Technical Inspection and Intervention Proposals for The Rehabilitation of a Multifamily Housing Building of the Decade of 60 of Last Century in Portugal

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Technical Inspection and Intervention Proposals for The Rehabilitation of a Multifamily Housing Building of the Decade of 60 of Last Century in Portugal

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Abstract. The Portuguese housing park, especially in what concerns to older buildings, is very degraded due to the lack of maintenance over the years, resulting in the depopulation of many historical centres of the country. The specialists usually characterize the housing park in different construction times, being based on the regulation and the implementation of different trends and technological evolutions in construction. In Portugal, the 60's decade of the twentieth century stands out by the construction of a significant number of multifamily residential buildings with a resistant reticulated structure and without concerns from the point of view of thermal behaviour. In this work, the case study of a multifamily building of the construction period mentioned previously, located in the city of Covilhã, in central Portugal, is presented. The analysis of the case study is divided into two main stages: technical inspection of the building and identification of intervention proposals based on the analysis of detected constructive fragilities. In the first phase of the study a technical inspection sheet adapted to multifamily buildings was created and applied, accompanied by a survey of the residents, in order to know the occupancy conditions, the sensitivity and the expectations about intervention. In addition, a thermal analysis was carried out with the support of thermography, data analysis of temperature and relative humidity measurements performed at certain periods of time and thermal quality evaluation based on the calculation methodologies for the energy certification of fractions. After analysing all the elements registered in the first phase of the case study, it was possible to propose duly substantiated intervention measures with the main concern of creating better access, use and comfort conditions.

1. Introduction

Urban rehabilitation has been increasing over the last few years, due to the need for intervention in old buildings both in Portugal and in Europe. The main types of intervention are to maintain architectural / urban heritage, improve conditions of use and comfort, and solve existing pathologies, physical and environmental deficiencies, representing a good alternative to new construction.

According to the Census 2001 in Portugal there are about 956.752 buildings in need of repair, of which 156.093 (46.8%) belong to the 1960s. The 1960s represent the beginning of large-scale construction of reinforced concrete structures in Portugal. This material significantly changed building and architectural solutions that were previously thought impossible. However, buildings are not

exempt from deterioration over their lifespan, usually estimated around 50 years. On the other hand, there are a significant number of buildings with reticulated structure in reinforced concrete and without concerns from the point of view of thermal behaviour and accessibility. For this reason, it is fundamental to carry out rehabilitation, since the current built park lacks this type of intervention. In this work, we intend to understand the main needs of the residents, to facilitate the inspection technique and to raise an alert to the lack of maintenance of these buildings.

2. Multifamily buildings inspection methodologies

2.1. Technical Inspection Checklist

The creation of the technical inspection checklist has as main objectives to assess the state of conservation of the building (EC) from a scale of 1 to 4, the extension of intervention (EI) that can be classified as: no need for intervention (SNI), localized, medium and extensive and perform the survey of materials, coatings, dimensions, among other parameters. The information sheet on the general infrastructures, the accessibilities and the conditions of fire safety is also included.

The significance of the scale used for the conservation status differs along the sheet, as does the extent of intervention depending on the element and / or sub element to be assessed.

The technical inspection checklist consists of the following components:

1. General information and building identification;
2. External evaluation;
3. Assessment of common zone and circulation;
4. Internal evaluation, which is subdivided into:
    - 4.1. Internal assessment- General;
    - 4.2. Internal assessment- Circulations and hall;
    - 4.3. Internal assessment- Kitchen;
    - 4.4. Internal assessment- Sanitary facilities;
    - 4.5. Internal assessment- Rooms and Rooms;
    - 4.6. Internal assessment- Other locations.

1. General information and building identification - This first sheet is intended to collect information on inspection, technical, building-related data and other data that may be supplemented by observations and photographic surveys.
2. External assessment - In the external evaluation, the objective is to evaluate the state of conservation of the external environment and the general infrastructures of the building under study and the extent of the necessary interventions. It is important to note that many anomalies present inside the dwellings result from the exterior anomalies. Take for example infiltrations that are more common on the roof or walls.
3. Assessment of common zone and circulation - The "common zone and circulation" sheet corresponds to the common interior in multifamily buildings. From the same point of view of the external evaluation, the state of conservation and extension of intervention is evaluated, the existing materials and the requirements related to general infrastructures are surveyed.
4. Internal Assessment - The first sheet concerns the identification of housing and the state of conservation of the elements common to all compartments. Similar to the previous sheets, for each compartment a survey of existing materials, general infrastructures and accessibility is carried out, evaluating the conservation status (EC) and the extent of intervention (EI).

2.2. Resident Survey

In the work previously developed [2], similar to the previously presented checklist, it was necessary to adapt a survey to be carried out to the residents. The main objective is to collect information about the profile and sensitivity of the occupants / users with regard to the knowledge of the problems that may

arise in their dwelling and the condition of use. In addition, it is important to collect information on past interventions and type of interventions that are to be undertaken in the near future.

The resident survey (Figure 1) consists of groups of questions from 1 to 15, with the aim of obtaining information on the conditions of occupation and degree of satisfaction:

1. Identification;
2. Residents;
3. Occupation;
4. Degree of satisfaction;
5. General activities;
6. General infrastructures;
7. Information on anomalies;
8. Conditions of use Kitchen;
9. Conditions of use Sanitary Installation;
10. Terms of use
11. Conditions of use Room;
12. Other equipment;
13. Relationship with neighbours;
14. Repair intervention;
15. Comments and suggestions;

2.3. Application to existing building

The supporting documents described above were applied to a case study (Figure 2). It is a multifamily building from the 60's, located in the city of Covilhã, Portugal, consisting of low-income public housing promoted by the former Caixa Sindical de Previdência. For the analysis of the information gathered, the building was divided into two blocks.

With the help of the technical inspection checklist, the survey was carried out in external elements, common zones and circulations and also in 12 apartments, assessing the constructive elements of the envelope, main general infrastructures, accessibility and the state of conservation was evaluated. Through the resident's survey, occupancy and use, data were collected in the same 12 apartments. The synthesis of the information collected through the methodologies described above is available in the master's thesis entitled "Inspection and Rehabilitation of a multi-family building from the 60's in Covilhã" [1] and the methodology of data analysis based on some previous research works [2,3].

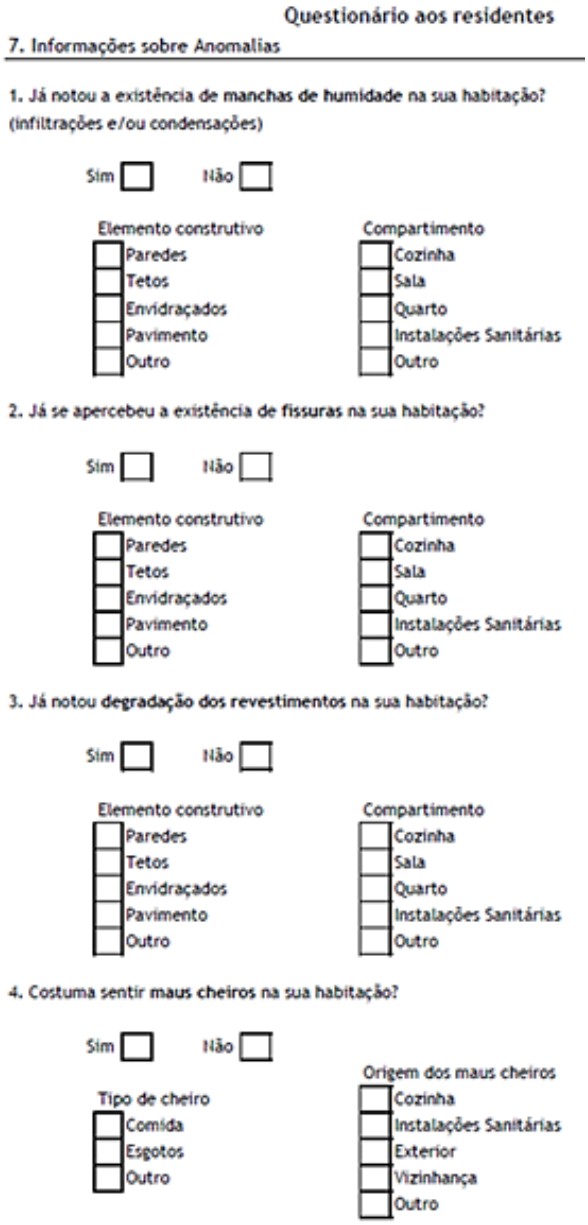
It can be concluded that the building under study has been poorly maintained over the years. Taking into account all the analysis performed, it is verified that the thermal discomfort is the most serious problem and that it is urgent to solve.

In a first approach, it was found that the infrastructures do not comply with the technical regulation. It was also found that all residents had made new plumbing of the water supply network and had changed the electrical panel recently. The individual counters (water and electricity) exist, however, are located inside the apartment, which makes it impossible for the intervention of the concessionaires in case of anomaly. As for the common facilities, in both blocks the building collector for domestic wastewater was altered. It should be noted that gas installations have been recently carried out and in compliance with technical regulations.

The telecommunication facilities do not comply in any way with the required technical regulations. In this way, there is a need to make a new installation, in accordance with the legislation, for better operation and comfort of its users. Since it is an old building, accessibilities are not in accordance with the technical regulations, namely the lack of access ramp to the building, the dimensions of the stairs and handrail. In the first phase, it is necessary to create ramps and improve the stair handrail.

The most obvious anomalies related to the appearance are associated with humidity and lack of maintenance. In general, the state of conservation of the apartments is satisfactory, since residents who are almost entirely owners are careful to maintain and rehabilitate some spaces, namely kitchens and

toilets. Nevertheless, it is the worst ranked compartments, similar to the corridors and hall, due to the non-compliance of the general infrastructures. The apartment in worse state of conservation is property of the Municipality that according to the residents only solves problems of serious operation of general infrastructures.



Questionário aos residentes

7. Informações sobre Anomalias

1. Já notou a existência de manchas de humidade na sua habitação? (infiltrações e/ou condensações)

Sim ☐ Não ☐

Elemento construtivo
- ☐ Paredes
- ☐ Tetos
- ☐ Envidraçados
- ☐ Pavimento
- ☐ Outro

Compartimento
- ☐ Cozinha
- ☐ Sala
- ☐ Quarto
- ☐ Instalações Sanitárias
- ☐ Outro

2. Já se apercebeu a existência de fissuras na sua habitação?

Sim ☐ Não ☐

Elemento construtivo
- ☐ Paredes
- ☐ Tetos
- ☐ Envidraçados
- ☐ Pavimento
- ☐ Outro

Compartimento
- ☐ Cozinha
- ☐ Sala
- ☐ Quarto
- ☐ Instalações Sanitárias
- ☐ Outro

3. Já notou degradação dos revestimentos na sua habitação?

Sim ☐ Não ☐

Elemento construtivo
- ☐ Paredes
- ☐ Tetos
- ☐ Envidraçados
- ☐ Pavimento
- ☐ Outro

Compartimento
- ☐ Cozinha
- ☐ Sala
- ☐ Quarto
- ☐ Instalações Sanitárias
- ☐ Outro

4. Costuma sentir maus cheiros na sua habitação?

Sim ☐ Não ☐

Tipo de cheiro
- ☐ Comida
- ☐ Esgotos
- ☐ Outro

Origem dos maus cheiros
- ☐ Cozinha
- ☐ Instalações Sanitárias
- ☐ Exterior
- ☐ Vizinhança
- ☐ Outro

Figure 1. Example of part of the resident survey

According to the analysis of the technical inspection checklist, there is condensation, mainly in the kitchen and sanitary installations. The lack of ventilation is common to all apartments, so it is necessary to improve indoor air quality, so that the conditions of thermal insulation can be improved without increasing the condensation. After the interviews, it was realized that the majority of the residents are over 61 years old. Most have resided in the building since its inauguration or have occupied the apartment during the first five years in use. In this conversation, they were found to be dissatisfied with the thermal discomfort of the dwellings.

Figure 2. Main facade of the building under study

However, they are also accommodated and not open to many changes, due to the inconvenience caused by the works, which can be explained by financial reasons. The occupants are dissatisfied with the secondary entrance due to its degradation. In block 1, the common areas and circulations present some anomalies at the level of the lining that bothers the residents. The use of portable heating equipment is avoided due to the high price of the electricity bill. Due to age and difficulty of locomotion the installation of an elevator, for most, would be of great help.

Taking into account the entire inspection methodology used throughout this section, the intervention needs were identified in order to establish priorities.

3. Measurements and thermal analysis of different apartments

3.1. Thermography

The thermographic analysis allowed us to prove the main constructive weaknesses of the external envelope, namely the flat thermal bridges (beams, pillars and shutters), the linear thermal bridges in the glazed spans, mainly sill and lintel, roofing slab and intermediate floor slabs. In Figure 3 some examples of the thermograms are shown where the fragilities previously mentioned are detected.

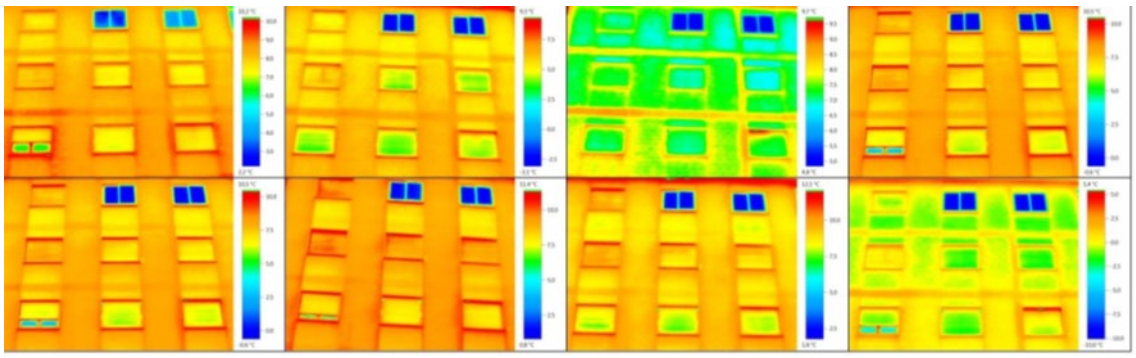


Figure 3. Examples of thermograms - Main facade

During two inspection periods with the help of thermography, it was verified that:

- The fraction which is a coffee shop presents temperatures superior to the rest of the façade, and thus transmits it to the ground floor;
- The rear façade is warmer when measured at night, due to the use of the kitchen;
- In the case of sanitary facilities, they are warmer during the morning;
- During interviews with residents it was found that people only warm up some compartments, especially at night, which have been proven by thermography;
- It was verified that some apartments are not occupied, allowing to confirm the occupancy rate.

3.2. Continuous temperature and relative humidity measurements

In a complementary way, continuous measurements of temperature and relative humidity were carried out in the winter and summer seasons. Relative data from May to July 2015 and from January to March 2016 be provided under Project 6.60.6 - Experimental Campaign [4] and values from July to September 2016 were measured in block 1 in order to complement the information.

In continuous measurements of temperature and relative humidity over different periods of time, it was concluded that in none of the apartments the temperature is between the stipulated values of 18ºC for winter and 24ºC for summer. Temperatures higher than 30ºC were recorded in summer and less than 10ºC in winter inside the apartment. The relative humidity should be between 35% and 85%. However, in the summer season, values were below 35% and winter values above 85%. It is concluded that the conditions within the apartments do not correspond to the requirements and cause discomfort for the occupants by confirming in practice the data obtained in the thermal calculation and the data collected in the surveys. 2 equipment were placed on attic over the last apartment and verified greenhouse effect due to the large thermal amplitudes. The maximum temperature recorded corresponds to 45,9 ºC in July and 12,4 ºC of minimum in September.

3.3. Thermal analysis of different apartments

From the technical point of view, energy certificates of all apartments were obtained and the respective energy classes are shown in Figure 4.

Figure 4. Energy classes of the fractions (Example Fraction A - Energetic Class D)

Table 1 shows the results of the calculations performed. In all apartments, the values of nominal energy needs for heating (Nic) and the annual nominal primary energy needs (Ntc) are higher than the regulatory reference value for Portugal. However, the values of nominal energy needs for cooling (Nvc) are below the reference values, with the exception of apartment I.

Table 1. Values for Nic, Nvc, Ntc, Ntc/Nt and energetic class of apartments

Apart.	Nic		Nvc		Ntc		Ntc/Nt	Energetic Class
	Value	Ref	Value	Ref	Value	Ref		
A	168.17	79.65	3.01	13.68	535.45	314.06	1.71	**D**
B	154.20	64.28	6.25		496.11	271.65	1.83	
G	308.46	93.21	11.49		881.89	344.07	2.56	**F**
H	182.70	78.60	2.73		571.78	311.42	1.84	**D**
C	112.99	53.43	3.52	13.68	397.51	248.58	1.60	**D**
D	123.32	62.24	10.15		426.00	265.33	1.61	
I	116.50	61.23	14.03		409.65	260.51	1.57	
J	107.39	53.65	3.17		383.50	249.06	1.54	
K	119.59	59.09	12.58		416.16	225.19	1.63	
M	109.51	52.80	5.20		384.39	242.95	1.58	
N	106.46	52.34	3.96		381.18	245.79	1.55	
O	140.71	70.72	8.44		464.01	289.20	1.60	
E	246.65	84.67	12.91	13.68	731.64	326.61	2.24	**E**
F	229.60	67.52	12.17		684.59	279.74	2.45	
L	259.59	78.68	14.73		761.21	309.11	2.46	
P	387.48	98.84	18.70		1079.42	358.15	3.01	**F**

As can be observed, the heaviest energy classes are located on the top floor (Table 1), because they are in contact with the attic, heavily ventilated and without thermal insulation. On the ground floor, the apartments with the lowest rating are in contact with non-useful space (ENU), namely the coffee shop, support store and a shop.

It should be noted that fraction B, despite being geometrically identical to fraction G, is in contact with unusable space ENU (box of stairs) and useable space EU (T1 type apartment). On the contrary, the whole fraction G is in contact with two unusable spaces ENU (staircase and coffee storeroom) that do not have any type of insulation. As for apartments of typology T3, similar values are observed, although the H fraction has slightly higher values.

Intermediate fractions present lower and similar values. It is evident that T3 apartments have lower values, since they only have two facades in contact with the exterior, as opposed to the larger apartments that have three. During the analysis, it was observed that the apartments with a sunroom have advantage over open balconies, because the atmospheric conditions outside are more burdensome than in the unusable space ENU.

The values of Nic, Nvc and Ntc of apartments D, I, K and O are higher because their envelope is defined by the two types of wall (PRE1 and PRE2) and in turn, PRE2 has a higher coefficient of thermal transmission (2.15 W / (m2.h)).

The last floor corresponds to the most serious situation in the building, in the case of Nvc, the values in fractions E and F are close, although they do not exceed the reference value. In apartments L and P, the values are higher than the reference values. In L, it is verified that the kitchen has been enlarged, so the type of wall present in the outer envelope is the one of smaller thickness (PRE2). Compared with the apartment E that owns the same typology and with a balcony, the ratio between the global needs is higher. In P, in comparison with F, since they have the same typology, it was found that the existence of a balcony exposes the fraction to the exterior and besides, F has double windows. It should be noted that E has a smaller area than F, but it has been found that it needs more energy, since in this case the glazed component consists essentially of simple glass, frame and exterior wood protection, allowing greater losses.

4. Proposals for intervention

After the technical inspection and the residents' opinions were known, there were some priority problems to solve, but the inertia of the residents and the financial limitations may become an

impediment to the execution of works. For this reason, priorities have been established and the intervention work has been proposed.

In the first phase, it is a priority to isolate the exterior envelope of the building (walls, roofing slab and floor), change the glazed spans and their respective solar protections (Figure 5). In order to improve the ventilation, it is intended to install mechanical extractors that work in the chimney on the stove and in the sanitary installations. In addition, implement the first phase of improvement of accessibility, which corresponds to the placement of two ramps at the entrance and another in the main lobby of the building.

The second phase corresponds to the improvement of the existing technical systems (AQS), through the installation of a wall-mounted natural gas boiler in each apartment with a power of 28 kW / h. New water supply facilities and remodel common areas and circulations where it is proposed:

- New coatings (walls, ceilings and floors);
- New handrail;
- Paint glazed window frames;
- New access doors to the building (including mailboxes).

In the third phase, it is intended to improve the indoor temperature and reduce the energy consumed by the users, by placing heating equipment and solar collectors. The previously installed boiler has a power of 22 kW / h for central heating and serves as an aid to solar collectors in order to regulate the desired outlet temperature. The infrastructures to be changed correspond to the electrical and telecommunication installations, taking into account the power required for installation of a lift in the framework of common services.

The second phase of improvement of accessibilities corresponds to the installation of an external lift platform (elevator) and a stair chair that is included in the fourth and last phase of intervention.

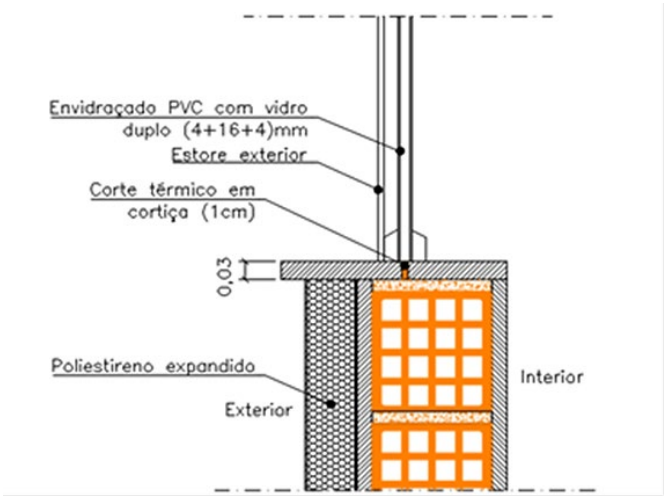


Figure 5. Constructive wall detail with ETICS system, sill and glazing [1]

5. Budget

For the completion of this budget, several entities with different competencies were contacted. After the collection of all necessary prices, a calculation was carried out in the computer program "*Estima*" [2].

The program has a database that has been updated by applying the currency devaluation coefficient of 1.16 [5]. In addition, there were added tasks that were not found in the initial database, with the support prices being provided by specialized entities. Table 2 presents the costs of each of the proposed intervention phases per apartment and the total and partial total cost. Table 2 presents the

costs of each work, the total of each phase, and finally the sum of the cost of all phases and the respective general costs.

Table 2. Description of works and respective costs

	Description of works	Cost (€)
PHASE 1	General charges	73,851.00
	Application of external thermal insulation system with mechanical fastening to the support	49,230.40
	Application of thermal insulation on horizontal attic slab	4,234.00
	Application of false ceiling with thermal insulation	1,213.92
	Replacement of glazed spans, white PVC frames, with double colorless glass (4 + 16 + 4 mm)	48,775.44
	Replacement of shutter in white thermal aluminum	1,867.32
	White opaque curtain / blind placement	109.89
	Replacement of sill in granite with dripping pan	3,489.00
	Ventilation System	7,490.00
	1st phase of intervention in accessibility	6,011.01
	TOTAL OF GENERAL CHARGES AND PHASE 1	**196,271.98**
PHASE 2	Improvement of technical systems (domestic hot water)	32,581.00
	Alteration of the water supply network	6,400.00
	Remodeling of common zones and circulations	30,363.51
	TOTAL OF PHASE 2	**69,344.51**
PHASE 3	Central heating installation	20,732.00
	Installation of solar collectors	32,546.00
	Alteration of electrical installations	42,780.00
	Alteration of telecommunication facilities	16,400.00
	TOTAL OF PHASE 3	**112,450.00**
PH. 4	Plataforma elevatória vertical	72,800.00
	Cadeira de escada interior	42,234.00
	TOTAL OF PHASE 4	**115,034.00**
	TOTAL BUDGET	**493,103.09**

The final price of the intervention corresponds to € 493.103,09. This is a costly price taking into account the residents' opinions on the financial availability for possible interventions. The ground floor will benefit from the intervention solutions, but within the price bracket only apartments are considered. Thus, each T3 apartment will pay 5.25%, which corresponds to 25.875,83 €. Those of T4 typology would pay 7.25%, which corresponds to 35.761,73 €.

6. Conclusions

The rehabilitation processes of existing multifamily buildings should guarantee the main steps such as: recognition of the need for intervention, application of technical inspection checklist, residents' survey, and finally, analysis of the information collected and duly substantiated diagnosis. If necessary to carry out further studies using equipment to complete diagnosis.

Taking into account the case study and the analysis carried out it, is concluded that:

- The studied building is outdated due to the construction period and lack of maintenance over the years;
- Given the era of construction, several factors such as economic conditioning, lack of knowledge and cost of living have dictated the option of ineffective intervention solutions;

- The intervention proposals were applied to the whole building, enabling it to become more comfortable, healthy and safe. However, they were designed in phases, supported by cost / benefit logic, correcting all detected fragilities;
- The opinion of the residents coincides with the technical perspective and the proposed phasing of the interventions. However, the implementation of improvement measures will only find acceptance if there is a short payback period and an awareness of residents towards possible reduction of energy consumption;
- It is important and necessary to make residents aware of the regular maintenance of buildings and of regular technical inspections.

This work was the example of the methodology applied to a building which represents a constructive time with great expression in relation to the total number of existing buildings in Portugal. Representative buildings of an era that today are located in central areas of the urban centres, which have many deficiencies from the point of view of constructive performance and where the most vulnerable sections of the population live, often due to their age or their economic situation.

The Portuguese authorities should complement the economic efforts of families by providing funds to support the rehabilitation of existing buildings in order to promote energy efficiency, health, fire safety and accessibility in these older buildings, which deserve to be respected, in the common interest.

Acknowledgment
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