determine their mechanical reasons and their aesthetic reasons.

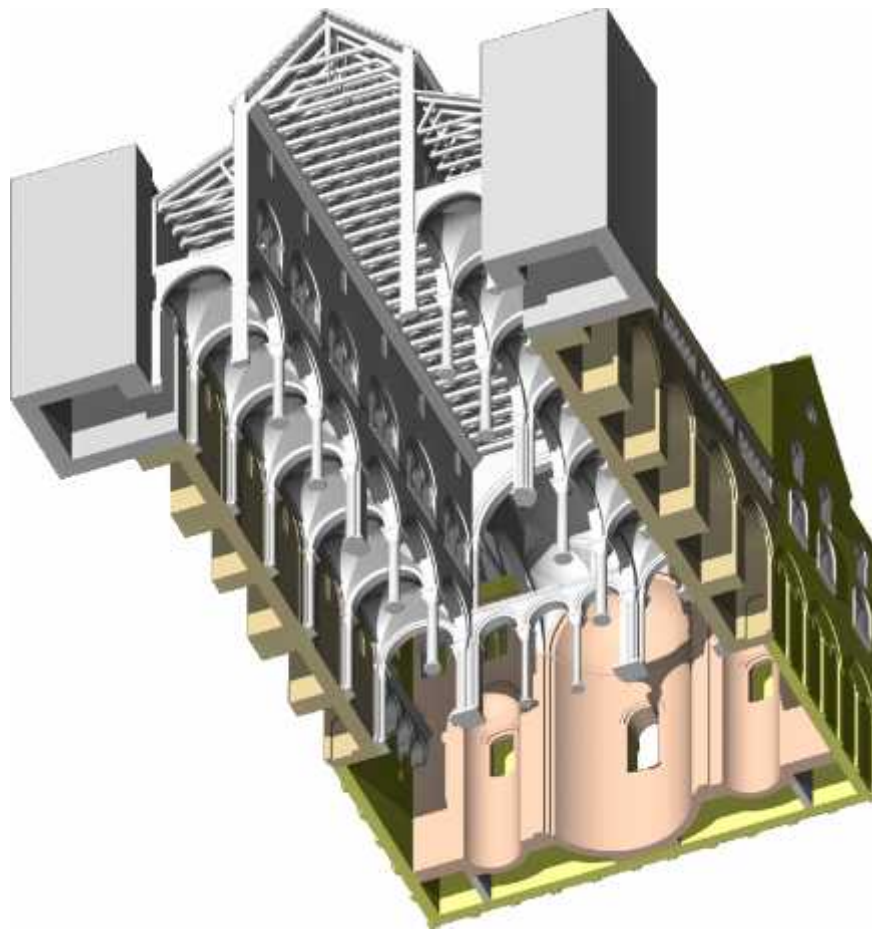


Figure 2 – Wall-paradigms. Yellow: plane; brown: multi-plane; pink: estroflex

### 3.1 Wall with plane development

The type of wall with plane development has a length, a height and a thickness, which determine the parallelepiped enveloping the full mass.

The subtraction of full mass occurs through the introduction of the arc that allows you to

relieve the masses underneath it from vertical load. Below the arch the wall mass can be reduced or removed, without affecting the static equilibrium of the structure as a whole.

The attributes of the wall are linked to the mode used for subtract the wall masses.

On the main façade and on the apsidal façade, the single arch participates in the single lancet windows, in the oculus and in the relieving arches, while the multiple arches participate in the larger and more complex openings, such as mullioned windows and rose windows. The arch in series intervenes in the wall along the entire perimeter of the transept and of the eastern bodies.

Pictures of the restoration of the Basilica of St. Nicholas evidence as the decorative motif consists of self-supporting arches made of cuneiform ashlar. The syntagma is composed of a pair of arcs supported by parastades, included within a second arch of greater size, projecting with respect to the bottom of about twenty-two centimetres, or of a tenth of the arc span and a third of the width of the parastades. The prominence of the minor arches takes the half of the projecting of the main arches from the closing plane. The top of the prospectus keeps the alignment of the main arch, so that the motif is completely included, or "hollowed out" by the thickness of the wall.

You can find the same motif on the transept wall in the cathedral of Bari, Bitonto and Trani. The Dome of Molfetta and the cathedral of Giovinazzo and Taranto exhibit variations with cross arches.

The wall with plane development achieves the stability necessary to the building, by increasing its base of support. It happens thanks to the projections of the parastades. Arches and parastades are also an innervation of the wall. They strengthen its structure.

From a mechanical point of view, the discontinuities in masonry allow the subtraction of mass and therefore the lightening of the wall. Then, the thickness required for stability can be achieved without causing excessive heaviness.

With respect to figurative instances, the thickness of the wall becomes the core subject for the plastic articulation of the façade plans, indoors and outdoors. A wide variety of constructive knots interrupts diffusely the ordinary texture of the wall, in order to highlight its section. The openings are of small size, so they preserved the integrity of the wall as *continuum*. However, they are proportionate on the figurative level to the grandiosity of the whole building, thanks to the plastic rendering of splays, overhangs, blocks specially shaped and sculptural apparatus.

From the formal point of view, the discontinuity in masonry allows the identification of the focal points of the building, such as passages and openings. At the same time, they allows the report of the thickness of the wall as aesthetic value of massiveness and strength.



Figure 3 From left: facade, south side, particular of the transept

### 3.2 Wall with multi-plane development

The wall with multi-plane development constitutes a border-line condition of the wall with plane development with arches. In this case, the vertical supports of arches assume the rank of dividing walls, perpendicular to the direction of development of the series.

The closing plan for the arches is reduced to a tamponade, placed inside or outside of the transverse partitions.

The thickness and the linear development of the wall in this case do not coincide with the sides of the enveloping parallelepiped.

In fact, the overall length of the stonework is equal to the sum by transverse partitions (support of the arches) and longitudinal partitions (tamponade). The total depth of the wall is equal to the length of the transverse partitions. It is far greater than the thickness of the individual partitions and individual infill.

The formal and structural solidarity between the transverse masonry and the longitudinal masonry is established through the planting of barrel vaults.

Therefore, in this type of wall the subtraction of mass occurs through the introduction of the paradigm of the span (barrel) within the paradigm of the wall.

The wall with multi-plane development can be traced in correspondence with the side of the Basilica of St. Nicholas. The septa support the arches have different thicknesses [2], from which springs the alternating rhythm A-B-A-B-A. Are all equal barrel vaults.

From a mechanical point of view, the wall with multi-plane development helps to stabilize the thrust of the internal cross-vaults, increasing the inertia to overturning of the wall. Internal vertical support of vaults are not fully aligned with the exterior septa, but they overlap at least in part to them. The exterior barrel vaults convey the weight force at the application of the thrusts of the internal cross-spans, helping make them more vertical.

From a formal point of view, this figure determines the reading of the side elevations according to horizontal levels. The arches go to equalize the projection of the transept of the cathedral determining the compactness typical in Apulian Romanesque. They constitute the deep shadow on the closing plane, which denotes the spatial articulation of the niches.

The niches also have a functional role: they are in fact a usable space, used in the past to “sepulturam extra ecclesiam iuxta parietem ecclesiae”.

The same motif appears on the sides of the main Apulian cathedral, as Bari, Bitonto and Altamura [3].



Figure 4 From left: north side, particular of the south side

### 3.3 Wall with estroflex development

The wall with estroflex development presents mixtilinear lying posture, with convex segments with respect to the frontal plane.

The thickness and the linear development of the wall mass does not coincide with the thickness and the width of the parallelepiped enveloping the wall.

The masonry mass is made up of straight segments and curved segments, distinguished by their thickness. The overall depth of the structure is equal to the depth of the curved segments from the frontal plane. This size exceeds the dimension of the mere thickness of the stonework.

In the same way, the linear development of the masonry mass coincides with the mixed-line lying posture, while the overall length of the wall is lower, as corresponding to the envelope of that lying posture. In the Basilica of St. Nicholas, as well as in most of the Apulian Romanesque buildings, this kind of wall coincides with the wall of the apse, where each apse corresponds to an aisle.

In the Basilica of St. Nicholas the central apse is more than four metres in deepness, but it maintains a wall section of less than eighty centimetres.

The wall with estroflex development, then, maximizes the reduction of the masonry mass against the increase of the base of the wall.

From a mechanical point of view, it achieves stability also for three-dimensional shape and not just for the thickness in each section.

From an aesthetic point of view, it shall communicate the expressive power of its masses going beyond mere thickness of the stonework. It acquires the soft chiaroscuro arising from the curvilinear giaciture system. The apses have spatial and figurative value: they determine the placement of chairs and church ornaments and participate in the establishment of the prospective goal of the aisles.

The coverage of the space underlying to the apses is obtained by vaults. The constructive

paradigm of the apsidal vaults connects in a progressive way the geometry of the set of the vault and the front of the vertical stonework. It absolves to a uniform design law, congruent to the mechanical, geometrical and formal needs of the tectonic node.



Figure 5 Apsidal facades from the interior

The characters mentioned above combine are enhanced through the adoption of a second wall, that hides the convexity of the apses from outside. This double casing increases the stability of the apsidal front. On a formal level, it incorporates the apses, the towers and the upper walkways, so it confers to the church the image of a stone fortress.



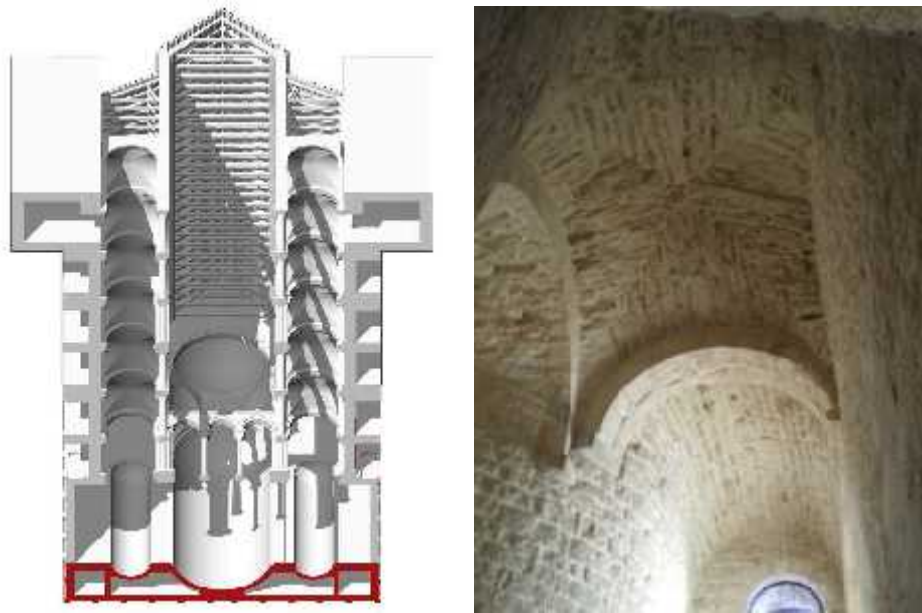


Figure 6 Double casing. From left: 3D model; view from the inside of the two walls

## CONCLUSION

From the foregoing it is clear that the wall participates in an organic way and with its three-dimensional value to the achievement of the dimensional and ethical greatness of the Basilica of St. Nicholas.

The wall-paradigms highlighted share the attainment of bases of support sufficient to ensure the stability of the wall, by unitary generation of space, form and structure. In particular, they allow the "measure" and the structural and figurative control of the more extensive plans, such as the facades and sides.

## REFERENCES

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Unless otherwise specified, pictures and 3D model are by the author