State of the Art: Portugal

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ABSTRACT: The aim of this paper is to give an overview of housing in Portugal, presenting the building stock characterisation, the related Portuguese legislation and the socio-economic aspects. For this purpose, the main housing building technology used in Portugal is described and the problems related to multi-storey family houses are identified.

1 OVERVIEW ON HOUSING STOCK

Portugal is constituted by the mainland and 2 Atlantic archipelagos (Azores and Madeira Islands). The mainland is located in the south-western Europe bordering the North Atlantic Ocean at west and south and Spain at north and east (Fig. 1). The mean geographic coordinates of the mainland are: Latitude - 39º30’ N and Longitude - 8º00’ W. Climate in the mainland is classified as maritime temperate, being cool and rainy in north and warmer and drier in south.

For statistical purposes, Portugal is divided in 7 territorial units. The mainland includes 5 territorial units (North, Centre, Lisboa e Vale do Tejo, Alentejo and Algarve) and the other 2 units correspond to the Azores and Madeira Islands (Fig. 2).

Figure 1: Map of Europe.

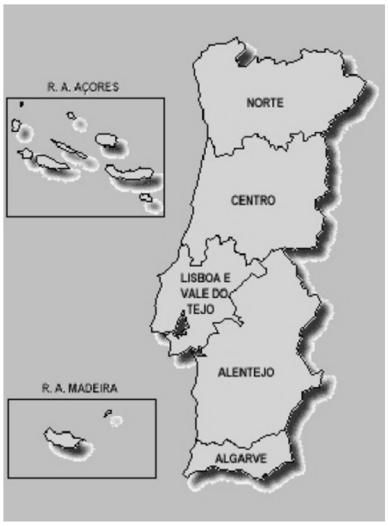


Figure 2: Portuguese territorial units for statistical purposes.

Table 1 lists the general data obtained from the Census 2001 (INE - Portuguese National Statistics Institute) that actually characterizes the country.

Table 1 – Portuguese general data (Census 2001).

Total Area (km^2)	92 141.5
Number of Councils	308
Number of Parish	4 243
Resident Population	10 356 117
Population Density (Inhab/km^2)	112.4
Resident Population – Man	5 000 141
Resident Population – Woman	5 355 976
Number of Families	3 654 633
Number of Family Dwelling	5 046 744
Number of Buildings	3 160 043

1.1 *Data related to building periods*

Table 2 lists the chronology of constructed buildings since 1919. The building stock grew almost 11 times during the period between 1919 and 2001. Figure 3 shows that the period of major growth of the building stock was between 1971 and 1990.

Table 2 – Constructed buildings (Census of 2001).

Before 1919	297 713
Between 1919 and 1945	335 280
Between 1946 and 1970	740 495
Between 1971 and 1990	1 187 423
Between 1991 and 2001	599 132
Total	3 160 043

Table 3 and Figure 4 show the distribution of the existing dwellings and buildings by the Portuguese territorial units.

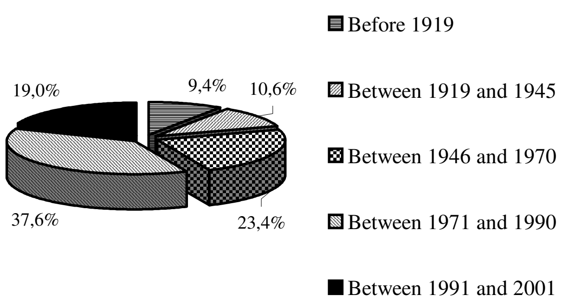


Figure 3: Constructed buildings (Census of 2001).

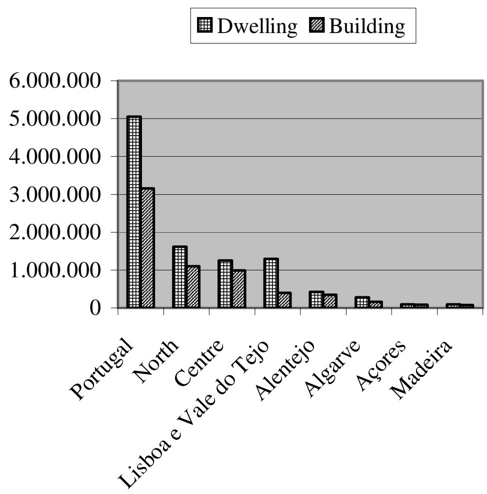


Figure 4: Dwellings and buildings (Census of 2001).

According to the Census 2001 there are almost 5.1 millions of residential units in Portugal for a total of 3.7 millions of families which represents a ratio of 1.34 residential units per family. From this, 18% correspond to seasonal residences while 11% are unoccupied. This means that Portugal has about 3.9 millions of permanent residential units.

Table 3 – Existing dwellings and buildings (Census of 2001).

Territorial Units	Dwelling	Building
Portugal -Total	5 054 922	3 160 043
North	1 613 781	1 100 329
Centre	1 254 701	992 321
Lisboa e Vale do Tejo	1 295 832	394 520
Alentejo	423 641	349 946
Algarve	278 418	160 543
Açores	95 241	87 585
Madeira	93 308	74 799

The building sector in Portugal is very active with a strong bet on new buildings. 20% of the existing buildings have less than 10 years and, between 1991 and 2000, the average rhythm of construction reached 84 000 new buildings per year. In 1999 and in 2000 this number raised till 100 000 new buildings per year. This means that, in the same period, were built 8.4 buildings per one thousand of inhabitants while in Europe this ratio is just of 5.5.

In Portugal, 80% of the new residential buildings are single-family buildings. However, the remaining 20% of apartment buildings represent 70% of the total housing units as it can be seen in Figure 5.

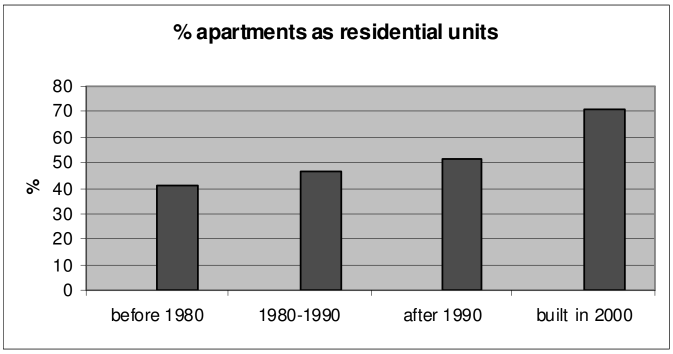


Figure 5: Percentage of apartments as residential units.

1.2 *Description of main typologies*

Until the early 80's the greatest part of the multifamily housing stock was realized as a chain of buildings, with three or four floors high, with slopping roofs. The building blocks are usually composed by symmetrical layout at the level of each floor, with the staircase hall in the middle, which give access to two or three dwellings per floor. In these buildings there were no elevators installed (Fig. 6 and 7). A multifamily building of this period would contain between 6 to 9 dwellings, in average.

The dwellings constructed in this period are small, they have two to three bedrooms, modest technical and functional quality, but they meet the mandatory rules of the time of their construction, concerning to buildings and dwellings layout and minimal usable floor area. The urban construction standard of that time, that was the General Regulation for Urban Construction (RGEU) – Decree-Law nº 38382/51, with subsequent alterations, is still in force but now it is under a revision process. This standard defines some different dwelling typologies, according to the number of bedrooms. In this standard, it is considered a bedroom all usable compartments, beyond the living room, kitchen and toilets. The mandatory minimum areas, according to the dwelling typology, are presented in Table 4.

After the Democratic Revolution held in 1974, the price of the land in the urban areas has initiated a continuous growing process. This reality implied the construction of higher buildings with greater number of floors and dwellings. The newly developed pre-strengthened concrete slabs allowed the design of new and larger floor plans. Up till now, larger building blocks with elevator access, composed by tens of dwellings were built, although buildings with more than ten floors are not very frequent (Fig. 7 e 8). The average area of the dwellings, their functional quality, and the area of the bathrooms, living rooms and common spaces increased a lot. The buildings of this period usually have flat roofs. In general, the dwellings have two or three bedrooms and, in the buildings built in the last ten years, are supplied with individual central heating.

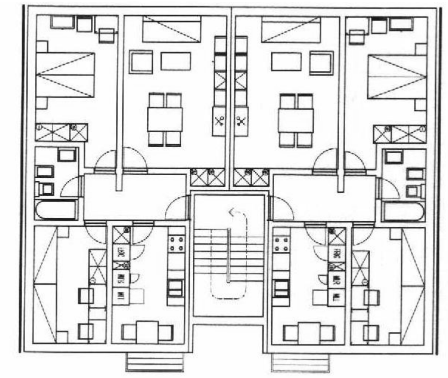


Figure 6: Position of the staircase and typical building's floor in the 50's and 60's.

Figure 7: Façade of a typical Portuguese building in the 50's and 60's.

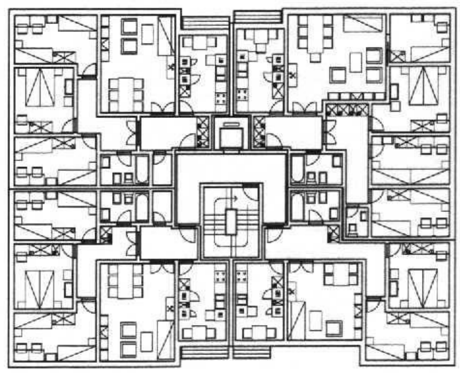


Figure 7: Position of the staircase and typical building's built from the early 80's up till now.

Figure 8: Façade of a typical Portuguese building built from the early 80's up till now.

The mandatory minimum areas don't fulfill the actual population's life standards and they are quite distant from the reality. While there isn't a new regulation some project teams recommend that the minimum accepted areas for each dwelling's typology should respect the values presented in Table 5. The reality shows that in general these values are respected and sometimes even exceeded, mainly in the dwellings with greater number of rooms.

Table 4 – Minimal number of compartments and areas according to dwelling's typology (REGEU, 1951).

	Dwelling's typology and related minimum number of compartments							
Typology	**T_0**	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**T_x >6**
Minimum number of comparments[(1)]	2	3	4	5	6	7	8	More than 8
Minimum usable areas (m^2)								
Couple bedroom		10.5	10.5	10.5	10.5	10.5	10.5	10.5
Double bedroom			9.0	9.0	9.0	9.0	9.0	Remaining: 9.0 m^2
Double bedroom				9.0	9.0	9.0	9.0	
Double bedroom						9.0	9.0	
Single bedroom					6.5	6.5	6.5	6.5
Single bedroom							6.5	6.5
Toilet	3.5	3.5	3.5	4.5	4.5	3.0	3.0	3.0
Toilet						3.0	3.0	3.0
Living room	10.0	10.0	12.0	12.0	12.0	16.0	16.0	16.0
Kitchen	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Supplement of area[(2)]	6.0	4.0	6.0	8.0	8.0	8.0	10.0	(x+4) m^2 (x= number of bedrooms)
Minimum gross areas (m^2)								
	35.0	52.0	72.0	91.0	105.0	122.0	134.0	1.6xAh[(3)]

[(1)]This number doesn't include halls, toilets, store rooms and other compartments with similar function.
[(2)]The supplement of area is for meals and clothes treatment and must be divided for the kitchen and living room.
[(3)]*Ah* is the dwelling's total usable area. It doesn't include halls, toilets, store rooms and other compartments with similar function.

Table 5 – Recommended gross area according to dwellings typology (Pedro, 1999).

AREAS	**T0**	**T1**	**T2**	**T3**	**T4**	**T5**	
Dwelling area							
Net area	42.5	42.5	52.0	77.0	88.5	117.0	m^2
Gross area	53.0	53.0	64.0	94.0	108.0	143.0	m^2
Dependent spaces area							m^2
Net area	1.5	1.5	2.5	2.5	2.5	3.5	m^2
Gross area	2.0	2.0	3.0	3.0	3.0	4.0	m^2
Common spaces area							m^2
Net area	4.3	4.3	4.9	6.9	8.0	9.4	m^2
Gross area	5.2	5.2	6.0	8.5	9.7	11.4	m^2
Total gross area	60.0	60.0	73.0	106.0	121.0	159.0	m^2

1.3 *Description of main technologies*

In Portugal the first high oven for Portland cement industrial production was installed in Alhandra (a village near Lisbon) in 1894. Since then, the building technology slowly started to change, taking advantage of the potentialities and versatility of the new building material, the concrete.

However, it was only after 1930 that the great development of concrete building construction took place. The change started in the pavements through the replacement of the wooden floors by reinforced concrete slabs. Afterwards, reinforced concrete porticos replaced the load bearing walls. These changes led to the building technology actually used in housing buildings in Portugal (Guerra 1995).

Since 1950 the building technology in Portugal is based on a steel reinforced concrete beams and pillars system. Although there are few exceptions to this general rule, it can be assumed that 99% of the housing buildings have the following pattern:

- Foundations: superficial pillar shoes made of reinforced concrete (depending on the soil load capacity);
- Bearing structure: reinforced concrete porticos forming the building skeleton (Fig. 9). Steel reinforced concrete pillars and steel reinforced concrete beams compose the resistant structure of this solution;
- Floors: reinforced concrete slabs in the southern part of Portugal and/or pre-strengthen beams and ceramic (or concrete) molding blocks slabs in the north;
- Roofs: tilted roofs and/or flat roofs (especially in the south). Usually the pendant of the tilted roof is made of pre-strengthen beams and ceramic molding blocks slab, constituting a non-ventilated attic (Fig. 11);
- Exterior walls: single or double leaf hollow brick walls (Fig. 12);
- Interior partition walls: single leaf hollow brick walls;
- Fenestration: after 1990 (because of the introduction of a building thermal regulation), most of the windows have double glaze (6+12+6 mm). The glass is clear on both sides in all the facades. Most of the windows frames are made of aluminum since the 70's (since the middle of the 90's appeared in the market PVC windows frames). Before the 70's the windows frames were in wood;
- Shading devices: due to the intense solar radiation almost all windows are protected with exterior roller shutters mostly made of plastic since the 70's (Fig. 13 and 14).

Figure 9: Partial view of the typical housing bearing structure.

Figure 10: Typical tilted roofs.

Figure 11 – Covering the roof slab with ceramic tiles.

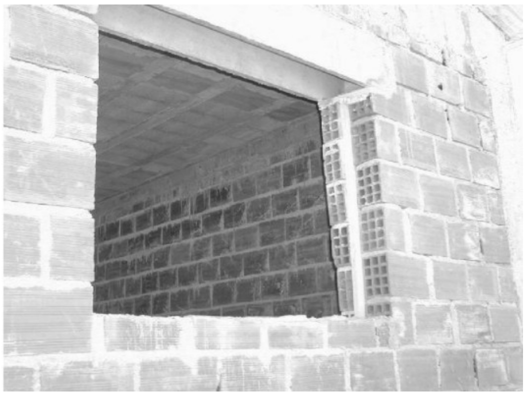


Figure 12 –Hollow brick cavity wall with insulation.

Figure 13 – Roller shutters used as shading devices.

Figure 14 – Balconies and roller shutters used as shading devices.

1.4 *Housing policy*

Construction codes

The principal Portuguese legislation that is applicable to the housing buildings is the following:

- General Regulation for Urban Construction (RGEU) – Decree-law nº 38382/51, of August 7th, and subsequent alterations (is now under a process of revision);
- Technical Recommendations for Social Housing - Ministerial Order nº 41/MES/85, of February 14th;
- Regulation on the Thermal Behaviour Characteristics of Buildings (RCCTE) - Decree-law nº 80/2006, of April 4th;
- Regulation on Building Acclimatisation Power Systems (RSECE) - Decree-law nº 79/2006, of April 4th;
- Safety Regulation against Fire in Residential Buildings (RSIEH) - Decree-law nº 64/90, of February 21st; changed by Decree-law nº 66/95, of April 8th;
- General Regulation on Public and Building Residual Water Distribution Systems - Regulated Order nº 23/95, of August 23rd;
- General Regulation on Noise (RGR) - Decree-law nº 7/2007, of January 17th;
- Regulation on Buildings Acoustic Requirements - Decree-law nº 129/02, of May 11th.

Economic aspects

In Portugal the prices of the housing rent were frozen for more than 2 decades. After the democratic revolution of April 1974, the housing rent froze was extended to the entire country, leading to the almost total extinction of the rental market and to a significant decay of a large portion of the housing stock. This situation ended during the 80's and led to some distortion in the housing market. Before 1980 the total number of non-owned dwellings represented 42% of the housing although after 1980 this percentage decayed to 21%. Figure 15 shows the property status of the occupied dwellings, according to the INE Housing Project, “Housing Inquiry – 1998”.

The Portuguese housing policy, that kept the rental prices frozen, last for over than 2 decades and led to the lack of dwellings to rent. In that period, the people that needed a new dwelling had to buy it. According to the IV General Housing Census (INE 2001) in 2001 the percentage of dwellings occupied by owners and tenants remains almost the same as it was in the eighties.

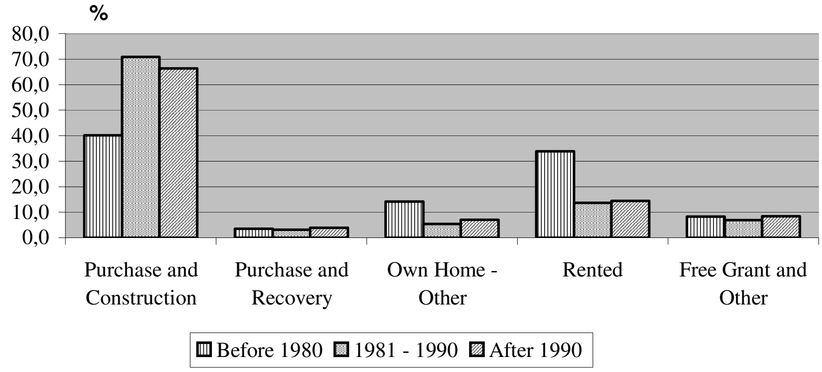


Figure 15: Property status of the occupied dwellings (1998).

According to the INE Housing Project, "Housing Inquiry – 1998", the main way to access to the dwelling property is by purchasing it, immediately followed by the construction of new homes. Figure 16 shows the distribution of the different ways of accessing to the dwelling property.

Although the expenses related to the ownership of a dwelling are more than two times the ones associated to the rented dwelling, the Portuguese prefer to purchase their own house instead of renting it. Figure 17 shows the monthly average expenses related to dwellings for all the Portuguese territorial units (2001).

Nowadays, the prices of the building construction are approaching the average European level and the Portuguese government is trying to develop the rental housing market, in order to be possible to renew the existing buildings and to promote people’s mobility.

The prices of dwelling construction depend on the location of the building and on the quality of the construction itself. According to data supplied by the Portuguese Northern Builders Association, the construction costs are bounded between € 430 and € 460 per m2, for current housing, and between € 300 and € 330 per m2, for social housing.

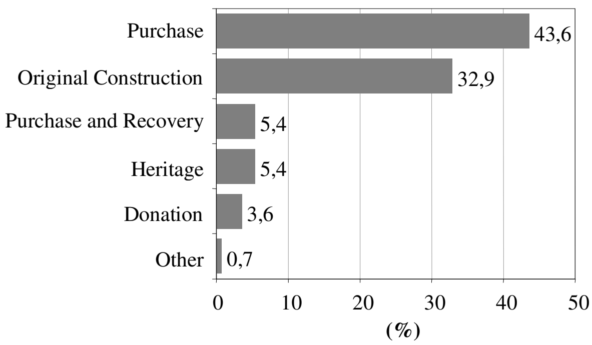


Figure 16: Ways of accessing to the dwelling property in Portugal (1998).

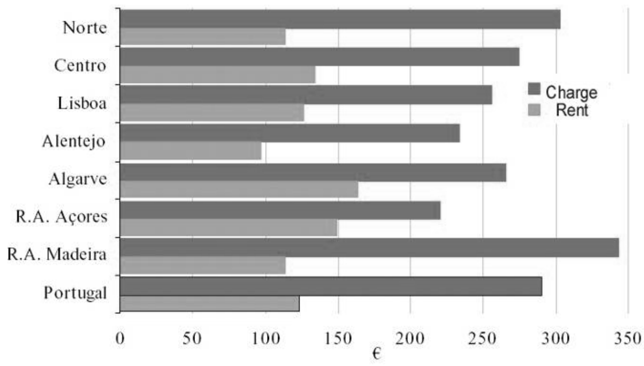


Figure 17: Monthly average expenses related to dwellings (INE, 2001).

Rehabilitation and maintenance cluster
In Portugal, the conservation/rehabilitation activity represents a market share of about 15% of the total civil construction and public works sector, while in the rest of the European countries this activity is near 35% (Bragança, 2003). Figure 18 shows the weight of building conservation and rehabilitation activities in the construction market.

The lack of investment in building conservation and rehabilitation justifies the high degradation level not only of the facades but also of the other building elements (Piedade, 1995). Figure 19 shows the Portuguese investment in the construction sector by types of activity.

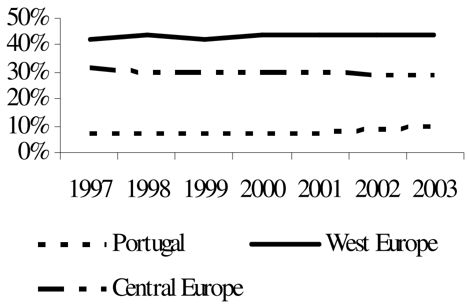


Figure 18: Weight of building conservation and rehabilitation activities in the construction market (2001).

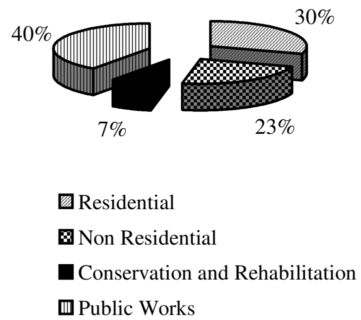


Figure 19: Portuguese investment in the construction sector.

It must be noticed that the data shown in Figure 18 also includes the investment in the conservation and rehabilitation activity promoted by public institutions in order to preserve the historical patrimony. This very low investment in the conservation and rehabilitation actions is not caused by the lack of need of this kind of works. According to data from 1996, the Portuguese housing stock needed at that time of an investment of approximately € 25,000,000 in the building rehabilitation and maintenance areas, although in that year it has been invested only a little bit more than € 1,450,000 (Afonso, 1998 and INE 1998). Studies from INE also show that the number of housing rehabilitation interventions is reducing since 1975 and that the new construction is continuously increasing (INE, 1998).

In Portugal, the low activity in the conservation and rehabilitation areas can be explained by several facts of recent history, where the old building rental policy plays the major role. This, together with the high inflation rates occurred during the 70's and 80's, made economically unviable the execution of maintenance works by the owners.

According to data published in the 2001 Census, almost 33% of the Portuguese buildings, built after 1946, require some kind of reparation. Figure 20 shows the level of the required intervention. The others 67%, at that time, do not need any reparation because those buildings have been object of more or less recent intervention by the owners in order to keep the housing units in good conditions of habitableness.

The need of intervention in façades, including walls and windows, is slightly higher than the need of intervention in the buildings themselves and is approximately 40% of the total buildings built after 1946 (Fig. 21).

The façades deterioration is closely related to the coating materials used. The results of the 2001 Census show that the most common used coating materials can be classified in 4 types: stone, concrete, plaster and ceramic tiles. The most common is the stone (38,2%), immediately followed by the concrete (31,6%) and the plaster (24,1%) and finally the ceramic tiles (5,8%). Only 0,3% of the building stock do not have any of these types of finishing (Fig. 22).

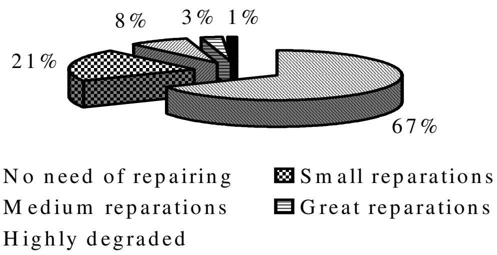


Figure 20: Level of required building intervention in Portugal.

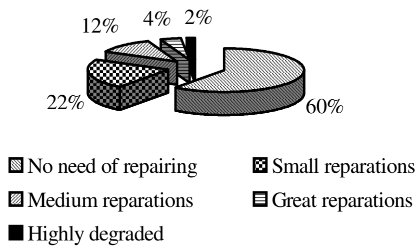


Figure 21: Needs of intervention in façades.

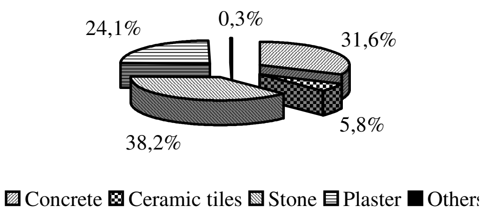


Figure 22: The most common used finishing materials.

Figure 23: Bairro das Estacas in Lisbon (International Style).

2 TOPICS, QUALITY OF THE POST WAR MULTIFAMILY HOUSING STOCK

2.1 *Architectural and urban aspects*

2.1.1 Aesthetic and social aspects

The architectural aspects can be divided into three main periods, marked by two important dates:

1) 1949-1974. Portugal did not participate in 2nd World War, so, the war period didn't have a so huge impact on the territory as in other countries. The post-war period was characterized by a dictatorial regime that had already been implemented in 1933. New Constitution delayed the come out of consumerism, differentiating Portugal, from the very beginning, from the industrialization and technological development that took place in other Western-European countries. This somehow pushed Portuguese architects towards intense adaptation work. The

industrialization on construction processes was rather difficult to implement. The 50's period would be marked by an irreversible transformation of the territory and, above all, by altering the scale of intervention. Stripped of its original content, that of a democratic architecture oriented towards the wellbeing of its users, a skin-deep functionalism was propagated as a formal model at one with the International Style, imposing itself in huge real-estate interventions, mainly in Lisbon. "Bairro das Estacas" in Lisbon is an example of these interventions, as it is shown in Figure 23. Portuguese Architecture from this period has a defined and centralized "Style", called the "Português Suave", especially in Social and Public buildings, but with some contributions from Modern Style, as the architects were present in the major interventions and regulations. The hilliness and dead of the Regime Prime Minister, Salazar, during the 60's and the Ultramarine Wars, led Portugal to some controversy and difficult period that culminated in a Revolution in 1974. However, the 60's period was already a transitory period, where some social housing was built, and punctual interventions were inspired on the "Athens Letter".

2) 1974-1986. The revolution of 25th of April 1974 marked the beginning of a Democracy in Portugal. Some housing dwelling initiatives were undertaken, especially in the two major cities, Lisbon and Porto, where the major transformations took place, both for the best and for the worst. In order to meet the social dwelling requirements, several medium scale urban interventions were done, mainly in central areas of major cities, and some Cooperatives were created. An example of this is the SAAL interventions in Porto, as the "Bairro das Águas Férreas" designed by the architect Siza Vieira (Fig. 24) or the intervention of another architect, Pedro Ramalho, in Guimarães, as it is shown in Figure 25.

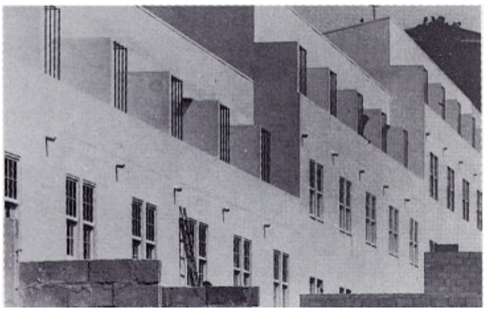


Figure 24: Bairro das Águas Férreas in Porto (Cooperative of Housing).

Figure 25: Cooperative of housing in Guimarães.

In spite of the existence of some problems related with the quality of construction, with actual consequences, the quality of the Architecture was one of the main concerns in these interventions. But, in this period, private promoters also found a fertile soil for speculation and disordered construction and non-regulated urban areas grown up, mainly in the suburbs of the major cities but also in the city centres. In most cases, Architects were not involved in this process, and this contributed to the mischaracterization of Urban and Rural Landscapes. The constructive aspects didn't change from the previous period, as some inertia on the introduction of new systems did not allow a significant change, and the relatively low cost of the hand labour was still a reality that permitted the maintenance of traditional constructive systems.

3) 1986-till now. 1986 was the date when Portugal joined European Economic Community. EEC cohesion funds gave a huge contribution to the economical and socio-cultural development of Portugal, but, at that time, there were many problems that could have not been solved, and some of them have even been aggravated. The consciousness that the kind of transformation that took place after 1974, should have been carried out at an urban level, with intervention of local authorities in order to assure a better connexion between these quarters and other parts of the urban landscape, only took place in the middle 80's, when it was already too late. Errors that took place in the previous period, due to the lack of urban regulation, led to

some incrusted problems that are now very difficult to undertake, namely the lack of green and leisure areas, the creation of urban "ghettos" in the middle of big cities and the difficulty of absorbing all the immigrant population that are now continuously arriving.

In what concerns the infra-structural transport subject, European funds were mainly conducted to improving road transports. The majority of the funds were used to build new highways. But this strategy led to an excessive car dependency that aggravated environmental problems and mainly cities accessibilities.

This period, after 1986, performed a significant improvement in the building sector, regarding architectural quality. However, the interventions are always operating in a small scale, as urban re-qualification interventions at large scale become much more difficult due to the previously identified urban errors and also to the saturation of the housing market. In this context, some buildings are now conceived by architects, because of an increasing demand of aesthetic and functional quality, but only in very discrete cases. In spite of this, some problems are still occurring, namely constructive problems, regarding the introduction of new materials, not yet very well tested.

Renovation and re-qualification of existing buildings are now giving the first steps in Portugal as construction reached the saturation point and the Population is diminishing. Improving and creating some leisure and green areas are also a growing concern, with some City Parks re-qualified or being created in many Cities.

2.1.2 Functional aspects

Portugal has four main differentiated soil occupancy geographical areas: littoral and interior, North and South. North interior territory is mainly composed of dispersed housing, mainly single-family type, with small partitions of land associated to them. On the contrary, in the interior South, the individual family houses are surrounded by large extensions of land and the urban areas are scarce, small and concentrate. In the littoral areas, both in Southern and Northern territory, the soil costs are very high so, the housing stock is mainly composed of Multi-Dwelling buildings concentrated in urban areas. Social problems are aggravated by the contrast between Littoral and Interior Areas. Interior areas are becoming deserted, while Littoral Areas are overpopulated, with increasing criminality and economical and cultural contrasts. This is more evident in the North than in the South.

The lack of public transport infrastructures is only now being mended and citizens are still excessively dependant on individual transports. It has been very difficult to convince people to use public transports since they are no more used to do it and there isn't yet a satisfactory transport net in the territory.

Portuguese regulation on Functional aspects is enough to maintain minimum conditions of inhabiting, in living areas, circulations and basic commodities. Projects are done regarding some acoustic comfort conditions and some minimal thermal comfort conditions that are only possible because of the mild climate in the majority of the Portuguese territory. Due to this low thermal quality of the envelopes, occurrence of condensation is one of the major concerns in Portuguese buildings.

Another general main problem is that buildings are built not taking into account maintenance costs. These costs become a major concern of their inhabitants after 15 or even 10 years of use, as promoters don't take this issue seriously. Even if the promoter is the state, namely in Social Housing, this aspect is neglected.

There is a main aspect that determines now the functional aspects of urban houses: the ownership. Housing owners that inhabit their houses are free to adapt and make the changes they consider necessary and, in many cases, they were even participating in their conception. In these cases they are more concerned and involved in their maintenance and they care for their good conditions. In central and historical urban areas and in Social Housing, where tenants pay very small rents, owners very hardly preserve their dwellings, as they sometimes pay more of municipal taxes than they earn on rents. Sometimes, are the tenants that make some urgent refurbishments, but, as they are not investing on their own property, they don't do major reconstruction works. Changing the policy of rents is now one of the major concerns of the government, namely after some accidents that took place recently, where some buildings ruined, in some cases even with casualties.

2.2 *Structural aspects*

2.2.1 Safety

Reports related to construction pathology in national buildings do not mention critical situations about the structural behaviour. The main reason for the scarcity of accidents at this level is the application of strong safety factors in the structural design.

The reinforced concrete bearing system is the structural solution in the majority of the buildings built in the second half of de 20th century. The first regulation about the structural safety of this structural system was published in 1967. In the structural design, beyond the static loads and the additional effects, some dynamic loads are considered (wind and seismic).

The poor quality of the foundation works is the main source of the majority of structural problems, but fortunately there are very few registered cases. The main reason of this reality is the tradition of not performing tests to the subsoil before the foundations' design. The most applied technique used afterwards to correct the subsoil resistance is the injection technique.

In façades and balconies, some problems could also be observed. The steel bars corrosion is a frequent problem in the façades' structural elements, what can, in a short period, compromise the buildings' structural stability. The insufficient protection of the steel bars and the fragility of the external surfaces or coatings are the main reasons of this problem.

2.2.2 Earthquake

Portugal, mainly at the South and at the Azores islands, has seismic related problems. Since 1755, with the Great Earthquake of Lisbon, some questions related to its seismic behaviour are considered in the design phase of buildings.

Nowadays, according the safety and loads statutory, the seismic loads are considered in the design phase, according to the seismic risk of each local.

The buildings in the mainland and Madeira Islands do not suffer considerable seismic loads along its life span. So, there is a very small number of buildings with problems. On the contrary, at the Azores islands the earthquakes are very frequent and, sometimes, strong. The last strong earthquake occurred in 1998 and had great social and economical impacts in the islands of the central group, destroying a big quantity of buildings. The majority of the buildings destroyed had load bearing stonewalls. The rehabilitation processes of those buildings respected the original architecture and improved its seismic behaviour.

2.3 *Physical aspects*

2.3.1 Thermal insulation

The first legal document concerning the building thermal performance was published in 1990. Its name, RCCTE (Decree-Law 40/90 from the 6th February) is the acronym for the Portuguese name "Regulamento das Características de Comportamento Térmico dos Edifícios" that means Regulation of Thermal Building Behaviour Characteristics.

This document had the general aim of promoting the general quality of the buildings and assuring better hygienic and comfort conditions, especially in residential buildings. This regulation had also the purpose of controlling the energy consumption for thermal (heating and cooling) and visual (lighting) comfort.

The RCCTE intended to impose the improvement of the thermal quality of the buildings envelopes as a strategy to improve the indoor comfort without increasing the energy consumption. To improve the buildings behaviour during winter, the reduction of the overall thermal coefficient (U) of walls and roofs was imposed through the definition of a maximum U-value. Since that time, the use of insulation materials and double glazing in widows started to become common in building construction. The most common insulation materials used in the envelope are the expanded polystyrene, the extruded expanded polystyrene and more recently the rock wool and the polyurethane foam.

Besides the thermal insulation improvement, it also promoted the use of efficient solar energy collection strategies through south oriented glazing, protected during night time by shutters or equivalent devices that can contribute to reduce heat losses during that period.

During summer, the strategy to avoid the energy consumption was the encouragement of the use of shading devices in all windows, mainly in the south oriented glazed areas to prevent overheating, and the use of cross natural ventilation strategies as a way of removing the heat gains from the interior.

In 1998 was published in Portugal another regulation concerning the building thermal performance. Its name is RSECE (Decree-Law 118/98 from the 7th May), which is the acronym for the Portuguese name "Regulamento dos Sistemas Energéticos de Climatização nos Edifícios", meaning Regulation of the Energetic Systems for Building Acclimatization. This regulation is targeted to buildings with significant energy consumption for heating and/or cooling. It is applicable mainly in office, commercial and residential buildings where the acclimatization energetic systems have more than 25 kW installed.

This regulation envisages mainly to avoid the exaggerated over sizing of the acclimatization systems and therefore reducing the corresponding energy consumption. As the previous regulation (RCCTE), RSECE also imposes a set of measures for rationalizing energy consumption, like the heat recovery, the passive cooling, the energy management systems, the power fraction of the cooling and heating equipments and its respective minimum efficiency, the good maintenance practice and the liability of the designers and installers, among others.

As nearly 80% of the building stock was built before the publication of the RCCTE, therefore without any thermal demands, its thermal performance is inadequate in almost all cases. In spite of this reality, thermal rehabilitation is not yet a common practice. Therefore there is still a great effort to be done in this context in Portugal in the near future.

In 2006, following Rio agreements and the necessity of reducing greenhouse gases emissions (Kyoto protocol), but mainly due to the European Directive 2002/91/CE of the European Parliament and of the Council of December 16, 2002 on the energy performance of buildings, the Portuguese government revised the thermal regulation to improve the quality level of the buildings.

The new regulation envisages the reduction of the building energy consumption in nearly 50% and the main changes are the following:

- improve the reference thermal characteristics of the building envelope;
- double the envelope insulation thickness, in general;
- mandatory use of double glazing in the coldest zones and for the orientations without significant solar gains;
- take into account the contribution of passive solar systems;
- take into account the energy spent in heating the sanitary hot water;
- mandatory use of solar panels for hot water production.

2.3.2 Protection against moisture

The protection of buildings against moisture is always done at three different levels: the roof, exterior walls and elements in contact with the soil.

At the roof level, the most common protection is carried out by tilted roofs using ceramic tiles as covering. However, in recent buildings the use of flat roofs is becoming more and more popular. In these cases, the protection against moisture is achieved through the use of bituminous sheets.

The protection against moisture of exterior walls is usually obtained by the use of a mortar layer with low porosity (rich cement mortar). The most common exterior wall technology is the double wall without any contact between panes, which is an important contribute to avoid the moisture penetration through the vertical envelope.

It is common the use of bituminous paints to waterproof the elements in contact with the soil (foundations and retaining walls). To avoid rising damp through the foundation elements it is current the use of waterproof additives in the concrete mixing.

Humidity inside buildings is one of the most frequent defaults mentioned in the Portuguese building stock. Three main reasons can be pointed out to explain this situation. The first one is technical and it is connected to an inappropriate design or to a faulty construction of a building component. At the roofs, the major defaults are found in the flat roofs, mainly due to the bad quality of waterproofing sheets and/or (mostly) due to its bad application. The most common problems are found in the interception of these sheets with the vertical elements (chimneys and roofs cross bands). Humidity in the envelope walls (exterior and interior surfaces) is becoming a common problem in recent construction buildings, mainly due to the bad quality of the finishings (high porosity) and to the recent architectural fashion of designing roofs without eaves. The eaves used in the traditional Portuguese buildings are a way of protecting the exterior walls from the rain water.

The second one is a result of the thermal improvement of the buildings envelope with the integration of insulating layers in the exterior components. This situation leads frequently, depending on the construction system, to the occurrence of thermal bridges with consequent air condensation on those areas. This is very common in the surfaces in contact with the structural elements and at the windows borders. This is a frequent default in recent buildings, mostly built after the publication of the first thermal regulation code (RCCTE of 1990).

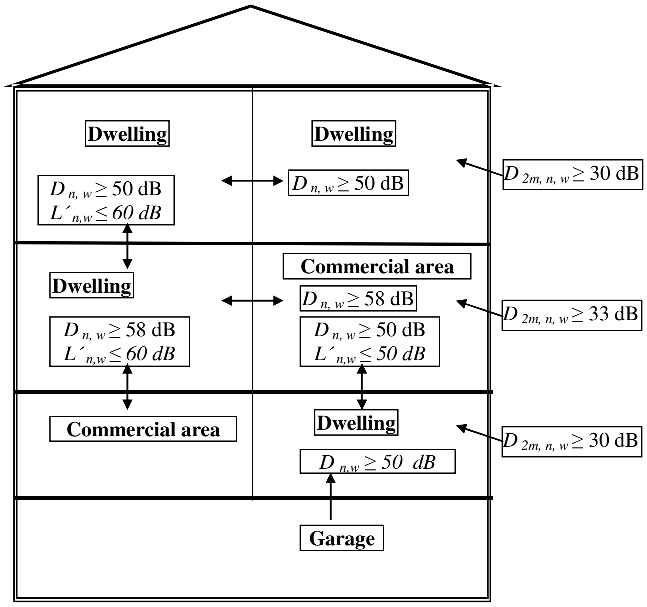
The third reason is generally due to ineffective ventilation in the rooms where moisture is produced (mainly in bathrooms and kitchens). In Portugal it is seldom the adoption of mechanical ventilation systems. This reality worsens the air condensation at the thermal bridges and contributes to the low quality of the indoor air. This anomaly is frequent in buildings built after 1990 due mainly to the adoption of low leakage windows.

2.3.3 Noise insulation

Acoustical comfort is now a very persistent problem for Portuguese people and it is the subject of frequent complains. Buildings built before 1987 were not submitted to any sound insulation regulation code. Between 1987 and 2000, there was an acoustic regulation code but, in general, it was not applied. Since 2001, a new code is in force which imposes serious requirements regarding the protection against sound and noise pollution.

According to the Portuguese Building Acoustics Legislation, partition elements must meet some acoustic requirements as shown in Figure 26.

The high mass of the conventional construction systems contributes to the satisfactory sound insulation of the vertical partition elements. The majority of complains is related to the horizontal partition elements, normally between commercial areas and dwellings, due to an insufficient airborne sound insulation level. The low impact sound insulation index observed between dwellings is another cause for complains. Floating slabs and suspended ceilings are the most common solutions used in the horizontal elements to solve these problems.



$D_{2m\ n\ w}$ - Airborne Sound Insulation Index of the facade

$D_{n\ w}$ - Airborne Sound Insulation Index of partitions

$L'_{n\ w}$ - Impact Sound Insulation Index

Figure 26: Mandatory sound insulation levels.

CONCLUSIONS

The existing building stock erected between 1946 and 1991 represents 61% of the entire building stock in Portugal. Therefore, there is a big number of envelopes to be improved.
The rehabilitation and maintenance will replace the new construction. Therefore more and more interventions in the buildings and mainly at the level of the most exposed construction elements (roofs and façades) will take place in the near future.

REFERENCES

- Afonso, F. et al (1998). O Sector da Construção – Diagnóstico e Eixos de Intervenção, IAPMEI, Lisboa, Portugal.
- Bragança, L.; Mateus, R.; Silva, A. (2003). Anomalias Mais Comuns nas Fachadas de Edifícios do Concelho de Guimarães. Paper presented in the PATORREB – 1º Encontro Nacional de Patologia e Reabilitação, Porto, Portugal, April.
- Guerra, Franklin (1995). História da Engenharia em Portugal. Author Edition, Porto Portugal.
- INE 2001. INE (Instituto Nacional de Estatística), Recenseamento Geral da Habitação – Censos de 2001.
- INE 1998. INE (Instituto Nacional de Estatística), Inquérito à Habitação – 1998.
- INE 1997. INE (Instituto Nacional de Estatística), Estatísticas da Construção – 1997.
- Pedro, J. Branco (1999). Programa habitacional. Espaços e Compartimentos. Colecção Informação Técnica Arquitectura, n.º5. Lisboa, Ed. LNEC.
- Piedade, A. (1995). Competitividade Industrial e Técnica na Construção de Edifícios, Jornada sobre Competitividade da Indústria da Construção, Lisboa, Portugal.
- Portas, Nuno & Mendes, Manuel (1992). Portugal Architecture 1965-1990. Editions du Moniteur, Paris.
- REGEU (1951). Regulamento Geral das Edificações Urbanas. Decreto-Lei n. 38 382 and subsequent alterations, August.
- Tostões, Ana (2001). The legacy of the "verdant 1950s' .pp 131-143 in 2G, International Architecture Review, nº 20.