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Thermal Code evolution and its contribution to the sustainable construction

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ABSTRACT AND KEYWORDS

In this paper it was analysed the evolution of the Portuguese Thermal Code in of face of sustainable parameters. The two versions were applied to the same housing building in two different positions in a way to improve the solar gains and be able to compare the results. The results gotten from the former steps were analysed, as well as the main differences noted between the two versions of the Codes. The calculus method pursued in the second version is similar to the first one, due to the technicians applying familiarity, but inserting new parameters and more demanding values.

Considering that the new construction exigencies, highly concerned with sustainable constructive principles and environment-responsive attitudes, a set of the main factors to take under consideration in face of the more recognized sustainable construction methodologies is presented.

The final stages of the paper focus the assessment of the collected results of the two versions of the Code, relating them with the sustainable construction criteria. These parameters allow outlining an overview about the Code evolution and its contribution to the improvement of the housing sector, in terms of the sustainable development.

Keywords: thermal comfort, sustainable construction, evaluation criteria

1. INTRODUCTION

In the early 90's, the first Code of Thermal Performance of Buildings was implemented in Portugal. This Code had two main ambitions: to introduce a new culture, paying special attention to the importance of the interior thermal comfort, involving maximum energy needs' levels, and; to provide new tools to avoid the moisture-related buildings' pathologies. Sixteen years after, the Code was revise and a new Code was published in the last month of April 2006, hoping to be implemented in July; this new Code has become more restricted and the interior comfort levels criteria were levelled higher.

In order to identify the key amendments in the Code and the resulting improvements, both versions were applied to the same housing building in two distinct positions: in the first one, it was used the original position; in the second one, a simulated rotation of 90º was considered, aiming to increase the incident solar radiation. The goals, in the second case, are to recognize the parameters that change due to the increase of incident solar energy values and to understand how much the Code shows that alteration.

2. PRESENTATION OF THE ANALYSED CODES

The first version of the Code of the Buildings' Thermal Performance Characteristics (RCCTE, 1991) was applied to each independent area of the housing building. It aims, firstly, to assure thermal comfort conditioning, reducing the energy consumption, and, secondly, to prevent the pathologies that take place due to the condensations in the constructive elements.

This study is attached to the attainment of values that are concerned with the heating nominal needs in Winter (Nic) and the cooling ones in Summer (Nvc). These are typified, respectively, for the amount of heat that will need to be provided and the excessive amount that should be removed, to maintain spaces' comfort conditions mentioned in the Code, i.e. the safeguarding of an internal temperature of 18ºC in Winter and of 25ºC in Summer.

$$N_{ic}=[\ ((L_{env}+L_{air})xGD_{15º}x0,02)-USG]/A_p \qquad (161.1)$$

Where:

- N_{ic} - Calculated heating nominal needs (KWh / m^2.year)
- L_{env} - Exterior envelope losses (W/ºC)
- L_{air} - Air flow losses (W/ºC)
- $GD_{15º}$ - Heating degrees-days base 15ºC (ºC . day)
- USG - Useful solar gains (KWh/ano)
- A_p - Useful pavement area (m^2)

$$Nvc=[(L_{env}+L_{air})x\ I\ x\ MLR]/A_p \qquad (161.2)$$

Where:

N*vc*	- Calculated cooling nominal needs (KWh / m^2. year)
L_{env}	- Exterior envelope losses (W/ºC)
L_{air}	- Air flow losses (W/ºC)
I	- Inertia parameter
MLR	- Medium level of radiation (months)
A_p	- Useful pavement area (m^2)

The calculated values according to the building characteristics and the fulfilment of the calculation sheets (Fernandes and Maldonado 1990) will be compared with the regulation values of Ni and Nv, which were established in each case accordingly with the formulas 161.1 and 161.2.

The second version of the Code (RCCTE, 2006) increases the number of criteria used to calculate some parameters, such as, in the Winter, the thermal losses for the exterior and interior envelope, the losses due to the air flow between interior and exterior, glazed surfaces' useful solar gains and, in the Summer, the solar gains.

In the new Code a new parameter is used: global annual specific needs of primary energy (Ntc), based in the equation 161.3.

$$Ntc=0,1\ (Nic/\eta i)F_{pui}+0,1(Nvc/\ \eta v)F_{puv}+Nac\ F_{pua} \qquad (161.3)$$

Where:

N*tc*	- Global annual specific needs of primary energy (Kgep/m^2.ano)
ηi	- Nominal efficiency of equipments (heating systems)
ηv	- Nominal efficiency of equipments (cooling systems)
F_{pu}	- Conversion of useful energy to primary energy
N*ac*	- Energy needs to prepare sanitary hot water

The value of Ntc is compared with a reference value Nt defined by the following equation:

$$Nt=0,9\ (0,01Ni+0,01Nv+0,15Na) \qquad (161.4)$$

Where:

N*t*	- Global annual specific needs of primary energy (Kgep/m^2.ano)

Besides these new parameters that were analysed, N*ac* and N*tc*, the new Code introduces some alterations in the calculus sheets' level used, both in number and content (Figure 161.1).

In the case of the heating season, the changes in calculus typology are relevant to verify the useful solar gains, starting by including the internal gains and other solar orientations apart from the south quadrant.

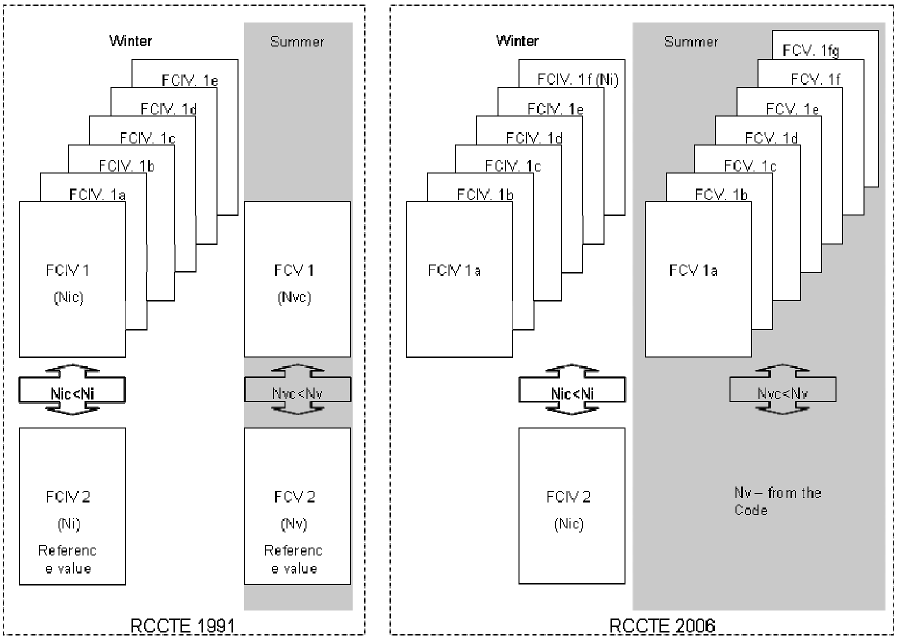

Figure 161.1 – Comparison between the codes

With respect to the cooling season, the increase of the number of calculus sheets shows a higher concern about the energetic consume during the warm months, namely using a more detailed methodology to determine the incident solar radiation.

The use of thermal storing walls, in what concerns passive systems' employ, they have its area ignored in terms of losses' quantification during the heat season, although it should be followed the minimum shade requirements in the Summer, in order to avoid overheating.

3. CASE STUDY

The Codes were applied to a housing building apartment located in the city of Castelo Branco, in the inner centre region of Portugal. In the scope of the climatic partition used in the RCCTE, that portray the Portuguese climatic Winter zones from I_1 (less severe) to I_3 (more severe), as well as the climatic Summer zones, from V_1 (less severe) a V_3 (more severe), Castelo Branco is classified in the I_2 and V_3 climatic zones.

The apartment has three façades, oriented at NW, NE and SE and it has an area of about 190m^2. It has double brick walls, with an insulation layer and a layer of air gap between the inside and outside masonry; the structure is made of concrete and the building's inertia, based upon the useful superficial mass (Kg/m^2), is categorized in the Code as "strong".

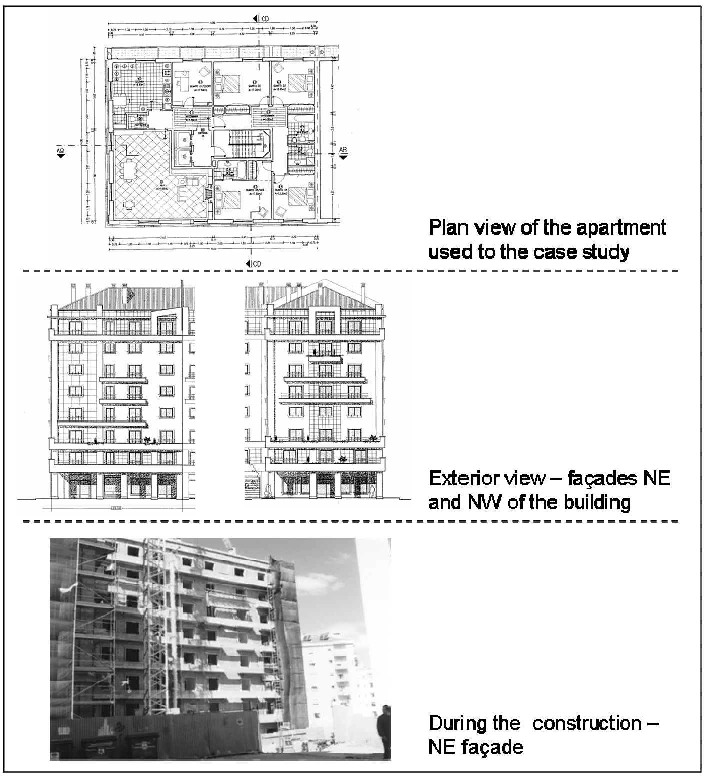

Figure 161.2 – Housing building presentation

Figure 161.2 presents the studied building and some of its architectural elements: the plan, the façades and the exterior aspect during the construction stage. The building has seven pavements, the ground floor has a commercial use and the other ones they all have a residential function.

4. RESULTS ACHIEVED

The two Code's versions were applied to the apartment presented in the previous chapter, considering first the original position and then the 90º rotation.

After the application of the Codes, the results gotten were synthesized in Table 161.1.

Table 161.1 – Comparison between results

Evaluated criteria	Unit	Original position RCCTE90	90º Rotation RCCTE90
Losses by exterior elements	W/ºC	87,17	87,17
Losses by interior elements	W/ºC	74,71	74,71
Losses by exterior glasses	W/ºC	80,80	80,80
Losses by air flow	W/ºC	168,08	168,08
Total solar gains	KWh/ano	1956,94	2866,50
Usefull solar gains	KWh/ano	1946,56	2786,33
Maximum Heating Nominal Needs (Ni)	KWh/m2.ano	53,73	53,73
Calculated Heating Nominal Needs (Nic)	KWh/m2.ano	32,44	27,86
Maximum Cooling Nominal Needs (Nv)	KWh/m2.ano	13,30	13,30
Calculated Cooling Nominal Needs (Nvc)	KWh/m2.ano	3,74	3,71
Evaluated criteria	**Unit**	**RCCTE06**	**RCCTE06**
Losses by exterior elements	W/ºC	76,75	76,75
Losses by interior elements	W/ºC	62,29	62,29
Losses by exterior glasses	W/ºC	80,80	80,80
Losses by air flow	W/ºC	134,46	134,46
Total solar gains	KWh/ano	4165,66	4938,64
Usefull solar gains	KWh/ano	7406,35	8036,68
Maximum Heating Nominal Needs (Ni)	KWh/m2.ano	69,68	69,68
Calculated Heating Nominal Needs (Nic)	KWh/m2.ano	36,18	32,74
Maximum Cooling Nominal Needs (Nv)	KWh/m2.ano	32,00	32,00
Calculated Cooling Nominal Needs (Nvc)	KWh/m2.ano	13,12	13,98

The major difference between the two building's orientation used can be appreciated in the solar gains values, with an increase of 46% in the first version of the Code and 19% in the second; this situation led to the consequent alteration of the heating needs' final result, with a drop of 16% in the first case and 10% in the second.

The alteration of the methodology of exterior elements' losses calculation it is not very relevant in the results achieved. The first Code version uses a factor of losses' concentration with the purpose of expressing the heterogeneity of the façades that, despite the predictable or approximate calculation, penalizes the apartment. The second version uses the thermal bridges' calculation and the losses trough the rest of the façades area, what allowing to get more accurate data about the elements' heat flow.

The cooling maximum needs, in the second version of the Code, are imposed by law, while that in the first version they were calculated considering the elements' reference values.

5. SUSTAINABLE PARAMETERS

5.1. Context

Sustainable construction became an undeniable and fundamental feature at construction's quality level. In fact, building design and construction could have a greater effect on reversing the pattern of global warming than any other industry sector (Mazria, 1979). The application of a few simple parameters affecting the selection of the proper materials and constructive techniques reflects both in the construction performance and in the environmental impacts of buildings.

It is expected that the codes incentive the adaptation to new realities and the implementation of good practices, and normally market's changes result of these adjustments, as well as the technicians' awareness to the new reality, so essential to the global development. The construction market, which is largely characterized by the presence of traditional SME's, must face the change at varied levels in order to decrease its impact on the environment, particularly because it is an industry whose economic and social importance are very dense: for example, in the European Union it represents 11% of the GDP and 25 million jobs. The concern about that impact extends to the built housing buildings, mainly through rehabilitation activities that aim to add some improvements, since it represents about 40% both of the energy consumption and waste production. (CIB, 1999)

5.2. Passive and sustainable parameters

Once that we are studying the code of thermal performance of buildings we now develop the parameters that affect it. In this sense, we now come close to the passive solar systems, that are, in fact, useful elements to improve the residence's performance and its application is rather simple, in terms of materials and techniques. (Richard and Gumuchdjian, 2001)

Regarding the construction elements, and besides the thermal characteristics of the used materials, the constructive systems are absolutely crucial to improve its performance. (Steven, 1998)

The direct gains are included in the calculation sheets that refer the gross solar gains and useful solar gains; even though, in the second version of the Code they include internal gains. The enclosure of these data leads to a significant upgrading of the final results, even if it 'benefits' buildings with less radiation incidence. It also considers more orientations, becoming more up-to-date, once that the first version only considered the south quadrant. (Moore, 1993; Gonzalo, 1998)

When using thermal storage walls, which own good performance in both seasons, in the Summer it must be assured the correct ventilation; this principle is encouraged by the fact that these elements are ignored in terms of the envelope losses' calculation. (Moita, 1998)

As far as the use of sunspaces, widely spread recurring to glazed surface's balcony closure, they aren't taken into account as energy collectors, despite the correct solar radiation incidence orientation.

The building's geometry limit the maximum heating needs value (Ni), since that this value is gathered accordingly to the construction's form factor.

Ventilation is considered through the heating needs calculation, in conformity with the air renovation of the interior ambience. The air flow, the existence of crossed ventilation or the geometry of the interior elements are not taken under consideration. (Olgyay, 1998)

The component related with the context where the building is located is also considered, in terms of the glazed surfaces' shading. The second version of the Code presents a more detailed methodology, regarding the shading elements in the building and in the surrounding buildings.

The new Code forces the use of solar thermal collectors, to provide hot sanitary water for instance, or other sources of renewable energies that captures a collector-equivalent volume of energy, since solar exposure conditions are granted.

The values concerning the limitation of the nominal needs of useful energy to provide heating, cooling, hot sanitary water production and the limitation of a building's global nominal needs of primary energy are updated by legislation. This appraisal allows the Code to be quite flexible and more real-time applied to the increasing exigencies of energy consumption cutback.

6. CONCLUSION

The evolution of the Code includes quite a few improvements in terms of the building's performance requirements. It were coupled several passive parameters that weren't taken under consideration in the first version. Nevertheless, some good practices of the Portuguese's typical construction, such as the use of sunspaces, are still disregarded from the Code.

A deeper analysis about the building's interior ventilation is neglected once again. This factor is highly relevant once that the Code incentive the use of thermal inertia as an element that contributes to attain Winter comfort. The non-verification of the crossed ventilation can lead to the construction of Summer overheated buildings, inducing increased energy consumption in the season. The presented case study is located in the most severe climatic region of the cooling season in Portugal, classified as V_3, inducing higher concern in this season.

The Code should present a key play role in the formation of the public's character, head guiding the "doing", suggesting techniques and materials and promoting these elements adequacy to each region's climatic characteristics, respecting the local know how.

The codes application at the building's level doesn't exclude the need of imposing urban management rules and urban mesh organization. Urbanism is a key condition in what concerns the thermal quality possible to achieve in the building, in face of issues like the solar radiation and the predominant winds orientation.

The concern about the built environment is taken into account for interventions out of historical zones. At this level the areas of urban space could be changed without accordance with the code exigencies, which was verified with the last version too.

Portugal is a country with a temperate climate and that shows one of the major levels of solar radiation in Europe. Even in this context it has one of the lower areas of installed solar collectors and it has registered the increase of energetic consumption. This energetic consumption level doesn't reflect the climate's severity, which is relative, but might present a weak performance of its buildings and increased thermal comfort exigencies by the users. These factors reveal the need to assume the compromise of increasing the quality of buildings and answer to the market needs, having in mind the exigencies imposed by the requirements of a responsible global development.

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