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# Durability of 20-year-old external insulation and assessment of various types of retrofitting to meet new energy regulations

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ABSTRACT

The exterior envelope of some social housing scheme buildings constructed at the beginning of the 1970s without thermal insulation has proved to be the cause of great thermal loss and condensation.

At the start of the 1980s, in order to resolve these problems, our research group carried out a study which led to the introduction of external thermal insulation (on the basis of previously developed performance specifications) and verification of the thermal performance achieved.

With the aim of verifying the efficacy of the intervention after 20 years and in order to assess the thermal–hygrometric performance and the state of conservation of the exterior envelope we carried out a two stage study:

1. Performance analysis carried out through monitoring and laboratory tests.
2. Formulation of hypotheses for retrofitting, assessed through simulations and parametric analysis.

The results showed the efficacy and durability from the thermal–hygrometric and mechanical point of view of the external insulation applied in the 1980s. It was also possible to verify energy saving for the different types of retrofit scenarios and to identify the correct positioning of the thermal insulation on the brickwork and on the floors so as to increase the surface temperatures in winter phase.


## 1. Introduction

At the start of the 1980s, our research group realized the retrofitting of social housing buildings through the introduction of external thermal insulation in order to reduce either the risk of condensation or energy consumption.

The present study is carried out with the aim of verifying whether after 20 years this type of intervention had maintained its efficacy.

In the first phase of the research we carried out a series of monitoring activities that allowed us to evaluate the thermal–hygrometric performance and the state of conservation of the exterior insulation.

Studies focusing on long-term assessment of thermal–hygrometric behaviour of external insulation coatings regard mainly component recently introduced into building technology (vacuum insulation panel, transparent insulation) and are about experimental analyses on laboratory-induced deteriorations [1,2]. Very interesting the experimental studies that focus on the effects of atmospheric deposition on the cement plaster [3], the durability of the finishing [4,5] and the degradation risk assessment of external envelopes [6].

In the second phase we simulated the buildings in dynamic conditions and we calibrated the virtual model by comparison with the experimental results.

Several researchers studied the importance of the monitoring activities in order to calibrate virtual models as close as possible to the reality [7–9].

This made it possible to achieve a "correct", realistic and reliable virtual model of the as-built case in which parameters could be varied by changing the characteristics at every new level of investigation (parametric analysis): it was possible to predict the effect of various types of retrofitting actions which respect the increasingly strict performance criteria laid down by new energy regulations and to compare the different conformations of exterior envelope to be used if designing new buildings.

The new regulations on energy saving, including Italian legislative decree No. 311/2006, aim at maximum reduction in wintertime heat dispersion and consequently at thermal superinsulation.

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**Fig. 1.** View of the building from the south-east.

Some researchers stressed that these kind of regulations, which set limits exclusively on transmittance and consumption values, brought about within the same climatic zone the use of envelopes seemingly with the same performance, but with very different behaviours as concerns comfort and internal surface temperature [10–12].

Our study made it possible to verify energy saving and internal surface temperatures for the different types of retrofit scenarios and to identify the correct positioning of the thermal insulation on the brickwork and on the floors in order to increase the surface temperatures in winter phase.

## 2. The case study

The study was carried out on a building located in the city of Pievetorina (central Italy), characterized by an Apennine climate and by 2189 degree days. The building is compact with two floors above ground level (Figs. 1 and 2). It is made up of four apartments, two on the first floor and two on the second. The ground floor houses a cellar space. The exterior envelope is made up of the layers shown in Table 1 verified using endoscopic inspection.

The envelope of the ground floor does not have exterior insulation. The apartments studied are on the first floor: one faces the north-east (squared hatch in Fig. 2) and the other the south-west (lined hatch in Fig. 2).

## 3. Methodologies

Monitoring and simulations were carried out in semi-stationary conditions so as to measure the heat transmission rate, and in dynamic conditions to study any aspects connected with the thermal inertia of the envelopes (time lag, decrement factor) by considering the variability over time of the thermal flow. In particular measurements were carried out inside the apartments in two ways:

- asking the users to keep the heating system continuously on during the data acquisition period with the internal temperature set-point at 20 °C. This apartment is indicated with squared hatch in Fig. 2.
- leaving the occupier freedom to select intermittent use of the heating system: this apartment is indicated with lined hatch in Fig. 2. The occupiers switched on the heating system between 7.00 a.m. and 9.00 p.m. with the thermostat temperature set at 18 °C.

### 3.1. Experimental facility

The following investigations were carried out on the building between 13 February and 10 March:

1. survey of the outdoor environmental conditions using an external weather station that included: hygro-thermal probe, wind speed and direction probe, solar radiation probe.

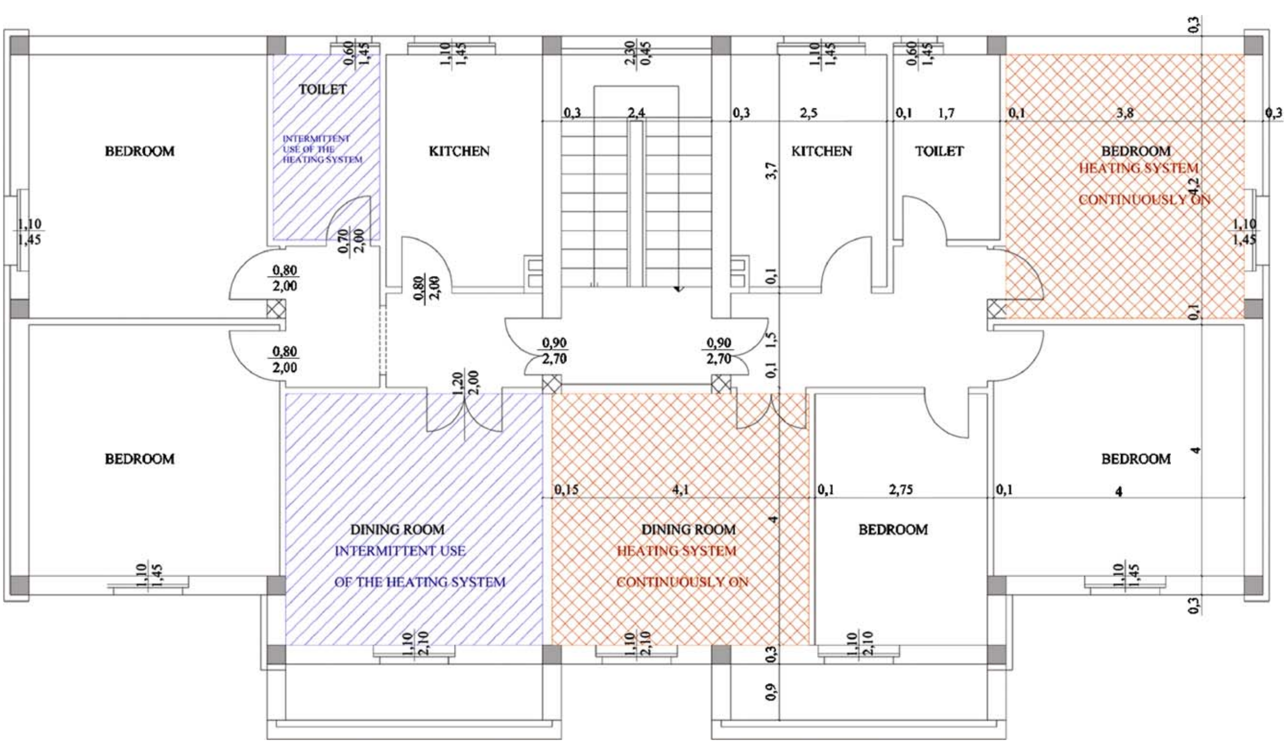


**Fig. 2.** Plan of the first floor.