

versus

VERSUS HERITAGE FOR TOMORROW

Vernacular Knowledge for Sustainable Architecture

edited by
Mariana Correia
Letizia Dipasquale
Saverio Mecca



This scientific publication resulted from an intensive and significant teamwork research, based on the common main aim of establishing key principles, regarding vernacular knowledge and its contribution for sustainable development.

Lessons learned from vernacular heritage are systematised through principles that define a wide number of strategies to consider and to integrate for sustainable contemporary architecture. This was possible through the initial establishment of operational definitions, regarding vernacular architecture and sustainable architecture. It was also critical to define a profound reflection concerning the state of the art of environmental, socio-cultural and socio-economic sustainability, as well as resilient vernacular heritage, and the definition of parameters for vernacular sustainability during the 20th Century.

This publication presents the design of the VerSus research method and operative approach, which were decisive for the systematisation of strategies and solutions identified in urban, local, architectural, technical and constructive terms. Each area of study was represented by specific case studies from Europe and around the world, addressing vernacular environments and contemporary contexts.

VERSUS, HERITAGE FOR TOMORROW: Vernacular Knowledge for Sustainable Architecture is the final outcome of VerSus, an European project developed in the framework of the Culture 2007-2013 programme, funded by the European Commission from 2012 to 2014.







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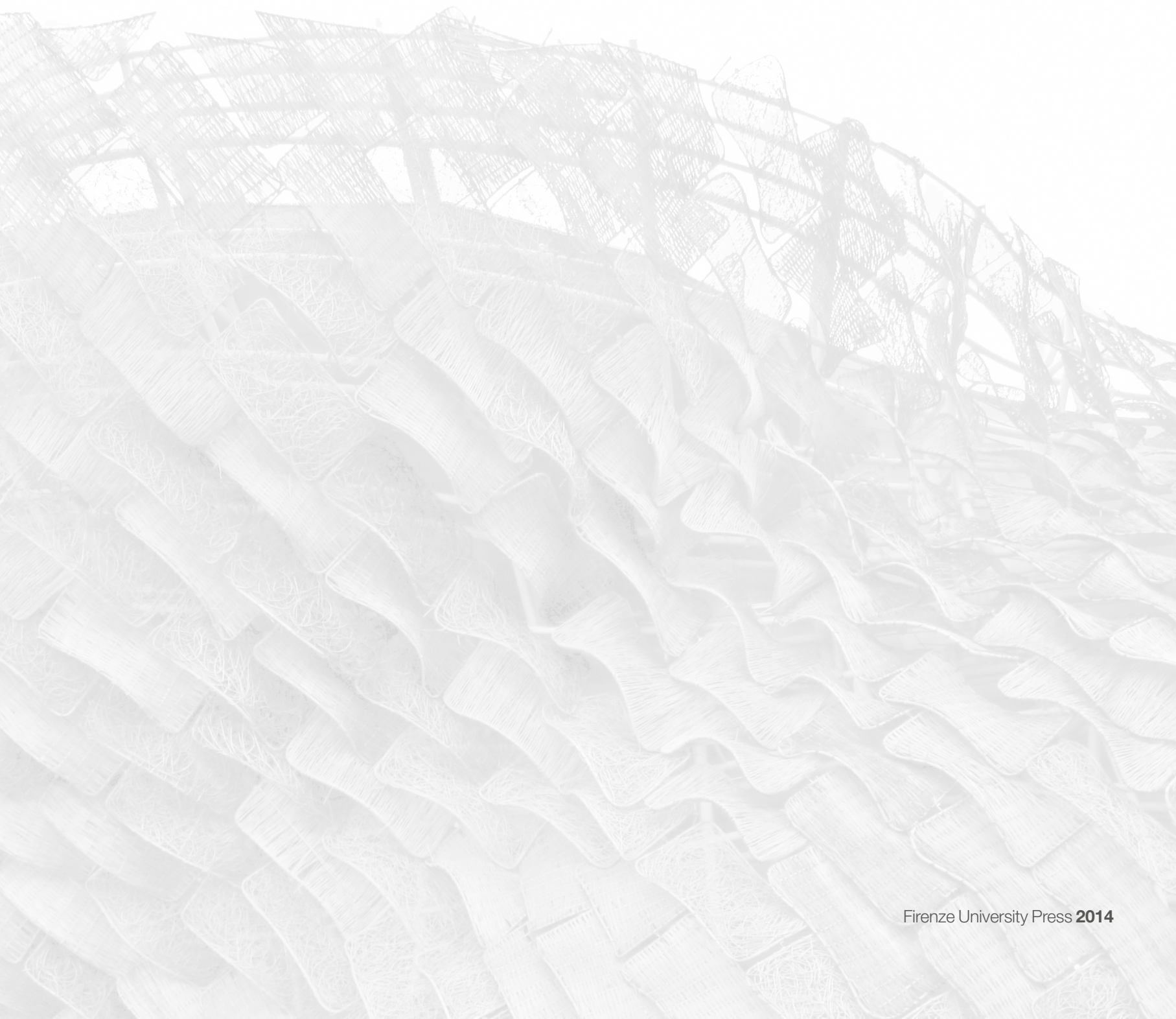
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Corbelled Domes dwelling near Aleppo, Syria,
(photo: S. Mecca)

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Mosque in Mopti, Mali
(photo: M. Correia)

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Earthquake resistant systems

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Seismic culture and vernacular earthquake resistant techniques

In regions affected by frequent and high intensity earthquakes, local communities have developed vernacular strategies to protect themselves from the risk, such as building systems or specific devices, designed to reduce the vulnerability of their building habitats. Seismic vernacular reinforcements are numerous, and in a lot of instances, depend on available materials, local building cultures and the skills of the builders. The entirety of knowledge, both pragmatic and theoretical, that has built up in a community exposed to seismic risks through time can be described as a seismic culture (Homan et al., 2001). The local seismic cultures include the earthquake-resistant regulations which have not been formally laid out in written code but which are still visible in the building characteristics, in the choice of the site and in the general layout of the territory (Ferrigni, 2007). The origins and persistence of a local seismic culture can be determined both by the scale of intensity and the frequency with which the earthquakes occur, and the economic and social conditions, including resource availability and the cultural traditions (Ferrigni et al, 2005). The ancient builders used all the well-known constructive criteria and devices to build houses able to resist earthquakes; perfecting them with time and experience, and comparing the performance of these systems with respect to the effects caused by earthquakes. In this way a process of technical evolution by experimental testing has been developed, that is based on the direct observation of the real behaviour, following telluric forces.

Buildings seismic response and requirements for earthquake resistance

Most of the buildings in Mediterranean area are made of bearing masonry walls. Masonry buildings are vulnerable to seismic event, since they are constituted by the assembly of heterogeneous elements and materials (as stones, earth or clay bricks), whose characteristic is the not tensile strength. The seismic forces are transmitted through the soil at the base of the building as horizontal actions. These forces give rise to a rotation out of lane at the base of the wall perpendicular to the direction of the earthquake, which tent to an overturning (first way of damage) and a consequent partial or general collapse of the masonry building. If the bonds between the orthogonal walls

are effective, the building shows a box-like behaviour: the overturn is avoided and the horizontal actions are transferred on the walls in the direction of the earthquake, as shear actions that produce diagonal cracks primarily distributed along the mortar joints (second way of damage).

The observation of the damages on the buildings affected by the earthquake and the identification of the main mechanisms of damage enable the identification of elements that affect the seismic behaviour of masonry buildings. Under seismic action, in order to avoid the first way of damage, the structure has to guarantee a box-like behavior that can be achieved through good connections in the corners between perpendicular walls and effective horizontal tying elements. The openings represent a discontinuity on the wall surface and a proper distribution and dimensioning is a fundamental anti-seismic rule. The wall is the base element of the masonry buildings and under horizontal forces it has to behave as a monolithic structural element. From the good workmanship depend the mechanical properties of the wall and the ability to perform small oscillations under seismic actions maintaining the integrity of the thickness. In general, the experience shows that masonry building, if properly designed and build according the rules of the art, have high chances to respond satisfactory to the earthquake.

Vernacular earthquake resistant strategies

Living under seismic risk, local builder had introduced technical solutions and technological devices, whose choice is a natural selection dictated by the climatic context and locally available materials. As safeguarding measures, in various historical and geographical contexts, can be found the adoption of geometrical and typological solutions, as the use of massive walls and buttresses or the disposition of the walls in dense orthogonal meshes, or through a technological and constructive approach by the introduction of wooden devices within the masonry structure.

The combination of materials with different characteristics between them, allow to give rise to a system responding against the damages produced by the horizontal actions: the excellent elastic properties of wood, the characteristics of flexibility and deformability without reaching break, allow the mitigation of the effects of the earthquakes on the buildings.

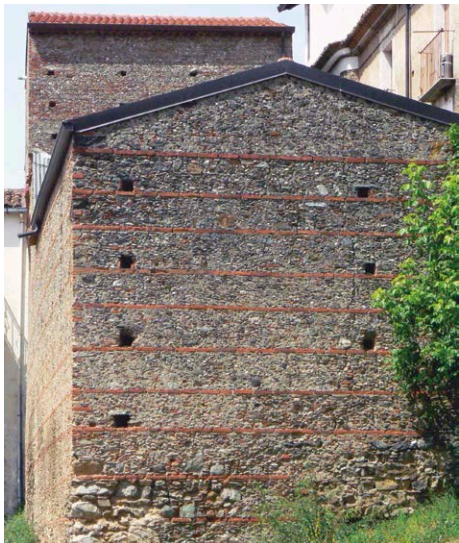


Fig. 1 Rows of bricks used for wall reinforcement, Lamezia, Calabria, Italy (photo: L. Dipasquale).



Fig. 2 Reinforcing all the ground floor at Civita di Bagnoregio, Lazio, Italy (photo: S. Onnis).



Fig. 3 Butress in a masonry building, Naples, Italy (photo: L. Dipasquale).

Historical earthquake resistant strategies in Mediterranean area

Amongst the ancient cultures the Cretan (2000-1200 BC) and Mycenaean (in the fourteenth century BC) had developed a great sensitivity towards earthquakes. Archaeological excavations have revealed some strategies for earthquake proof buildings used in the ancient buildings. Amongst the remains there exists masonry composed of limestone and gypsum stones, where some of stone elements are placed systematically in the direction perpendicular to the wall. The walls intersect each other tightly and, always crossing at right angles, form dense rectangular mesh networks. This planimetric configuration allows the creation of patterns capable of withstanding strict regimes of dynamic stress. In addition, the work of archaeologists have unveiled inside the large stone blocks, the housings of large pins crossing the rocks to accommodate wooden connecting elements, with the purpose to keep the various blocks connected and to give a strong plasticity to the whole structure. In ancient Roman building traditions, rows of bricks were set down

horizontally through the conglomerate wall section, functioning not only to connect and reinforce, but at the same time serving to interrupt the possible spreading of cracks. This technique is still visible in many stone walls of the Italian historic cities (fig. 1).

Masonry reinforcement measures

In seismic regions where stone, earth or bricks masonry is the prevalent building technique, the most frequent prevention and/or reinforcement measures consist of adopting the mechanism of mutual contrast between (or part of) the buildings to counteract horizontal forces. Following are described the most common traditional devices used to the scope of contrast and seismic reinforcement in vernacular masonry buildings.

- *Buttress*, or *counterfort*, with a rectangular or trapezoidal cross-section, are made of strong materials, such as brick or stone. They are placed against and embedded to the wall in more stressed areas, to resist the side thrust created by the load on an

Fig. 4 Anchor plates in a stone building in Florence, Italy (photo: L. Dipasquale).



Fig. 5 Anchor plates in a rammed earth building, Mertola, Portugal (photo: M. Correia).



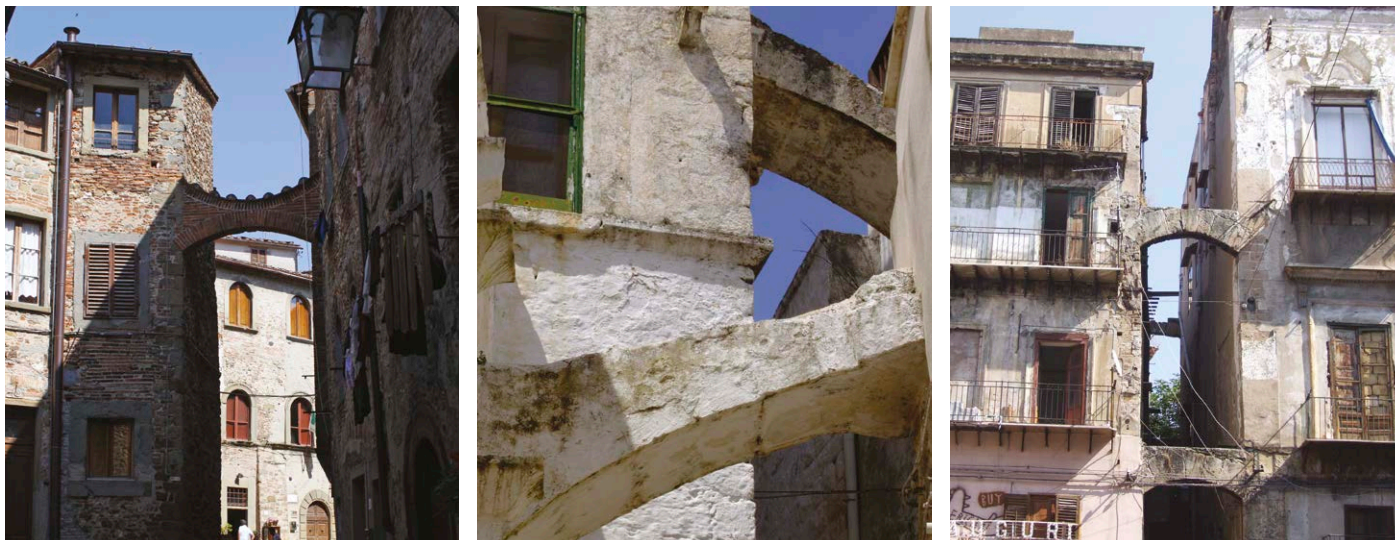


Fig. 6, 7, 8 Reinforcement and discharging counter arches in Anghiari (Tuscany), Ostuni (Apulia) and Palermo (Sicily), Italy (photos: L. Dipasquale).

arch or a roof. Buttress can be added to existing walls or they can be built at the same time as the building, with the purpose to reinforce corners or walls with wide openings (fig. 1-3). In Southern Italy and in southern France, the traditional *loggia* can be seen as an evolution of the buttress system (Ferrigni et al., 2005). It is used as reinforcement at the base of the building and at the same time it provides a shading space at the entrance of the house.

- *Anchor plate (or wall washer)* is an iron plate, connected to a tie rod or bolt, used to assemble the braces the masonry wall against lateral bowing. Iron-rods are stretched across the building from wall to wall, creating a horizontal clamping between the outer walls of the building. Anchor plates are made of cast iron, sometimes wrought iron or steel and can be also fixed at the ends of the wooden floor beams. This technique is used on brick, stone, or other masonry-based buildings (Bucher, 1996, p.576) (fig. 4, 5).
- *Reinforcement or discharging arches* are stone or bricks masonry arches set between two opposed buildings separated by a small

street or a narrow passage. They allow the transmission of horizontal constraints to the opposite building at the level of the floor. In this way buildings behave as an ensemble of dynamics block, not as isolated elements (fig. 6-8).

- *Lowering the centre of gravity.* Several techniques were used to increase buildings stability by concentrating their mass closer to the ground. The most common solution is the use of increasingly lighter materials. In the ground floor walls are heavier, being made by strong and compact stone (responding also at the need to resist to water pounding the base of the building), and present higher depth than in the upper floors. In the South of Italy vaulted spaces at the ground floor are very common. After the earthquake of 1793 in South-East of Sicily, for example, almost all the ground levels of reconstructed building are covered by a masonry vaulted structure, while the intermediate floor structure is made of wood. Also buttress and staircases at the base of the walls contribute to lower the centre of gravity of the building (fig. 9, 10).

Fig. 9 Stone masonry vaults increase the mass of the building at the ground floor and create a solid connection between opposed walls. Lunigiana, Tuscany, Italy (photo: L. Dipasquale).



Fig. 10 External staircases lower the centre of gravity of the building and reinforce its base. Ragusa, Sicily, Italy (photo: L. Dipasquale).





Fig. 11 Masonry building with timber hooping in Albania (photo: I. Hasa).

Fig. 13 Stone and adobe building with hooping reinforcement in Kastaneri, Greece (photo: S. Mecca).

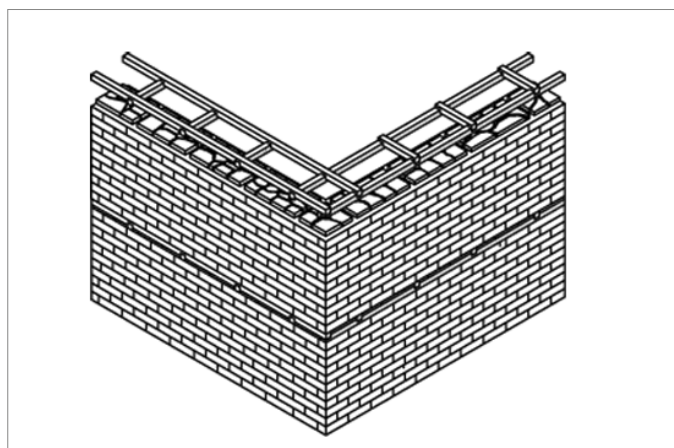


Fig. 12 Building system scheme of timber hooping (drawing: D. Omar Sidik).

Timber frame earthquake resistant reinforcement

In areas where earthquakes are endemic, a recurring strategy is the use of wooden elements as devices to improve the earthquake-resistant performance of the building, and also to increase the structural behaviour of the stone, adobe or bricks masonries.

The great elastic properties of wood, its characteristics of flexibility, lightness and deformability without reaching the breaking point, offers good resistance capacity against horizontal loads, and enables the dissipation of substantial amounts of energy. Moreover, timber elements divide the structure into sections, which prevent the spread of cracks occurring in portions of the masonry. By creating horizontal and vertical connections, wooden devices applied to structures with good compression behaviour (such as stone, adobe or brick masonry) can improve the resistance to shearing, bending and torsion forces.

There can be various uses of wood as earthquake-proof reinforcement material, but two main categories can be identified: the *hooping* and the *frame systems*.

The first provides the arrangement of the circular or square section wooden beams, horizontally disposed within the load-bearing masonry during the construction phase (fig. 11-13). In many cases two beams are used, one to the inner side of the wall and the other to the outer, connected by transverse wooden pieces. The empty spaces between the beams are filled with fragments of brick or stone. Interlocking systems of nailing's are used for the connections between perpendicular elements. The ring beams can be inserted at the height of the floors, in correspondence to the openings and lintels or regularly distributed along the height of the construction. This system can be found elsewhere in seismic regions of Mediterranean areas: from Balkans, to Turkey, Maghreb Greece (it is systematically used in houses in Akrotiri on the island of Santorini) and Italy.

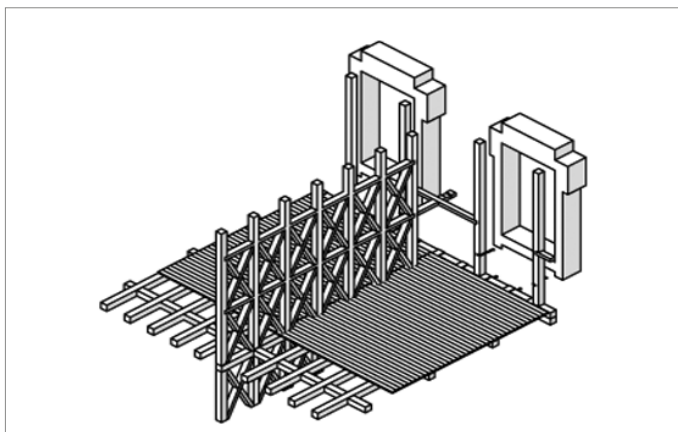


Fig. 14 Gaiola building system in the downtown of Lisbon center, Portugal (drawing: D. Omar Sidik).

The second category include wooden frame systems, which are articulated in round or square section beams and pillars, and frequently, diagonal bracing elements. The empty spaces defined by the frame are filled with locally available materials (earth, stone or brick). If the beams are not as long as the entire wall, timbers are connected together through elaborate interlocking systems. In some cases the longitudinal beams are held together in the thickness of the wall by transverse elements that are wedged or nailed, and the corners present additional reinforcement.

One of the most ancient examples in Italy of timber-frame buildings techniques is the *opus craticium* by Vitruvius, today visible in some of the surviving houses of the archaeological sites of Herculaneum and Pompei. The *opus craticium*, was largely diffused in the Roman Provinces, and later developed in different ways in a large number of Mediterranean and European areas.

In the Mediterranean area relevant traditional examples of timber frame structures together with masonry can be found in Turkey¹, in Greece and parts of Eastern Europe. In these countries common traditional buildings techniques are based on the use of masonry laced bearing wall constructions on the ground floor level, and lighter infill-frames for the upper stories. The ground floor masonry walls are often laced with horizontal timbers; these elements can be thin timber boards laid into the wall placed so that they overlap at the corners or squared wooden beams.

¹ In northern Anatolia, traditional wooden frame type building type, called *Duzce*, consist of a massive foundation walls constructed with stone (sometimes built up to the first floor), while upper floors have timber framed structures with stone or brick infill. *hımış* buildings are composed by a timber frame filled with stone, adobe or brick. In the building constructive system called *Bagdadi*, the voids between the timber frame structural elements are filled with lighter construction elements such as lime mortar or plaster applied on timber laths.

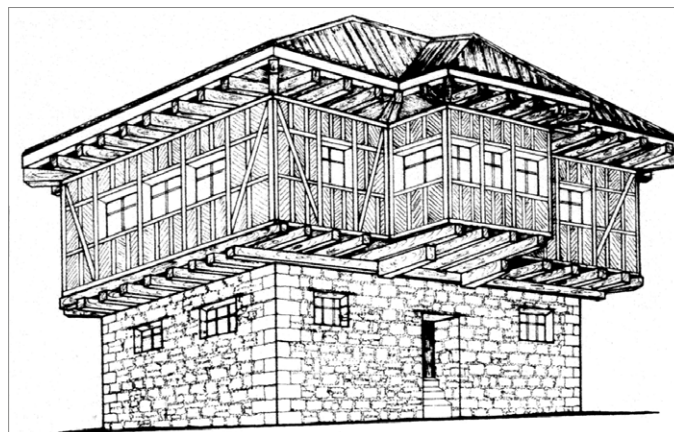


Fig. 15 Wooden frame uilging system of traditional ooden frame system on the upper floor is Adapazari, Turkey (drawing: M. Ciampa).

A very significant example of the use of timber framed structures for masonry anti-seismic reinforcement is the so-called *gaiola* system, diffused in Lisbon after the earthquake of 1755. The technique of *gaiola* includes the use of the 'Pombalino' wall (fig. 14). This system consists of a set of timber members, embedded along the inner face of the main stone masonry façade wall. The timber elements are made of oak or holm oak squared beams, with a section of 9-12 cm². The wooden elements of the structure are framed form-

Fig. 16 House with a stone-built ground floor and a wooden frame structures with stones infill in the region of Gotse Delchev, Bulgaria (photo: S. Mecca).



ing a pair of crossing braces, called in Italy *St. Andrews Cross* and are connected with both the walls and the floors timber beams, forming a cage (*gaiola*) (Ruggeri et al, 1998, Gulkan, 2004, Paula et al, 2006). The frame is filled with brick, whole and broken pieces, and stone rubble. The interior walls are covered with plaster, hiding the infill and the timber frame. The building is no more than four storeys high, with masonry arcades at the ground floor level, external structural masonry walls (*gaiolas*), internal timber-masonry walls (*frontais*), and internal partition walls (*tabiques*) (fig. 5). All these structural elements combined have very good anti-seismic performances, as many experimental studies have shown.

Wooden frame structure are used in many earthquake vulnerable areas in Latin America, Eastern Europe, Middle East, and Asia. The constructive system is always based on a grid of wooden poles making the main structure, while infill techniques vary depending on materials locally available (stones, bricks, adobe, cob, daub or mixed materials). Many studies, proving the seismic resistance of wooden structure, are developed in Turkey, Bangladesh, India, Pakistan, Haiti², Chile, Italy and other countries recently affected by earthquakes. Timber frame system – using traditional timber housing system, light timber frame systems or platform systems, and new type of techniques such as crossed laminated timber – begins to be extensively used across northern Europe countries and European seismic zones, because of its many positive factors besides the good seismic inertia, such as the low environmental impact of the material, the higher level of industrialization and prefabrication, and the short time of assembly in the building process.

Sustainability of vernacular earthquake resistant strategies

Nowadays advanced technologic systems – such as base isolation and vibration control, or new materials as large space membranes, etc. – allow to build structures with the highest level of seismic inertia. However, the elevate earthquake resistance is not ever corresponding to a good level of sustainability of the building. Vernacular

architecture has proven to be resilient in disaster prone areas due to its evolution over time and ability to adapt to nature. Using vernacular systems and adapting them to properly evolve, can reconnect inhabitants to their history and their cultural heritage, and provide environments that can respond to future disaster with even greater resilience (Audefroy, 2011).

Underling the characteristic of sustainability of vernacular seismic resistant techniques we would demonstrate the value of local knowledge, skills and capacity to find new appropriate solutions and to make societies increasingly resilient to natural hazards.

Environmental sustainability

The knowledge contained in vernacular constructive systems can help improve project implementation by providing valuable information about the local context. Starting from the analysis and understanding of local constructive systems help to find appropriate solutions for improving the seismic resistance of buildings, which are connected with the place and its characteristics. The benefits of employing local materials and low-tech solution inspired by vernacular constructive systems are numerous: arousing wider ecological benefits, enhancing local resources, saving energy, reducing transports and pollution, and definitely favours a deeper respect the environment.

Sociocultural sustainability

The incorporation of local knowledge in reconstruction policies encourages the participation of the affected community and empowers its members to take the leading role in all disaster risk reduction activities (Shaw et al., 2008; Mulligan and Nadarajah, 2011). The scope of local knowledge, skills and capacity is very wide and it encompasses technical, social, cultural and other forms of knowledge. The building culture, as already seen, performs an important role as a vehicle to express values and identity, and have a powerful influence on people's choices, behaviours and wellbeing. The acknowledgment and conservation of the vernacular cultural heritage, fair access to it and equitable sharing of the benefits deriving from its use enhance the feeling of place and belonging, mutual respect and sense of collective purpose, and ability to maintain a common good, which has the potential to contribute to the social cohesion of a community and strengthening the social relations and a collective maintenance culture (Shaw et al., 2008). Local communities can be empowered to reduce the risk from and vulnerability to the natural haz-

²An analysis on local building practices conducted by CRAterre, in collaboration with Haitian association, between 2012 and 2012 demonstrated that the damages on traditional wooden frame housing (Clissage were very limited and concerned mostly the plaster (Caimi et al. 2013).

ards they face through better and more accurate engagement and participation. Moreover, community participation in this process can help to define more suitable and efficient techniques and buildings can receive adequate maintenance and undergo compatible modifications when people is familiar with the constructive techniques.

Socio-economic sustainability

The socio-economic environment needs to be taken into account in a profound way in the seismic design. A properly seismic resistant structure does not necessarily have to be extremely strong or expensive. It has to be properly designed to withstand the seismic effects while sustaining an acceptable level of damage.

Traditional structures proving a good behaviour against the impact of natural hazard, can be an affordable start point to build improved resilient buildings. Indeed, in case of earthquakes, damage mostly affected the secondary structures of traditional seismic resistant buildings, while the main structure were preserved, making them easily repairable, both financially and technically (Caimi, 2013; Jigyasu, 2008; Audefroy, 2011; Mulligan and Nadarajah, 2011). Therefore, in post-disaster phase the use of local materials, technique and skills can optimize construction efforts, enhance local activity and reinforce the community self-sufficiency.

Using local knowledge and systems to built future seismic resistant constructions

It is widely demonstrated that local wisdom can offer useful input to find even new earthquake resistant solution, since traditional construction and technologies have been tested over generations and are best suited to local environment and cultures.

Building knowledge and know-how learned over the years in seismic areas have for centuries formed the unwritten earthquakes resistant building codes; these were codified in recommendation and regulation only since the eighteenth century. Observing the traditional earthquakes resistant structures we have understood some common rules that can improve the seismic inertia of the buildings, such as: a good execution of the work, a good connection between the elements of the buildings (walls, floors, roof, façade elements.), a progressive reduction of materials weight from the bottom to the top of the building, devices capable of counteracting horizontal forces, and systems able to increase the ductility of the buildings.

Despite traditional building knowledge has potential for mitigation against earthquakes, when we look at the actual situation, vernacular communities are often most adversely affected from natural hazards.

This occurs because a culture of conservation and maintenance is not so diffused, and local knowledge, skills and capacities for disaster mitigation are often obscured by the impact of existing development models and last transformation processes. Houses constructed with traditional good quality materials performed poorly when built without proper and professional knowledge, such as, in absence of proper application of professional know-how, even reinforced concrete structures can became highly hazardous during severe shaking (Shaw et al., 2008).

Afterwards one of the missions of the scientific community is to better understand traditional knowledge while also recognizing how this knowledge can evolve and innovate to work with modern materials and techniques. Reducing the vulnerability of ancient buildings, as well as modern buildings, through the lessons of local seismic culture can achieve an appropriate and innovative response to emergencies. Therefore the appropriate use of modern techniques and materials, together with vernacular strategies and devices, can help to rehabilitate and improve traditional structures and thus combine safety with preservation of a rich architectural heritage.

Identifying and taking into account the local specificities of existing buildings and know-how can be the basis for improving construction methods and building skills, as well as a way to reduce the vulnerability of local communities in the long term.

The awareness of the extraordinary quality of many traditional solutions, and the interest in the preservation of this heritage and the building culture, represents essential achievements through which we can compose models for appropriate effective rehabilitations, future sustainable architectures and settlements. The recognition of local seismic cultures requires a systematic and homogeneous form of cataloguing and archive work, that can used to improve building codes, and to create protocols listing, which can aid technicians to identify suitable methods for protecting and reinforcing buildings against earthquakes, geared as closely as possible to the specific features of ancient buildings in the local area, respecting the original structural concept and, therefore, their authenticity.



THE BARACCATA HOUSE

CALABRIA, ITALY

author

Letizia Dipasquale, Dalia Omar Sidik

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The *baraccato* construction system has been widespread in Southern Italy from the fourteenth century and it was originally identified as temporary barracks used as shelter in the periods immediately after an earthquake. After the disastrous earthquake of 1783, the Bourbon government issued the guidelines for the construction of new earthquake resistant houses the technology of the *baraccata* house. The buildings are one or two stories high, with regular and symmetrical plant. The structural system consists in a masonry structure with a wooden frame integrate in its interior. The elements of the frame are not visible from the outside and are thus protected from the deterioration caused by insects and atmospheric agents. Beams and columns have a 10/12 cm wide square section and its are arranged in perimeter walls according to horizontal and vertical warpings, the partitions instead present St. Andrea cross ties. The masonry, consisting of stones or, in some cases, of raw earth bricks, collaborates with the inner wooden frame to provide a resistant behavior both against horizontal loads and horizontal seismic forces.

The good anti-seismic performance of this system was tested during the earthquakes that struck Calabria in 1905 and 1908, registering a magnitude of 9: the buildings suffered few significant damages and limited portions of masonry collapsed. In the following decades the *baraccata* system has not been implemented with the original rigor and often it present insecure timber connections; in the last decades it was definitely abandoned.

In 2013, a research conducted by the Italian National Research Council (CNR-Ivalsa) and the University of Calabria, scientifically demonstrated the validity of this building system as effective seismic resistant solution.

ENVIRONMENTAL PRINCIPLES

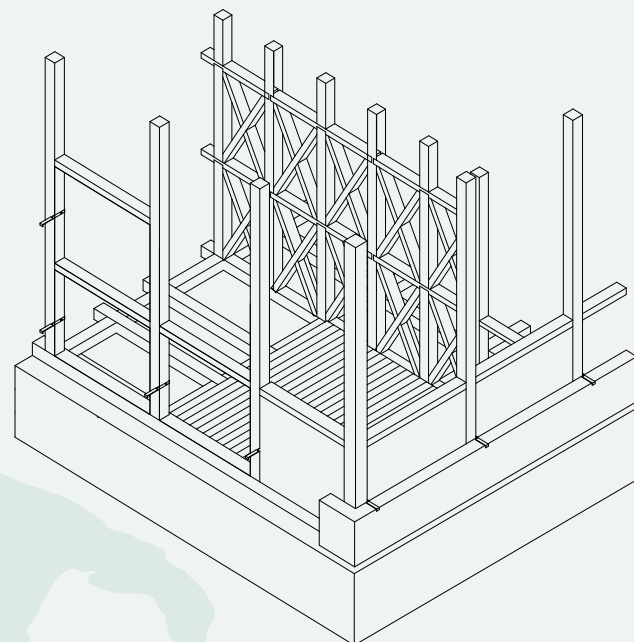
to respect environmental context and landscape to benefit of natural and climatic resources to reduce pollution and waste materials to contribute to human health and welfare to reduce natural hazards effects

SOCIO-CULTURAL PRINCIPLES

to protect the cultural landscape to transfer construction cultures to enhance innovative and creative solutions to recognise intangible values to encourage social cohesion

SOCIO-ECONOMIC PRINCIPLES

to support autonomy to promote local activities to optimise construction efforts to extend building's lifetime to save resources



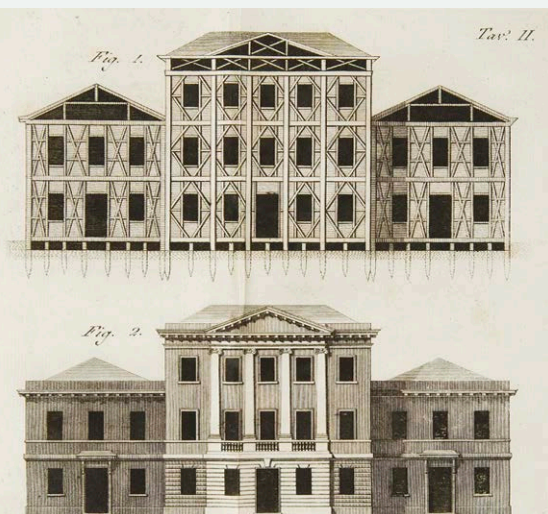
The structural system of Casa Baraccata (drawing: D. Omar Sidik).



Casa baraccata in the drawings of Giovanni Vivenzio.

Test in a vibrating table conductedz on a 1:1 scale portion of a wall of the bishop house of Mileto (Calabria), by the Italian National Research Council (CNR-Ivalsa) of San Michele (TN) and the Department of Earth Sciences, University of Calabria (UNICAL).

Old *baraccata* structure during restoration works site in Lamezia terme, Calabria, Italy (photo: E. Pelaia).





WOODEN FRAME FILL WITH *ADOBILLO* BLOCK

VALPARAÍSO, CHILE

Author
Natalia Jorquera

The *adobillo* is a daubed earth building system which originated in Valparaíso, Chile, in the middle of the 19th Century, when the city was the country's main harbour on the Pacific Ocean. At that time, hundreds of wooden logs used as ballast in ships arrived to the city, changing the old tradition of building with adobe masonry through a massive use of a mixed wood-earthen building system, which permitted an architecture that is able to adapt to the intricate topography of the hills of Valparaíso, as wood was the loadbearing structure. The building system consists of a wooden frame composed by logs set systematically every 60cm, and horizontal twigs infilled with a special kind of earthen block of 60x15x10cm, which has the particularity of having two notches in every extreme of 1" in which a little piece of wood is introduced to fix the block into the wooden logs.

This very efficient mechanism of connection between wood structure and in-fill prevents the overturning of the blocks from the structure in the case of an earthquake and in fact, this technique became widely-spread after the earthquake of 1906 in Valparaíso, the biggest so far in the history of the city. This technique is hidden under corrugated metal plates, which is why it is little-known, however much of the architecture of Valparaíso is built using it. One last interesting aspect is that this technique represents a transition point between artisanal construction processes and modern standard ones, as a result of the incipient industrialization process experienced by the city in the 19th Century. It is interesting to notice how behind the variety of the vernacular architecture of Valparaíso, there exists this homogeneous and hidden building technique that has proven to be earthquake resistant until today.



The *adobillo* block and structural system (drawings: R. Cisternas).



Detail of *adobillo* technique. Corrugated plates that hide the technique Valparaíso architecture built with *adobillo*.

(photos: R. Cisternas)

ENVIRONMENTAL PRINCIPLES

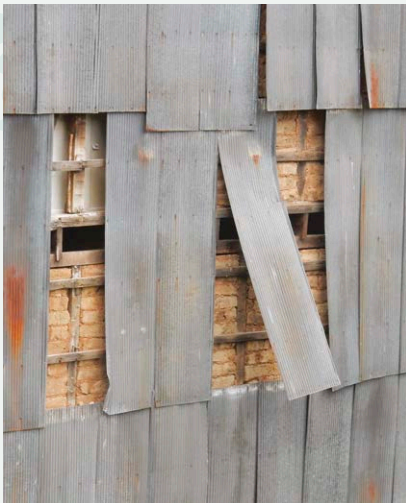
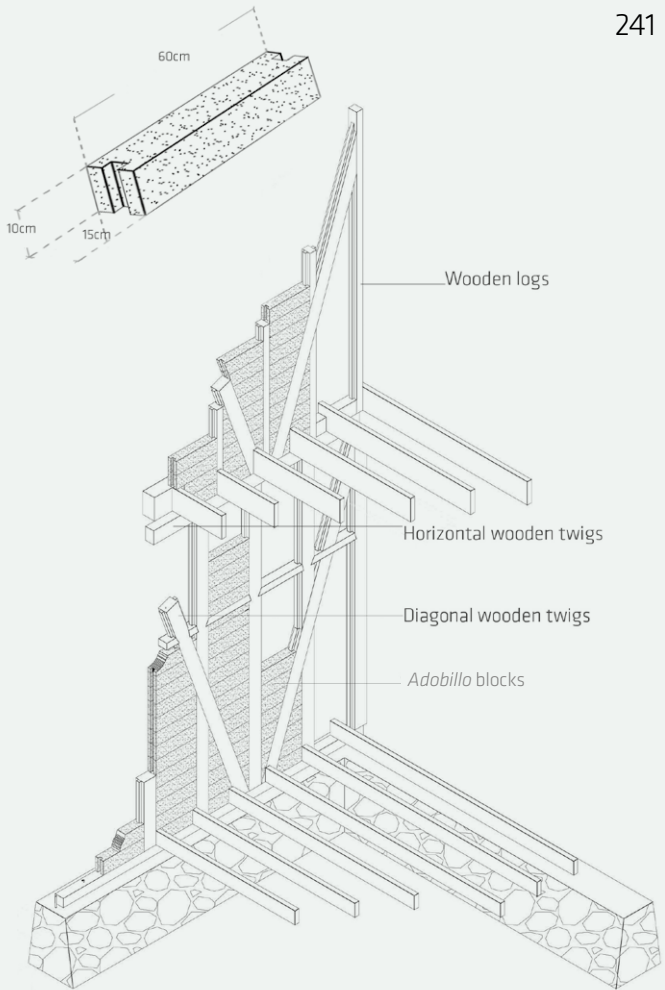
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WOODEN FRAME STRUCTURE IN THE OTTOMAN HOUSE

TURKEY, GREECE, BALKAN AREA

authors

Dalia Omar Sidik, Letizia Dipasquale

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Wooden frame construction systems are widespread in Turkey and in the places that have been subjected to the influence the Ottoman empire, such as Greece and the Balkans. It consists of a wooden frame infilled with stones, bricks or adobe, held together by earthen mortar, and it takes many local variations depending on the materials available. The buildings realized with this technique can be isolated as rural housing, but also townhouses in the historic centers.

The structure usually consists of two or three floors above ground and a symmetrical plant. Foundations can reach great height and form a solid base of stone masonry. In many cases the whole ground floor is made by stone bearing masonry – often reinforced through the use of horizontal timbers embedded – while the timber framework is used for the upper floors.

The wooden frame is divided into a main structure of the timber elements, square section of about 15 cm to the side, horizontally and vertically arranged, and a secondary structure of sub-elements of smaller cross-section (10 cm side) placed in a horizontal, vertical and diagonal. The voids identified by the frame are generally filled with raw earth bricks, whole or portions of them, or stones and, in mountain environments, the filling is made with lightweight materials, such as wattle. The reduced thickness walls are coated with a layer of earthen plaster on the inner side and, in some regions, also on the external front. The wooden skeleton is usually visible. The roof is pitched and overhanging and it originally was made of straw and covered with earth.

ENVIRONMENTAL PRINCIPLES

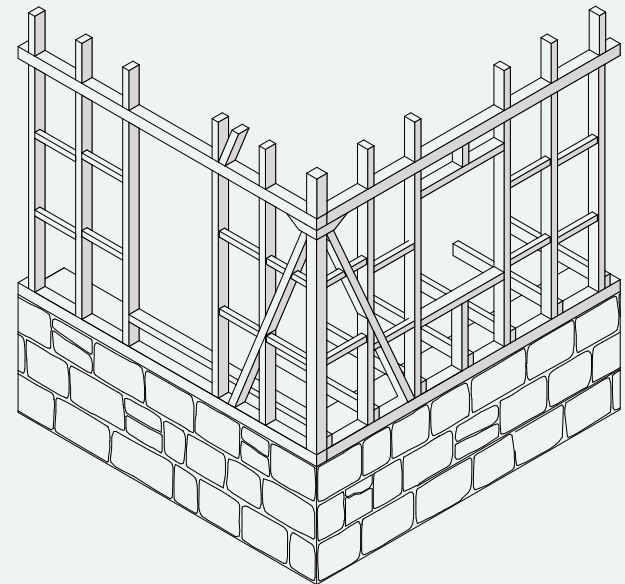
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Ottoman wooden frame building system (drawing: D. Omar Sidik).



Wooden frame building (locally called *hımış*) in Safranbolu, Karabük, Turkey (photo: Uğur Başak).

Wooden frame building in Albania (photo: I. Hasa).

Wooden frame building on the second floor of a building in Kastaneri, Greece (photo: S.Mecca).

