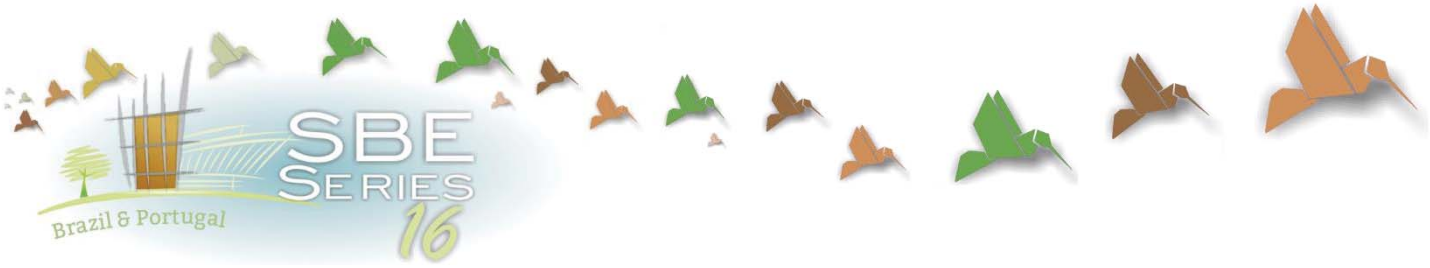

Analysis of the Portuguese building retrofitting market

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ABSTRACT: The Portuguese socio-economic context of the last decades of XX century led to a great investment by the construction industry in new construction. This tendency continued even after the number of buildings had largely overcome the number of families. Nowadays, there are in Portugal more 45% of dwellings than families. On the other hand, the existing buildings were several times built without a proper consideration of important issues, such as thermal comfort, acoustic comfort, ventilation needs, natural lighting, among many others. For these reasons, many Portuguese buildings have big retrofitting needs. This study intends to present a statistical analysis of the Portuguese residential buildings retrofitting needs. Additionally, it was intended to study in what extent the retrofitting works currently being carried out overcome these needs. This analysis was made based on collected data from a survey responded by construction companies operating in Portugal.

Keywords *Retrofitting; Building Market; Construction companies.*

ISBN: 978-85-92631-00-0

1. INTRODUCTION

The number of buildings being built in Portugal has increased substantially from the 70s of the twentieth century. Around 63% (3 544 389) of the existing buildings in 2011 has been built after 1971 (INE & LNEC 2013). Figure 1 presents the number of existing buildings in Portugal sorted by construction period.

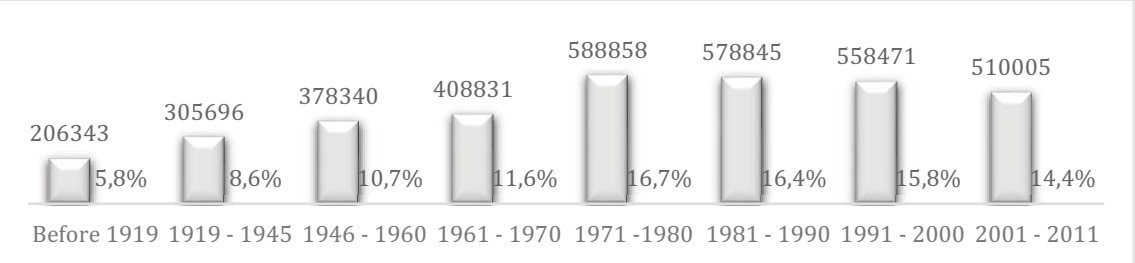

Figure 1. Number of Portuguese buildings sorted by construction period. Adapted from (INE and LNEC, 2013).

The Portuguese building stock can be divided into three main periods: old buildings, constructed before 1960; buildings built between 1960 and 1990 in the period of expansion of reinforced concrete as a structural material (Freitas 2012); and buildings built after 1990 (date of the entrance into force of the first thermal regulation). Figure 2 presents the distribution of the existing buildings for these three periods.

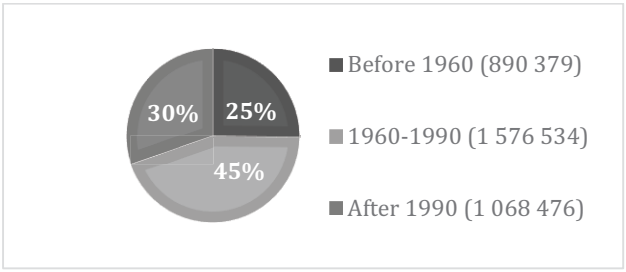

Figure 2. Percentage of Portuguese buildings by period of construction (INE & LNEC 2013).

According to data provided by 2011 census, 1 022 937 Portuguese buildings have retrofitting needs. However, these data only consider the conservation state of the buildings envelope and structure. The number of buildings in need of being retrofitted in order to have a proper level of comfort is however much higher. Additionally, in 2011 there were 1,4 family buildings for each family (4 043 726 families to 5 859 540 family buildings) (INE & LNEC 2013). Thus, both the buildings conservation state as the number of existing buildings clearly demonstrate the need to stop investing in new construction and start to retrofit the existing building stock.

In fact, the Portuguese building sector is already changing and the retrofit operations are increasing. Thus, it is extremely important to analyze the actual building retrofitting needs. It is also important to verify if the retrofitting operations currently being carried out are focused on those needs. In this paper, it is presented an analysis of the Portuguese building retrofitting needs as well as the results of a survey sent to building sector professionals, where the retrofitting activities currently being performed in Portugal have been analyzed.

ISBN: 978-85-92631-00-0

2. PORTUGUESE BUILDINGS RETROFITTING NEEDS

The number of Portuguese buildings with retrofitting needs and the excess of buildings in the Portuguese territory, demonstrates the need to turn the construction market attention from new construction to retrofitting.

It is very important to understand the national buildings conservation state as well as the most common pathologies in the existing buildings. Across the last years, some studies have been developed with this goal (PTPC 2015; Appleton 2003; Freitas 2012; INH & LNEC 2006; Lourenço 2013; Mateus 2013; Saint-Gobain Weber 2013). The problems identified in these studies can be grouped in four main issues: buildings layout; safety; hygiene, health and comfort; and energy efficiency.

2.1 Buildings Layout

The problems related to buildings layout are different according to the building age. In older buildings (mainly on those constructed before the publication of the buildings and urbanizations general regulation – RGEU) the problems are usually more serious. It is common to see pathologies such as an insufficient dimension of staircases, inexistence of service common spaces, inexistence of elevators or space to install them, interior rooms without direct access to exterior, rooms with very small dimensions, etc. (INH & LNEC 2006).

The publication of RGEU has led to the correction of many of these problems and to the assurance of better safety and healthiness conditions. However, after the 70´s the Portuguese building sector faced a boom that led to the construction of many of the existing buildings (Figure 1). However, most of these buildings were constructed without any urban planning concerns and under a high market pressure. The building sector was extremely profitable, the buildings were built in this perspective and without a proper care regarding the construction quality. Therefore, many of these buildings present several layout problems such as ground floors non-protected from exterior views; low natural light availability; lack of storage spaces; absence of cross ventilation, etc. (INH & LNEC 2006).

2.2 Safety

Safety can be divided into four main areas: structural; fire; intrusion; and utilization. The problems related to intrusion and utilization safety are not very relevant in the Portuguese buildings and so they will not be considered in this work.

Structural safety is one of the most important issues in a building. In retrofitting it is more relevant in older buildings. Buildings built before 1960 have more than 50 years and therefore already exceeded the lifespan for which they have been dimensioned. A large part of these buildings are still in use and many of those have been adapted to new user needs. However, in many cases, the structural performance has not been properly adapted (Appleton 2003). After 1960, the reinforced concrete became the dominant structural material in the Portuguese buildings. This has eliminated many of the existing structural problems (rottenness of structural material, disaggregation or crushing).

Decree-Law 220/2008 of November 12 (Legal Regime of Fire Safety in Buildings – RJ-SCIE) defines the criteria with which buildings should comply with fire safety. The buildings built

ISBN: 978-85-92631-00-0

before the RJ-SCIE have several fire safety problems: resistance to fire of the building materials, paths inside the building that do not allow quick access for firefighting, lack of firefighting infrastructures, etc. (INH & LNEC 2006). The buildings built after the publication of the regulation for fire safety should not have problems in what concerns this issue. However, some of them do not fulfill the legislation requirements and thus also have retrofitting needs at this level.

2.3 Hygiene, Health and Comfort

Regarding hygiene, health and comfort, the main problems of Portuguese buildings can be divided in: sanitation of buildings; humidity; thermal comfort; acoustic comfort; and lighting.

After 1951, with the entrance into force of RGEU (Portugal 1951), the majority of the buildings sanitation problems has been resolved. However, several buildings built before the publication of this regulation face some problems such as inexistence of sewage systems, inexistence of drinking water systems, inexistence of sanitary facilities, etc..

The presence of humidity/mould in buildings is a main issue since it is related to the deterioration of building elements, with the salubrity conditions and hygrothermal behavior. The humidity can appear due to different phenomena: construction humidity, ascending from the soil, precipitation or condensation (Appleton 2003). From these, the final three are the main responsible for the Portuguese buildings humidity related pathologies. Problems with humidity from precipitation and ascendant from the soil are more common in older buildings where a proper waterproofing was not applied (Appleton 2003; Lourenço 2013; Saint-Gobain Weber 2013; INE & LNEC 2006). In the case of most recent buildings, this type of situation only occurs in situations of bad construction. The most common humidity problems in recent buildings (those built after 1990, year of the publication of the first Portuguese thermal regulation) are related with condensations (Appleton 2003; Saint-Gobain Weber 2013; INE & LNEC 2006).

Concerning to lighting, Portugal has good conditions to take full advantage of natural light benefits. However, some aspects prevent that to happen: obstructions in front of the windows; bad orientation and inappropriate characteristics of windows; interior rooms without direct access to the exterior, etc. (INE & LNEC 2006). Thus, despite the studies (Buratti et al. 2013; Wu 2003) that prove the importance of natural light to the well-being of the buildings' users and to energy efficiency, there are several problems at this level in the Portuguese buildings.

In 2004, the Portuguese agency for consumers defense (DECO) has performed a study aiming to analyze the buildings acoustic insulation. 27 buildings located in Lisbon and Porto were analyzed. It has been verified that the majority of these buildings presents insufficiencies concerning the acoustic performance (DECO 2004). Before the entrance into force of the Regulation of buildings acoustic requirements in 2002 (subsequently amended for the Decree-Law 96/2008 of June 9) (Portugal 2008), the buildings acoustic insulation was treated as a secondary subject. Around 80% of the Portuguese buildings were built before that. Thus, the majority of those was designed without any care regarding the acoustic performance.

ISBN: 978-85-92631-00-0

According to a study performed in 2003, Portugal is the European country with more winter mortality (Healy 2003). Since Portugal has mild weather, this fact is related to the buildings lack of quality (Lopes 2010). Around 2,5 million Portuguese buildings were built before the publication of the first thermal regulation. Before that, the application of thermal insulation on the envelope was not common. Table 1 presents the number of Portuguese housing with thermal insulation on the envelope.

Table 1. Portuguese housing with thermal insulation. Adapted from (INE & LNEC 2013)

Insulation element	Nº of housing	%
Exterior walls	828 494	21,1
Roof	434 099	17,1

Besides the lack of insulation, the majority of the Portuguese buildings does not have centralized acclimatization systems (INE & LNEC 2013).

2.4 Energy Efficiency

The production and use of energy are two of the main causes of the severe environmental crisis faced by the planet. In the EU-27, 80% of the greenhouse gasses are energy related (EEA 2011). In 2007 the Intergovernmental Panel on Climate Change (IPCC 2007) stated that the biggest portion of growth in carbon emissions was related to the buildings' operation. The building sector is responsible for consuming approximately 32% of the final energy and almost 40% of primary energy in Europe (EU 2010). However, in Portugal, it is estimated that more than 50% of the buildings energy consumption can be reduced through energy efficiency measures (ADENE 2016). This demonstrates the high level of energy inefficiency of the Portuguese buildings.

3. PORTUGUESE BUILDING RETROFITTING WORKS – SURVEY

With the goal of analyzing the Portuguese buildings retrofitting works going on, a survey was conducted. The main questions addressed were the following:

- To what extent is the Portuguese building market focusing on retrofitting?
- What aspects are being considered in the retrofitting process?
- Are these aspects meeting the Portuguese building retrofitting needs?

The survey was sent to professionals currently working, or that have worked in the past 5 years, in a construction company with activity in retrofitting.

3.1 Methodology

The survey was sent by electronic mail to around 700 professionals. 100 responses were received, corresponding to around 14% of the sample. Three answers were not considered valid since the respondents do not work in companies with activity in retrofitting.

The survey has six questions. Three of those were meant to characterize the companies and the other three were intended to provide an answer to the survey's main goal:

- Companies dimension;

ISBN: 978-85-92631-00-0

- Companies' intervention zone;
- Type of buildings usually intervened by the company;
- Percentage of activity dedicated to retrofitting;
- Type of pathologies on which the retrofitting works incur;
- Type of building solutions applied.

3.2 Results

3.2.1 Companies characterization

The majority of answers obtained (61%) belongs to professionals working in micro-companies (less than 10 workers). The remaining responses belong to: small companies (between 10 and 49 workers) -21%; medium companies (between 50 and 249 workers) - 9%; big companies (more than 250 workers) - 9%. It was expected that the majority of responses came from micro companies since those represent the majority of the Portuguese construction companies (Banco de Portugal 2014).

Regarding the companies' intervention zone, it was possible to obtain answers from all regions of Portugal (Figure 3). The regions with more respondents are Estremadura, Minho and Douro Litoral. According to a study performed by the Bank of Portugal, these are the Portuguese regions with the larger number of construction companies (Banco de Portugal 2014).

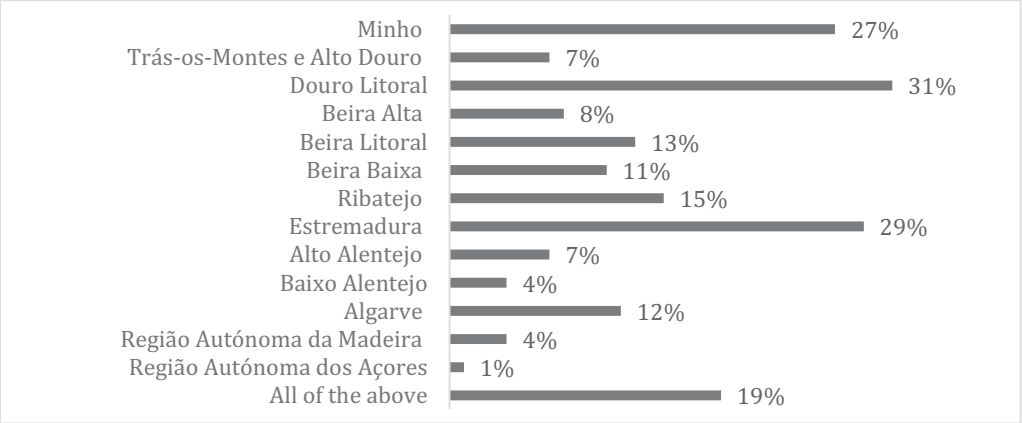

Figure 3. Geographic distribution of the companies' intervention zone.

Figure 4 presents the types of building that are usually the target of the retrofitting works performed by the respondents companies. The majority of companies is essentially focused on residential buildings, the most common type of buildings in Portugal.

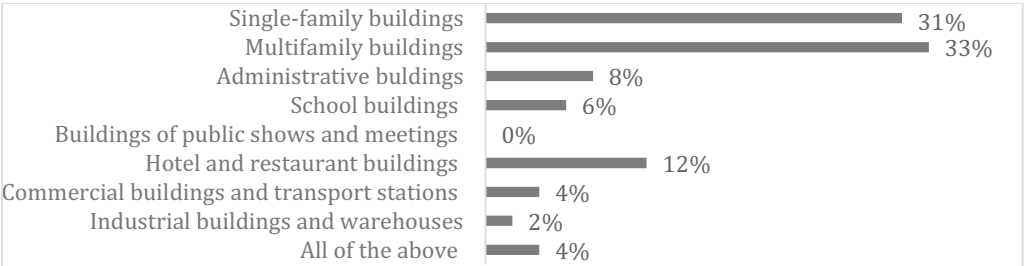

Figure 4. Type of buildings usually intervened by the companies.

ISBN: 978-85-92631-00-0

3.2.2 Retrofitting Works

The 4th question of the survey regards the companies' percentage of activity dedicated to retrofitting. Table 2 presents the mean, median and mode of the obtained results.

Table 2. Statistical data on the companies' percentage of activity dedicated to retrofitting.

Mean	46%
Median	40%
Mode	10%

Taken into account the Portuguese building stock, these values are not the ideal. However, Portugal is a country with a strong construction culture focused on new construction. Thus, the fact that almost half of the construction companies' activities are on retrofitting clearly demonstrates a new tendency.

The results regarding the question about the type of pathologies on which the retrofitting activities usually incur are presented in Figure 5.

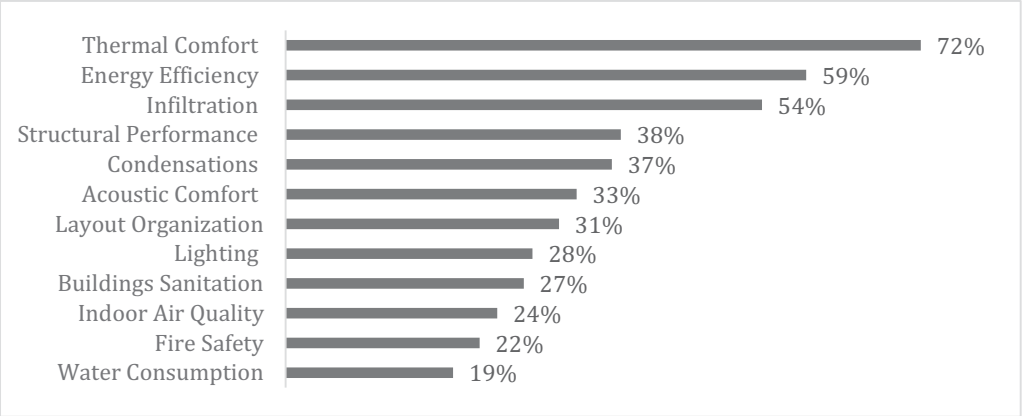

Figure 5. Type of pathologies on which the retrofitting activities incur.

The options with more responses were "Thermal Comfort" and "Energy Efficiency". This could be related to several reasons. The transposition of the EPBD 2002 and 2010 (EU 2010; EU 2002) into the Portuguese legislation motivated deep changes in the construction solutions applied to buildings. It brought to the public discussion questions about these two topics and the population and technical community are now more sensitive to these subjects. Some energy efficiency related programs and financing schemes have been launched in Portugal. Additionally, those are aspects that the population understands as essential to the buildings' comfort and operation costs.

Another issue that interferes with the building energy efficiency are the lighting conditions. The relation between these two subjects is probably the reason why there are 28% of responses on the option "lighting".

The options "Infiltrations" and "Condensations" are also among the most selected. These aspects motivate several problems in the Portuguese buildings and interfere with the building aesthetic, thermal comfort and indoor air quality. These aspects could motivate several building owners to invest in the correction of these problems.

ISBN: 978-85-92631-00-0

The Portuguese building stock has a large amount of old buildings. Thus, it was expected that the structural performance was the goal of a big amount of retrofitting operations. The number of responses on this option could be also related to the programs to support urban regeneration that have been launched in the recent years. Also related to these programs may be the amount of selections on “Layout Organization” and “Buildings sanitation”.

Due to the construction boom occurred in Portugal, a lot of buildings are located in zones exposed to high levels of noise. Additionally, it is very common to see residential buildings with commerce or services on the ground floor. Thus, many buildings face acoustic discomfort which can motivate many owners to invest in acoustic retrofitting.

The options with fewer selections were “Indoor air quality”, “Fire safety” and “Water consumption”. These three aspects are many times neglected in the Portuguese buildings. However, the number of selections on these options allows concluding that this tendency is starting to change.

Figure 6 presents the results for the last question of the survey. The figure shows the type of solutions that are most and less applied when performing a retrofitting operation. As expected, the solutions most frequently applied are related to the type of pathologies most selected in the previous questions.

Solutions	Selections
Improvement of the envelope thermal insulation	72
Repairing / Replacement of roofs	71
Repairing / Replacement of roofs and windows	62
Installation / Replacement of acclimatizaton systems	61
Repairing / Replacement of interior floor and ceilings	55
Replacement of lighting systems	49
Painting / Replacement of exterior coatings	49
Painting / Replacement of interior coatings	48
Repairing / Replacement of electric instalations	44
Reorganization of building interior rooms	44
Replacement of kitchen or bathroom equipment	43
Envelope waterproofing	43
Repairing / Replacement of structural elements	42
Repairing / Replacement of interior walls	42
Repairing / Replacement of rainwater drainage system	40
Instalation of renewable energy systems	40
Repairing / Replacement of potable water equipments	37
Repairing / Replacement of gas network	36
Improvement of the envelope acoustic insulation	30
Instalation / Replacement of mechanical ventilation syste	29
Instalations of ventilation grids	27
Repairing / Replacement of groundwater drainage system	23
Adoption / Replacement of shading elements	23
Replacement of exterior walls	20

Figure 6. Type of solutions applied in retrofitted buildings.

These results also show that it is more frequent to improve the buildings’ envelope than to install acclimatization systems. However, the adoption of acclimatization systems was one of the most selected options. This demonstrates the need to improve the energy efficiency

ISBN: 978-85-92631-00-0

of these systems and to invest in renewable energy systems. However, the installation of renewable energy systems was not one of the most selected options.

Additionally, some of the most selected options allow concluding that a big part of the Portuguese buildings being retrofitted are either old buildings or present big retrofitting needs. It is the case of: "painting / replacement of interior or exterior coatings", "repairing /replacement of electric installations" or "reorganization of building interior rooms".

4. CONCLUSIONS

Portugal has a large amount of buildings when compared with the number of inhabitants. A big number of these buildings has retrofitting needs. This shows that it is necessary to change the building sector paradigm from new construction to retrofitting.

In this paper, the main Portuguese buildings retrofitting needs were identified. These were grouped into four main aspects: buildings layout; safety; hygiene, health and comfort; and energy efficiency.

A survey was developed and sent to active building sector professionals. It was concluded that the building retrofitting operations currently being carried out are properly addressing the Portuguese buildings retrofitting needs.

5. ACKNOWLEDGEMENT

The authors acknowledge the Portuguese Foundation for Science and Technology and POPH/FSE-MCTES for the financial support for this study under Reference SFRH/BD/112703/2015.

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