Investigating the Performance of Mechanically Ventilated Double-Skin Facades with Solar Control Devices in the Main Cavity

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Abstract

Introduction
The use of ventilated facades may reduce the cooling and heating energy demands of the building. Double-skin facades (DSFs) belong to the wider group of ventilated facades and currently represent one of the most interesting and studied facade systems. The purpose of this study is to investigate the thermal behaviour and performance of a DSF being designed for a real project in the Middle East. The DSF is comprised of two double glazing units, a mechanically ventilated air cavity and solar control (shading) devices placed within the cavity (Figure 1).
The objective of the analysis is to realize the full design of the facade system, particularly looking at the following aspects:
- Select appropriate construction materials
- Estimate thermal performance in terms of U-value
- Establish thermal loads on each structural element
- Determine position and design of inlet and outlet
- Determine the effect of the shading devices on fluid flow and temperature distribution

Use of COMSOL Multiphysics®
The main challenge about modelling DSFs regards the complexity in predicting accurately the temperature profile across them. Another potential concern regards the possibility of reaching very high temperatures within the cavity due to the presence of the blinds and to an insufficient supply of air. The "Conjugate Heat Transfer" and the "Surface-to-Surface Radiation" interfaces have been used to model the heat transfer mechanisms in the DSF. The use of ECOTECT has assisted in defining appropriate peak values of solar radiation to use as input in the COMSOL Multiphysics® software. Different configurations were tested varying the positions of air inlet and outlet and orientation of the shading devices in the cavity in order to improve the thermal efficiency of the system and thermal comfort in the indoor environment, reducing the solar heat gain during the summer season.

Results
The results show that the thermal behavior and performance of the DSF strongly depend on the air inlet velocity and on the type of flow present within the main cavity (Figure 2). The thermal performance of the facade also depends on the position of the air inlet(s) and outlet(s), on

thermal properties of the glazing units and on the orientation of the shading devices. The results were then used as input for the structural analysis undertaken in SOFiSTiK (Figure 3) in order to evaluate the structural performance of each facade component under thermal stress and the effect of temperature on its resistance to blast loading, which was one of the main design requirements for the project.

Conclusions

The current study demonstrates how COMSOL Multiphysics® can be used as an important design tool within the process of optimizing complex facade systems. More specifically, the study shows that COMSOL Multiphysics® can predict temperature distribution and air flow in DSF with shading devices which are within the range of expected values observed in previous projects. In order to provide a further validation, an empirical test would be recommended. In addition, the study illustrates how COMSOL Multiphysics® can be utilized in combination with other digital tools to achieve the design of high-performing facade systems.

Reference

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R. Waldner, G. Flamant et al., “BESTFACADE, Best Practice for Double Skin facades” - Åke Blomsterberg, Energy and Building Design, University of Lund, Sweden, 2007.

Figures used in the abstract

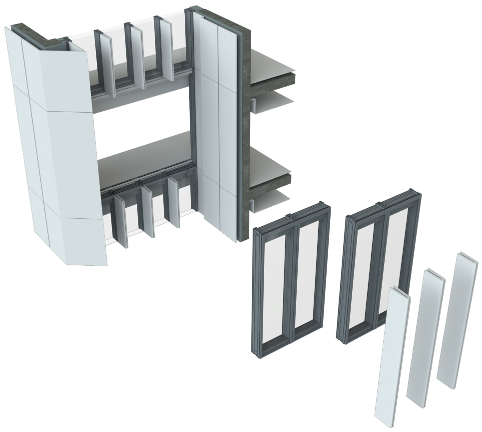

Figure 1: Exploded view of the Double Skin Facade with external louvers.

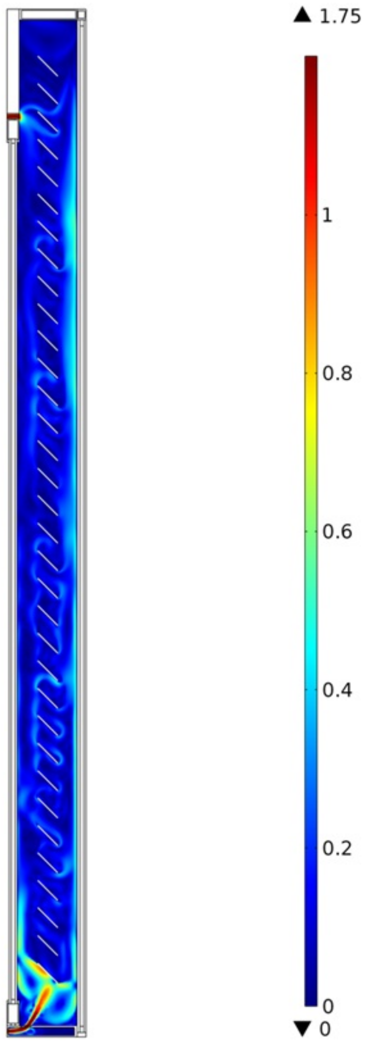

Figure 2: Fluid flow in laminar regime within the Double Skin Facade cavity (air velocity in m/s).

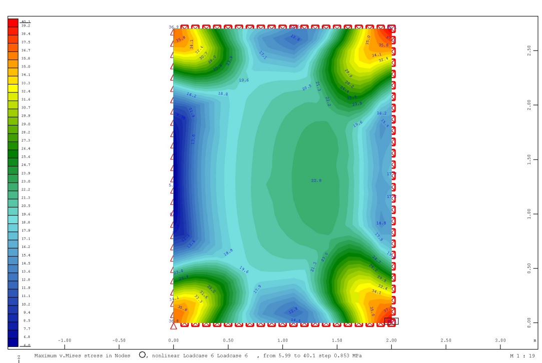

Figure 3: Structural finite element calculation on a glass pane (v. Mises MPa).