A building thermal bridges sensitivity analysis

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HIGHLIGHTS

- Heat transfer through the most typical thermal bridges is analyzed through a finite difference method.
- The linear thermal transmittance for a large number of design parameters is catalogued.
- Non-linear regression models of the most typical thermal bridges are identified.
- A sensitivity analysis of the most relevant design parameters is carried out.

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ABSTRACT

Along with the entry into force of the new European Directive 2010/31/EU on the Energy Performance of Buildings (EPBD recast), each Member State has the responsibility of supporting activities for the construction of nearly zero energy buildings with a very high energy performance. In order to achieve the new EU directive targets, designers, in addition to having to use innovative building components, also have to pay more attention to the construction details which mostly affect building envelope heat losses. It is therefore necessary not only to properly design structural nodes, in order to minimize such energy losses, but also to identify accurate numerical methods in order to appreciate the benefits of a proper design. A sensitivity analysis based on an extensive study of the linear thermal transmittance value of many types of thermal bridge, based on the methodology specified in EN ISO 10211, has been carried out in the presented work. After having defined the input design variables and considering a range of variation for each of them for the linear thermal transmittance evaluation, a non-linear regression model has been specifically developed for each analyzed thermal bridge, considering the output values of a numerical code as data set. In order to perform the sensitivity analysis a significant and representative number of cases have been generated, using a sampling technique. The ANOVA–FAST method has been performed, on the basis of the obtained results, in order to assess the contribution of each input design variable to the deviation of the linear thermal transmittance for each kind of thermal bridge.

1. Introduction

1.1. Influence of thermal bridges on building energy performance

With the entry into force of European Directive 2010/31 on the Energy Performance of Buildings (EPBD recast) [1], each Member State is required to draw up national plans to increase the number of nearly zero-energy buildings. Moreover, starting from European Directive 2002/91/CE, the Italian national legislation on building energy efficiency (Legislative Decree no. 192/2005, Legislative Decree no. 311/2006) has led to an improvement in opaque and transparent envelope performance.

In order to achieve the objectives of the EPBD recast, the designer is required on one hand to use innovative envelope components, while on the other hand to pay greater attention to construction details.

In fact, the mere addition of an insulation layer only reduces the one-dimensional heat flow, but does not significantly decrease the multi-dimensional one, if no attention has been paid to the heat flow through thermal bridges. Although it is not possible to obtain general results concerning the weight of thermal bridges on the energy needs of buildings, several studies have presented numerical results for different cases. A study was conducted in Greece on a typical three-storey apartment building with an open ground-floor space (pilotis) and a flat roof; the façades are composed of two brick layers with interposed insulation [2]. The study shows that the double brick wall construction widely used in Greece is affected to a great extent by thermal bridges. Even if the actual construction presents high insulation levels, the heating need can be 30% higher than the one calculated without taking into account the thermal bridge effects. Cappelletti et al. [3] have shown that the weight of thermal
Some studies focus on window thermal bridges giving practical and technical solutions to minimize their effect on building thermal losses. Thermal bridging has been evaluated through three different methodologies specified in the relevant technical standards [8,9], which present both simplified and detailed approaches to calculate heat losses, in order to make it possible to appreciate the benefits induced by a correct design. The heat exchange through thermal bridges can be calculated using the different methodologies specified in the relevant technical standards [8,9], which present both simplified and detailed methods to calculate thermal losses through thermal bridges under steady-state conditions.

In this paper the thermal bridging effect is evaluated by means of the linear thermal transmittance approach. Since this parameter is calculated under stationary conditions, it is generally applied for building energy need assessment through quasi-steady state methods in the framework of energy performance technical standards and regulations. The use of linear thermal transmittance approach presents some limitations for building energy simulations (BESs); therefore the aim of this paper is not to implement it in dynamic energy simulation codes.
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