Architectures and earthquakes. Resistant solutions for the protection of the traditional construction in Abruzzo

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Abstract - **The traditional building construction in Abruzzo has been strongly characterized by the presence of earthquake resistant systems because of the many earth tremors happened through the centuries. Between the 15th and the 20th century the region was characterized by very strong earthquakes which modified the historical and figurative features of the buildings and submitted them to a technical and empirical analysis, studied through the seismicity of the areas and the possibility of resources or the possibility building yard.**

Today, little remains of this reality, not so much because of the lack of technical and building expertise that has produced it, but because of the renovation culture almost always misunderstood, and radically different from that one of the past, which proceeded in a timely fashion, replacing the irreparable damages, reinforcing the inefficient parts but without ever changing the substance of the factory.

Keywords – earthquake solutions; historical heritage; conservation; restoration.

Historical construction in Abruzzo is far, not only geographically, from the main consolidation issue[a] that have been characterizing it since 17th century. Even the terrible consequences of the earthquakes of L'Aquila in 1703 and Sulmona in 1706, and innovations after the earthquakes in Lisbon in 1755 and Calabria in 1783, influenced just a few the local building art, which kept on using materials and techniques available at the moment, improving them only when required, depending on the circumstances and necessity. There is not clear references in Abruzzo about "cage house" developed during the reconstruction of Lisbon, and about "casa baraccata" by Giovanni Vivenzio, doctor in Kingdom of Naples, in his book *Storia e Teoria dei Terremoti*, published in Naples in 1783. Even earth houses with rafters, that we could see in some part of Fucino area some years ago, appeared like poor constructions (farms) and not like earthquake resistant construction. Only in the beginning of 19th century the region paid attention to the materials and techniques of the building, explaining it in a very few documents. At the beginning of 19th century the architect Nicola Maria Pietrocola of Vasto, the only author of a little treatise on building practice in Abruzzo, became for a lot of strengthening works on monumental farms, carried out new technological innovations which developed and improved the local building art, without introducing new theories [3].

The change of the long time constructive tradition of Abruzzo happened after the earthquake in Marsica in 1915[b] and Maiella in 1933[c], accompanied by landslides which brought the transfer of entire villages modifying wild land areas[d]. Troubles caused by

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[a] The reference to a constructive art to be carried out with "kindness and ability" appears in all the building yard documents since the 16th century, setting up an unwritten law that guarantee all the building safety [1]. On the importance of the respect of the "construction art" earthquake proof aims see [2].

[b] The focus of the earthquake was in Marsica area. But the geographical area interested by the earthquake was wilder, considering that its intensity reached the XI degree of Mercalli scale, lower only than the earthquake in Reggio Calabria and Messina in 1908. More than 30000 people died. The centres devastated by the earthquake were almost 150, in a area that included Lazio, Umbria, Marche and Molise [4].

[c] The name "Earthquake in Maiella" had already been given at the earthquake on November 3th, 1706 which had the focus in Maiella area itself [5].

[d] The royal measure on May 18th 1933 included Borriello (Ch), into the list of villages that had be partially transferred at State expense according to law July 9th 1908, n. 455. Among the reasons there is the "Continuous Earthquake" in the area, with over fifty houses already

earthquakes were pointed out by geographer Mario Ortolani. In his book *La casa rurale in Abruzzo* in 1961, he shows how to recognize the areas devastated by earthquakes: previous four-five floors houses decreased and took their place the lower ones. This house "decapitation" was planned by common sense and by laws, increasing the number of houses and the villages rebuilt as new districts, making out a more different and abnormal landscape than neighboring regions.

In the first decade of 19th century the damages caused to the Abruzzo patrimony were followed by a development and experimentation of new materials, first of all the reinforced concrete. The fight of the region against this material failed, attending the renewal in action but even this time without great news. The new earthquake resistant product, for the most destroyed villages as Pescina, Avezzano and Gioia dei Marsi after 1915, consisted in one floor reinforced boxes, 8 x 4 meters, and they were considered more as makeshift shelter than houses built according to the local rustic culture, destined to be quickly replaced or converted into blocks of wilder volume, often with two floors [6]. The law n. 573 of 29/4/1915 which set the coefficients to be used in calculation of building stability depending on the new materials based on iron and cement as well as the new integrations until 1938, and the law n. 1165 which passed the consolidated act, were never respected, not only for the cost of materials and supply. There is no connection between the lack of height in reconstructed buildings and law. The law n. 573 of 1915 provided that the height of the buildings in reinforced concrete had to be no more than 10 meters and buildings in brickwork had to be no more than 7 meters, with no more than two floors, the width of the road had an average of 10 meters, while the law n. 2089 of 1924, changed the limits, increasing until 12 meters for private buildings and 16 meters for the public ones, the consolidated act of 1938 changed again the height limit, although just a little, distinguishing from time to time by their category (first or second) and the material used: stones for foundations, listed masonry for outside wall, bricks for partitions, wooden lintels for frames and roofs[e]. The only parts where modern materials were used as the concrete for stringcourses and plastered wire netting for ceilings, confirmed the persistence of the tradition that continued until the reconstruction of the second world war, when there was a definitive break with the past [7].

The most of the Abruzzo medieval villages were born under a closed box design, planned as earthquake resistant place. Mario Ortolani established a correspondence between the morphologic features of the settlements and design features used to control the vertically and horizontally strength of the walls; the structure of the building works as factor of resistance, more or less with efficiency, depending on the joint in the wall[f]. Especially, in mountain villages of Abruzzo, mechanical and earthquake-proof behaviors of the buildings depend on the building typology, made in rows with partition walls: this circumstance depends on the difficult of topographic conditions, which could be compared to a fabric with urban behavior and systems. Among these systems the most basic and effective is certainly the perimeter, almost always scarp wall, that surrounds villages with boundary houses also known as living wall, and its earthquake resistance and defense brought these features even in areas with low seismicity and without reasons to defend itself. Many historical constructions in Abruzzo still have the façade in "scarp profile", although sometimes imperceptible, according to habits that explains the theories of the 19th century. Their diffusion – as earthquake resistant system or construction system – is the most characteristic element of the historical patrimony, and it also spreads in its decorative work. In local building tradition survived the habit to give structural value at decoration until the arrival of new technological systems and materials. The unaesthetic use of frames obstructed the height of the scarp walls considered intrinsic to the structure, closing as a cage all the construction, everything in a statically efficient system.

Al least until the 19th century, when the consolidation is of priority importance, the earthquake resistant construction became a category united to building construction: suggested by common sense and traditional habits, erecting well structured walls. In Abruzzo and anywhere we cannot talk about earthquake resistant strategies before improving our knowledge about the soil and the horizontal forces of the buildings. Therefore only the distinction between earthquake resistant constructive system and earthquake resistant remedies is possible, where the first one is conditioned by the choice of materials and techniques[g].

Lower walls with arches at ground floor and wooden beam floor upstairs, unloading arches on the walls, doors and window; "soprastrada" arches among houses, opposing vaults to oppose the horizontal thrust, especially at lower floors; no pushing roofs

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collapsed, and twice over unsafe, being «seriously damaged and deformed by humps and overhangs which strongly compromised the stability». ASCh (Archivio di Stato in Chieti), *Fondo prefettura*, b. 86.

[e] An example of resistence to new techniques is the S. Nicola church in Lettopalena, strongly devastated by earthquake in 1933. The report by Civil Engineers (ASCh, *Genio civile, terremoto* 26/9/933, edifici di culto) in fact, declared that there was a detaching of the wall from supported wall and a serous cracks to the bell tower of about eight meters. Among the remedies, in addition to the "blinder" of the construction by a riddle of reinforced concrete around all the perimeter, there was the partial reconstruction of the bell tower «with the same material and the same project», the replacement of elements of the destroyed roofs and the construction of four spurs to reinforce the longitudinal walls of the aisle, placed on the top of double-T iron beams, coupled and placed in correspondence to the transversal arches of the side aisles: everything accompanied by filling the cracks, plastering the walls and "rincocciature" of walls. Material used, in special way, from the demolition at risk, according to the traditional building yard. See Montenerodomo in ASCh, *Fondo prefettura*, b. 278, Serie II, V versamento, affari comunali 1904-1971.

[f] See [8]. On other typological studies see [9].

[g] Important the letter that the Mayor of Borrello sent to the prefect of Chieti on November 1932 to denounce the demages of the buildings by earthquake and landslides, despite the local construction tradition: only two-floors houses «in order to load the ground as less as possible» using, in the place of arches, «beam floor and tables, to remove and push agaist the unsteady walls», putting cobbled paving in all the streets and squares «to prevent any seepage of water in the soil». ASCh, *Fondo prefettura, Corpo Reale del Genio civile*, p. 3751.

built in “pseudo-truss”, or chains blocked outside by “capochiave” stakes, toothed corners, “radiciamenti” (the wood in the wall) systems: they measures to prevent the collapse of the wall[h] were necessary, always considered as the weakest point in the structures but in many cases it was important to solve important technical issues (Figg 1-6).

Figg.1-6. Some example of seismic devices. From the left to the right: buttress (1); scarp wall (2-3); “radiciamenti” (4); “soprastrada” arches (5-6).

We know that the geometrical and material features of the wall had influenced the resistance, so it was important to choose dimension and thickness for each part of the building, with the tendency to filling rather than emptying: doors, windows, chimney flues or linking trapdoors could almost always compromise the static, especially if not in a column.

One of the basic principles of the local art building was the excessive size of the masonry, especially in the foundation, destined to prevent static damage caused by earthquakes. Constructions built in stones and in brick have an average size of 2-3 palms (50/70 centimeters). This size was changing along the wall, increasing in the foundation and decreasing in higher parts depending on the lose of weight[i].

Foundation’s data are just a few and they can be calculated just in a particular case. Starting from the end of 19th century, in absence of scientific criteria on the valuation of the soil’s hardness, these were the least calculable parts, especially concerning the size, decided on experience, common sense and available resources. In a contract in 1537 to build a house with tower on the top in

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[h] In Molise, latest earthquake showed than the damages are proportional to the absence of measures: the collapse of façade is caused by the lack of tooth in stones, lack of chain in roofs, weight roofs built in reinforced concrete, hammering of beam floors and tables, poor quality of mortars, loaded walls, chimney flue placed inside the wall. See [10].

[i] It’s important to know how during the creation of foundations L.B. Alberti exhorts the builder to dig «until you’ll find the solid ground and good luck» [11]. Even Gallaccini says that foundations is the main factor for the instability of the building, remediable only with increasing of sections [12].

Lanciano, was established that the walls had to be three members high, that is to say 3 meters and 2,5 palms wide; instead the tower had to be six floor high and 3 palms wide from the foundation until the third floor: thickness can be used with two vaults[j].

We can often see in documents the filling of the foundations, intending it as reuse and recycling operation of used materials - cheaper than the building of the wall - inside excavations throughout the perimeter of the building, deep up to a considered solid level where the thickness is from 1/2 palm to 1 palm more than the wall itself. In building yard in Molise [14], to build foundations are used stones which have more "humps", they are more angular, but using wide stones to scarf the all structure [15].

In the 19th century there were more precise requirements for the building of foundations, not only for new constructions but for interventions of consolidation too. In 1840 in Vasto, to build the New Cemetery, the architect Nicola Maria Pietrocola, required that the foundations of the boundary walls were composed by «broken and halved cobbles», cemented with lime and sand, 3 palms thick (about 70 cm) and 7 palm high (1.85 cm) up to a palm under the base floor[k]. From this point will begin the clump a sort of stringcourse of the foundation which connects the foundation itself to the wall, an 1/2 palm shorter, 2 palms high, one above and one beneath the country floor, built with broken and halved cobbles, cemented with lime and sand but closed by bricks: it is used to build wall in elevation, 10 palms high and decreased half a palm by the clump. The correlation between the thickness of the structure and the heights of the walls is the same of the chapel, where through its high (25 palms) we can establish, empirically, the parameters of the foundation: 14 palms high and 4 thick.

S. Maria Maggiore church in Vasto is a building yard where the foundations were built to prevent the collapse: in 1838 the project required that the buttresses used to reinforce the old damaged choir had a "base of iron stones" - very hard sandstones - and another similar one but covered with bricks, like really buttresses, in scarp style up to the cornice.

A fundamental key to contain efforts is the use of not smooth but inclined bricks, as the best constructive tradition of spurs and buttresses, to follow the thinning of the structure. Therefore a scarp foundation, expressly designed to prevent the collapse, and with earthquake resistant efficaciousness, well tied to the existent structure by dentil protruding every three palms and tied with mortar of plaster, considered much more "strong and tough" in dry condition than mortar of lime and sand, for its capability to "inflate" helping the setting up of the structure[l].

An important factor in the strength of the wall, in addition to its size, is its equipment, and which depends on the material used in the different regional areas. In sandstones areas, the wide Apennines areas at the edge of Vomano river, among mountains and the sea, the elements of the masonries have generally homogeneous size with joints mainly horizontal well united among them and with the angles iron characterized by bigger elements[m]. The problem of the historic building yard was constituted, in this case, by the lack of good binders, due to the scarcity of limestone and the total absence of volcanic soils from which obtaining hydraulic mortars.

The lack of good binders, in certain areas of Abruzzo, seems to have been decisive for the survival of the buildings. According to the historian Gavini, the damage caused by earthquakes in the Marsica region are linked primary to poor mortars, being unknown to the traditional building yard the quarry clay in Magliano dè Marsi and Tagliacozzo. In areas rich in clay and on the Adriatic coast, on the contrary, the abundance of this material would have worked like a favorable circumstance for the preservation of buildings heritage [18].

One possible way to solve the lack of good binders and to ensure the building of walls in the best way, is the accustoming, especially in the province of Teramo from the 1st centuries after the Year One Thousand, to mix them with stones and bricks, alternated with interstices of various thickness according to the size changing time to time in favor of the latter. The numerous examples of civil and religious architecture that use this constructive reason for texturing walls and arches framing, confirm a research entrusted not only to the aesthetic effects resulting from dichromate of materials, but also to the effectiveness of bricks capable to act in cushioning the efforts and leveling of stones not always smooth. Of course the best examples, especially in terms of stability, are when the bricks have regular alternation of cutting head and, acting as a belt, all the more urgent as the number of interstices[n].

In areas of limestone, walls have taken a different shape, linked to the hardness of stone and its corresponding workability, ranging from well-squared masonry, in areas rich in limestone or laminated tuffs, supplemented with mortar of good features that have made unnecessary the use of rescheduling rows [21].

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[j] ANDL (Archivio notarile in Lanciano), *Notary A. Macciocchino Lanciano*, vol. 7, cc. 73, Act of 26 April 1537, in C. Marciani 1989: 94-95 [13]. Requirements of robustness required in the document where expenses for stones, woods and bricks "to build and tie" the structure to be charged to customer.

[k] ASV (Archivio Storico in Vasto), cat. IV, b. 59, fasc. 128-129.

[l] ASCh, *Fondo Intendenza, Affari Ecclesiastici. Chiese di Regio patronato 1827/1866*, b. XIII, doc. of July 7th 1838. For the contract of renovations and improvements of the royal church S. Maria Maggiore in Vasto. A typical good restructuring of foundations was made by Pietrocola for the church from the side naves by twin columns, using "divided foundations" in order to save materials and avoid "dangerous" building for the parts of the construction without bearing function.

[m] See [16]. On other studies see [17].

[n] For further discussion, see [18] [19] [20].

From the seismic point of view, a fundamental aspect of the historic building is the relationship between the main walls and front walls: the first designed as load-bearing structures, the second as linings of individual cells, parallel to the texture of the floors so that the laying work does not interfere with their elevation. Releasing the front walls from the rest of the façade of the building and intending them as a control zone of environment conditions and space delimitation, he deprived them of effective constraints on the telluric movement requiring the use of additional elements. Among these, the most interesting are the arches of "controspinta" between two houses, also known as "soprastrada arches", widespread in all the centers of Abruzzo Apennines: real constructive expedients against earthquakes, useful to control the distribution of horizontal loads with considerable advantage for stability. Used like structures to link buildings overlooking, these strings in many cases has lengthened the wire of the façades in form of real structures, with a "barrel geometry", aimed to provide covered passages among streets and precious space enlargement of buildings on the upper floors. Of these strings, mostly made of rough stone, there are several original examples in the centres of mountain Abruzzo, where the high seismic activity and the severity of the slope have often given extremely compact houses, which articulated like a tunnel between the buildings have helped to reduce the solutions of continuity and to enhance the consistency and appearance of structures tortoise [22]. Sometimes the construction of "controspinta arches" has also spread outside the inhabited areas, and applied every time, the two sides looking were useful to the implementation: in the church of S. Maria delle Grazie in Caramanico, probably 16th century foundation, the face still bears the traces of the two stone arches connecting the church to a front building, engaged in the border area between the vessel and the central lateral vessels, confirming an earthquake resistant set enhanced by the lateral scarp walls.

To correct the rotation of the walls, often caused by insufficient "ammorsatura" among the septa, the historic yard has made frequent use of spurs in masonry made of bricks, for better adaptability of more standardized elements, or stones, with partially squared hewn stones, sometimes mixed with bricks.

Leon Battista Alberti already suggested the use of spurs, as a sort of "permanent crib", opening for such structures a success that has never failed, both in the recommendations of the treatises and in constructive practice. After the earthquake of 1703 there are numerous spurs of stone made in L'Aquila supporting ruined fabrics: among these there are the spurs that support the apse of the church of S. Domenico in Vigliano, marked by Rodolico for the resistance and the beautiful appearance and the left side of the church of S. Maria in Collemaggio, on the left of the transept of S. Pietro in Coppito[o].

The constructive use of a system supported by tradition is held between the end of the 18th century and the beginning of the 19th century, widespread tendency not only in Abruzzo. For example, the spurs proposed by Canina in mid 19th century, in stone lined with brick, for villa Adriana in Tivoli, or those of the Sanctuary of Ercole Vincitore. The support of manuals in that time for the use of such system is total: taking up the caution in the use of new materials, especially iron, in the restoration of old factories, the use of spurs is indeed considered the most effective remedy for the deformation of traditional structures. In his *Teoria e pratica dell'architettura*, published in Rome in 1788, Girolamo Masi says that «scarps and spurs are necessary in case of the walls are gone from the perpendicular, and have no overhang to have sufficient thickness to resist the thrust of the vaults, or for any other reason (..)». At his concern, in building scarp walls or spurs, to «concatenate and to merge them using the same materials with the old wall, at which they pick and make the tracks and tunnels that you can intern the new material» it echoes a few decades. Later Giuseppe Valadier in *L'architettura pratica*, where the earthquakes are considered one of the seven fundamental causes of repairing the buildings, proposing to alleviate it using the buttresses, which, however, to be effective, they must be well-anchored to the masonry to be with them like a single body: the essential fact to give comfort to the cliff walls and provide a basis for wider support. Starting from the first half of the 18th century the manual of Rondelet - the first translation into Italian is of 1834 - will bring the spurs as excellent systems for consolidation into a paragraph dedicated to them[p].

A constructive expedient in the implementation of the spurs in Abruzzo is also the inclination of its constituent elements according to a practice as old as effective. In seventeenth-century cloister of Capuchin convent in Montorio Vomano, in the province of Teramo, the large spurs of stone raised to counter the rotation of the east wall of the old refectory are made of stone masonry with exterior brick lining inclined approximately 90 degrees from the direction of the spur, giving the mortar of adjustment function of the evolution of rows. The construction of them seems not due to natural disasters but to the decline that the convent is suffering from the last decades of the 19th century, and perhaps coeval to the consolidation done inside the church with the use of chains anchored to its side walls.

On the same logic, buttresses and rough walls underwent interventions of lining, also useful for any modification of appearance of peculiarity and figurative style. Buildings of L'Aquila have been consolidated in a different way after the earthquake of 1703, interventions of "placcaggio" façades turned buildings in fact formally different from the original ones[q]. The thickness of the

[o] The use of spurs for the consolidation of the buildings after the earthquakes is widespread in many regions. After the earthquake in Valnerina of 1792, the chambers architect Pietro Ferrari propose the construction of spurs and buttresses associated with systems connecting wooden or iron between the walls and "sbatacchio arches" between two houses [23].

[p] See [24] [25]. To the theme of consolidation and restoration is dedicated the volume IV, in particular the section XX entitled *The way to observe the lesions in the buildings, and method to detect the causes, and cautions to repair* [26].

[q] The destructions made by the earthquakes were often used as propulsive elements ideas for the renewal of the affected cities, undertaken with "palaziamento", very popular from the 18th century onwards, resulting from the joining with pre-existing cells, evident on the façade with the addition of functional and decorative elements to mix together and give it a new urban status.

linings are of course functional to the extent of ruin, and generally not less than 15 centimeters. In the intervention of the church of S. Tommaso in Caramanico in 1884 the façade is consolidated using a swelling of the counter, to a thickness throughout the height of 40 centimeters [27]. Frequently in the documents of the 19th century the "ricocchiatura" is used to describe interventions in refurbishing crooked walls, often using pieces of bricks.

Lining intervention of a wall built with a scarp profile is the one in the southern wall of the church of S. Giuseppe in Vasto, interested, in the middle of the 19th century, by a phenomenon of rotation caused by the thrust of the roof and the dilapidated state of its materials. The consolidation is implemented, even here, not with the operations of replacing, but in addition to it, giving effectiveness "ammorsatura" to the intervention[r].

One of the parts of the building that always engaged the historic yard for its vulnerability to earthquakes is the top of the walls, difficult to anchor to the structures of coverage. Its reconstruction is a constant in the operations of consolidation performed in the course of centuries, and very often made of brick curbs, useful to provide more effective support to the thrust of the roof and to avoid, where possible, more expensive re-roofing in terms of expenditure and effort. Systems strengthening in the top of the walls include the ones based on the use of wooden beams incorporated into the body of them, for almost all the thickness.

The system, well-known in the historical yard in the Abruzzo region, is that of roots, always used with the objective of increasing the capacity of resistance of the building. Beams of wood, often oak, inserted into the walls with the dual purpose of absorbing horizontal forces and to strengthen, when extended to the perimeter, the walls of the field, avoiding the collapse[s].

Although the Italian treatises have always been skeptical about the use of chain-especially following the recommendation made by Vignola not support the factory with strings - in the yard of Arbuzzo the use of metal rods is very frequent, especially for thrust containment of arches and vaults. Their location are usually in the "reni", although there are also examples of more complex solutions. A singular application of chains "braga" on the extrados of the arcades, used in the yard of Bologna, is in the consolidation of the choir of the church of S. Maria in Vasto, in 1838. Understood as an operation designed to improve and to correct the old fabric, according to the Alberti restoration, the intervention consisted in a system to chart the arch of the choir in front of the nave, divided into horizontal and vertical elements, useful to satisfy the static requirements without offending the aesthetic. The chain itself is recessed into the wall and anchored on the heads of two vertical elements, so-called "staffoni", fixed on the external sides to a height slightly greater than the arch, and stopped with other horizontal elements that cross the walls to the inner face of the piers: all with a specially designed timber, to put the chains in tension and to protect the fabric in the most solicited points[t].

On the vaults, one of the most popular system of reinforcement is the inclusion of tightening strings, often on the extrados after emptying too heavy fills. These are the so-called "combs", with ribs made of bricks arranged in packets of three alternated elements of "rib" and two flat, to ensure the necessary "ammorsatura". A singular declension of this technique is in the convent of S. Berardo in Città Sant'Angelo, where the vault presents "folio" on the extrados, ribs crossed with nodes reinforced by additional elements. Often the system of arches stiffening is associated with the construction of "frenelli", walls, mostly in brick, built on the "reni" to their support and assistance. The geometry of the vaults is not discriminated by the use of ribs.

The Palace Castiglione in Penne presents an application of these ribs on the vault that covers the main floor of the room, divided into six segments by corresponding "costoloni" placed on "frenelli" and converging over the central to make a stronger structure of bricks. For easing the vault there is the singular use of "procelle", little bricks in foil embedded in the filling. In the villa Baiocco of San Valentino (Pe) of the 19th century, the partial collapse of the vault of one of the rooms on the ground floor has revealed the presence of three on the extrados of three "procelle", in line with the lunette below, which evidently wanted to preserve the risk of an overweight.

The historic yard has rarely used, in consolidation of floors and coverings, the replacement of the main elements. Interventions on the floors of reinforcement were often limited to inclusion of additional elements, to reduce the lights, or, in less serious cases, wedges and chocks to fill the gaps by putting in tension the structure. Compared to floors, roofs needed more difficult operations, not only for greater articulation of the structures but also for the intrinsic conditions of vulnerability. Example of a case of roof

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[r] ASCh, *Fondo Intendenza, Affari Ecclesiastici. Chiese di Regio patronato 1827/1866*, b. XII, II-1, doc. of 1847, directed repairs to the capitulate church of S. Giuseppe in Vasto of "Regio Patronato". Diveded the height of thirty palms of the wall into three areas, for the first ten is prepared in a stone building with brick lining, the thickness at the base, two palms and a half, requires few "ammorsature", for the next seventeen the wall has only bricks-to meet the needs of alignment, and it is linked to the old one with a palm deep "addentellato" and repeated for a palm at each height; the height remaining, the demolition of the wall and the building unsafe in its instead of a new, sandstone "hard" coated with bricks, it is useful to take the curb to the property and provide a sufficient response to the thrust of the roof.

[s] The examples found are extremely numerous, although care in their implementation, and the accuracy of embedding in the case, frequently, the assembly of several elements, depends directly on the possibilities of the yard. See [28] [29]. In their most aware application, the use of wooden beams on the wall refers to systems used in house shacks made after the disastrous earthquake in Lisbona in 1755 and Calabria of 1783. And certainly from this time that the seismic matter becomes urgent, monopolizing the whole culture on construction safety in building. The use of wooden beams is common to the entire historic Italian shipyard, with very interesting dialectal declinations. In the Lombard yard are mentioned "ligati", oak or larch rods, whose erection is often omitted in the capitulate because already granted [30]. For the Roman yard see [31].

[t] See footnote k.

repairing widespread throughout the region is the repairs, in 1839, of the church of S. Matteo in Teramo, residence the Royal College, whose project wanted to reinforce the roof with the «braking of the king-posts with stirrups placed horizontally between a king-post and another and affixing "saettoni" between the king-posts and thighs»[u].

Frequent is the strengthening of trusses with the graft, on the intrados of the chains, of metal elements through the thickness of the walls and out for a sufficient length to anchor the poles with "capochiave" stakes put in tension with wedges. The trusses of the church of S. Antonio in Barete (Aq) are treated in this way, medieval but almost entirely rebuilt after the earthquake of 1703, and also the one already mentioned in the Capuchin convent in Montorio Vomano, united by the presence of gutters on "palombelli" with "pedagnola" wood, which has enhanced the constructive care likely due to a state of necessity. In the church of S. Croce in L'Aquila, the chain of the truss, probably also renewed after the earthquake, has been prolonged outside and stopped by a wooden "capochiave pole", inserted into a hole made on purpose (Fig.7).

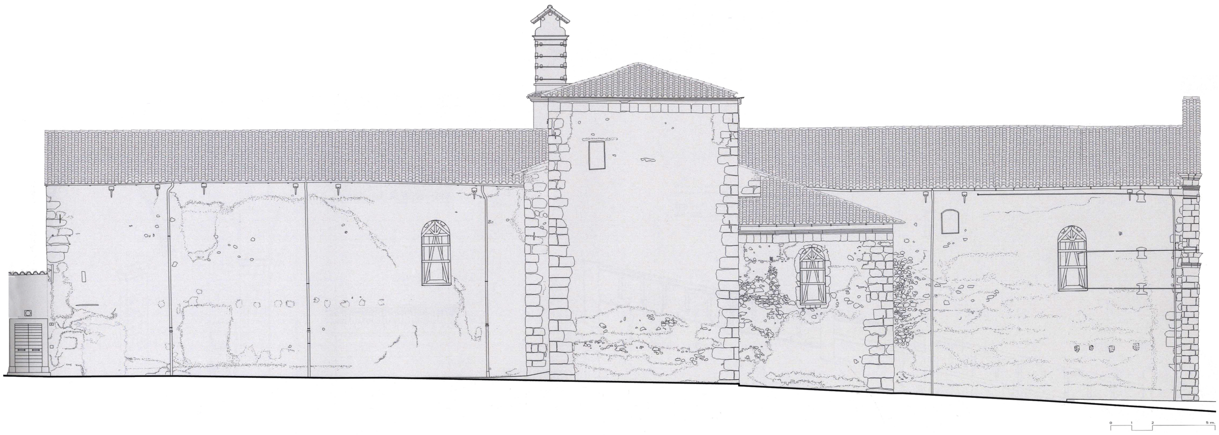

Fig.7. S. Maria del Soccorso in L'Aquila. Example of trusses united by the presence of gutters on "palombelli" with "pedagnola" wood.

Sometimes for strengthening coverage beams with features of paradoxes, the historic yard has used real "truss corner". In the Palace Coppa in Città Sant'Angelo, made in the seventeenth century within the convent of S. Bernardo, the main truss, with king-post and "controcatena" is strengthened, at the pavilion in the corner, by an additional truss, probably built during the nineteenth century, during a renovation of the building, and featuring not only "controcatena" but also "contropuntoni", held together by a metal bracket to anchor central "imbretella" that the "puntoni" to the king-post, passes on the "controcatena", wraps the chain, is depreciated on a bar of wood under it, clutching it in a statically efficient system.

Associated with the strengthening of floors and roofs are usually the renewal of the leg support of beams and rafters, extremely vulnerable to the stresses induced by earthquakes, so often undermined by the degradation associated with the stagnant humidity.

It was very difficult, as already noted, to fix continuity between the art of building and strengthening systems of fabrics. The technical and material continuity that has marked the history of the Abruzzo region avoids any temporal sequence. However, the power and value of tradition had to surrender to a forced renewal in the last decades, perpetrated, as we know, with the use of abuse of the assets as the only alternative to disuse and abandonment. Except in some cases, luckily for our study, of non-renewal of the fabrics, predominantly because of abandonment, the same examples that we have in this note are often the residue of the existing processing operations implemented with the latest requirements. These examples, however, in their relationship to a new misunderstanding, have made the difference and they have indicated a new road to recovery, emancipated from a modernity at all costs, and finally more attentive to the fate of the property than to the verification of the means for its preservation.

[u] ASTe (Archivio di Stato in Teramo), *Fondo Intendenza Borbonica*, pacco 60/B, fasc. 189 - Teramo 1839, *Scandaglio de' lavori eseguiti dalla vedova Girali per la riduzione dell'ex Monistero di S. Matteo ad uso di Collegio Reale*. Complementary to the work of the roof are the compensation of the walls built with "stone factory", the realization of fake cloister vaults, plastering the lime and whitening, the building of cloister vaults with bricks and chalk.

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