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Survey and Restoration: The Case of the Block Between Vicolo II and Vicolo III at the Giudecca of Ortigia, Sicily

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ABSTRACT: The paper presents a case study carried out by the authors, under the auspices of the local administration, on a building block located in the Giudecca quarter in the Ortigia island in Sicily. It represents the application of a methodology presented in this conference in a companion paper (Braga et al. 2006). The critical and theoretical awareness of limiting the approximation as to the survey has required the development of a rigorous methodology to represent, in a more systematic way, the complex relationship between spatial aspects (and sizes) and architectural aspects (and materials). Under such a perspective, the survey aims at the knowledge of the authentic forms of the architecture, instrumentally investigating all its aspects: from the dimensional ones to the geometrical ones, from those pertaining to the conservation state to those pertaining to the construction techniques and to the employed materials.

1 INTRODUCTION

This paper presents a study of urban preservation based on a method extensively presented in a companion paper (Braga et al. 2006). The study has a strong multidisciplinary character, trying to bring together and to profit from different skills pertinent to restoration, be them of historical-critical nature, or of urban-planning, architectural, technical-scientific, or even philosophical and methodological. The proposed intervention stems both from a careful analysis of the urban fabric and from a ‘critical interpretation’ of the ‘growth mechanisms’ of two quarters, among the oldest and most stratified of Siracusa: Giudecca and Graziella.

The proposal is perfectly in line with the theory of restoration, by constantly recalling its fundamental guiding criteria, defined during a century-old research work: recognisability of old and new, reversibility, physical-chemical and linguistic-figural compatibility, expressive authenticity and, above all, minimal intervention.

2 THE FIRST EXPERIENCE OF THE METHOD APPLIED ON AN URBAN SCALE

2.1 Ortigia – A brief history

Ortigia, off the coast of Siracusa (presently linked by three 80 meter bridge-causeways), in Sicily (Figure 1-2), is one of the first Greek settlements in Italy, whose foundation dates back to 700-600 BC.

With a complex urban setting, it is a unique laboratory for archaeologists, historians, architects and engineers, because its buildings are an astounding mixture of construction techniques representative of the various dominations that haunted it over more than two millennia: the Greeks (650-212 BC), the Romans (212 BC – 410 AD), the Goths (410-565), the Eastern Ro-
man Empire (565-878), the Arabs (878-1086), the Spanish (XII-XVII c.), the Kingdom of Naples (XVIII-XIX c.), until it became part of unified Italy in 1860.

In addition to a history of multiple cultural occupations, Ortigia has an intense seismic history. In recorded times we have the following notable seismic events:
- 1542, Dec 10, MCS IX, Atenaion’s (now Ortigia’s Cathedral) columns were displaced 70 cm
- 1693, Jan 11, MCS X, in Val di Noto, 4000 casualties were recorded in Sicily
- 1908, Dec 28, MCS X, in Messina, 75,000 casualties and 300,000 homeless
- 1968, Jan 15, MCS IX-X, in Belice, 300 casualties and 80,000 homeless.

All of this resulted in a city fabric that is now extremely articulated and stratified, both in plan and elevation, resulting in a sort of time-space conundrum.

Yet, in the current “form” of the city we can still discover and recognize the original archetypal planning scheme drawn by the ancient Greeks.

2.2 The archetypal urban pattern at the Giudecca

The formal structure of the original town is visible today in the configuration of the Giudecca, where the alleys (stenopoi) demarcate the rectangular blocks (insulae). Varied building systems,
which maintain the prominent characteristics of their origins, produce a complex form which remains visible to the observer.

The new forms are, however, compatible with the archeological level (Figure 3). The structure gets transformed, while it grows, into a new entity (an architectural compound including houses, churches, mansions, convents, monasteries, theatres, etc.) and occupies the space of enclosures that were originally empty.

2.3 Arrangement of blocks at the Giudecca

Two archetypal houses are found. One consisted of a single door and window and was used for housing only (Figure 4, top). A second archetype, consisting of one arched door with flanking windows on each side, was a warehouse, used for storage (Figure 4, bottom).

Originally, the East-West blocks were subdivided into 15x15 m squares, each facing a stenopos (Figure 5). The blocks were 6 lots long (approximately 90 m) and insulae (linear multi-building façades, one story in height) were developed. In a probable building sequence that maximized exposure to sunlight, the first 15 m development strips to be built were those facing South on a stenopos, while the second would be facing North.

Access to the courtyards was directly from the street (Figure 5). The lots facing North on a stenopos developed North-facing facades, while their courtyards were South-facing. The North-facing houses, owned by late comers, were 5 m wide (NS) by 12 m long (EW), with the last 3 m on the lot (EW) consisting of access corridors to inner courtyards (Figure 5).

2.4 The block 74 at the Giudecca

Block 74 of the present Giudecca was identified for possible restoration. The block has irregular plan with longitudinal length of about 67 m, and lays on a slight slope between the Vicoli (alleys) II e III. One end of the block faces Via Alagona, while the other is adjacent to the church of St. Philip (not included in the project). The block width varies between 14 and 18 m and encloses five courtyards of different size. The block has elevations from one to four stories.

Notice in Figure 3 that the present Giudecca Vicolo II is almost coincident with the original Greek stenopos (grid superimposed on the present plan), while Vicolo III has been pushed about ten meters North of its original location, signifying that at some indefinite time, possibly after a seismic event, insulae owners of the North side of block 75 (directly below block 74) moved the street North, invading the South courtyards of the Southern insulae of block 74. Thus the Vicolo was irregularly moved and the new Vicolo became curved.
The application of the methodology presented in (Braga et al. 2006) brought to the recognition of the constructive sequence both in plan (Figure 7) and in elevation (Figure 8).

Figure 7: Examples of analysis identifying courtyards (top left), original cells (top right), insulizations (bottom left) and tabernizations (bottom right).

Figure 8: Example of typological reading of the elevations for the recognition of the basic cells described in Figure 4 on the South elevation.

3 THE CRITICAL-CONSERVATIVE RESTORATION PROJECT OF BLOCK 74

Presently, the serious conditions of environmental and physical degradation compromise the dwelling and commercial functions of the area, magnifying the depopulation phenomena, and, most of all, determining a real danger situation for the inhabitants.

The critical-conservative restoration of block 74 represents the minimal operational dimension where one can effectively develop and qualify the – constructive, functional, and formal – relationships of the building with themselves and with the spaces determined by them.

Within the block, the residual empty spaces of the courtyards have been re-configured, the provisional volumes have been demolished being contradictory with the real ever-changing form, walls and building cells have been rebuilt or requalified, with a caring look at the permanent, through a critical eye and modern sensitivity.

The form of the block has been the basic reference also for the mechanical and structural design that, for the different states and ways of collapse, has activated material resources within the whole fabric, distributing the seismic forces over the whole spatial set of cells.

3.1 The architectural intervention

Figure 9-10 show a design example aiming at re-composing the elevations. This is achieved either suppressing wall openings based on morphology coherence with the architecture of the building unit, and with the established facade configuration aspects. Also, new openings have been inserted based on internal space organization. Finally, demolition of superfetations that are precarious, recent, and extraneous to the formal structure of the texture (and to a “mature” evolutive process) is envisaged.
3.2 The structural intervention

3.2.1 Description of the construction typology

The elevation walls are all in masonry, usually made from irregular stones of size variable between 30 and 90 cm. For the masonry material properties, the following values have been assumed: elastic modulus $E = 1500$ MPa, shear modulus $G = 150$ MPa, weight density $\gamma = 19$ kN/m$^3$, compressive mean strength $f_u = 2.4$ MPa, characteristic shear strength $\tau_k = 0.13$ MPa.

The slabs are essentially laid parallel to the longitudinal walls and are of various typologies: timber, or steel and planks, or concrete and masonry.

The roofs are in timber if inclined, in concrete and masonry if horizontal.

3.2.2 Out-of-plane (overturning) analysis of walls

In the first phase of the study, the analysis of walls subjected to out-of-plane excitation has been carried out. In order to numerically verify the vulnerability with respect to overturning, dynamic analyses on whole walls have been performed. The nine walls analyzed have been selected among those showing significant outwards eccentricities or deformations and are shown in Figure 11.
Each wall has been modeled as a rigid block, oscillating about the lower external edge (Figure 12) at diversely located points. The presence of transverse walls has been considered both by imposing that no inward rotation can take place (monolateral constraint) and by damping the kinetic energy after the impact of the perimeter wall on the transverse one. Connection to the transverse walls has been neglected.

The nine walls have been analyzed under dynamic excitation, represented by three accelerograms, each one scaled to three peak ground accelerations (PGA): 0.15g, 0.25 g and 0.35g, corresponding to the 3rd, 2nd and 1st seismic zone in Italy, respectively.

The analyses performed showed that 3 out of 9 walls overturn under a PGA of 0.25g, and 7 out of 9 walls overturn under a PGA of 0.35g.

![Figure 11: Location of nine walls analyzed for overturning.](image1)

![Figure 12: Adopted model and overturning modes.](image2)

### 3.2.3 In-plane (shear) analysis of walls

Based on the information gathered in the first phase of the study regarding the walls structural continuity, a Finite Element (FE) model of the block was set up for nonlinear pushover analyses (e.g., Figure 13). The block has been modeled through the program Mas3D (Braga et al. 1997), which allows to account for particular aspects such as misaligned walls and slabs, sloping foundation, different in-plane stiffness of slabs according to their typology, trapezoidal loading areas, and monolateral constraint at the foundation level.

The block was modeled with 134 walls and 130 connections. The 35 slabs have been grouped based on their in-plane stiffness: 11 rigid (terraces with concrete/masonry slabs) and 24 flexible (timber slabs). The total slab surface load varied from 1.6 N/m² to 5.8 N/m², according to the slab typology.

![Figure 13: Transverse walls considered continuous in the FE model.](image3)

The FE model allowed to obtain valuable information on the block seismic performance. In particular, the resisting force $F_{res}$ has been evaluated as ratio to the overall weight $W$ for the two
principal directions: X (longitudinal) and Y (transversal) in two verses (+ and -). Being the block longitudinally non-symmetric, its response is different in the two verses, while the transversal analyses give practically the same response. The results are shown in Table 1.

<table>
<thead>
<tr>
<th>Direction</th>
<th>$F_{res}/W$</th>
</tr>
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<tbody>
<tr>
<td>+X (longitudinal)</td>
<td>13.8 %</td>
</tr>
<tr>
<td>- X (longitudinal)</td>
<td>10.2 %</td>
</tr>
<tr>
<td>+Y (transversal)</td>
<td>20.5 %</td>
</tr>
<tr>
<td>- Y (transversal)</td>
<td>20.5 %</td>
</tr>
</tbody>
</table>

The block shows a resisting force that is lower than that of the 2nd seismic zone in the transverse direction and even lower than that of the 3rd seismic zone in the longitudinal direction. Based on the observation that each existing wall shows a satisfactory behavior with no damage concentration, it can be said that the poor overall performance is essentially due to the low number of resisting walls.

3.2.4 The intervention

Regarding the overturning of the façade walls, their inertia forces are transferred to the transverse walls by means of slightly pre-tensioned (600-1000 N) tendons, positioned within the slab concrete cover thickness (Figure 14).

Such measure also produces an effective connection among the seismic resistant structures of the masonry building at the slab levels, so that a monolithic behavior is attained without alterations of its architectural design.

Where anchorages are located, the masonry strength should be improved by means of local strengthening measures.

Figure 14: Example of collocation of tendons and some technological details.

Regarding the in-plane response, it should be observed that the very fact of eliminating and of regularizing the block configuration, as shown in the previous section, has significantly improved the seismic performance, because of the reduction and better distribution of the inertia forces.

Moreover, the usual solution of in-plane stiffening the slabs is abandoned. With flexible slabs, seismic forces are isostatically distributed among walls, regardless of their stiffness. However, façade walls must be stabilized out of their plane, as shown previously. The damaged slabs have been either restored or replaced with new timber slabs without connecting perimeter beams.
The choice of infinitely flexible timber slabs allows to minimize the seismic forces activated by the slabs mass, and it is all too evident that the overall intervention decreases the demand on the walls thus allowing for a non-invasive intervention.

Finally, an intervention aiming at better distributing the inertia forces of the roof levels and at constraining the walls at the top was designed (not shown here). Such intervention consists in realizing a steel truss close to the roof/wall connection and in rebuilding the top of the wall itself in order to allow an effective anchoring of the steel truss.

After having included the intervention measure in the FE model, additional analyses have been performed on the upgraded model, according to the same scheme shown in Table 1, which have given the results presented in Table 2, where it can be seen that the proposed design produces a regularization of the seismic resistance in the two directions. The overall seismic resistance has been ameliorated to achieve 80% of that required for the 2nd seismic zone.

<table>
<thead>
<tr>
<th>Direction</th>
<th>$F_{res} / W$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$+X$ (longitudinal)</td>
<td>20.8 %</td>
</tr>
<tr>
<td>$-X$ (longitudinal)</td>
<td>19.2 %</td>
</tr>
<tr>
<td>$+Y$ (transversal)</td>
<td>22.4 %</td>
</tr>
<tr>
<td>$-Y$ (transversal)</td>
<td>19.2 %</td>
</tr>
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4 CONCLUSIONS

In occasion of the drafting of the new Detailed Plan, the trial of the developed method has involved, in this first phase, the quarters of the Graziella and of the Giudecca, at Ortigia.

New studies are currently under way in the historical town of Gaeta, in Latium (Italy).

The criteria, the rules, and the changes, the persistence and the differences have been analyzed and interpreted that have characterized the gradual growth of the two fabrics considered, designating and specializing the processes and the principles of transformation of the built environment.

This investigation has therefore revealed that:

1. the specific characters of “substratum” of the two areas, conditioned by the different orientation of the leading routes, by the dialectic between “main type” and “synchronic changes of iso-orientation” (fabrics in a closed series with iso-oriented lots), by the relationship between the building front and the pertaining area, by the access system to the courtyards and to the building units and by the original dimension of the enclosures;
2. the characters common to the growth and physical transformation processes of the historical built environment: enlargement of the front through incorporation or fusion of adjoining buildings or through separation of multi-cell building types into basic units, horizontal and vertical additions, ranking of entrances, transformation of an entrance into a window and vice versa, introduction, suppression or relocation of internal and external stairs, creation of floors, development of holes, balconies and terraces, introduction of decorative elements such as stringcourses, cornices and frames of doors and windows, etc.);
3. the parasitic characters hampering a coherent and organic reading of fabrics and buildings are generally represented by the obstruction of courtyards, raisings, non-integrated ordisharmonic additions, also by reduced performance, functional capabilities, static capacity and environmental characteristics of continuous buildings.

REFERENCES
