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Earthquake – Historical memory and awareness, tools that reduce risk of disasters

Abstract

This study has collected and compared data from the two last strongest earthquakes which occurred in Italy, in the regions of Abruzzo and Emilia Romagna, respectively in 2009 and 2012. Its goal is to understand how the history of places, their built environment and people have influenced the reconstruction after the disasters. The comparison is aimed at identifying elements that could help to find strategies to enhance the communities' resilience.

The data had been collected through an extensive work in the field begun in 2009 and concern 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 Abruzzo and Emilia regions are different due to their location, history, geographical characteristics, economy and their construction techniques. People from Abruzzo periodically suffer strong earthquakes, whereas people from Emilia had not expected strong seismic shakes before 2012.

The collected data shows that the history of the built environment, together with the natural environment and people's beliefs, have strongly influenced the reconstructions.

Both events show that old towns are very often vulnerable due to their past history, because of the use of old construction materials and techniques and certain urban morphology. But recent history, together with lack of prevention and the lack of awareness that the earthquake could occur has made the difference: old brick buildings have been lightly damaged in Abruzzo's towns where suitable prevention measures had been carried out during previous reconstructions, whereas they were seriously damaged in Emilia, because few prevention measures were taken before the earthquake. On the other hand, over the last decades, renovation works carried out using unsuitable techniques on old structures in Abruzzo made buildings collapse. In Emilia new industrial warehouses collapsed because they were built without anti-seismic techniques. Both Abruzzo and Emilia have chosen to preserve the architecture of their old towns, allowing reparation interventions instead of demolition and reconstruction, but due to the large amount of damages suffered by the growth and production areas, Carpi and Novi have also 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.

Before the disasters occur, the institutions should educate people on awareness and prevention. They also could better manage lots of data that they have collected about buildings, in order to map and monitor the vulnerability of the urban and rural environment.

Keywords: vulnerability, prevention, reconstruction, earthquake, awareness

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Introduction

The last two major earthquakes that have stricken Italy occurred in Abruzzo region in 2009 and in Emilia Romagna region in 2012. The first is situated in the center of Italy and the second one is situated in the south part of northern Italy. L'Aquila and Bologna, their capital towns, are less than 300Km apart as the

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crow flies. Despite this short distance, their history, geographical characteristics, economy and construction techniques make them 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 teach us about recovery and reconstruction. The cases are discussed comparing the same aspects.

The data have been collected through an extensive work in the field begun in 2009 and concern mainly the historical centres, also including some considerations about industrial and rural typologies that have had particular relevance in the two cases.

Method: 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. Sulmona is situated in Peligna Valley, a plateau that can be considered among the few and biggest plains of the province. The orography and the emigration have strongly influenced the urbanization: over 50 municipalities have less than 1000 inhabitants and 25 of them have less than 500 people. The small municipalities are about 50% of the total, having just the 8% of the inhabitants of the province. The average height of the villages is 812 mamsl.

The GDP per capita in the province of L'Aquila in 2012 was 19.893,4 euros.

Lots of earthquakes have struck the Province of L'Aquila throughout the centuries. The major ones occurred in 1706, 1905, 1915, 1933, 1984 and 2009.

Due to the frequency of these events the province of L'Aquila has been considered among the highest seismic areas of Italy since 1915. The legislation provides specific rules for the construction of buildings.

Sulmona is a town of 24.275 people and is at an elevation of 405m above the sea level. It was built in the Peligna Valley between two rivers, Gizio and Vella, to be protected from enemy attacks. During the middle ages it was expanded southbound between the rivers and later also northbound. The current road system of its old town still traces the "castrum" built by the Romans and the later medieval urban development. Due to the severe earthquakes that have hit the town and repeatedly damaged its built environment, it seems that the renaissance building stock have been largely replaced in since the 18th century. The town expanded between the 1960's and the 1980's due the industrial development. The productive district currently has about 92 companies, whose 9 are industrial facilities and 83 are craft industries. Few buildings have been lightly damaged by the earthquake occurred in 2009 and only two requests for state aid have been submitted to the municipality. In 2012 in Sulmona there were 1.872 companies: 84 in agriculture and livestock farming, 187 in industry, 1.600 in the tertiary sector.

Anversa is a town of 368 people and is at an elevation of 604 m above the sea level. It was built along a steep mountain side and next to deep gorges to be protected from enemy attacks. The urban development has been limited on the west side by the river Sagittario, that flows at the bottom of the gorge, and on the east side by a large area subjected to landslides. The current urban structure traces the medieval pattern in which the castle overlooked the valley and the narrow alleys were developed parallel to the mountain side, being connected by stairs. The town has suffered severe earthquakes that have repeatedly damaged its built environment so it seems that the current building stock is constituted by some medieval elements such as the so-called "house-boundary walls" with their battlements, the blocks built by Maestri Lombardi after the earthquake that occurred in 1456, and several buildings built in the 16th century. It had 1934 inhabitants in 1901, that have progressively decreased until now, so that currently 64,52% of the apartments are second residences and few buildings have been built since the last century. In 2012 in Anversa there were 28 companies: 7 in agriculture and livestock farming, 1 in industry, 20 in the tertiary sector.

Castrovalva, currently Anversa's hamlet, is a small village of 19 inhabitants situated at 865 m above the sea level and perched on the mountain that is in front of Anversa. It can be reached only by a narrow road that rises along the sides of the mountain through hairpin turns. Its spindle-shaped urban pattern has developed along the crest of the mountain since the middle age.

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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. The remaining 53% is hilly (17%) and mountainous (36%).

In the last century the population of the plain area has increased especially in the main towns and where the economic growth has been higher, such as in Carpi and Novi, whereas the population of the mountainous areas has decreased. For example Carpi had 37.841 inhabitants in 1951, 55.494 in 1971, 60.786 in 1991 and 67.268 in 2011.

It means that the average number of people in each municipality is about 13.960 and the smallest one is Camposanto, with 3.249 inhabitants. In fact the number of inhabitants of about 50% of the villages in the province of L'Aquila can be compared with the inhabitants of the hamlets of the municipalities in the province of Modena. The average height of the villages is about 26 mamsl. The GDP per capita in the province of Modena in 2012 was 29.628,3 euros.

The Province of Modena has been struck by various earthquakes throughout the centuries. The last and strongest before 2012 occurred in 1570 and 1796. Other minor events occurred in the following centuries and the last one was in 1996.

Due to the frequency of these events the province of Modena has been considered among the lowest seismic areas of Italy.

Carpi and Novi di Modena are in the Po Valley.

Carpi is a town of 67.268 people and is at an elevation of 26 m above the sea level. The urban pattern of the town, with quite regular blocks delimited by streets, was influenced by the Roman centuriation and its architecture dates back to the Middle Ages with a complex later evolution and modifications over time, especially since the 18th century. There are mainly brick structures of 3-4 floors and some buildings of historic and artistic value. In 2012 in Carpi there were 7211 companies: 644 in agriculture and livestock farming, 1576 in industry, 4991 in the tertiary sector.

Novi di Modena is a town of 10.972 people and it is at an elevation of 21 above the sea level. The road network of the old town dates back to the Roman centuriation, whereas the northern part of the old town was built in the 16th century as a small village outside the castle walls. The overall current urban pattern is the result of the evolution of this ancient unit, that was extended southbound at the beginning of the 20th century. The architectural environment of the town is therefore quite heterogeneous. There are indeed some rowhouses in the northern part along the main street, but also detached houses with gardens. They are mainly brick structures of 2-3 floors, but also some concrete frames and the streets are quite large. In 2012 in Novi there were 1114 companies: 216 in agriculture and livestock farming, 365 in industry, 533 in the tertiary sector.

Considerations about the urban scale

On a urban scale, the location and shape of these towns give information for example about the accessibility, the availability of safe places in case of emergency, rescue times and costs of reconstruction.

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 event of strong earthquakes few places can be considered safe other than the squares. Novi is partly an exception due to the historical development of its old town. But while in Sulmona, Carpi and Novi, in the event of an emergency, rescue operations can be carried out reaching almost all the damaged areas and the rescue units are able to place their materials nearby, in places like Anversa most of the inhabitants can be rescued only climbing the steep staircases and if the buildings collapse streets and buildings might become an indistinct heap of rubble as happened in Onna, near L'Aquila, on 6th April 2009. Besides, rescue times and risks are very high as well as costs of collection and disposal of ruins and reparations and reconstruction costs.

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It means that in easily accessible places the location slightly influence the reparation and reconstruction costs because construction materials and rubble can be easily collected and transported to the garbage dumps. Instead the difficulty of access to places like Anversa and Castrovalva increases the costs of design and reparation of the single buildings and the duration of the works. For example scaffolding for facades on narrow alleys or on cliffs need specific design and construction, the lack of storage areas near the building sites involves the temporary occupying of public spaces as part of the alleys and squares. Besides the fact that construction materials and rubble have to be carried from the main streets to the building sites manually or through small machines, increases the duration of the works and the costs of reparation by up to 2%.

Considerations about the built environment

The built environment is the result of the history of the towns and their location. The shapes of the buildings, materials and construction techniques inform about their vulnerabilities, seismic behaviour and mechanism of damage and therefore indicate time and cost of reconstruction.

Except the old town of Novi that has quite large streets and quite short buildings, 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 along narrow streets, with main walls in common. In particular people from Anversa and Castrovalva made blocks of flats whose number of floors, shapes and dimensions are very irregular because follow the development of the road system along the mountain side, with significant difference in height between the edges of the buildings. In general they withstand the earthquake as compact blocks in which every structural unit contribute to the overall resistance.

The construction materials come from the natural environment surrounding the villages and the construction techniques were quite homogeneous: in Sulmona and Anversa they built mainly stone walls, light timber frame roofs and vaulted ceilings. The vaults are often thick and made by stones at the lower floors and thinner and made by bricks at the higher floors, where they sustain lighter weights.

In Carpi and in some buildings in Novi they built brick walls, light timber frame roofs and wooden ceiling beams. 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 typical structures of the ancient 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. And it influences their seismic resistance.

Rich people from the sample municipality usually built good quality houses. In Sulmona and Anversa they built thick walls made by well moulded stones and quite big flats with regular shaped plant on every floor. In Carpi and Novi they built quite thick brick walls, quite well connected with each other and sometimes the insertion of ties, very often not visible on the facades.

For example in places like Anversa as poor families grew, they enlarged the apartments including rooms obtained from the neighbours, or adding one more floor, or part of it, with the construction materials that were available. These structural additions, still partly visible in the sample municipality on the not daubed walls, were made using particular construction techniques in order to make the added walls light. Nevertheless the lack of strong connections between walls, the different stiffness of the parts and the overall irregular shape of the block increased the vulnerability of the buildings. Besides, in the four municipalities of the sample, many people have lived in the buildings throughout the centuries and have often modified the original main structures from the inside, according to their needs. Consequently lots of vulnerabilities that make the difference in case of earthquake can not be seen from the outside. For example in the 19th century large poor families that lived in very small flats in the province of L'Aquila used to carve recesses in the main walls to store things like kitchenware or clothes, making those walls weaker. Other common kinds of alterations, visible also in the province of Modena, consist in demolishing part of the main walls to connect rooms and in building main walls not aligned with the ones on the lower floors, which overloads the weak part of the main structures such as vaults. This means that, in order to understand the vulnerabilities and the seismic behaviour of structures like these, it would be important to know the main

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characteristics of their inner structural development or at least whether the structures have anomalies. These information, added to the analysis of structural elements of specific typology and materials, give a clear idea about the behaviour of the single block in case of an earthquake.

Another element that significantly impacts the times of the reconstruction, especially in the small villages as Anversa, is that in lots of blocks of flats there is no correspondence between the facades and the inner development of the apartments so that the structural units can not be easily identified by looking at the blocks from the outside. For this reason the identification of the structural units calls for inspections and accurate surveys to be carried out by technicians. This process takes months because the blocks do not have a manager and many flats are empty for almost the entire year because they are second residences. Accessing the flats to make inspections is complicated.

Unlike Sulmona and Anversa, in Carpi and Novi they built blocks of flats whose number of floors, shapes and dimensions are quite regular. Besides, the analysis of the layout of the old town of Carpi and Novi shows that on average in the blocks of flats there is correspondence between the facades and the inner development of the apartments so that the structural units can be easily identified looking at the blocks from the outside. For this reason both in Carpi and in Novi just one team of technicians were able to identify the structural units observing the buildings from the streets. They completed the work analyzing the damage surveys carried out by the Civil Protection in order to define the blocks that needed a unitary intervention of repair. 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 damage surveys carried 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 longer and the more expensive is the repair. But on the other hand, unlike Abruzzo, Carpi and Novi do not have the difficulty of managing building sites in awkward and narrow places. So on the whole, time, costs of repair or reconstruction can be lower.

Considerations about people

Considering the impact of people's belief in recovery and reconstruction, the study shows that in Sulmona and Anversa one of the main strengths is people's awareness that earthquakes can occur. One of the clearest proofs of it is that they have been reinforcing buildings throughout the centuries, not only after earthquakes but also for ordinary renovations. In those cases they carried out small and local works that improved the resistance of the buildings. Historians can date the renovation of the buildings by analyzing the shape and dimensions of the ties that have been inserted at the intersection of the main walls and the floors. Both rich and poor people have tried to make their houses safer and in fact the use of ties, that is still nowadays considered one of the best anti-seismic measures, is very common and has protected the houses from serious damages and collapse during the seismic tremors. Besides, after every earthquake the damaged buildings have been strengthened to be ready to withstand a possible future event. A study conducted by Istituto Nazionale di Geofisica e Vulcanologia 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. Data referring to the structural units defined and repaired after the earthquake occurred in 1984, compared with data referring to the buildings damaged by the earthquake occurred in 2009 clearly show this point. A study conducted by the Istituto per le Tecnologie della Costruzione of L'Aquila shows that in 2006 over 63% of the buildings in the old town of Sulmona had already been reinforced by the insertion of ties. 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 implementing scientific studies together with the difficulty in assessing

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the structural behaviour of masonry and mixed stone structures, may imply the application of incorrect technical solutions. A typical example is the habit of building thick and heavy reinforced concrete edge beams at the top of ancient walls in order to give them stability. This was a very common technique used during the reconstruction following the earthquake of 1984. Damages provoked by the earthquake occurred in 2009 have shown that the technique contributed positively to achieving the box behaviour of structures made of thick and resistant walls, but it also 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 after the earthquake occurred in 1570 in Ferrara, 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, whereas people from Emilia have only occasionally reinforced buildings throughout the centuries and seldom during ordinary renovations. Another clear example is the theatre of Novi, a brick structure that was designed and built in 1926 with careful attention to the smallest details, including ties at every floor, that suffered light damages in 2012, whereas most of the other buildings of the old town have been severely damaged. The habit of inserting ties was common almost only in some kinds of structures such as the vaulted ceilings of traditional barns, the portico walkways in the old towns and in some churches. But also in these cases they had put very local reinforcements, essentially ties whose plates are not generally visible from the outside, so that they were mainly aimed at withstanding vertical loads rather than the dynamic action caused by earthquakes. Also the habit of building edge beams at the top of ancient walls was definitely uncommon before the emergency law *Ordinanza 3274/2003*, that was issued after the earthquake that affected San Giuliano di Puglia, (Province of Foggia, Italy) and that entered into force in 2005. It reclassified the seismic vulnerability of every area throughout the whole national territory. This law also ordered that 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. The unawareness of the seismic risk in people's belief and in the body of law, 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 year 2000's and were severely damaged or collapsed due to the earthquake.

The only prior event of the last century seems to be the earthquake that occurred in 1996 that did not affect Novi and provoked only light damages in Carpi. Data retrieved in the archive of the city council show that after that event the municipality received 63 requests for state aid for the reparation of damaged buildings. The comparison of buildings repaired after 1996 in the old town centre, with the buildings damaged in 2012 shows that only 3 structures strengthened after the first earthquake were damaged by the second one. It is basically the same situation observed in Abruzzo.

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. As Castelli and Camassi from Istituto Nazionale di Geofisica e Vulcanologia observe in their study on the province of Ascoli Piceno which borders in the south with the province of L'Aquila, earthquakes seems to be almost a taboo in local culture and the situation seems similar in Sulmona and Anversa. For example the scholar of dialect Pasquale Mininni from Anversa and old people do not remember specific expressions or proverbs that mention them, even though the dialect is still spoken. The same situation is in Modena. But the other hand, 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.

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. The cult is indeed venerated in lots of seismic areas around the world including parts of the province of L'Aquila. The data collected show that in both Anversa

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and Sulmona the Saint was venerated especially after the earthquake that occurred in 1915 and in any case until the '60s because people that have lived through that disaster were still alive. In particular masses were celebrated in his honour every year on 13th January, the day on which the earthquake occurred. For example not far from Anversa, in the small town of Frattura, that was completely ruined by the earthquake that occurred in 1915, they still celebrate the mass for Sant'Emidio. The cult of Sant'Emidio is instead not very significant in the local culture of the area of Carpi and Novi. This indicator could be a further confirmation of people's lack of awareness about the earthquakes, but maybe could also mean that the popular religiosity of the two areas is different and that nowadays it is expressed differently than in the past. The same can be said about the diffusion of the name "Emidio", quite popular in the province of L'Aquila, especially in the past, but quite uncommon in the province of Modena.

People's imagination of places in the reconstruction planning

The relationship between people's imaginations of place and reconstruction planning can be found in the number of laws and restrictions that regulate construction activity in the old towns. It shows people's awareness of the uniqueness and value of their historical centres and it represents the willingness to protect not just single buildings but the urban environment as a whole. As usually happens in Italy, the local council of Sulmona has classified the single buildings of the old town by historical relevance, applying specific restrictions in order to regulate the construction and renovation activities. The growing areas of the city are dictated by different and less severe restrictions. The interventions on the old town proposed by private technicians are evaluated by the Technical Office with the supervision of Soprintendenza per i Beni Storici, Artistici ed Etnoantropologici dell'Abruzzo (Department of Regional Heritage and Cultural Activities). On the other hand the whole territorial area of Anversa is also protected by environmental restrictions according to two Ministerial Decrees (D.M. 26/1/85 and D.M. 21/05/85) connected with the presence of the the Natural Protected Area of "Gole del Sagittario" and the protection of Valle Peligna, that means that any kind of construction activity that could modify the landscape as well as the external sight of ancient or modern buildings, has to be authorized by both the Technical Office of the municipality and the Soprintendenza, which is a department of Ministero dei Beni Ambientali e Culturali - MIBAC. Therefore both the built and the natural environment are considered heritage to protect. Referred to the damages caused by the earthquake, the emergency laws Ordinanze 3778/2009 and 3779/2009 concerning light and medium structural damages allow only interventions of reparations on any kind of buildings, whereas the emergency law Ordinanza 3790/2009, concerning severe damages, allows a comparison between reparation cost and reconstruction cost in order to choose the cheaper intervention, notwithstanding the restrictions that protect the building heritage from demolitions. In the final analysis the damages suffered by both the municipalities have not been severe enough to call into question the restrictions of the ordinary regulations.

Like in Sulmona and Anversa construction activities in Carpi and in Novi are dictated by several laws, from a national to a local level, in order to define the interventions allowed on each single building. But unlike the Abruzzo region's towns and 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, from December 2013 to October 2014, promoted and managed a participatory community based planning entitled "Fatti il centro tuo", ("Make your own centre"), that involved people from any age and sector of society. It was aimed at gathering information about people's imaginations of places in order to inform the designers about people's needs and expectations. The process has been considered an interesting experience, not always easy to develop in parallel with the emergency environment of recovery and reconstruction.

Results

The comparison of the case studies show how different environments can influence recovery and reconstruction.

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Accessibility to mountainous areas is more difficult than to flat areas. As a consequence rescue operations could take more time, could be more expensive and risky also in terms of human losses.

Buildings situated in different places with similar construction techniques and age have similar vulnerabilities. But, in order to understand their actual behaviour we should also consider specific and more hidden conditions such as their structural development throughout time and their possible anomalies. Poor quality buildings can create problems especially if they have never been reinforced or if their structure is not coherent (shape, mass, stiffness).

Buildings reinforced adopting appropriate structural criteria stand the earthquake better and suffer less damages than buildings that have never been reinforced. The severe damages suffered by the industrial plants in Carpi and Novi show on one hand the importance of people's awareness of the risks and on the other hand that the wealth of an area is not always related with the prevention, awareness and safety. Besides the different living standard has not significantly influenced the recovery and reconstruction of private households because in both cases most of the people have asked for state aid before starting the works. A reliable estimate for production activities can not be carried out because in Sulmona because they only suffered light damages.

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.

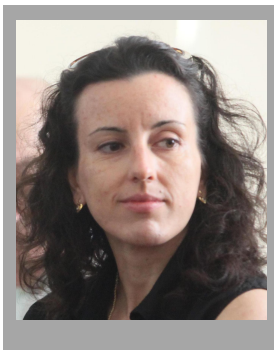
Indicators that show how people's imagination of the places are captured by the reconstruction could be the laws that regulate the municipality, the participatory planning and the plans for the reconstruction.

On the whole the main key-elements identified by this study and that could be monitored are: accessibility, construction techniques, age of the buildings, previous structural renovations, quality of the materials, typologies of the structural units, structural anomalies, people's awareness, body of law, plans for the reconstruction, participatory planning.

The municipalities should adopt measures in order to be more resilient to the earthquakes. For example they could have an updated map of the vulnerability of buildings, as a result of their specific characteristics and previous renovations. They could also define the structural units putting together the various information that they achieve through the building permissions (plans, prospects, sections, etc). A restrictive anti-seismic legislation plays a very important role in preventing severe damages and contributes in making people more aware of the risks.

The reconstruction could be an opportunity to make cities more coherent with their inhabitants' needs and the reparation of ancient buildings could make them "smarter" with the insertion of sensors that monitor their behaviour before the earthquakes occur.

Author's Biography



An Architectural 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 both as a freelance Designer, Projects and Work Manager and as a salaried Technical Officer for local councils, managing the whole reconstruction process, from damage assessment to the assignment of public funds to finance the works, including project control and site inspection.

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).