ABSTRACT

Globalization, competitiveness and the current world economy require an increasing capacity to fulfill ever rising levels of excellence and demand. Faced with such challenge, Construction has to strive for constant improvement in its quality, optimizing the cost/benefit relation with fairness and justice, safeguarding both the comfort and the dignity of the users in the context of cultural values and local resources. Architecture has to provide quality of design with technically adequate materials and constructive solutions, innovative or re-interpretative, mostly local, despite budget limitations (considered on a life-cycle analysis). However, if the economy of the planning and building process is an essential concept nowadays, it should not be confused with cheap building.

This paper recalls the necessity of developing new operative approaches that combine quality of construction, optimal cost/benefit relation and careful architectural design, regarding an effective response to the needs of contemporary Portuguese society, considering international experiences and the ongoing discussion of urban and
environmental topics. Price and quality being two different parameters, what does cost awareness mean?

Key words: Standard housing, cost-effective building, local construction techniques and materials.

Introduction

An understanding of the political and economical context in Portugal after the 1974 Revolution is needed in order to follow how the building process has evolved, as well as to identify the current characteristics of standard housing. A large number of houses have been built in the 1980s and 1990s, mostly without a sustainable cost/benefit ratio despite initial budget limitations. Nowadays, cost pressures and quality constraints (especially new Energetic Certification requirements, following the 2002/91/CE directive), are leading to marked changes in building construction in almost every countries in Europe. What is proposed in this paper is to present a cost-effectiveness parameter that can help to characterize the current standard house construction in Portugal, indispensable for the identification of available possibilities for improvement, through a life-cycle analysis.

Economic Concepts: Architecture and Its Construction

Architectural Practice: Project Methodology Regarding Construction

To achieve better results in his practice, an architect should consider different types of knowledge. Firstly, construction quality and its environmental sustainability (in the context of local resources) are aspects of main importance. Secondly, from the point of view of its “constructability”, there is the building economy, as well as its adequacy to local planning guidelines and regulations. Furthermore, construction should always take in account ethnical and cultural values of the future users, which in turn cannot be dissociated from the expectations of the collective imaginary. Finally, all these factors must be hierarchically conjugated through a process that leads to a project hypothesis - the plan - which is also a consequence of a creative demand. This hypothetical construction obeys an aesthetical intention that cannot be understood as a mere exercise of aesthetic composition, but must also succeed in the insertion of the architectural project within a particular cultural and artistic context.

Why Finiteness and Cost Awareness?

“In an ever smaller world, the permanent home of the human adventure, finiteness opens new opportunities to an architecture with ethical responsibility, social relevance
and physical meaning” [1]. If from one point of view architecture can be seen as a “luxury” – especially if considered in limit situations with low economic capacity – to plan with economic concepts (as initial low-budget or cost-effectiveness ratio) is seen by some architects as a “strategy” [2]. To Jean-Philippe Vassal, this strategy is not just useful in developing countries, but also in the developed ones. This architect (teaming with Anne Lacaton), goes even further, qualifying this strategy as “a form of intelligence” with “elegance in the way you do it” [2]. This would lead us to another perspective in which good design is much acclaimed as a form of “adding value” [3] doubtless of great importance. Nevertheless, what is of particular significance to this paper is that societies nowadays are facing problems directly connected with the energetic paradigm change - such as scarcity of resources and environmental problems, or the situation of the worldwide economy and globalization effects, competitiveness and acculturation - which enlighten the necessity of a reflection towards both the concepts of finiteness [1] and cost awareness [4, 5].

Economical Optimization of Housing: A Contemporary Necessity

This article is based on a belief that it is possible to restore an equilibrium between Construction quality and its good design, concerning “non luxury” Architecture in Portugal. In this framework, architects are seen as agents of great potential operativeness, not only from the point of view of project-decision making, but also through the establishment of a desirable and closer “dialogue” with contracting authorities (mainly public institutions which are also responsible for regulating building activity). Following this idea, a more effective answer seems possible to the needs of contemporary societies without being necessary “more expensive” buildings. Architects should then have a previous knowledge of technical aspects and regulations, so they can propose methodologies with efficient operative levels to face ever rising demands of the following parameters: cost (economic investment, construction cost and life-cycle cost), quality (construction energetic efficiency, durability), feasibility (political and regulatory), and careful design (conjugating formal and functional aspects with good design, always aiming at adequate urban integration), regarding a higher sustainability.

Characterization of the Standard Housing Context in Portugal

To study the possibilities for improvement of the current standard housing in Portugal in order to achieve more cost-effective solutions, one needs to relate to its historical evolution in the Portuguese context. At present, existing constraints about low-budget construction are based on prejudice equating cheap with low quality and careless design. For this reason, there are constructive solutions or materials that are not well accepted by the users, locally. A political and economical context is also responsible for the low acceptance of reduced-cost (not necessarily cheap) construction in Portugal, which will be briefly presented.
Political and Economical Context and Regulations

After the Portuguese Revolution in 1974 there was a huge shift in the political landscape and economy, which gave rise to a strong activity in the construction sector that became of great importance for the Portuguese economy [6, 7]. “Until the end of the 1990s, buildings were the most important construction activity; this effort being focused on new buildings (...)” [6]. Statistically, “housing buildings represent almost 75%” of construction activity [6]. Consequently, a large number of constructions, mainly housing, have been built in the 1980s and 1990s, not all of which were economically sustainable in a medium-long term analysis, as these were built regarding initial budgets. Actually, many of the constructions that have been built in this period do not present a satisfactory quality level (constructive but also architectural) [7], not complying with some of the present regulations and living standards. This is also a consequence of the current Portuguese codes of practice (now under revision following recent EC directives) that are complex without being always adequate or efficient [8]. One main code - the most important legal document to regulate construction activity till nowadays - is the *Regulamento Geral das Edificações Urbanas* (1951), which was prepared long before the 1974 Revolution. Responding to the post 1974 pressures, this code post updates would effectively put some order on legal aspects (e.g., as minimal distance between buildings or minimal areas of interior living spaces) but it was quite general respecting construction quality restrictions. In this context, enrichment opportunities on one hand, and lack of inspection and efficient regulations on the other, contributed to less rigorous practices within building activity that unfortunately were not much under control of the authorities.

The European Directives and the Building Sector Efforts to Adaptation

Nowadays, cost pressures and quality constraints (especially new Energetic Certification requirements, following the 2002/91/CE directive) are leading to marked changes in building production in developed countries in Europe. With the implementation of Quality Energetic Certification from the EC directives a better understanding of the current house construction concepts is needed in order to identify the available possibilities to improve it. Comparing to other European countries, where construction and planning codes had been constantly improved in the past years in order to be ever more adequate to higher construction quality (as in France or Germany e.g.), the Portuguese regulations have now a longer update to be made. Taking in account the existing disorganization of the building sector, as well as its inefficient codes and inspection, this revision is leading to marked changes in construction activity in Portugal. The urgent update required to the technicians involved in this sector is originating ever more research.
Current Standard Construction

By the middle of the 20th century, “building solutions and technologies have quickly evolved the traditional practices being progressively replaced by new ones, not always adapted to local conditions as formerly” [6]. The good tradition of the former housing in Portugal, usually presenting regional solutions well adapted to climatic conditions mainly characterized by a heavy enclosure wall with resistance role [8] gave way to a large number of constructions which were mainly built in reinforced concrete frame with brick external and internal walls [6, 7]. This structural solution - that became ever usual, close to 90% nowadays [7] - was not always well executed and is partly responsible for the generalized “low quality” of the buildings [7].

Following Hipólito de Sousa and Fernanda Carvalho, “by the end of 1940’s, and mainly in urban regions, the use of concrete structures would become widespread (…). At the time, the walls lost their resistance role and became only infilling elements, the stone being replaced by clay bricks (…)” [6]. In the 1960s, enclosure cavity walls made of clay bricks were generalized. In the 1980s, “the concern for thermal comfort and energy conservation and the consequent publication of the respective code [Regulamento das Características de Comportamento Térmico dos Edifícios, 1990] led to the (...) use of thermal insulation products filling the air space cavity walls” [6].

Besides this, some materials were used excessively in a wrong manner, e.g. as the aluminium window frames or the ceramic decorative covering (commonly called “pastille” in Portugal), and as a result some characteristics of these buildings that were not necessarily “bad” became known as “not good construction” indicators.

Cost-Effectiveness Parameter Considered on a Life-Cycle Analysis

Though the present paper focuses the need of new approaches from the point of view of housing architecture and its construction - not only considering a numerical characterization but also qualifying parameters which are not necessarily countable (conjugating formal and functional aspects with architectural strategies towards a good design and adequate urban integration) - it is therefore aimed a comprehensive understanding of optimal cost-benefit technical aspects. For this reason, to help characterizing current housing economically, it is proposed an analytical parameter which is directly based on a study developed in Universidade do Minho, by Paulo Mendonça [8]. Following this author, two essential components must de distinguished in order to evaluate construction environmental impact in a life-cycle analysis: the energetic component on one hand (that does not only refer to primary resource extraction and production process, but which must consider a building life-cycle, including construction phase (choose of materials, transport and construction itself), occupancy phase (energetic heating and cooling needs reduction, maintenance costs,
durability) and its post demolition and recycling or preferably re-use of materials and building components); and the materials component on the other hand (concerning prime-materials used during construction phase, which in turn do not implicate high costs when not too transformed). Thus, for obtaining more cost-effective housing solutions, economic concepts cannot only take into account the construction phase, but should also integrate costs during building life-cycle.

The research by Paulo Mendonça “demonstrates that the reduction of the weight of the construction systems and materials can have a great influence on achieving more sustainable buildings (...) [when] safeguarding the high temperature, acoustic and natural illumination performance, without forgetting the security (structural and fire resistance) and aesthetic aspects. For this research two Test Cells were constructed and monitored, (...) both with passive solar systems thermal gaining systems oriented to South, indirect in CET 1 and direct in CET2. CET 1 is a mixed weight building system, using lightweight materials in the envelope and heavyweight materials in an interior nucleus made with adobe walls, steel reinforced concrete structure and alveolar slab pavements. (...) The evaluation of a zoning strategy of the interior spaces was also made, defining different thermal characteristics: greater inertia for the sleeping zone of the bedroom and living room and minor inertia in the remaining compartments - essentially of working in diurnal use. On CET 1 is proposed natural illumination from the North façade, because of the indirect gain strategy for thermal gains the closes South façade. CET 2 simulates a conventional construction, made with a reinforced concrete reticular structural system, pot and slab concrete pavement and ceiling and exterior double hollow brick walls. From the analysis of the Test Cell rehearsals conducted, was demonstrated that the proposed solution allows a significant reduction of the primary energy consumption (...)” [8]. The monitorized Cells pretended to simulate a housing unit with 20m² (total external perimeter area), with a room and a bathroom.

Optimizing construction cost-benefit ratio does also mean to optimize local conditions and natural resources, attending to the constructive traditions. Many differences may be described trough Portugal from climate to local resources, geographically and culturally. “Portugal is a South European Country, Mediterranean on the Center South, but with increasing Atlantic influences on the Northwest. The Population, of almost 10 million inhabitants, is concentrated near the sea.” [6]. The reference cases to choose, in order to demonstrate the parameter, should belong to the same geographical area so they could be framed on the existing study [8]. Two housing reference cases were chosen regarding the following criteria: (1) geographical location; (2) careful design and adequate urban integration; (3) constructive solution and enclosure walls. The analysis focuses the reference cases enclosure walls costs (construction and energetic) in comparison to a conventional enclosure wall (commonly used in current standard construction in Portugal). The three situations – being one hypothetical (the conventional enclosure wall, as a comparison reference)
and the other two related to housing in Porto - are schematically identified in the Figures 1, 2 and 3.

Table 1 is directly based on the results obtained in the Test Cells [8]. Some differences between the enclosure walls that were executed in the reference cases and the illustrated enclosure wall-types may exist. The data used to exemplify this parameter was limited to the specific composition of each wall-type that was studied in the available research, and so there has been an effort of correspondence.

Figure 1  Current standard construction (conventional structural solution). Correspondent studied wall-type cf. [8], Housing in Lordelo, Bairro Económico Marechal Gomes da Costa, Porto.

Figure 2  Housing in Aldoar, Cooperativa CETA / Cooperativa SACHE, Porto, 1994/98. Correspondent studied wall-type cf. [8]. Architectural design: M. Correia Fernandes.

Table 1 Wall-type enclosures comparison: construction and energetic costs in a life-cycle analysis [8]

<table>
<thead>
<tr>
<th></th>
<th>Current standard housing (wall-type studied*)</th>
<th>Housing in Aldoar (wall-type studied*)</th>
<th>Housing in Massarelos (wall-type studied*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constitution of the wall-type infilling the concrete frame structure</td>
<td>mortar 2 + clay brick 15 + th. ins. 4 + cavity 5 + clay brick 11 + mortar 2</td>
<td>mortar 2 + clay brick 11 + th. ins. 4 + cavity 5 + face brick 11,5</td>
<td>mortar 2 + clay brick 22 + mortar 1,5 + ETICS 6</td>
</tr>
<tr>
<td>Thickness (cm)</td>
<td>39</td>
<td>33,5</td>
<td>31,5</td>
</tr>
<tr>
<td>Specific Weight (kg/m²)</td>
<td>313</td>
<td>348</td>
<td>268</td>
</tr>
<tr>
<td>U value (W/m².ºC)</td>
<td>0,49</td>
<td>0,54</td>
<td>0,42</td>
</tr>
<tr>
<td>Acoustic Insulation (dB(A))</td>
<td>51</td>
<td>52</td>
<td>53</td>
</tr>
<tr>
<td>Primary Energy Consumption (kWh/m²)</td>
<td>910</td>
<td>1093</td>
<td>858</td>
</tr>
<tr>
<td>Economical Cost (€/m²)</td>
<td>63,35</td>
<td>57,85</td>
<td>63,15</td>
</tr>
<tr>
<td>A</td>
<td>-</td>
<td>-</td>
<td>362</td>
</tr>
<tr>
<td>B</td>
<td>-</td>
<td>-</td>
<td>362</td>
</tr>
<tr>
<td>C</td>
<td>362</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Economic Necessities Cost (NI) (€/m²)</td>
<td>-</td>
<td>-</td>
<td>331</td>
</tr>
<tr>
<td>Primary Energy Consumption (€/m²)</td>
<td>191,9</td>
<td>87,8</td>
<td>266</td>
</tr>
<tr>
<td>Transport Cost ** (€/m²)</td>
<td>5,3</td>
<td>2,4</td>
<td>20,0</td>
</tr>
<tr>
<td>Construction Cost</td>
<td>138,4</td>
<td>63,4</td>
<td>1112</td>
</tr>
</tbody>
</table>
What is proposed is a parameter presented in percentages related to a common enclosure wall-type (reference wall), in order to characterize the cost-effectiveness of other enclosure walls solution. This paper believes this parameter is particularly helpful if observed during planning conception phase.

Considering data from Table 1, the enclosure wall system in Massarelos presents a total cost variation of -0.9%, while in Aldoar the cost variation is of -0.7%. However, depending on which values are compared, the two solutions in Aldoar and Massarelos present different results. If this cost is calculated with the external perimeter area (instead of total used floor area) Massarelos and Aldoar would not present almost any percentage difference when compared with the conventional solution. In comparison to the conventional reference wall (39,0cm), both walls in Massarelos (31,5cm) and Aldoar (33,5cm) benefit of lower thickness. Both solutions are adequate to Portuguese thermal regulations, being the U value in Massarelos -14,3% than the one of the reference wall, and being the U value in Aldoar respectively +10,2%. Concerning heating necessities (energetic necessities to the northwest of Portugal) the wall solution in Massarelos has considerably -8,5% while Aldoar has only -0,1% of the conventional solution (which, if considered in a life cycle analysis leads to considerable differences). If Primary Energy Consumption is analyzed, Massarelos has -5,7% while Aldoar has +20,1% of the reference solution. Regarding all these
aspects, the enclosure wall system in Massarelos comes out as the more cost-effective wall system solution in a life-cycle analyses, though External Thermal Insulating Composite Systems do not present a high durability.

**Conclusion**

**Research Studies in Portugal**

There are many ongoing research studies, mainly academic, regarding “standard construction and management concepts” in Portugal. Some of these studies analyze construction optimization techniques in different perspectives, getting across economic concepts on various aspects. Some studies focuses on management methodologies (construction process but also contractor enterprises). Other studies look for approaches that can help to optimize the energetic performance of the buildings (searching for building economy through a life-cycle analysis). Finally, others focus on materials and constructive systems experimentation (aiming to reduce costs during construction, unitary and labor costs). Despite many research studies are being developed in Laboratório Nacional de Engenharia Civil (LNEC), Faculdade de Engenharia da Universidade do Porto (FEUP); and Universidade do Minho (UM), in Guimarães, among many other institutions, most are targeted in the field of Civil Engineering. Those focused in architectonical approaches, do mainly analyse housing residential quality, with special emphasis on external spaces in residential areas evaluation.

**Ongoing Research**

The development of the parameter presented in this paper, applied in the analyses of different housing case-studies in the northwest of Portugal, looking for new approaches from the point of view of housing architecture and its construction, is a further development of the ongoing PhD research by Joana Restivo. In an advanced stage of this research, it is hoped a better knowledge of advisable reference values for housing, regarding cost-effective solutions. Portuguese Government establishes an average value (€/m²) for building, annually updated [9], that regulate taxes and which is usually adopted by municipal procedures, though different values, depending on new buildings or rebuilding, are not considered e.g.. The Government also establishes, annually [10], cost values for housing, which slightly differ depending on the area of Portugal, and a formula is presented in order to calculate low-cost-housing. An important aspect is that this cost values use floor area instead of total area (particularly important when working with walls with different thickness). As a result of the dependence on municipal taxes - these values are the economical reference to legalize buildings for the local authorities - the “official” numbers (on which statistics data on construction costs are based) do not translate the “real” construction costs
This may be one of the reasons, among others, why such studies are not widely developed in Portugal.

References