CERAMIC CONSTRUCTION SOLUTIONS FOR IMPROVING ENERGY EFFICIENCY IN BUILDING RENOVATION

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RENOVATION, A KEY PRIORITY

Buildings and the construction sector generate about 30% of energy consumption and CO_2 emissions into the atmosphere, so that actions aimed at improving their energy efficiency have become a top priority in achieving the Agenda 2030 sustainable development goals. However, International Energy Agency (IEA) data confirm that the average renovation rate is insufficient and only involves light, superficial renovation.

Although many research projects carried out with national and European public funding have confirmed, on a prototype scale, the technical feasibility of different innovative solutions (ventilated envelopes, nocturnal radiation, collectors and exchangers, etc.) for reducing energy consumption relating to thermal conditioning and air renewal (HVAC), the energy saving resulting from their application in building renovation cannot be estimated because they are not available in the recognised energy certification tools (HULC, CERMA, CE3X). According to EIT InnoEnergy reports, this uncertainty regarding their economic feasibility is one of the main obstacles to decision making for building renovation, given the high initial investment and long payback periods.

In order to overcome current barriers and raise the annual home renovation rate in Spain, in this project, technically and economically optimised solutions are being studied as a function of climatology and types of building, integrating the simulation models of these construction systems into the EnergyPlus™ program to assess their efficiency in reducing energy consumption and supplying the market with reliable information on the real savings resulting from their implementation in building renovation.

SOLUTIONS AND RENEWABLE ENERGY

To carry out the project, a demonstrator designed to enable simulation of buildings with the external insulation characteristics of the 1980s was built, in which different innovative façade and roof solutions have been integrated, with a view to assessing their ability to reduce the energy demand under real-life conditions (Figure 1).

The demonstrator, located on the roof of the Instituto de Tecnología Cerámica (ITC), contains two symmetrical enclosures for simultaneous comparative assessment of the solutions and their possible optimisations. The demonstrator is fitted with about 130 sensors that enable the evolution of the internal and external conditions regarding temperature, humidity, radiation, wind direction and speed, heat gains and losses and many other variables to be continuously monitored, as well as being fitted with actuators for home automation systems with active thermal conditioning control.

Figure 1 *N/W view of the demonstrator*

Internal enclosures and monitoring system

Façade comparison

During the summer and autumn of 2023, different construction solutions with features for reducing cooling energy demand in dwellings and buildings (ventilated façade, radiative sky cooling, nocturnal ventilation, etc.) were assessed under real-life conditions. For each of these solutions, different configurations of each construction system were analysed in order to optimise their design for enhancing efficiency and lowering energy consumption (e.g., channel depth, joint opening, size and characteristics of the cladding items in the ventilated façade envelope). The data collected in the demonstrator is being used to develop mathematical models for simulating the thermal performance of the construction solutions, based on the recorded external environmental conditions (radiation, ambient temperature, wind speed and direction, etc.).

During the winter and spring of 2024, further study will be conducted on construction solutions for mitigating heating energy demand (hot air collector façades, hot water thermal collectors, etc.), as well as their possible use in assisting thermal conditioning systems, preferentially by aerothermal energy. After assessment in the summer–autumn stage of 2024, possible active solutions that enable building envelopes to be used to reduce energy consumption, both in summer and in winter, will be analysed.

ECONOMIC FEASIBILITY IN RENOVATION

Interfaces are being programmed to allow integration into the EnergyPlus™ program of each mathematical model of the technically feasible solutions, in order to enable assessment on a building scale of the reduction in annual energy demand in different climate zones, orientations, and characteristics of the buildings to be renovated. This will enable assessment of the savings from the reduction in building energy consumption from renovation and obtainment of reliable information on investment return time, facilitating decision making and fostering the necessary rise in the building renovation rate.

Integration has already been performed into the EnergyPlus™ program of the mathematical model for different types of ventilated façade, this currently being in the validation stage by comparison of the resulting calculations with the data recorded in the demonstrator (Figure 2).

The tools developed in the project will enable experimental study of new renovation systems, optimising existing ones, and analysing their adequacy as a function of climatology, building type and characteristics, as well as allowing comparison of different renovation proposals, using both technical and economic criteria.

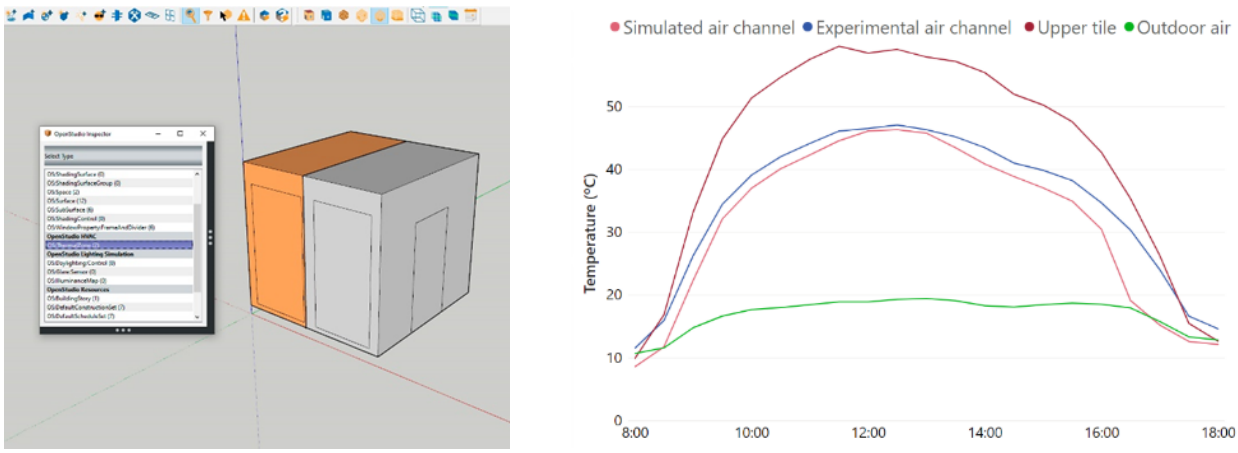

Figure 2 *Modelling of the enclosures in E+ and validation results*

ACKNOWLEDGEMENTS

Project funded by the Regional Department for Innovation, Industry, Commerce and Tourism of the Autonomous Government of Valencia (GVA), under the Grant Programme for Technology Institutes for Innovation projects in collaboration with companies in smart specialisation. Project ES4RE3 "Semi-active building envelopes for optimising energy efficiency in building renovation".

Collaborating entities:

BECSA, S.A.U.

SB Consulting, S.L. (ARQKEY)

SALTOKI, S.A.

THESIZE SURFACES SLU (NEOLITH)

EXAGRES, S.A