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Proyecto de rehabilitación para uso residencial de la antigua abadía de salas de Bureba (Burgos)

Rehabilitation project for residential use of the old abbey of salas de Bureba (Burgos)

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Resumen-- **La rehabilitación de edificios es clave para luchar contra el cambio climático y ofrece oportunidades para fijar población en el medio rural, revalorizar su patrimonio y ayudar a descongestionar las ciudades. Además, tiene un menor impacto ambiental que la nueva construcción. Con esta contribución, se presenta el proyecto para la rehabilitación de la antigua Abadía de Salas de Bureba, situada en el Valle de Caderechas, al Norte de Burgos. El objetivo es devolver el edificio a su estado original, para lo que se ha realizado un estudio de patologías constructivas, aplicando las soluciones óptimas en cada caso, con un enfoque de eficiencia energética y sostenibilidad. Tras un estudio energético detallado, se han propuesto mejoras pasivas combinadas con la instalación de energías renovables. Este proyecto, ya en ejecución, ha obtenido una calificación energética doble A, lo ha permitido que opte a las ayudas del Programa PREE 5000.**

Palabras clave— Economía circular; patrimonio; rehabilitación; sostenibilidad.

Abstract— **The rehabilitation of buildings is key to fighting climate change and offers opportunities to fix population in rural areas, revalue their heritage and help decongest cities. In addition, it has a lower environmental impact than new construction. With this contribution, the project for the rehabilitation of the old Abbey of Salas de Bureba, located in the Caderechas Valley, north of Burgos, is presented. The aim is to return the building to its original state, for which a study of construction pathologies has been carried out, applying the optimal solutions in each case, with a focus on energy efficiency and sustainability. After a detailed energy study, passive improvements combined with the installation of renewable energies have been proposed. This project, already in execution, has obtained a double A energy rating, which has allowed it to opt for aid from the PREE 5000 Program.**

Index Terms— Circular economy; heritage; rehabilitation; sustainability.

I. INTRODUCTION

IN this first section, the building is presented to understand its historical and architectural importance, the pathologies of the initial state and the scope of the intervention.

A. Historical description of the building

The first reference to the Abbey of Salas de Bureba is made by Emiliano Nebreda (Nebreda Perdiguero, 2016), who states that: "attached to its northern gable (that of the church) is preserved the building of an old palace, which previously housed a Benedictine abbey, which tradition maintains was founded by King Recesvinto in the year 666."

It appears in some chronicles as the year of the foundation of an abbey of Benedictine nuns in Salas in the year 966: "in the

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Fig. 1.Views of the building as a whole (left), and Tower (right). (Source: Paula Montoya Saiz)

year 966 a Benedictine monastery was founded in this municipality that did not join Oña until 1011, as stated in the founding document of the Oniense abbey, signed by Count Don Sancho and his wife Doña Urraca, his daughter Tigridia being abbess. In 1067 Don Sancho II donated a serna in Salas to the aforementioned monastery and in 1085, Pedro Díaz allocated a fifth of his assets in that town to his parish church. Two years later he granted the Cathedral of Burgos the church of Santa María, deciding to bury him in it" (Fundación Santa María la Real, 2019), and already with a historical and documented character, it is cited: "the foundation by D. Pedro Díaz in 1087 of the abbey of Salas de Bureba, added to the Cathedral of Burgos" (Serrano, 1935).

This detail of "added to the Cathedral of Burgos" is important and we find in the archive of the Chapter numerous entries on the abbey of Salas or its abbots, although they do not provide information on its construction or subsequent modifications (Cathedral Chapter of Burgos, 1556). It is possible that a first monastery of Benedictine nuns founded in the seventh century, or in the tenth century, was transformed in the eleventh century into a boys' abbey. In the records we only find abbots from that date, or perhaps Lupián de Zapata invented an earlier monastery, annexed to that of Oña by Count Sancho García (967-1017), to justify and make the rights of Oña (founded in 1011) prevail over those of the Cathedral.

The current building, new abbey, palace, rectory or priest's house, of classicist (Renaissance) style, seems to have been built by the impulse of D. Andrés del Castillo Pesquera, Abbot of Salas, dignity of the Cathedral of Burgos and patron of the Monastery of La Merced, in the last years of the sixteenth century or the beginning of the seventeenth. between 1581 (Historical Archive of the Cathedral of Burgos, 1581), when he took possession of the abbey, and 1610, (Blanco Díaz, 1948), the year of his death.

B. *Initial state of the building*

The building, also known as "Casa del Cura", is located on a central promontory of the municipality next to the Church of Santa María. The preliminary historical analysis shows an old collegiate abbey-of monumental size, with two rectangular squared bodies and two levels of semicircular arches, possibly intended to be completed in a square cloister (Fig. 1). At the meeting of both bodies, a Tower with openings (Fig. 2), possibly for bells of rectangular proportion, rises a second level above the access level. The building is decorated with three coats of arms where we find the cape and cardinal's cord, the best preserved being that of the impost line of the Tower.

The construction was carried out with ashlar in compact sandstone with exterior walls between 0.60 meters and 1.00 meters thick, probably with two locked leaves leaving the carved ashlar on the outside and masonry on the inside joined with cyclopean concrete as mortar.

The building has two bays: the interior one forms the body of the cloister gallery 3.20 meters wide, whose arches were blocked with different materials throughout its history. The second and fourth openings form transverse arches to brace both bays. On the façade, the voussoirs can be seen in corbels to connect with the bodies that were to close the cloister. Behind a wall 1.00 meters thick, the interior bay is a spacious diaphanous nave about 5.00 meters wide, only cut by a few partitions made of adobe or rough masonry.

On the north side of the main bay is the large main staircase that communicates with the upper floor by means of a stone staircase of three sections. The double-height space is covered with a structure with triangular vaults in the form of false lunettes, as can be seen in Fig. 2.

Fig. 2. Partitioned vaults over the main staircase. (Source: Imanol Ruiz de Vergara Ruiz de Azúa)

Fig. 3. Wooden structure of the sloping roofs and interior of the body of the Tower. (Source: Paula Montoya Saiz)

There is another wooden staircase of little historical or constructive value that was made for the conditioning of the body where the priest's house was located for many years. There were bedrooms and bathrooms and rooms with an irregular and non-original distribution.

The structure of the slabs is made of solid wood joists without beams with an upper entablature to support the flooring on the first floor.

It is estimated that the roof is built on hipped slopes with solid wood beams, the covering element is completed with pairs and shingles on which there are tiles placed in the traditional style, without receiving. It is observed that there is no clear system of trusses, having built a precarious structure to support the inclined beams, as can be seen in Fig. 3.

The front wall at the west end has an unfinished roof finish with a wall element of plastering, as if it had intended to extend the building on that side, as can be seen in Fig. 4.

The architect who drafted the Rehabilitation Project, Paula Montoya Saiz, has made several visits to the building to carry out a detailed survey of the property, a photographic report and an analysis of the most pressing pathologies of the construction.

The main pathologies detected are the following:

- The foundation is the extension of the walls themselves to the surface, and does not seem to present any problem, except for settlements in the Torreón area.
- deteriorated construction state of the slabs, although it seems that the supports are in good condition, which generates a serious threat of collapse of the roof structure, the bell tower and part of the interior slabs (Fig.5).

Lack of resistance and rigidity capacity in some of the existing slabs due to the addition of masonry on them and, in general, for current regulatory requirements.

- Severe damage to the roof, where the loss of the tiles has caused collapses of some roof areas (Fig. 6), under the roof and first floor, allowing the permanent passage of rainwater and generating dampness in the walls. In July 2022, the roof structure of the Tower collapsed.

Cracks in the south and west facades, due to the deterioration of the masonry that have not been able to withstand the horizontal thrusts due to the collapse of the roofs (Fig. 7).

- Cracks in lintels, and alternations in façade openings in general, totally or partially blocked with masonry, brick or rammed earth masonry, as well as with added metal carpentry (Fig. 8). The façade openings of the upper body of the Tower have been vandalized and the voussoirs of the arches in the back of the central openings have been removed.
- Cracks and deterioration of the vaults of the main stairwell, lack of interlocking in its walls, and generalized vandalization (Fig. 9).

The historical relevance of the building is undoubted, due to the cultural and religious significance that for several centuries has completed the urban layout of Salas de Bureba. The environment cannot be understood without the union between the Church and this Abbey that give meaning to each

Fig. 4. North façade with Tower and West headwall. (Source: Imanol Ruiz de Vergara Ruiz de Azúa)

Fig. 5. Generalized deterioration of the slabs. (Source: Paula Montoya Saiz)

Fig. 6. Damage to the roofs. (Source: Paula Montoya Saiz)

Fig. 7. Damage to the facades due to the collapse of the roofs. (Source: Paula Montoya Saiz)

other and that were most likely the origin and support for the construction of the human community that developed under its protection.

The architectural value of the building is very remarkable, due to its entity within the historical layout of the municipality and although the constructive solutions used are simple and absent of ornamental elements, the proportions of the construction and the Tower or bell tower make it a very beautiful Castilian architectural complex.

For all these reasons, and although it does not have explicit protection by the Heritage of the Autonomous Community of Castilla y León, it has been considered essential to preserve the values of the building and its indivisible presence in the memory of Salas de Bureba.

II. METHODS

This second section presents the approaches to the energy study of the building for its energy improvement, as well as for the architectural rehabilitation actions of the Abbey of Salas de Bureba. The results and their discussion are presented in the next section.

A. *Conditioning factors of the energy rehabilitation project*

As it is the execution project for the rehabilitation of an existing seventeenth-century building, compliance with the requirements of the DB-HE Energy Saving of the Technical Building Code (Ministry of Transport, Mobility and Urban Agenda, 2022a) presents difficulties in preserving the architectural and historical essence of the building. However, the provisions of Section IV Criteria for application in existing buildings, of the Introduction of the DB-HE, have been taken into account:

- Criterion 1. No worsening:

The thermal qualities of those elements in which historical conservation criteria will not be intervened, such as the exterior and interior sandstone walls, and the floor of the main staircase, will not be reduced. The restoration work, reintegration of volumes, replacement of mortars and sealing of cracks will improve its thermal performance. In the rest of the elements of the thermal envelope, intervention will be carried out and the DB-HE requirements will be met.

Fig. 8. Cracked lintel and blinded gap. (Source: Paula Montoya Saiz)

Fig. 9. Deterioration of the main staircase. (Source: Paula Montoya Saiz)

- Criterion 2. Flexibility:

Solutions will be adopted that allow the highest degree of compliance with the DB-HE, taking into account that the building is supposed to have a recognized historical or architectural value, and that other standardized solutions such as the insulation of its stone walls would unacceptably alter its character or appearance, even if it were done for its interior.

- Criterion 3. Repair of damage: All restoration and reconstruction work will aim to solve the damage observed in relation to the DB-HE area. This project is part of the refurbishment of an existing building, in which more than 25% of the thermal envelope is intervened, and the air conditioning and domestic hot water (DHW) production systems are changed.

B. Energy simulation of the building

First, a detailed energy simulation of the building in its initial state has been carried out, to know its thermal behaviour. The calculations are made hourly for a year, obtaining the energy demands, energy consumption and CO2 emissions, global and by services. In addition, it has been possible to calculate the thermal transmittance values of the enclosures and partitions. The thermal transmittance of the frames and glass of the openings, the solar factor of the glasses, and the air permeability of each opening have also been characterized and evaluated.

Subsequently, new energy simulations have been developed to evaluate the different possible measures to improve the energy efficiency of the building, studying functionally, technically and economically viable solutions. The selected passive measures and the new installation for heating and DHW will be explained in subsequent subsections.

To carry out all these dynamic energy simulations on an hourly basis, the computer program Unified Tool LIDER-CALENER (HULC) (Ministry of Transport, Mobility and Urban Agenda, 2022b) has been used, which has been provided by the Ministry of Transport, Mobility and Urban Agenda of the Government of Spain to verify compliance with the DB-HE. Likewise, this computer program is a Document Recognized by the Ministry for the Ecological Transition and the Demographic Challenge of the Government of Spain as one of the General Options to carry out the Energy Certification of Buildings. In this way, the results obtained serve both to carry out a detailed energy study, and to justify compliance with the Energy Regulations in force in Spain when carrying out the execution project of the rehabilitation of this building.

C. Climate data from Salas de Bureba

The building is located in the town of Salas de Bureba, belonging to the Caderechas Valley, north of Burgos. It has an altitude of 636 m above sea level, so it corresponds to the E1 climatic zone, in accordance with the provisions of Annex B Climate Zones of the DB-HE. These climate data are incorporated into the HULC software, and are the ones used in this study.

D. Geometry of the building in its initial state

The building is "L" shaped, with two wings of a semi-cloister, which at its junction has a tower. The Ground, First and Lower Deck Floors have a constructed area of 411.00 m^2 each, and the building has a maximum height of 14.00 m. Fig. 10 shows the location plan of the Cadastral File.

Fig. 10. Location plan of the building. (Source: Cadastre)

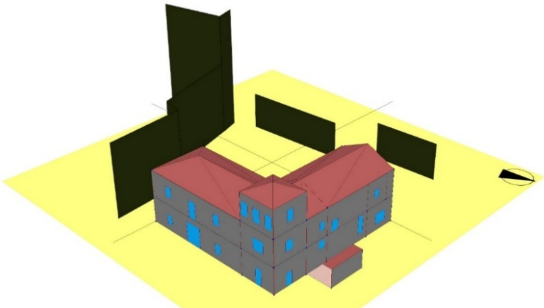

Fig. 11. Northeast view of the 3D model of the building in its initial state. (Source: Raúl Briones Llorente)

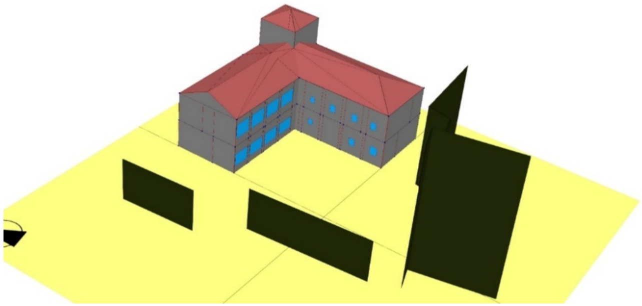

Fig. 12: Southwest view of the 3D model of the building in its initial state. (Source: Raúl Briones Llorente)

Fig. 11 and 12 show two views of the 3D modeling of the building in its initial state, made with HULC. It can be seen that many holes have been modified, as they have been partially or totally blocked. The facades of the surrounding buildings have also been included as shadow objects.

E. Construction and operational characteristics of the building in its initial state

In order to know the main constructive characteristics of the building in order to carry out its energy simulation, data have been obtained on the composition of the elements of the thermal envelope, as well as on the previous partitions. To this end, the document of the Execution Project for the Rehabilitation of the Old Abbey of Salas de Bureba, prepared by the Architect Paula Montoya Saiz, has been examined. In addition, *on-site* visits have been made to collect data and check. In addition, some thermographic images have been taken to look for discontinuities in the constructed panels, using a FLIR E75 camera.

The Database of Opaque and Semi-transparent Enclosures of the building has been created with HULC, composing all of them layer by layer, and choosing the materials most similar to those existing in the building. The HULC Database contains the Catalogue of Construction Elements (CEC) (Ministry of Public Works, 2011), which is a Recognised Document of the CTE. The performance resulting from the enclosures and partitions of the building in its initial state is far from the requirements of the CTE DB-HE.

In accordance with DB HE-1 (Ministry of Transport, Mobility and Urban Agenda, 2020) and the UNE-EN 12207:2017 Standard (AENOR, 2017), the air permeability of the openings in the thermal envelope has been determined. The total solar energy transmittance of the glazing with activated mobile shade device, which are interior curtains in pastel shade, has also been taken into account. All the frame fractions of the doors and windows have been calculated one by one.

For all thermal bridges, those that most closely resemble the constructive reality of the building have been chosen from among the models listed in the HULC Database.

The absorptivity of the exterior enclosures and frames has been taken into account.

The existing spaces in the building have been classified for geometric definition in HULC, into non-habitable spaces, unconditioned living spaces and conditioned living spaces, in accordance with the DB-HE:

- Profile of use of living spaces: Residential.
- Profile of use of non-habitable spaces: Watertightness level 5.

F. Installation of heating and domestic hot water of the building in its initial state

The building has a mixed system for heating and DHW, which only serves the rooms that made up the Casa del Cura, located on the First Floor. It consists of a 20 kW boiler powered by diesel, a 50-litre capacity DHW tank, and hot water radiators. In addition, there were other air conditioning installations for other areas of the building, which used fireplaces, stoves and glories. They are deteriorated and vandalized.

For the energy simulation, given the characteristics of the building, and based on experiences in previous work in facilities of that time, the terminal units have been estimated with an installed power of 100 W/m^2 of useful surface.

G. Geometry of the building in its rehabilitated state

The building, as it could not be otherwise, will maintain its volumes and geometry, as well as its orientation. The geometric differences will be inside, with a new redistribution of spaces according to the new needs for private residential use, throughout the built area. Also, the original geometry of the openings in facades will be recovered.

H. Construction and operational characteristics of the building in its rehabilitated state

The Database of Opaque and Semi-transparent Enclosures of the building has been modified from HULC, recomposing layer by layer all those that are going to receive some type of thermal insulation or change in the rehabilitation. Next, the layer-by-layer composition of the interior enclosures and partitions is described, with their thicknesses in brackets in centimeters, citing first those that are preserved without additional insulation:

- Façade and interior partition wall throughout the building (100): sandstone masonry (30) + sand and gravel infill (40) + sandstone masonry (30).
- Cellar floor in the basement: topsoil (50).
- Floor of the main staircase on the ground floor: sandstone (40).
- Sloping roof skirts: ceramic tile (2) + horizontal slightly ventilated air chamber (5) + low-density polyethylene sheet (0.1) + medium-density coniferous wood board (2) + mineral wool insulation (16) + medium-density coniferous wood board (2).
- Ground floor except for the main staircase: stoneware tile (1) + cement mortar (4) + expanded polystyrene insulation (8) + reinforced concrete (5) + polypropylene (0.5) + horizontal unventilated air chamber (15) + mass concrete slab (15) + gravel (20).
- Floor of the First Floor minus the main staircase, and of the Tower: stoneware tile (1) + cement mortar (4) + expanded polystyrene insulation (8) + medium density coniferous wood board (2).
- Floor of the Lower Roof: cement mortar (4) + expanded polystyrene insulation (8) + medium density coniferous wood board (2).
- Façade wall throughout the building (80) lining: sandstone masonry (30) + sand and gravel infill (20) + sandstone masonry (30) + cement mortar (1) + mineral wool insulation (16) + low-density polyethylene (0.1) + triple hollow brick masonry (10) + plaster lining and plastering (1.5).
- Façade wall in window panels of the semi-cloistered cladding: sandstone masonry (30) + cement mortar (1) + mineral wool insulation (16) + low-density polyethylene (0.1) + triple hollow brick masonry (10) + plaster lining and plaster (1.5).
- Light partition partition separating spaces throughout the building: double plasterboard panel (2.8) + mineral wool insulation (4) + double gypsum board panel (2.8).

The new glass has been defined for all types of doors or windows:

- Double low-emission glass, with solar control and outdoor security.
- Thermal transmittance: Ug = 1.10 W/m^{2}K.
- Factor solar: g = 0,19.

Similarly, the new frames have been defined for all types of doors or windows:

- Vertical frame made of American cedar wood, with a density of 490 kg/m^3.
- Thermal transmittance: Uf = 1.15 W/m^{2}K.
- Thickness: 80 mm.

The air permeability values of the thermal envelope voids have been updated:

- 60 m^3 / h×m^2, at 100 Pa, for doors, according to a default value of HULC (Class 3 according to the UNE-EN 12207:2017 Standard).
- 3 m^3 / h×m^2, at 100 Pa, for windows (Class 4 according to the UNE-EN 12207:2017 Standard).

For the total transmittance of solar energy of the new glazing, opaque interior solar protection devices made of dark wood have been arranged. All the frame fractions of the doors and windows have been recalculated one by one.

All thermal bridges have been redefined, choosing from the models that appear in the HULC Database, those that most resemble the new construction reality of the Execution Project for the Rehabilitation of the Building.

The classification of new spaces in the building, into non-habitable spaces, unconditioned living spaces and conditioned living spaces, has been updated in accordance with the DB-HE:

- Profile of use of living spaces: Residential.
- Profile of use of non-habitable spaces: Watertightness level 3.

I. Installation of heating and domestic hot water of the building in its rehabilitated state

The building will have a new mixed system for heating and DHW based on a mixed condensing boiler powered by pellets, with a power of 45 kW. It will have an accumulator tank for DHW with a capacity of 200 liters.

The conditioned habitable rooms of the building will have underfloor heating circuits with hot water at low temperature. After the rehabilitation, an installed power of 75 W/m^2 has been estimated.

J. Objective of the rehabilitation project

The scope of the first phase of intervention, currently in process, is structural consolidation and consists of:

1. Preliminary actions: perimeter fencing and installation of shoring, scaffolding and other auxiliary means for initial work and detailed study of pathologies.
2. Replacement of the roof: disassembly of tiles, shingles and purlins. Lifting and removal of wooden beams, cleaning of supports at the top of walls. Securing cornice pieces. Reconstruction of the roof structure with wooden trusses. Execution of new roof skirts using sandwich panel with thermal insulation, waterproofing and ventilated tile with aged finish. Gutters are not planned, but the traditional system of overflowing the cantilevered tile and the cornice as a drip is reproduced.
3. Bracing of wall crowning elements (if necessary).
4. Dismantling of crumbling or poorly maintained slab panels. They will be rebuilt with wooden joists similar to the existing ones, and thermal insulation will be placed on all the floors of the building.
5. Tying of wall elements, lintels and arches, with special attention to the openings of the Tower, whose condition will be unknown until safe access can be reached.
6. Cleaning and recovery of façades by restoring the coats of arms and recovering those areas where the ashlars are in the worst condition.
7. Recovery of the stately staircase by replacing the corner pieces with stone similar to the existing one and the ceiling with false plaster lunettes.
8. Elimination of elements inappropriate to the original construction, such as partitioning or blinding of arches and openings.
9. Dismantling of the wooden auxiliary staircase, which was built in the 50s to adapt the priest's house and was executed in untreated rough wood, which has led to an inexorable deterioration, currently in a ruinous state.
10. Renovation of the exterior carpentry for new high-performance ones, with wooden frames and high thermal insulation glass.

Fig. 13 shows two moments of the rehabilitation works.

This project, whose execution has already begun, has obtained a double A energy rating, which has allowed it to opt for aid from the PREE 5000 Programme (Ministerio para la transición ecológica y reto demográfico, 2021).

Fig. 13: Dismantling of the old roof and assembly works of the new one. (Source: Paula Montoya Saiz)

III. RESULTS AND DISCUSSION

This section shows the results obtained after carrying out detailed energy simulations of the building, both in its initial state and in the refurbished state, incorporating the best energy improvement measures chosen and exposed in the previous section. The result of the architectural rehabilitation measures applied to reverse each of the pathologies detected is also shown graphically.

A. Results of the energy study of the building in its initial state

The building in its initial state is exempt from DB-HE compliance. However, thermal transmittances of the interior enclosures and partitions have been compared, and as expected, none meet the limitations currently imposed.

Regarding the annual calculations on an hourly basis, Fig. 14 shows the results obtained when carrying out the Energy Performance Certificate of the Building in its initial state:

- Non-renewable primary energy consumption: 595.38 kWh/ m^2 year (Class G).
- CO2 emissions: 152.22 kgCO$_2$/m^2 year (Class G).
- Heating demand: 407.45 kWh/m^2 year (Class G).
- Cooling demand: 0.85 kWh/m^2 year (not assessable).

The Old Abbey of Salas de Bureba, in its initial state, despite the fact that it only has a conditioned living area of 148.29 m2 that groups the spaces on the First Floor intended for the Casa del Cura, presents a very poor energy performance, which is not surprising considering the deficient construction characteristics described.

Of particular note are the very high values for heating supply, in terms of energy demand, non-renewable primary energy consumption and CO$_2$ emissions. They are coherent, since the heating system has an inefficient boiler, powered by diesel.

Taking into account the climatic conditions, with a long and severe winter and a summer of mild temperatures, the HULC computer program does not take into account the values related to cooling, as they are not significant compared to those of heating.

The HULC software also provides values for the supply of DHW, even if they do not appear on the labels shown above. In any case, they are also insignificant in relation to those of heating:

- Non-renewable primary energy consumption: 11.79 kWh/m^2 year (Class B).
- CO2 emissions: 3.11 kgCO$_2$/m^2 year (Class C).
- DHW demand: 8.50 kWh/m^2 year.

TABLE I
ANALYSIS OF THE THERMAL TRANSMITTANCES OF THE BUILDING'S ENCLOSURES AND PARTITIONS IN THEIR REHABILITATED STATE, EXCLUDING THOSE THAT DO NOT UNDERGO ANY INTERVENTION

Name	Thermal transmittance (W/m^2·K)			Compliance
	Closing	Table 3.1.1.a	Table 3.2	
Sloping roof	0,18	0,33	---	YES
Sloping roof	0,18 0,21	0,33	---	YES
Floor under cover	0,40			
PB Floor	0,34	0,59	---	YES
Wall 80 cm lined	0,17	0,37	---	YES
Lined wall	0,17	0,37	---	YES
First Tower Floor	0,40	---	1,00	YES
Light partition	0,59	---	1,00	YES
Hollow	≤ 1,25	1,80	---	YES
Glass	1,10	---	---	---
Frame	1,15	---	---	---

B. Results of the energy study of the building in its refurbished state and savings achieved

As the building is for private residential use, but it is not a new construction, but it is an existing building that is going to undergo a major intervention in more than 25% of its thermal envelope, only the enclosures and interior partitions in which intervention is being carried out, and not the interior sandstone walls that are only restored, are subject to the limitations of the DB HE-1.

It can be clearly seen in Table 1 that all the proposed enclosures and interior partitions comply with the limitations of thermal transmittance, except for those in which no intervention is going to be carried out, and which would be exempt.

With regard to the annual hourly calculations, Fig. 15 shows the results obtained when carrying out the Energy Performance Certificate of the Building in its refurbished state:

- Non-renewable primary energy consumption: 7.04 kWh/m^2 year (Class A).

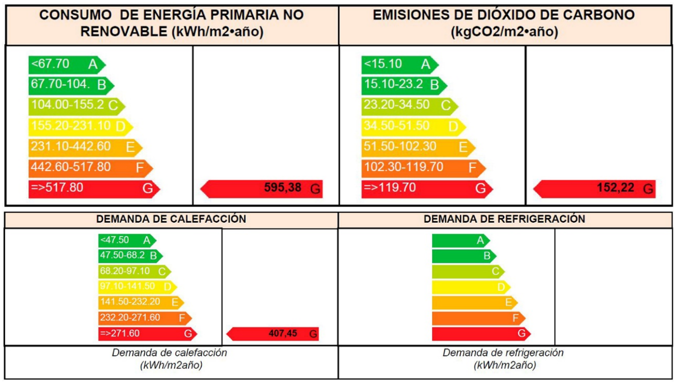

Fig. 14: Energy Performance Certificate of the building in its initial state. (Source: Raúl Briones Llorente)

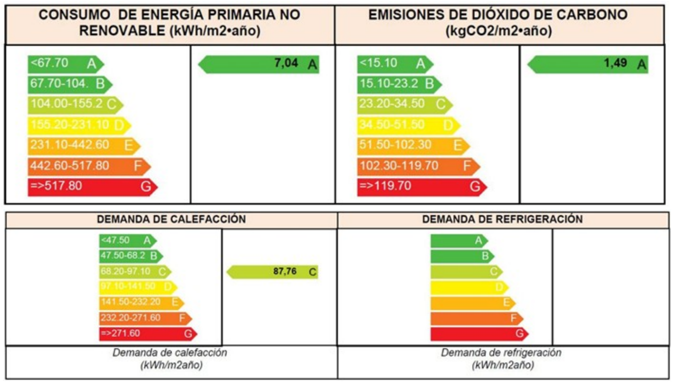

Fig. 15: Energy Performance Certificate of the Building in its rehabilitated state. (Source: Raúl Briones Llorente)

Fig. 16: Rehabilitation of the roofs. (Source: Paula Montoya Saiz)

- CO2 emissions: 1.49 kgCO$_2$/m^2 year (Class A).
- Heating demand: 87.76 kWh/m^2 year (Class C).
- Cooling demand: 0.08 kWh/m^2 year (not assessable).

The Old Abbey of Salas de Bureba, in its rehabilitated state, goes from having a conditioned living area of 148.29 m^2 (Casa del Cura), to 967.89 m^2. Despite the fivefold increase in the number of conditioned spaces, the energy performance of the overall building improves very significantly.

The decrease in heating demand by 78.46% stands out, going from 407.45 kWh/m^2 per year to only 87.76 kWh/m^2 per year. This is directly due to the significant improvement of the thermal envelope.

Non-renewable primary energy consumption has decreased by 98.82%, from 595.38 kWh/m^2 per year to only 7.04 kWh/m^2 per year. This is due to the combined effect of the improvement of the thermal envelope to lower the demand for heating, and the change of the mixed system for heating and DHW for a more efficient one that uses a fuel of renewable origin.

CO$_2$ emissions have decreased by 99.02%, from 152.22 kgCO$_2$/m^2 year to only 1.49 kgCO$_2$/m^2 year. The two causes of this great reduction are the same as those explained in the previous paragraph.

The HULC software still does not take into account the values relating to cooling, as they are insignificant compared to those for heating.

The new values relating to the supply of DHW, although they do not appear on the labels, would be the following, but they are still not significant in relation to those for heating:

- Non-renewable primary energy consumption: 0.38 kWh/m^2 year (Class A).
- CO2 emissions: 0.08 v kgCO$_2$/m^2 year (Class A).
- DHW demand: 4.43 kWh/m^2 year.

The good results obtained in improving energy efficiency for the rehabilitation of the Old Abbey of Salas de Bureba have made it possible for this project to be included in the 2022 call for the PREE 5000 Energy Rehabilitation Program for existing buildings in municipalities with a demographic challenge.

Specifically, the subsidized action for existing complete buildings (Option A), is divided into two clearly differentiated typologies: Improvement of the energy efficiency of the thermal envelope (Typology 1), and Improvement of energy efficiency and renewable energies in thermal installations for heating, air conditioning, ventilation and DHW (Typology 2), specifically, in subsection 2.3 Replacement of conventional energy with biomass in the thermal installations. Thus, between both Typologies, aid has been requested that represents 75% of the total amount of material execution of the energy improvement works of the building.

Fig. 17: Rehabilitation of the structure. (Source: Paula Montoya Saiz)

C. *Results of the rehabilitation project*

This subsection describes the main corrective measures carried out for the different pathologies described above, as well as the current visual appearance of the rehabilitation works.

Rehabilitation of the roofs (Fig. 16):

- Sanitation of supports at the top of walls and securing of cornices.
- Roof structure with trusses, purlins and pairs of compact wood.
- Skirts with sandwich panel with 16 cm MW insulation and wood finish.
- Roof with curved Arabic tile recovered from demolition.

Rehabilitation of the structure (Fig.17):

- New solid wood joist slabs and compression layer with mesh.
- New sanitary slab on coffers on the ground floor with 8 cm XPS.

Rehabilitation of the walls (Fig. 18):

- Cleaning and tying of walls, lintels and arches with stainless steel rods.
- Restoration of coats of arms and ashlars in poor condition, and topping with bastard mortar.
- Thermo-clay walls + 16 cm MW + ceramic lining, clad in lime biker.
- Cedar wood carpentry and double insulating safety and low-emission glass.

Rehabilitation of interiors (Fig. 19):

- Replacement of pieces of the main staircase with similar stone.
- Repair of plaster lunettes of the vault.
- Elimination of all elements inappropriate to the original construction.

Fig. 18. Rehabilitation of walls. (Source: Paula Montoya Saiz)

D. *Social, economic and sustainable dynamisation*

From the beginning of undertaking this project, the relevance of the building for centuries as a meeting place where community activities took place for the residents of the town became clear. Part of that community life also took place in the property's orchard, located on an adjoining plot to the north of the house, with a surface area of one hectare.

The use for the organic cultivation of fruit trees and orchards will be recovered (Fig. 20), in a permaculture and pest control strategy without pesticides and through the use of ecological fertilizers. In this way, it is intended to establish a testing ground for experimentation with these procedures, optimised irrigation systems and the recovery of varieties of old trees and vegetables with behaviour appropriate to changes in the climatic conditions of the area.

The town is home to the headquarters of the Valle de las Caderechas farmers' association, which would manage the implementation of this experimental field including a workshop school. With this association, a framework collaboration agreement is being finalized, thus helping the social, economic and sustainable revitalization of the town and its environment.

Fig. 19. Rehabilitation of interiors. (Source: Paula Montoya Saiz)

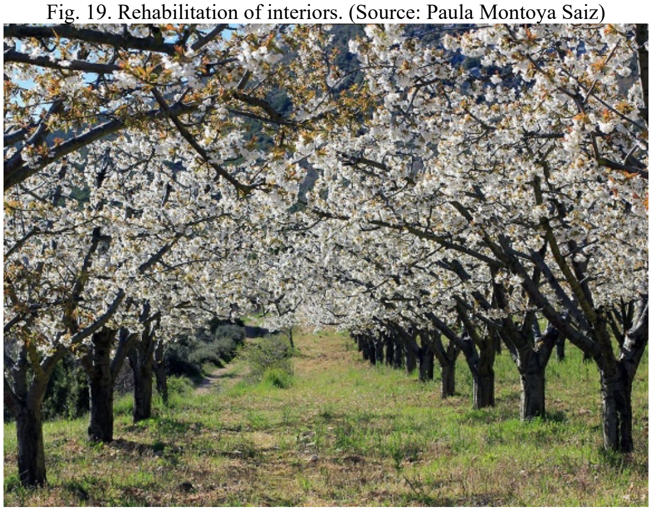

Fig. 20. Cherry tree cultivation in the Caderechas Valley. (Source: One Click from Adventure – Travel Blog)

IV. CONCLUSIONS

The old Abbey of Salas de Bureba, known locally as "Casa del cura", is a magnificent representative of the religious/civil architecture of the Caderechas Valley and an exponent of the value of coexistence between the Clergy and the inhabitants of the town over the centuries. Therefore, it is absolutely essential to preserve it to prevent its disappearance.

A complete restoration is being undertaken, adapting the building to private residential use with current standards, but maintaining the original architectural richness, and with a focus on energy efficiency and sustainability during its life cycle.

A detailed energy simulation of the building in its initial state has been carried out to know its thermal behaviour, calculating on an hourly basis for the period of one year, the energy demands, energy consumption and CO2 emissions, global and separately, for heating, cooling and domestic hot water. Measures to improve the energy efficiency of the building have been evaluated, studying functionally, technically and economically viable solutions. The passive measures selected are based on the addition of thermal insulation in the opaque elements of the envelope, except for the walls, and on the placement of new high-efficiency carpentry. A new installation has also been designed for heating and domestic hot water, with a low-temperature boiler powered by biomass.

The building was based on an energy rating of G, both for non-renewable primary energy consumption, for CO2 emissions and for heating demand. An A rating has been achieved in the first two indicators and a C in the third. The savings obtained are 98.82%, 99.02% and 78.46%, respectively.

A study has been made of all the construction pathologies presented by the roofs, structure, walls, interiors and facilities of the building. For all of them, different architectural rehabilitation measures have been designed and implemented, which are currently in a very advanced state of execution.

This project, as a whole, fulfils a function of social, economic and sustainable revitalisation of the town of Salas de Bureba and its surroundings, which transcends the mere rehabilitation of the building. It will be a driving force for tourism development, and a plot of sustainable and experimental cultivation of fruit and orchard species typical of the area will also be implemented.

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