The 2009 L'Aquila Earthquake
Securing of Monumental Heritage,
Government Palace,
St. Just Church, Centi Palace in L’Aquila

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ABSTRACT
The article deals with the methodology of the securing of Monumental Heritage damaged by the earthquake in Abruzzo (April 2009). Article describes the different types of interventions focusing in detail on three important buildings like Government House, “Centi Palace” Head Quarter of Region Abruzzo and Church of Saint Just, located in the historic center of L’Aquila. In the outline will be explained the technical-administrative procedure, general criteria observed during the design and implementation of interventions performed by the Firemen and Private Companies.

1. PREMISE

Securing intervention of the Monumental Heritage is a delicate issue of emergency seismic management due to limited knowledge of the building construction and its nature. Following the earthquake a restoration way (already utilized in other seismic events like in Umbria and Marche 2007 and Molise 2002) has been performed. This planning provides the collaboration between different institutions (Commons, Regions, Mibac, DPC, Firemen, Scientific Community…). In this case, earthquake of Abruzzo 2009, a technical group has been created to design the securing interventions of Cult building. Firemen performed these securing interventions. The projects are about 200, designed by CNR-ITC, UNIPD and UNIGE, and a 30% of these have been performed in the Historic Center of L’Aquila. In some case the end of the works has been performed by Builders. The bound public or private Palaces have been followed by Common of L’Aquila approving the designs wrote by professional man by a dedicated commission.

2. GENERAL CONSIDERATIONS

It is necessary to highlight some general considerations about the short-term provisional works, securing intervention of public space and critical situations of high damage, and the final works to restore accessibility and usability conditions, as made for some monuments of L’Aquila (Basilica of Collemaggio, Church of the Holy Souls).

The aim of provisional works is to restore the safety level present before the earthquake awaiting final works. It is possible to expect final aids if they are adequate and efficient (like chains). The danger reduction must be considered for static conditions or possible other seism, while the measuring of provisional works must be performed considering the residual strength of the structures. The decisional process must provide the building type, the size of the damage, the damage mechanism activated and finally, beside the evaluation of necessary provisional intervention also the identification
of intervention type and the right technology. The design of provisional works can be simply followed by a code, like manual available in literature (OPUS 2005 written by DPC and STOP 2009 written by Firemen), so to perform a fast design of securing interventions.

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<th>Table 1. Level of damage and aim of the intervention of securing</th>
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3 INTERVENTION TYPES OF SECURING

Here below are listed some intervention types of securing performed in Abruzzo. First, the public space have been put in safety by removing dangerous high elements and by creating a protected transit to allow the admission of buildings. After, cribs have been placed to contain possible slough or maintain vertical load. Support interventions are vertical wood or steel props, sbatacchiature delle aperture, vault arch centering, one-dimensional elements ringing. Check elements, provided to control mechanism outside or inside the floor, are inclined shoring systems and the ringing.

Figure 1. Vertical Props
Figure 2. Sbatacchiatura (Propping) of openings and sew-unstitch honeycomb
Figure 3. Bending of arch
Figure 4. Ringing of pillars
Figure 5. Examples of Shoring retaining in steel and wood

4 GOVERNMENT PALACE SEAT OF PREFECTURE, PROVINCIAL COUNCIL AND RECORD OFFICE

The government palace is in the historic Center of L’Aquila near the main place of the city in a location re-designed over a conventual settlement and adapted to offices structure following the earthquake in the 1703.

The building has an irregular shape and it is composed by two main parts:
- the church of St. Agostino;
- the Government Palace having the main front, of two levels, at place of the prefecture, where the entrance is built with Doric columns that confer to the façade a neoclassical aspect and allow the admission to the main courtyard.

The façade is expanding in width and two smooth false ashlar are on the two lateral side returning on the centre of the façade with a neoclassical window. The palace has six opening at the ground level added in a subsequent time but similar to central opening. The second level has two simple windows like cornice crowning without moldings.

The plant has a trapezoidal shape and there are three courtyard where the offices at first level and the warehouse at basement overlook. The courtyard have regulated the alignment of the walls that are perpendicular in the south side but not perpendicular in the north side. The main front seems a fifth stage of fitting the square. The ground floor was the seat of L’Aquila Record Office while at the first level there were Government Palace offices and in the west side of the factory there was the Prefect’s House.

4.1 Ceiling and Wall Quality

From a first analysis of wall parameters at the last level and attic, reveal the presence of masonry made by small and medium stone consists of two or more hanging not clamped between them filled with incoherent. This type of masonry and the inclusion of brick masonry incorporated into the tissue wall for functional requirements indicates the presence of a recent elevation. The first level is characterized by brick and stone vaults while the floor of the high levels are in iron and “tavelloni” covering by a wood structure.

4.2 Summary of the seismic damage

At the ground floor the walls and the ceilings don’t show significant damages except some environments near the inner courtyard where the damages has been accentuated because of collapses of the higher floor. The last practicable floor (second level at Prefecture’s Square and third level at the
backside) shows an heavy damage due to many collapses. The mechanisms activated are attributed to a deficient of link between the attic and the covering and to the pushing action of the covering. Indeed end of attic collapsed on the same piazza roof structures. The mechanisms activated is in parallel to a horizontal deflection of the longitudinal oblique wall evidenced by the collapse in the central part (operating room). The walls of the inner courtyards at the second level and with minor size, are broken, partially reversed with serious cracks cutting, the damage in this area is somewhat confused by collapses. In the back side the mechanisms are better defined and has been found at the last floor an overturning of the wall with deep damages. In the area opposite to the theatre are present collapses confirming the mechanism of the corner overturning. The covering are wood made by a mixed system of trusses and pushing beams; therefore are present many interventions performed during the time and it shows the ‘no connection at the level of coverage. The walls facing the inner courtyards are being rotated in some places and are in serious development.

4.3 Securing intervention description

The Firemen have performed a first intervention of the Government Palace and after has been written a general planning about securing of the palace that will be realized by a professional company. The intervention of the Firemen has been:
- Propping the main entrance made of columns and architraves; tube coupler and bending by lattice
- Demolish a part of architrave and subsequent replacement;
- Propping the main entrance to the courtyard with tube coupler system and bending by grid made by steel pipe and wood honeycomb elements;
- Sbatacchiatura of some openings;
- Propping section of dangerous covering traves;
- Applying of hydraulic mortar on the broken wall
- Performing a light roof in the part in front of the square.

The securing intervention performed by a private company. This intervention is based on a design foreseeing removal of ruins and the safety of whole building. The moving of the ruins has been
performed by dividing the building in four areas so to make simple the intervention following a stability verification of the areas and controlled removal of vertical elements dangerous covering pieces. Further more has been provided a selection of the great value elements to classify. Removal has been performed by two ways of roller amassed in two main courtyards.

Figure 22. Design for the handling of debris and deposit of debris in the courtyards

Intervention on the building has been divided in the south-east side, seat of the Prefect’s House, the room of the provincial council and the Ubertina room. This area contains many artistic elements with a great value but it is the most damaged. The wall, deeply cracked by collapses and overturning, has lost the load bearing capacity so has been provided an intervention to restore the deficient capacity by coating the walls with two steel grids vertically and horizontally placed and linked by steel bars. Section profiles with dimension of cm150 are placed in pair and join by a box, they are connected at the masonry by steel and tightened with plate nuts on the both side of the wall. The contrast system created leads to a wooden table 5 cm thick and sits on a “sleeper wooden”. The design foresee to conclude the intervention by a building of a temporal covering that push on these sections. Steel grid begins at the ground level until the covering where are integrated all existing structures by replacing of damaged structures supporting the secondary warp where the roof is still present. Where was the hall will be built a tube – coupler bridge with wooden table and wooden bending to protect the painted vault.

Figure 23. Plans and sections of the south east which the securing intervention has been realized

5 ST. JUST CHURCH IN L’AQUILA

5.1 Historical information

The church is located in the historic centre of L’Aquila, in one of the most defined zone of the town for the presence of some palaces like Dragonetti, Alfieri e Centi surrounding it on the four sides. It is one of the first church built in town, around 1257, even though there are only few elements related to that period: the apse and the main altar goes back to 1316. The horizontal crowned façade is subsequent, but of the same century and it is in Romanesque-gothic style, subdivided vertically by LESENE divided by a horizontal frame into two orders. The church is all made of travertine, the portal has a splay building with columns and capitals: it still has the ancient wood leafs enriched of intaglio and friezes and the primitive fresco in the lunette but this is damaged. In the superior order there is a rose window made of stone of the last gothic period. At the lateral side there are lunettes of the seventeenth-century.
The interior was originally divided into three aisles transformed later into chapels; it has a large sanctuary that covers the entire width of the building, and three apses. The transept is the element of separation between the aisles and the area of the apse and it has a wooden coffered ceiling. There are great value works like a Gothic Choir (wood) and the main altar, five-seventeenth-century, carved and gilded with a temple and statues on the various orders. Among the paintings there are two most notable of Bedeschini in the last chapel on the left, while in the sanctuary are the remains of frescoes dating between 400 and 500.

5.2 Summary of the seismic damage

The church is affected by the reversal of the right wall of the transept with partial removal of external hangings at the top of the facade, detachment from the body of the sail facade of the church and serious damage with partial collapse interesting the vaults and the triumphal arch, collapse of the bell gable on the front right of the transept and belly flop and local crushing of the pillars of the triumphal arch. Activation of reversal mechanisms of the apse and side chapels of the nave.

5.3 Securing intervention description

The church has been already interested by a first securing intervention performed by the Firemen. A support structure has been built in the upper part of the façade by elements in pipe connection. Subsequently the sbatracchiatura has been performed on the windows of the façade and on the back apses by steel pipe and wood honeycomb elements, hoops of the transept and apses with steel ropes 16 mm in parallel with multiple anchors at three points and closure of passages in the corners with sew-unstitch honeycomb wood.

It highlights the special intervention encircling the apse and facade on Piazza St. Just where, due to the collapse of half hanging, a system consisting of contrasting pairs of tubes stuck on the side walls with steel bars and / or tubular elements with bases on adjustable tables has been designed.

Figure 29. Side view  
Figure 30. Facade of transept  
Figure 31. Sew-unstitch honeycomb wood.  
Figure 32. Static Multiple anchor

The second part of the action, that will be performed by a professional company, is expected to conclude the intervention of securing the transept, protect and support the wooden altar against possible overturning, to ensure the safety of apse and side chapels, contrast the misalignments and the crushing of the columns where the triumphal arch is, contain the overturning mechanism of the side chapels and contrast the apparent belly flop of the central area in the first chapel on the right. In the transept there is a space frame able at contrast with the outer walls and connected by with two pairs of tube coupler beams. Both frames will reach the altitude of the ceiling and give the same support
through tubular elements with adjustable bases on polystyrene sheets. For the triumphal arch is provided encircling of the two arch columns to contrast the misalignment with tubular elements with adjustable bases on plates pushing on them. Propping of the chapels is made by a grid composed by four pillars (70x90cm) one for each corner and placed to contrast the outer walls. Outside to avoid the chapels overturning there is a frame in tube coupler (on the side in front of St. Just Square) and a UPN profiles system (140mm) vertically placed over tables at the same levels of side chapels separators. The two frames are joined by a 16cm steel cable at the corners and the tops of the semicircular windows.

![Figure 32. Plants and sections of the securing intervention performed by private company](image)

6 CENTI PALACE HEAD QUARTER OF REGION ABRUZZO

6.1 Historic News

Centi Palace, a baroque building, was built in the eighteenth century. It has different tardomanieristici elements and in its façade there is a big balcony kept by seven Ionic columns in Borromeo style standing over the majestic portal. At the corners of the building there are big lesene sperone. The palace was the seat of the Regional Presidency, it spread for a block and it is the highest expression of L’Aquila baroque art. The building has a rectangular plant and it is expanding for two levels beyond the ground level, it has a wide entrance and an inner courtyard. The great popularity of Centi Palace comes from its preservation over the times, its feature of being isolated on the four sides and its great relief architectures. The first and second level ceilings are in arch bricks vaults, the roof is made by wooden tie beams, by terracotta flat tiles, and it is covered by bent tiles. The castellina ceiling, on the north side, is made by wood and its cover is the same of the palace. Outside there are the masonry carrying structure and the stone cantonale.

6.2 Summary of Seismic Event

Following earthquake of 2009, the Centi Palace has shown a light damage to carrying structures while more damages resulted at the vaults on the first and second floor and at the castellina: The flight of steps in eccentric position and the outer passage in the inner courtyard linked to inner structures without partition walls, have favoured the brick vaults crushing both in flight of steps and in passage. In many environments, particularly at first and second floor, some vaults (in straws) are collapsed due to a removal of imposts that may be found in the activation of overturning mechanisms and in the horizontally and vertically bending of the outer walls. There are link floors strongly stressed by
seismic action and in some points of the building these are resulted not sufficient to contrast it. There is an heavy damage in the castellina, built with a unique environment without pin walls, due to a cut on the outer walls.

6.3 Securing Intervention

Design and intervention securing of Centi Palace performed by Abruzzo Region and CNR-ITC, requires both provisional and final works. Provisional works concern:
- the propping of vault environmental of the first and second floor, of the staircase and the passage with a centric system in coupling tube
- the soldier sets of the flat arches
- the ringing of the CASTELLINA using steel cables over wooden tables and steel profiles.

Final works concern the production of links between various levels using plate steel profiles (100mm * 8 mm) connected to all outer walls with steel bars chemically or mechanically anchored. At the corners of the walls the plate is welded to a steel bar blocked on the outer wall with a contrast steel element. The aim of this action is connection walls strengthening resulting efficiency both mechanisms outside the floor and mechanisms inside the floor. Vault ceilings may be put agreement vault impostas and corner profiles connected to ceiling beams may be foreseen where are wooden or steel ceilings. During the final intervention the anchorages may be integrated in reinforcement action so to replace only the anchors constructed by UPN profiles with bolt or packed plates not predictable during the phase of putting in safety.

REFERENCE

[3] Direttiva per la valutazione e riduzione del rischio sismico del patrimonio culturale, approvata con Decreto del Ministero dei BBC pubblicata sul supplemento ordinario n. 24 della gazzetta ufficiale n. 25 del 29 gennaio 2008