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

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SYSTEM DESCRIPTION AND CONTEXT OF THE ANALYSIS

Figure 1. Building Scale (South-oriented Facade)

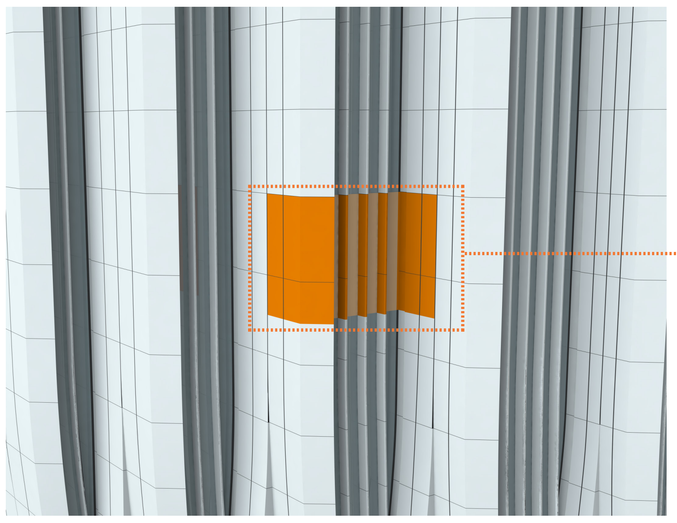


Figure 2. Typical Bay

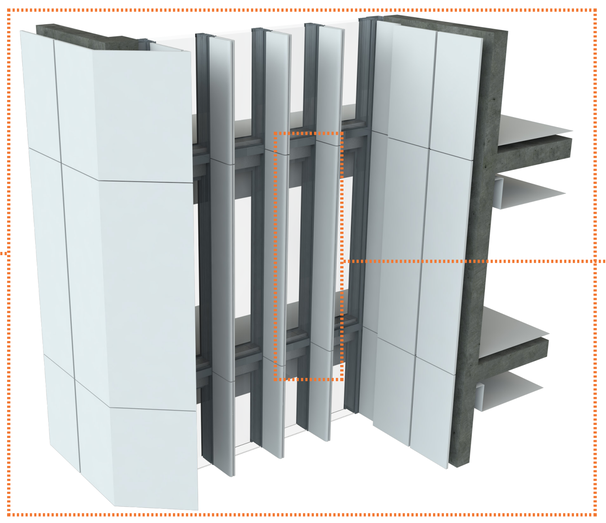
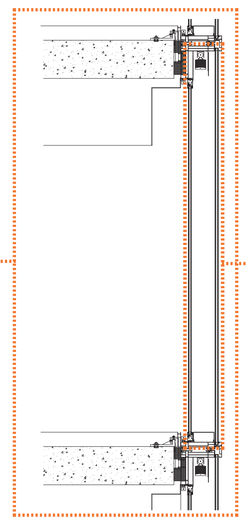
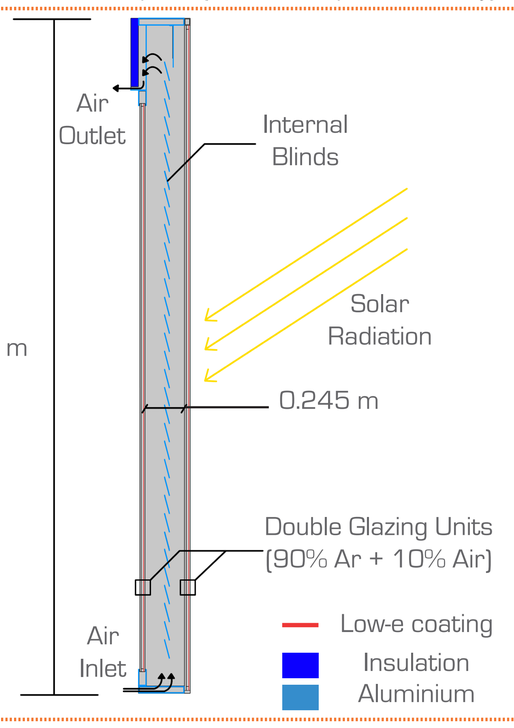


Figure 3. Double-skin Unit



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 4**).

Figure 4. System Description (COMSOL Input Geometry)



INPUTS

The "Conjugate Heat Transfer" and the "Surface-to-Surface Radiation" interfaces have been used to model the heat transfer mechanisms in the double-skin facade.

GLASSES ENERGY PROPERTIES

OUTER DOUBLE GLAZING UNIT

Property	Unit	Value
α_g1 (absorptivity outer glass)	[-]	0.2
τ_g1 (transmissivity outer glass)	[-]	0.73
ρ_g1 (reflectivity outer glass)	[-]	0.07
α_g2 (absorptivity inner glass)	[-]	0.33
τ_g2 (transmissivity inner glass)	[-]	0.51
ρ_g2 (reflectivity inner glass)	[-]	0.16

INNER DOUBLE GLAZING UNIT

Property	Unit	Value
α_g3 (absorptivity outer glass)	[-]	0.2
τ_g3 (transmissivity outer glass)	[-]	0.73
ρ_g3 (reflectivity outer glass)	[-]	0.07
α_g4 (absorptivity inner glass)	[-]	0.18
τ_g4 (transmissivity inner glass)	[-]	0.58
ρ_g4 (reflectivity inner glass)	[-]	0.24

MECHANICAL VENTILATION INPUTS

Parameter	Unit	Value
Air Inlet Velocity	[m/s]	Variable (0.1 - 1)
Air Inlet Temperature	[degC]	26

EMISSIVITY OF MAIN MATERIALS

Material	Unit	Value
Aluminium	[-]	Variable (0.1 - 1)
Glass	[-]	0.89
Glass (Low-e Coating)	[-]	0.03

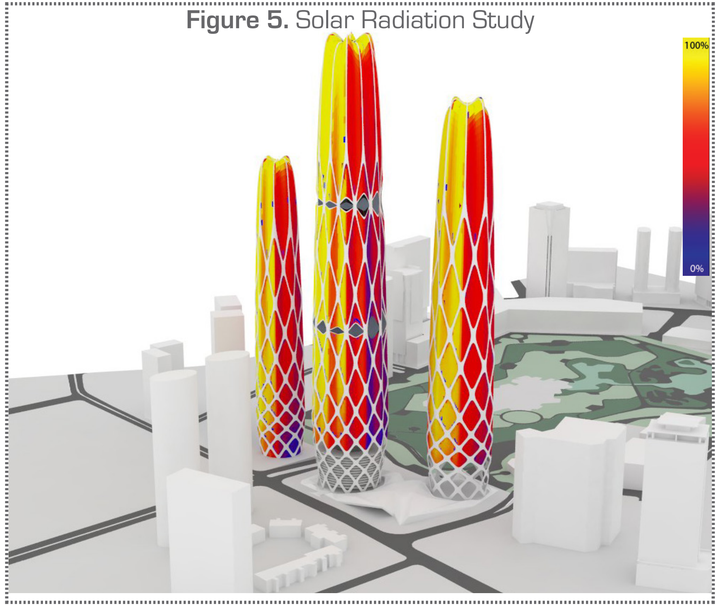
ABSORPTIVITY OF MAIN MATERIALS

Aluminium	[-]	Variable (0.1 - 1)

SUMMER PEAK DAY-TIME CONDITIONS

Parameter	Unit	Value
Outdoor Temperature	[degC]	50
Indoor Temperature	[degC]	24
Global Radiation	[W/m^2]	1020

Figure 5. Solar Radiation Study



The solar studies (**Figure 5**) provide a means of assessing the level of exposure and the amount of direct solar radiation at any point on the facade. The double-skin facade is south-oriented, and therefore more exposed to the sun. However, the effect of the external shading has to be taken into account in order to evaluate the correct amount of radiation hitting the facade.
The other main input parameters used for the analysis are shown in the tables above.

INVESTIGATION ON MATERIALS PROPERTIES AND AIR INLET VELOCITY

INITIAL DESIGN

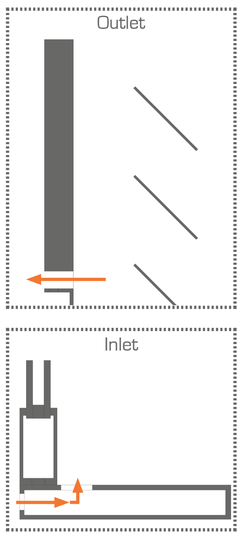
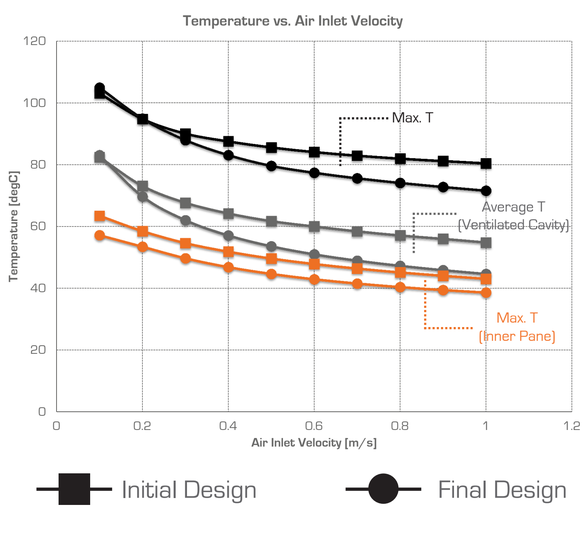


Figure 6. Maximizing Cooling Efficiency



FINAL DESIGN

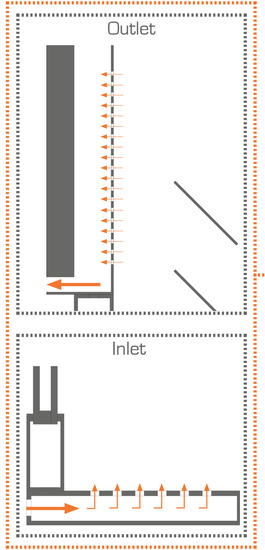


Figure 7. Material Selection: Absorptivity of Blinds

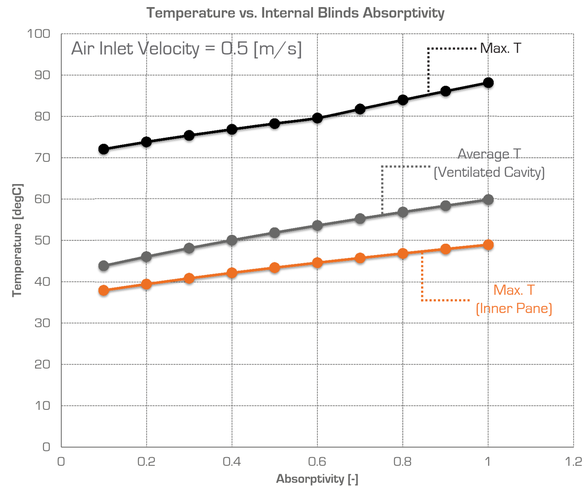
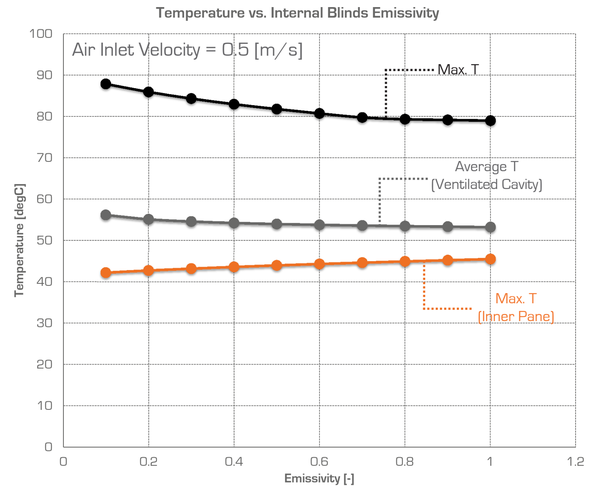
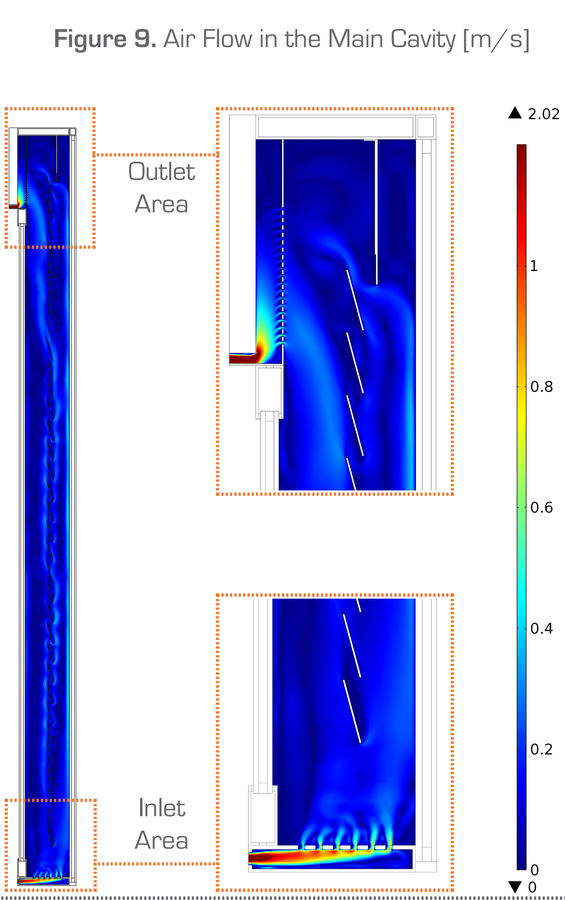


Figure 8. Material Selection: Emissivity of Blinds



FINAL DESIGN (Absorptivity = 0.5, Emissivity = 0.72)

Figure 9. Air Flow in the Main Cavity [m/s]



In order to meet blast resistance requirements, the inner glazing pane must not exceed 40 degC (**Figure 11**).

Figure 10. Temperature Profile [degC]

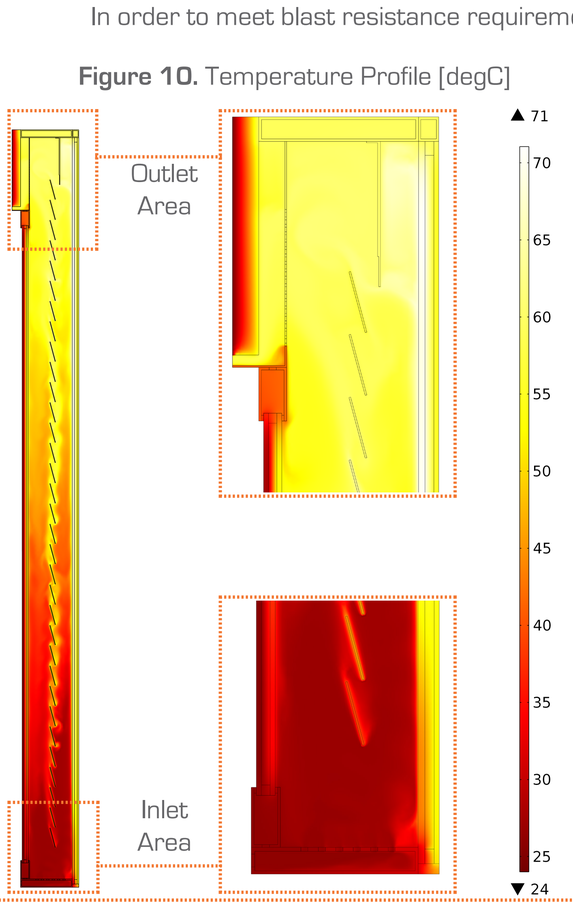
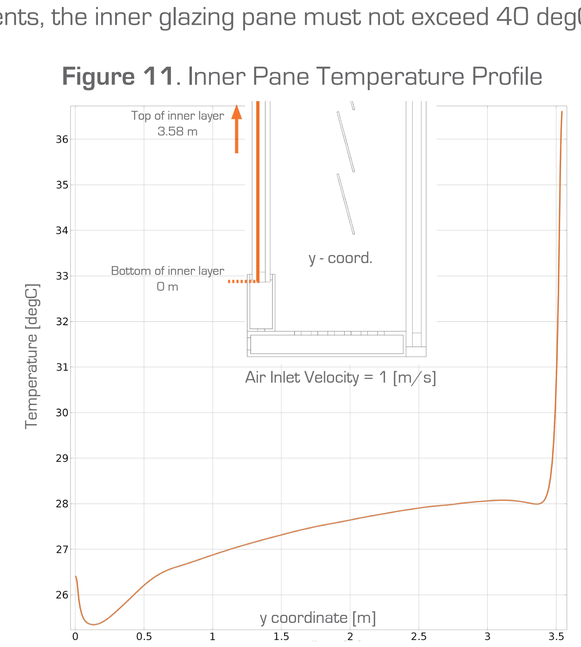


Figure 11. Inner Pane Temperature Profile



The energy efficiency of the facade depends on the U-value, defined in the following way:

$$U\text{-value} = Q_{tot}/[A*(T_{out} - T_{in})]$$

For the double-skin facade considered it is:

U-Value < 0.3 W/m^2*K

Figure 12. Heat Flux

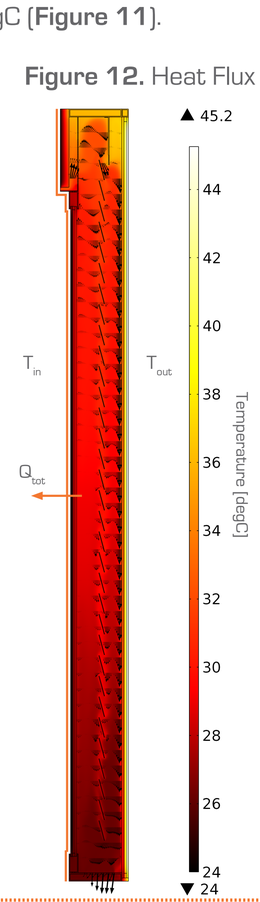
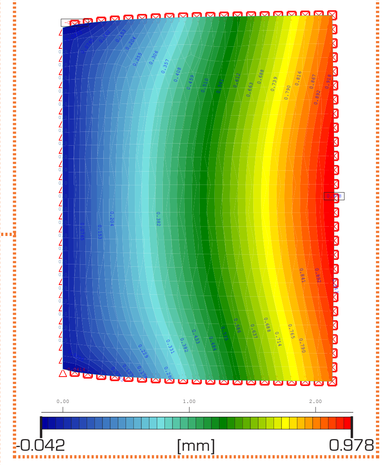


Figure 13. Thermal Loading on Glass



The current study demonstrates how COMSOL Multiphysics® can be used as an important design tool within the process of optimizing complex facade systems. The results show that the thermal behaviour and performance of the DSF depends on many parameters such as material properties and the mechanical ventilation rate. Thanks to COMSOL Multiphysics®, the system can be explored in detail and relevant parameters can be computed to check that all the technical requirements are met.

Excerpt from the Proceedings of the 2014 COMSOL Conference in Cambridge