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INTERVENTION ON THE REHABILITATION OF RURAL HOUSES IN PORTUGAL AS A CONTRIBUTION TO SUSTAINABLE CONSTRUCTION

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Abstract

ome relevant data about Portuguese housing stock are presented in this paper, according to Census 2001 and the 4th General Housing Census, particularly in the Centre Region, Beira Interior and Cova da Beira. These data show that the percentage of single family housing, in Portugal, is very high. On the other hand, the index of building ageing indicates that the situation is worrying if there is no investment in maintenance and rehabilitation. It is also presents characterisation and evaluation work as well as proposals of immediate intervention on a set of houses placed in rural areas of a council located in the centre countryside region of Portugal, in Cova da Beira. The houses external and structural conditions, as well as other aspects related to occupation and use have been evaluated. The necessities of immediate intervention were noticed and a graduated list of conservation conditions of the buildings has been established. Finally, obtained results are discussed and proposals of intervention and rehabilitation of rural houses are presented, as well as some ideas of investigation, so that the interventions may have as an objective the promotion of Sustainable Construction.

Streszczenie

Dane dotyczące portugalskiego budownictwa domów są zaprezentowane w tym artykule według Spisu w roku 2001 i 4-tego Ogólnego Spisu Domów, uwzględniającego centralny Region, Beira i Cova da Beira. Te dane pokazują, że procent jednorodzinnych domów w Portugalii jest bardzo wysoki. Z drugiej strony, indeksy budynków wskazują na starzenie się ich, sytuacja jest niepokojąca jeśli nie ma żadnego planu inwestowania w utrzymanie ich i rewitalizację. Przedstawiono charakterystykę, ocenę pracy i propozycje natychmiastowej interwencji na przykładzie domów zlokalizowanych w wiejskich obszarach, umieszczonych w centralnej części Portugalii, w okolicy Cova da Beira. Ocenie zostały poddane zewnętrzne i konstrukcyjne warunki oraz inne aspekty związane z zastosowaniem. Natychmiastowa interwencja stała się koniecznością, została uwzględniona i to stało się założeniem do utworzenia listy warunków niezbędnych dla przeprowadzenia konserwacji budynków. Ostatecznie otrzymane rezultaty: propozycje interwencji i rewitalizacji wiejskich domów, są dyskutowane. Tym samym założenia i wyniki badań nad interwencją mogą stanowić cel promowania Zrównoważonej Konstrukcji.

Keywords: **Housing in Portugal; Rural housing; Rehabilitation of houses; Sustainable construction; Building ageing.**

1. INTRODUCTION

The market of maintenance and rehabilitation represents around 50% of the businesses of the European building companies. Paradoxically, the information given by the media and by the official bulletins of the associations of building industries keep highlighting the new construction, not giving the necessary attention to the most important activities of the sector and forgetting around two thirds of industrial services and supply sectors.

The statistics are very poor but it is estimated that the number of existing buildings is 50 to 100 times higher than the number of those built every year. In what concerns to the housing sector, there exist around 145 millions of dwellings in Western Europe but only 2 millions of new dwellings are built every year.

These numbers show that a special importance must be given to the maintenance and rehabilitation sector, which is fundamental, in European terms, namely for the definition of strategies of development in the construction sector.

For that, it is necessary to know the sector in detail, and the information given to the decision makers must include the knowledge of relevant statistic indicators, namely:

- The size (in square meters) of construction of existing housing
- The percentage of the built area in relation to the total area surface of the country; (for example, in Spain this value is 20%, in Sweden and in Finland it is 40%, in France it is around 75% and in Portugal 180%);
- The percentage of the built area in relation to the number of inhabitants (ha/inhabitants); (for example in Spain it is 15%, in France it is 70% and in Portugal it is 160%);
- The importance of single-family buildings in Portugal, especially in rural areas
- The age and the global condition of buildings

in order to assure the coherence between the investments in new construction and the investments in the existing buildings.

It is predicted that in Portugal, in coming years, a great increase in the rehabilitation market of housing buildings is possible, due to the following reasons:

- Old housing stock starts to be relevant;
- The "rent buildings", from private enterprise, built in the 50s and 60s, are degraded;
- The necessity of transferring resources to the rehabilitation of the existing buildings as an indirect consequence of the limits to the growth of urban areas predicted by the municipal plans;
- The necessity of contradicting depopulation in the ancient urban areas of the cities, as for example Lisbon "Pombalina" downtown and Oporto downtown, in favour of the tertiary sector and a great attention to the rehabilitation of the patrimony and historic centres of Portuguese cities
- The problems in use and early degradation in recent buildings, and
- The need to improve the single-family buildings conditions, particularly in rural areas.

The statistic indicators show that the percentage of single-family buildings is very significant in European countries and especially in Great Britain and Portugal. For example, in Germany it is 56%, in Spain, 33.3%, in Italy, 45.5%, in France 69.1% and in Portugal, 86.9% (see Figure 1). In case of Centre Region of Portugal, the percentage is 94%. There are areas of statistical analysis, such as Pinhal Interior Sul, where the percentage is 97.1%.

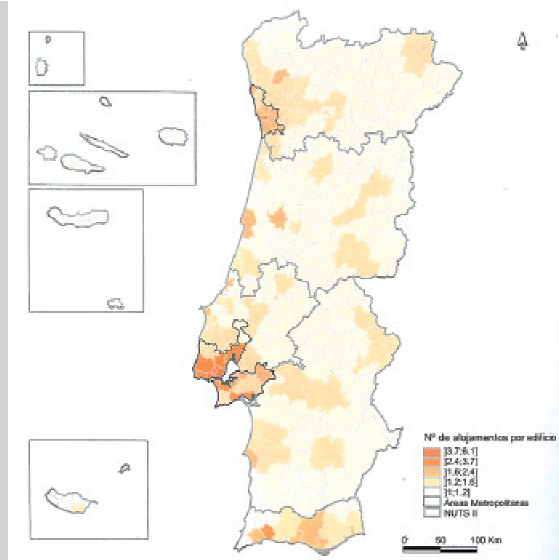

Figure 1.
Average size of buildings in Portugal, Census 2001.[1]

Before this numbers, it is necessary to give special attention to individual housing if the global objective is to stop depopulation in rural areas and contribute to the sustainability of the territory.

On the other hand, considering the age of the buildings, the situation in Portugal starts to be quite worrying. The statistical data related to the age of the buildings usually show good information regarding their physical characteristics, since the buildings are the result of the appliance of building techniques common at the time of construction. At the same time they give information about their quality, when compared to the present parameters. The evaluation of present thermal quality is one of those examples. According to Census 2001 and the 4th General Housing Census, the percentage of buildings over 31 years in Portugal was 43.2% and the percentage of buildings over 56 years (higher than their life expectancy) was almost 20% (see Figure 2).

It is a valuable patrimony that has resulted mainly from the financial effort of families and to whom the public authorities have given little attention. There is much concern about the new construction, social

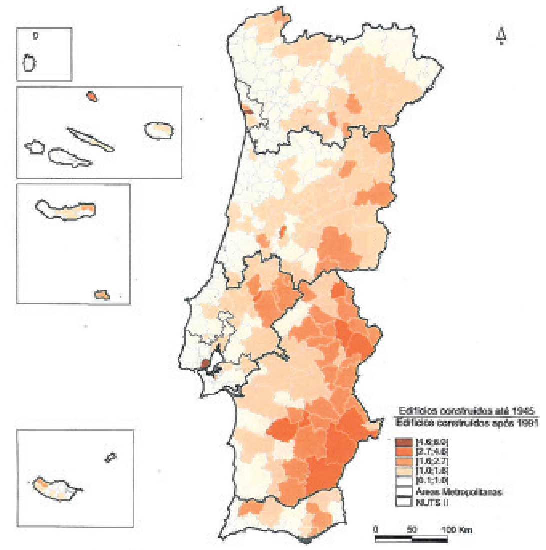

Figure 2.
Index of building ageing in Portugal, Census 2001. [1]

housing programmes, rehousing, but the single-family buildings are degraded and the maintenance of this Particular Cultural Patrimony must be considered as a national priority.

In case of the subregion of Beira Interior, in Portugal, the situation is even worse, reaching the percentage of 46% of buildings over 31 years and 23.4% over 56 years. The number of buildings that have overcome their life expectancy is higher than 25%.

From a more global perspective, the index of building ageing of Portuguese housing presents worrying values and these values are especially high in the countryside. It is a statistical reality, but one just has to observe attentively the general state of housing constructions from the countryside and from the historic centres of big cities to confirm this worrying reality.

2. HOUSING IN THE CENTRE REGION OF PORTUGAL

According to Census 2001 and the 4th General Housing Census, in the Centre Region there existed 757.476 buildings, around 24% out of the national total number (3.149.973). Among the existing buildings in 2001, in the Centre Region, 18% were built in the last decade (after 1991) and 19% are quite old, showing the ageing of housing in the Region. Most of the buildings were built between 1971 and 1990 – around 39%. [2]

On average, the Centre Region has a housing set a bit older than the national average. The index of ageing of the Centre Region is 104.3 buildings built before 1945 out of each 100 built after 1991. At national level, this index equals 104. The counties of Castanheira de Pêra, Vila Velha de Ródão, Celorico da Beira and Castelo Branco have the oldest housing stocks. Sátão, Marinha Grande, Vagos, Viseu e Leiria are the counties with the highest number of new constructions (see Figure 3).

In the Centre Region, as to construction, the buildings are mainly single-family. The single-family buildings represent 95% of the total number of buildings in the Centre Region, being the national average 87%. The number of buildings with 7 or more dwellings represents 1.3% of the total number of buildings in this region, and the national average for this parameter is 3.6%. The counties of Sabugal, Penamacor, Idanha-a-Nova and Vila de Rei have the lowest values – only 1.02 dwellings per each building.

Among the 78 counties that are part of the Centre Region, 65 present values under the regional average. Coimbra is the county that stands out the most for the average size of the buildings, with 1.92 dwellings per building. Next come Figueira da Foz (1.67), Aveiro (1.63), Covilhã (1.53), Castelo Branco (1.5), Viseu (1.43), Marinha Grande (1.4), Leiria, Ovar, Guarda and Ílhavo (all with 1.39) and Murtosa (1.26). However, these 13 counties are the only ones whose values are above the regional average. [2]

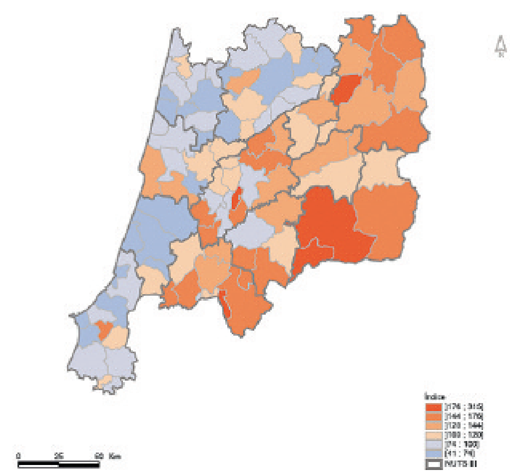

Figure 3.
Index of ageing of buildings in the Centre Region, Census 2001. [2]

3. HOUSING IN BEIRA INTERIOR AND COVA DA BEIRA

In the regions of Northern Beira Interior (counties of Almeida, Celorico da Beira, Figueira de Castelo Rodrigo, Guarda, Manteigas, Meda, Pinhel, Sabugal and Trancoso), Southern Beira Interior (Castelo Branco, Idanha-a-Nova, Penamacor and Vila Velha de Ródão) and Cova da Beira (Belmonte, Covilhã and Fundão) the housing stock is worrying as well, in what concerns to its ageing. In these three regions, which are located in the countryside of the Centre Region of Portugal, there are 154.352 buildings, according to Census 2001, 36.288 out of which were built before 1995 and 23.884 after 1991. The index of ageing of buildings in these three regions is 152, being 92.5% of the buildings constituted of single housing buildings.

In these three regions there are only 1441 buildings that have between 7 and 12 dwellings and 446 buildings with more than 13 dwellings that are concentrated in the counties of Guarda, Covilhã and Castelo Branco.

From the total number of buildings that have between 7 and 12 dwellings, 70% are placed in these three counties that have the biggest cities; 338 belong to Guarda (23.5%), 133 are in Covilhã (9.2%) and 528 are in Castelo Branco (36.6%). The same happens to the 446 buildings with more than 13 dwellings, 76 have been built in Guarda (17%), 133 are in Covilhã (29.8%) and 195 in Castelo Branco (43.7%). [2]

Considering that these three regions are markedly rural and taking into account the index of ageing of the building stock, it is estimated that, out of the 142.764 single-family buildings existing there, a great majority is rural housing (or have been built in rural areas).

There are several places and historic villages identified in these regions, whose rural housing has been characterised and some of them have been recovered due to its cultural, historical, architectural and constructive value, such as, for example, the villages of Sortelha, Almeida, Castelo Novo, Idanha-a-Velha, Monsanto, Piódão, among others.

4. CHARACTERISTICS OF RURAL HOUSING IN COVA DA BEIRA

The rural construction is normally very diverse, from Region to Region and inside the same Region. It varies in its characteristics and materials, as well as in its quality. For example, in Minho, Trás-os-Montes, Beira Baixa and Beira Alta the application of apparent stone, the construction of verandas, sheds and roof-edges is very usual.

In Baixo Alentejo, Ribatejo and Algarve the application of adobe, pug, brick (and later, cement block), lime washing of walls, coating of the ceilings with reed, artistic tracery of the chimneys predominate, among other aspects [3].

Figure 4.
Examples of rural housing (isolate and in a village) in Cova da Beira

Figure 4 presents two examples of rural housing in the sub region of Cova da Beira. They are simple houses, which normally do not have the minimum required conditions to live in with the necessary thermal-hygrometric comfort.

As to the materials that have been used and to building aspects, in this kind of houses, one must refer to the fact that the foundation is made upon stone, and it is generally very near to the surface, being constituted only by some blocks which permit the contact between the walls and the soil. This superficial foundation, promotes the constant appearance of humidity, which infiltrates the walls of the house by capil-

Figure 5.
Examples of rural housing in Cova da Beira – Paúl

larity. The walls are usually made of ordinary masonry (irregular stone) or regular masonry (rectangular stone) and laid with lime, cement and sand mortar (at least till the first floor).

The most used stone in Cova da Beira is granite. Normally stiffer stones and with a better appearance are chosen and laid on one of the faces. The corners are built using bigger stones (bond stones) to help fixing of the walls. The external walls are plastered first with clay and after that with lime and sand mortar, and may be lime whitened or painted in the outside finishing. Brick masonry is also used to build the external walls of the first floor and the mud wall, both for external and partition walls. Another common material used in this kind of houses is timber. It is used in the construction of wooden floors, supported by wooden beams, and attics and roofing that are coated with ceramic tiles.

In Paul, a village located in Cova da Beira, 12 km distant from Covilhã, there are rural houses (Figure 5) with a particular form of construction of external walls. Near the local stream bed there exist very stiff granite pebbles (cobble stones), with spherical or ovoid shapes. These materials have been used to build the walls of the old houses in the village and also sidewalks, laid with mortars of sand of red clay, which predominates in place. Pebbles were broken in middles to compose the walls, which finally get an original shape, marked also by the application of schist or granite flagstones, forming the windows frames. The common tile of roofing is Portuguese tile and the timber that is used for wooden floors and roof structures is chestnut or pine, which are abundant materials in this region.

In the village of Casegas, 20 km distant from Covilhã (near Paúl), the prefered building material for walls is schist, which predominates in the place, where, due to their geological constitution, very ancient schist fields prevail. In these houses (Figure 6), the stability of the schist walls is reinforced with lintels and corners of granite inserted in current masonry. Only in some privileged places is it possible to extract a stone for a door or window frame from a piece of schist. This difficulty has imposed the use of thin-grained granite in this area. Although the use of granite in the windows and doors frames is the most common situation, timber is also used instead. The roofing is made of ceramic tile, fixed to a timber structure, and stones are put on them in order to avoid the wind effect.

Figure 6.
Examples of rural houses in Cova da Beira – Casegas

Another example of rural housing in Cova da Beira can be seen in the village of Sobral de São Miguel. Most of the constructions are in schist masonry (dominant in the geologic composition of this place), and the roofing is made with slate flagstones. Schist replaces granite because it is easier to stock it locally being granites only used for the richest houses in the village. Schist is used almost exclusively in its extraction natural forms, in masonry walls, much less stable than the granite ones, or in simple roofing of poor

Figure 7.
Other examples of rural houses in Cova da Beira

buildings, being the flagstones fixed to a timber structure. The lintels of the doors and windows are made of solid and lasting timber, almost always chestnut timber, which looks very similar to schist, throughout the years. Others examples of rural houses (Figure 7) may be found in rural agglomerates in the region of Cova da Beira. Unhais da Serra, Sarzedo, Barroca or Janeiro de Cima are some of this examples.

5. STUDY ON THE STATE OF DEGRADATION OF A SET OF RURAL HOUSES LOCATED IN COVA DA BEIRA

The development of this multidisciplinary social-housing project involved the study of a group of 74 families distributed among 7 villages of a council with rural characteristics, located at the interior centre of Portugal. One of the main axes of the project was to intervene in the buildings with the objective to provide basic living conditions

To accomplish such objective, a study was made by the technical team of the Architecture and Civil Engineering Department of University of Beira Interior (U.B.I.) participating in the project with the priority to evaluate and make the characterization of the houses internal and external conditions and establish house ranking that would set the intervention priorities.

5.1. Adopted Methodology
5.1.1. Inspection and Diagnosis

The preliminary visit to the places and houses being the object of study demonstrated that the group of houses had diversified characteristics. The houses presented a low level of construction quality and living conditions. For that reason, a methodology to pick up data oriented specifically for the sample study object was developed. Obviously, this methodology is very different from the other methodologies that are usually adopted for buildings of medium quality [4,5,6]. It was also concluded that most of the houses under analysis were single-family houses, having a mainly rural architecture, and built with the use of local building materials, usually not being the subject to periodic maintenance works.

During the development of this new methodology [7] it has been established the necessity of organising the data gathering has been agreed in order to get three information levels:

a) HOUSING SURVEY – This inquiry "picks up" detailed information on the house type. It collects elements for characterization of the house, occupation regime, infrastructures and available equipments and main internal and external anomalies. The objective of this inquiry was, fundamentally, to know the houses general conditions and to provide the statistical treatment of this type of information.

b) OPINION SURVEY – Its objective was to gather the opinions of the residents as to their house. It intends to confront their opinion relatively to the general requirements of comfort and living conditions that are defined by regulations and to detect eventual anomalies or systematic disconformities in respect to that. This inquiry can help to define intervention priorities based on resident's expectations with respect to their comfort and living conditions.

c) DIAGNOSIS SURVEY – Through this last indicator it was intended to get a technical evaluation of the situation. Having as an objective the quantitative study of the quality of the houses and of their conservation/degradation conditions, the filling form that has been created assumes the existence of 33 observation points. The defined structure permits to know the building in three main aspects: external conditions, structural situation and interior living conditions. The possibility of not being possible to evaluate the house in its totality is assumed then, remaining, even so, the possibility of a partial evaluation. In this diagnosis

Figure 8.
Examples of analysed rural houses

filling form, the external evaluation has been subdivided in 4 main areas: roof, external walls, window system and pluvial drainage system, a total of 14 observation points.

The evaluation of the structural situation system includes 5 observation points.

The evaluation of the internal situation includes the observation of 14 points, including evaluation of constructive anomalies, safety conditions, living conditions, basic available sanitary infrastructure and occupation conditions.

The survey of house detailed construction considers the graduation of all inspected points (elements) in 4 levels, being accompanied by an auxiliary record of graduation created for the effect, describing the evaluation conditions of each one and the respective classification. It is intended with this auxiliary document that the analysis is rigorous and technically based, avoiding subjective appreciations.

Since this kind of inspection has a remarkable technical character it is obvious that its should be performed qualified and technically informed personnel.

5.1.2. Evaluation and production of complementary information

The application of the house detailed conditions survey resulted in two main documents: a record of house individual analysis and a record of global analysis for the group of houses.

These two records were specifically created to give the inter-disciplinary project intervenient partners a working document, easily understandable, that objectively helps the intervention decisions for each house.

5.1.3. Record of individual house analysis

The record of results relative to each inspected house, as presented in figure 2, includes an identification code and a picture for each house. In this record, the treatment of collected data is organized in such a way that gives the possibility to analyse needs of immediate intervention and state of house conservation.

5.1.3.1. 1st Analysis – Needs of immediate intervention

The 1st analysis is the primary “screen” of the detected anomalies. Its objective is to evaluate an immediate intervention to be done, whenever people's and goods safety is at risk or whenever minimum living conditions are not guaranteed.

The 1st analysis gives clear indicators of risk alert. These indicators are organized on 4 levels, which reflect the degree of severity of the conditions found in each house, for decreasing order of importance, as follows:

- Level 1.1 - Structural safety (5 checking points): To intervene whenever the ruin is eminent;
- Level 1.2 – Utilisation safety conditions (3 checking points): To intervene whenever conditions of safety related to gases extraction or electrical system are seriously deficient;
- Level 1.3 – Water penetration (1 checking point): To intervene whenever serious problems of water infiltration exist;
- Level 1.4 – Living conditions (3 checking points): To intervene whenever public water supply, domestic sewers and sanitary facilities are inexistent as well as in cases where the house is over occupied (more than one family or inadequate bed room sharing).

Whenever one of these checking points is recorded by the inquirer, an alert and intervention information is immediately available and highlighted. For example, if risk of eminent ruin is indicated in the checking point corresponding to the diagnosis of the structural elements, this will highlight the respective alert indicator.

Furthermore, as complement of each one of the alert indicators, the respective corrective actions are immediately presented.

5.1.3.2. 2nd Analysis – Level of conservation of the house

A resulting graphical analysis of the state of conservation of the building is supplied, in agreement with 3 evaluation levels:

- Level 2.1 – External envelope quality level;
- Level 2.2 - External envelope and structural quality level;
- Level 2.3 - Global quality level (external, structural and internal).

The graphical analysis results are estimated based on weight factors, considering the different checking points of survey and diagnosis phase. The weight factors were established in an empirical way, based on the number of inspection points and the consequences of different house construction anomalies and its expected effect on the evolution of the conservation conditions and global behaviour of the house. The weight factors give more importance to the consequences of the eventual problems on the roof, the defects of pluvial water drainage and the structural anomalies in the evolution of the state of degradation of the house, as thus have higher relative weight as to other aspects.

As it can be verified this methodology of individual house analysis is progressive. It considers the inspection points and depends on the possibility of visiting or not the interior of the house. In this last case, the external situation of the house prevails.

5.1.4. Record of global house analysis

As it was referred previously it is intended that intervention decisions would be objective and based on documents of easy interpretation and use, although essentially technically based.

To accomplish this objective a global analysis record, which allows comparison of all studied houses and

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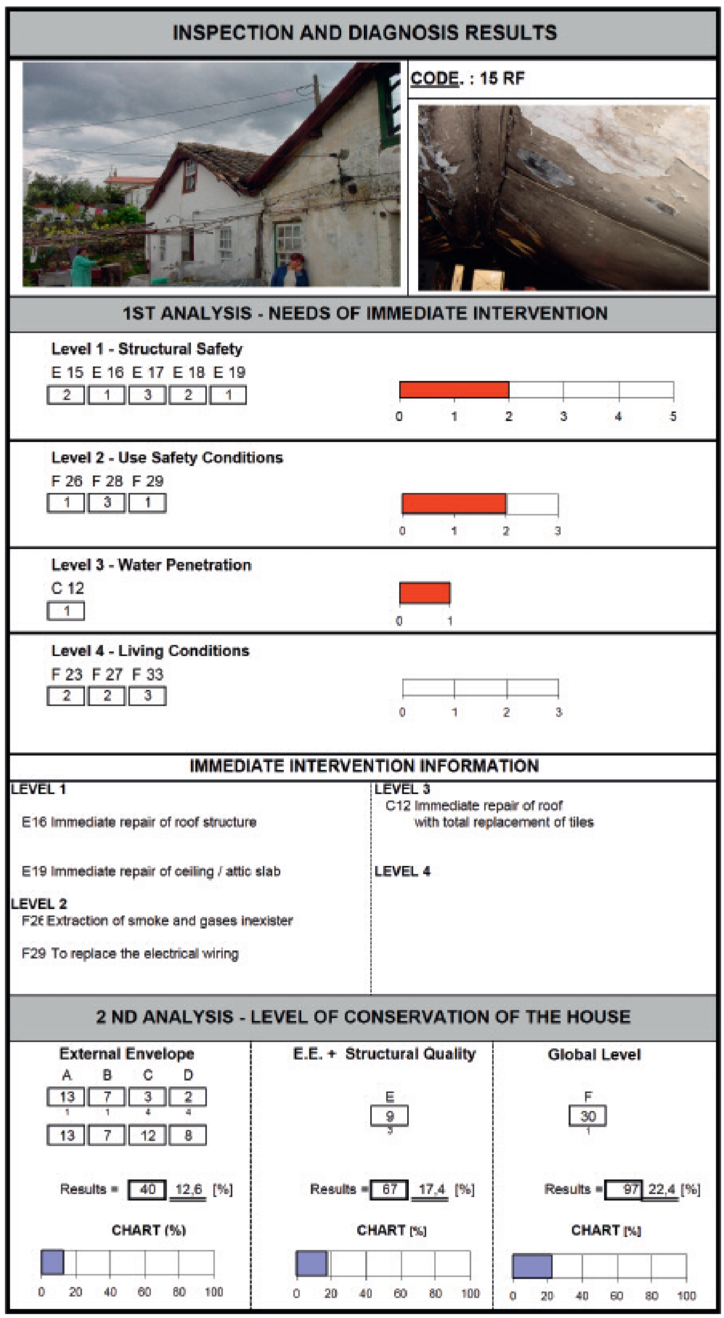

b

Global House Analysis

CÓD.	E					F			C	F			EXT		E+E		Glo	
	15	16	17	18	19	26	28	29	12	23	27	33	Res	%	Res	%	Res	%
15 RF													40	12,6	67	17,4	97	22,4
49 TGp													40	12,6	76	24,2	105	27
30 RJF													41	13,8	68	18,2	101	24,7
12 RF													59	34,5	104	45,5	138	46
48 TGp													39	11,5	87	32,6	114	32,2
54 RGp													49	23	82	28,8	103	25,9
19 RJF													34	5,75	64	15,2	80	12,6
40 RJFg													50	24,1	92	36,4	123	37,4
28 RJF													51	25,3	96	39,4	131	42
52 TGp													60	35,6	111	50,8	136	44,8
25 RJF													79	57,5	136	69,7	175	67,2
09 RCp													83	62,1	140	72,7	176	67,8
35 RLb													33	4,6	87	3,6	126	39,1
51 TGp													58	33,3	115	53,8	151	53,4
45 TGp													61	36,8	118	56,1	155	55,7
21 RJF													80	58,6	137	70,5	183	71,8
44 TGp													47	21	92	36	129	41
27 RJF													62	37,9	122	59,1	166	62,1
55 RGp													37	9,2	88	33,3	128	40,2
20 RJF													59	34,5	101	43,2	133	43,1
17 RF													63	39,1	105	46,2	139	46,6
42 TGp													78	56,3	123	59,8	156	56,3
26 RJF													64	40,2	115	53,8	158	57,5
04 RCp													63	39,1	117	55,3	159	58
03 RCp													68	44,8	122	59,1	161	59,2
10 RF													63	39,1	114	53	164	60,9
13 RF													63	39,1	114	53	164	60,9
56 RGp													74	51,7	125	61,4	166	62,1
38 TSC													70	47,1	121	58,3	170	64,4
01 RCp													70	47,1	127	62,9	172	65,5
05 RCp													68	44,8	128	63,6	174	66,7
22 RJF													76	54	136	69,7	177	68,4
33 RLb													83,2	62,1	134	68,2	178	69
57 RGp													90	70,1	144	75,8	178	69
46 TGp													94	75	154	83	195	79
58 RGp													98	79,3	158	86,4	203	83,3
6 RCp													60	35,6	99	41,7	135	44,3
14 RF													43	16,1	88	33,3	126	39,1
16 RF													64	40	115	54	157	57
39 TSC													55	29,9	100	42,4	150	52,9
24 RJF													61	36,8	115	53,8	161	59,2
34 RLb													64	40,2	118	56,1	165	61,5
43 TGp													70	47,1	130	65,2	172	65,5
47 TGp													84	63	135	69	185	73
32 TRLb													90	70,1	141	73,5	193	77,6
02 RCp													87	66,7	144	75,8	197	79,9
53 TGp													90	70,1	147	78	198	80,5
59 RGp													96	77	150	80,3	204	83,9

Figure 9.
Example of an individual filling form (left – a) and of the global filling form (right – b)

gives relative graduation between then, was produced. This makes possible the definition of the intervention priorities.

The elaboration of this record, that establishes the ranking of the houses in the same way, considers the levels of 1st analysis of immediate intervention as well as the levels of 2nd analysis.

5.2. Results

– After analysing the global filling form of the 74 inspected rural houses it has been concluded that 54 of them (73% of the total) have immediate

intervention needs, which reveals the high state of degradation of the group of houses and shows that the care with the definition of the most adequate methodology have been adequate, before the expected results.
- The main problems detected in using houses are the inexistence of any sanitary installation (43% of the cases) and to the handicaps detected in the kitchens (42% of the cases). In case of kitchens, the inexistence of chimneys or domes to extract smokes and gases is common.
- The opinion survey has shown that humidity, thermal comfort conditions and, mainly, the non-efficiency of warming systems are the main worries of the residents. No kind of sensitivity to noise or bad-smell problems has been observed.

This methodology has also been successfully applied in the project of rehabilitation of houses developed some years after this initial study in the parish of Cantar Galo, Covilhã.

6. THE INTERVENTION ON THE REHABILITATION OF RURAL HOUSES AS A CONTRIBUTION TO THE SUSTAINABLE CONSTRUCTION

The obtained results reflect the need to study further the global situation of the rural type of houses. It seems evident that, besides natural degradation of the constructive elements, great deficiencies in the use of the houses were verified, above all for lack of the residents' information. It will be opportune to develop some activities that would complement the simple actions of constructive rehabilitation, such as:
- Create a guide to use the house properly;
- Give basic notions on use of kitchens and sanitary facilities;
- Explain the causes of more common degradation of the houses;
- Develop awareness of hygiene habits;
- Implement integrated housing pilot program destined to study new house solutions to the aged rural populations.

In Portugal a very significant number of this type of houses exists, usually in bad state of conservation and for that reason it is necessary to develop in the future this kind of measures that may have a great impact on the populations.

The investigation on the field of rural houses rehabilitation must also be a priority. It must consider, among others, the study of new solutions to improve the quality of this kind of construction and, particularly, improve the hygrometric and thermal comfort of these houses.

Some ideas follow, as a conclusion of this work, so that the investigation and intervention on the rehabilitation of rural houses may be carried out from the perspective of Sustainable Construction:
1. To improve the thermal and hygrometric comfort of these houses must be one of the main priorities of investigation and intervention.
2. To study new solutions to improve the thermal behaviour of ground floors, masonry walls and timber roofing structures. Obviously, those solutions must be cheap so that the rural population may adopt them and they must be adequate to this kind of construction. To study their combination with the traditional heating systems and with new heating solutions, more ecologic and with renewable power supply (particularly geothermal and solar power).
3. To study new constructive and architectural solutions so that the heat losses are less important but thermal inertia and the solar gains be improved, namely with more openings in the south quadrants.
4. To take advantage of the existence of trees in the rural environment to ventilate and cool the houses must also be a theme to develop.
5. To study solutions to rehabilitate the houses in order to prevent the infiltration of water through the roofing, walls and pavements, in a lasting way, in particular to eliminate the ascensional humidity and the problems of infiltration through the door and windows frames, which are very common in this kind of houses.
6. To promote the use of the traditional materials, as far as possible, in the rehabilitation solutions.
7. To act carefully in the demolitions. Many rural houses may be demolished, due to its state of deterioration. Thus, the existence of adequate municipal infrastructures must be promoted, to reuse and increase the value of the wastes produced in the demolitions. [8]
8. To study solutions to separate the waste produced during the demolition and store it accordingly to its origin. To use deconstruction and disassembly techniques instead of making massive demolitions. [8]
9. To forbid the incineration of construction wastes or the deposition of contaminant substances in the general sanitation infrastructures and control the harmful emissions: noise, dust, water (leakage

Figure 10.
Examples of rehabilitated rural houses in Portugal

or waste water), etc. to minimize the environmental impact in the demolition phase. [8]

10. To execute rehabilitation works by accomplishing the duties, regulations and environmental laws, guarantee taking of safety and health measures assumed by the regulation and take the actions of

quality control needed to guarantee a good final quality.

11. To have specialised personnel in the assembly of pre-fabricated or industrialised building systems to guarantee their good functioning and durability.
12. To plan and control the execution of works so that the product wasting may be avoided.
13. To take advantage of the existence of demolition materials and smashed petro wastes to do drainage works or under-basis pavements. To separate the waste produced during the demolitions and store them in different boxes, accordingly to their origins. [8]
14. To respect the rural environment, obliging the contractor to declare the volume of waste produced and to specify its final destiny, as an indirect way of promoting the elimination of wastes, the adequate management of the wastes and avoiding the deposition of wastes in non-controlled places.
15. To promote the use of equipments and auxiliary execution elements reusable and with low gases or noise emission levels and to control the harmful emissions in the phase of construction.
16. To avoid the application or production of work materials waste potentially dangerous: welding products, bitumen or asbestos mastics, preserving biologic agents (germicides, antioxidants, creosote), paintings and varnishes (waste), lead-based paints, diverse chemical products (anticorrosion, fungicides, insecticides, solvents, diluents, acids, abrasives, detergents, etc.) [8]

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