Mediterranean traditional architecture and tools for the recovery. The case study of Dellys in Algeria

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Highlights
The main research objective consists of examining the possibilities of recovering the pre-modern historical and traditional architecture in seismic areas, by using a methodological approach that combines the conservative needs with the modification needs of the built heritage, which we can still consider as capable of providing quality responses to the living conditions of local communities. Drawing on the most significant experiences of the Mediterranean countries, with particular reference to the Italian recovery manuals, the base for the definition of guidelines for the recovery, according to compatibility and sustainability criteria, is the in-depth study of the constitutive rules of settlements and of the traditional and historical building knowledge.

Abstract
This contribution shows the research work carried out within the pilot projects of the Rehabimed International Consortium, for the definition of guidelines for the recovery of the historical city of Dellys in Algeria, which was almost completely destroyed by a catastrophic earthquake in the early 2000s. In order to encourage re-population, the research was aimed at the study and recognition of the morphological, typological and constructive structure characters of the traditional architecture of the casbah, in order to direct the re-qualification actions for this significant traditional and historical heritage, also taking into account the seismic criticality of the area.

Keywords
Historical and traditional architecture, Recovery, Recovery manuals, Construction and recovery techniques, Dellys-Algeria

1. INTRODUCTION
The conservation and reuse of traditional and historical architecture, with the idea of constituting a “living” heritage intended to accommodate inhabitants and their activities, is a subject theme that is central to current issues that introduces critical questions for the definition of intervention approaches in terms of culture, heritage, design, construction and, more generally, strategy, especially in highly seismic contexts. The difficulty that the culture of the modern project incurred in taking care of basic architecture (i.e. the historical building heritage traditionally conceived as non-monumental), namely the significant portion of architecture which has long been considered as of “minor” importance, and which defines a process of continuity with the past, produced a profound caesura between the pre-modern and twentieth century heritage, with respect to settlement principles and construction techniques.
The loss of knowledge among the local traditional building cultures, which occurred as a consequence, constitutes a factor of extreme vulnerability of the basic architectural heritage, and underlies the inability to find a balance between the values regarding history, vestiges, culture, use and transformation. The case study of the city of Delys in Algeria is emblematic in this regard. In fact, it was almost completely destroyed by a catastrophic earthquake at the beginning of the 21st century. It was an historic city, which was extremely valuable from a point of view of its urban space and social settlement fabric, which was structured by the hybridisation between the ancient kasbah and the new colonial expansion, which was built in about one hundred years during French colonisation. The obvious consequence was the sudden abandonment of the old city centre for safety reasons. After the emergency, the old town was recently and progressively re-appropriated by the community with informal customs and means. This contribution discusses the research conducted by the DICAAR of the University of Cagliari within the Montada international project whose strategic objective was that of repopulating the historical city. The DICAAR worked on studying the form, structure, characters, problems, degradation of the historical city (primarily in relation to the seismic action), in order to define some guidelines for its sustainable regeneration. The method used refers to the recovery manuals and codes of practice, and is enhanced by the study of some of the most significant international works such as those related to manuals for specific cities (Rome, Città di Castello, Palermo, Sassi di Matera, Ortigia) or territories (Lebanon, Syria, Sardinia, Piedmont and Liguria), assuming the use of a tool of knowledge aimed at various levels of users: conservation institutions, designers, workers and owners, often the first to operate in auto-construction.

2. URBAN FORM OF THE HISTORICAL CITY

The historic city of Delys consists of the ancient kasbah and the colonial city, which was built under the French dominion, in the period between the second half of the 1800s and the first half of the 1900s. The kasbah is the oldest existing core of the city of Delys. The analysis of the historical maps, the oldest of which dates back to 1845, shows the image of a strongly hierarchical urban structure. First maps show a road structure ruled by the main and founding “Grande Rue Arabe”, which is oriented along the north-south axis and defines the half-coastline of the slightly sloping area (from sea level to approximately 70 m a.s.l.) on which the old building are located. This road, along which there is the Grande Mosquée, also delimits the upper part from
the lower part of the casbah. The lower part is more densely built up and has a privileged view overlooking the sea. The main road opens transversely to the secondary pathways (terraced paths or consisting of a single continuous and strongly declining plane) that run along the main slope lines. The mesh is hierarchical and stretches where the fabric is denser. Some alleys branch off from the main and secondary paths, allowing the penetration to the denser and more compact fabric; the alleys give access to the innermost areas, which do not face main roads and which structure the proprietary parcelling of the larger blocks.

The streets are narrow and can be accessed only on foot. The slopes are often resolved with terrace steps along the whole development of the road; the terraced steps also structure the entrance to the houses. The adherence of the morphological structure to the site and orography of the soils is an element of great urban strength and clarity. The paths are never straight and are characterised by the continuous presence of interruptions, small widening areas and sudden changes of direction. In the upper and lower part of the casbah, the paths leading down to the coast and harbour are characterised by continuous and differentiated glimpses towards the sea. As for the colonial city, in 1845, just a year after the French occupation of Dellys, the paper of the “Directions des Finances - Province d’Alger – Service de Dellys” states the will of the colonists to operate on the territory for the construction of a “new city” at the foot of the ancient casbah. The process started straight away with the commissioning of large transformation works circa 70 metri arriva fino al livello del mare. Questo percorso, lungo cui si incontrano la Grande Mosquée, delimita inoltre le due parti della casbah, quella alta e quella bassa, più densa e costruita e con relazioni di affaccio privilegiato sul mare. Il percorso matrice si apre trasversalmente ai percorsi secondari che corrono lungo le linee della massima pendenza, e gradonati o costituiti da un unico piano continuo, fortemente declivi. La maglia si gerarchizza e si infinitisce laddove il tessuto è più denso, dai percorsi principali e secondari si diramano i vicoli che permettono di addentrarsi all’interno dell’abitato più fitto e compatto; attraverso i vicoli si accede infatti ai tetti più interni che non hanno un affaccio diretto sulle vie principali e che strutturano la parcellizzazione proprietaria degli isolati di grandi dimensioni. Le strade sono strette e praticabili solo a piedi. Spesso le pendenze sono risolute con gradonate che si susseguono lungo tutto lo sviluppo del percorso e gestiscono, a differenti quote, gli accessi alle case. L’aderenza della struttura morfologica al sito e all’orografia dei suoli è un
of the existing heritage and with the construction of a new urban centrality according to the “European model”. These transformations included the construction of via Nazionale 24, which divided the Casbah into two parts, disrupting the original structure of the historical fabric and compromising the mutual relations of the settlement; the two parts of the ancient city had an independent and completely new configuration.

Figure 2. Plan with walls and urban section of the ancient casbah.
The conformation of the French city, where the slope of the ground is gentle enough, is characterised by rectangular, narrow and very long blocks, articulated in rows of counterposed compact lots overlooking two parallel streets. Besides, in the areas of greater declivity, the narrow, deep, pass-through lots are laid out along the main slope lines.

3. FORMS AND DENSITY OF THE ANCIENT CASBAH

The casbah consists of a dense fabric, principally made up by residential and religious buildings (the mausoleums and the ancient mosque). The blocks, which have different shapes and sizes, are generated by the convergence of parcels with different and irregular conformations; the mesh of the fragmented fabric gradually clusters near the main street embracing the fabric portions that are denser and more densely inhabited, even nowadays. The shape of the blocks is generated by the repetition of the patio type, which constitutes the principal rule of the housing fabrics in these places, and is based on the introversion of the domestic spaces. The recurrent patio type generates a fabric in which there is a strong prevalence of the solids on the voids of the inner courtyards, by introducing a varied repetition within the urban system of the casbah. The continuity of façades is interrupted only by the entrances of the houses and by small openings, and is generated by the common practice of closing towards the roads. The only openings are towards the interior patio, as no openings that overlook the neighbours are possible. The Mediterranean character of the introverted habitat is declared by a clear separation between the public and private spaces. Inside the blocks, the dwellings are placed at different levels, as the soil is structured on different terraced planes that manage the altitude differences of the area. The discontinuity of the soil never interferes with the aggregating system of the dwellings, as it is always in correspondence with the border walls. This determines a clear system, which can be defined as “terrazed”. On the terraces, the buildings, with their walls partially against the ground, structure the entire fabric of the block in a compact and unified way. Blocks are deeply rooted in the natural soil and their structure is significantly strengthened by the fact that contiguous buildings share the same structural wall. The slope of the soil does not obstruct the formation of significantly deep and compact blocks; in fact, the terraced management of the soil, together with the patio type, allows the block to be formed by numerous lots placed next to each other that, despite their contiguity, share no permeability and facing relations. The only formal variant of the blocks occurs when there is the need to ensure...
the access to a “locked” lot; the block is therefore “cut” by one or more alleys. The alley adds a layer to the hierarchy of the different spaces of the paths; in this case, the public space becomes semi-public, mainly related to the space characters of the alley, that is narrow and closed, and to the use value added by the fact that the alley gives access to a limited number of houses, often only to one or two.

4. INHABITING FORMS IN THE HISTORICAL CITY

The Casbah of Delys is structured upon the repetition of a multi-family house with a common patio, totally introverted, enclosed by high walls protecting its intimacy and finds contact with the street by means of two extremely interesting typological and spatial devices: the “squifa”, which is a complex entrance threshold with a chicane structure, and the “qbou”, which is a projection of the living areas, from where the road can be monitored through small openings without being noticed. When the occupation process of the lot has reached its maximum development, the structure of the house shows its perimeter as entirely built by two level buildings with a simple thickness, which surround a central patio. The number of family units, which inhabit the lot, usually corresponds to the number of its built arms. A system of common stairs and galleries, developed on two levels around the patio, serves the floor circulations and the accesses to the different houses, characterising the language of the dwelling in an almost polarised way: closed and hermetic on the outside toward the street, open and permeable on the inside towards the patio.

Conversely, in the colonial expansion the intention was to standardise the residential “dimension” of the new city by using a terraced house model developed on two levels. The “European city”, therefore, gives a horizontal character to the built pattern, which is structured by long and continuous linear blocks where the same building type is repeated, albeit including some size and linguistic-formal variations.

The house faces only two opposite sides, the road and the back, usually near a small pertinent courtyard. The resulting urban sequence is very simple and consists of the road-dwelling-courtyard succession, which is reflected symmetrically along the borderline on the back. The hierarchy of spaces and their property are clear and do not have complex or intermediate conditions between the public and private spheres: the public space of the road, in fact, is counterposed to the private one of the single-family house. The most widespread floor plan system is symmetrical with a double thickness body of buildings, generated by the juxtaposition of a double row of three

infatti, proprio la gestione del torno a terrazzi e il tipo a patio fa sì che l’isolato si componga di numerose parcelle accolte che, pur nella continuità derivante dalla giustapposizione, non presentano alcun vincolo di mutua permeabilità e di affaccio. La varietà formale degli isolati è presente solo ed esclusivamente quando, dovendo garantire l’accesso a una parcella intercussa, l’isolato stesso viene “tagliato” e attraversato da uno o più vicoli. La presenza del vicolo gerarchizza maggiormente le differenti spazialità dei percorsi; lo spazio pubblico in questo caso assume una connotazione semipubblica legata soprattutto ai caratteri spaziali del vicolo, stesso che permette l’atto d’uso dato dal dover rispondere alle necessità di accesso di un numero limitato di case, talvolta solo una o due.

4. FORME DELL’ABITARE NELLA CITTÀ STORICA

La casbah di Delys è strutturata sulla ripetizione di un tipo di casa plurifamiliare a patio comune, totalmente introv ersa, racchiusa da alti muri che ne proteggono l’intimità, che entra in relazione con la strada con due dispositivi tipologici e spaziali di estrema interesse: la “squifa”, soglia complessiva di ingresso con impianto a chicane e il “qbou”, proiezione in aggetto degli spazi di soggiorno dai quali attraverso piccole aperture è possibile sorvegliare la strada senza essere visti. L’impianto delle case, quando completo nel processo di occupazione del lotto, si presenta con l’intero perimetro costruito con corpi di fabbrica su due livelli a spessore semplice, che delimitano un patio centrale. Qui ad ogni braccio costruito corrispondono solitamente altrettanti nuclei familiari. Un sistema di scale comuni e gallerie che si sviluppano sui due livelli attorno al patio risolvono le circolazioni ai piani, in quota e gli accessi alle differenti abitazioni e connotano il linguaggio della casa in un modo quasi bipolare: chiusa ed ermetica all’esterno verso la strada, aperta e permeabile all’interno verso il patio. Nell’espansione coloniale invece si prevedeva di uniformare la “dimensione” residenziale della città nuova, ricorrendo a un modello di casa in linea sviluppata su due livelli. La “città europea” dunque presenta un carattere orizzontale dell’edificato, che si struttura per lunghe stecche continue in cui lo stesso tipo edilizio, seppur con alcune variazioni dimensionali e linguistico-formali, si ripete. La casa dispone di soli due affacci contrapposti, uno su strada e l’altro sul retro, generalmente in prossimità di un piccolo cortile di pertinenza. La sequenza urbana che ne consegue è molto semplice e data dalla successione strada-casa-cortile che si specchia simmetricamente lungo la linea di confine sul retro. Anche la gerarchia degli spazi e il loro statuto proprietario sono chiari e non presentano complessità o condizioni intermedie tra pubblico e privato; allo spazio pubblico della strada, infatti, si contrappone quello privato della casa monofamiliare. L’impianto piantometrico più diffuso è
rooms. The entrance is generally located in the central area of the row facing the road, and the same place, on the row of rooms on the back, corresponds to the area, which contains the stairs that lead to the first floor.

5. ELEMENTS OF THE TRADITIONAL CONSTRUCTION PRACTICE

The traditional construction in Dellys is characterised by the systematic use of natural materials readily available at a short distance. Therefore, the local wood and stone are the basic raw materials used for the construction of the houses in the Casbah.

Pre-modern architecture, here as elsewhere, is inspired by the principles of necessity, which reduce the level and complexity of the material processing and lead to the simplification of the construction. The stones are often used as found or after a simple rough-hewing in order to give them a suitable shape for wall making; the wood, inside the most archaic dwellings is directly used with its natural configurations, including significant curves. Wood and stone

Figure 3. Building types and constructive systems of the ancient Casbah.

sulla fila di vani disposta sul retro, l’ambiente con la scala che consente di raggiungere il primo livello.

5. ELEMENTI DELLA COSTRUZIONE TRADIZIONALE

La costruzione tradizionale a Dolly si caratterizza per l’uso sistematico di materiali naturali facilmente reperibili a breve distanza, pertanto la pietra e il legno locali costituiscono le materie prime di base per l’edificazione delle case della casbah.

L’architettura premoderna, qui come in altri luoghi, si ispira a principi di necessità che riducono il livello e la complessità di lavorazione dei materiali e conducono alla semplificazione delle operazioni di costruzione. Le pietre vengono spesso usate come trovanti o con semplici sbattiture per sagomarne le forme per gli apparecchi murari; il legno, nelle abitazioni più arcaiche, viene impiegato direttamente con le sue configurazioni naturali, anche se con curvature rilevanti. Al legno e alla pietra si affiancano terra cruda,
are flanked by raw earth, used for the filling and floor layers, and fired earth used for making bricks, tiles and roof tiles.

The wall is the most important structural element in Dellys and is entirely made of stone, while the compressed structures, in particular the arches, are made of stone or fired bricks; the horizontal structures and the roofs are made, in the more traditional dwellings, with wooden trunks which are directly placed on the walls and that form the bearing framework supporting the secondary framework, if provided, and the finishing layers. The resulting construction system is dry; it involves the use of mortars with lime or earth base and limited resistance capacities, and it is conceived as a large assembly box. The structural system is based on the mass, weight and the load transmission through the static principles of the compression of the elements, without considering the elastic capacities of materials. The constraints between structural elements and between different materials are conceived within the mutual support and mutual contrast, and ensure freedom of movement allowing the natural adjustments of the building, due to its constitutive nature - based more on the assembly of single elements rather than continuous elements - but are unable to effectively deal with the dynamic effects of earthquakes. Despite the strong seismic characterisation of the Algerian coastline, in fact, the techniques used in the construction of the Casbah do not have special constructive and structural arrangements necessary to increase the resistance to oscillatory and up-thrust stress produced by earthquakes.

Chaining systems - both wooden and metal - and the optimisation of the collaboration level between walls of the cells or between the masonries and the horizontal elements in order to increase the resistant capacities of the building, which are widely used in seismic areas, do not belong to the building tradition of Dellys. Here, the resistance of the buildings appears to be associated with the massive nature of the wall structures, to the use of masonry textures that introduce herringbone patterns, according to a medieval technique used also in Italy and in other Mediterranean countries, to the intensification of wooden beams in the intermediate slabs, following a principle of inertia related to the oversize of the structural elements, rather than resorting to techniques that are directly aimed at producing an active behaviour of the structures when dynamically stressed.

Historically, this led to a greater vulnerability of the buildings, which were significantly damaged during the last considerably intense earthquake that occurred in 2003, which led to the almost total abandonment of the Casbah by its inhabitants.

The construction of the colonial city introduced in Dellys some solutions
which belonged to the French set of engineering manuals and treatises of the 1800s: starting with this period, new construction features were largely used in the building industry, such as wooden horizontal structures with squared beams and planking, mixed horizontal structures with metal beams and vaults, reinforced concrete slabs and complex and articulated wooden roofing structures.

It is easy to understand, that the same techniques will be used in the maintenance and replacement processes of the Casbah, often resulting in interesting technological and linguistic combinations.

6. DEGRADATION PROBLEMS

The architectural heritage of the Casbah, is now abandoned and left in a particularly critical state of conservation, mainly due to the damage caused by the earthquake which overall affected the walls and roof structures.

The roof structures appear to be the most degraded and just a few houses still have, though not in perfect conditions, the traditional wooden structures and their technology packages. In fact, the oscillatory earthquake action, which produces a progressive loss from bottom to top of the monolithic behaviour of the masonry and of the integrity of the anchoring between the walls, which constitute the masonry cell, had caused the greater damage at the top of the buildings. The oscillation of the terminal parts of the walls facilitated the slipping out of the wooden roof structures from their provided support slots inside the masonry, in addition to the collapse of large top portions of the walls themselves. The walls have been affected by different cracking and/or rupture mechanisms; the most frequent are:

• ground collapses in corner or intermediate positions which cause the detachment of the overlying masonry portions, with respect to the parts not involved in the cave-in;
• inflection of the walls along their axis, especially with free spans without intermediate stiffeners, due to the top compression action transmitted by the roof which could be possibly accentuated by the dynamic action of the earthquake;
• the detachment of portions of the masonry resulting from bad corner connections, resulting in the triggering of kinematics according to the cylindrical hinge models, with the axis horizontal to the rigid base of the wall and diagonal.

In all these cases, the primary damage and collapse mechanisms associated with the single walls produce deleterious effects also for the correct functioning of the structural system based on structural cells, typical of the masonry
traditional architecture. In parallel with the deterioration produced by the earthquakes, which is by far the most significant and critical for the traditional buildings of the casbah, we must not underestimate the impairment level of the heritage resulting from the use of industrial construction techniques to recover and re-qualify the numerous traditional buildings. In particular, the use of building elements and materials that are not compatible with those of the local building tradition, such as reinforced concrete and concrete and cement prefabricated blocks, causes further damage in several respects. Firstly, the substantial linguistic and constructive continuity at the base of the modifications and additions, which occurred over time on the historical and traditional architecture, is seriously compromised and the introduction of elements, which are far from the handcrafted dimension of the historical buildings, contributes to the loss of their identity.

Furthermore, the different mechanical nature of some of the materials used, such as concrete, with respect to the natural ones historically used in the Casbah, produces unexpected reactions by the entire structural system when subjected to dynamic forces attributable to de-compensations and imbalances of the structure behaviour among the parts with different levels of rigidity.
Cultural matters on the one hand and structural and technology issues on the other, therefore, suggest that it would be a good idea to pay particular attention when using newly-developed materials for the recovery of the traditional architecture, and above all to require a deep knowledge of the historical buildings and the compatibility of the traditional heritage with the necessary constructive innovations.

7. CONCLUSIONS: PRINCIPLES AND GUIDELINES FOR THE RECOVERY

The guidelines for the recovery of the built heritage of Delys are based on an approach of continuity and compatibility between contemporary and traditional techniques and materials.

The reference principle of the entire manual is that of using solutions to counteract structurally the seismic forces, which are in line with the already-known and explored solutions, optimising them. The organisation of the manual is directed towards the definition of guidelines for the recovery of recurring situations of degradation. These guidelines are necessary for the re-qualification of the traditional buildings in their formal and constructive completeness, and for the enhancement of the performances of the structural systems especially in critical conditions of mechanical stress due to seismic action.

In this sense, the manual is conceived as a reference written work, which recovers the interrupted connection between what the traditional and cultural heritage can offer and what the contemporary technical skills are, through the analysis of some examples of good intervention practices. It is therefore an attempt to rediscover the huge popular building knowledge gained over centuries of practical experience, which could otherwise be lost, and to integrate it and make it consciously live side-by-side with the current scientific and technological dimension. Within the wide range of cases of degradation of the traditional and historical heritage and of the colonial city and consequent recovery possibilities, significant priority has been given to the structural consolidation issues with the introduction of techniques that have been borrowed from the Mediterranean traditions and not only from those in Algeria.

Firstly, the manual proposes a systemic reading of the structural behaviour of the historical buildings, according to which the structural elements of the building contribute to their mutual support, through a principle of mutual collaboration. Following this principle, floors and roofs are stiffening elements.
that improve the behaviour of the masonry cell, and, if connected by contrast to the septa that support them, they can be configured as chaining elements, reducing the effects of the horizontal actions and significantly improving the capacity to cope with seismic tremors.

Therefore, the proposed intervention techniques focus on the use of elements capable of reducing the horizontal actions (chains, wall rooting, wood anchoring systems, steel, bricks), on obtaining the monolithic aspect of masonry units, on consolidating the masonry corners (optimisation of the anchoring system between orthogonal septa) made with the use of large, crafted stone elements that are suitably staggered and overlaid, of laying surfaces of the horizontal elements (intermediate horizontal structures and roofs) made with solid edging bricks, etc.

Figure 5. Interpretation of the systemic structural behaviour of the urban aggregate and kinematics of the walls.
The choice of technical intervention sheets as tools for easy consultation is aimed, on the one hand, at the disclosure and use of the manual as an instrument of knowledge and awareness about heritage recovery issues even for non-experts, and on the other, at facilitating its consultation by technicians and workers.

8. REFERENCES