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Indoor and outdoor environment impact over the generic conditions for thermal bridge appearance

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Abstract

The presented study considers the numerical modelling of a thermal bridge distribution, based on conjugated heat transfer and Computational Fluid Dynamics (CFD) model of approximated external concrete wall. The thermal bridge distribution is cross-analyzed relative to the indoor and outdoor air parameters, under the corresponding structure's thermal properties. The main analyzed parameters in the study are the surface temperature on the exterior wall, outdoor air temperature and wall thermal conductivity. The integrated modeling results show the complex environmental impact over the generic conditions for the thermal bridge existence. The further analyses will include the relative humidity and dew point temperature impact over the thermal bridge distribution. These additional parameters may be used for moisture accumulation indicator, in the developed numerical model.

Keywords: Thermal bridge, conjugated heat transfer, CFD, indoor and outdoor environment

1. Introduction

For the purpose of building design, the "thermal bridge" is defined as an isolated zone, where construction elements have higher thermal conductivity, compared with the rest of the building envelope. Consequently, especially in cold winter conditions, a significant temperature difference may exist between adjacent solid surfaces and the air volumes within the occupied areas. Thus, the energy performance of the buildings is mostly affected by the appearance of the thermal bridge, due to the increased heat losses from the rooms. The linear thermal bridges may increase the heating energy need of the buildings with above 30% [Erhorn-Kluttig (2009)]. But also, increased indoor humidity and moisture related problems in the indoor environment are possible, due to the lowered surface temperature in these zones.

Today, different standards exist for thermal bridge avoidance, especially during the building design stage [*Papadopoulos (2016)*]. They also provide the necessary conditions and parameters for the thermal bridge appearance analyses [ISO 10211 (2017)]. However, thermal bridges still exist and may be localized easily in older buildings, where no energy efficient measures have been considered. In such buildings, the thermal bridge impact over the indoor air quality may become significant, due to the distinguished cold areas, which are common precondition for moisture related problems in the buildings [*Ivanov (2019)*]. That is why, the development of accurate, multiparametric numerical models for prediction of the generic conditions for thermal bridge appearance are considered to be valuable for the buildings design practice.

2. Aim of the presented study

The aim of the presented study is to investigate numerically the indoor and outdoor environment impact over the generic conditions for thermal bridge appearance in a model of concrete external wall, by the methods of CFD and conjugated heat transfer.

3. Numerical model and experimental set-up

The numerical simulations in the presented study are performed with the Ansys Fluent 16.0 CFD software. In total of 35 steady state simulations are made, with the use of Realisable k-epsilon turbulence model and standard wall function. The utility snappyHexMesh is used for the numerical discretisation, creating a hexahedral and polyhedral computational grid of 485608 control volume cells. The modelled concrete wall section is with dimensions 1 m by 1 m, and thickness of 0.2 m, as presented on Figure 1. The entire test sections, both for the simulated indoor and outdoor spaces, are with dimensions 4 m by 4 m. The properties of the selected concrete are: density of 2400 kg/m^3, specific heat of 750 J/(kg K). For the purposes of the parametric study, thermal conductivity of the material vary from 0.009 to 3.6 W/(m K).

The indoor environment space is modelled under constant air temperature condition of 24 ^oC. For this purpose, a constant air flow is provided along the interior surface, with uniform velocity of 0.1 m/s, parallel to the test section. Thus, the impact of the tested material properties over the interior surface temperature would be emphasised. In the same way, the outdoor environment space is modelled with constant air temperature of -20 ^oC

and with uniform velocity of 0.5 m/s parallel to the exterior of the test section.

4. Numerical results

The combined results for the outdoor air temperature and wall thermal conductivity impact, over the internal wall surface temperature are shown on Figure 2. It is seen that the decrease of the outdoor air temperature leads to significant decrease in the indoor wall surface temperature as well. This behavior represents a typical generic condition for the thermal bridge appearance, which confirm the proper work of the presented numerical model. Furthermore, with the decrease of the thermal conductivity, the indoor wall surface temperature increases, which is also normal effect of the related physical phenomena. In the simulated extreme cold outside conditions, at -20 ^{o}C, the wall thermal conductivity drop has more distinctive effect. The decrease from 0.09 W/(m K) to 0.009 W/(m K) leads to almost 10 ^{o}C increase of the inner wall surface temperature.

Besides the thermal conductivity and outdoor air temperature, it is considered that more distinctive impact over the internal wall surface temperature will have the wall roughness and the wind speed alteration, which are also simulated and analyzed, and will be presented in another supplementary paper.

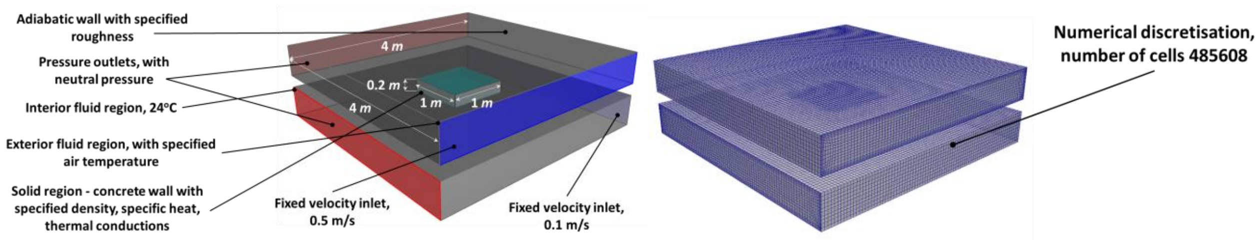

Figure 1. Experimental geometry and computational mesh

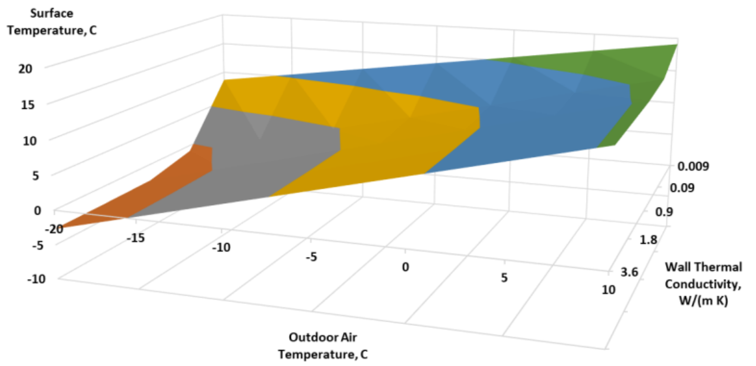

Figure 2. Numerical results for surface temperature, outdoor air temperature and wall thermal conductivity

5. Conclusion

A CFD based numerical study is performed of the indoor and outdoor environment impact over the generic conditions for thermal bridge appearance, in a model of concrete external wall. The results from the applied conjugated heat transfer method prove that with the decrease of the thermal conductivity, the indoor wall surface temperature increases. The developed model could be used for further moisture accumulation analyses.

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References

Erhorn-Kluttig H., Erhorn H. (2009), "Impact of thermal bridges on the energy performance of buildings", Paper P148 of the *EPBD Buildings Platform*.

ISO 10211 (2017), "Thermal Bridges in Building Construction - Heat Flows and Surface Temperatures. Detailed calculations", *International Organization for Standardization*.

Ivanov M. (2019), "Instantaneous field measurements of thermal bridge parameters in ground floor residential room", Submitted for publishing in: Proc. of "*8th Int. Conf. on Thermal Equipment, Renewable Energy and Rural Development – TE-RE-RD'19*".

Papadopoulos A. (2016), "Forty years of regulations on the thermal performance of the building envelope in Europe: achievements, perspectives and challenges", *Energy Build.* **127**.