



The 6TH April, 2009 L'Aquila Earthquake: Restoration Choices and Pathways

The restoration choices following catastrophic earthquakes have historically pursued different philosophies and methodologies especially with respect to the historical monuments. In Italy there were “centralist” reconstructions as in the Val di Noto, 1693, L'Aquila, 1703, or more pragmatic interventions, like in Friuli 1976 and Irpinia 1980. On the occasion of the most recent earthquakes, Umbria-Marche and Molise, restoring cultural heritage has been classified among the top priorities at the local and national levels, ensuring the reconstruction in a perspective seismic improvement, i.e., without heavy structural measures. The application of the same logic in the case of L'Aquila, where the earthquake hit the center of a capital city, rich in historical and monumental heritage, very significant and concentrated in a limited area with limited access and narrow streets, reduces the possibility of interventions on several structures simultaneously, imposing the securing of the structures for a long time. Securing actions have been designed so as not to change the structural behavior of the damaged artifacts

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The earthquake strikes heavily and traumatically the inhabitants of a territory, whose stability is severely tested as individuals, families, community and the whole local social system. Regardless of type, extension, and historical-architectural value, each single building always represents the principal reference for the resident population. Hence, its damage or complete destruction always implies a significant loss of identity for the territory, which will hardly be restored showing the original aspect.

The reconstruction initiatives launched after several

harmful events – whether natural or wartime – which over time affected the inhabited areas inside and outside Italy, followed different policies and approaches. As a matter of fact, it was decided to proceed case by case with: on-site reconstruction, restoration of the surviving buildings, full replacement of the historical and architectural heritage, delocalization of neighbourhood or town, or a range of interventions based on the damage assessment and the cultural values that places were assigned by their dwellers. Historically, in Italy decisions were mostly based on absolutist evaluations by the Central Government, who in many cases decided to assign one minister plenipotentiary the task of controlling the reconstruction, often adopting compulsory measures against the populations opposing the government's decisions. In this regard, it is worth mentioning the reconstruction

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FIGURE 1 Val di Noto, 11th January, 1693
Source: Author's personal archive

modes implemented in Val di Noto or in L'Aquila after the 1693 and 1703 earthquakes, respectively.

The strong central decision-making power exerted for the demolition of historical buildings and their reconstruction under different form is evident even more recently, at the beginning of last century when the earthquakes of Messina (1908) and Avezzano and Marsica (1915) occurred. Conversely, in the second half of the XX century, the reconstruction choices following the Friuli (1976) and Irpinia (1980) earthquakes were definitely more pragmatic and relevant to the actual extent of the damage to buildings.

In Friuli, large demolitions were made in the areas of Gemona and Venzone: in the former case, besides some isolated monuments, only the buildings overlooking a stretch of urban street were spared, whereas for the latter – mostly thanks to the intervention of Roberto Pirzio-Biroli, Head of the Technical Office for Reconstruction as well as coordinator and founding member of the owner consortia of urban aggregates – the historical centre was reconstructed as and where it was, with the reconstruction of the Dome in terms of careful and rigorous anastylosis by a team headed by Francesco Doglioni, professor of the Venice University.

The type of most proper reconstruction and/or



FIGURE 2 Messina 1908 earthquake
Source: Author's personal archive

restoration is often influenced by the changes that the societal and cultural systems are coping with – particularly in terms of economic development – triggering effects on and changes in the societal texture and the environment that can be evaluated only after a good while. In any case, the cultural heritage of a territory substantially affects the perceptive perspective of the resident population, whether it be a cultural heritage acknowledged preserved by the State Government, or considered as such for history, tradition or mere affection reasons by the local population. Choosing the right kind of intervention to be implemented is a problem arising all the same also following traumatic events such as floods, wars or other catastrophes, causing the loss of significant references for the societal, economic and productive textures in addition to the shock for what occurred. The same may happen for man-made strategic events purposely caused on the grounds of strong economic interests. Such was the case of the construction of the Aswan High Dam, decided by the Egypt and Sudan Governments to foster the development of Ancient Nubia. This area



FIGURE 3 Securing the Torrino in Foligno, following the 1997 earthquake
 Source: Author's personal archive

was subject to the conflicting economic goals of two nations and attracted the cultural interests of the international community, so that under the aegis of UNESCO many countries bore the very high costs for moving monuments to other places, to save them from being doomed to be submerged: the international interest for the local cultural heritage made it worth choosing its full delocalization.

The reconstruction criteria adopted following conflicts were alternatively affected by either the choice to wipe out the signs of events or to leave their trace strong and readable. With regard to the post-World War



FIGURE 4 Restoration of the S. Francesco d'Assisi fresco, following the 1997 earthquake
 Source: Author's personal archive

Two period, most remarkable is the case of Coventry, where the choice was made to leave visible memories of the war events just after the war itself. The same was decided for Berlin's Cathedral. Conversely, in the case of Dresden, it was decided to fully reconstruct the city only after a long time since the end of war during such period the city kept showing the ghostly signs of destruction and, with them, the entire memory of its recent history. Such a choice was shared by Warsaw also, albeit immediately after the end of war.

In many of such cases, the abstract cultural assessment ended up with being replaced by much more forceful and cogent factors, such as people's expectations about the future of their own territory and, at the same time, the valorization of their cultural heritage. The local or central governments' choices were basically oriented to follow this dual vision of the future of the affected territories.

In the light of the above, the need to inform, stimulate and sensitize the awareness of the affected populations is crucial to start up and manage the reconstruction. Essentially, each city changes its structure and functions over time, evolving in accordance with the societal and economic changes it is affected by, even as a consequence of the development of new building technologies (just think about the invention of reinforced concrete and its effects on the urban context). Such changes usually occur in a natural,



FIGURE 5 Securing the bell gable of the Basilica di S. Bernardino in L'Aquila, following the 2009 earthquake
 Source: Author's personal archive



FIGURE 6 Restoration and screening of the ruins in the Church of S. Maria di Collemaggio in L'Aquila, following the 2009 earthquake
 Source: Author's personal archive

balanced and progressive way, taking its historical heritage into account, it too modified and consolidated over time, representing a strong identity element in the urban context. The reconstruction interventions following catastrophic events likewise represent an evolutionary moment of the urban texture, a stage when the traumatic component acts as an incentive to restore the memory of what has been wiped out by events not dependent on the citizens' will.

In the case of the latest national earthquakes, the prevailing trend acknowledged by the Government was to restore the cultural heritage, as clearly stipulated in the related laws in favour of the restoration of the heritage under protection (simpler procedures, fewer technical restrictions, higher economic funds for owners, etc.).

The choice between "seismic upgrading" and "seismic improvement" was strongly debated—where "seismic upgrading" stands for all the works required to ensure that the building safety level is elevated to that of a new building regardless of the original functioning; on the other hand, "seismic improvement" means all interventions are made with almost no alteration of the building while providing it a much better seismic response. Such choice ended up with adopting the seismic improvement, which became one of the qualifying elements of the whole related regulation procedure. At the same time, interventions on the law-protected buildings were made

considering the different "restoration charts" and cultural evolutions in Italy, upon which technicians and restorers had based their work.

When the latest earthquakes occurred, particularly those of Umbria and Marches, and the immediately following Molise quake, the cultural heritage restoration was set among the top priorities at the local and national levels. It was in fact unconceivable not to restore the Upper Basilica in Assisi or the "Torrino" in Foligno, the churches in Fabriano or the damaged parts of the Ducal Palace in Urbino, as well as many other churches and monuments spread all over the affected territories. Any intervention on the cultural heritage posed a serious conceptual, technical and method dilemma: whether following the criteria of scientific restoration as much as possible, restoring just what did remain, or else making interventions to reconstruct the heritage exactly in its original form, though with possible, even substantial integrations in the case of demolitions or collapses.

In Umbria, a mixed criterion correlated to the actual damage was opted for, so as to make interventions as much accurate as possible; nevertheless, should this not be possible due to collapse, intervention of mere actual reconstruction could be envisaged. Typical examples of the kind are the above-mentioned "Torrino" of the Municipal Palace in Foligno (where

only the belfry collapsed, whereas the actual medieval tower was saved thanks to the protection facilities), the Civic Tower in Nocera Umbra (severely damaged and then restored and partially reconstructed), or the Upper Basilica in Assisi (where the vaults, partially collapsed, have been reconstructed with techniques and materials similar to the original church, providing an anti-seismic consolidation system for both the surviving and the reconstructed parts, so ensuring that the complex has an effective, homogeneous seismic response; the decorations of the vaults with frescoes of the greatest value have undergone a massive restoration campaign, based on the strict compliance with the Brandian restoration criteria, and completed with the in-situ repositioning of the restored parts and the neutral (“a neutro”) treatment of those remaining. Following the Umbria emergency, the first securing measures were implemented over the whole damaged territory, allowing to begin the following restoration in a very short time and in a functional and fruitful way, thanks mostly to the optimal architectural conservation methodology and to the consequent opportunity to set-up many building sites at a time, without any interference with one another.

By doing so, it was possible to employ securing facilities particularly innovative and effective, as shown by the manufacturers’ certifications, whose actual duration over time had never been tested before. The use of the so-called “crick” belts – i.e., synthetic belts made of nylon and polyester, provided with proper fastener and traction mechanisms, typically used in transporting, handling and fastening of loads – stemmed from the need to work as fast and easy as possible against drastic curbs on costs. Based on the analyses of damage mechanisms, the application technique was then coded by the Office of the Vice-Commissioner for Umbria, whereas the special VVF squads¹ took care of the installation and set-up of securing facilities. Actually, the suppliers’ information about duration and resistance of synthetic belts was very cautious, since these devices did remain fully efficient even after three years of exposure to atmospheric agents.

Opting for the intervention described above has considerably reduced the amount of economic funds to be specifically allocated, which was also possible

thanks to the unexpected availability to implement and set up securing measures by the special fire department squads who, unlike the past, did not limit themselves to removing the unsafe elements that are dangerous for population.

The whole operation was carried out on the basis of an accurate analysis of the damage and the mechanisms caused by the earthquake, taking into account the research conducted over time by the GNDT group² and in-situ investigations by several damage detection groups. In this way, it was possible to code the mechanisms of the damage to square-base towers and one- or multi-storey belfries. By so doing, the related securing systems resulted as more agile, functional and effective, so as to avoid redundant or unnecessary interventions. The effectiveness of the implemented systems has been fully confirmed on site, even in the case of late restoration interventions. Another factor taken into account was that the seism did not cancel the network of major and minor historical centres, so that no intervention on the urban texture was demanded. Conversely, a different scenario is shown for L’Aquila, where interventions were made in a context particularly difficult and complex due to the extensive damage and the reduced area, just a few hectares, of the related historical centre, characterized by an extraordinary concentration of buildings with a high artistic and historical value. Another constraint was the likelihood of very long-term restoration interventions with respect to their complexity, the reciprocal interference of sites and the huge amount of funds to be allocated. In addition, due the size of the historical centre, particularly binding were the interactions between what was law-protected and the remaining part of buildings to be correlated to monumental emergencies: this necessarily implied that restoration interventions were to be included in the more general context of urban planning, inevitably delaying their execution. In any case, this slowed the decision process down, although such delay could have offered better conditions and chance to re-design L’Aquila in terms of both the historical centre development and the requalification of the city outskirts.

For this earthquake too it was necessary to allow the population to immediately have their retrievable belongings back, which demanded implementing

all measures to ensure people to access their own dwellings as much easily and safely as possible.

In the light of the above-mentioned factors and the will to fully safeguard the principles of the “restoration charts” and the lessons of past experiences, it was thought to preserve everything as much as possible albeit damaged, so that the surviving architectural structures, or what remained of them, could be re-used and integrated in following restoration interventions. Such criterion was also applied to minor buildings in their role as necessary general context of monumental buildings.

This guideline has been widely shared by the municipal administration –who was in charge to materially ensure the emergency securing interventions– and the Italian Ministry of Cultural Heritage in concert with the Vice-Commissioner for the protection of Cultural Heritage, so that in L’Aquila and in the other towns affected by the earthquake no authorization was issued to demolish cultural heritage elements, just like it previously happened in Umbria.

It is clear that in many cases the surviving parts were so small that the reconstruction of the damaged heritage was not possible. Yet, by preserving them a modern intervention can be made taking into account the pre-existing parts and including them in the framework of an overall design. That is what already happened for the Church of San Gregorio Magno, in San Gregorio dell’Aquila: the Vice-Commissioner issued an international design contest for the restoration of the church.

The earthquake of 6th April, 2009 severely affected the city of L’Aquila, also regional capital, hosting almost a hundred thousand people, with a very rich artistic and monumental heritage, mostly included in its historical centre. Choosing to implement securing measures and restore this essential part of L’Aquila has proven to be an unprecedented effort in the national cultural heritage scenario, due to the need to secure a very high number of monuments and movable heritage, some demanding very urgent, complex and delicate interventions.

Each catastrophic event is a moment for testing and improving the techniques and methods used in the previous emergencies. In 1997, when the Umbria-Marches earthquake occurred, the Office of the Vice-Commissioner for Cultural Heritage, assisted



FIGURE 7 Securing and roofing the transept in the Church of S. Maria di Collemaggio in L’Aquila, following the 2009 earthquake

Source: Author’s personal archive

by external consultants and the special VVF squads, developed an innovative set of securing techniques which has been effectively implemented in the following earthquakes, thus becoming the key know-how and expertise used in L’Aquila emergency events. For instance, the analysis of damage evolution in the belfry of Santa Maria Assunta in Sellano provided the outline for the intervention on the belfry of the Basilica di San Bernardino in L’Aquila, whereas Doglioni’s studies on the collapse mechanisms of great churches in Friuli, re-elaborated and enhanced during the emergency in Umbria, allowed to build provisional works in Abruzzo, just limited to the parts of structural complexes more at risk, such as façades and apses. The lesson learned by experience is that securing interventions are effective when they do not alter the structural behaviour of the damaged buildings, which must consequently be restored if needed, as in the case of the detachment of the façade from the rest of the walls or when the wall resistance is interrupted. Such interventions must never hamper the following restoration operations, but rather be a functional tool propaedeutical to the execution of works.

While designing the securing systems it is important to keep in mind that earthquakes are dynamic events which, regardless of their violence, do not end with



FIGURE 8 Securing the dome of the Church of S. Maria del Suffragio in L'Aquila, following the 2009 earthquake
 Source: Author's personal archive

one stress action but rather they repeat over time with further stress on the already damaged structures. In the light of this, solutions based on structures in contrast must be avoided, because they could cause hammering, due to the aftershocks, badly damaging the buildings to protect. Therefore, the securing intervention stems from the observation of structures and their damage, allowing to exactly detect the collapse mechanism and implement the provisional solutions most suitable and effective. With the Umbria-Marches emergency of 1997, the securing intervention techniques were considerably enhanced, mostly thanks to the use of innovative methods and materials and the support of specialized operators of the SAF (speleo-alpine-fluvial) squads of the fire department. The scientific progress lead the sector to further improve its operative capabilities

through a set of new technologies such as, e.g., the laser-scanner detecting systems, stainless steel braided wires, high-resistance fiber artifacts, and FRP section bars, all resources that have been widely and differently used in the provisional works in L'Aquila. Composed of a huge amount of art works, paintings, sculptures, books and documents, the mobile artwork heritage affected by the Abruzzo earthquake has been retrieved and/or made safe with large use of technical and human resources, often working in dangerous conditions because not always clearing could be carried out once the provisional works had started. Examples are the recovery interventions of the materials of the Archivio di Stato³ in the Prefecture Palace, and the National Museum in the semi-collapsed part of the Spanish Fort, which were made before the securing interventions, in order to avoid the risk of further damaging due to atmospheric events. In these cases, the VVF played a key role, so did the volunteers of the Civil Protection Department. As a whole, over 5,000 mobile artworks and 250,000 books have been removed and recovered. Thanks to the recovery of all these books the Archivio di Stato was opened in a new palace after only a few months.

Due to the particular scenario of L'Aquila a dual intervention approach was implemented, as it was not possible to make the huge quantity of damaged buildings safe only by the support of VVF. In fact, the monuments recorded in the whole affected territory are about 1,800, single buildings and building complexes, besides all the buildings representing the urban texture of the centres belonging to such a context. This heritage is mostly concentrated in the historical centre of L'Aquila. Taking into account these conditions, the Vice-Commissioner Office ensured, through the VVF or private enterprises in the worst cases, that most important buildings protected by laws were made safe, whereas the municipal governments were responsible for the provisional interventions on the remaining buildings, in accordance with projects elaborated with the Vice-Commissioner Office in cooperation with private firms.

The need to quickly reduce the spreading of the so-called "red zone", i.e., the no-access area subject to armed surveillance by the Army, was immediately

clear for two reasons mainly. On the one hand the need to allow the population to retrieve their belongings basically safeguarding their personal identity, on the other the need to give the citizens of L'Aquila access to their life places (actually only some main streets) as soon as possible, in order to prevent them from disaffection phenomena, further delaying the following reconstruction. This phenomenon already occurred in Umbria, precisely in Nocera, where the whole historic centre was indiscriminately closed, and the population built their new dwellings out of that area, thus losing interest in and motivation to the following recovery opportunity.

In the light of the above, and urged by the need to avoid that the provisional works could hamper the reconstruction phase, an intervention design criterion was defined, aimed at restoring the vertical load-bearing capacity of masonry buildings by using vertical elements capable of ensuring the plane stability of the perimeter walls (along with opening ringing, filling of the collapsed portions, etc.), devices ensuring the good cohesion of the external walls (wooden or iron beam grids on the external surfaces), and systems of metal tie beams properly tightened between the walls so as to ensure that the structure had a "box" behaviour. Specific completion facilities (provisional roofing, rockfall protection structures, etc.) were provided wherever needed.

The above resulted in extended and non-invasive safe condition allowing to plan the final works without rush, so as to provide streets reasonably accessible, use of some of commercial spaces and the possibility for citizens to access their own dwellings and still be able to partially live the historical centre.

This choice was correlated to the will of safeguarding what remained of L'Aquila historical centre and the law-protected parts of the minor centres of the territory, being well aware that indiscriminately demolishing the non-law-protected buildings would not have saved time, just as it happened in some hamlets of L'Aquila, e.g., in San Gregorio or Onna, with the false illusion to speed up the reconstruction works. As easily verified, also in these places the restoring times depended on the complexity of problems rather than on the administrative will. In this sense, the hamlet of Paganica



FIGURE 9 Securing and roofing the Church of S. Maria di Paganica in L'Aquila, following the 2009 earthquake
Source: Author's personal archive

with its ruins tenaciously protected by the population is a virtuous example of heritage safeguarding.

The Vice-Commissioner Office, with the support of VVF squads mainly, ensured that the law-protected and particularly important heritage was made safe, intervening on the severely damaged structures whose collapse could have caused them further damage. Some examples are the recovery of the remains of San Bernardino in the convent of the same name, and the securing interventions to the belfry and the dome of the Basilica dedicated to the saint, directly borrowed from the interventions made in Umbria after the 1997 earthquake. By other means yet by the same technique that led to the private housing projects, the stability of the most ancient part of the XVI century Castle was ensured by tying the internal double-lodge structure (almost overturning on the court) with the robust external masonry of the fortress by way of stainless steel tie beams and metal partition structures placed on the internal façade, also affected by some collapses on the second floor.

In the framework of assessing the damage to cultural heritage, the Church of Santa Maria del Suffragio (or delle Anime Sante, built following the 1703 earthquake in memory of the casualties) drew a particular attention, mainly for the very severe conditions of its dome, a valuable architectonic element attributed to Giuseppe Valadier, mostly collapsed and for this reason to be



FIGURE 10 Securing the Duomo in L'Aquila, following the 2009 earthquake
 Source: Author's personal archive

necessarily secured to ensure its correct restoration. The intervention was characterized by many dangerous aspects both for the reiterating quakes and for the precarious situation of the artifact remains. Using a sophisticated laser-scanner to survey the damaged structures was fundamental to design the system of provisional works required to ensure the complex stability. Besides providing very-high-precision measurements, the laser-scanner device allowed the technical staff to investigate the dome in complete safety, since the overall operation was carried out with automatic-control mobile machines transported on site by a remote-control mechanical shaft.

The laser-scanner survey allowed to define a securing intervention to be carried out in more phases and times: firstly an outringing to prevent the stump from overturning; then the prefabrication of three metal structures: two of them allow to restore the tambour continuity interrupted by the collapse, and the third one acts as internal contrast element allowing to avoid the implosion of the whole structure (remaining parts of the dome and the tambour). The laser-scanner investigation also allowed to make proper simulation to fine-tune the times and modes of operation, and to schedule a specific training of the VVF squads responsible for the intervention.

Many observers criticized the efforts to safeguard the surviving parts of the dome and the tambour of the

Anime Sante, erroneously thinking that they would be demolished anyway in the following reconstruction phase. Such evaluation was completely wrong since the project, designed by Italian and French technicians, provides the preservation and integration of all surviving parts, making the reconstruction of the lacking elements as much accurate as possible, enabling to follow the traces and remains of the elements lying on site. On a much larger scale, this may be said for the whole city of L'Aquila, where the historical centre could not certainly be consolidated in the state it is secured today, however it will be reconstructed in a proper and philologically correct way thanks to the traces left by the preserved parts.

Another intervention with a very remarkable effort was that made on the Basilica di Santa Maria di Collemaggio, which consisted in recovering the remains of Pope Celestine V, securing the whole complex (by selecting the collapsed materials, retrieving the gravestone elements and saving the pipe organ), and setting-up and installing a massive metal roofing structure, allowing to re-open the Basilica for Christmas 2009. The provisional works were inspired by several different technologies, as shown by the synthetic-belt ringing of the columns of the naves, the steel wires to avoid the possible overturning of the side walls, the centering of the arches most at risk and installing on the transept a light translucent roofing, supported by steel trusses standing on reticular metal bases. Besides fast re-opening the Basilica to the public, the intervention allowed retrieving, with archaeological methods, all the fragments from its interiors, thus also enabling to fully recompose the decorations in the choir of the organ (a valuable high-age piece made of carved and gilded wood) and the related sound-amplifying apparatus.

The most complex interventions were subject to continuous instrumental monitoring by several Italian and international Universities: IUAV in Venice, Faculty of Engineering – University of L'Aquila, Building and Transport Department – University of Padua, Faculty of Engineering - Politecnico di Torino, the Tokyo Japan Society for the Promotion of Science Tokyo, the Istituto Superiore di Conservazione e Restauro of the Italian Ministry of Cultural Heritage.

The principal danger for L'Aquila and, mostly, its historical centre, is that the very long-term reconstruction – due to



FIGURE 11 Securing historical palaces in the historical centre of L'Aquila, following the 2009 earthquake
Source: Author's personal archive

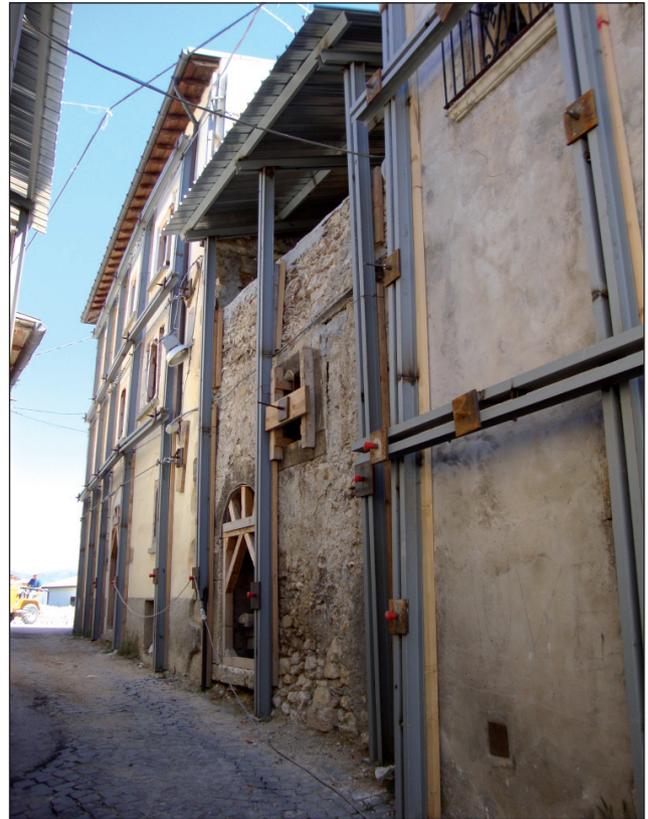


FIGURE 12 Securing historical palaces in the historical centre of L'Aquila, following the 2009 earthquake
Source: Author's personal archive

many complex problems and above all the “physically” impossible setting-up and management of hundreds of site yards in a few hectares area – might make the population lose their motivation, determination and interest in making their city rise again, a city surely made of dwellings, churches and monuments, but mostly of a widespread sociality without which other essential realities and activities are impossible. Securing interventions were made in the attempt to avoid such a risk, and some streets and areas symbol of the town were re-opened as sooner as possible, so that all citizens could keep their link with what will be possibly restored strong and alive. In this sense, securing the old Convent of Sant’Agostino – the headquarters of the Prefecture Office – so criticized in terms of opportunities, is a kind of intervention propaedeutical to a restoration capable of integrating the surviving parts into a great

project of re-use and completion well integrated in the urban texture of the city. The careful work of conservation and restoration of all that has not been completely destroyed by the earthquake will allow, starting from the existing elements, to reconstruct L’Aquila in complete accordance with its soul and its millenary past, learning from the earthquake event the lesson to make the city, its historical centre and the entire territory safer, more welcoming and functional, being aware of the Nature’s dangers and the possibility to face and overcome them.

Notes

1. Special Fire Department squads.
2. GNDT is the acronym for Gruppo Nazionale Difesa dai Terremoti (the Italian National Group for Earthquake Protection).
3. The Public Records Office.