

“MESSINA: STORY OF A TOWN” EXPERT” ON EARTHQUAKES VIA RISORGIMENTO, A PALIMPSEST OF “ANTI-SEISMIC” BUILDING SYSTEMS”

Ornella Fiandaca^{*,1}, Raffaella Lione¹

⁽¹⁾ Dipartimento di Ingegneria, Università degli Studi di Messina, Messina, Italy

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ABSTRACT

The tragic earthquake of 1908 affects the area of the Strait already strongly proven in previous centuries and with its destructions, first, and reconstructions, after, makes the city of Messina a field of verification of previous construction solutions and experimentation of “innovative” technical, new methods of calculation and ad hoc regulations.

Through archival documents, technical reports, publications of the time, standards issued for reconstruction, the article analyses the pre and post earthquake situation of 1908, with particular attention to the composition of lands, sub-layers, foundations and of the structures in elevation. In particular, it lingers on the Via Risorgimento area, which has a rich palimpsest of techniques and shrewdness of that period.

1. INTRODUCTION

A succession of earthquakes interfered with the urban development of Messina, which can be defined as a town of multiple foundations and re-foundations. In the “modern” age we can remember those related to the years 1693, 1783, 1894, and 1908, cornerstones of transformations characterized by different geotechnical, stylistic, technical-constructive, and cultural choices.

The first event, with epicenter in Noto on 11th January 1693, creates the occasion for rethinking of a late Renaissance city, almost a rarity in a widely Arab-Norman or Greek-Byzantine Sicily, included within a less and less defensive and more excise walls, in which, together with commercial traffic, the effect of flows of artists and Tuscan workers was registered: Camillo Camilliani, Giovanangelo Montorsoli, and Andrea Calamecca are

among the best known.

Two interventions characterized the aspect of Messina: in 1576 the opening of Via Austria from Piazza Duomo to the Royal Palace goes beyond the medieval districts in favour of bourgeois wings, sculptural fountains, and commemorative statues; in 1622 the regulations issued by the viceroy Emanuele Filiberto of Savoia for the redevelopment of the harbour docks through the replacement of the medieval curtain with the “Palazzata”, an architectural front extended over a kilometer, with 13 blocks joined by 18 monumental gates, based on a unitary design by Antonio Ponzello.

The actions undertaken after the earthquake of 1693 amplify the image of a baroque town, with the creation or the stylistic transformation of a significant number of churches by the religious Orders that had settled in Messina since the end of the sixteenth century; the squares

in front of these constructions were enlarged or enriched and some streets were rectified to favour scenographic wings or perspective backdrops [Aricò, 2014].

This is the appearance of the town surprised again by the earthquake of 5th February 1783, whose relevant effects were faced with a conservative approach. Indeed, the first “anti-seismic” prescriptions were formulated by the mathematician Andrea Gallo for the entire urban fabric as the basis for the reconstruction plan, drawn up by the military engineer Gianfrancesco Arena. The lines of intervention were summarized as follows: 1. preserving the ancient historical road system, 2. intersecting the pre-existing urban fabric with a series of roads that would serve as escape routes, 3. designing a new “Palazzata”, as a symbol of the town and its harbour, and realizing the behind Via Ferdinanda; 4. restoring the medieval districts also through a new road system; 5. providing urban expansion to the north [Aricò, 1988; Arena et al, 2018].

Lights and shadows, therefore, in the stratification of a “safe” urban design that should have maintained aesthetics and identity of the existing town. The historical road system that included five “main streets” was restated but expanded only where possible, the escape routes required a greater transversal fragmentation of the urban fabric and of the project of a second “Palazzata” that had to represent the fulcrum of continuity for the collective memory. On the ruins of the previous one, sometimes exploiting its foundations, the construction site was started in 1803 on a project by Giacomo Minutoli; he pro-

posed again, with neoclassical language, the architectural body along the dock, regularizing the building with the opening of Via Ferdinanda in this way determining a behind façade and creating a double number of entrance doors / escape routes compared to the previous one, equal to 36, main and secondary, to give access to citizens towards the sea (Arena et al, 2018).

Once the “historical” town had been settled, it was necessary to foresee its expansion beyond the town walls, in agricultural areas, therefore not compromised by rubble, which became the object of a long debate that ended with the drafting of an expansion plan in the area of the Moselle in the south part approved with *Regio Decreto* (RD_Royal Decree) 02/21/1869. A further urban growth, required beyond the walls to the north, was distributed along the sea route with summer residences where the Liberty style was experimented in Messina.

Therefore, the town of the nineteenth century presented a modern appearance, with mobility infrastructures that overlapped the historical ones in the north-south direction and with new escape routes in the east-west direction, towards the sea and on the different torrents that were covered, Portalegni, Boccetta, Trapani, S. Francesco di Paola.

This system proved to be vulnerable during the earthquake of 1908, both because the most aggressive threat to the urban fabric came precisely from the sea, and because large areas for the collection of citizens in safety were absent; moreover some buildings were close to the torrents or on pre-existing bottoms.

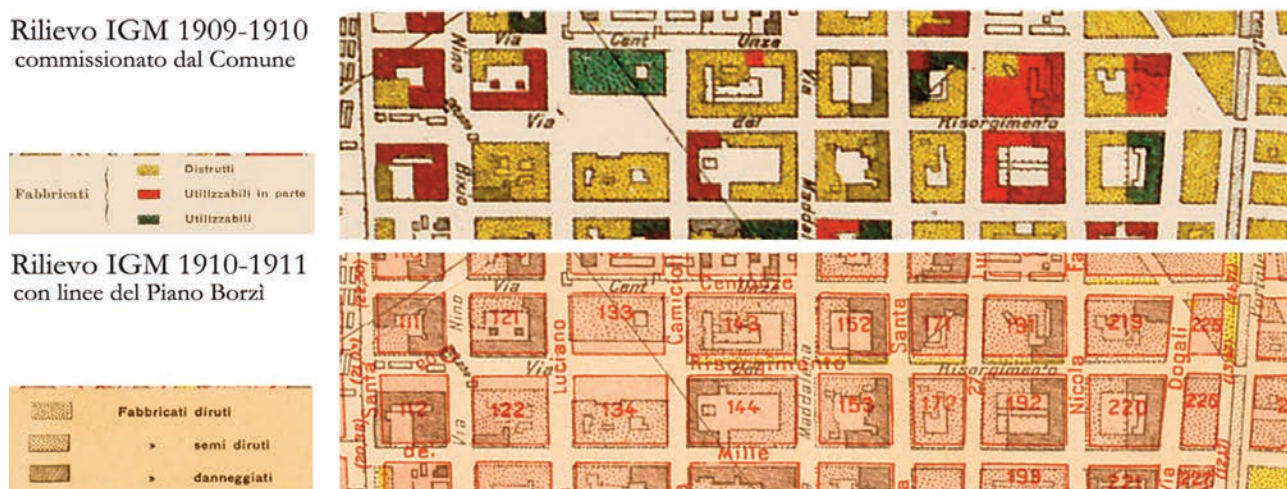


FIGURE 1. Excerpts from the IGM survey of 1909–10 and of 1909–11 on the south expansion area (via Risorgimento). A comparison between the two topographic survey highlights some inconsistencies because the second does not repeat the definition “usable”, assimilating this and the attribution “usable in part” in the category more vague of “damaged”. [Messina distrutta col piano baraccato, Rilievo IGM 1909–1910 (up); Pianta della città di Messina e dintorni con le linee del Piano Regolatore, Rilievo IGM 1909–1911(down)].

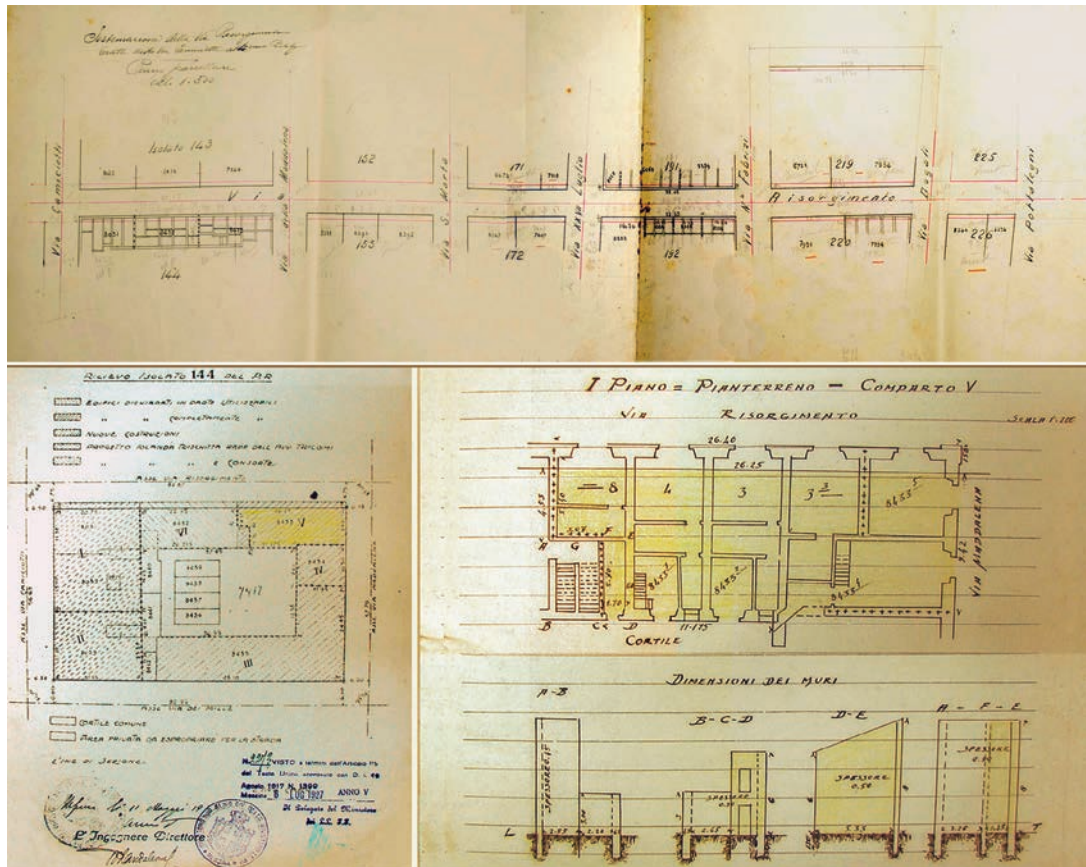


FIGURE 2. The cuts on Via Risorgimento in the survey of the Ufficio Speciale delle Espropriazioni. Below details of the intervention to be carried out in the block 144 / comp V. [ASC-Me / USE-IV, Faldone 43 (up) and Faldone 106 (down)]. A recent examination of the surviving heritage, still present in the urban fabric of Messina (not replaced by building after World War II), has indexed the following blocks/sector: bl.109; bl.110/s.III; bl.121/s.I; bl.133; bl.144/s.I; bl.145/s.III; bl.154/s.II; bl.171/s.II; bl.274A; bl.310/s.II; bl.465/s.II-III; bl.478; bl.487/s.IV.

Yet in spite of what is narrated by several bibliographic sources, the recent consultation of an unprecedented archival fund, at the Municipal Historical Archives of Messina (containing the practices drawn up by the *USE - Ufficio Speciale delle Espropriazioni* for the application of the reconstruction plan elaborated by Luigi Borzi in 1911 has allowed us to highlight a less ruinous scenario: the engineers of the Surveyor's Department office, called to write up the reports of consistency of damages for the valuation of real estate to be allocated to streets, squares, blocks, described the building units mainly as "fully usable" or "partially usable" in the face of a smaller number of declarations of uselessness [Arena et al., 2018].

A photograph of the situation the day after the earthquake can be deduced from the map-making designed to assess the damage extent: a first survey carried out by the *Istituto Geografico Militare* [IGM 1909-1910] on behalf of the Municipality of Messina distinguished buildings destroyed, usable in part, and usable; in a slightly later map, dated 31st March 1911, the IGM reported de-

stroyed, half-destroyed, and damaged buildings, under the blocks of the just drawn up Borzi Plan.

Hence, the significant number of surviving buildings in the areas of expansion to the north and south of the town, settled in the second half of the nineteenth century, does not surprise. Their concentration proposes a very interesting field of investigation to give some answers about the anti-seismic culture that, early in twentieth century, could be inferred from the practice or defined by theoretical studies and normative prescriptions.

As a representative sample for the undertaken analysis, the Via Risorgimento has been identified, from Via Santa Marta to Via Cannizzaro (Portalegni torrent), with a view extended to the parallel streets, as it offers a repertoire of variegated and plural technical-constructive solutions and allows to study: the foundations and elevation structures that resisted earthquakes and the way they were reinforced; the solutions adopted for the reintegration of the cuts imposed by the Borzi plan; the constructive systems adopted in the substitutions of dam-

aged buildings (even if they could be used in whole or in part) in the following phases of the reconstruction, according to theoretical convictions and changeable normative indications; the storeys built on to buildings of the 1950s and the substitutions, sometimes unjustified, of the second post-war period.

2. DEBATES ON CHOICES TO BE MADE AFTER THE EARTHQUAKE OF 1908

The anti-seismic culture has strengthened in the Calabrian-Sicilian area in the first decade of the twentieth century, to be then exported elsewhere, according to non-linear paths that clashed with prejudices and ignorance, urgencies and procedures, professionalism, and speculations.

A synthesis of the doubts encountered in tackling the reconstruction theme returns the uncertainties of a period in which synchronic and diachronic considerations followed the debate; the latter contributed to the development of theories and practices to ensure resistance to the earthquake actions, not scientifically known yet at the beginning of the century.

The first and most significant controversy about the opportunity to settle again the affected towns where they were and how they were comes back to every catastrophe, even recently. Also for Messina the pros and cons of the various options were discussed, concluding for the maintenance of the historical fabric as a support on which superimposing an “anti-seismic” urban design. The two

Royal Commissions, one scientific-seismological and the other technical-constructive, entrusted with the assessment of the earthquake effects, were agreed in recognizing the cause of the collapses in the absence of already well-established precautions such as an appropriate foundations system, the use of good building materials, the correct too things of masonries [Bertolaso et al, 2008; Miraglia, 1920; Valenti 1909, 1922]. The damage census, carried out with a spot check by the seismologist Mario Baratta, but also by Giuseppe Mercalli and Secondo Franchi, on how much was still usable, revealed some widespread negligences identified in: a wrong positioning of the chains; the use of poor quality mortars for irregular masonries; an inadequate connection among load-bearing walls and among these, floors and roofs [Baratta, 1919, Franchi, 1909, Mercalli, 1910]. Many articles, taken from specialized publications – *Giornale del Genio Civile, Il Monitore Tecnico, Giornale del cemento* – restated that disasters were related to the construction way, already weakened by previous seismic events and that, where repairs or buildings had been erected in compliance with the provisions in the field (after the earthquakes of 1783, 1894, 1905), they had resisted all subsequent earthquakes.

Yet once again it was decided to preserve, as far as possible, the existing road system and, up to the 1920s, also a substantial part of buildings declared usable, in whole or in part. We have recognized an attempt of unprecedented urban redefinition, which preserves, repairs, restores, consolidates, reconstructs parts or the whole but with the intent of taking root in the pre-earthquake urban fabric.



FIGURE 3. Background layers and archaeological remains in the city: the difference in height around the Catalan church (left) and the Roman *antiquarium* in the courtyard of the Town Hall (right). [Photos of the authors]

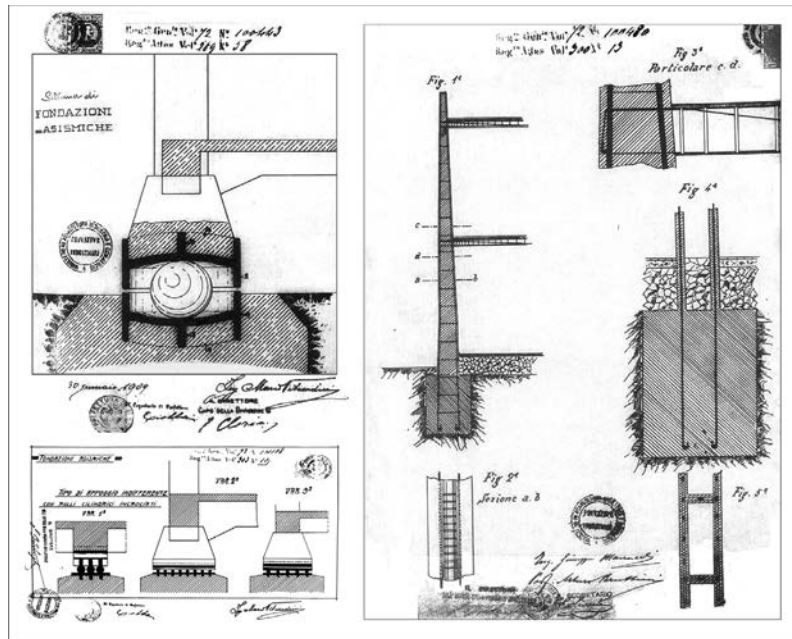


FIGURE 4. Patents on foundations with "dumpers" (on the left Mario Viscardini No. 10044, Genoa 30.01.1909) and on rigid foundations (on the right Giuseppe Marucchi and Arturo Bruttini No. 100480, Rome 10.02.1909). [ACS-Rm].

For road extensions the procedure was to propose, when possible from one side, a cut of buildings, even when not damaged, in compliance with the alignments provided by the Borzi Plan; the owners, to whom portions of buildings were expropriated, obstinately secured the surviving ones, rebuilt their fronts and continued to live there.

This practice generated non-virtuous and certainly vulnerable behaviours in the discontinuities introduced between the pre-existing wall system and the rebuilt part in reinforced concrete (inadequate correlations, different static behaviours, etc.). Interventions of strengthening are still evident in the pre-earthquake building fragments recognizable along Via Risorgimento (and the parallel streets) for distributive-functional model (mixed-type: residence-shop with mezzanine) and for construction techniques (stone masonries with strips and little brick walls).

The relevant problem of rubble and foundations was faced in a superficial way, at both private and institutional level.

In case of total or partial expropriation of buildings that hindered the execution of the Borzi Plan, owners had to provide for demolition and removal of all materials of which they remained in possession. Passed sixty days by the notification without results, the Municipality intervened to continue the operations and appropriated the remains.

The foundations, on which ruins and rubble burdened, remained submerged under fills; they brought the new level to rise above the original even a couple of meters on average and the new foundations to conflict with uncertain stratifications.

It is not infrequent to see in Messina the "pre-earthquake" towns in the "archaeological" excavation areas of the San Giacomo church, near to the Cathedral, in the Roman remains emerging in the inner courtyard of City Hall or in the portions of the Jesuit College that could be visited among foundations of the University buildings.

As further proof of this confused and permissive practice, from the technical reports of the repair and/or reconstruction projects consulted at the State Archives of Messina [Fund Genio Civile-Servizio Terremoto], it is clear that the foundations of the collapsed buildings were examined, in case of excellent conditions, they were conserved, reused and eventually integrated with a "concrete slab of fat lime, pozzolan and granite stones" [AS-Me, Genio Civile-Servizio Terremoto: block 123/sector I, bl. 110/s. III].

Even the regulations, at least at the end of the 1920s, considered possible the use of pre-existing foundations if they did not show damages or deficiencies [articles 27 and 32 of R.D. 1912/1080], without reflecting on materials, dimensions and congruence with the elevation structure. The provision to evaluate these parameters appeared only in the R.D. 1937/431, at the art. 32. In case of inadequacy, foundations had to be demolished, repaired or reinforced with appropriate measures to be submitted to the competent Surveyor's Department office to which the approval was due.

It was a clarification perhaps necessary owing to the arbitrariness with which buildings were erected on the remains of demolitions, without the prudence due to security purposes.

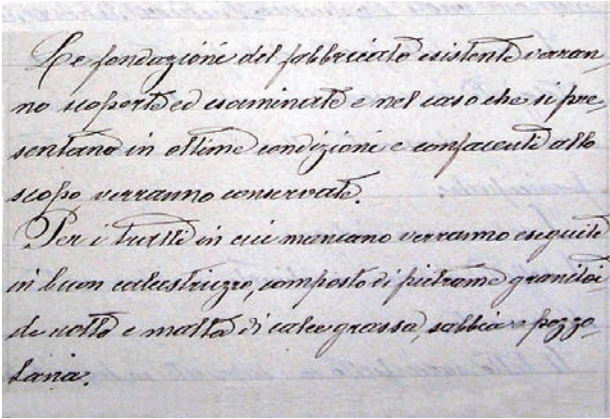


FIGURE 5. Technical report extract. [AS–Me, Isolato 123: Busta 223, Posizione 3598–99].

Another reason of “scientific” conflict was about the structural concept of anti-seismic foundations to be adopted: rigid or damped system. This too is a theme that returns to the present day.

A significant number of patents issued between 1909 and 1911 mainly proposed rollers, spheres, springs, slipping plates or any technical solution to dissipate the earthquake effects by disconnecting the foundations structure from the elevation one [ACS–Rm, Patents 1909–1012].

They were rejected by seismologists, geologists, engineers and institutions that should have supported the conceptual definition of the anti-seismic culture, owing to difficulties of execution and high costs, their maintenance and durability over time; even if they recognized a better theoretical profile than the rigid systems in reinforced concrete. These were preferred and widely suggested because it was believed that they responded in agreement with elevation to the earthquake effects, moving without damaging or producing injuries in the elevation structures.

A citation, functional to demonstrate this assumption, came from the conclusion of the report drawn up by the Geological Commission of the United States after the San Francisco earthquake of 18th April 1906, which faithfully enunciated: “concrete, and mainly the reinforced one, because of its great resistance and its continuity proved that it is the most satisfying (anti-seismic) material. Its monolithic structure gives a material with a wonderfully resistance to the shakes, since it moves all of a piece [...] [Flament, 1909]”.

Thus, the choice of a foundation structure rigidly linked

to the elevation one was generalized, and therefore it was able to guarantee the connection of the building to the ground. This result could be obtained by laying foundations directly on compact rock or on solid ground but, in the absence of these conditions and depending on the “inclination to subside” of the terrain, it was adopted a “raft foundation” or in any case “beams connecting the pillars to the base” [Unione Edilizia Messinese, 1917] constituted by rigid elements.

Sometimes the entire basement or semi-basement, made up of reinforced concrete walls connected by a raft to the base and a floor at the top, constituted a foundation with a very rigid “empty raft” and with the further advantage of lowering the centre of the building [Fiandaca, 2014].

About the “theoretical” possibility, considered the real quantity of rubble and previous stratifications, to insert, between the foundation structure and the ground, a bed of sand or debris to which giving the role of dampening seismic actions, the studies were too superficial to be able to consider this as a valid solution.

The debate was proposed again for the elevation structure about the constructional systems to be considered as anti-seismic. The uncertainties were registered in the arduous normative path that highlights, in the proposals formulated in 1909, 1912, 1913, 1917, 1924, and 1935, the prejudices that accompanied the diffusion of reinforced concrete as a material with an “anti-seismic vocation”.

Comparing the constructive systems allowed in the first normative formulation, and in the revisions resulting from the contribution of reflections and suggestions of additions and amendments [La Rassegna Tecnica, jun–jul–nov 1912], a terminological confusion is perceived that is probably the reflection of a conceptual one.

The R.D. 1909/193 considered, without any exclusion, all the structural options, from traditional to innovative ones:

art. 7¹

Gli edifici debbono essere costruiti con sistemi tali da comprendere un'ossatura di membrature di legno, di ferro, di cemento armato o di muratura armata capaci di resistere contemporaneamente a sollecitazioni di compressione, trazione e taglio. Esse debbono formare un'armatura di per sé stante dalle fondamenta al tetto, saldamente collegata con le strutture orizzontali

¹ art. 7. Regio Decreto 1909/193 - Buildings must be built with systems such as to include a skeleton of wood, iron, masonry with diffuse reinforcement or reinforced concrete, that are capable of withstand stresses from compression, traction and cutting. They must form a self-supporting structure from the foundations to the roof, that is firmly connected with the horizontal structures and containing in its meshes the material that forms the wall.

portanti (solai, terrazzi e tetti) e che contenga nelle sue riquadrature, oppure racchiuda nelle sue maglie, il materiale formante parete, o vi sia immersa.

art. 13²

Per i sistemi intelaiati o baraccati è obbligatorio uno almeno dei mezzi di irrigidimento seguenti:

- a *connessioni rigide delle membrature nei punti di incrocio;*
- b *collegamenti diagonali o controventi;*
- c *riempimento o rivestimento di struttura tale da opporsi efficacemente alle deformazioni.*

art. 14³

Per riempimento o rivestimento, nelle costruzioni intelaiate o baraccate, sono ammesse le strutture seguenti:

- a *muratura armata, animata od ingabbiata, od altrimenti consolidata specialmente quando costituisce mezzo di irrigidimento:*
- b *pareti semplici o doppie di lastre naturali o artificiali, di reti metalliche intonacate, di tavolati di legno iniettati o rivestiti, o di qualunque altro materiale che presenti solidità, leggerezza e sia immune, per quanto è possibile, dall'azione del fuoco e dell'umidità atmosferica.*

The urgency with which the *Regio Decreto* was issued did not give time to mature and study the different construction methods. Hence a succession of interpretations, experiments, revisions that led, with different outcomes but not for this more reasonable, before the draft of 1912 and then the *Testo Unico* (Sigle Text) of 1913.

In the review [art. 8 *Regio Decreto* 1912/1080; art. 192 *Testo Unico* R.D. 1913/1261] we read:

Gli edifici debbono essere costruiti con muratura armata o con muratura animata o con sistemi tali da comprendere un'ossatura di membrature di legno, di ferro o di muratura armata o di muratura animata capaci di resistere contemporaneamente a sollecitazioni di compressione, trazione e taglio. Essi debbono formare un'armatura completa di per sé

*stante dalle fondamenta al tetto, saldamente collegata con le strutture orizzontali portanti (solai, terrazzi, tetti) e che sia o immersa nel materiale formante parete o lo contenga nelle sue riquadrature, oppure lo racchiuda nelle sue maglie, e sia con esso saldamente collegata.*⁴

The "reinforced concrete structure" disappears, and becomes *muratura animata* (reinforced masonry), thus ratifying no longer a frame concept but a wall system with horizontal and vertical elements in reinforced concrete. This hypothesis is confirmed, in redefining the art. 12, by the suppression of point a) which provided for the possibility of erecting structures composed of frames with rigid nodes. The coming in succession of prescribed technical solutions continued to betray the fluctuating dilemma between a constructive tradition that was mastered and the task of innovation that intimidated.

The structural types continued to be discussion topics for a decade, repeating them with very small variations in the normative precepts that followed one other [art. 8 *Regio Decreto* 1915/573; art. 2 *Decreto Luogotenenziale* 906/1916; art. 211 *Decreto Legge Luogotenenziale* 1399/1917].

In the entry "prescribed masonries", we continue reading:

Gli edifici debbono essere costruiti con muratura armata o con muratura animata o con sistemi tali da comprendere un'ossatura di ferro, o di muratura armata o di muratura animata, capace di resistere contemporaneamente a sollecitazioni di compressione, trazione e taglio.

E' ammessa l'ossatura di membrature di legno, purché bene stagionato, per le case col solo pianterreno. Le ossature debbono formare un'armatura completa di per sé stante dalle fondamenta al tetto, saldamente collegata con le strutture orizzontali portanti (solai, terrazzi, tetti) e che sia od immersa nel materiale formante parete o lo contenga nelle sue riquadrature, oppure lo racchiuda nelle sue maglie, e sia con esso

² art.13_ *Regio Decreto* 1909/193 - For framed systems it is mandatory at least one of the following stiffening means: a) rigid connections of the structural elements in the nodes; b) diagonal or bracing connections; c) filling or coating of such structure for effectively oppose the deformations.

³ art.14_ *Regio Decreto* 1909/193 - The following structures are permitted for filling or cladding in the constructions framed systems: a) reinforced, animated or caged masonry, or otherwise consolidated, especially when it is a means of stiffening; b) simple or double walls of natural or artificial slabs, of plastered metal nets, of wood plank or of any other material that has lightness, solidity and has immune as far as possible from the action of fire and humidity atmospheric.

⁴ art. 8_ *Regio Decreto* 1912/1080; art. 192_ *Testo Unico* R.D. 1913/1261 - The buildings must be constructed with masonry with diffuse reinforcement or reinforced masonry or with systems that include a framework of wood, iron or masonry with diffuse reinforcement or reinforced masonry, capable of simultaneously withstanding compression, traction and shear stresses. They must form a complete armature, self-standing, from the foundations to the roof, firmly connected with the horizontal load-bearing structures (floors, terraces, roofs) and that is immersed in the wall forming material or that containing it in its squares or enclosed in its meshes.

*saldamente collegata.*⁵

The reinforced concrete with rigid nodes appears again in the 1924 regulations (R.D. 2089/1924).

The supporters affirmed that the reinforced concrete, in addition to its great qualities of resistance, continuity, elasticity and incombustibility, offered a high resistance to the “earthquake actions” “by virtue of its ho-

1909; Fiandaca, 2014].

The detractors stigmatised the constructive procedure that prevented controlling the installation of the quantities evaluated by calculations which were anyway still under development in light of seismic emergencies. The uncertainties spread, besides to the quantity to be considered for an adequate mechanical response, also to the



FIGURE 6. The types of structures for “anti-seismic” foundations realized for the economic houses program managed by the UEM in the first years of the reconstruction: basic rigid frame; detail of the concrete steel foundations; reinforced concrete bed; slabs of hollow foundations. [Unione Edilizia Messinese, 1917]

mogeneity; the latter allowed the unit of vibration and acceleration, main and essential factor for the preservation of buildings in the event of an earthquake. Its characteristic of being monolithic was exalted, guaranteed instead of heterogeneous solutions with more overlapping or placed against materials, more or less well assembled; on this peculiarity it was concentrated every reasoning that led to the conclusion that the reinforced concrete, judiciously studied and applied, was the only constructive procedure “susceptible, if not to avoid totally the great cataclysms of the globe, at least to mitigate them to the greatest extent” [ACS-Rm, Patents 1909–1912, Flament,

quality of the composite material; about the latter, the concrete composition and the type of reinforcement had to be evaluated to ensure the best possible synergy, able to optimize the mechanical response and to evade defects of the parts (ingredients, constituents) individually considered.

The fears derived: from the incompetence of workers in correctly placing the reinforcing steel, mainly in the nodes; from the impossibility to carry out corrections after the concrete pouring that required informed and timely checks; from the lack of means to evaluate the earthquake magnitude and especially from the shortage of theories for-

⁵ art 8_Regio Decreto 1915/573; art. 2_Decreto Luogotenenziale 906/1916; art. 211_Decreto Legge Luogotenenziale 1399/1917 - The buildings must be constructed with masonry with diffuse reinforcement or reinforced masonry or with systems that include a framework of iron or masonry with diffuse reinforcement or reinforced masonry, capable of simultaneously withstanding compressive, tensile and shear stresses.

The framework of wooden membering is allowed, as long as it is well seasoned, for houses with only the ground floor.

The skeleton must form a complete armature, self-standing from the foundations to the roof, firmly connected with the horizontal load-bearing structures (floors, terraces, roofs) and which is immersed in the wall forming material or that containing it in its squares or else enclosed in its meshes.

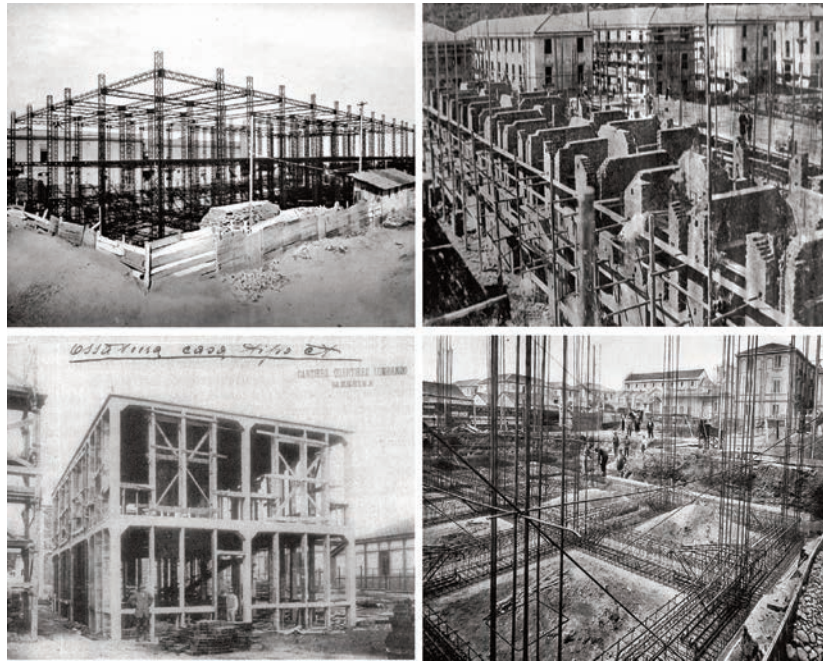


FIGURE 7. The construction systems for "anti-seismic" elevation structures permitted by the regulations in the subsequent emanations: frames of steel (1909 et seq.); reinforced masonry (from 1912 to 1924); reinforced concrete frames with diagonal bracings (1909); frames in reinforced concrete with rigid knots (1909 and then since 1924).

mulations able to translate the phenomenon into a correct prevision of type, extent and distribution of reinforcements [ACS-Rm, Brevetti 1909– 1912, Fiandaca, 2014].

It needed confronting with a variegated cultural background, constantly evolving, with vocation to empiricism and conditioned by decision-making and fashion pressures of different competences: scientific, institutional, professional, and operational.

The evolution of reinforced concrete finds in Messina, in its application to structural types, different "anti-seismic" development models if we consider realizations in three different periods of reconstruction: before 1922; from 1922 to 1939; after 1939 to which the following motivations correspond respectively: scientific scepticism, ministerial constraints, and autarchic prohibitions.

A walk along Via Risorgimento, among surviving pre-earthquake buildings, additions of the early 1920s, substitutions imposed by the reconstruction accelerated during

the Fascist regime, repairs after the second post-war period, and new buildings of the 1980s, offers a fundamental opportunity to follow this technical-constructive path.

3. THE TECHNICAL-CONSTRUCTION LESSON WRITTEN ON VIA RISORGIMENTO

The extent of damage caused by an earthquake depends on different causes; the most important are the mutual connections among the energy of a seismic action, the nature of ground and of the layer involved in foundations, and the type of elevation structures.

Alluvial deposits, for example, amplify the effects of seismic waves and maybe this was a relevant factor for Messina because the town is crossed from east to west by a network of torrents that report the presence of unstable and incoherent grounds on which entire districts



FIGURE 8. Via Risorgimento – Via Nino Bixio, a surviving nineteenth-century building in block 121 / sector III. [Photos of the authors]

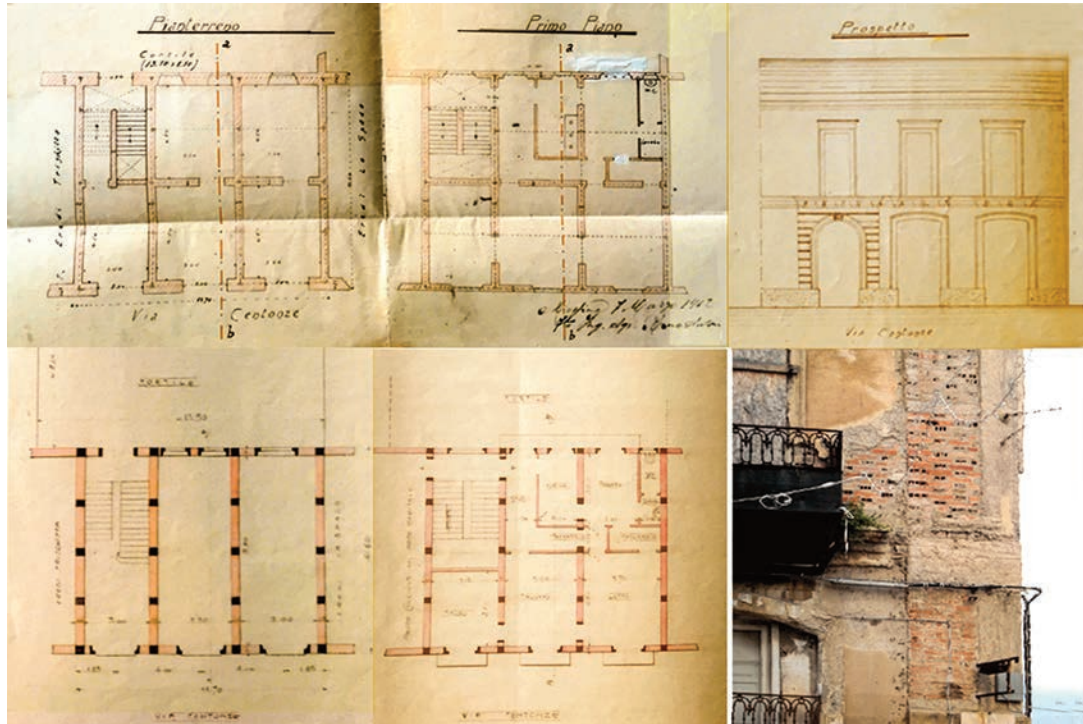


FIGURE 9. Structural restoration project for the block 121/ sector I with a caging of the existing building system masonry carried out by reinforced concrete elements. [AS-Me, Isolato 121: Busta 463, Posizione 34055]

were founded. Also the surface aquifers can have influenced the intensification and the propagation of oscillations.

The lithological constitution induced different responses to the earthquake in the western part of the town: where the Pliocene formations were present, there were great ruins, while in the Miocene ones damages were minor. Where crystalline formation emerged, in the southern area, even smaller collapses were registered.

It is here that the Via Risorgimento is placed, an almost exhaustive palimpsest of the evolution of an anti-seismic culture that strengthen between the nineteenth and twentieth centuries. There are buildings that survived the earthquake and were consolidated according to the 19th century “tradition” or reinforced according to the

“innovation” of the twentieth one; others were realized with the constructive systems from time to time coherent with current regulations; others had repairs or replacements made after the Second World War.

A first analysis, led on an urban scale and on the repeated surveys drawn up by the IGM from 1909 to 1911, allowed us to understand the real outcomes of the earthquake, which confirm for this area a significant presence of “damaged” but not devastated buildings, “ruined or semi-ruined”.

A further assessment of the operative strategies resulting from these surveys was carried out, on a building scale, consulting the correspondence produced by the USE – Ufficio Speciale delle Espropriazioni (Special Office for the Expropriations) of the Messina’s Municipal–

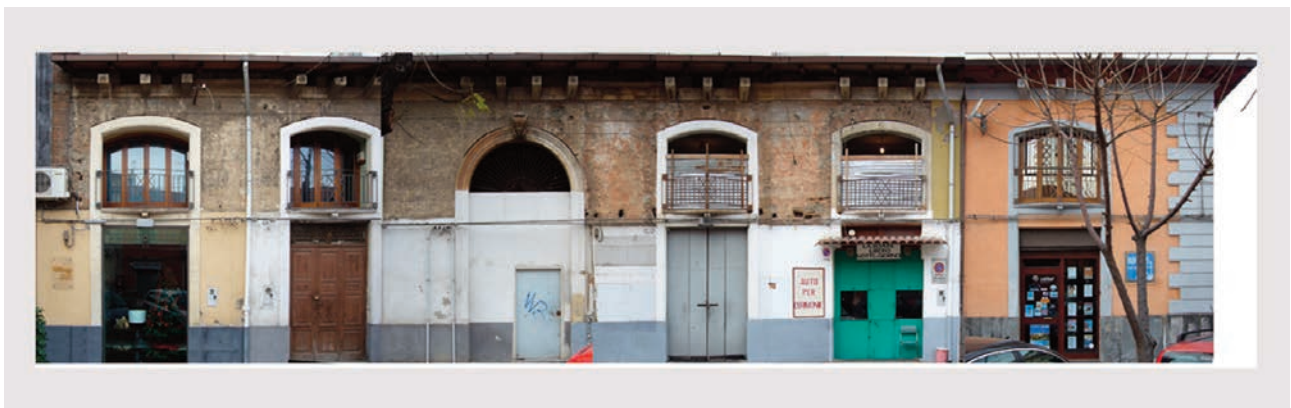


FIGURE 10. Via Risorgimento–Via Camiciotti, a surviving nineteenth-century building in block 133. [Photos of the authors]

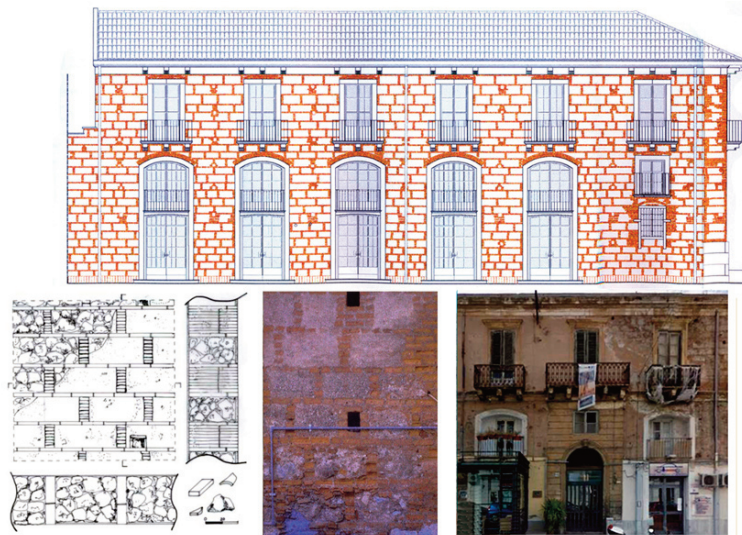


FIGURE 11. A survey on peculiarities of the nineteenth century "mixed type" buildings, observed in the surviving constructions. [Processing of the authors]

ity. The Surveyor's Department engineers described the extent of damage of each housing unit to estimate what was necessary to expropriate to allow the execution of the Borzi Plan that overlapped a new urban fabric to the previous one, following the anti-seismic requirements imposed by the *Regio Decreto* 193/1909 (Royal Decree with its modifications and additions).

The simultaneous presence of the two fabrics, the existing one and the expected one, revealed that it was necessary to decide what to do in the presence of "damaged" buildings but usable in part or entirely, which interfered with the extension prescribed for the neighbouring streets, and what to propose for the elevations above the two permitted floors, that even if not damaged were considered with an high seismic vulnerability.

USE imposed the cut of building portions that went beyond the alignment expected by the blocks of the Borzi Plan, which were expropriated and reimbursed. The owners, in contrast to any criterion of static safety, (paradoxically) in compliance with the rules, worked to rebuild the demolished wings on the edge of the new road and to provide for the too things with the existing masonries.

Along Via Risorgimento the operation was suggested for buildings "usable in part" that insisted on blocks 121, 144, 152 (corner via Santa Marta), 191 (corner via 27 Luglio), 192, and declared destroyed on the blocks 143, 152 (corner via Maddalena), 171, 191 (corner via Nicola Fabrizi), 219.

A representative intervention, among those with similar conditions and widespread in the town, is the one shown in the project filed at the State Archives of Mess-

ina, Fund Genio Civile – Servizio Terremoto (Civil Engineers – Earthquake Service) for the block 121.

The cut or collapsed portions were restored with a solid brick wall system up to the second level and above with a perforated bricks one, with strengthening made of horizontal and vertical reinforced concrete elements.

In order to fulfil the normative requirements concerning the prescribed maximum heights, the upper floors of buildings included within the block 133, which still shows the support shelves of the third level balconies, and within the blocks 134, 143, 144, 171, which present a flat roof in reinforced concrete, were demolished.

4. CONCLUSIONS

No one questioned about the reasons that avoided the collapse of buildings partially surviving the 1908 earthquake, located in the nineteenth-century expansion areas of the town.

We want to dwell on these architectures, also present in via Risorgimento, expression of an entrepreneurial middle class – called "mixed type" because they superimposed to a group of residences-shops a type with master houses – and try to provide some answers on the peculiarities that allowed to oppose an adequate resistance to the earthquake effects.

The first one, of a geotechnical nature, can be interpreted precisely in the foundations system made up of masonries with a thickness slightly higher than that of the elevation structure but which brought back a very reduced load directly on the rock.

The second one, of typological nature, concerns the presence of a mezzanine floor that in the “structural geometry” of these buildings lowered the barycentre of masses.

The third one, of a constructive nature, is to be ascribe to the wall system classified as a masonry “in heap of stones with brick lists and little walls”, a further characteristic of the province of Messina.

It is a conglomerate, composed of lime mortar and stone pieces of variable dimensions, listed horizontally and divided vertically by clay-bricks that form a grid with staggered meshes and transversely wedge the entire wall. This type of masonry can be considered as “anti-seismic” by virtue of an “homogeneous response” to external actions, due to the properly made construction – which guarantees a uniform distribution of loads and without preferential paths – and an “elastic response”, due to the weaving with brick lists and little walls – which opposes a good flexibility in the settlement induced by the shakes both “sussultatory” and “undulatory”. In fact, it is necessary to underline the best behaviour of this wall texture not only for actions in the plan of the principal masonry walls (sussultatory/vertical) but also for actions outside the plane (undulatory/ transversal).

We can conclude by stating that the lesson learned in Messina from the study of its “stormy” past and of a path of “natural selection” that left the strongest species alive could bring a significant enrichment to the current anti-seismic awareness landscape.

REFERENCES

- Arena A., M. Arena, O. Fiandaca and F. Passalacqua (2018). *L'altra Messina: una città di carta. Tracce di DNA restituite dai documenti dell'Ufficio Speciale delle Espropriazioni.* Aracne, Roma.
- Aricò N. (1988). *Cartografia di un terremoto: Messina 1783*, in *Storia della città. Rivista internazionale di storia urbana e territoriale*, n. 45, Electa, Milano.
- Aricò N. (2013). *Architettura del tardo rinascimento in Sicilia.* Giovannangelo Montorsoli a Messina (1547–57), Leo S. Olschki Editore, Firenze.
- Aricò N. (2014). *Una città in architettura. Le incisioni di Francesco Sicuro*, Caracol Edizioni, Palermo.
- Baratta M. (1910). *La catastrofe sismica calabro messinese. 28 dicembre 1908: relazione della Società Geografica Italiana*, Arnaldo Forni Editore, Roma.
- Basile F. (1960). *Lineamenti della storia artistica di Messina: la città dell'Ottocento*, Edizioni Leonardo, Messina.
- Bertolaso G., E. Boschi, E. Guidoboni and G. Valensise (a cura di), (2008). *Il terremoto e il maremoto del 28 dicembre 1908, analisi sismologica, impatto, prospettive*, INGV–SGA, Roma–Bologna.
- Fiandaca O. (2014). *Le Béton Armé “Système Hennebique” a Messina fra XIX e XX secolo*, Aracne, Roma.
- Fiandaca O. and A. Recupero (2017). *Riflessione diacronica sulla vulnerabilità sismica del patrimonio edilizio storico messinese*, Colloqui.AT.e 2017, Demolition or reconstruction? Edicom Edizioni, Gorizia, 299–311.
- Flament R. (1909). *Il calcestruzzo armato e i terremoti*, conferenza dell'ing.re Flament–Hennebique alla società degli ingegneri civili di Francia a Parigi nella seduta del 5 marzo 1909. Traduzione dell'ing.re Ernesto Paternò Castello, Editore C. Galàtola, Catania.
- Franchi Secondo S. (1909). *Il terremoto del 28 dicembre 1908 a Messina in rapporto alla natura del terreno e alla riedificazione della città*, Bollettino del Regio Comitato Geologico d'Italia, s. IV, 10, fasc. 2, Tipografia Nazionale di G. Bertero e C., 111–157. *Gazzetta di Messina e delle Calabrie (poi Gazzetta di Messina) dalla riedizione del 4 febbraio 1909 fino agli anni '50.*
- Masciari Genoese F. (1915). *Trattato di costruzioni antisismiche*, Ulrico Hoepli Editore, Librario della Real Casa, Milano, Capitolo CLII “Tipi e sistemi costruttivi speciali più notevoli in Italia e all'Estero”.
- Mercalli G. (1910), *Contributo allo studio del terremoto calabro-messinese del 28 dicembre 1908*, Atti del Regio Istituto di incoraggiamento di Napoli, s. IV, 7, Cooperativa Tipografica, Napoli, 249–292.
- Miraglia E. (1920). *Relazione delle modificazioni apportate dal piano regolatore di Messina 31 dicembre 1911, agli edifici monumentali o interessanti l'arte e la storia*, Manoscritti, 5 Qq. E. 155, n. 2, Biblioteca Comunale di Palermo.
- Rassegna Tecnica (1912). *Circa le norme tecniche obbligatorie*, in *La Rassegna Tecnica*, giugno 1912, fasc. I, 2–6.
- Rassegna Tecnica (1912). *Circa le norme tecniche obbligatorie. Memoriale della società Ferrobeton*, in *La Rassegna Tecnica*, luglio 1912, fasc. II, 33–40.
- Rassegna Tecnica (1912). *Le nuove norme tecniche ed igieniche, dalla Gazzetta Ufficiale del 19 ottobre 1912 n. 247*, in *La Rassegna Tecnica*, novembre 1912, fasc. VI, 141–152.

- Relazione della Commissione nominata con R.D. del 15 gennaio 1909, incaricata di studiare e proporre norme per le riparazioni, ricostruzioni, nuove costruzioni da eseguirsi nelle regioni colpite dal terremoto del 28 dicembre e da altri anteriori. (1909). Il Giornale del Genio Civile, anno XLVII, 339–352.
- Relazione della Commissione Reale incaricata di designare le zone più adatte per la ricostruzione degli abitati colpiti dal terremoto del 28 dicembre 1908 o da altri precedenti (1909). Tipografia della R. Accademia dei Lincei, Roma.
- Riccò A., E. Camerana, M. Baratta and G. Di Stefano (1907). Il terremoto del 16 novembre 1894 in Calabria e Sicilia, in *Annali del R. Ufficio Centrale Meteorologico e Geodinamico*, vol. XIX, parte I, Tip. Nazionale di Giovanni Bertero e C., Roma.
- Unione Edilizia Messinese (1917). L'Opera dall'Unione Edilizia Messinese per la ricostruzione di Messina (febbraio 1914 – giugno 1917) – Relazione del Regio Commissario Comm. Avv. Cesare Cagli, Istituto italiano d'arti grafiche, Bergamo.
- Valenti F. (1909). Ispezione ai resti monumentali della città di Messina dopo il disastro del 28 dicembre 1908 e calcolo sommario dei primi lavori abbisognevoli, *Manoscritti*, 5 Qq. E. 155, n. 1a, Biblioteca Comunale di Palermo.
- Valenti F. (1922). Relazione dell'arch. Francesco Valenti incaricato dalla Direzione dei Lavori ai Monumenti della città di Messina e provincia a sua Ecc. il Ministro della P.I., *Manoscritti*, 5 Qq. E. 155, n. 5, Biblioteca Comunale di Palermo.

ARCHIVE DOCUMENTS

Archivio di Stato di Messina (AS–Me)

- Fondo Genio Civile – Servizio Terremoto
 Isolato 110, Busta 944, posizione 18254–18257
 Isolato 121: Busta 463, Posizione 34055.
 Isolato 143, Busta 134, posizione 8278; Busta 199, posizione 12313
 Isolato 144, Busta 766, posizione 56585–56586
 Isolato 145, Busta 868, posizione 62289
 Isolato 171, Busta 911, posizione 2985–2988; Busta 364, posizione 22209

Archivio del Comune di Messina (ASC–Me)

- Fondo Ufficio Speciale delle Espropriazioni– Infrastrutture Viarie (USE–IV)
 Faldone 42 vol I: Espropriazione per la sistemazione

della via Risorgimento (tratto dalla via Camiciotti al Torrente Portalegni)

Faldone 43: Espropriazione per la sistemazione della via Risorgimento

Faldone 106: Espropriazione per la costruzione delle vie in giro all'isolato n. 248 del P.R.

Archivio Centrale dello Stato, Roma (ACS–Rm). Ministero d'Agricoltura, Industria e Commercio, Ufficio della proprietà intellettuale, Elenco degli attestati di privativa industriale.

Sono stati consultati i brevetti dal 1909 al 1912, con riferimento alle classi XIII Costruzioni civili, stradali ed opere idrauliche e XIV Materiali laterizi, cementi, calci ed altri materiali da costruzione.

NORMS

- Regio Decreto 16 settembre 1906 n. 511
 Regio Decreto 18 aprile 1909 n. 193
 Regio Decreto 6 settembre 1912 n. 1080, convertito in Legge 11 luglio 1913, n.1039
 Regio Decreto 12 ottobre 1913 n. 1261
 Decreto Legge 29 aprile 1915 n. 573
 Decreto Legge Luogotenenziale 19 agosto 1917 n. 1399
 Regio Decreto Legge 9 Maggio 1920 n. 665
 Regio Decreto Legge 27 ottobre 1922 n. 1475
 Regio Decreto Legge 23 Ottobre 1924 n. 2089
 Regio Decreto Legge 13 Marzo 1927 n. 431
 Regio Decreto Legge 4 Aprile 1930 n. 682
 Regio Decreto Legge 25 marzo 1935 n. 640
 Regio Decreto Legge 22 novembre 1937 n. 2105
 Regio Decreto Legge 7 Settembre 1939 n. 1326

*CORRESPONDING AUTHOR: Ornella FIANDACA,
 Dipartimento di Ingegneria
 Università degli Studi di Messina, Messina, Italy
 email: ofiandaca@unime.it

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