Sauris residential building type. Analysis of typologic and constructive characters for a coherent rehabilitation intervention

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Highlights

This paper discusses possible actions for rehabilitation and performance improvement of alpine architectural heritage in Sauris. It is described a methodology for an intervention approach caring to the safeguard of vernacular architecture, both in spatial distribution and in construction techniques and used materials. Rehabilitation aim to perform specific purposes as structural restoration, ground-damping control, energy performance improvement. Technological solutions for building envelope and horizontal structures, compatible with original architectural content, are shown.

Abstract

This research is focused on alpine building heritage in Sauris, a settlement in Carnia. Its residential building type is characterized by almost homogeneous spatial distribution and construction techniques, historically developed due to geographical isolation of this German speaking area and to availability of natural resource as wood, stone, soil and road-metal. To meet requirements for resettlement and Alpine tourism services, a methodology for rehabilitation is applied to Sauris building type. The proposed actions are compatible with original architectural characters and let a performance improvement in structural safety and energy consumption control.

Keywords

Sauris, Cultural heritage, Renovation, Vernacular architecture, Blockbau technique

1. INTRODUCTION

Architectural heritage in mountain areas represents the answer to living needs expressed by a population in a specific geographic and climatic context. The historical evolution of this heritage is related to the adoption and a progressive, gradual improvement of functional and technological solutions, whose utilization depends on material resources availability.

The rehabilitation of buildings in mountain areas is an operative scope in which two different needs occur: on the one hand, functions and performances adjustment to present standards; on the other hand, the preservation of historical and cultural values owned by this vernacular architecture that connote the building and the community that expressed it. Intervention on this heritage should be based on a modern approach, capable of investigating mountain architecture features and local raw materials utilization, specifically.
About the architecture located in Friuli - Venezia Giulia, this approach has been firstly introduced by regional legislation following the seismic event of May 6, 1976. The aim for a new functionality of existing buildings, hitherto investigated in their history and perceptual aspects, is supported now by a specific attention to construction materials and building techniques, so to define a more reasonable approach for asset recovery and for the protection of vernacular architecture characters, combining the experience of building tradition and the site identity.

In this context, the research aims to identify actions for a functional and technological rehabilitation of Sauris building type, defining solutions capable of an improvement of structural and energy performances and, at the same time, compatible with architectural and material features connoting this heritage. The architecture of Sauris represent a peculiar built heritage base on alpine original matrix, with lesser diffusion in other valleys in Carnia. Sauris residential type is rich in characters referable to the modern concept of sustainability and, at the same time, requires protection to match renewed trends for resettlement phenomena and the recent development of alpine tourism in this mountain area. These trends, involving the activation of entertainment activities and new accommodation services, such as the ‘Albergo Diffuso’ practice, provide an opportunity to proceed, with renewed care, to the rehabilitation of this heritage and its territory [1].

2. BACKGROUND AND STATE OF ART

Studies about settlements in Sauris Municipality consider two main themes: the first one concerns the specific ethnic and cultural characters of German-speaking population; the second one refers to the site geography that determined the settlement process [2]. A more recent study line is devoted to a detailed acknowledgement in spontaneous architecture in Carnic Alps, between Italy and Austria, developed with the seismic events in 1976, because of which vernacular architecture has been examined to regulate the reconstruction of the architectural heritage of the region [3].

The studied building type is spread in Sauris di Sotto and Sauris di Sopra settlements and in Lateis hamlet, located on the southern slopes of Mount Morgenleit, at almost 1,200 m above sea level in the Lumiei stream valley, in the historic region of Carnia. This closed-type valley has historically emphasized the isolation of settlements towards both Carnia and Cadore regions, during the whole winter and the early spring season. High-altitude muleteers represented the only way to reach Sauris until 1934, when the construction of the valley street connected the three settlements with main
road network of Carnia region. During its history, Sauris community has developed as an independent economic unit, characterized by self-sufficiency and trade limitation.

In Sauris architecture, a careful use of local natural resources occurs: building materials supply matches rationality and availability control criteria. The development of construction techniques, aimed at seeking the optimum performance with minimum consumption of raw materials, proves a strong synergy with surrounding landscape. One of the main values of this architecture lies in a sustainable land use, first choosing the most suitable place for settlement development depending on sunlight, shelter from cold winds and atmospheric agents, protection from landsliding; then, in the exploitation of traditional materials: stone, wood, soil [4].

In Sauris settlements, climatic and historic reasons, in association with a large availability of natural resources, drove the growth with homogeneity of a building type peculiar for functional distribution and construction techniques. The original typological matrix of alpine wooden house has a rectangular shape, bounded at its perimeter by wooden load-carrying walls in superimposed beams, interlocked at corners according to blockbau construction technique; eaves protecting the access [5] characterize the roofing. A first differentiation of this primitive building type gave a distinction in daytime and nighttime rooms, with the inclusion of an atrium, as distributive space, on the main façade. These peculiarities in distribution are recognizable in Sauris residential type, characterized by a remarkable modularity in spatial elements [6].

The position of the access, the orientation of the pitched roof along North-South direction, finally the relationship between built volume and variable ground slope connote the architecture of Sauris house. The ground slope determines the partial or total laying underground of the lower built level, on one perimeter side or more.

In Sauris house it is highlighted a central distribution corridor (labe) to which all primary relational functions refer, such as room access at different levels and temporary storage of building materials and foodstuffs. In single module type houses, the frame of wooden floors is perpendicular to access corridor, a binding condition for structure dimension, not exceeding 6 meters in width.

The enlargement evolution of housing takes place by side juxtaposition of a second modular type similar to first one, devoid of an additional labe; this double modular type has the largest diffusion in Sauris settlements (Fig. 1).

In the double modular type, primary indoor spaces take place on Southern façade, at a lower elevation if compared to Northern one. At ground floor take place the kitchen (haus) for domestic activities, labe and two cellars (kellder),
devoid of any opening and partially underground. In plots with a remarkable ground slope, a crossing labe is preferred, in order to give a double access to the dwelling from opposite sides. At the upper level, characterized by the adoption of blockbau technique and thus differentiated by stonewalls, night rooms take place, typically consisting in a main bedroom and two ancillary spaces. Access to floor is given by internal stairs taking place in the labe; from the corridor (teine) it is possible to reach the balcony on Southern façade. In the double modular type balcony is often extended to both sides adjacent main façade; along these sides, take place rack wooden structures (pirl) for hay drying process [7].

Figure 1. Indoor spaces in single modular type (a.) and double modular type (b.) Sauris house: at lower living level, labe (central access space, 1); haus (kitchen - living room, 2); stube (scullery, 3, only in double modular type); kелlder (cellar, 4). At the upper level: teine (corridor, 5); sollder (balcony, 6); kommber (bedroom, 7). Authors’ drawing.

Transformation process in Sauris houses also concerns technical elements, showing a progressive evolution by substitution: from fully wooden structural systems to combined ones in timber and stone materials, distinguished by level and finally to recent vertical structures entirely in stonewalls.

Sauris housing type summarizes the specific answers to living needs that population found in this geographic area, by the evolution of an original typological matrix gradually revised and improved; this evolution refers to material substitution in technical elements, change in spatial distribution, diversification of intended use towards more complex spaces.

3. METHODOLOGY

The methodology for the definition of rehabilitation intervention in Sauris building type starts with the analysis of settlement characters and assesses the relationship with site morphology, unitary architectural characters, typology of technical elements, conservation status, transformations occurred. Sauris houses represent a settlement type derived from a continuous improvement of spatial and technological issues and determined by the need to control local geographic and climatic factors, so to passively exploit solar energy,
to control effects of dominant winds, rainfall and snowfall, to reduce ground slope negative effects.

The study of Sauris settlement, anyway located on the sunny valley side according to a linear superposition scheme, perpendicular to the slope, highlights technical solutions spread in each residential building; these solutions are declined through repeated structural and formal criteria. The roof ridge oriented along North-South direction let a uniform pitch exposition to sun and snow loads; the first floor raises above the ground and the maximum winter blanket; finally, roofing eaves keep external meteoric humidity at a distance from indoor living spaces (Fig. 2).

![Figure 2. Bioclimatic principles in a cross section of Sauris building type. An unheated attic (1) works as buffer space for nighttime spaces (4), protected at sides by pirl structures (3) and open wide towards the balcony on main façade. An additional volume at attic level (2) protects the balcony from bad weather elements. The kitchen (haus, 5), the main space for domestic activities, enjoys full solar access during winter. On the opposite Northern side, partially underground (7), the vertical distribution space take place (6). Authors’ drawing.](image)

In Sauris houses, the rooftop covering was historically built in larch wood shingles directly supported by ancillary frame; it is an element of remarkable interest due to the control of snow loads. The pendency of the pitched roof is usually reduced to 30% or below, therefore different by other Alpine houses geometry [4]. The control of stormwater speed and the protection from air humidity is coupled with the need to ballast shingles during winter, in which uncovering wind action shall prevail on shingles own weight. Moreover, snow accumulation on the roof provides an integrative thermal insulation for the
attic space, an unheated space where woodworking activities were carried out in winter (Fig. 3).

The evolution of Sauris building type also refers to on-site availability of local raw materials such as wood, soil, stone and road-metal, whose overriding use has led to the development of both constructive, firstly, and typological processes, definable as vernacular (Fig. 4): as result, a remarkable unity, a formal and functional homogeneity are noticeable in the settlements [8].

The use of other earthen materials allows for a longer lifecycle and improves thermal insulation and airtightness of envelope technical elements. Originally, weathering tightness was ensured with soil, moss, lichen or tarred oakum along horizontal joints due to leaking geometry of trunks used in blockbau.
technology.
Masonry-work at lower building level usually consists of stone and road-metal raised locally, sited by selecting the most suitable elements; only in a few buildings, stone is bound with natural lime. The lack of building material involves an accurate arrangement of stones and pebbles in horizontal lines, with huge squared tuff stone elements at corners position (tof).

Sauris houses rooftop are usually characterized by two pitches; finishing layers, covering and elements concerning stormwater flow drainage system are built in wooden elements too. In the historical construction technique, shingles in larch wood, a native species water resistant and connotated by a long lifecycle, are placed in a way that offers, in every covering cross-section, at least a triple protection layer against weathering. Therefore, a longer lifecycle of each shingle is possible: covering actions for maintenance, based on the alternate rotation and reversal of shingles, give a slower and more uniform degradation. Shingles covering is supported by battens, in turn bearing down to rafters sloping from ridge wooden beam to triple supporting sleepers, then beyond the perimeter described by blockbau structures, to achieve eaves usually longer than 1 meter.

Original windows, obtained by interruption of longitudinal trunks with insertion of vertical wooden jams, are devoid of any airtight system, whose performance is carried out by the wolf-shaping of the interface between moveable and fixed frames. The protection of construction tradition asks for the maintenance of internal position of the window compared to blockbau envelope.

Spaces distribution in Sauris houses is strongly influenced by the position of the fireplace, the ancient heating system in the building type. The kitchen was the only space permanently heated by the fireplace, located in a corner; inside the room no exhaust fumes duct was provided, but there was a simple vent heading to the chimney in spruce wood. This vent, placed at first level floor intrados, conveyed exhaust fumes through first level nighttime spaces. The final opening height is usually 1÷1.5 meters above rooftop covering, in order to overcome the blanket thickness collected on the pitch; the traditional truncated pyramid shape in the final part of the chimney refers to the discontinuous finishing layer in big wooden shingles.

Once identified the main features of Sauris building type, project actions for functional restoration, structural improvement and energy retrofit are discussed. These actions allow for preservation of building technical elements in the scopes of protection of vernacular architecture characters and of the unitary perception of the settlements.

[4]. L’esigenza di allontanare le acque meteoriche si compone con la necessità di zavorrare le scandole nella stagione invernale, in cui è prevalente l’azione di sollevamento del vento; inoltre, l’accumulo della neve in copertura comporta un isolamento termico integrativo per il vano sottotetto, spesso non riscaldata in cui nella stagione invernale avvengano luogo le attività di lavorazione del legno (Fig. 3).

L’evoluzione del tipo edilizio saurano è associata inoltre alla disponibilità di materiali locali quali legno, terra, pietra e pierrico, il cui impiego prioritario ha portato allo sviluppo di processi prima costruttivi, poi tipologici, definibili come vernacolari (Fig. 4): l’ordine unitario ed omogeneità formale e funzionale dell’insediamento [8].

L’utilizzo di altri materiali consente di incrementare la durata di vita e migliorare l’isolamento termico e la tenuta all’aria degli elementi d’involucro: in origine, la tenuta agli agenti atmosferici era ricercata inserendo terra, muschio, licheni o stoppa catramata lungo i margini orizzontali dovuti alla non perfetta linearità dei tronchi utilizzati nella tecnica blockbau.

La muratura portante al livello inferiore è di solito realizzata con pietrame reperito in loco, posto in opera in seguito alla cernita degli elementi più adatti; solo in alcuni fabbricati si è fatto ricorso a fanghi (calce naturale). La scarsità del materiale legante ha portato ad un’accorta disposizione di pietre e ciottoli in corsi orizzontali, con realizzazione degli elementi d’angolo in grosse pietre di tufo squadrature (tof).

La copertura delle abitazioni saurane è frequentemente del tipo a due falde, realizzata in legno fin negli elementi di finitura e nei componenti del sistema di allontanamento delle acque meteoriche. Nella tecnica costruttiva storica, le scandole in legno di larice, essenza resistente all’acqua e di elevata durabilità, sono poste in modo tale da offrire, in ogni sezione trasversale del manto, uno strato di protezione contro gli agenti atmosferici almeno triplo: in questo modo si ottiene una maggiore durata di vita delle singole scandole, la cui manutenzione prevedeva l’alternativa rotazione e inversione per esporle ad un più lento e uniforme processo di degrado. Il manto è appoggiato su listelli, a loro volta gravganti sui falsi puntoni digradanti dalla trave di colmo ai tripoli dormienti d’appoggio, ed oltre il perimetro esterno delle chiuse termiche, a realizzare uno sporto di dimensione solitamente maggiore al metro.

I serramenti lignei originali, ricavati per interruzione dei tronchi longitudinali con inserimento di montanti verticali lignei, non sono provvisti di un sistema di tenuta all’aria, che è affidata alla sagomatura ‘a bocca di lupo’ dell’interfaccia tra telaio mobile e fisso. La salvaguardia della tradizione costruttiva richiede il mantenimento della posizione interna del serramento rispetto al sistema blockbau.

La distribuzione dei vani nell’abitazione saurana è fortemente influenzata dalla posizione del focolare, il sistema di protezione riscaldata della casa. Il
This approach is consistent with the content of Friuli-Venezia Giulia Region Law No. 30/1977. Art. 8 individuated criteria to be applied to buildings carrying environmental, historical, cultural and ethnic values to increase the dwelling availability demand due to seismic events of May and September 1976. The following Decree of Regional President No. 1615/1977 fixed accommodation and functionality levels to be reached through buildings retrofit and reparation, with reference to new layouts in indoor spaces, the use of adjacent existing volumes in each plot, the compatible volume increase to provide new toilet facilities to the dwellings [9]. The importance of this legislation is to enlarge the regulatory approach from structural safety and functionality criteria to suggest technical and operative actions to protect this cultural heritage [3].

4. RESULTS AND DISCUSSION

The actions identified refer to ground damp and moisture control in foundation elements, to structural improvement, to functional retrofit of building envelope and internal technical elements.

At the lower level, the effects of damping phenomena on stonewalls partially underground are reduced by the provision of a crawlspace for stormwater drainage that gives a separation of the basement from the natural ground soil. In indoor spaces, the removal of the existing stone flooring allows for the realization of a horizontal crawlspace and for a congruous enlargement of stone linear foundation elements.

Masonry-work reinforcement, in the absence of natural lime through the entire thickness of the walls, is feasible by the sealing of open joints around square stones arrangement with removable plaster and reinforcing hyperfluid lime injection in piping systems, previously carried out by coring out or drilling operations. Final hollow joint sealing operation occurs with deep scarification, low-pressure grouting, and deep sealing with hydraulic lime, silica inert materials and dolomite.

The improvement of energy performance of wooden envelope, to avoid an unacceptable visual alteration of the building type, must be performed on the original internal surface. Moreover, blockbau construction technique is not characterized by perfectly flat finishing surfaces, then not suitable for the preparation of a rigid thermal insulation layer in direct contact. The shaping of superimposed trunks, in addition to cyclical expansion and shrinkage phenomena, affects this technique to air leakage in horizontal joints.

The proposed technological solution (Fig. 5) considers a double thermal insulation layer, the outermost in cork panels with waterproofing characteristics,
that ensures a continuous insulation. Panels fastening is performed through non-centred tessellation to alternate trunks, to avoid the propagation of potential hidden cracks. No joint sealing along trunks is performed to ensure the wall transpiration and to remove moisture excess. The internal thermal insulation consists of semi-rigid rock wool panels, placed in a new stiffening wooden frame in common studs and trimmers; a counter-wall with wooden finishing is fastened to stiffening frames to preserve the original visual aspect of indoor spaces.

In this technological solution, rock wool insulation gives commendable reaction to fire and density performances, delivery and siting costs, production energy demand that suggest its application. Alternatively, wooden fibre panels or aerogel panels finished with polypropylene membrane reinforced with fiberglass can be used. The latter, with a thermal conductivity equal to 0.015 W m\(^{-1}\) K\(^{-1}\), allow for a remarkable reduction of the overall thickness of retrofitted wall, avoiding a noticeable decrease of useful floor area in indoor spaces. The outermost insulation layer provides a regular flat siting surface.

Proposed technological solution gives an overall thermal resistance value equal to 3.77 m\(^2\) K W\(^{-1}\), higher than the minimum value defined by Ministerial Decree 26th June 2015 for first level energy retrofits.

![Diagram of the proposed solution](image)

**Figure 5. Proposal of technological solution for the retrofitting of non-airtight blockbau envelope, whose thickness is about 18 cm (1).**

It is proposed a first, outermost, waterproofing thermal insulation layer, fastened by tessellation to the original wall, 6 cm thick (2), a second insulation layer in wooden fibres (4) of equal thickness placed among the uprights of a new internal stiffening wooden frame (3). The solution is completed with an internal wooden finishing layer (5), preserving the original visual aspect. Authors’ drawing.

Intervention on rooftop elements is evaluated with reference to covering deterioration condition and to shingles residual performance in protection against weathering. It is possible to preserve original technological solution in non-liveable attics, where moisture control occurs by natural ventilation.
If inadequate waterproofing performances are found, it is possible to keep original covering with the inclusion of a new wooden plank, equipped with a waterproofing layer in adhesive slated sheath (Fig. 6). It newly supports covering in shingles through polyurethane foam bands parallel to ridge beam and grouped in discontinuous rows.

Windows are kept in their original internal position, intermediate if compared to the new retrofitted technological solution of blockbau envelope. It is considered a retrofit with the adoption of high thermal resistance windows with reduced air permeability: these performances are given by triple glazing (4+10+4+10+4) type, with double low-emissive coating and air space buffer fulfilment in Argon at 90% rate, warm edge spacers in stainless steel alloy and elastomeric seals in butyl, capable of reducing previous linear thermal transmittance, maintenance of wooden frames with polyurethane foam insertion, with adequate seals, to preserve the original visual aspect.

Building thermal insulation upper border takes place at attic floor, considered a non-liveable space due to its reduced net height. After checking the conservation status of the original wooden plank, it is proposed the insertion of a 6-cm-thick joist system aiming to the structural stiffening of the floor, placed at a-degree angle compared to the existing horizontal frame direction, with a thermal integrative insulation layer; the finishing layer is given by a second wooden plank perpendicular to the original one. Joists dimension reduces the available thickness for a congruous thermal insulation; to verify the minimum thermal resistance value defined by Ministerial Decree 26th June 2015 for floors facing unheated spaces (4.35 m² K W⁻¹), it is considered a solution with compact felt mat panels in nanoporous aerogel, with fiberglass finishing: the overall thermal resistance value is equal to 4.70 m² K W⁻¹.

This technological solution can be fastened to sloping roof beams through
threaded rods fixed by steel sections to the floor (Fig. 7a).

Chimney substitution, in order to let the installation of a new heating system, aims to answer to three problems related to the original fireplace location: tightness to exhaust fumes, control of surface temperature, and dimensions of floor crossing holes. It is provided a new chimney in ecoceramic material in shaped blocks with vibration-compressed reduced concrete sleeve, an internal wooden finishing layer and a quadrangular constraint by four trimmers at rooftop rafters height; about the quote visible outside, it is provided a sloping external finishing by juxtaposition of wooden boards and a chimney protection with wooden cap and back-flow devices in copper sheet (Fig. 7b).

5. CONCLUSIONS

This research is a contribution for the rehabilitation of traditional buildings in Sauris settlements, characterized by spatial distribution and technological elements attributable to the scope of vernacular architecture.

Solutions for the rehabilitation of Sauris building type, whose consistency and definition must be adapted to each single case, aim to improve energy efficiency in envelope technical elements and to increase structural safety, at the same time safeguarding peculiar cultural values and typological characters of the settlements. This methodology follows Regional Law No. 30/1977 approach, that established static and functional rehabilitation of existing built heritage recognizing, for the first time in Friuli-Venezia Giulia, the relationship between traditional cultural values and local architecture, with a regulation concerning intervention actions as result of technical surveys.
Intervention design for rehabilitation and antiseismic upgrading of buildings was targeted to avoid any alteration to architectural characters of damaged built heritage [9]. It is intended that the reversibility of proposed rehabilitation actions lead to a possible interpretation of sustainability, because it pursues the conservation of authenticity of this built context and its connoting spatial and technological contents in favour of future generations.

6. REFERENCES


5. CONCLUSIONI

La ricerca sviluppata è un contributo per il recupero degli edifici tradizionali dei centri abitati di Sauris, connotati da elementi spaziali e tecnologici riferibili all’ambito dell’architettura vernacolare. Le soluzioni di recupero dell’abitazione saurana, la cui consistenza e declinazione devono essere adattate ad ogni specifico caso, si prefiggono il miglioramento dell’efficienza energetica degli elementi tecnici d’involucro e l’incremento della sicurezza strutturale, con l’obiettivo di preservare i valori culturali e i caratteri tipologici degli insediamenti. Tale metodologia si pone in continuità all’approccio contenuto nella Legge Regionale n. 30/1977, che si propose il recupero statico e funzionale del patrimonio edilizio esistente riconoscendo, per la prima volta a livello regionale, il rapporto tra i valori culturali tradizionali e l’architettura locale e disciplinando modalità di intervento in base agli esiti di indagini tecniche; la progettazione delle opere di riparazione e di adeguamento antiseismico fu mirata ad evitare l’alterazione delle caratteristiche architettoniche del patrimonio edilizio danneggiato [9]. Si ritiene che la reversibilità delle azioni di recupero proposte costituisca una possibile declinazione del concetto di sostenibilità, in quanto persegue, a favore delle future generazioni, la conservazione dell’autenticità del contesto costruito, nonché dei contenuti spaziali e tecnologici che lo definiscono.