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Earthquake – Knowledge of Places, Historical Memory and Awareness to Reduce Risk of Disasters

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Abstract

This study has compared data from the two last strongest earthquakes which occurred in Italy respectively in 2009 and 2012. The data has been collected through an extensive work in the field begun in 2009 and concerns mainly the local architecture of the historical centres, the environment, people's traditions, institutions and legislation of the towns of Sulmona and Anversa degli Abruzzi, situated in the Province of L'Aquila (Abruzzo) and of the towns of Carpi and Novi di Modena, situated in the Province of Modena (Emilia Romagna). The goal is to understand how the history of places, their built environment and people have influenced the reconstruction after the disasters in order to identify indicators that could help to find strategies to enhance the communities' resilience and to give some suggestions about prevention.

The Abruzzo and Emilia regions are different due to their location, history, geographical characteristics, economy and construction techniques. People from Abruzzo periodically suffer strong earthquakes, whereas people from Emilia had not expected strong seismic shakes before 2012.

The main key-elements identified are: accessibility, knowledge of the structural development of buildings and structural anomalies, anti-seismic legislation, people's awareness, participatory planning, plans for the reconstruction. An efficient management of data about buildings and the urban environment could allow the municipalities to make prevention and to be more resilient.

Keywords: vulnerability, prevention, reconstruction, earthquake, awareness

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Introduction

The last two major earthquakes that have struck Italy occurred in Abruzzo region in 2009 and in Emilia Romagna region in 2012, situated respectively in the centre and in the southern part of northern Italy. Despite L'Aquila and Bologna, their capital towns, are less than 300km apart as the crow flies, the history, geographical characteristics, economy and construction techniques make the regions different.

This article analyses some of the historical, urban and cultural aspects of two areas hit by the disasters, focusing on the municipalities of Sulmona and Anversa degli Abruzzi in the Province of L'Aquila and on the municipalities of Carpi and Novi di Modena in the Province of Modena, in order to identify key-elements that can inform us on recovery and reconstruction. The data has been collected through extensive work in the field begun in 2009 and concerns mainly the historical centres, also including some considerations about industrial and rural typologies.



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Overview of the Province of L'Aquila - the towns of Sulmona and Anversa degli Abruzzi

About 90% of the Province of L'Aquila is mountainous. The orography and emigration have strongly influenced the urbanization: the small municipalities (less than 1.000 people) are about 50% of the total. It is a quite low industrialised province (21.000€ of GDP per capita in 2012, against an Italian average of 24.200 €). Lots of severe earthquakes have struck the Province of L'Aquila throughout the centuries. The last events were so frequent (1905, 1915, 1933, 1984, 2009) that the legislation has considered this area among the seismic of Italy since 1915.

Sulmona is a town of 24.275 people situated in the Peligna Valley at an elevation of 405 mamsl and Anversa is a small town of 368 people built along a steep mountain side and next to deep gorges (Gole del Sagittario) at an elevation of 604 mamsl. Castrovalva, currently Anversa's hamlet, is a small village of 19 inhabitants situated at 865 mamsl and perched on the mountain that is in front of Anversa.

The natural environment has influenced the urban development of Sulmona, whose old town was built in a plain area between two rivers, and has strongly limited the urban development of Anversa, whose urban structure traces the medieval pattern with narrow alleys parallel to the mountain side and connected by stairs. Due to the severe earthquakes that have hit the towns and damaged their built environment, the medieval building stock have been largely replaced respectively since the 16th and the 18th century (Grossi 2007). While Sulmona expanded between the 1960's and the 1980's due the industrial development, Anversa's people have progressively decreased until now, so that currently 64,52% of the apartments are second residences. In 2012 in Sulmona there were 1.872 companies: 84 in agriculture and livestock farming, 187 in industry, 1.600 in the tertiary sector. In Anversa there were 28 companies, whose 7 in agriculture and livestock farming, 1 in industry, 20 in the tertiary sector (Camera di Commercio, 2015).

Overview of the Province of Modena - The Towns of Carpi and Novi di Modena

About 47% of the Province of Modena is part of the Po valley, the largest plain in Italy, whose population has increased in the last century especially in the main towns and where the economic growth has been higher, such as in Carpi and Novi di Modena. It is one of the wealthiest and more industrialised provinces of Italy (30.000€ of GDP per capita in 2012, against an Italian average of 24.200 €) The average number of people in each municipality is about 13.960, higher than the inhabitants of Celano, the 4th biggest town of the province of L'Aquila. The province of Modena has been considered, also by the legislations, among the lowest seismic areas of Italy until 2005 because the last and strongest earthquakes that struck it before 2012 occurred in 1570, 1796 and 1831.

Carpi (67.268 inhabitants) and Novi di Modena (10.972 inhabitants) are in the Po Valley, respectively at an elevation of 26 and 21 mamsl. Both their road networks were influenced by the Roman centuriation, but while the architecture of Carpi, with mainly brick structures of 3-4 floors and some buildings of historic and artistic value, dates back to the middle ages with a complex later evolution over time especially since the 18th century, the architecture of the old town of Novi is quite heterogeneous, with mainly brick buildings of 2-3 floors, but also some concrete frame structures, as the result of the evolution of an ancient unit that was extended at the



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beginning of the 20th century (Gruppo Storico Novese 1983-2007-2013). In 2012 in Carpi there were 7211 companies: 644 in agriculture and livestock farming, 1576 in industry, 4991 in the tertiary sector. In Novi there were 1114 companies, whose 216 in agriculture and livestock farming, 365 in industry, 533 in the tertiary sector (Camera di Commercio, 2015).

Considerations about the Urban Scale

The location influences the accessibility: while the old town of Sulmona, Carpi and Novi can be accessed by several streets, Anversa can be reached by three streets and Castrovalva just by a narrow one and with small means of transportation.

In Sulmona, Carpi, Anversa and Castrovalva most of the buildings are very close each other and the streets are narrow so that in the event of strong earthquakes few places can be considered safe other than the squares. But while in Sulmona, Carpi and Novi, rescue operations can be carried out reaching almost all the damaged areas, in places like Anversa most of the inhabitants can be rescued only climbing the steep staircases so, if the buildings collapse, streets and buildings might become an indistinct heap of rubble. It means that in easily accessible places the location slightly influences the reparation and reconstruction costs, whereas in difficult accessible places it increases the rescue time and risks, the costs of design and reparation of the single buildings and the duration of the works.

Considerations about the Built Environment

The construction materials come from the natural environment surrounding the villages: in Sulmona and Anversa they built mainly stone walls, light timber frame roofs and vaulted ceilings. In Carpi and in many buildings in Novi they built brick walls, light timber frame roofs and timber beam ceilings. There are vaults in some buildings of historic value and along the portico walkways. Flat ceilings with iron beams and segmental vaults built since the beginning of the 20th century can be found in all the municipalities of the sample. In Carpi and Novi they are the typical structures of the old rural houses.

Although in the towns the materials and the construction techniques were quite homogeneous, the quality, shapes and historical development of the buildings over the time make them very different from each other, with consequences on their seismic resistance.

Rich people usually built good quality houses, that withstand the earthquake quite well: in Sulmona and Anversa thick walls made by well moulded stones and quite big flats with regular shaped plant on every floor, in Carpi and Novi thick brick walls, quite well connected with each other and sometimes the insertion of ties.

In the four municipalities of the sample, especially poor people that have lived in the buildings throughout the centuries have often modified the original main structures inside and outside, according to their needs. It increased the vulnerabilities that are invisible to the untrained eye but make the difference in the event of an earthquake. In Anversa as poor families grew, they enlarged the apartments also adding floors, or part of them, using poor quality construction materials. The consequences were the overall irregular shape of the blocks and the lack of appropriate connections and different stiffness between the old and added parts. Besides, flats were often so small that people used to carve recesses in the main walls to store things like



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kitchenware or clothes, making those walls weaker and, also in the province of Modena, people often built main walls not aligned with the ones on the lower floors, which overloads the weak part of the main structures such as vaults.

Besides, in Carpi, Sulmona and Anversa, due to the medieval urban development, most of the buildings are quite tall (2-6 floors) and have been built close to each other with the main walls in common, so that they withstand the earthquake as compact blocks in which every structural unit contribute to the overall resistance. But in Anversa and Castrovalva the blocks of flats are very irregular for number of floors, shapes and dimensions because follow the development of the road system along the steep mountain side, whereas in Carpi they are quite regular because they have been built in a flat area. As a consequence in Anversa there is usually no correspondence between the facades and the inner development of the apartments so that the structural units that need an unitary intervention of reparation can not be easily identified by looking at the blocks from the outside, whereas in Carpi and Novi the situation is just the opposite. For this reason in Anversa the identification of the structural units called for inspections and accurate surveys to be carried out by technicians that started analysing the damage surveys filled out by the Civil Protection. This process took months because many flats are second residences and so they are empty for almost the entire year. On the contrary in Carpi and Novi just one team of technicians were able to identify the structural units observing the buildings from the streets. This process has been quite long but not excessively difficult also because almost all the flats were used as main residences and had a manager and so the damages surveys filled out by the civil Protection were quite exhaustive.

In brief repairing buildings in the old towns is technically complicated, long and expensive, mainly because many hard to predict situations can occur during the works, sometimes needing a review of the project and new authorizations from the municipalities. So the more they are damaged, the longest and the more expensive is the reparation.

Considerations about People

In both the provinces the Civil Protection has been very efficient in managing the emergency response, with volunteers and aids come from all over Italy.

In Sulmona and Anversa one of the main strength is people's awareness that earthquakes can occur. One of the clearest proof of it is that both rich and poor people have been reinforcing buildings throughout the centuries, not only after earthquakes but also for ordinary renovations. A study conducted on the old town of Sulmona compares the buildings damaged by the earthquakes occurred in 1915, 1933, 1984 and 2009 showing that on average the structures damaged by an earthquake were different from the ones damaged by previous ones (Galadini and Carozzo 2014). A study shows that in 2006 over 63% of the buildings in the old town of Sulmona had already been reinforced by the insertion of ties (Cifani et al. 2006). The same link can be found analyzing data from the earthquake occurred in 1984 and in 2009 in Anversa. This reasoning does not apply to the occurrence of catastrophic tremors or in case of buildings that have been damaged in previous earthquakes, but still not repaired years later, when the next tremors occur. Besides, an already reinforced building may be seriously damaged by another earthquake if the reinforcement is not enough or even not appropriate. The difficulty in



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implementing scientific studies, together with the difficulty in assessing the structural behaviour of masonry and mixed stone structures, may imply the application of incorrect technical solutions, such as the habit of building thick and heavy reinforced concrete edge beams and roofs at the top of ancient walls in order to give them stability, that was very common during the reconstruction following the earthquake of 1984. Damages provoked by the earthquake of 2009 have shown that the technique contributed positively to achieving the box behaviour only of the few structures made of thick and resistant walls, but contributed to the crumbling of weaker buildings. In some cases buildings lightly damaged and soon repaired in 1984 were severely compromised in 2009. The earthquake is actually the true tester of construction and reparation techniques and so the next one will test the use of reinforced carbon and glass fiber that have been largely used since 2009 as innovative materials for structural reparation and strengthening. Considering Carpi and Novi, the research shows that one of the main weaknesses is people's lack of awareness that earthquakes can occur, probably due to the exposure at low-frequency and high-severity events throughout the centuries. A clear evidence of this is that although after the catastrophic earthquake occurred in 1570, not far from the epicentre of the earthquake of 2012, the architect Pirro Ligorio designed the first anti-seismic house with criteria that are still valid nowadays, people from Emilia have only occasionally reinforced buildings throughout the centuries and seldom during ordinary renovations. An example is the old town of Novi in which most of the buildings have been severely damaged by the earthquake, whereas the theatre, designed and built in 1926, with careful attention to the smallest details, including ties at every floor, was left almost undamaged. Actually the insertion of ties was mainly aimed at preventing bulging walls and was common as very local reinforcement of some kinds of structures such as the vaulted ceilings of traditional stables, the portico walkways and some churches. Only after the emergency law *Ordinanza 3274/2003*, that was issued after the earthquake that affected San Giuliano di Puglia (Province of Campobasso, Italy), the structural design and implementation had to be carried out according to anti-seismic criteria, whereas before this law the designer could choose whether to design with anti-seismic criteria or not and the market usually required traditional construction because it was less expensive (Meletti and Stucchi, 2009). This explains the large number of precast warehouses with isostatic structure, that were built in the municipalities of Carpi and Novi from the '80s and the 2000's and were severely damaged or collapsed due to the earthquake. The economic loss suffered by this area, that is one of the wealthiest of Europe, has been devastating. On the contrary in Sulmona industrial plants had built with anti-seismic criteria and were lightly damaged by the earthquake occurred in 2009. Research on other indicators that can reveal people's awareness of the earthquake has not found such clear results as that of people's habit of strengthening buildings. For example scholars of dialect from Sulmona and Anversa do not remember specific expressions or proverbs that mention the earthquake, whereas lots of people from Modena and the areas nearby have heard old people saying in dialect expressions such as: “Satta Modna a gh'è l'aqua. Sa vin un teremòt an fa gninta” - “There's water beneath Modena. If an earthquake occurs it does not provoke damages”, that seems to confirm their lack of awareness about that kind of event (Mininni 2015). Other traces can be found in Sulmona and Anversa in the religious cult of Sant'Emidio, because the Catholics think it protects them from the earthquakes (Castelli and Camassi 2004). The cult is



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indeed venerated in lots of seismic areas around the world but is not very significant in the local culture of the area of Carpi and Novi.

People's Imagination of Places in the Reconstruction Planning

The many laws and restrictions that regulate the construction activity in the old towns of the sample show people's awareness of the uniqueness and value of their historical centres and represent the willingness to protect not just single buildings but the urban environment as a whole and, in the case of Anversa, also the natural environment. The damages suffered by the municipalities of Sulmona and Anversa have not been severe enough to call into question the restrictions of the ordinary regulations. On the contrary, due to the large amount of damages suffered by the growth and production areas, Carpi and Novi have designed a plan for the reconstruction aimed at updating and rationalizing the rules and the constraints of the zoning plan, in order to manage the reconstruction in a more flexible way. They have reviewed the historical and typological constraints both in the urban and in rural areas, also allowing demolitions and the relocation of industrial plants and warehouses. Moreover the municipality of Novi promoted and managed a participatory community based planning that involved people from any age and sector of society. It was aimed at informing the designers about people's needs and expectations.

Results

Some indicators can reveal how different environments can influence recovery and reconstruction. Accessibility of an urban environment influences the rescue operations, the risks, time and reconstruction costs.

The knowledge of the structural development of buildings throughout time and their possible anomalies, together with the knowledge of the behaviour of their structural elements of specific typology and materials, allow us to understand how the single buildings withstand an earthquake.

The severe damages suffered by the industrial plants in Carpi and Novi show that the wealth of an area does not necessarily imply that there are prevention, awareness and safety.

A restrictive anti-seismic legislation plays an essential role in preventing severe damages and contributes in making people more aware of the risks.

People's awareness that a disaster may occur can be revealed by the prevention measures that they adopt in order to reinforce their buildings. In some contexts other indicators might come from the popular culture and religious traditions.

People's imagination of the places could be revealed by the laws that regulate the municipalities, the participatory planning and the plans for the reconstruction.

In order to be more resilient to the earthquakes the municipalities could organize databases about structures and maps of the vulnerabilities managing all the data collected over time through building permissions (plans, prospects, sections, etc) and other documents. An efficient data management could allow them to better know the characteristics and vulnerabilities of the buildings, of the urban environment and to define the structural units before the earthquake occurs. It would make the reconstruction faster and cheaper.



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The reconstruction could be an opportunity to make cities more coherent with their inhabitants' needs. For example the ancient buildings could be made “smart” with the insertion of sensors aimed at monitoring their structural anomalies and vulnerabilities over time.

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Author's Biography



A Building Engineer (MSE), she has been working in the reconstruction field for six years following the major earthquakes that occurred in Italy in 2009 and 2012. She has been dealing with the reparation and reconstruction of buildings.

In 2013 she was invited by the Faculty of Engineering of the University of Bologna (Italy) to give a lecture on the reconstruction of ancient buildings damaged by the earthquake. She attended a course for Disaster Risk Management (World Bank, 2014)