Analysis and Technology Rating of the Rural Architecture

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***Abstract*—**The architectural heritage belonging to "rural culture" constitutes a resource of extraordinary importance, therefore it must be preserved, protected and enhanced not only for its intrinsic value, but above all, as a witness of an almost completely disappeared reality.

For its proper recovery a careful analysis is required for locating its physical and morphological consistency. In the critical reading of an architectural work it becomes essential to adopt a tool of classification and analysis to highlight the aggregation structure of the technical elements and their state of preservation. The aim of this paper is to provide a new systematization for the knowledge of architectural objects characterized by a significant and complex number of parts. The analysis and the technological classification is developed by reference to the classification systems of the technical elements (ex. UNI, NORMAL,) adopted with amendments and additions. The classification, in addition to morphological data, will include those constructive and material, functional joints related to different uses, conditions and causes of deterioration. By overlapping and comparing all the information, divided into more specific and restricted parts, you can make a filing able to support choices between different technical solutions in order to provide the greatest adequacy to analyzed building system in the restoration project.

***Keywords*—** Rural architecture, technology rating.

I. Introduction

The architectural heritage belonging to rural culture constitutes a resource of extraordinary importance, expression linked to production cycles, working or processing of agro-forestry products. It, therefore, must be preserved, protected and enhanced not only for its intrinsic value, but, above all, as a witness of reality almost completely disappeared. The urgency of protecting traditional rural buildings is derived from the need to protect the few still intact witnesses, because in most cases for the adaptation to new functions or housing standards, the buildings have undergone renovations and extensions that have impoverished and homogenized the original language of the building system rich in multiple technical solutions deeply linked to the territory. Episodes of rural architecture, although they can not be considered of particular historical and artistic value, are significant evidence of an expression of the material culture of places. Typically, the constructive simplicity of the rural artefact is complementary, however, to a complex mechanism of operation to which it was destined. The knowledge of an artefact complexity is indispensable to deal with any type of intervention, from the protection and enhancement, functional adaptation, structural or technological, up to the consolidation and restoration. This knowledge must be acquired through activity of analysis and diagnosis of the building making it possible to understand its structural and constructive characteristics, of design and function and its relations with the local context. The relief, fundamental analysis tool, must include not only metric data, constructive and materials, but must explain the aggregation structure of the technical elements in order of detail and understanding of the relationship of the various constituent parts of the building system, the functional joints linked to different uses, pathologies affecting and the causes of decay.

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II. Description of the Methods of Analysis of Building Types & their Classification

The aim of this paper is to provide a new systematization for the knowledge of traditional rural buildings, characterized by a large and complex number of parts. For each building structure, chosen for its characteristics and peculiarities, it has made a first macroscopic morphological study (photographic survey campaign at various levels, visual analysis, tactile), for the compilation of ID cards. Subsequently, the building structure is decomposed (by reference to the UNI classification system of technical elements) (Fig.1) into more specific and restricted fractions, identifying the types of construction, the materials, the technical elements, their state of decay and residual performance. All information will be useful to the compilation of fact sheets that will be overlaid and compared to develop a correct restoration project. Here below they will be illustrated, by way of example, the description, analysis and classification only of vertical elevation structures and top closures. In research also are present analytical data sheets for materials[1], for internal and external horizontal structures[2], for internal vertical elevation structures, doors and windows, etc.

Structures of vertical elevation (SEV) - In different studied areas, we have been detected different types of walls made

[1] Material coding:
Natural stones (MLN): MLNt - Tuff , MLNa – Sandstone, MLNc – Limestone, etc.
Artificial stone materials (MLA): glass, bricks, porcelain, mortar, (MLAL – bricks, MLNc – porcelain, etc.)
Metal materials (MM): MMa – steel, MMg – cast iron, MMr – copper , MMp – lead , MMz – zinc, etc.
Organic materials: wood (MOL): MOLc – chestnut, MOLl – holm, MOLr – durmast, MOLf – Beech, MOLcr – Cerro, etc.

[2] The slabs present in the concerned areas, in most cases, are composed of parallel beams (with a distance between the beams of about a meter) with warping simple or double, with overhanging deck. The section of the beams varies from circular trunk simply barked, in a square section beams.

with different constructive techniques depending on the local context and the relative availability of materials. However, the small heights of the buildings do not require high thickness of the walls, which, typically, are never lower than 40 centimetres. With the exception of dry walls, in almost all masonry, the stones are bound with lime mortar, and coarse sand from local quarries (often mixed with small amounts of land that gives the mortar an amber colour). The types of analysed masonry almost always use (especially when the transverse dimensions are significant) the bag technique that involves the construction of two walls spaced apart which enclose a core consisting of elements of small size with mortar. There are some stone elements arranged transversely to connect together the two outer walls, thus ensuring greater stability and compactness of the masonry. Rarely, the walls are coated with plaster and the geometry of the masonry varies depending on the use of stones more or less square, having, in most cases, regular horizontal courses. The chromatic ranges differ depending on the used stones, of their exposure to the atmospheric agents, of the inserts in different materials between the joints (fragments of roof tiles, bricks, etc.) and the level of degradation. The design solutions are therefore quite homogeneous in all areas analyzed, while the diversification is essentially due to the different method of laying in work of the individual stone, to their size and the nature of the used materials. The masonry analyzed with focused photo surveys (with diffuse and oblique light) allow a hierarchical reading of the individual components (prevalent, filling and connection), the size of the same, their disposition and the relative texture (in relation to the plot or warp, regular / irregular) determine the texture (uniform/ smooth / moved / wrinkled) of the facing. More formal configuration parameters are defined by colours (primary / complementary) of the elements, their tone and the plastic effect of apparatus of joints (strong / weak) (Figure 2). In the discretization, the technical element is divided into areas or homogeneous volumes for construction type, identifying: the type of material (the rock types[3], the arboreal essence, etc.), The degree and the type of work for the preparation of the material; the type of installation, the arrangement of stones or bricks on the exposed face; the size of the individual elements and their average size (statistically processed); finishing techniques of the material, especially stone, through the traces left by the used tool on the surface, the type of mortar, the type of components that make up the mortar and the characteristics of the joints (the presence of the courses, the geometry of the same, the integration of connection elements, etc.). The subsequent examinations are directed in the reading of finishing elements of the walls[4], the openings, the crowning frames, doors and windows, etc. (Figure 4,5) enabling an analysis of how the components are presented and combine with each other by establishing concordances typological through effects: colour (homogeneous / mixed); light / dark (strong / weak); geometric (agree / disagree); textural (homogeneous / inhomogeneous). The schematic, settled in the interpretation of the structure of the relationship between the components and the analysis of the intensity of the resulting relationship, allows us a catalogue of perceived patterns most common in the areas under consideration. The detected and identified components can be described through the nature or origin and their specific properties, depending on: size - significant / insignificant (in relation to the observed system); geometry - linear / polygon; form - simple / complex; disposition (with horizontal development force lines, vertical, oblique, etc.); contours (soft / net, closed / open, continuous / discontinuous).

Top closures (CS) - In all the analyzed areas, the traditional roofs are mainly pitched; only in areas close to the coast are found flat or with the upper surface vaulted outside. The flat roofs are made with a primary framework of beams and a deck made with chestnut wood small boards that support a very thick slab of wrought lapillus. In areas where it was more difficult to get the wood, the buildings use the vaulted roof extrados, the vaults are mostly barrel (there are also those hipped and sail), realized with blocks of local stone, have the top surface coated with wrought lapillus, often shaped to channel the rainwater in cisterns. The pitched roofs are generally classified into the usual morphological families (in a flap, double-pitched, hipped, multi-pitched) but using simplified static solution (the trusses are almost entirely absent). The covering structure of the examined buildings is mainly achieved by the main structure (warping carrier in the transverse dimensions of beams proportional to the distance of the supports, with a section rather irregular, approximately rectangular or circular, of a size of about 25 or 30 cm.) which supports a transverse secondary structure of slats (small size 7/8 cm thick, placed at a distance of 40 cm.) on which are resting the orthogonally clay roof tiles (irmici). The roofing is closed and completed in the upper with roof bent tiles (cavallotti). The wood used is the chestnut, more rarely oak. In roofs in a flap, the load-bearing structure consists of beams resting on the perimeter walls of the ridge and eaves. In buildings with two flaps roof, the frame is placed on a median wall at right angles, or more rarely on a central longitudinal ridge beam embedded in the tympanum of the transverse walls. The slope is around 30-35%, upper limit beyond which the weight of the roof, under the wind loads and dynamic effects, results in slippage of the tiles. When installing the mantle, some stones were placed along the first row of tiles at the level of the eaves, which were used to prevent the lifting of roof tiles under the action of wind (fig6). Typically the eaves node of rural buildings is pretty simple, solved by protruding very little the last row of tiles from the vertical, without the presence of a gutter. A different solution, with a greater degree of finishing (however having the structural components in view and rarely plastered), is represented instead by the cornice which, depending on the rows of which it is composed, can be distinguished in simple, when it results from the horizontal overlap of two or more tiles of files, or composite, when the bent tiles of files interpose horizontal rows of brick

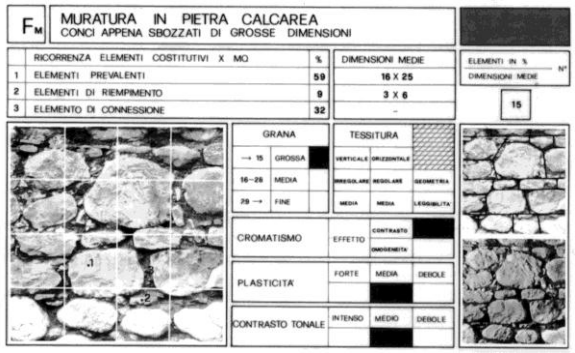
[3] The building stones used were mostly obtained directly from natural gravel (erratics) and river pebbles or extracted from quarries split and hewn on site.

[4] Very often it occurs at the stone elements, often square, which protrude from the facing profile to mark the openings frames, sills, basements, cantonal, etc..

or stone slabs (the concavity of the bent tiles places below the line of the eaves is either facing up or down) (figure 7).

Classi di unità tecnologiche	Unità tecnologiche	Classi di elementi tecnici
P.1. Struttura	P.1.1. Struttura di fondazione	P.1.1.1. Strutture di fondazione dirette P.1.1.2. Strutture di fondazione indirette
	P.1.2. Struttura di elevazione	P.1.2.1. Strutture di elevazione verticali P.1.2.2. Strutture di elevazioni orizzontali ed inclinate P.1.2.3. Strutture di elevazione spaziali
	P.1.3. Struttura di contenimento	P.1.3.1. Strutture di contenimento verticali P.1.3.2. Strutture di contenimento orizzontali
P.2. Chiusura	P.2.1. Chiusura verticale	P.2.1.1. Pareti perimetrali verticali P.2.1.2. Infissi esterni verticali
	P.2.2. Chiusura orizzontale inferiore	P.2.2.1. Solai a terra P.2.2.2. Infissi orizzontali
	P.2.3. Chiusura orizzontale su spazi esterni	P.2.3. Solai su spazi aperti
	P.2.4. Chiusura superiore	P.2.4.1. Coperture P.2.4.2. Infissi esterni orizzontali
P.3. Partizione interna	P.3.1. Partizione interna verticale	P.3.1.1. Pareti interne verticali P.3.1.2. Infissi interni verticali P.3.1.3. Elementi di protezione
	P.3.2. Partizione interna orizzontale	P.3.2.1. Solai P.3.2.2. Soppalchi P.3.2.3. Infissi interni orizzontali
	P.3.3. Partizione interna inclinata	P.3.3.1. Scale interne P.3.3.2. Rampe interne
P.4. Partizione esterna	P.4.1. Partizione esterna verticale	P.4.1.1. Elementi di protezione P.4.1.2. Elementi di separazione
	P.4.2. Partizione esterna orizzontale	P.4.2.1. Balconi e logge P.4.2.2. Passerelle
	P.4.3. Partizione esterna inclinata	P.4.3.1. Scale esterne P.4.3.2. Rampe esterne
P.5. Attrezzatura esterna	P.5.1. Arredi esterni collettivi	
	P.5.2. Allestimenti esterni	P.5.2.1. Recinzioni P.5.2.2. Pavimentazione esterna

1



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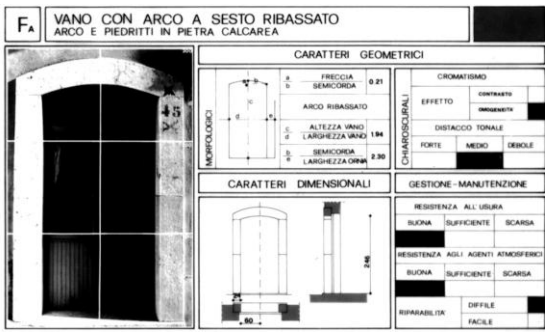

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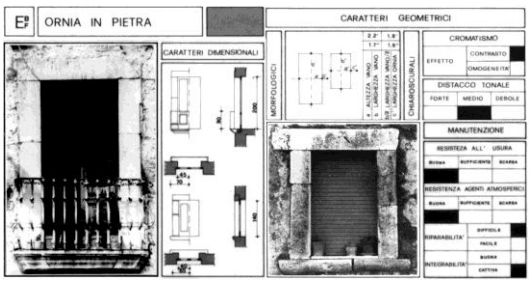

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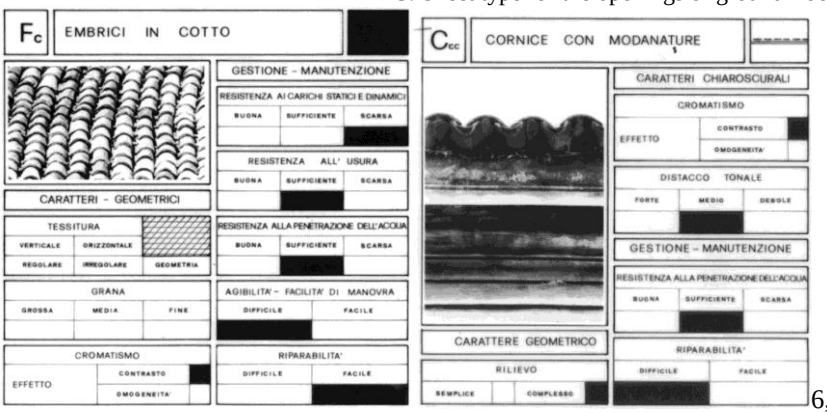
Numero conci x mq.	10~20 (grandi dimensioni)	squadrati	**SEVgq**
		sbozzati	**SEVgb**
	20~30 (piccole dimensioni)	squadrati	**SEVpq**
		sbozzati	**SEVpb**
ORDITO ricorsi orizzontali	Regolare		**SEVor**
	Irregolare		**SEVoi**
TRAMA ricorsi verticali	Regolare		**SEVtr**
	Irregolare		**SEVti**
Materiale	omogeneo		**SEVmo**
	eterogeneo		**SEVme**
Finitura (intonaco)			**SEVi**

2

Fig 1: Building structure decomposition sheet, 2 - 3: analysis of masonry and the classification table with the encoding for masonry typology, 4 - 5: Sheet type for the openings of ground floor and upper floors



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Alterazioni volumetrica (ACv)	**ACv1**	sopraelevazione
	ACv2	volume addossato
Alterazioni chiusura superiore (ACsp)	**ACsp1**	copertura inclinata
	ACsp2	volta estradossata
Alterazioni delle strutture di elevazione esterne (ASes)	**ASes1**	rimozione di protezioni
	ASes2	aggiunta di protezioni
	ASes3	apertura di bucatura
	ASes4	chiusura di bucatura

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Partizioni interne verticali (piv) frazionanti la singola originaria unità ambientale	**PIv1**	pareti interne verticali
	PIv2	infissi interni verticali
Partizioni interne orizzontali (pio) aggiunte di uno o più livelli della originaria volumetria	**PIo1**	ammezzati
	PIo2	soppalchi
Partizioni interne orizzontali non strutturali (pios) aggiunte per la riduzione dell'altezza originaria	**PIos1**	controsoffittature, incannucciate
Partizioni interne inclinate (pii) collegamento alle partizioni interne orizzontali	**PIi1**	scala interna
	PIi2	rampa interna

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Fig 6 - 7: Classification of roof coverings and crowning cornices, 8 - 9: Alterations in environmental units (typological-functional - AUA) and the volumetric configuration (typological- formal - AC)

III. Classification of Alterations' Typologies and Analysis of the Condition

The rural architecture is often the subject of a slow and gradual degradation inevitably linked both at the abandonment of agricultural activities and to the difficulty of adapting the buildings to the new living standards. Where the interventions were made, these have resulted in alterations such as: typological-functional and typological-formal. In the reading of rural buildings, therefore, they have been identified all those operations that for their inconsistency (demolition or achievements of technical elements) or which by their nature and how they have been inserted, altered the formal balance of the building. The subsequent analysis of the conservation status is accompanied by the study of evolution or events involving the artefact, to justify any discontinuities, unevenness or damage in the structure, it is of fundamental importance for the structural setting of the building checking and for the subsequent interpretation of the decay and possible causes that determined it. The alterations of the technical components have been indicated in the relief of crack patterns, together with the tracking of the areas affected by the phenomena of moisture (wet patterns). In unused buildings there are frequent collapses of parts or entire components. The missing parts, which are also listed and coded, are due: to the lack of maintenance, to the removal of materials and elements for the purpose of their reuse in other constructions, to traumatic events such as foundation settlement, earthquakes, etc. In the drafting of the crack pattern, injuries and deformations of structural elements were highlighted (misalignments, morphological alterations, etc.). In the following survey and classification of wet patterns it is necessary to identify the presence of moisture and the extent of the phenomenon to determine the nature and the possible causes mainly determined by: *moisture of capillary rise* - the water present in the soil penetrates into the masonry bodies, impregnates them, and then proceeds upward, through the surface tension and capillary, overcoming the force of gravity; *moisture infiltration* - attributable to water of precipitation (rain, snow) that penetrates into the masonry for direct infiltration through cracks, micro-cracks, carpentry, macro porosity, etc.; *condensing humidity* - the phenomenon of condensation occurs when the temperature of the walls, or of the thermal bridges, is lower than the indoor air dew-point[5]; *accidental moisture* - from accidental and unintentional events such as leaks, cracks and deterioration resulting to poor maintenance of pipes, plants, etc. Using the performed analyzes in the previous phases, in which were identified the material consistency, construction techniques and the conservation status, it is possible, at this point, to analyze and classify the degradation of materials.

Reading the conditions of degradation of natural stone materials (DMLN) - In the first level of survey you develop a reading of all the particularities of the stone elements which have importance for the purposes of a first diagnosis on macroscopic alterations: colour, crystal habit, cleavage planes, sedimentation levels, pathologies of degradation, etc. Then you can draw a map, so that the overlap will highlight the state of alteration and degradation, while identifying the intrinsic and extrinsic causes, direct or indirect, generating pathologies. The procedures, terminology and practices to be adopted for the preparation of the degradation relief will refer to NORMAL[6] recommendations on natural and artificial stone materials. This survey will be open to further investigation, in a second-level analysis in which you can use other tests to determine the following necessary diagnostic tests. Based on the information acquired in the first level of investigation, in fact, you can perform in-depth analysis, the least destructive, useful to accurately determine all the causes of the alterations, the physical-chemical characteristics of the material and of chemical and physical agents that have determined the state of degradation.

Detection of the static conditions of the wood components (LCS) - In the processing the survey of collapses, further analysis consist of the reading of the static conditions of the wooden components (windows, louvers roofing and floors, etc.). The reading identifies the deformations in the components, the disconnections between the individual elements and the detachment of the component by the different structural parts of the building[7].

Reading the conditions of degradation of wooden artefacts (DL) - The first investigation level will be based on a careful visual examination of the artefacts and the conditions of use, useful for deciding the priorities for action and define the subsequent diagnostic investigations depth. The analysis must be carried out by directly observing the outer surface of the elements and wooden artefacts highlighting all the details that have importance for a first macroscopic diagnosis. They will therefore identify the wood species and the birth defects that can affect the mechanical properties of wood, assessing the alterations and degradation suffered over time from the material.

Congenital defects of wood (DLC) - The irregularities of a trunk are features common to all tree species, but when they, at the time of utilization of the wood, reduce the workability and the technical characteristics of the wooden element, you can define them as real anomalies. The anomalies in general are attributable to growth irregularities (sometimes deformations may occur, sometimes production of woody tissues with

[5] Water vapour, condensing, assumes a liquid state. The origin of the water vapour is to be ascribed to the breathing of the inhabitants, the production of steam of kitchens and bathrooms and the return water (steam) from part of the walls. The phenomenon can manifest itself prominently, on the surface, when the ventilation is inadequate and / or incorrect and covertly, hidden in the masonry, when it originated as an insulating correctness.

[6] CNR-ICR NorMaL 1/88 - Raccomandazione dal titolo: *Lessico per la descrizione delle alterazioni e degradazioni macroscopiche dei materiali lapidei*. Edited by Commissione NOR.MA.L (Normativa per i Manufatti Lapidei).

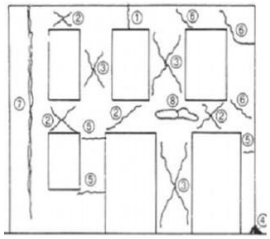
[7] Disconnection (SN) is determined as a result of the break up into individual elements constituting the component, due to the failure of the bonds in the nodes.

Detachment (DS) is determined as a result of the failure of the elements which connect the component with the various structural parts of the building artefact.

Deformation (DF), defined as morphological changes of the component as a result of the alteration of one or more constituent elements.

different structure respect to normal xylem, or more), or to exogenous factors (insect attacks, lightning, frost, etc.).

Degradation of wood (DL) - The diseases that can afflict the wood materials can vary for a multitude of reasons. When these adaptability are not sufficient to cope with the external aggressions, the wood develops diseases that can take it up to complete destruction. These diseases can be of three types: Physical (dehydration or rotting), Vegetables (fungal parasites) and animals (parasitic wood-eating insects). The defects and pathologies involve the often irreversible deteriorations which can lead to a progressive loss of the wooden artefact.



1.	QF1	Lesioni verticali sugli architravi di porte e finestre.
2.	QF2	Lesioni diagonali nei parapetti delle finestre, negli architravi di porte e finestre.
3.	QF3	Lesioni diagonali negli elementi verticali (maschi murari) tra due apertura contigue
4.	QF4	Schiacciamento della muratura per concentrazione locale degli sforzi, consistente in sgretolamento (con eventuale espulsione di materiale) dei componenti lapidei del paramento (parte superficiale) del muro.
5.	QF5	Lesioni orizzontali in testa e al piede dei "maschi murari".
6.	QF6	Lesioni in corrispondenza degli incroci tra muri perimetrali con tendenza all'espulsione dell'incrocio stesso.
7.	QF7	Distacchi verticali agli innesti tra muri ortogonali.
8.	QF8	Espulsione di materiale in corrispondenza degli elementi orizzontali di sostegno ai solai.

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QUrc	Umidità di risalita capillare	Acqua che procede verso l'alto attraverso le tensioni superficiali e capillari, vincendo la forza di gravità
QUI	Umidità di infiltrazione	Acqua (pioggia, neve) che penetra nelle murature per infiltrazione diretta attraverso fessure, microfessure, carpenterie, macroporosità, ecc.
QUc	Umidità di condensazione	*Condensazione* dovuto a ponti termici
QUa	Umidità accidentale	Proviene da eventi conseguenti ad una cattiva manutenzione di pluviali, di canalizzazioni, di impianti, ecc.

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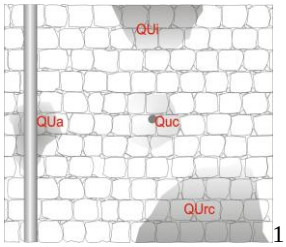

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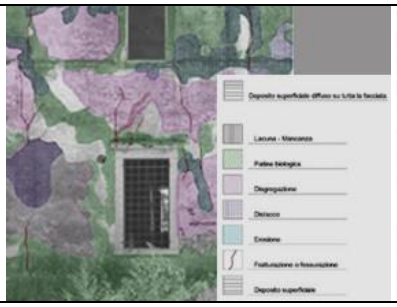
Fig. 9 - 10: Frameworks Sheet of crack patterns of the walls (QF) -from the Ministry of the Interior Circular No. 28/1991, and supplemented by specific classification. 11 - 12: Detection of wet patterns (QU)



DFi	Imbarcamento	Distorsione di forma cilindrica nel senso della sua lunghezza
DFsv	Svergolamento	Deformazione in forma elicoidale.
DFod	Ondulazione	Deformazione in forma sinusoidale.
DFav	Alveolizzazione	Degradazione con alveoli prodotti da insetti xilofagi
DFcf	Carie da funghi	Diminuzione dello spessore e conseguente fessurazione
DFdt	Degradazione termica	Degradazione del legno a causa di un aumento della temperatura in assenza *(carbonizzazione, combustione lenta) o* presenza d'aria *(combustione viva).*
DFfr	Fori di rosura	Degradazione prodotta da insetti xilofagi che non implica riduzione della sezione resistente.
DFfe	Fessurazione	Degradazione con formazione di distacco macroscopico delle sue parti
DFft	Fratturazione	Degradazione con interruzione con o senza spostamento relativo delle sue parti
DFif	Infradiciamento	Degradazione con formazione di masse brune polverulente ricche di sostanze umide
DFpm	Perdita di materia	Degradazione che si manifesta con mancanza di parti o pezzi, asportati da eventi traumatici.

Fig. 12 - 13: Detection decay sheet for masonry walls (Normal 1/88) and Coding of the static conditions of wooden components

DLCct	Canastro	Alterazione per eccesso di compressione in fase di crescita
DLCfc	Fibre contorte	Deviazione dall'asse geometrico delle fibre legnose
DLCcp	Cipollature	Distacchi di anelli contigui sia parziali che totali
DLCcr	Cretti	Lesioni di tipo radiale
DLCtr	Tacche di resina	Fenditure all'interno delle quali vi è resina
DLCdf	Distacco di fibre	Caduta di materia per effetto dello sbalzo rapido di temperatura
DLCtl	Tarlo	Gallerie o fori prodotti da insetti
DLCnd	Nodo	Parti più dure, derivanti dalla diramazione dei rami dal tronco
DLCfd	Fenditure	Rotture longitudinali profonde (in direzione radiale)
DLCmz	Marezzatura	Perimetro sinuoso del tronco tipico di alcune essenze (ulivo)
DLCmc	Marciume	Effetto di decomposizione da attacco fungino

DLal	Alterazione cromatica	Variazione: tinta, chiarezza, saturazione
DLasf	Alterazione superficiale da funghi	Alterazione che si manifesta con muffe polverose e lanuginose.
DLi	Incrostazione	Deposito stratiforme di sostanze inorganiche o da strutture di natura biologica (fonte: Normal 1/80, 1/88).
DLp	Patina	Modificazioni naturali delle superfici dei materiali
DLsg	Sgranatura	Ruvidità più o meno estesa della superficie dei profili o dei pannelli.
DLm	Macchie	Pigmentazione accidentale estranei al substrato (fonte: Normal 1/88).

Fig. 14: Sheet for the survey of slab made of chestnut wood with the classification of congenital defects and wood degradation

IV. Conclusions

In preparing this contribution, for brevity, most of the methods and of recording are omitted and those present are just examples; the work should be seen as a further effort to preserve the memory and identity of rural architecture, often in severe conditions of neglect or defaced by improper restructuring and reconversion inadequate. Careful documentation and classification activity is functional to the definition of "rules" for a proper recovery to occur through compliance with the typological, morphological and material artefacts. The classification of the components in rural buildings and their codification would allow the construction of a repertoire of typological solutions as a reference to preserving the memory of configurative experience of the traditional built heritage and for the education and training of all those who, in different roles, they are involved in the management of the traditional built heritage.

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