Structural analysis and restoration of the Guglia della Madonna di Bitonto

Tommaso M. Massarelli
Second University of Naples, Department of Restoration and Construction of Architecture, Aversa, Italy

ABSTRACT: The Guglia della Madonna is a prestigious spire of the Baroque architecture, which is located in the centre of Piazza Cattedrale in Bitonto (Bari – Italia). This monument was built to commemorate some adversities and to sustain the Madonna’s metal statue. The structure has a vertical diminishing development till a pointed top, with cornices, decorationes and applied sculptures. The calcareous stone masonry shows, for a long time, signs of structural damage, with prolonged cracks and misalignment. The restoration, which has a significantly structural connotation, includes the reinforcement of foundation with a ferroconcrete substructure and elements for the deviation of the loads, the rehabilitation of the masonry with new mortar and the insertion of protecting devices. These works follows essentially the modern restorative criteria and show that strengthening intervention for historic buildings cannot be traced within predetermined models. This is just the creative aspect of structural intervention related to the architectural heritage.

1 HISTORIC NOTATIONS

The Guglia della Madonna in Bitonto (Province of Bari) is the architectural pivot of Piazza Cattedrale, which is one of the most distinguished places in Apulia. It dates back to 1733–34 when private customers wanted to thank the Virgin for preserving the village and their life during the earthquake in 1731 and other adversities. So they financed the collocation of Madonna’s metallic statue on the top, as testified by the attached inscription on the monument.

The artefact is enriched with a number of ornamental and memorial elements (volutes, sculptures, crests, plates with inscriptions), all of them made of calcareous stone. For its shape and decorative elements it ranks among the Italian Baroque monuments.

At the beginning the spire was also furnished with stony angels, which partially fell down in the first half of 1900 and later they were mislaid. Only recently they have been found again and restored.

The Guglia della Madonna’s restoration has been necessary because of the seriousness of its structural damage and deterioration. The project includes conservation of surfaces, strengthening and replacement of the putti on the monument’s body.

2 PRELIMINARY STUDY AND STRUCTURAL PECULIARITIES

The building is made of white local calcareous stone and presents a plint and three tapering decorative orders, which are bordered with suitable cornices and soaring till 12 mt. It has quadrangular shape in plan with ribs which intercept the quoins and give almost domed horizontal profile to the quadrilateral.

The perfect-moulded face brickwork is of calcareous stony blocks and ornamental elements of various shapes. Preliminary and in progress researches have set inspectional digs, specifications of structural survey and damage configuration, interim extraction and subsequent replacement of some unframed elements, in order to check the relation of structural endurance of the face with respect to the nucleous; extraction of cylinders of interior masonry with micro-logging instruments, for examining the solidity of inner material, carried out on former damaged parts and sectors of nucleous which are temporary free from superficial blocks.

According to such researches, the masonry proves to be built with face of squared blocks and nucleous of shapeless stony material with deteriorated mortar. The face’s thickness is thin but becomes stronger in corrispounding with cornices.

3 STATE OF THE FOUNDATION

Digs and stratigraphic extraction analysis have cross-checked foundations with a depth of about 3 mt. This part of structure is characterized by double-offset masonary singol plinth.

The bordering ground is essentially fluid and quite damp with markers of viscous deformation in the
4 STATE OF THE PROTRUDING STRUCTURE

Static and dynamic analysis of the monument, accomplished by observing the structure, crack configuration, general and seismic calculation, have led to important outcomes. The shaft is crossed by cracks in the following shapes:

- extending vertical cracking between parastades and interposed face, particularly in the central zone of the spire;
- dissociation among overhanging elements, as horizontal translation and misalignment of the three top cornices;
- slight disjointedness among face blocks, which are occasionally present all over the shaft, where it is noticed the fall of cementing substance; crack of some blocks of face;
- horizontal split between shaft and moulding where there is an easy water seepage;
- a northward disalignment of the structure.

The crack configuration, put in relationship with the peculiarity of the observed structure, shows a mechanism of horizontal deformation and stiff rotation of the whole shaft of the spire.

The out of alignment is traceable to a failing of foundations: a strain whose origin is not easily verifiable, but on which they must have contributed the road traffic, being occurred for years nearby and seismic events to which similar buildings are quite sensitive.

The crack board proves to be consonant with the above-said misalignment: zones of the shaft, more sensitive because of their lack of mesh, have opened this way causing the standing deformation. The crack configuration noticed on the trunk-column and on the overhangs have caused the entrance of rainy water inside the masonry nucleous. Consequent formation of weeds and radications have worsened the general situation.

The structural analysis of cornices loaded on their ends with the putti (in their original position on the spire) has shown a centred load which is constantly carried on extremities. The overhangs’ work condition appears exuberant, particularly in case of seismic stress. This has explained the reasons of the putti’s past fall.

It has not been ignored the possibility of seismic acceleration, which could worsen the cy nematic board verified and the dynamic exaltation of the concentrated loads.

In conclusion the structure’s working condition is currently asymmetrical, not homogeneous and, in case of the putti’s replacing, exuberant in some zones. As a consequence the whole stress board proves to be improper from a static point of view and appreciable in case of telluric movement.
5 REHABILITATION AND STRENGTHENING OF THE FOUNDATION

To better the static condition of the masonry they are necessary interventions which have the following aims:

– improvement of the original working condition of foundations;

– betterment of load transmission by restoring original conditions of contact between basement and foundations;

– reduction of cortical loads and partial redistribution of these ones on the plinth's central inertia nucleus;

– inhibition of dampness characteristic of some sectors which are more susceptible to water attack in the long run.

High-conservative intervention realizes the following works:

– injection in foundations of regenerative mixture of lime and micronized flints;

– reintegration of superficial natural lime mortar;

– insertion of steely anchor pin leaned on the shorter sides of the foundation;

– construction of a perimetric curb (stiffening ring) of ferro-concrete pozzolanic mix, which is in part fitted in sub-basamental area, with a shape subsidiary to the lacking part of masonry plinth.

The intervention is accomplished with dampness insulator in foundations, made of geotextile barriers, dry stones with restrained granulometry and ventilation system.

6 REHABILITATION AND SEISMIC PROTECTION OF THE PROTRUDING STRUCTURE

The intervention of structural consolidation of the spire is characterized by restoring the masonry's original supporting capacity, decayed because of both deterioration and crack, preventing effects of the previous rotation and the standing strain of the trunk, specially related with seismic stress, and shifting of the putti’s load towards more fitted areas of the masonry (the architectural design provides that the aforesaid putti are replaced on the cornices).

To gain such aims it’s necessary to repair the masonry (in addition to reinforce foundations) and to
accomplish a system of structural protection for both static and dynamic loads.

The technical solutions related to the protruding structure are the following ones:

– regeneration of nucleus and its rejoining to external masonry by injection of new mortar formed by lime and pozzolana. These injections are executed directly in the nucleus through masonry areas which can be penetrated without damage;
– restoration of external masonry by replacing the old binder with new natural mortar.

To contain effects of potential seismic actions they are planned protection devices that realize an encircling/support system, settled immediately over the cornices. They are small horizontal metallic structures made of angle-steel, tension rods, plates and anchor pins, realized with titanium TiGR.5, projected for preventing horizontal strains of the Guglia, gathering the putti’s load from the cornices and shifting them towards the interior of the masonry body.

This “belt” is projected around the third and the fourth decorative order, immediately over the cornices. A titanium hook (or snap-hook) prevents from the fall and the fraudulent removal of the small statues.

The small integrative structure cannot be seen from the bottom and is essentially reversible. It has the least direct contact with the monument matter, is accessible

7 CONCLUSIONS

The structural restorative project of the Guglia della Madonna di Bitonto has followed essentially the modern restorative criteria, such as physical-mechanic compatibility, durability, differentiability, reversibility, least intervention. But the approach in structural key has required tolerances, according to the circumstances. The reversibility, in the practical outcome of the
intervention, has shown a shifting from its theoretics statement. The metal pins, inserted in the monument’s body, make the supporting system not completely reversible. The effects of the injections of new binder cannot be considered reversible: their chief contribution is just in their adhesive power which represent an inalienable quality in the successful rehabilitation of a masonry structure.

To modern restorative criteria it’s to be conjugated the principle of efficacy but this latter often rejects reversibility or allows tolerances at any one time.

Another fundamental aspect concerns the strengthening contents of a structure. When we work on historic buildings, these contents cannot be standardized as predetermined models of intervention.

The Guglia della Madonna di Bitonto has a plan halfway between a quadrangular shape and a round one. The small integrative structure follows this shape becoming halfway between a chaining and an encircling, to which they are connected also by-passing elements for the putti’s load. These peculiarities generate a system of structural protection (chaining-encircling-supporting) which is not conventional.

Intervention on historic handworks needs devices always different at any one time according to the peculiar characteristics, because the existing structure obliged to a specific conditions at any one time. These conditions, nevertheless, are not to be translated like conditioning. On the contrary, they represent opportunities for a structural creative conception, which realizes itself by making constitutive elements of the ancient structure as guidelines for shape, quality and effectiveness of the integrative elements.

REFERENCES