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The applicability of passive solar solutions to Portuguese traditional buildings

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Abstract

This work enhances the application of a clear and concise methodology to help choosing the most accurate passive solar techniques according to local climate and its influence on construction. To carry out these goals, the analysis of concepts of fictitious temperatures, the psicrometric diagram and its relation to passive solar systems zones previously established and, finally, the constructive changes that each technique requires is needed. This last factor mentioned took into account the technological and scientific knowledge, as well as the current constructive solutions applicable in the building construction sector in Portugal.

The article clears these questions from the design point of view, establishing a straight interdependence between theoretic concepts and its practical application, framed by a context of optimisation, adopting the Portuguese traditional construction as the experimental scenario.

1 Introduction

The braking of a secular tradition in the human being existence, featured by the relation between construction and the environment, led to high and unsustainable costs in environmental terms and unknown health consequences. Although allowing to achieve acceptable comfort levels, the adopted strategy is based on non renewable energies.

The high energetic consumption and most aggravating persistent increase of this consumption (mainly in housing buildings), came to redirect the interests on an international scale, becoming truly essential to acquire severe energetic policies in order to control and contain those statistics.

2 National climate and passive solar technologies

2.1 Portuguese climatic conditions

With the aim of characterizing the passive solar technologies to be used in a certain area it is necessary to carry out an analysis of the correspondent climate. In Portugal, our Thermal Code [1], which has as a principal goal the establishment of the minimum limits of comfort in the inside of the housing and control the energetic wastes of the buildings, divides the country in three winter and summer climatic zones (Figure 1). The zone "I3" is the most severe in winter and the zone "V3" is the most severe in summer.

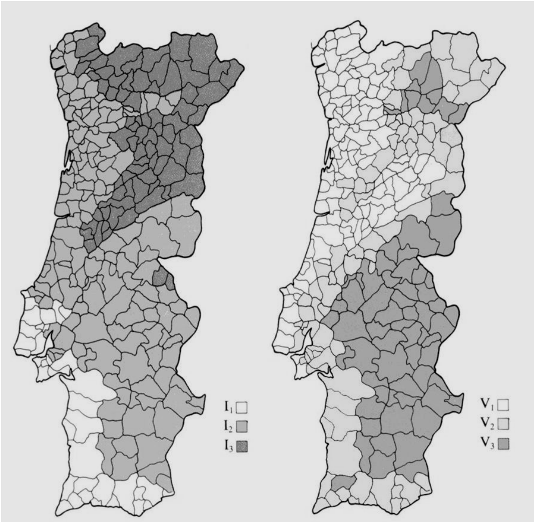


Figure 1: Winter and summer climate division of Portugal

This division was elaborated with basis on the isothermal lines from the national territory, leading to the use of reference values and, consequently, the nominal needs of heating and cooling. The increasing of the consumes verified in the past years, mainly in the housing building sector, enhances the importance of the application of techniques which allow the control of the energetic wastes, more relevant for the heating.

The fact that Portugal presents a moderate climate and the highest levels of insulation in Europe shows the great potential that can be explored in the sense of beneficiating from the good comfort levels and low consuming rates.

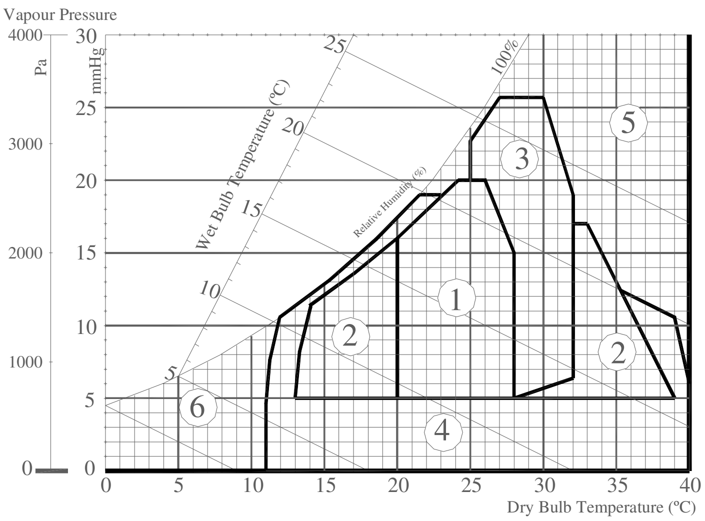
2.2 Passive solar technologies

The passive solar construction is characterized by the use of constructive elements: walls, windows, roofs and floors, which collect, store and distribute the thermal energy provided by solar radiation and also preventing the overheating. The heating flows happen mainly through the natural mechanisms of

conduction, convection and radiation instead of the use of mechanical equipments, which carry energetic wastes. The objective is to control these energetic flows and make available comfort conditions in the housing construction zones in any season of the year [2] [3] [4] [5].
The passive solar systems of heating consist in the captivation and distribution of solar energy without the need of using mechanical ways, which demand external energy for their function. Although small mechanical devices may be integrated in these systems as a way of increasing its efficiency, without leading to significant consume raises, generally inferior to two percent of the received energy. [6]
Two forms of the energy captivation can be distinguished: through the environment, by its direct heating due to the solar radiation or through the existence of a stored mass that, after being heated by the sun or by the contact of the heated air, transmits the heat with a break in relation to its capitation (delay).
The passive solar systems of cooling consists in the use of natural ways (ventilation, vegetation, etc.) and constructive elements (windows, shading elements, constructive elements of great inertia, etc.) with the aim of producing the housing cooling or avoid its overheating.
The applicability of solar systems technology is based on its indirect use through the optimisation of the construction elements, which consists, for instance, in using thermal parameters that express solar passive performance in current constructive solutions properly conceived.

3 Definition of technologies based on the climate

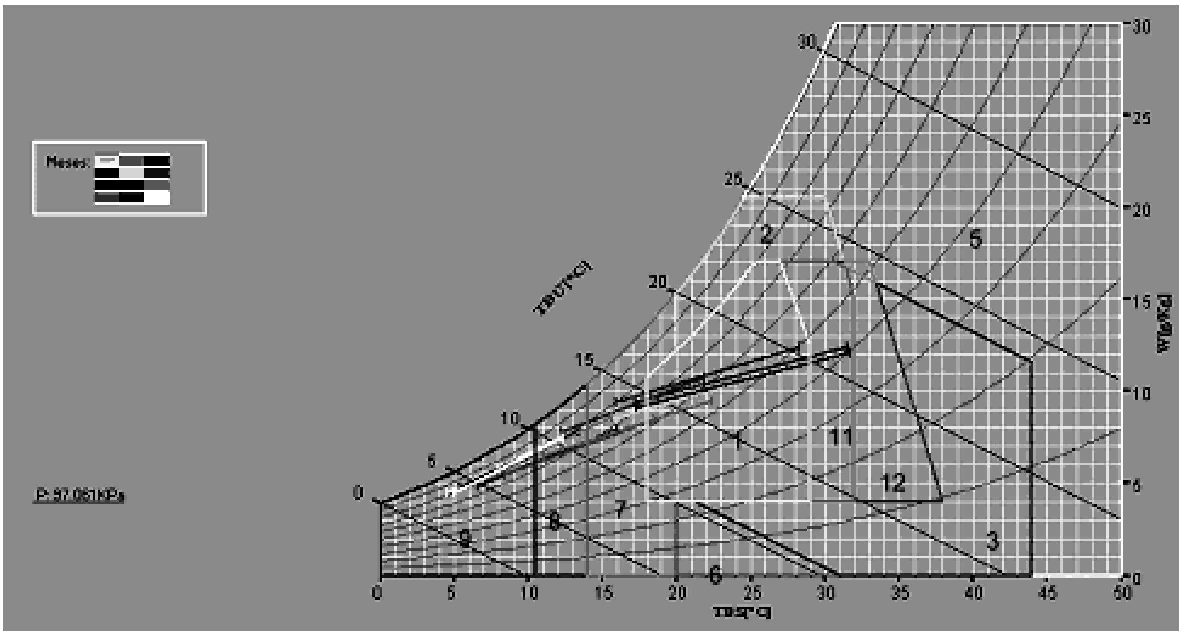
The Analysis 2.0 Bio program was developed by Federal University of Santa Catarina – Brazil, and its aim is to define the passive solar solutions, which are more effective in each situation, from the analysis of the climate data of the place where the building is to be located. The work methodology consists in over putting the climate data given to the psicrometric diagram to calculate the percentage of the time of the year in which thermal discomfort or comfort occur and the percentages in which each strategy is more appropriate. Each area of intervention of the passive solar solutions is already pre-established through the definition of nine climate zones where some overlaying can exist, being necessary the use of strategies simultaneously or separately. The Figure 2 presents the definition, made by Baruch Givoni, of the comfort zones' extension based on the psicrometric diagram.



1	Comfort
2	Thermal inertia
3	Ventilation
4	Occupant behaviour
5	Air conditioning
6	Artificial heating

Figure 2: Givoni's comfort zones

The software was applied to the city of Castelo Branco, located in the centre of Portugal, an area of high thermal variations as well as in the winter and summer. This application was shown in the graphic presented in Figure 3 and its use in this distinguished climate reveals completely different results. We can quote as an example the similar application in a work done in Cape Verde (city of Praia – Santiago Island) which reveals compatible cooling strategies with the description of a arid climate and consists in the use of cooling systems by evaporation.



Legend :

1. Comfort	6. Humidification	11. Ventilation / Mass / Cooling by evaporation
2. Ventilation	7. Thermal mass / Solar heating	
3. Cooling by evaporation	8. Passive solar heating	12. Mass / Cooling by evaporation
5. Air conditioning	9. Artificial heating	

Figure 3: Software application to Castelo Branco – Portugal

The results presented, based on the overposition of the monthly climate data (graphic lines) to the comfort zones, reveal that Castelo Branco has comfort values of about 32,93% of the time of the year, not being necessary the use of any additional energy resources to obtain and maintain a temperature of 18ºC inside of the building. The most mild temperature are predominant in the equinox and in some periods of the hottest season, the summer.

The highest level of discomfort in this climate zone is reached in the winter months, between November and April, where the need to use the artificial heating exists due to the lowest temperature with a bigger problem in the months of December and January which are characterized by the severity of the season.

The thermal inertia interferes in the comfort of the months of March to November and can cause its increase in 17,49% of the time of the year for the heating and in about 3,02% of the time of the year to the cooling in the months of July an August. The use of the inertia allows the reduction of the thermal amplitude between the interior and the exterior space, as well as the storage of heat in the heating and cooling season, in which exists the need to eliminate this stored heat in the cooler period (night) through ventilation to avoid the overheating.

Table 1: Results of the application

Passive solar solution	**Month** (% of solution utilization need)												**Year**
	Jan	Feb	Mar	Apr	Mai	Jun	Jul	Aug	Sep	Oct	Nov	Dec	(%)
Comfort				4,95	38,59	75,00	76,92	76,39	83,06	40,20			32,93
Thermal mass / Solar heating			21,27	39,61	35,09	25,00	5,60	4,87	16,94	41,23	20,25		17,49
Passive solar heating	21,05	36,25	37,23	34,65	26,32					18,56	44,30	24,65	20,25
Artificial heating	78,96	63,76	41,50	20,80							35,46	75,35	26,32
Ventilation / Mass / Cooling by evaporation							17,48	18,75					3,02

Considering the contribute of thermal inertia in the percentage of the days of the year in which the discomfort is verified, the values increase in about 30% in the winter and summer months; this is the same value of the contribute of the passive solar heating, as long as the artificial heating comes to supply the remaining of the 40% of the needs to the attainment of the thermal comfort.

4 Project implications for the implementation of passive solar systems

Further on we have a summary table of passive solar technologies (Table 2), relating them with the necessary changes to its implementation, more precisely: the need to a bigger area of glass window to allow the solar radiation; the need to increase the thermal inertia of the constructive elements to guarantee its capability of storage or heating dissipation; the need of the elements existence with specific characteristics, such as circuits, which enhances project alterations in a way to make available its execution; elements existence, structural or not, which allow the shadowiness of space [2] [6] [7].
According to the Table 1, the raise of thermal inertia, or better, the presence of a stored and more effective mass, is a very important change that interferes in the behaviour of all passive solar systems of heating and in the half of the cooling ones, being so, more reliable in the conceptual view of this work.

Table 2: Passive solar technologies and their implementation

Passive solar systems	Passive solar technology	Constructive action			
		Glass window	Thermal inertia	Circuits	Window shade, other elem.
Heating	Collectors (glass)	x	x		
	Stored walls		x		
	Water walls		x		
	Greenhouses	x	x		
	Convection circuits	x	x	x	
Cooling	Ventilation	x			
	Shadow				x
	Radiation		x		
	Evaporation and dehumidification			x	
	Thermal inertia		x		

The inertia increase in the heating season origins a solar gains management, direct or indirect, more efficient due to the storage possibility and a post use well planned. Its use as a passive solar system of cooling consists in this same ability of storing: the mass absorbs the heat in the warmer periods of the day, and afterwards, when the changes with the environment begin, the free heat must be eliminated by ventilation to avoid the space overheating.
The implementation of passive solar technologies must be reviewed to the project level because it has profound influence on the conception and design activities and, consequently, is a product of the technical-scientific knowledge of the project designer.

5 Conclusions

The worry with the increase of the energetic consumes, verified worldwide, it must be confronted with the responsibility of the project designer. The new energetic policies adopted by the European Union are based in the need to implement a system of energetic certification in a way to possess a more consistent tool to control the wastes verified at the level of the buildings. The housing buildings must be analysed in a particular way, due to the increase of life conditions making available the comfort in buildings construction were thermal behaviour of its elements presenting a quite reduced quality. This comfort is obtained through the raise of energy consumes and with bills to be paid by future generations.
The article has as a goal to demonstrate that the consume decrease is possible through the use of constructive technologies and systems adopted to the climate characteristics of each region. Its up to the project author to execute the correct analysis and to proceed to the most adapted techniques. Some of them possible only when previewed in the conception phase. The case of Portugal shows the possibility to extend the comfort zone in about 30% of the year with the use of thermal inertia, which allows to obtain comfort in about 65% of the time of the year. This possibility is way behind the reality, where the use of energy has been increasing from year to year, mainly in the housing sector.
The knowledge of technicians is fundamental with the domain on the use of the potentialities of the passive solar systems and with the conviction that our ancestors would recognize the need of a construction in dialogue with the climate.

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