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Architectural survey, realized with integrated methodology, of the complex of Walser houses in Alagna Valsesia, Italy

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Abstract

The subject of this paper is the architectural survey, realized with integrated methodology, of three Walser houses, located in Ronco Superiore, within the Alagna Valsesia (Vercelli, Italy) municipality. The task of surveying the complex was assigned to us by the Superintendence of Archeology, Fine Arts and Landscape for the provinces of Biella, Novara, Verbano-Cusio-Ossola and Vercelli in cooperation with the Regional Secretariat of Piemonte. The aim of the work was that of providing graphic and metric references for the houses, which are a typical example of the rural architecture at the foot of Monte Rosa, to be made available for subsequent interventions of restoration and enhancement. The Superintendence took over the safekeeping of the site from the Public Property in 1998 and, since then, has promoted a process of recovery of the buildings, winning the Europa Nostra Award in 2014. Granting access to visitors has given a larger audience the possibility of knowing the history, the constructive peculiarities and the works of conservation carried out in this area. Specifically, the complex of Walser houses is the most ancient settlement in Alagna, built between the end of XVI century and the beginning of XVII century. Walser houses have a stone basement and wooden roof and walls. The latter are built with the Blockbau technique, i.e. a superimposition of trunks and beams, juxtaposed to shape walls; interlocking connections ensure the rigidity of the structure. First, we have acquired the morphometric characteristics of the buildings; then, we have elaborated them graphically, by employing a georeferenced, 3D laser scanner. Photogrammetric data have, instead, been acquired using digital cameras and drones.

Keywords: *Walser houses; point cloud survey; drone survey; Alagna Valsesia.*

1. Introduction

In the last decade, architectural surveys realized with integrated methodology (laserscanning and photogrammetric data) have been playing a major role, especially in restoration projects (Balletti et al., 2015; Remondino & Stylianidis, 2016; Valente et al., 2019; Patrucco et al., 2020; Zaragoza et al., 2021). In fact, this way of proceeding allows one to gather metric references about the existing buildings which are more accurate than the ones obtained with a traditional relief. The present paper is the result of an architectural survey of a complex of Walser houses situated in Alagna Valsesia, i.e. a peculiar example of vernacular architecture of the Italian mountain area. The aim of the work (assigned to us by the Superintendence of Archeology, Fine Arts and Landscape for the provinces of Biella, Novara, Verbano-Cusio-Ossola and Vercelli jointly with the Regional Secretariat of Piemonte) was that of creating graphic and metric references[1] of three Walser houses (Fig.

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1). Besides, our work updates the existing relief of the latter ones, realized before the last restoration works, concluded around 2012. During this conservative intervention, construction elements were disassembled and reassembled; the aim was that of understanding which materials were used to restore the houses by adopting the techniques originally employed by the Valsesian artisans. The architectural conservation project won the 2014 *Europa Nostra Award*, within the *Conservation* category, as decided by a jury of experts from 30 countries worldwide, who selected it among the ones that benefited from the support of the European Union Culture Program[2].

Fig. 1. Aerial view of the three Walser Houses shot by drone (Source: Frosini).

As frequent relief campaigns are desirable for preserving the structural details of architectures considered fragile and highly perishable (Balletti et al., 2014; Hu et al., 2016) because of the substantial use of wood constituting the upper part of the buildings, like in this case[3] (Fantoni, 2008a, p. 27), the survey of the Walser houses carried out by us will ensure any future restoration project to be based on an up-to-date documentation of the buildings themselves.

2. The Walser architecture

The Walser architecture characterizes several areas of the Italian region of Piemonte. The name derives from that of the Walser population, who migrated to Italy from the Swiss Canton of Valais[4] (in German *Wallis*), located nearby the Monte Rosa mountain massif. The Walser population, first, settled in semi-nomadic conditions; subsequently, created stable settlements, while maintaining the original Germanic customs (Giordani, 1973). To survive the conditions of inaccessible, mountainous areas, the Walser population deeply changed the rural landscape, by transforming the woods into productive pastures, cultivating the land up to the highest slopes, raising cattle. Moreover, Walser people adopted a strongly-characterizing architecture for the construction of their houses,

2 *Europa Nostra* represents a rapidly growing citizens' movement for the safeguarding of Europe's cultural and natural heritage: see European Heritage - Europa Nostra Awards (2022, March 26).

3 The location in high altitude settlements of Walser houses also favored their degradation due to natural causes: some wooden houses were destroyed by the weight of the snow, by floods or avalanches, by fire. The reconstruction generally coincided with the abandonment of the wood and the new houses were rebuilt in masonry, as happened in Alagna at the end of the XIX century.

4 The name *Walser* is precisely a contraction of the name *Walliser* (Valaisan, inhabitant of Valais).

built with the aim of optimizing the available, environmental resources and further fostering the social cohesion: the life of an individual was not conceivable without a family and the family itself was integrated within the larger community of the village (Zanzi & Rizzi, 1988).

The “house” is, thus, the most significant expression of the Walser architecture, providing an answer to a specific (economic, social and climatic) need, i.e. gathering men, animals, stables, kitchens and granaries under one roof. From an urbanistic point of view, houses are often built very close to each other: the aim was that of leaving a covered passage (ensured by the sloping roofs) between the two, allowing people to circulate while remaining sheltered from rain and snow; moreover, the houses are usually built in a place exposed to the south, close to pastures and safe from avalanches and floods.

2.1. Three Walser houses in *Oubre Rong*

In the XIII century, the first Walser communities in Valsesia (an alpine valley that occupies the northern part of the province of Vercelli) settled in Alagna, Rima and Rimella. Among the many, existing Walser houses[5] in the hamlets of the municipality of Alagna Valsesia (Daverio, 1983; Mirici Cappa, 1997), those in Ronco Superiore (*Oubre Rong*, in the Walser dialect) are the oldest. The path to Ronco Superiore (part of the group of upstream hamlets, called *Unna Hin*) starts from Pedemonte and passes through the village of Ronco, where the Ecomuseum[6] of the Walser culture can be found. The village of Oubre Rong stands on a steeply sloping ground at an altitude of 1320 meters above sea level and is constituted by a complex of Walser houses that looks like a small, very compact group of buildings, with the western front looking towards the Mud valley and the northern one looking towards the Mud brook (Mesturino, 1960).

The monuments analyzed by us, whose safekeeping was taking over by the Superintendence from the Public Property in 1998, are the southernmost ones among those located into the area of Ronco Superiore. Coming from the valley, four Walser houses, built between the end of the XVI century and the beginning of the XVII century, are visible. The first two houses, almost perfectly-squared[7], are called House 1 (the southernmost) and House 2 (the northernmost); behind these, House 3 and House 4 constitute a parallelepipedic structure (whose base measures 6x12 square meters): in fact, the block of House 3 and House 4 consists of two separate units with common external spaces and fronts[8]. Our work focused on the northern portion of such a block (i.e. House 3), as the southern portion (i.e. House 4) cannot be accessed, being a private property (Fig. 2).

Fig. 2. Planimetric map with identification of Walser Houses surveyed (Drawing by Di Paola).

House 1 and House 2 represent the typical Walser house for a family unit, i.e. a single building organized on several floors (three for House 1

5 We refer to the censuses performed for the first time by the engineer Arialdo Daverio in the 1980s.

6 An *Ecomuseum* indicates not only a building but a territory characterized by traditional living environments, relevant naturalistic and historical-artistic heritage.

7 The first floor of House 1 measures 6x6 square meters.

8 The House 1 is engraved with the date *1594* on the lintel of the door located of the highest floor on the west front; House 2 and House 3 are considered to be a little later.

and four for House 2), a barn to preserve the fodder and a stable for the animals.

Each floor is surrounded by an external porch, accessible through a staircase built with stone and wood and located on the east side of the houses to take advantage of the smaller height difference caused by the slope of the ground. This external gallery (from 1.20 meters to 1.60 meters wide) is closed by a sort of horizontal railing, formed by rods inserted on vertical, wooden beams. On the ground floor, these vertical wooden beams rest on a stone plinth, which has the function of detaching the humidity of the ground (Daverio, 1983, p. 199). The horizontal poles allowed the farmers to arrange hay, barley and straw on them to dry the forage even on rainy days.

Lower floors were employed as food stores, as in House 2, or as stables, as in House 1. Here, stables were adjoining to the living room (the mangers with separation poles are still visible) to use the heat produced by the animals in the winter - so much, in fact, that between the stable and the living room there is no dividing wall but just a simple wooden partition. A passing stove was, then, placed on it, to allow the two rooms to be heated at the same time. An open fireplace (1,10 x 1,10 m) was also present in the living room, put directly on the floor of the room in a central position (Fantoni, 2008b, p. 79). The kitchen area was made of stone, like all the flooring at the ground floor, and built in the north wall. The upper floor housed the bedrooms, arranged above the stable to take advantage of the heat produced by animals; each room occupies half of the overall floor area (on average, a room measures 3x6 square meters and is 1.80 meters high) and has access to the exterior gallery. The upper floor also hosted several rooms that served as a warehouse, a granary and a barn (Fig. 3).

Unlike House 1 and House 2, House 3 is composed only by a barn (which measures 5.93x6.36 square meters and is 1.83 meters high) and a storage room (which measures 5.66x6.03 square meters and is 3.82 meters high).

Fig. 3. Transversal section drawing of House 1. At lower floor, stables and the living room divided by a wooden partition; at first floor bedrooms; at the upper flow warehouses reachable by an external wooden (Drawing by Verona).

From the structural point of view, the ground floor of the three Walser houses[9] considered by us is in masonry, made by small, worked stones and a bit of mortar. Masonry was used because it could contain fires and resist to winter storms; it is of considerable thickness, in some places up to 70 cm, to prevent heat dispersion and give the structure a solid base to support the wooden part[10]. All the floors above the stone basement are entirely made of wood, including the roof (but not the roof covering).

The external walls are enclosures[11], formed by four walls of half trunks (usually in spruce or medium-sized larch) joined at the corners with U-shaped incisions that allow the wooden elements to be interlocked. The walls are built with the *Blockbau technique*, i.e. a superimposition of trunks and beams, juxtaposed to shape walls:

9 Unlike the other two, House 2 has stone walls for both the ground floor and the basement, whose face is partially visible from the north front.

10 A particular interruption between the two materials is found in House 3, where the wooden part is divided into two level and the lower one is suspended from the basement with massive wooden pegs with tapered bases, to keep rodents away.

11 The length of the wood available influenced the dimensions of the structure. The beams hardly exceeded 5-6 m: therefore largest room in the house generally measures from 4.5 x 4.5 to 6 x 6 m.

the trunks were squared with large axes, sawn in half and planed on the inside to form a smooth wall while the dried moss was used to supplement the thermal insulation and to seal the joints (Fig. 4).

Fig. 4. Detail of the *Blockbau technique* at the House 2: half-log walls joined at the corners (Source: Di Paola).

The internal walls are erected with wooden planks as well, wedged into the floor and the ceiling via small beams with a central groove. The floor consists of wooden boards, whose thickness is about 3 cm, placed on a horizontal beam and fixed to it by means of wooden nails.

The roof is gabled with two pitches, composed of a wooden skeleton and a mantle of stone slabs, called *piode*. Initially, the mantle was also made of wood; however, the need for constant maintenance led it to be gradually replaced by heavy stone slabs (weighing about 6 q/m^2). In order for such a roof to be capable of carrying the weight of the stone and of the winter loads of snow, its structure is reinforced by two pediments interlocked in the *Blockbau*, linked by a mighty ridge beam. The rigidity of the structure is further increased by two beams, acting as chains, that cross the former one; two compact half-walls of interlocking trunks, wedged into the external walls, reinforce the structure between the ridge and the underlying chain beam. The two minor frames (perpendicular to each other) that carry the *piode* are placed on the main roof beams. The gutters themselves are made of wood, obtained from dug half-trunks of larch (Fig. 5).

Fig. 5. Detail of the structure of the roof built with three frames, carrying stone labs (Source: Di Paola).

2.2. The architectural survey

The survey of the three Walser houses and the surrounding land required tools capable of collecting as much data as possible to create multipurpose databases for future use (e.g. structural analyses, study of construction techniques, restoration and communication projects). It was executed by employing data for locating the houses according to their terrestrial coordinates (i.e. georeferencing them).

Our first aim was that of delivering a 3D model (colored point cloud), able to provide dimensional information on the houses and allowing one to virtually tour them through 360 pano pictures. Our second aim was that of extrapolating orthophotos (scale 1:50) and vectorized CAD drawings (including the ones of the technology systems of the three buildings). Accordingly, the tolerated measurement error had to be smaller than the graphism error at the chosen representation scale, i.e. less than 1 cm. In order to reach both aims, we used three different tools: a flight-time 3D laser scanner, a couple of photo-sensors (a quadricopter of 900 grams with a camera 1” CMOS on board; a SLR camera) (Kraus et al., 1998; Micieli, 2019) and a GPS GNSS RTK receiver (Cina, 2014; Leick et al., 2015).

The planning of the survey required a careful identification of both logistic and technical problems and an accurate organization of the work phases on field. After having identified the geomorphological characteristics of the site and the critical issues about the use of the technical equipment, we positioned the control points (Docci & Maestri, 2009).

From an operational point of view, we set up a first net, composed by two types of targets (rectangular B/W and circular 8 bit), for the facades; a second net, composed by PVC, rectangular (50x50 square centimeters), yellow-black colored, weatherproof targets, was positioned on the ground (*Ground Control Points*). The first net allowed us to link the point cloud from the photogrammetric survey (obtained from drone and SLR camera) with the point cloud from the laser scanner; the *Ground Control Points* allowed us to link the photogrammetric survey of roofs with the point cloud from laser scanner and the total point cloud with data from GPS (Barzaghi et al., 2018).

The laser scanner survey was obtained by means of 208 scans, each scan having a density of one point every 12 mm at 10 meters of distance. At every position, the laser scanner took a panoramic image, allowing for the creation of an RGB-colored point cloud and of a pano picture for virtual tours: 360 pano pictures gave us the possibility to measure what is captured by the scanner directly onto the panoramic image.The integration of the laser scanner survey with the photogrammetric survey [12] was necessary to complete the operations on the sides that were not accessible (i.e. the sides of the Walser houses overlooking the Mud brook and the roofs) and execute orthophotos of facades.

In order to carry out the photogrammetric survey, the GSD (*Ground Sample Distance*) was set to 0.5 cm/pixel; the maximum distances for the photographic shooting were about 14 meters for the drone and about 20 meters for the SLR camera (based on the characteristics of the instrumentation used and the required resolution). The number of photos to be taken has been calculated to guarantee a lateral overlap of at least 90% between contiguous frames and a vertical one of 80%. Due to the characteristics of the site, the photographic distance was smaller, but constant, for each side of the houses.

At completion, *Ground Control Points* were taken with the GPS receiver.

2.3. Methods of data processing

The individual scans obtained from laser scanners have been combined into a single reference system by using a dedicated software (Fig.6).

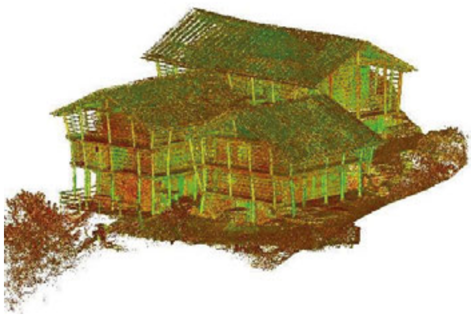

Fig. 6. Image of point cloud from laser scanner 3D (intensity view) created by 208 setups (Source: Vecchio).

The 3171 images of the photogrammetric survey were equalized and imported into the photogrammetric processing software with the Structure from Motion (SfM) approach; these have been placed in a unique workspace and

12 The *photogrammetric technique* is a methodology based on the acquisition of images of the same area from different points of view and partially overlapped: exploiting the principle of stereoscopy, starting from the data relating to the positioning and orientation of the camera at the time of shooting, from the type of lens used and the resolution of the images, the mathematical reconstruction of the perspective geometry allows to carry out an optical triangulation of the points identified by the pixels of the images and to reconstruct the three-dimensional geometry of the photographed areas.

integrated. We, then, exported two outputs: the point cloud and the orthophotos of the facades and roofs (Fig. 7).

Fig. 7. Image of point cloud from photogrammetric survey (RGB view) of House 3 (Source: Frosini).

The georeferencing of the data took place by inserting the coordinates of each *Ground Control Point*, acquired by using a GNSS receiver. The procedure used made it possible to scale the three-dimensional model allowing the point cloud from laser scanner to be merged with the point cloud from the photogrammetric survey, thus enhancing the accuracy of the relief by limiting the metric error.

The obtained point cloud was imported into a CAD environment where it was used, together with orthophotos, to draw plans, sections and elevations and create the required drawings (Fig. 8).

Finally, the panoramic images taken with the laser scanner were uploaded to an online server, in order to make them accessible to cultural heritage operators. The system allows one to navigate between photos as if you were on site, simulating a virtual tour in which users can use measurements and annotation tools to work on the state of play of the three Walser houses.

3. Conclusions

This project confirms the great potential of point clouds in the managing activities concerning the cultural heritage. Point clouds can be used for metrology and inspection and for a multitude of applications, such as visualization, animation, rendering and mass customization. Moreover, exporting data in different formats allows one to reach multiple stakeholders. Although an in-depth integration of multi-sourced information has not yet been achieved, the approach we have followed for this survey greatly facilitates data

Fig. 8. Ortophotos of House 2 's facades (west and north) overlapping CAD drawing (Source: Frosini).

sharing. Machine learning methods represent the next step for improving the analysis of the cultural heritage and, in turn, enhancing the automation of the processes constituting the surveys to be taken.

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