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ENERGY REHABILITATION OF THE THERMAL ENVELOPE OF EXISTING BUILDINGS

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Abstract

Residential buildings are great producers of CO2 while the current energy context is trying to minimize these emissions into the atmosphere. In order to achieve the requirements imposed by legislation, we must improve the energy performance of buildings by reducing energy consumed in heating and cooling.
The research presented here focuses on the rehabilitation of existing buildings, where there is the greatest potential for savings. We propose the renovation of the thermal envelope of existing buildings applying only passive measures. We selected a building of homes with architectural value as a prototype for this study, which can be extended to other buildings with similar characteristics and rating in the future.
Firstly, we analysed the existing building and obtained a rating level energy of E. After applying several improvements involving the implementation of thermal insulation, we determined a rating of D. Even though this is a positive result, the objective was to reach a rating at least of C. In order to do this we needed to analyse the exact influence of the different elements on the energy performance of the building and implement those improvements that will have a greater impact. We ran several simulations in order to quantify different effects and found that facades and windows are the most decisive items on improving the rating of this particular building.
Finally, we implemented these measures in the thermal envelope of the building and reached a rating level energy of C. Simulation of the effect improvements allowed us to determine the savings in energy consumption due to the rehabilitation of the building as well as the reduction of CO2 emissions.

1. Introduction

The building sector has a very important role in global energy consumption. It has a great influence on CO2 emissions into the atmosphere.
The energy demand of residential buildings depends on many variables but, we can claim that increased consumption is due to the use of the air-conditioning system in order to achieve thermal comfort, both in heating and cooling, accounting for 42% of the energy consumed [1].
Thus, the main measure to improve the energy performance of buildings is to act on its thermal envelope, in order to minimize its losses and therefore, minimize energy demand. The afore mentioned being the goal to obtain more energy efficient buildings.
This leads us to comply with an commitment which is to reduce carbon dioxide emissions to acceptable limits, to improve the energy efficiency of buildings, as provided for in Directive 2002/91/EC [2] on the energy performance of buildings. The Spanish legislation since 2006, has included in the Código Técnico de la Edificación [3] as one of the instruments to achieve those objectives.
The problem is not so reflected in the new buildings, which are projected according to the appropriate measures under the aforementioned legislation, but lies mainly in the existing building stock, which in Spain amounts to more than 8 and a half million residential buildings, accounting for 11% of the country's energy consumption [4]. Therefore, the greatest potential for savings is in the existing building stock. This paper 'Rehabilitation of the Thermal Envelope of existing buildings', is going to argue this.

For the study, we selected an actual building of homes located in Castellón de la Plana, which was built in 1948 and which is representative of the existing buildings built at that time. It also has the peculiarity that its facade has architectural value, a condition that will be a drawback, because the renovation cannot result in the alteration of the outside of the building, just the inside. Another limitation is set by the activity inside the building, because it is busy and in use. Figures 1 and 2 show a picture of the building and a floor plan type.

Fig.1. Picture of the study building

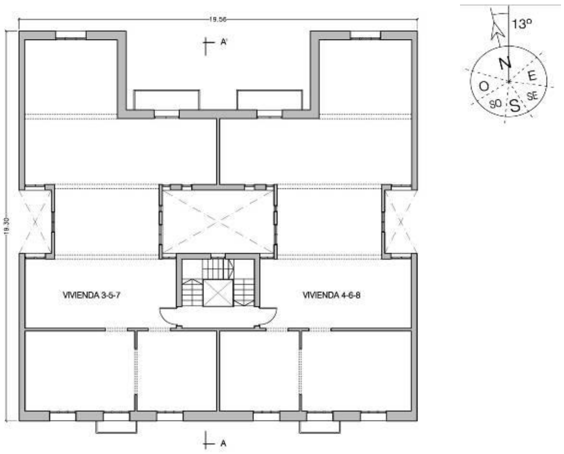


Fig.2. Type floor plan and solar orientation

2. Research questions and objectives

The main objective of this research is to find solutions, both technical and economic viability, which would improve the energy performance of the building in order to achieve high ratings of energy Certification or at least C and D, on the scale of energy performance of buildings.
The questions to which we try to answer with this research are:
What are the most viable renovation solutions for an old building with architectural interest and that interfere less with of domestic activity?
How can we define and classify the existing buildings energy performance and apply our conclusions and findings to other buildings with similar characteristics?
What range of improved energy rating can be achieved with the rehabilitation of the thermal envelope of existing buildings with only passive measures?
What energy and CO2 emissions savings involve the energy rehabilitation of an existing building?

3. Methodology

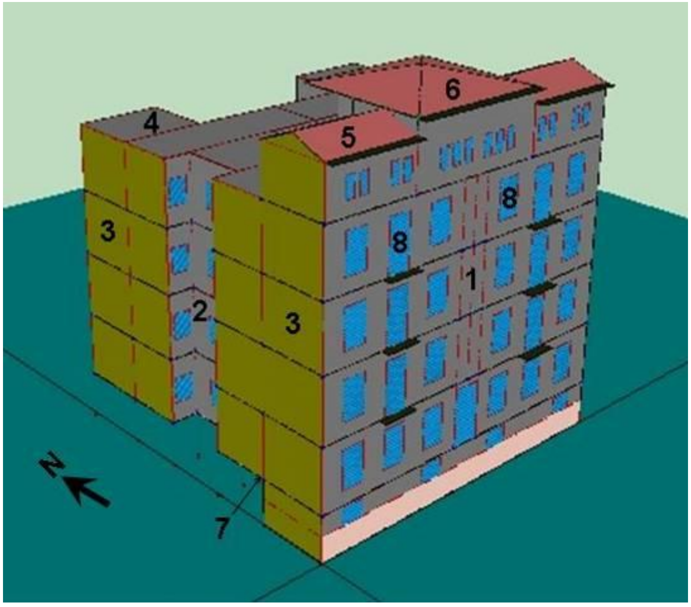
3.1 Analysis and building energy rating in its current state

In order to proceed to the analysis of the building in its current state, we had to make two important steps in order to collect data. Sketching and technical drawings were done to define all plans of the building and we conducted work to discover the composition of the building systems, considering: facade walls, floors, roofs, glazing and window system.
Once this data was known, we proceeded to the simulation of the building with LIDER [5] and CALENER VyP [6], both recognized by Spanish law, and used to calculate the energy demand of the building and the rating energy, respectively. With this process we also reached calculating the thermal transmittance (W/m2k) of the building elements and obtained a rating level energy E [7]. This rating E, is what this study hopes to improve.
Subsequently, we defined the new thermal envelope of the building, which will determine the elements on which we have to act and provide it with thermal insulation.

3.2 Proposal of modification of the thermal envelope

On identification of the thermal envelope, different solutions were proposed to act on it, all them as passive intervention measures. Therefore, the installations are outside the scope of study.
These proposed solutions are such that their incorporation into the building are constructively feasible, taking into account that the work should affect the daily activities of the occupants and users of the property, as little as possible. So, it is worth noting that the proposed solutions are not only based on consideration of technical and constructive factors, but also economic and energy efficiency factors.
Modification of the thermal envelope is performed in two different ways:

Providing thermal insulation in the items that define the thermal envelope: facades, roofs and floors. Replacement of the window frames and glazing.
The incorporation of thermal insulation is not recognised in the same way in all elements, because each one has different requirements.
The front facade can not be modified, so the provision of thermal insulation is carried out on the inside. In shared walls the only feasible actuation is also on the inside. However, the facades in the courtyards are isolated from the outside, which is more favorable because it avoids thermal bridges.
The pavement of the ground floor is covered by thermal insulation and above this, we put a new pavement.
There are two types of roofs: a flat roof, where the insulation is provided on the outer face (inverted roof) and it is projected a floating pavement with ventilated air chamber; and the tiled roof, where the insulation is provided on the inside of the non-habitable space between the slab and the roof.
In relation to the windows, we studied the possibility of maintaining the existing wood because it has a low thermal transmittance. However, after studying the situation, it was decided to replace the windows with new frames and glazing, for maintenance reasons. We proposed an aluminium frame and double glazed windows with 4mm-thick glass and 6mm air chamber. The calculation programmes are then applied to the alterations made and an energy rating of D is obtained. These decisions are made with the support of Guía Técnica para la Rehabilitación de la Envolvente Térmica de los Edificios (Andimat) [8].



1 Masonry stone walling 43-50cm
2 Brick walling 14cm
3 Brick walling 28cm
4 Flat roofing
5 Tiled roofing over sloped slab
6 Tiled roofing over flat slab
7 Concrete Flooring
8 Simple glazing and wooden frame

Fig.3. Simulation with LIDER and CALENER VyP

3.3 Optimization and improvement of the rating level energy

The rating level energy obtained is a positive result, as we managed to improve two levels above the rating of the building in its current state. Despite this, we intend to carry out further improvements on the building, suggesting improvements that allow us to reach a rating at least of C.
To do this, we wanted to study what is the exact influence of the different elements on the energy performance of the building, in order to select and implement those improvements that will have a greater impact allowing for optimal results.
To achieve this goal, we made a total of 25 simulations in both calculation programmes, LIDER y CALENER VyP, acting separately on facades, roofs, floors and windows. And finally, acting on all together.
The conclusions are represented graphically below:

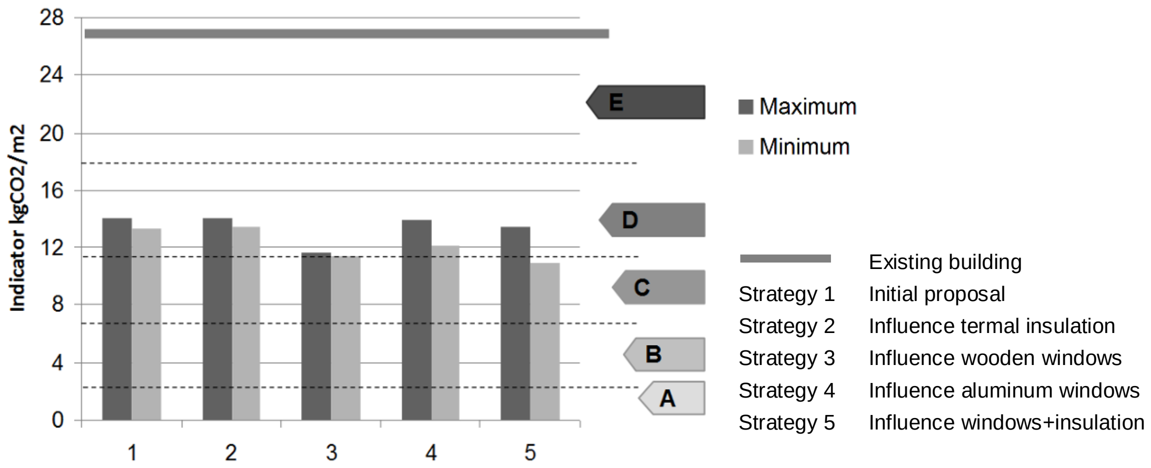


Fig.4. Results of 25 simulations to optimize the solution

3.4 Definition of the rehabilitated building

Based on our findings, we decided which items should be prioritized for the rehabilitation. These are, facades, other vertical walls and windows, which are the most decisive influence on improving the rating, due to the form factor of the building.
The following Table 1 shows the comparison between existing solutions and new solutions proposed to achieve the energy rating C:

Building system	U existing building (W/m²K)	U required CTE (W/m²K)	U rehabilitated building (W/m²K)	%U reduction	Thermal insulation	
Masonry stone walling 50cm	2.49	1.07	0.37	85.14%	MW 6cm	VERTICAL WALLS
Masonry stone walling 43cm	2.37	1.07	0.38	83.97%	MW 6cm	
Brick walling 14cm	2.49	1.07	0.43	82.73%	PUR 5cm	
Brick walling 28cm	1.84	1.07	0.40	78.26%	PUR 5cm	
Concrete flooring 10cm	2.15	0.68	0.37	82.79%	XPS 8cm	FLOORS
Flat roofing	2.34	0.59	0.34	85.47%	XPS 3cm	ROOFS
Tiled roofing	2.59	0.59	0.31	88.03%	MW 8cm	
Slab+tiled roofing	1.97	1.07	0.47	76.14%	MW 8cm	
Frame	2.20	5.70	3.30	-50.00%	RPT>12mm	WINDOWS
Glazing	5.70	5.70	3.20	43.86%	4+6+6	

U Thermal transmittance
RPT Thermal bridge breakage

Table 1. Final solutions applied in the thermal envelope

4. Conclusions

From this research we can conclude that we have found the most appropriate solutions to implement in the rehabilitation of an existing building, according to constructive, economic and energy efficiency criteria. This allows us to classify the building in its current state and in the future apply these findings to other buildings with similar characteristics.
We have achieved a significant improvement in rating scale of energy performance, from level E to C, only with the implementation of passive measures, ie, acting only in the thermal envelope of the building. This fact leads us think that if we acted both in the building installations and the thermal envelope, we could get an even better rating, possibly levels B or A.

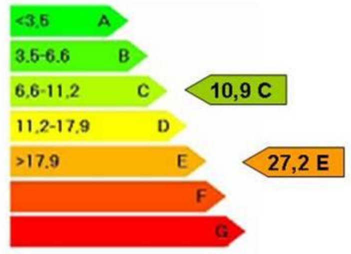


Fig.5. Energy performance label of the building C

Finally, we achieved to determine the consumption energy savings that will involve the rehabilitation and also, the reduction of CO2 emissions, as can be seen from the graph below.

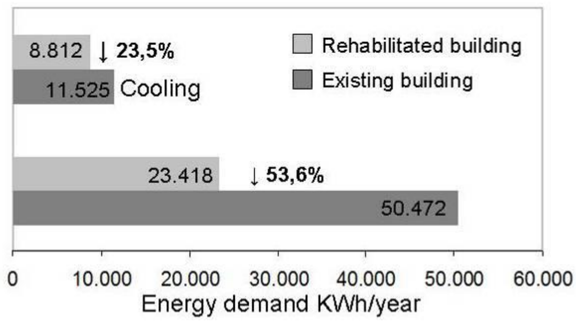


Fig.6. Energy consumption savings

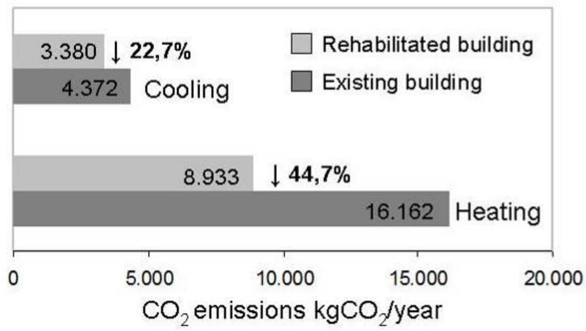


Fig.7. CO_2 emissions reducing

References

[1] IDAE, Instituto para la Diversificación y Ahorro de la Energía. http://www.idae.es [Last access on the Internet 6/07/2010]

[2] DIRECTIVE 2002/91/CE of the European Parliament and of the Council, of 16 December 2002, on the energy performance of buildings. Official Journal of the European Communities. 2002

[3] Código Técnico de la Edificación, REAL DECRETO 314/2006, de 17 de marzo. Ministerio de Vivienda. Official Journal of Spain. 2006

[4] Institut Cerdà, Proyecto RehEnergía. Rehabilitación energética de edificios de vivienda, Jornada de Rehabilitación Energética, Ministerio de Vivienda (2008). http://www.icerda.es [Last access on the Internet 2/07/2010]

[5] LIDER, Documento Básico HE Ahorro de energía. HE1: Limitación de la demanda de energética. Documento Reconocido. Ministerio de industria, turismo y comercio.

[6] CALENER VyP, Calificación energética de edificios. Edición: Viviendas y edificios terciarios pequeños y medianos. Documento Reconocido. Ministerio de industria, turismo y comercio.

[7] REAL DECRETO 47/2007 de 19 de enero, por el que se aprueba el Procedimiento básico para la certificación de eficiencia energética de edificios de nueva construcción, Ministerio de Vivienda y Ministerio de Industria, Turismo y Comercio. Official Journal of Spain. 2007

[8] Asociación Nacional de Industriales de Materiales Aislantes (ANDIMAT), Guía Técnica para la Rehabilitación de la Envolvente Térmica de los Edificios. IDAE, Madrid (2008), ISBN: 978-84-96680-37-1. http://www.idae.es/index.php/mod.pags/mem.detalle/relcategoria.1030/id.48/relmenu.53 [Last access on the Internet 30/10/2009]