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Some refurbishment particularities: An older building case study

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Abstract. Portugal has many old buildings with historical and cultural values in advanced degradation. Many of them have an architectural interest, special values and some other characteristics with interest to preserve, which contribute to keeping the building originality and singularity. These building could be retrofitted for new facilities of uses increasing the levels of comfort similar to new buildings. However, all project management of that kind of buildings is more specific, complex and requires special knowledge in the management of the particularities of their work, even other factors related with misunderstandings, inheritance problems, and many others. This research describes a case study that involves the surveying of constraints and other problems concerning the retrofitting works of an old building located in Montesinho village (Bragança-Portugal). In their retrofitting works were applied some parameters of the “Retrofitting management system for buildings located in consolidated urban areas” to support the project design and the building existential particularities. Besides, the management system considers regulations obliged, sustainable practices and possible constraints particularities for that old building case study's project management. The results show constraints, problems, but also solutions application to solve and reduce them, being a contribution to many other old buildings with similar retrofitting needs.

1. Introduction

During the life cycle of existing building is of crucial importance to have conservation and maintenance practices which contributes to their assumed sustainable development, fulfilling of its everyday needs and keep comfort conditions. [1]. Original old buildings reflect the difference compared with recent buildings solutions, because sometimes that buildings revealing some rare and most often very ingenious technological solutions, meanwhile abandoned or forgotten [2]. In most cases, it is possible to understand the social context of that time, while they keep unique architectural and artistic features with interest to preserve, which is not the case in new buildings [3]. Monumental buildings are even more specific in these cases, possessing acknowledged details and cultural values with national, public or municipal interest [4].

Many of monumental buildings with private owners, such as manor houses, are degraded without habitability conditions and far away from the expectable investment needs. Nevertheless, it is possible to refurbishment and dignify the appearance of old buildings with or without architectural and cultural interest for several different purposes, such as touristic or even cultural aspects, attending to very specific commercial demands, develop historic centres or specific local areas [3].



However there are some problems linked to their refurbishment process, some of them related to localization aspects, cultural and patrimonial constraints, real estate pressures, demolitions of possible reusable elements, and difficulties in adaptation to realistic needs, mistakes in building planning, time overruns and increases in expected costs, among others [5].

The case study deals with the investigation of constraints and other specificities of an old building destined a house focusing on technical recommendations, sustainable practices and looking for adequate solutions that match the building existences. For that purpose, a toolkit “management system for refurbishment of consolidated urban centre localized buildings”, here after called “management system”, is used [6]. This toolkit considers the application of sustainable practices to help in the management of the whole building complex, besides contributing in the decision-making of the different parts involved in the refurbishment process.

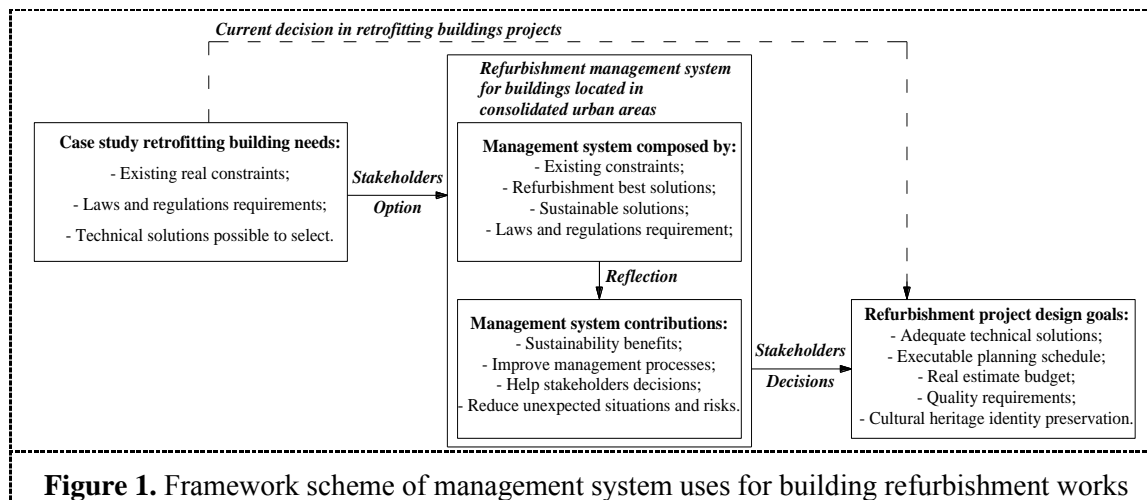
2. Research methodology

This paper has adopted a case study to research the management of building refurbishment works in an old building located in the little village Montesinho, at 20 km distance from Bragança city (Portugal). The characterization of that building is attending in the research. The research methodology involves a qualitative study and uses available documentation (building project design) and direct observation (“in situ” real and direct observation) which may permit a better convergence of available information [7]. Table 1 contains strengths and weaknesses of data sources used in the case study.

Table 1. Strengths and weaknesses of data sources used in the case study (Adapted from Yin [7]).

Data Resources	Strengths	Weaknesses
Documentation (Design project)	Stable (it could be revised sometimes); Discreet (not used as result); Exact (names, references and details); Wide coverage (time, events and distinct environments).	Recuperation low capacity; Tendency selection (if data collection is not complete); Pre-conceived ideas of the author; Information access could be deliberated.
Direct Observation	Events in real time; Contextual (take the event context).	Selectivity, much time and expensive; Reflexivity (The event could be differentiated).

The management system was developed in a research to support old buildings rehabilitation, retrofitting, refurbishment, reconstruction or other project types. Each parameter has 3 possible choice options, classified from less sustainable to more sustainable. The main goal consist in the reflection and option for viable solutions in old building project and report each parameters solutions recommendation to design projects. And whenever possible, it is chosen the option for solutions that have more benefits to sustainability and without forgetting costs aspects. Figure 1 show a framework scheme about the methodology used in this paper research which used about 39 parameters from a set of 50 parameters management system [6].



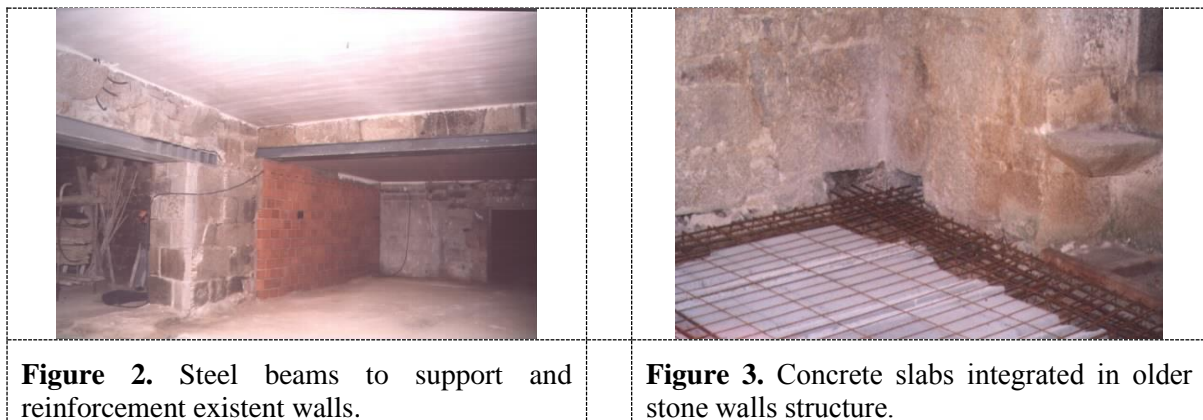
Each solution/option proposal or recommended has a careful reflection in the project and these selected solutions intend to give more benefits to sustainability when compared with conventional or similar solutions. Some management system solutions are proposed to improve building management process, such as reducing some unforeseen problems [8].

The management system could give a contribution in the project design phase about the adequacy of technical solutions and also in weighting some aspects about planning, budgeting, quality and preservation of existing heritage building. These aspects are frequently often neglected or are not managed in a correct way forgetting old building particularities [5].

3. Old buildings refurbishment particularities and proposals

Refurbishment is the “process to encompass rehabilitation, alteration, adaption, extension, improvement, modernization and repair work carried out to an existing building to permit it reuse for various specific reasons” [9]. However, this definition described the main reasons of refurbishment, which is to make sure a building is able to operate continuously, and offer better services that suit the demand of the tenants. And also, in technical point of view, refurbishment is the process of making as good as new, including essential modernization and renovations.

Old buildings refurbishment actions consider the re-use of pre-existing materials, fitting them to promotion of sustainable practices and keeping, as much as possible, the buildings’ original features. Meanwhile some interventions on these buildings are built as new building constructions, with total ruin of the existing elements, using only the exterior walls, contradicting part the original ideal of refurbishment concept much as possible, Figures 2 and 3.



3.1. Constraints connected to old building refurbishment works

Many old buildings refurbishment works need some specificity solutions attended in design projects to solve problems occurrences and also existent constraints and specificities or particularities [3]. Many factors could had contribution to them, especially according to old technologies used, villages or historic centres morphology which differ from recent regulations to attended new building construction [2]. Some constraints are connected to “Surroundings and location”, such as [5]:

- Frequently, new buildings in recent areas are predicted than old buildings.
- Car parking spaces are limited and inexistence of gardens areas and common areas.
- Fire risk propagation is very difficult to control in fire cases.
- Narrow streets, opposite building proximity, low mobility people.
- Infrastructure networks maintenance or substitution needs.
- Main old buildings surroundings are degraded and uncharacterized.

3.2. Management system to support old building refurbishment works

The management system parameters are presented in Tables 2 and 3. Its uses are optional but it takes the design projects more consistent in technical point of view, with reflection and pondered solutions adjusted to refurbishment works. This tool is structured in 4 thematic groups, 15 indicators with 50 parameters. The main goal of this toolkit is to support old buildings works from viability to use, involving design project and construction works and also in other hand their stakeholders. It contains some solutions which help in reflection about technical aspects sometimes neglected in intervention works such as refurbishment works. The management system contains refurbishment constraints, frequent regulations to attend and better solutions to promote sustainable aspects.

Table 2. Management system thematic areas, indicators and parameters (part 1) [5].

Area	Indicators description	Parameters description	
A1. Surroundings and location	I1. Mobility and amenities	P01. Public transport	
		P02. Car parking	
		P03. Local amenities	
	I2. Local infrastructures	P04. Outward firefighting means	
		P05. Technical networks in public space	
		P06. Urban space quality	
I3. Land use occupation		P07. Land occupation	
		P08. Total area and deployment area	
		P09. Gardens and leisure places	
I4. Solar orientation and exposure		P10. Solar exposure	
		P11. Solar orientation	
A2. Project design	I5. Characterization of building conditions	P12. Request for technical studies	
		P13. Characterization diagnoses of building conservation status	
		P14. Project Design specificities	
	I6. Architectonic organization and salubrity		P15. Conceptual architecture configuration and adaptability
			P16. Ratio useful floor area/Gross lettable area (GLA)
			P17. Acoustic insulation and indoor air quality
I7. Infrastructures, foundations and		P18. Building technical networks	
		P19. Peripheral retaining structures	
		P20. Foundations	

structural elements conditions	P21. Structural elements
18. Materials	P22. Materials reuse P23. New materials P24. Fire safety
19. Sustainability promotion	P25. Water recovery and reuse P26. Solar collectors for hot water production P27. Electrical energy production P28. Energetic efficiency in thermal comfort P29. Other solutions for energetic efficiency P30. Bioclimatic solutions P31. Other sustainable solutions

Table 3. Management system thematic areas, indicators and parameters (part 2) [5]

Area	Indicators description	Parameters description
A3. Construction works and site works	I10. Initial works constraints	P32. Site works and surrounding space P33. Adjoining building conservation state P34. Stabilization and consolidation of building works and adjoining buildings P35. Adjoining buildings waterproofing
	I11. Industrialization/ execution of works	P36. Workforce P37. Specialized workforce and company's technical capacities P38. Specialized subcontracts P39. Technical requirements monitoring
	I12. Risk and constraints potential	P40. Propensity to project design changes P41. Propensity to the occurrence of unexpected works P42. Propensity to time overruns P43. Propensity to other work constraints
	I13. Other features resulting from works	P44. Archaeological Works prospection P45. Construction and demolition waste management P46. Needs of occupant's relocation
A4. Costs	I14. Work costs	P47. Costs of urban space works P48. Costs of general building works
	I15. Tax incentives and other costs	P49. Possibility to apply for benefits and tax incentives P50. Maintenance and conservation strategies

4. Case study

This case study approach the constraints study support related to an old building refurbishment works considering best solutions chosen during project management. This building attended village morphology and the façades characterization contribute to maintain the village preservation, identity and it is also an imposition requires in that place. Though this old building study in the case study is not a heritage building with cultural interest, their contribution to surrounding area is important in set of all building because these buildings define the streets and complement each other's in architectural and aspect characterization.

4.1. Old Building description and characterization

The old building studied in this case study research was in ruins and threatens collapse of neighbouring buildings (figure 4 and 5), predicting 120 years old from existence. It is located in Montesinho village, near from Bragança city (Portugal), and it is integrated in Montesinho Natural Park which is preserved by their lovely nature. The building has not cultural interest individually but it contributes to building set of village preservation. The original building was in reality 2 separated buildings very similar, each one with 2 floors, stone walls, floors in wood and also roof structure in wood with slate tiles. Only the stones colours aspect, positions integrated with black roof slate tiles differentiate all landscape near and away. The design project was made in 2009 while the refurbishment works started in 2010 and it was finished in 2014.



Figure 4. Principal façade with balcony.



Figure 5. Internal ruin collapse structures.

4.2. Old building constraints and particularities

The old building included in the case study had all the interior structure and part of the exterior walls in ruins without any technical or economical possibility of recuperation, figure 4 and 5. A direct observation put in evidence some constraints and particularities described in table 4.

Table 4. Constraints and particularities of the old building case study

Code Group	Description:
(A) Existent and design project aspects	<ul style="list-style-type: none"> - (A1) Principal façade has some elements to maintain and preserve exterior stairs and old balcony, figure 4; - (A2) The building had 2 storage floors. The first one had 2,2 m of finish ceiling height and the second one had 2,3m; which does not allow regulatory height; - (A3) Some internal walls in stone had no interest to preserve, figure 5; - (A4) Vacant state with internal floor and roof wooden structure and some exterior walls in ruins, though the floors and roof structure was supported by walls, figure 5; - (A5) Fragile and poorly consolidated exterior walls; - (A6) Lateral façades leaning against an adjoining building; - (A7) Principal façade define the street direction; - (A8) The posterior façade had not connection and continuity in wall, figure 6. - (A9) One of the first storage floor gate has 1.6m width and 1.8m height; - (A10) The adjoining building façades have more than 8meters of height and they were built in little stone pieces, figure 7; - (A11) Electrical cables networks crossing the building, figure 7; - (A12) Building foundations had structural problems in local;

	<ul style="list-style-type: none"> - (A13) The building had not water and electricity networks; - (A14) Some doors closure and their height need adaptation changes; - (A15) Thermal and acoustic insulation were not existent. - (A16) The refurbishment works has technical complexity and constraints;
(B) Cultural and historical aspects	<ul style="list-style-type: none"> - (B1) Important landscape views and village preservation history which give the name of the Montesinho Natural Park; - (B2) The building has lot of stone pieces to preserve and with possible use. - (B3) The owners have lot of interest in preservation old existing materials adapting them to increase internal comfort conditions.
(C) Economical, financial and sustainability	<ul style="list-style-type: none"> - (C1) The Priority intervention was to protect exterior and lateral walls from rain; - (C2) Maximal limit of economic resources were imposed without margins; - (C3) Costs of demolition, cleaning works and shoring façades are significant; - (C4) Water pipes were inexistent even solutions for consumption reduction; - (C5) Energy networks were inexistent even solution for consumption reduction; - (C6) Regulatory verification are above conventional minimal requirements; - (C7) Some materials with environmental concern were present in design project; - (C8) Procurement of local construction and materials supplied companies; - (C9) Construction supervision by engineer service's needs was imposed.
(D) Refurbishment works	<ul style="list-style-type: none"> - (D1) Inexistence of space for site works needs to put materials and tools deposit; - (D2) Site works was in internal building spaces and the access were narrow; - (D3) Cleaning needs were necessary and also demolition waste management, figure 5; - (D4) Support lateral façades with shoring structures - (D5) Narrow street which has low traffic cars movement.



Figure 6. Posterior façade without connection and continuity.



Figure 7. Adjoining building façades with little stone pieces. Electrical cables networks crossing the building

4.3. The contribution of the management system in the proposal studied

This building has the proposal to be used by a family and in possible cases seasonal rental for tourism. Besides architectural proposal by design project for the adaptation of that building, has a set of technical solutions [10] which made it possible to manage the refurbishment process, minimizing resources, costs and time [11]. These solutions were developed attending to the existing constraints and using the management system previously, mentioned in point 3.2. The main goal is assuring options for more sustainable solutions [5] [12] [13].

All management system parameters from (A1) “surroundings and location” area, parameters P1 to P11 were not considered in this study because the building was acquired yet with conditions accepted and

assumed by the owners, which do not give any sustainable increment for the project in that thematises. In other words, it is not possible to improve suggested requests by the parameters P1 to P11 about surroundings and existing location.

Tables 5, 6 and 7 address the areas “Project design”, “Construction works and site works” and “Costs” of the management system, which include from P12 to P50 parameters. In these areas were attended all constraints and other problems analysed in table 4, solved or lessened with recommendations of different parameters’ attending sustainable solutions as possible [14, 15, 16].

Table 5. Parameters options from “Project Design” area.

Code and Parameter Solution selected	Constraints
P12 – Realization of geometrical drawings only requires traditional equipment’s.	A4,A10,A16
P13 – Foundation solved by traditional engineering solutions without specific tests.	A12
P14 – Design project were revised internally by different engineers. The design project contains technical solutions to a construction sustainable.	A16
P15- Existing building constraints solved in design project, preserving some elements with historical and cultural values which contribute to maintain the authenticity and identity of the building such as the façades and also the village preservation. The design project study improve the existing building conditions, such as the constraint (A2) has 2.6m for ceiling height in each floor, readapting exterior and consolidate lateral walls.	A1, A2, A5, A6, A8, A10, A11, A14, A15, A16, B1, B2, B3
P16 – The refurbishment works promoted internal remodelling, create partial habitable area in roof which increasing construction area fulfilling legal regulations.	A2, A3, A4, A9, A14, A15
P17 – The design project considered legal regulations superior than minimal requirements in thermal, acoustic and air renovation requirements.	A15, A16
P18 – The building need all infrastructures and networks connections.	A13
P19 – The building has some peripheral containment needs, and it needs some simple solutions which promoted the existing elements reinforcement of all walls.	A6, A10, A12
P20 – Isolated foundations were built for pillars support and the exterior and lateral walls need reinforced concrete footing.	A5, A12, A16
P21 – The exterior walls are reutilized complying the regular requirements but lateral walls ante first floor level is reinforced with concrete walls (figure 8). The internal structure was built in steel profiles in pillars and beams. Some part of the beams transmits their loads to external walls with load levels very similar to original ones. The floors area was built in prefabricated concrete slabs. The roof structure was built in steel profiles and wood with slate tiles (figure 9 and 10)).	A15
P22 – Façades and up to 25% of other materials quantity (stone and wood) were reused.	A3, A4, A14
P23 – The design project had some concern in materials selection coming from manufacturing sites near from building localization which was not superior of 50% cost.	C7,C8
P24 – The building meets all fire legal regulations.	A4, A6, A16
P25 – The design project only contains water reduction in all taps and it has a deposit for rain water reuse for toilets and garage cleaning, which reduce 25% of consumption.	C4
P26 – Solar collectors will be used in a roof place not visible from the streets.	C5
P27 – The building contains installation for Photovoltaic panel’s connection.	C5
P28 – The building had preview class energetic A+ with thermal insulation thickness superior than minimal requirements. The heating system is with biomass solution.	C6

P29 – The design project has some energetic efficiency concerns about natural light and LED artificial ones, renewable resources for building heating systems (biomass). It contains some monitoring equipment's for control and saving energy consumptions.	C5
P30 – The existing constraints do not only permit in the architecture design project the promotion of solutions for heating passive performance. Some glasses at South orientation is possible to put but it is not enough for needs.	C5, C7
P31 – The design project has preview an uncovered courtyard where is possible a garden	C7



Figure 8. Lateral walls at first floor in concrete.



Figure 9. Roof with metal steel beams and wood.



Figure 10. Roof with slate tiles.

Table 6. Parameters options from “Construction works and site works” area

Code and Parameter Solution selected	Constraints
P32 – Site works limitation space and access restrictions are presented in building equipment's assembly. Some examples: Deconstruction of principal façade and posterior façade for architectural and structural requirements. The design project preview ready-mixed concrete pumped as solution to eliminate aggregates in situ for concrete composition.	A9, A13, D1, D2, D4, D5
P33 – The adjoining building has good conservation state and stability but the walls from building studied need some stability works.	A6, A10
P34 – The lateral walls need some stabilization which is frequent in that works.	A10, A16
P35 – The adjoining building are in good maintenance performance but the roof need some waterproofing cares and drainage.	A6, A8
P36 – The refurbishment works requires smaller quantities and rhythms of labour than new construction. Ex: The steel structure was built in beams and pillars steel profiles.	A4
P37 – Building refurbishment works only require companies with some labour specialization in that works, namely with experience and technical knowledge in similar works. The companies might be regional and they had not requirements needs of management systems certification.	C8

P38 – Specialized subcontracting companies was necessary for reconstruction walls in stone and to put slate tiles in the roof which require complexity and preservation cares.	C8
P39 – This refurbishment works were quite similar to new construction where the dimension and technical works complexity were not required permanently an engineer’s supervision.	C9
P40 – The design project are detailed without fails detection with unrequired changes.	C2, C9
P41 – The design project has a description of all the constraints described in that parameter management system and it also has some procedures to mitigate and control.	C2, C9
P42 – The design project has a description of a set of factors to develop a planning map adjusted to works complexity, without unforeseen works appearance but allowing with some difficulty the fulfilment of deadlines.	D2, D4
P43 – This refurbishment works has some constraints, such as: construction works signalization on the streets, some traffic problems, overhead electrical power lines over building, materials transport and supply, lack of parking, supplementary Safety and Health Plan measures are need.	A9, A11, D2, D3, D4, D5
P44 – The Montesinho village has no evidences in archaeological remains existence. In other hand the design project describe some notes to attend in occurrence cases.	A16
P45 – The design project preview some deconstruction works, façades reutilization, and it define also some proceedings for construction and demolition waste reutilization.	A1, A7, C1, D3
P46 – The building is vacant without occupants with relocation needs.	A4

Table 7. Parameters options from “Costs” area

Code and Parameter Solution selected	Constraints
P47 – The buildings surrounding are preserved.	B1
P48 – The building refurbishment costs was estimated in 600€/m ² (plus VAT)	A16,C2,C6
P49 – These works were not covered by benefits, tax incentives, or other programs.	C2
P50 – The design project describes the forecast of reactive maintenance strategy with costs which could be larger in repairs of systems and equipment (repair after failure).	C2, C4, C5

The old building refurbishment works studied show a set of possible options [16] according to a selection from each management system parameters option possibilities present in table 2 and 3. Each parameter has 3 possible options, classified by levels from 1 (less sustainable) to 3 (more sustainable) [5]. The level 2 is considered with conventional options without increase sustainable benefits. Table 8 has a description of the management system thematic parameters by selection levels choices from each parameter.

Table 8. Levels of sustainability selection of the thematic parameters

Parameter level selection/option	Parameters
1 (less sustainable options)	P19, P34, P49
2 (conventional sustainable options)	P12, P13, P18, P20, P24, P30, P32, P33, P35, P36, P39, P43, P48, P50
3 (more sustainable options)	P14, P15, P16, P17, P21, P22, P23, P25, P26, P27, P28, P29, P31, P37, P38, P40, P41, P42, P44, P45, P46, P47

The case study only used 39 parameters from the management system predominating sustainability levels above conventional and better solutions to promote sustainability in 22 parameters. Conventional levels of sustainability and no surcharge for sustainability benefits were found in 14 parameters solution

options. The solutions levels of sustainability used in parameters P19, P34 and P49 were less than conventional solutions.

Thus, according to the management system, the total options have been used to improve sustainability benefits in 56% of the parameters used. The detail and organization of the project design attending by designers and engineers team considered some sustainable solutions. In other hand, this old building project had so many constraints and a refurbishment operation with some particularities very specific to attend. The management system could be an important auxiliary by toolkit guide form to reducing failures, omissions and errors, deadlines control, improving quality level, costs control, managing risks and other unforeseen events [5, 17]. However, it requires some care and management specialized during old building refurbishment works because constraints are in considerable number with difficult resolution. But the result is a very beautiful building with external older aspect integrated in village architectural preservation and within internal comfort to their users, Figures 11 to 13.



Figure 11. Principal façade.



Figure 12. Internal building aspect.



Figure 13. Living room.

5. Conclusions

The old building in research study was no more than 120 years old without heritage classification which it is located in a Village of the Natural Park of Montesinho. All constraints and particularities were described in an exhaustive way, looking for solutions by the design project that enhances sustainability benefits and a more efficient management. However this refurbishment works shows a complex project to implement with solutions different than conventional ones such as the sidewall shoring, demolition works, comfort requirements, legal regulations imposed, rebuild stone walls and to keep a traditional context from exterior outside building. During design project develop the management system parameters were utilized from parameters P12 to P50, which including “project design”, “construction works and site works” and “costs” areas.

In 56% (22 parameters) of used parameters were chosen more sustainable ideas than conventional ones, but in 14 parameters solutions (36%) the solutions were conventional without sustainable increasing. In different perspective some solutions were less than conventional ones and represent 8% (3 parameters). These solutions were required because specific building constraints which were impossible to change in a different way such as sidewall shoring, more structural reinforcement needs

and inexistence of benefits or tax incentives for refurbishment works in that time Portugal villages. Although many parameters were considered with conventional solutions for sustainability benefits and less that conventional ones, the majority parameters number were used in the design project with more sustainable solutions.

In other perspective, the study shows a balance between the realities of refurbishment works difficulties within pre-existences, technical requirements attending to legal regulations and also sustainable solution implementation in spite of the overall comprehensiveness of the whole project design. The management system was an important auxiliary during project phase, especially for design project phase, with a strong contribution for planning, budgeting and quality in building refurbishment works [17]. This toolkit is not obliged but their uses promote a reflection more consistent to take better support decisions based on particularities and unforeseen not only in the building existences but also in surroundings area, including lateral buildings, streets, traffic, site works, and many others forgotten frequently during design project phase by designers.

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