Technische Universiteit Eindhoven University of Technology

Master the winds for cooling

7SS25 Masterproject 2

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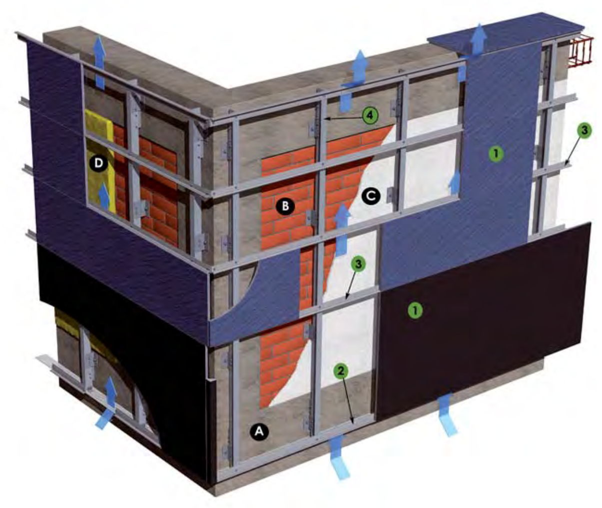

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Introduction

The application of ventilated façades can help reduce thermal loads during high temperatures and solar radiation, which in effect reduces the energy consumption due to air-conditioning systems. This is a passive cooling technique that could be developed to a greater extent in order to improve indoor climatic conditions and the microclimate around buildings.

This study discusses the use and effect of ventilated facades, with an external façade cladding, a sub-structure anchored to the wall surface of the building under solar radiation, while designing façade elements numerically with a finite element method tool (COMSOL), to create the highest achievable velocity inside the air cavity.

A ventilated façade offers benefits above a conventional sealed façade, because part of the solar energy that is absorbed by the façade elements can be transported by ventilation air inside the cavity, which is created by wind and natural convection as shown in **Figure 1.**

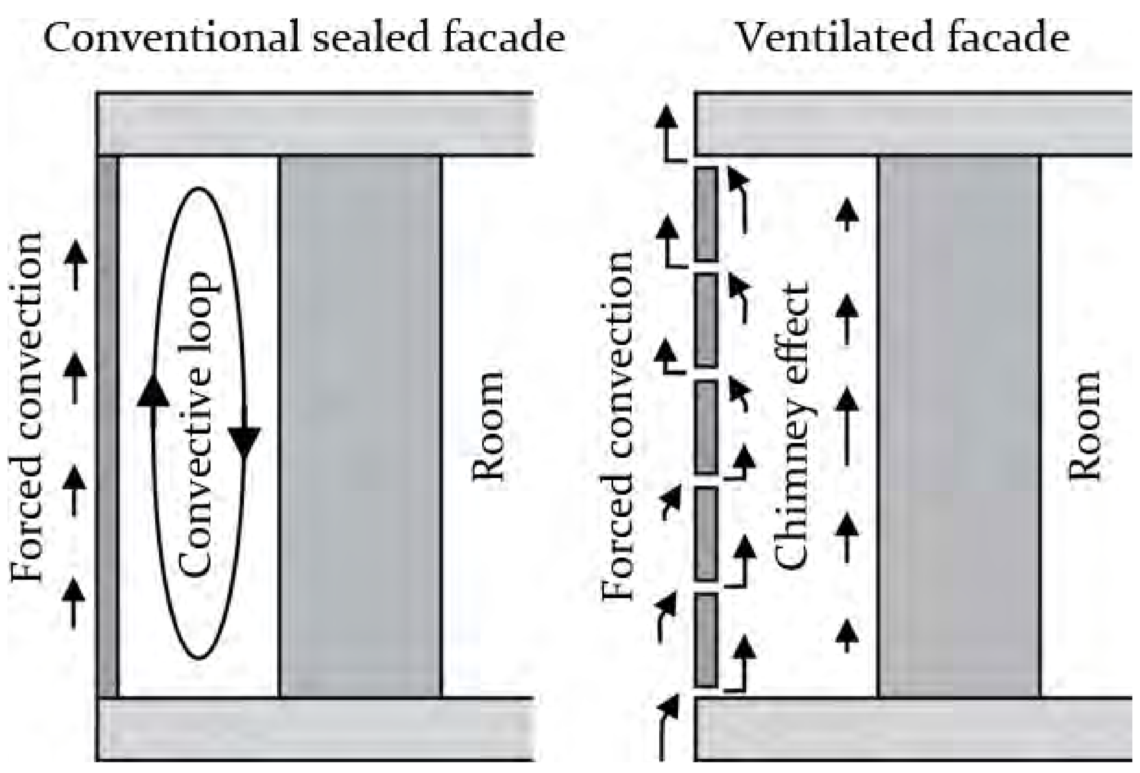

Figure 1 (Sanjuan et al.): Heat fluxes in a façade with an air cavity

Heat balance

The heat transfer flows at the interior side are directly influenced by the incoming air through the openings in the external layer. A model is created that simulates different inlet velocities with a range of outdoor temperatures and two levels of solar radiation for a facade construction as shown schematically in **Figure 2**, with results in **Figure 3**.

There is a fast reduction in the heat transfer into the room and reduction in the cooling load for velocities up to 0.8 m/s at the inlet (range of 0.15-0.45 m/s inside the cavity). The energy saving increases remarkably as solar radiation intensity increases; the ventilated facade turns out to be more efficient from an energy saving point of view.

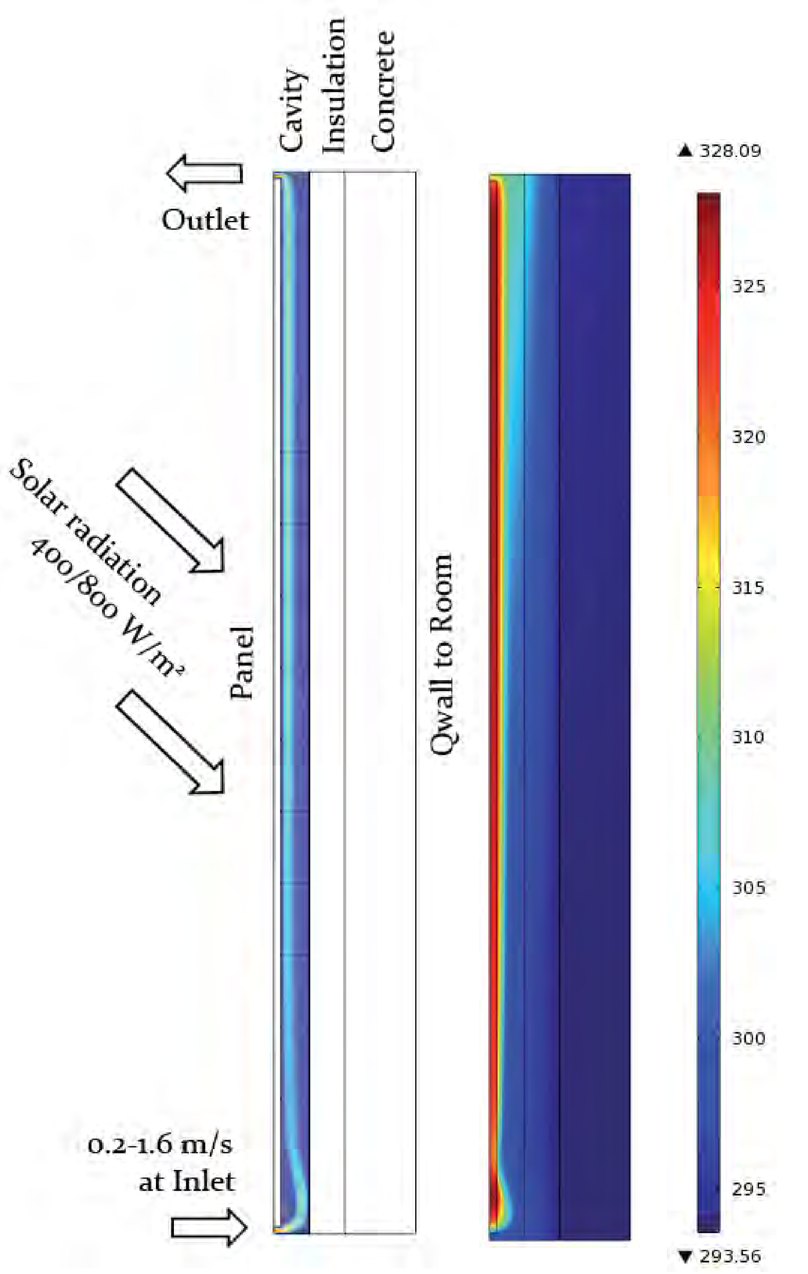

Figure 2: Schematic model of the facade construction

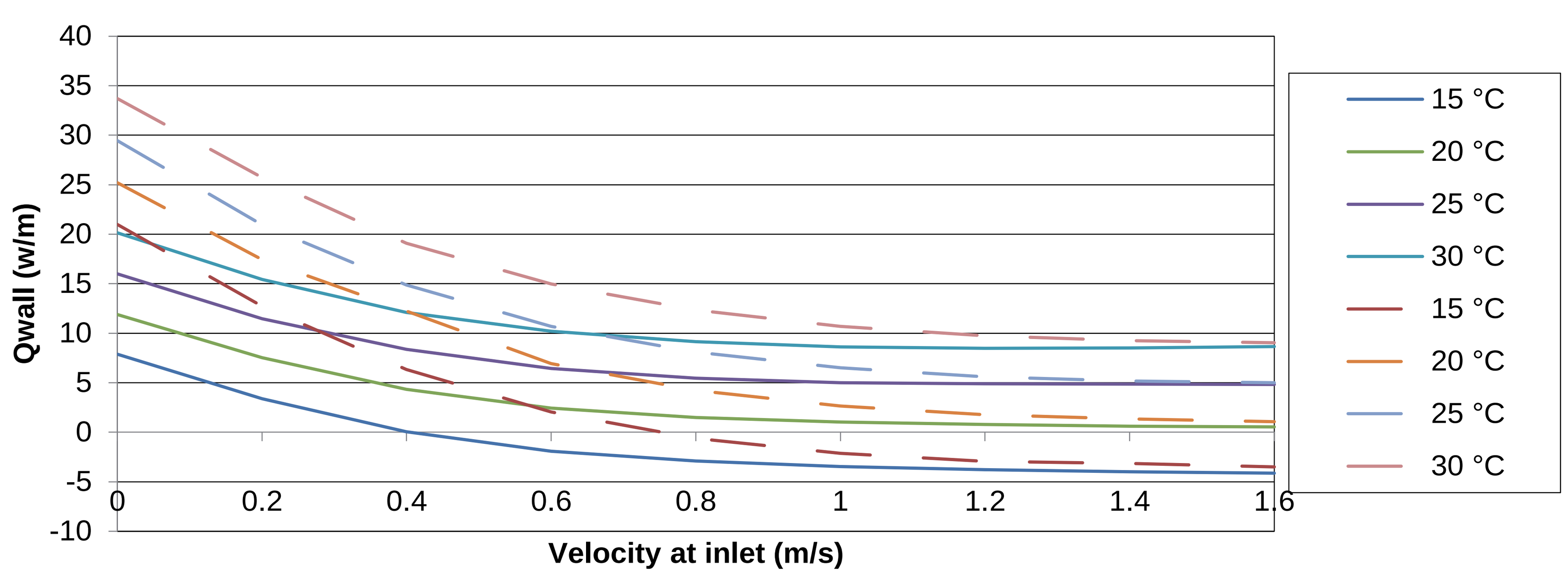

Figure 2: Graph of the heat transfer at the inside internal wall to the room, set off to the velocity at the inlet (dashed lines are 800 W/m^2).

Table 1: Range of velocity in the cavity for different inlet velocities.

Velocity at inlet (m/s)	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6
Velocity in cavity (m/s)	0.04-0.19	0.08-0.26	0.12-0.33	0.15-0.40	0.20-0.45	0.25-0.50	0.30-0.55	0.35-0.60

Facade designs

To create insight in the changes in velocity with different façade designs, a model has been created with COMSOL that simulates the wind flows and their behavior at the façade. Three types of wind flows as shown in **Figure 5 and 6** are used to compare which facade design obtains the highest velocity values inside the cavity.

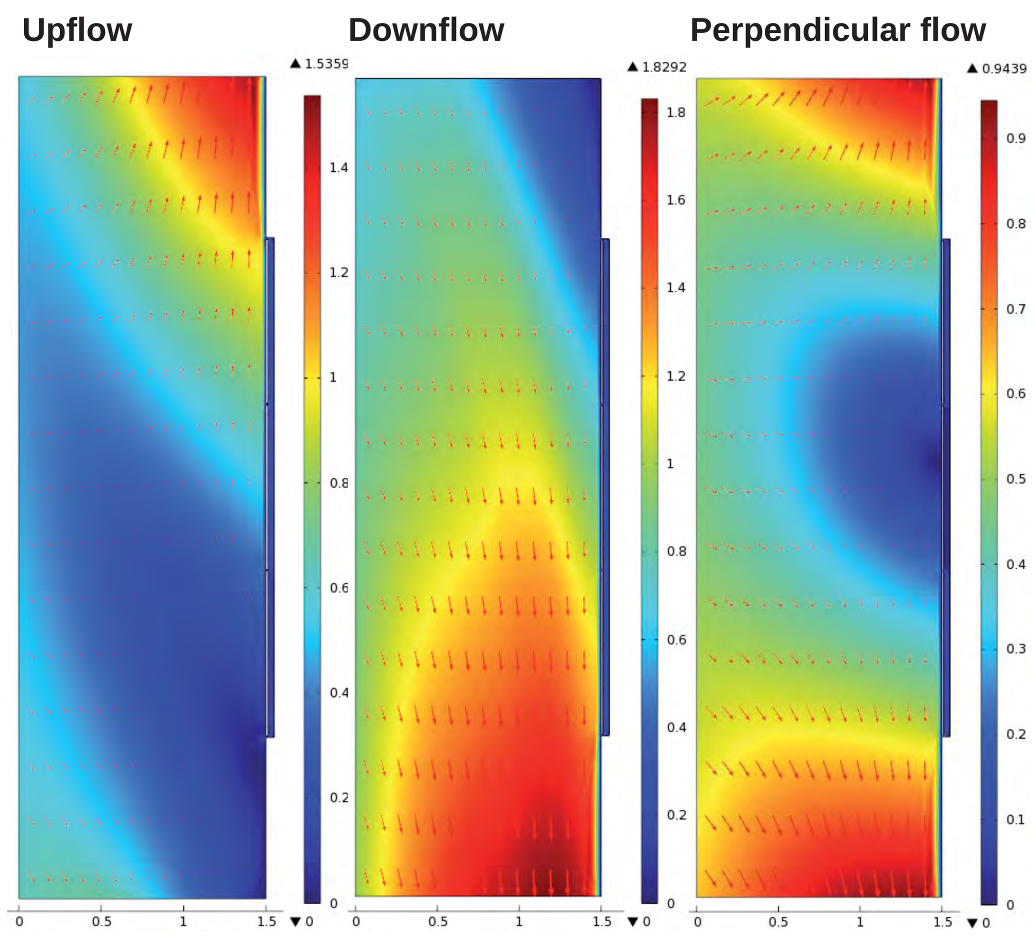

Figure 5: 3 Different types of air flows at the facade.

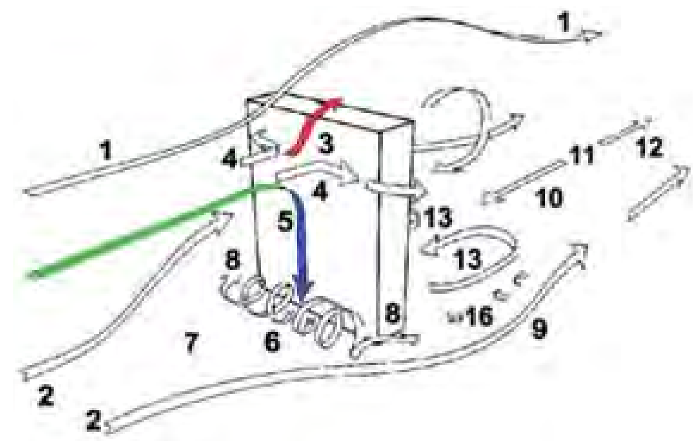

Figure 6 (adjusted from (Beranek & van Koten, 1979): Upflow (red), Downflow (blue) and perpendicular flow (green).

Façade elements can be designed in numerous forms. By starting simulations for a normal flat surface and 4 openings, a reference point is created, where other designs are compared to.

In total 5 base cases (shown in **Figure 6**) have been simulated, while some have been adjusted to increase their performance. The reference case exists of a flat façade with three 1 meter panels (4 openings).

Design 3 shows the highest potential among the base cases, by adjusting the shape into Design 3H the velocity increases even more for downflow, this design is mirrored for upflow to be as effective. A comparison between Design 0 and Design 3H can be seen in **Figure 7.**

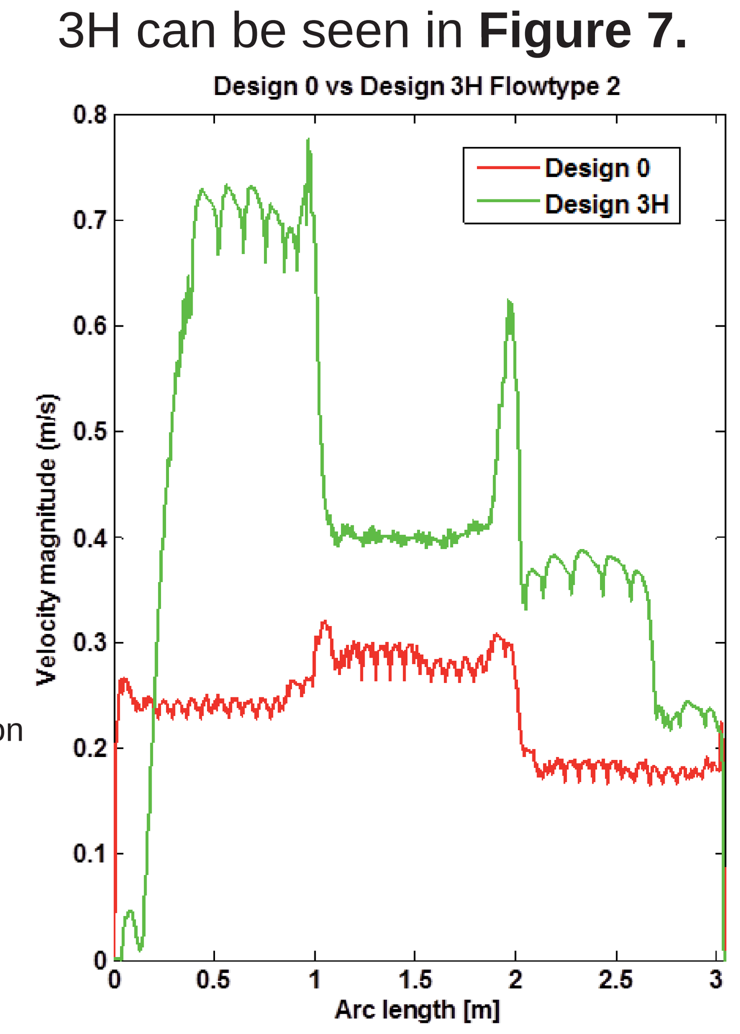

Figure 7: Velocity along the middle of the cavity for design 0 and 3H for flowtype 2.

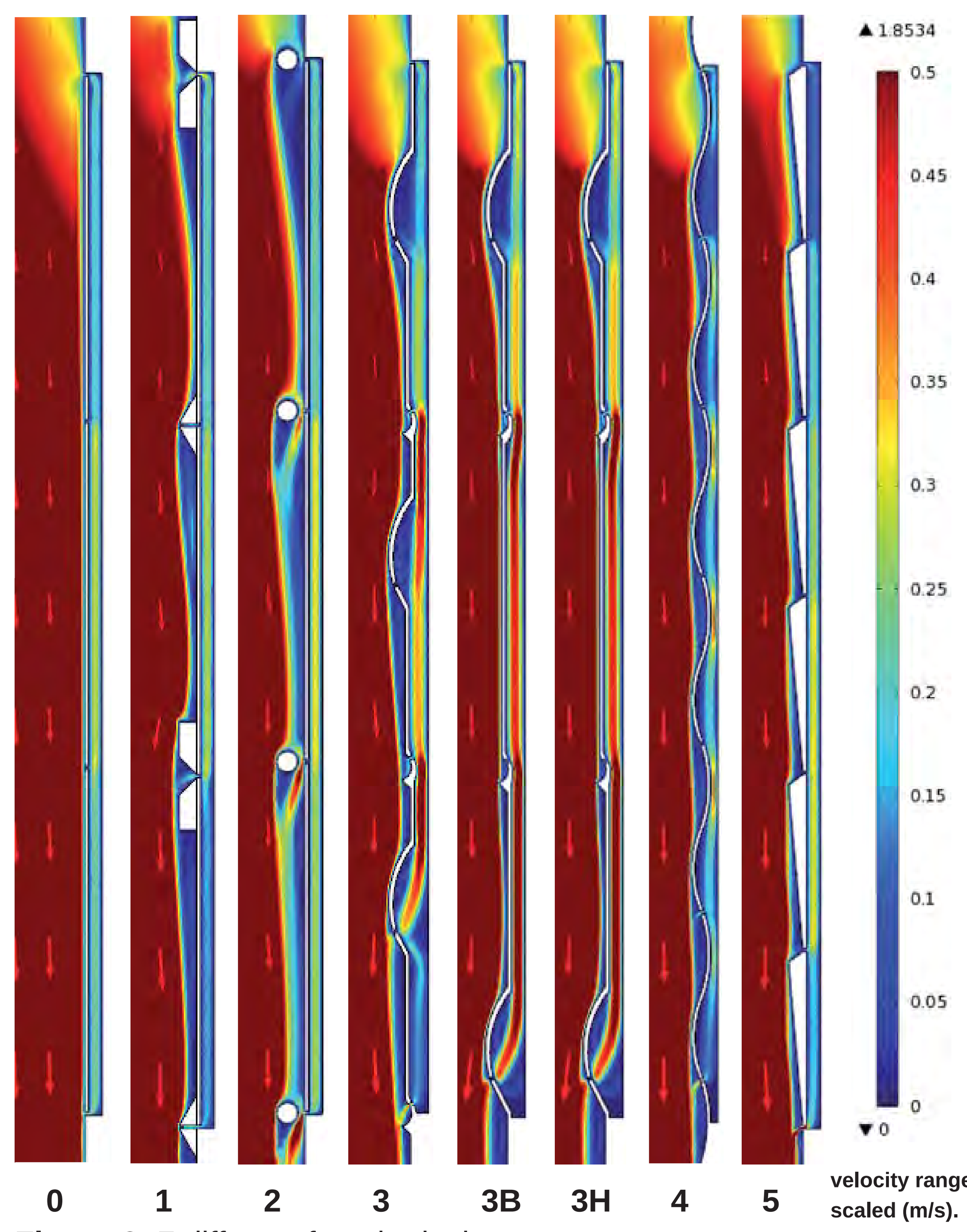

Figure 6: 7 different facade designs.

This shows that it is possible to increase the velocity inside the cavity by using forms based on principles of Bernoulli to create different pressure zones.

Conclusions & Recommendations

Energy saving is increased with a ventilated façade instead of a sealed façade, and is more effective for higher solar radiation. The higher the air velocity inside the cavity the more heat is carried away.

Façade elements can be designed in such a way that they accelerate the air velocity inside the cavity of a facade construction to remove heat.

More investigation is needed on the actual air velocity inside the cavity by doing coupled CFD simulations and simulate different facade designs and also solving the heat transfer equations.