

The effects of earthquakes in historical cities: the peculiarity of the Italian case

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Abstract

Knowledge of the urban seismic scenario raises complex elements for technical and cultural consideration which may improve the analysis of the conservation and restoration of historical buildings and monuments. These elements cover various specialised viewpoints, from historical seismology and the history of architecture and town planning, to engineering and economic and social history. In this paper we have outlined a conceptual framework based on three aspects. First, the definition of *seismic disaster* which is the result of the interaction between the activity of seismogenetic sources and the characteristics of buildings. The next aspect is the characteristic proper to strong earthquakes as factors of change, sometimes of entire settlements. Thirdly, we have stressed the fact that one must take into consideration the variety of administrative and economic situations in the Italian territory from the fall of the Roman Empire to date as they may have important implications for the analysis of the effects of a large earthquake on the human environment. The demographic impact of earthquakes is historically correlated to the economic condition of the damaged sites. The urbanistic consequences are addressed once the problems concerning the planning of the reconstruction and its accomplishment are solved. Finally, we have tackled the problem of seismic events of a lower destructive level in the art and tourist cities.

Key words *historical cities – seismic hazard – seismic disaster*

1. Introduction

The scientific value of the historical seismic scenarios needs no further proof: indeed, it has been acknowledged that the knowledge on the already occurred effects provides very useful qualitative elements for the evaluation of future seismic effects on present buildings, as regards historical and monumental constructions as well as more recent housing. The data resulting from

research on historical seismology, collected in this *Catalogue of Strong Italian Earthquakes* (CFT13), contain interesting practical elements and make up a basis of knowledge which can be further expanded and detailed in the future. On the one hand, we have investigated the delicate relationship between seismic activity, inhabited territory, *i.e.* towns and villages, and the multiple economic and cultural values of the seismic reconstructions; on the other hand, we have looked deeper into the importance of the existence or not of a local seismic culture and its influence, at different levels, on the characteristics of historical buildings.

Through the use of «seismic histories», according to which our information system is organised, the data allow us to outline seismic scenarios with localisations of the effects, also

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in the urban fabric. In order to exploit such data to the full, some preliminary considerations on the relationship between the earthquakes and the characteristics of the anthropic contexts may be necessary. Therefore, we will look deeper into: i) a definition of seismic disaster and its fundamental characteristic as factors of change; ii) a division into periods of the urbanistic development of Italian cities; iii) an outline of the consequences of seismic disasters in inhabited centres, which, because of their complexity, have been divided into three sections, regarding impact on: a) the economy; b) the demographic levels, and c) the urban structure. In the final part we will tackle some problems related to the seismic scenarios of a lower destructiveness concerning art cities or large tourist centres.

2. Earthquakes in nature and history: a definition of seismic disaster

Anthropic systems are the result of the use of a territory, the signs left by historical, economic and cultural characteristics which have developed in the various inhabited centres. As the earthquake effects represent a «relationship» between the seismic activity and the human presence in a particular territory, they can vary in relation to the habitational characteristics. A seismic disaster can thus be considered the result of the interaction between the activity of seismogenetic sources and the characteristics of the constructed area. To break this definition down according to its specific aspects, we will look more closely into the concepts of «disaster», «relationship» and «adaptation».

There exists a *theory of disasters of natural origin* which defines as an *extreme event* any event which, in a geophysical system, deviates substantially from the mean value measured for that event. If the event exceeds the ability of the human system to assimilate or reject it, it becomes a *disaster* (Alexander, 1990). The effects of an extreme event are thus the *relationship* between a phenomenon of natural origin and certain characteristics of an anthropic system. Indeed, a society may or may not have developed forms of activity and response (including reconstruction) aimed at reducing the impacts.

The «responses» to the disaster are usually defined as *adaptation*. The more a society elaborates such responses in the layout of the territory, in construction and in its culture, the less readily will extreme events become disasters.

3. Strong earthquakes as factors of change

For many Italian cities and for a huge number of smaller historical centres earthquakes were one of the main reasons for changes or replanning of the town. In many areas, they have represented a dynamic element in changing of the entire settled urban network. The knowledge gained from the study of earthquakes as factors of change, today allows us to give the main outlines of local seismic histories and to form new considerations on the history of the towns in Italy today.

We have analysed a total of 605 earthquakes (see in the CD-ROM) from the 5th century B.C. to the 20th, thus localising and evaluating 34 762 effects in terms of intensity degrees in individual sites. It emerged that more than 7800 sites have experienced seismic effects of, or greater than, the degree VII on the Mercalli-Cancani-Sieberg macroseismic scale (MCS). See figs. 1 to 4 showing the distribution of the sites, according to the various intensity degrees:

- i) including degrees VII and VII to VIII: 4073 sites;
- ii) including degrees VIII and VIII to IX: 2276 sites;
- iii) including degrees IX and IX to X: 982 sites;
- iv) including degree X and higher: 521 sites.

It should be noted that for the first and second degrees of damage studied, the relevant maps present an incomplete number, since not all known earthquakes of an epicentral intensity between degrees VII and VIII are included at the present stage of research in the CD-ROM. Instead, the maps relative to the higher degrees of damage can be considered almost complete.

The logical arrangement of the information system of this catalogue structures the data in such a way as to make it easy to consult the effects in the individual sites and also to construct «seismic histories». In addition, the head-



Fig. 1. Damage scenarios in inhabited centres: no. 6014 for $I = VII$ and VII-VIII MCS; no. 4073 involved sites.

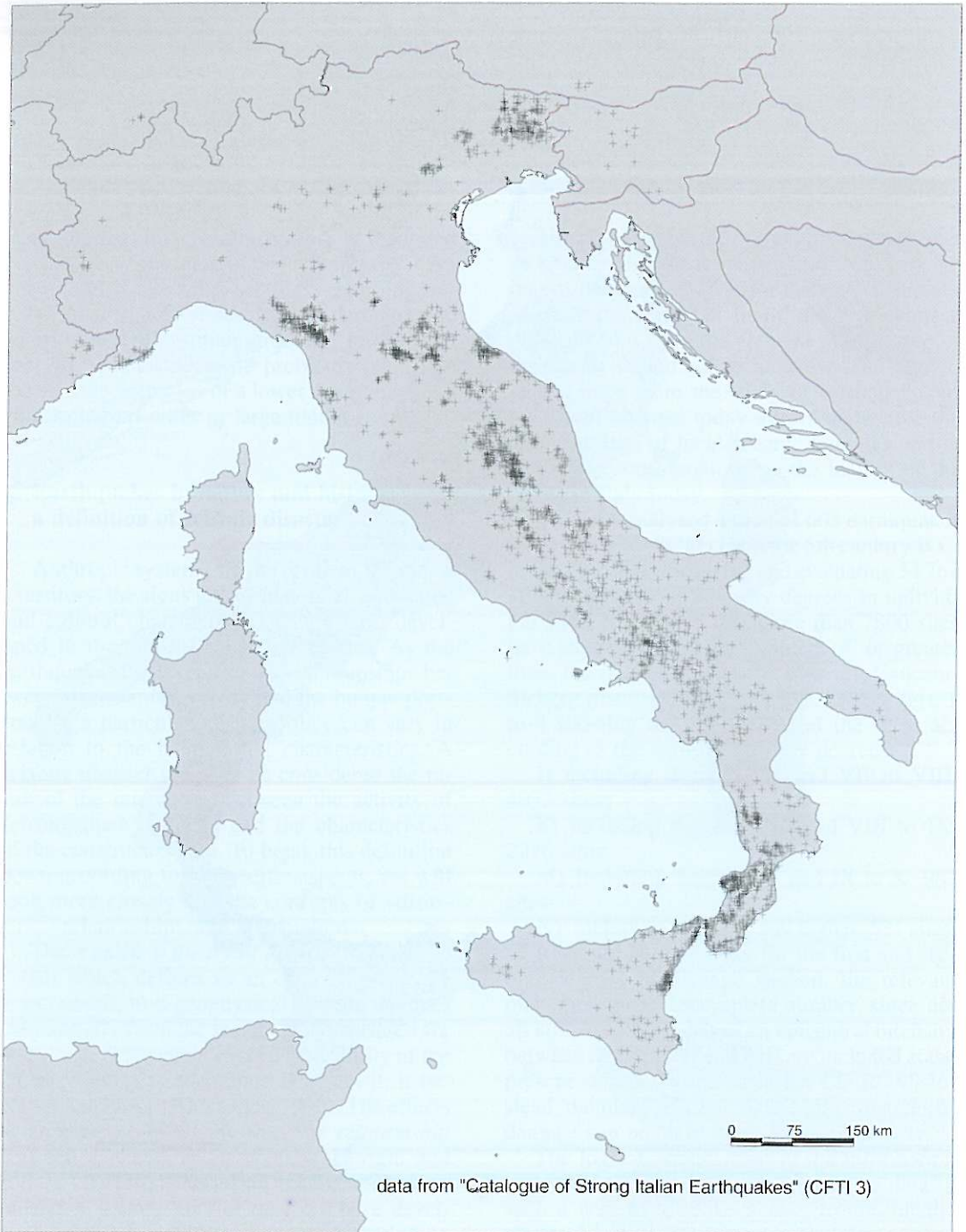


Fig. 2. Damage scenarios in inhabited centres: no. 3064 for $I = VIII$ and VIII-IX MCS; no. 2276 involved sites.



Fig. 3. Damage scenarios in inhabited centres: no. 1177 for $I = IX$ and IX-X MCS; no. 982 involved sites.



Fig. 4. Damage scenarios in inhabited centres: no. 568 for $I \geq X$ MCS; no. 521 involved sites.

words «elements of demography», «elements of historical building heritage», «social response», «institutional and administrative responses», «reconstruction, site moving» (see in the CD-ROM) are expressly intended to provide a better definition for this particular seismic history of sites.

4. Division of the cities into periods: elements of the particular situation in Italy

In every age, cities, intended not only as inhabited centres, concentrations of population but also as a whole of the political, administrative and cultural functions it expresses, are part of a wider context and lie within roles, priorities and hierarchies whose social and economic meaning depends on the larger administrative structure enveloping and linking them. As Gambi (1982) notes, it is not possible to refer to the cities of Italy as a unity, for fifteen centuries, that is, from the fall of the Roman Empire to the unification of Italy, there was indeed no historical unity on the current Italian territory. Instead, numerous and quite different political, administrative and economic situations have co-existed (see historical maps at the end of this volume); situations which have often been hostile towards each other, and which had unequal growth rates and often far-removed or rival centres and dynamics. These differences resulted in diversities combining to form distinct building and cultural landscapes which today make up an extraordinary historical and artistic heritage.

Nevertheless, the need for simple (though not simplistic) and adequate functional and analytical instruments forces us to ask whether it is possible to identify common phases for the entire national urban fabric. A single division into periods, even with the limits it implies, would in fact favour the analyses of the seismic scenarios and reconstructions, and at the same time identify possible periods of vulnerability of urban construction. With a view to this, we adopted the model proposed by Gambi (1982) which, identifying five significant periods in the development of Italian cities:

- 1) from the 5th century to the 11th century;
- 2) from the end of the 11th century (or the beginning of the 12th) to the mid-14th century;

- 3) from the second half of the 14th century to the 16th century;

- 4) from the 17th century to the 18th century;

- 5) from the 19th century (Napoleonic era) to the first half of the 20th century.

4.1. *From the 5th century to the year one thousand*

The first period, from the 5th century to the 11th century, was historically characterised by quite different tendencies between north and south Italy. While certain urban areas in the north were reduced in size or were actually abandoned during the early centuries of the Dark Ages (also see Fumagalli and Guidoboni, 1989 for some specific aspects), the South saw an expansion in some urban centres, such as Benevento, Capua and Salerno.

Certain towns developed as small fortresses in areas of different military influence (Udine, Crema and Ferrara), other centres attracted fugitives from other parts (Venice, Amalfi). In Sicily, after the Arab conquest (9th century) several, even quite smaller towns underwent a period of vigorous demographic growth and economic development (Marsala, Mazara, Castrogiovanni, Taormina and Cefalù).

4.2. *From the end of the 11th century to the early 14th century*

During the second period, from the end of the 11th century, or the start of the 12th century, to the mid-14th century, the city asserted its power as regards its «regional» space. According to Gambi, only a few inner areas of the Southern Italy were excluded from this process. In Northern Italy, this phase was brought about by the expansion of local self-government based on military defence. This led to the centralisation of the population within the city, to an increase in building within the city walls and, once the inner space was saturated, to the beginning of a phase of *building verticalism* that changed the sight of the city and which still today characterises the Italian medieval town

centres. During this period, many northern cities expanded, they built new additions to the existing urban area and new, wider city walls (Verona, Padua, Bologna, Genoa, Florence, Pisa, Ancona, Perugia, etc.).

The ratio between the population and the space available within the walls was for a long time a problem difficult to resolve in the Italian cities and there were, with times of solution which were often very different solution times for the North and the South. According to Gambi, the major extensions to the urban area of this period should be considered part of organised projects, of real planning, foreseen on the basis of demographic and economic increase. Moreover, in this second period, a kind of «urbanistic enterprise» developed – much more in the North than in the South – which planned the formation of new urban centres. To the North of the Tiber alone, more than 200 were built, including free towns, new villas, new estates, etc., often no more than 30/40 km from their «mother cities».

In the South, however, few new centres were built: the most important ones were Augusta, towards the end of the thirteenth century, and L'Aquila and Manfredonia in the fourteenth century.

4.3. *From the second half of the 14th century to the 16th century*

Gambi (1982) defined the third period, from the second half of the 14th century to the 16th century, as an apparently less dynamic period than the previous one. However, in many cities, the areas within the walls were subject to changes and renovations were made. Some cities, such as Milan, Naples, Bologna and Messina, were sometimes given new, wider perimeters. In some very old Italian states even new foundations were being laid for town with a mainly military purpose, like Carlentini (South Eastern Sicily) in 1551 as a protection against Turkish raids, Terra del Sole between the Grand Duchy of Tuscany and the Po plain in 1564, between the Grand Duchy of Tuscany and the Po plain and, Palmanova (North Eastern Italy) on the borders with the Austrian dominions in 1593.

During the sixteenth century, in many smaller towns major rebuilding and restructuring of the medieval walls were carried out. These interventions were intended to integrate a system of defence based on key-cities in the territory and to consolidate the domination policies of those cities on which the smaller towns depended. A general militarisation of the cities led to the architectural fortification of castles, towers and residences. The central governments committed themselves especially to these functions, while minor civil construction work was still more or less overlooked. Moreover, at a local degree, this construction stage triggered off new demographic and economic dynamics.

4.4. *From the 17th to the 18th century*

The fourth period, from the 17th to the 18th century, featured recession and slow recovery, both demographic and economic. On the whole, the city layouts formed thus far were maintained. The only exception was Turin, the capital city linked to the expansionist destinies of its monarchy. At the end of the eighteenth century, Rome and Milan contained about 125 000 inhabitants; Naples, with over 400 000 inhabitants, was the most heavily populated city in Italy and one of the largest in Europe.

For Sicily, it was a time of new settlements, aimed at colonising new farming lands. During this period more than 150 new inhabited centres were founded on noble estates, former pasture or abandoned land. The earthquake of 1693 (see in the CD-ROM) happened at the start of the expansion of the built-up environment and therefore the measures taken to repair the damage caused by the earthquake acted in a certain sense as a «spur» to economic recovery, even though the actual reconstruction of the damaged sites was less than planned (affecting about one tenth of the Sicilian cities). Similarly, of the villages destroyed by the Calabrian earthquakes of 1783 only a few were actually reconstructed (Principe, 1976).

In the same period, on the Adriatic coast, radical urban reconstruction was undertaken which changed the appearance of towns which had previously still been medieval centres like

Trieste, Cervia, Ancona and Senigallia; Bari was to have its first expansion project outside its medieval walls only as late as 1790.

4.5. *From the last decade of the 18th century to the first half of the 20th century*

The fifth period, from the Napoleonic era to the first half of the twentieth century, was characterised by new hierarchies formed between the different cities, due to the restructuring of the public administration and the new territorial divisions. Within the cities, new roadways were opened up which connected the old historical centres with the new transit routes, consisting above all of railway stations. In many cities, even smaller ones, the old centres were restructured through the demolition of medieval parts or towers (as in Bologna), ancient city walls and porticoes. For the first time, the cities experienced a sort of «social specialisation» of the urban area, unknown at the time of the principle formation of the city (second period). This aspect also had a strong influence on the quality of the urban construction heritage and therefore its present vulnerability.

5. The last fifty years

From the post-war period to date, a new phase has been underway in which the appearance of the cities has changed to a greater extent in the suburbs than in the historical town centres. As regards seismic effects, the vulnerability of the old city (the historical heart of the settlement) differs very much from that of the residential areas. In order to give a proper evaluation of a recent seismic scenario, it has often been necessary to separate the effects in the historical part of the old city from those in the area of recent urbanisation. The effects in the former have often been found to be one or two degrees higher in intensity than in the latter (see, in the CD-ROM, the cases of the earthquakes in Palermo in 1940, Parma in 1983, and Syracuse in 1990). The construction features of buildings of the last 50 years can be deduced from national censuses and are an integral part of the seismic engineering data.

6. The consequences of seismic disasters in the cities

The long-term consequences of seismic disasters in cities are severe and complex. We will give a general outline of the economic, demographic and urbanistic consequences; the social and cultural consequences, which certainly play a considerable role in the evaluation of the seismic scenario, but which lie beyond the scope of this paper, are therefore not taken into consideration.

6.1. *Economic consequences*

The different administrative procedures in force in Italy for many centuries have led to the consolidation of *institutionally different ways* of intervening after a seismic disaster, both during the survey of the damage and during the reconstruction phase.

The administrative policies of old in Italy concerning seismic disasters may be grouped into three categories: i) the policy of economic incentives; ii) the policy of tax relief; iii) the policy of the distribution of funds collected through a once-and-for-all tax, plus tax relief. The first type of intervention was linked to the fluctuation of the available money, which was distributed in the form of loans with very low interest rates over very long periods of time, and which came from state funds. This was the administrative policy applied in the Grand Duchy of Tuscany, from the Medici family till the Lorraine family. The policy of tax relief, on the other hand, involved tax exemption from one to ten years. This was basically all that was done in the Kingdom of Naples (apart from the exceptional case of the 1783 reconstruction), in the Kingdom of Sicily during the Spanish and Bourbon eras (except for the reconstruction of 1693) and partially in the Republic of Venice. The policy of distributing funds collected through a once-and-for-all tax plus tax relief was a sort of «mixed» system. First, a general tax was applied, then, once the system of tax exemption had been established, the distribution of the collected funds was decided upon once the system of tax exemption had been established. This was the administrative policy

applied by the Papal State from the early seventeenth century. Redistribution of the funds was mainly entrusted to the parish priests and was slow and muddled.

These different fiscal measures were often applied in the same territory. This therefore enforced a strikingly different recovery rates. Above all, it implied a different *quality* of reconstruction which, as already said, is being considered as one of the most important «responses» to the seismic features of a territory. Thus, over time, the different administrative policies have shaped different «cultures of seismic disaster» which can still be perceived on a regional scale in Italy today.

In order to explain this concept, we will refer here to the concrete interventions of the Grand Duchy of Tuscany, the Papal State, the Republic of Venice and the Kingdom of Naples (see the historical maps at the end of this volume). In the first case, the leading power developed a kind of «institutional paternalism», as historians have defined it. First under the Medici and then under the Lorraine an enterprising reconstruction spirit was forged through the use of loans with easy repayment terms. This was also decisive for the territorial rooting of the populations hit by earthquakes as it was committed towards recovery and was tied to the central power by the obligation to repay the debts. Even though this loan policy was limited economically, it had no equal anywhere else in the old Italian states.

In the second case, the Papal State, the administrative procedure was on the whole inadequate. The mild reformism put into practice was based on the exemption from some Treasury duties and on the division of a fund collected as a tax which also entailed long bureaucratic delays. The practice was open to much unfairness, which obviously did not help to solve the problems of reconstruction and which in many cases even discouraged the production and artisan classes, often forcing them to emigrate (as in the case of the earthquake in Romagna on 11 April 1688, see in the CD-ROM). Only in certain special cases did the Papal Chamber undertake to support the reconstruction by financing local production. This happened in Benevento after the earthquake of June 1688 when considerable sums were made available to support the silk industry. Since this city was a papal *enclave*

within the territory of the Kingdom of Naples, a mass exodus on the part of the artisans was feared, which would have meant its death.

The fiscal policy of the Republic of Venice was very similar to that of the Papal State, in other words, the tax exemptions were not followed by incentives. The available State funds were spent exclusively on the restoration of the public structures for trade and defence, that is ports, bridges and fortresses.

To conclude, exemption from Treasury duties was practically the only measure applied also in the Kingdom of Naples. The various offices of the *Camera della Sommatoria* formed the great «administrative filter» which collected the requests for exemption made by the local communities and feudal lords.

A seismic disaster was almost always followed by a serious economic crisis, due to the collapse of the local economy and to the uncontrolled rise in prices. The shortage of labour and lack of essential commodities soon created problems of public order. When not only the grain supplies, but also the infrastructures for food supplies (mills and ovens) were destroyed, there was often a considerable food crisis which the central authorities tried to stem by bringing in food stuffs from outside. As a result the number of deaths due to a seismic disaster continued to increase in the following months.

As regards the monetary cost of the earthquakes, for much reconstruction work there are estimates in terms of money. A calculation of its absolute incidence is practically impossible, because of the different economic and monetary systems often based on mixed economies, although estimates in terms of money have been identified for much reconstruction work. Only for relatively recent earthquakes has it been possible to make such calculations. For example, the earthquake in the Messina Straits in December 1908 razed 57 inhabited centres to the ground, including Messina and Reggio Calabria – two cities in the modern sense of the word. In Messina alone, the value of the buildings destroyed was estimated at 150 million lire. Altogether, this seismic disaster cost the community of Italy of the time the total sum of 600 million lire; a figure higher than the total interest on the National Debt between 1907 and 1912.

6.2. Demographic consequences

The complex and important relationship between urban economies and demographic degrees has already been mentioned. Destructive earthquakes have become part of this dynamics, at times creating demographic «gulfs» which have had serious repercussions also on the quality of the reconstructions.

The data of pre-modern times regarding the deaths caused by seismic disasters are often believed to be overvalued and exaggerated by inaccurate texts. In many cases this is true, but when research has at its disposal sources with accurate and reliable data, the figures speak for themselves. The social and economic significance of the demographic crises triggered by such losses are important for the subsequent history of the cities and often of the entire region affected. The determining factor, however, does not lie in the losses in themselves (albeit serious if only from a human and social point of view), but in the concomitant economic conditions.

Some examples relating to earthquakes of both pre-modern and modern times may help to explain the observations made so far. The earthquake of December 1456 (Central Italy) hit the Kingdom of Naples. It had devastating effects on 95 inhabited centres; of these, seven lost 50% of their inhabitants (Ariano Irpino, Bojano, Apice, Campochiaro, Isernia, Paduli and Tocco a Casauria). There was a total of more than 70 000 deaths, but nevertheless in this case the earthquake did not interrupt the positive demographic trend that the Kingdom of Naples was experiencing in those years. The process of abandonment of the site was not due to the earthquake, as traditional historiography generally believes, but to changes in some economic alliances. From this we can deduce that if the economy is going through a positive phase a seismic disaster can always be assimilated.

The 1693 earthquake was a seismic disaster of exceptional dimensions for Sicily, bringing about the deaths of 54 000 people: 63% (12 000) of the inhabitants of Catania; 51% (5045) of those of Ragusa; 30% (1840) of those of Augusta; 23% (3500) of those of Syracuse and so on. Also in this case, the demographic crisis was

overcome by the start of a reconstruction process which called for a large labour force and an influx in population from outside.

Another cause for the population loss of a town could be emigration and abandonment. Slow and inadequately supported reconstruction could lead to large migratory fluxes within the span of five to ten years following an earthquake. Economic crises and building speculation occasionally paralysed the local economy, preventing the return of the population, who took its trades elsewhere. This happened, for example, in Syracuse which remained uninhabited for almost twenty years after the earthquake in 1542, due to a series of unfavourable circumstances, even if the damage itself was not particularly serious (VIII MCS, in Boschi *et al.*, 1995).

As for the contemporary era, the earthquakes occurring in Basilicata (Southern Italy) on 16 December 1857 and that in the city of Marsica (Central Italy) in 1915 can provide more data on the importance of demographic consequences. The former caused 19 000 deaths out of a total of 418 000 inhabitants, practically 4.6% of the population resident in the hit area. Some local figures are particularly striking: in Montemurro, an old town with city statute in the province of Potenza, 75% of the population perished. In the hardest-struck area, the towns saw a fall in population from 10% to 20% over the following twenty years. In this case, a phase of evident administrative degeneration coincided with the unification of Italy. During the reconstruction process the local communities defined a kind of «anti-seismic legislation» which, though beset with difficulties and incredible delays, was intended to regulate reconstruction in the various towns. However, in the years immediately following unification, these lands were «forgotten» from an administrative point of view and were drawn into the sphere of banditry, poverty and economic isolation.

The seismic destruction of a town may seem a distant and isolated reality today, but the destruction of the cities in Marsica in 1915 is not so remote.

Avezzano was a farming centre in full expansion thanks to the reclamation of Lake Fucino, the earthquake of 13 January caused the

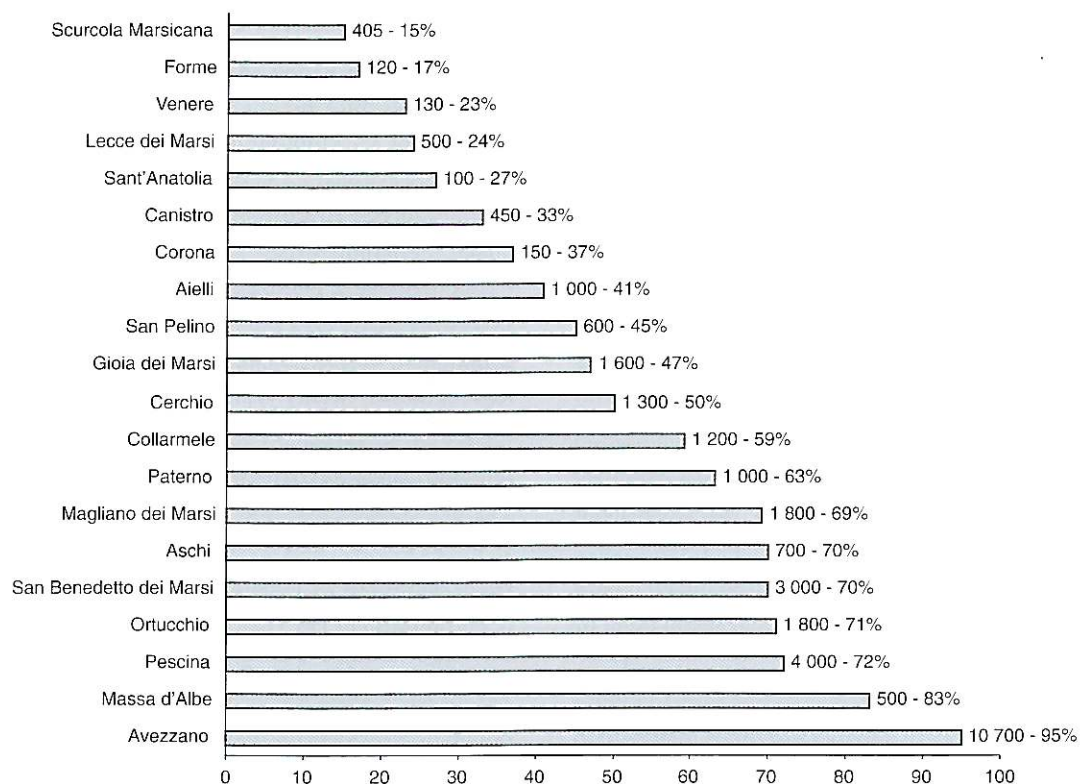


Fig. 5. Earthquake at Marsica of 13 January 1915: number and percentage of deaths in the 20 worst hit villages (total 31 055); total of deceased in the area about 33 000.

deaths of 95% of the resident population, equivalent to 10 700 people (see some data in fig. 5 and table I).

7. Urban consequences for town-planning and changes in the network of territorial settlements

In the majority of cases, reconstruction after an earthquake drew on the already poor local economies. Some large earthquakes however, were followed by proper reconstruction planning which not by chance coincided with a favourable economic and reform phase. This was the case for the measures for reconstruction after the earthquakes in Eastern Sicily in 1693

and the Calabrian earthquakes in February-March 1783, referred to above. These are two very well-known events, among the very few that have attracted the attention of historians and of which an analysis has been made of the decisional economic and political processes behind the reconstruction projects.

The earthquake of 1693 hit an area of 14 000 km² in Eastern Sicily, destroying 70 towns and villages. The huge reconstruction project implemented by the Spanish government allowed entire towns and villages to be rebuilt. This was a historic occasion to redesign the built-up areas along new lines. A result of this seismic reconstruction is the extraordinary baroque appearance of the towns in Eastern Sicily. As regards the Calabrian earthquake of 1783, to gain the

Table I. Number of ascertained deaths caused by the large seismic events of the 19th and 20th centuries in Italy: total number 142330.

Year	Month	Day	I_{MAX}	Epicentral area	Deaths
1805	07	26	X	Molise	5573
1818	02	20	IX-X	Catanese	72
1832	01	13	X	Valle del Topino	Approx. 55
1832	03	08	X	Crotonese	234
1835	10	12	X	Cosentino	115
1836	04	25	X	Northern Calabria	239
1846	08	14	X	Northern Tuscany	60
1851	08	14	X	Basilicata	1000
1854	02	12	X	Cosentino	500
1857	12	16	XI	Basilicata	10939
1865	07	19	X	Etna area	74
1870	10	04	X	Cosentino	117
1873	06	29	IX-X	Bellunese	80
1883	07	28	X	Casamicciola Terme	2333
1887	02	23	X	Western Liguria	631
1894	11	16	IX	Southern Calabria	100
Total of the 19th century					22 122
1905	09	08	X-XI	Calabria	557
1907	10	23	IX	Southern Calabria	167
1908	12	28	XI	Southern Calabria-Messina	80000
1910	06	07	IX	Irpinia	50
1914	05	08	X	Etna area	69
1915	01	13	XI	Marsica	33000
1919	06	29	IX	Mugello	100
1920	09	07	X	Garfagnana	171
1930	07	23	X	Irpinia	1778
1968	01	15	X	Valle del Belice	231
1976	05	06	X	Friuli	965
1980	11	23	X	Irpinia-Basilicata	2914
Total of the 20th century					120 002
A further 17 earthquakes each caused fewer than 50 deaths					206

funds for the reconstruction of entire towns and villages the government of Naples had attempted to implement major reforms of the landed

property (based on baronial and ecclesiastic property). It was an enlightened project but it was only achieved in part, since it clashed with

very strong local powers and conflicting interests. Only a few centres were in fact rebuilt along new urbanistic shapes. Nevertheless, maps and drawings still remain to testify to this extraordinary planning effort.

8. Types of reconstruction

The history of reconstruction is part of the history of the cities and the territory. When the causes are forgotten, the signs of the transformation are no longer evident. However, research helps to render them comprehensible. We have identified three types of solutions adopted after a strong earthquake: i) reconstruction *in situ*;

ii) the abandonment and disappearance of the site; iii) the shifting of the site and reconstruction from scratch.

8.1 Reconstruction *in situ*

Historians often interpreted reconstruction *in situ* before our contemporary era as an indicator of a «moderate» seismic level. However, the criteria to reconstruct *in situ* were essentially linked to economic and communication advantages, that is why even badly damaged sites were rebuilt or repaired in the same place. This was the case for Catania; after the great destruction of 1693 the city altered its urban layout

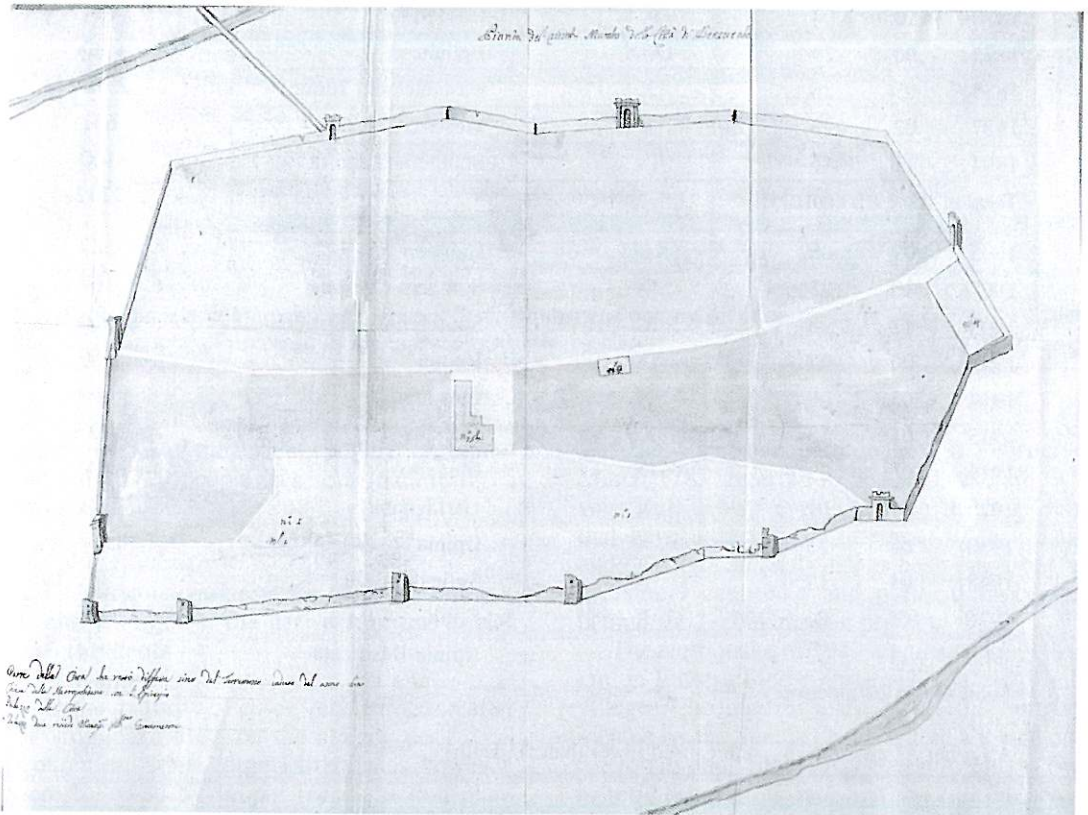


Fig. 6. Benevento: plan of the town walls. The first walled area, from the bottom, is the part of the town defined as «destroyed» by the 1688 earthquake. The map was drawn by the architect Carlo Boratti, appointed by Pope Clement XI to survey the damage caused by the 1702 earthquake. *Archivio di Stato di Roma, Cam. III, b. 361, fasc. 38.*

although it remained on the same site (see also the case of Benevento for the earthquakes in 1688 and 1702, figs. 6 and 7).

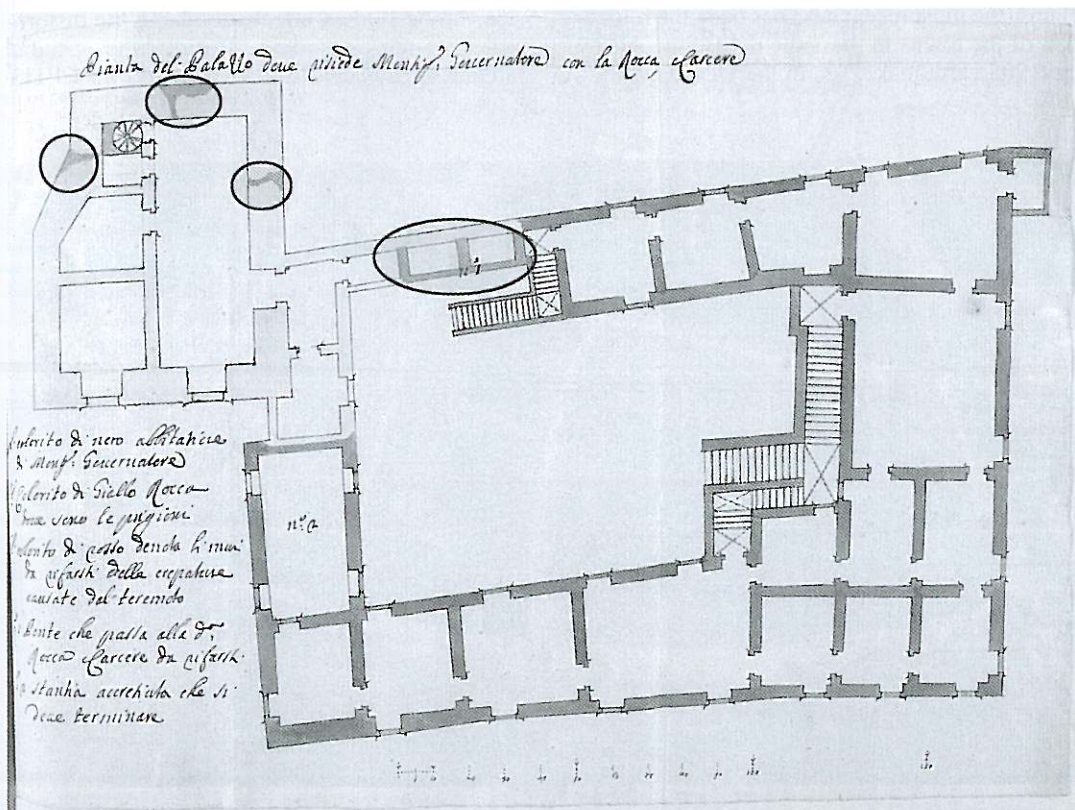
The average duration of reconstruction, for the period between the 12th and 19th century, was probably between 10 and 40 years. Even when the previous urban layout was retained, the reconstruction always involved some changes in the use of the surviving buildings, which modified previous structures and involved the construction of new buildings.

Pompeii is a striking example of the stability of the general reconstruction criteria to be found in Italy at least until the beginning of the contemporary era. 17 years after the earthquake of 62 A.D., Pompeii was still building site in fer-

vent activity. This time interval, between the destroyed city and its reconstruction, can be considered average. Bear in mind that even in 79 A.D., the year of the great eruption recorded by Pliny, the reconstruction was not finished over and another 4 to 5 years would probably have been necessary for its completion.

8.2. The abandonment and disappearance of the site

When the destruction was widespread, generally in small villages and in an economic situation with almost no resources, the «choice» was to abandon the site. The population scat-



tered to other sites or emigrated. After a seismic destruction, small towns and villages in Central Southern Italy without reconstruction resources just disappeared from the inhabited network.

8.3. *The shifting of the site and reconstruction from scratch*

The site was generally shifted to between 300 m away (reconstruction in Basilicata in 1857) and 12-15 km (reconstruction in Sicily, post-1693).

In modern and contemporary times, the site has almost always been shifted in the direction of new routes of communication. The old inhabited centres, towns which were formerly situated in the mountains, on hilltops or even on rocky crags gradually moved down towards the plains (the most recent case has been the relocation of the towns in the Valle del Belice, hit by the 1968 earthquake, see in the CD-ROM).

9. Seismic scenarios of minor destructiveness in art and tourist cities

The economic significance of the seismic effects differs widely depending on the value and importance of the hit urban centre. Indeed, there are towns of particular importance for summer and tourism for art where even minor or medium seismic damage can affect their economy to a significant level. Various cases already studied, such as Rome (Molin and Guidoboni, 1989; Molin, 1995); Syracuse (Boschi *et al.*, 1995); Rimini (Guidoboni and Ferrari, 1986); Florence (Guidoboni and Ferrari, 1995); Padua (Guidoboni *et al.*, 1997); Bologna (figs. 8 and 9, Guidoboni, 1997b; SGA, 1997) and Palermo (fig. 10, Guidoboni and Mariotti, 1999; Guidoboni *et al.*, 2000) show how the seismic scenarios can be studied effectively using the historical long-term approach. Besides the specific studies already developed in this field, the CFTI3



Fig. 8. Bologna: detail of the large map commissioned by Pope Gregory XIII and frescoed in 1575. This section represents the Borgo Paglia, one of the areas most damaged by the earthquake of January 1505: the precision of the representation highlights the building characteristics and typologies of this urban part. *Vatican Palaces, Bologna Hall.*

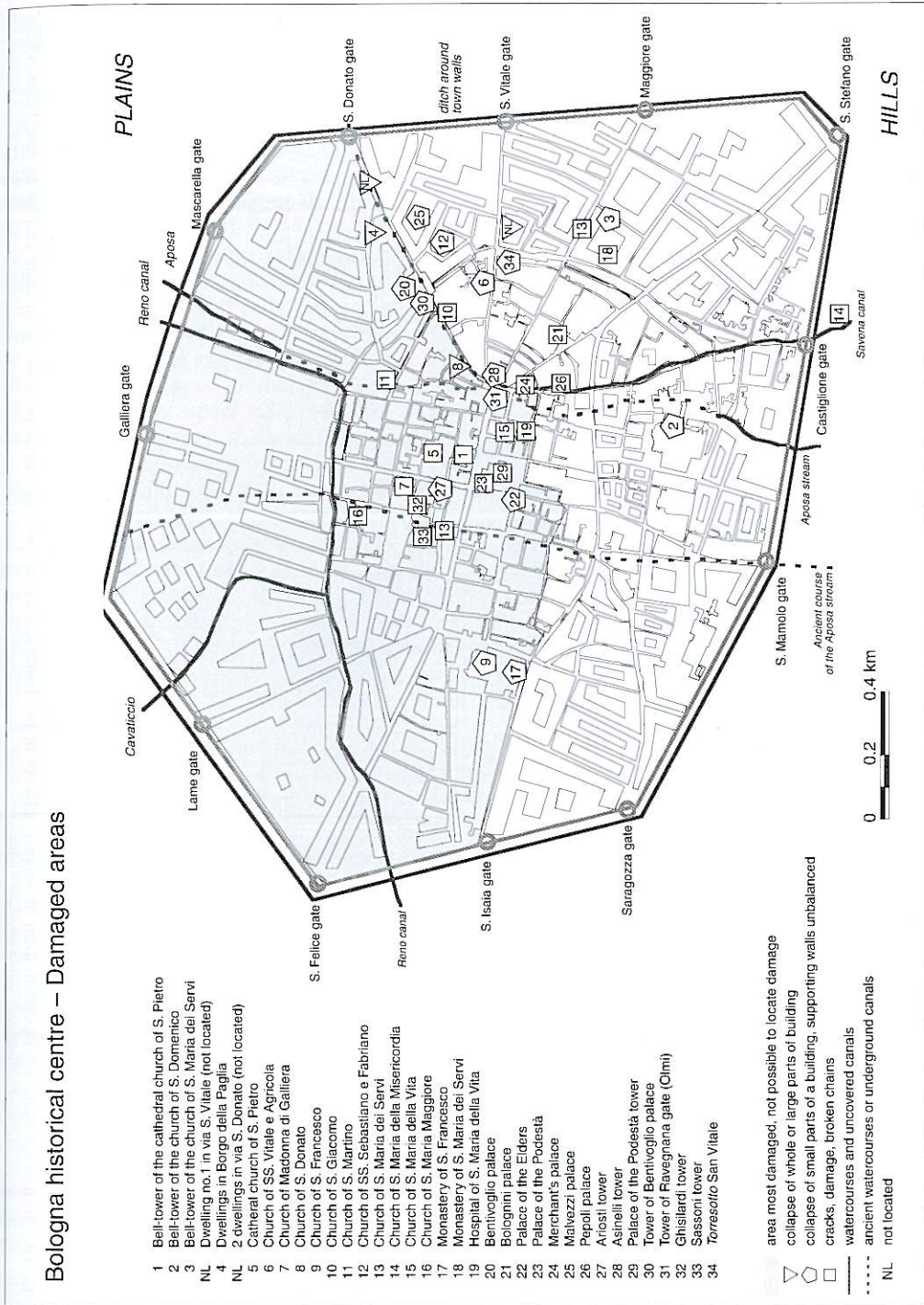


Fig. 9. Seismic sequence of December 1504-January 1505: distribution of damage within the urban area.

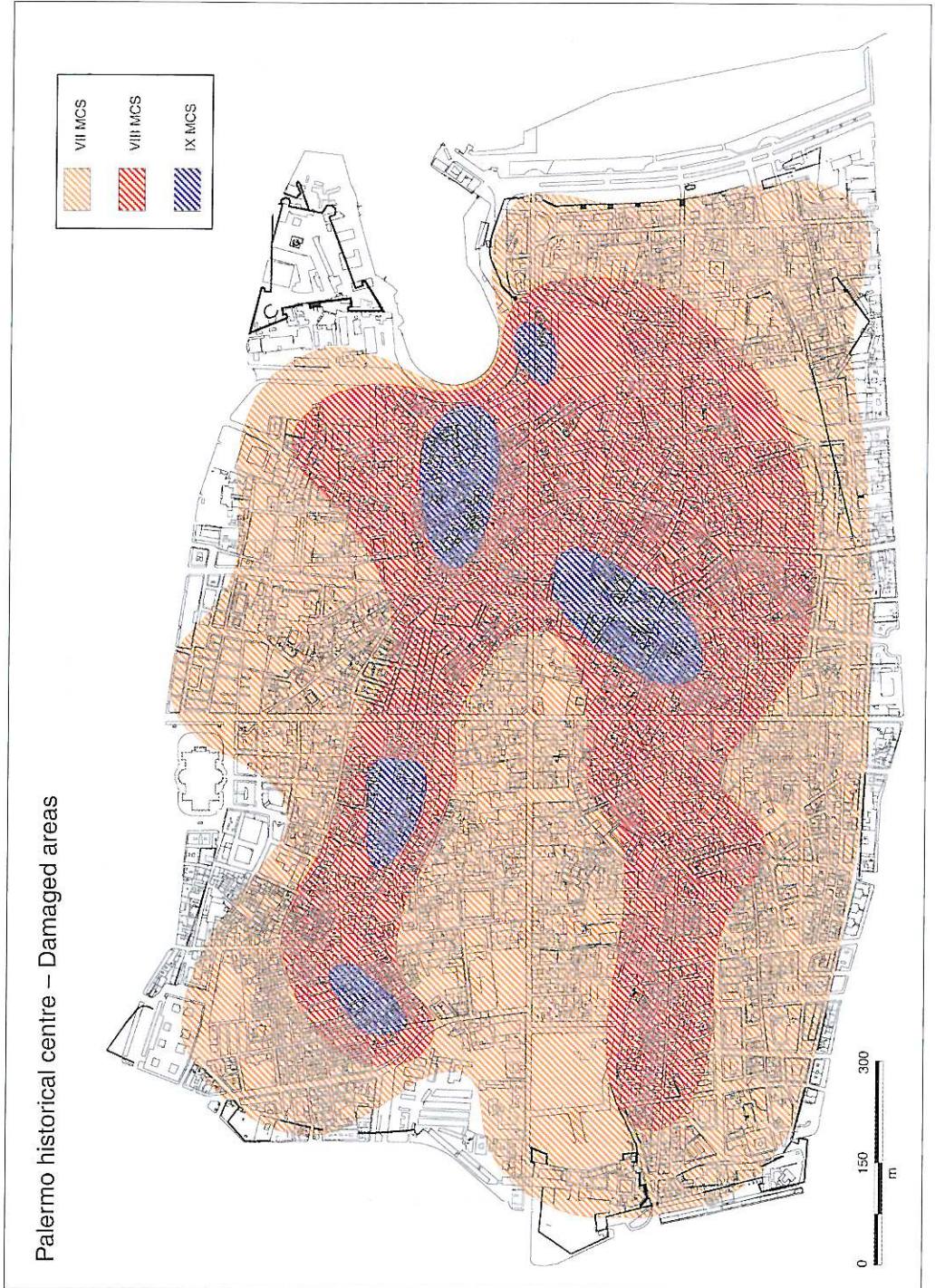


Fig. 10. Simplified map of the distribution of seismic effects in the historical centre of Palermo representing damage caused by the 1726, 1823, 1940 earthquakes (from Guidoboni and Mariotti, 1999).

contains original information of great interest for the construction of «seismic histories», which in many cases present quite complex and detailed level of knowledge. See of the larger cities the scenarios of damage in Benevento, Catania, Naples, Palermo, Siena and Venice, the seismic histories of myriad smaller centres also reveal the indelible traces of the damage and destruction experienced.

The minor seismicity which affected the historical city centres and which was the cause of damage and disorder to buildings has so far been largely neglected by risk experts because of underestimation due to two elements. The first is the urgent need to intervene for the sake of prevention, an aspect that so far has almost exclusively concerned the areas most exposed to risk, in other words, the areas in which the historically recorded degrees of maximum intensity are very high. Yet recent studies have shown that in certain urban contexts lower degrees of intensity (VII-VIII MCS) can cause economically significant damage. The second element is the fact that it is not easy to make a prior calculation of the seismic response in the historical cities, particularly for specialised types of architecture. To be able to define these evaluations, we need to gather knowledge based on the descriptions of already damage experienced in the past, and on structural observations regarding the vulnerability of the current historical and artistic heritage. It is from this disciplinary convergence of disciplines, based on historical seismology, engineering and the history of architecture, that we can discover elements for new evaluations of risk in historical centres.

Furthermore, a careful reading of the history of the most important monuments, also testified by reports, surveys and drawings may reveal that, to a greater extent than is commonly believed, seismic events have played a significant role in the existing conformation of buildings and in their preservation. Also extremely useful is the knowledge of the «conscious» planning choices of the master-builders of the past as are their analyses of the disorder, their judgements and their intervention decisions (Guidoboni *et al.*, 1997). This knowledge today represents a valuable contribution to the assessment of the

seismic risk to which historical buildings and monuments are subject and provides an indispensable guide to interpreting the true state of preservation of these structures. Thanks to this type of analyses and the specific contributions of historical disciplines it will be possible to better identify the elements which influence the choice of restoration and consolidation projects.

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