PORTUGUESE MASONRY BUILDING ENCLOSURES PRACTICES AND PROBLEMS

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SUMMARY

For a better understanding of the Portuguese reality a simple tentative to describe Portuguese practices and problems related with masonry buildings enclosures is made. After a short review of recent Portuguese evolution concerning housing buildings, a description of the most frequent structures, masonry materials and enclosures is presented, illustrated by images. The principal problems and pathologies related with these practices are summarized.

1. INTRODUCTION

According to the strategy defined in previous CIB W23 Wall Structures meetings, four ad-hoc groups have been constituted. The AH1 deals with buildings masonry enclosures systems and an effort to transmit national perspectives has been considered interesting.

Masonry is perhaps the buildings technology more deeply affected for regional and traditional practices concerning materials, detailing and construction. To understand the masonry specialists concerns in different countries is fundamental to know the specificities and real problems of these subjects in each country.

The purpose of this report is to briefly present the recent Portuguese situation concerning this matter. Is shown that in the last years a quick evolution occurred on masonry practices that produced several problems that must be well studied and explained, opening important and interesting research perspectives.

2. PRACTICE

2.1.Fitting

Portugal is a Southern European country, Mediterranean in the Center and South, but with increasing Atlantic influences in the Northwest. The population, of almost 10 millions inhabitants, is much more concentrated near the sea. The construction activity is important to the economy and represents near of 7% of the Gross Domestic Product and 9% of employment [1].
Buildings are the most important construction activity; this effort is yet turned toward new buildings, fig. 1[2].

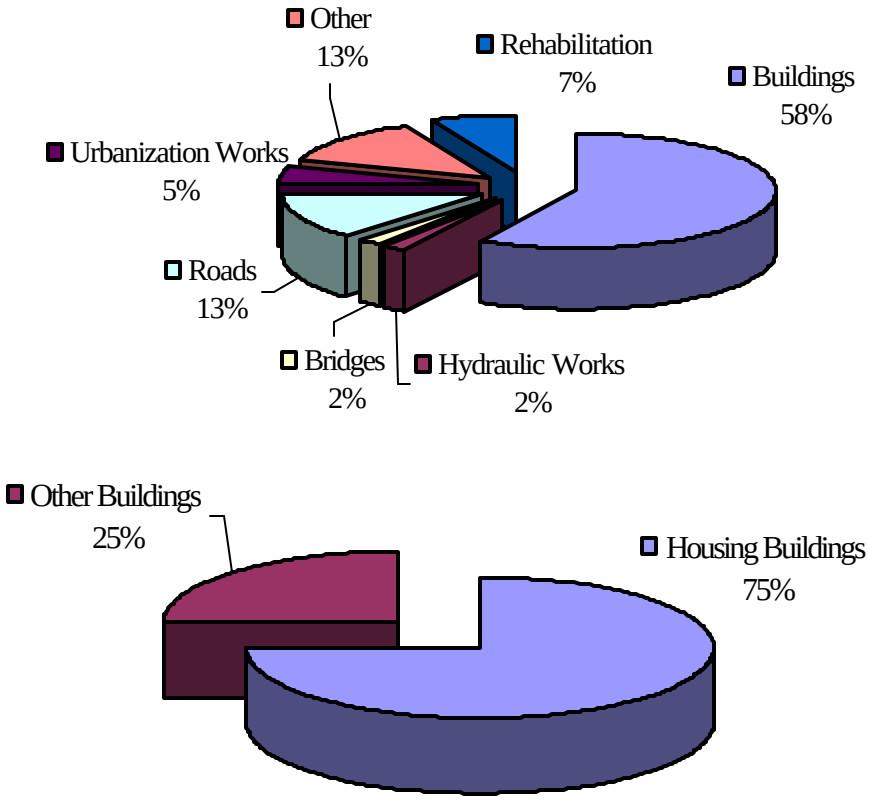


Figure 1: Buildings construction importance according Portuguese statistic information [2]

After World War II buildings solutions progressed in a quick way, not always adapted to local conditions.

In the past, the traditional Portuguese architecture usually presented regional solutions, very adapted to climatic conditions. The use of stone in heavy and thick walls was predominant. Except in some rustic regions or in more primitive buildings of the countryside, where the stone remained not finished, usually the stone walls were covered by a thick porous render, with low modulus of elasticity and made in multiple layers for very skilful workers.

In the Atlantic seaboard, in the zones more exposed to the rain, it was usual to impr ove the watertightness of the render by the introduction of an water-proof layer, directly applied beside the support, made of asphaltic mortar or a very rich Portland cement mortar with an hydrofuge adjuvant. With the same purpose of improving the watertightness, but with a more regional character, ceramic decorative coverings and claddings made of slate or fibre-cement profiled sheets, mainly on gables, were used, fig. 2 [3].

By the end of the 1940s, and mainly on urban regions the use of concrete structures becomes widespread, first on the floors and progressively extended to the vertical support elements. The walls lost their resistance role and became only fulfilling elements, being the stone

replaced by clay bricks. Clay brick producers developed a multitude of shapes, but always progressing from solid to large horizontally perforated elements.

Figure 2: Examples of some Portuguese traditional buildings

The importance of rain watertightness, associated to the thickness and weight wall reduction, led in the 1960s, to the generalization of cavity walls made of clay brick, introduced with adaptations from abroad. In the 1980s, the care with thermal comfort and energy conservation and the consequent publication of the respective code, pushed to the vulgarized use of thermal insulation filling the cavities of cavity walls.

In this evolutive process the tradition of rendering the walls with cimentitious mortars remained, but the quality of execution decreased and the regional character of architectonic solutions was lost, fig. 3. Although in this evolution the walls lost some importance, they remain an important constructive element in both economic and functional terms.

2.2.Buildings structure

In present days the major buildings structures are in reinforced concrete frame. The other solutions like metallic, masonry and wood structures are seldom used, even in small and one family houses, fig.4. Also the structures in reinforced concrete walls are only used in few buildings, special ones, or where the fixing of heavy claddings imposes it.

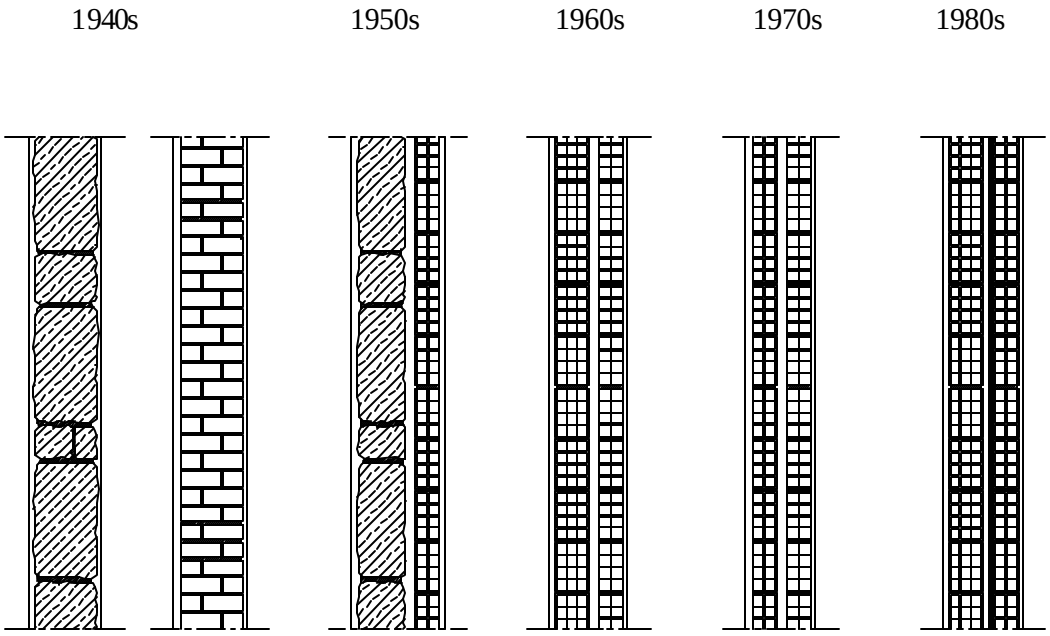


Fig. 3 - Synthesis of Portuguese walls evolution process

Some small tentative of changing this anomalous situation are beginning. In the Civil Engineering and Architecture Schools the attention paid to alternative structural solutions is growing, supported by the Eurocodes and international images and models. Otherw ise the material producers and traders see in these alternatives and new materials good opportunities for business.

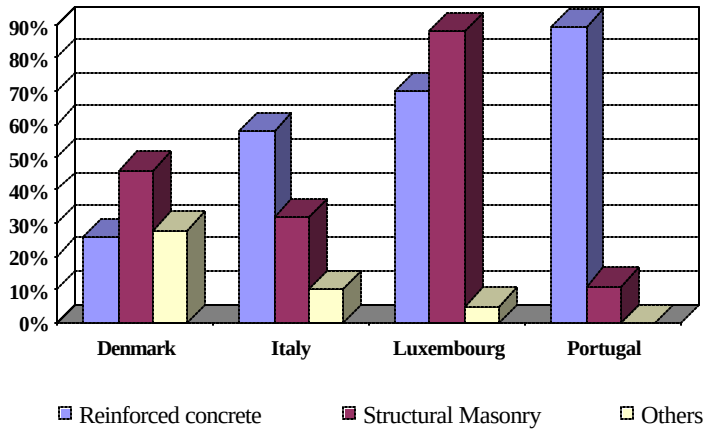


Figure 4: Comparison of buildings structures in some European countries [2, 4, 5, 6]

2.3.Masonry materials

2.3.1. Masonry units

In the Portuguese market current masonry units (traditional) and some new emergent units (not traditional) are generally available. Actually the industrial level of Portuguese factories of masonry materials is generally good, but there is no sufficient effort in the development, characterization and quality control of the products. The traditional material producers only sell the units and not the total masonry system. This fact makes that usually the walls singular points are solved on site by improvisation. The traditional present masonry materials are:

- clay units, large horizontally perforated, used on enclosure and internal walls (group 3 according to EC6);
- clay units, solid or vertically perforated (facing bricks or not) used only in external walls (group 1 and 2 according to EC6);
- aggregate concrete units, dense or lightweight, used more in external walls (group 2 according to EC6);
- natural stone, which use is limited to some small regions.

The most popular materials are the clay units that represent more than 90% of the units used in walls.

The new masonry materials, not traditional, are:

- autoclaved aerated concrete units;
- split dense aggregate concrete units;
- lightweight clay units, vertically perforated;
- special shape units.

Generally these news products are well developed and studied, but their cost is higher than traditional ones. Otherwise certain conservativeness exists that make difficult to accept new materials and solutions. The importance of these products in terms of market is residual.

The most important characteristics of the traditional materials are presented on Tables 1 and 2. Some values are approximated because there are not actual characteristics of most productions.

2.3.2Mortars

In Portugal masonry mortars are usually made in site, with Portland cement and sand. The use of lime, hydrated or hydraulic, frequent in the past, is not common at the moment.

The mixes are generally rich (1:3 or 1:4). Usually all types of Portland cement are equally used. There is no masonry cement in the market. The use of ready mixed or pre-mixed mortars is not yet frequent, but is growing. The use of adjuvants to improve watertightness is frequent on facing masonry.

2.3.3. Wall ties and reinforcements

The use of wall ties and reinforcements is not current on Portuguese masonries. There is no national production of this kind of materials for masonry; in few cases, expensive imported materials are used. More frequently builders improvise connectors.

The ties in cavity walls are in some cases specified by the designer (generally the architect), but in site they are not placed, or some wires of dubious efficiency are placed. The use of rigid thermal insulation in cavity walls increases the difficulty of the correct placement of ties.

Figure 5: Examples of some ties and connectors used in Portugal

In lintels generally some bars are included in the mortar joint. The use of prefabricated reinforced concrete lintels is frequent for the inclusion of the roller blind. As the Portuguese masonries are generally of simple infilling, the masonry attachment to the structure should be improved by anchors, which are only used in few cases, fig.5.

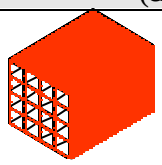
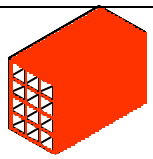
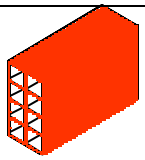
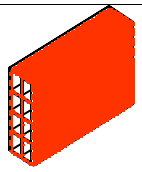
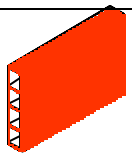
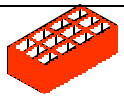
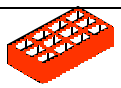
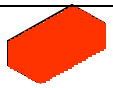
2.3.4 Damp proof course

Damp proof course near the soil and flashing are generally made with rich hydrofuge mortar reinforced with glass fiber mesh. The use of metallic, plastic, rubber or asphaltic sheets is not frequent.

2.3.5 Thermal insulation

Although the Portuguese climate is moderate and the National thermal code requirements are not very severe (U value in the coldest region = 0.95 W/(m^2ºC)), the conscience of the need of thermal comfort in buildings in winter and summer is a reality today.

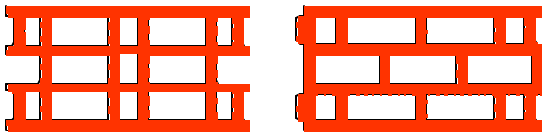
Table 1 – Clay units most important characteristics [8, 9]

	Dimensions and shapes (cm)		Weight approx. (kg)	Volume of holes (%)	Compressive strength [2] (MPa)
Horizontally perforated		30 x20 x22 [1]	7-11	55-70	1,9-3,9
		30 x20 x15 [1]	5-7	50-65	2,5-4,9
		30 x20 x11 [1]	4-6	50-65	2,8-5.2
		30 x 20 x 9	3,5-5,5	40-60	3,0-5,7
		30 x 20 x 7 [1]	3-5	40-60	3,7-7,0
		30 x20 x4	2-3	40-50	6,0-7,0
Vertically perforated		22 x11 x7 [1]	1,5-2,5	25-40	8,0-9.5
		22 x11 x5	1,2-1,7	25-40	8,0-9.5
Solid		22 x11 x7 [1]	2,5-3,5	-	17,0-48,0

[1] Sizes according Portuguese standards

[2] Expressed in terms of gross area of the specimens, not normalized by shape factors

Table 2 – Concrete blocks most important characteristics

Dimensions and shape (cm)	**Weight approx.** (kg)	**Volume of holes** (%)	**Compression strength** [(1)] (MPa)
(50 or 40) x 20 x30 	20-29	45-65	3,5-4,5
	20-25	45-65	3,0-4,5
(50 or 40) x 20 x25			
(50 or 40) x 20 x20 	15-22	40-50	3,0-4,5
(50 or 40) x 20 x15 	12-18	40-50	4-5
(50 or 40) x 20 x12 	12-15	40-50	4-5
(50 or 40) x 20 x10	10-13	30-50	4-5
(50 or 40) x 20 x8 	8-12	30-50	4-6
(50 or 40) x 20 x5 	8-10	-	6-8

[(1)] Expressed in terms of gross area of the specimens, not normalized by shape factors

In most common cavity walls a thermal insulation is provided in cavity. In single leaf walls an external insulation is applied between the finishes and the body of the wall. In some cases the use of units with improved thermal behavior allow to satisfy largely the thermal code requirements without thermal insulation. The most popular thermal insulations, fig.6, are:

- expanded or extruded polystyrenes in boards;
- projected polyurethane foam.

a) projected polyurethane foam

b) extruded polystyrene

Figure 6: Example of thermal insulations

2.4.Wall finishes

Usually in Portugal all types of walls were covered with traditional renders. These renders were normally painted, fig. 7, but at the moment alternative solutions have significant expression. The problem of maintenance costs, the need to improve wall waterproofing and the difficulty of getting skilled workers to finish renders, lead to the growing of alternative solutions:

– use of claddings of ceramic tiles and thin stone plates glued to a first layer of render is perhaps today, one of the most frequent solution; these elements, mainly the ceramic, are available in a lot of different dimensions and aspects; some of them seem ceramic facing bricks, fig. 8;
– use of ready-mixed rendering materials applied in a single layer with pigments, colored sand or small pieces of stone, one coat render, fig, 9;
– use of cavity walls with facing units, fig. 10;
– use of thin synthetic render, reinforced with glass fiber mesh, beside thermal insulation, fig. 11.

Other different wall finishes are used but with low expression in residential buildings.

b) in execution

b) painted

Figure 7: Example of traditional render

a) Ceramic tiles

b) Granite stone plates

Figure 8: Example of cladding finishings

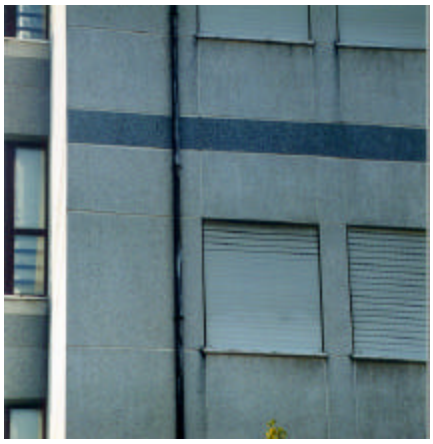


Figure 9: Example of ready mixed one coat render finishing

a) Clay units in execution

b) Clay units finished

c) Split dense aggregate concrete units

Figure10: Example of a cavity facing units wall

In execution (rehabilitation)

Finished

Figure 11: Example of a synthetic render beside thermal insulation

2.5.Windows and doors frames

In present the openings of building enclosures are generally closed with painted aluminum frames and double glass windows, fig.12.

In housing, the solar protection and the night occultation are normally made with plastic roller blind that is disguised in a box on top of the openings. The sills are normally in stone plates. The door and windows jambs are in the same material of the wall finish or in stone plates.

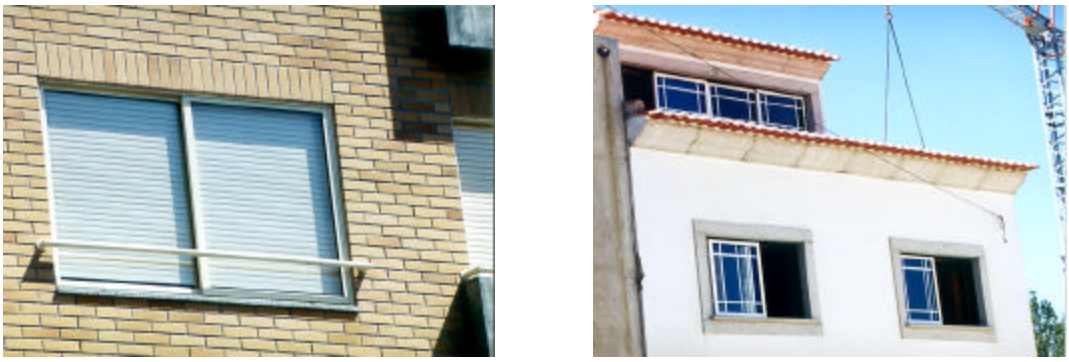


Figure 12: Examples of current Portuguese frames

2.6.Most popular masonry building enclosures

At the moment the most popular Portuguese masonry buildings enclosures, fig.13, of simple infilling, are:

- Cavity walls made with clay units of high horizontal perforation and low strength, the thickest leaf usually do not exceed 0.15 m, with plates of thermal insulation in the cavity. These walls are generally poorly cared concerning wall ties, damp proof barrier, insulation fixing, thermal bridges and structural connections. The finishes are various as referred below.
- Cavity walls with external facing units. The internal brick is horizontally perforated, generally with 0.11 or 0.15 m. The external face of the internal leaf has improved waterproofing using a cementitious or synthetic painting, in some cases with a reinforcing mesh. The thermal insulation is made with plates or by projection. The wall ties and thermal bridges protection, when exists, are not too cared. Some weepholes are generally foreseen.
- The use of concrete blocks occurs in some small constructions sometimes with structural contribution in confined masonry solution. In this case the walls are double, cavity, and the inner leaf is on clay brick.

The use of single leaf wall solution is growing but is not yet frequent. Lightweight aggregate, autoclaved concrete and lightweight clay blocks are also used. These units are vertically perforated and the unit's thickness is usually between 0.25 and 0.30 m.

In all these solutions if the unit's thickness is greater than 0.15 m normally the vertical mortar joint is not filled with mortar.

Typical housing building structures and cavity clay units walls

Box for roller blind

Lintel

Application of “monocouche” render

Single leaf wall in lightweight concrete

Single leaf wall in lightweight concrete

Figure 13 – Examples of current Portuguese masonry buildings enclosures

3. PROBLEMS

3.1. Principal requirements

The most important requirements of external walls are presented in fig. 14.

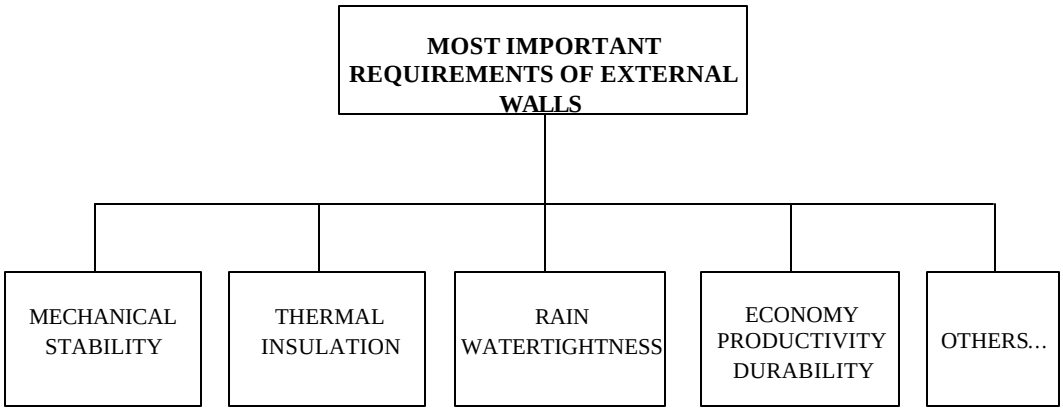


Fig. 14 – Most important requirements of external walls

In the design of masonry buildings enclosures all those requirements must be considered and established in a general form. In Portugal the task is more difficult because there are not normative documents for:

- Mechanical stability of infilling masonry, considering the interaction with building structures;
- zonements that make possible to choose wall adequate solution considering the localization and driving rain.

3.2. Difficulties

3.2.1. Design and construction

The design of non-structural walls is committed to architects, but generally there is not a deep specification of masonry works concerning the type of materials, characteristics, details of execution and singular points. As the buildings structures and installations are involved with masonry works, there is a special need of compatibilization that normally is not correctly done.

Otherwise the designer has difficulty to describe the construction requirements because there is not a code of practice for these works. Chose masonry materials is difficult because only few producers have published the characteristics of their products and there is a generalized low quality of units and non-existence of real masonry systems. So is usual in site, during the construction process that the real quality of masonry walls is defined. With a good project, if the contractor does a correct preparation of the work and the workers are skilled, the masonries have quality. Otherwise, without harmonized mechanisms, it is very difficult to control and oblige the contractor to do a good work.

3.2.2. Special difficulties

The main problems detected in Portuguese masonries, that are in origin of an important number of pathologies, fig.15, are:

- Reinforced concrete slabs excessively deformable, producing mechanic actions and cracking of masonry;
- Connections between walls and structure (including renders) not correctly solved, aggravated for some incorrect tentative to avoid thermal bridges;
- Cavity walls mechanical weak and incorrectly done considering cavity cleaning, ties, holes, position and fixing of thermal insulation;
- Singular points around openings not studied and generally solved in site with too much improvisation;
- Finishes, renders and tiles choused without a technical reflection and applied to fast;
- Architectonic solutions that admit ideal situations to the façades and do not examine carefully the incidence of rainfall, the actual conditions of workmanship quality and the need of durability.

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