Subject
Numerical and experimental analysis of transparent ventilated façades

List of proponents (with e-mail address of the responsible person)
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Description of the international background of the proposal
Energy usage for room heating, cooling and ventilation still accounts for more than one third of the total, primary energy demand in the industrialised countries, and is in this way a major polluter of the environment with CO₂ and greenhouse-gases. To successfully achieve the targets set out in the Kyoto protocols it is necessary to identify innovative energy technologies and solutions for the medium and long term which facilitates the implementation and integration of low carbon technologies, such as renewable energy devices within the built environment. Deployment of low carbon technologies still faces major barriers in the built environment especially in relation to costs, building logistics, technological challenges, lack of understanding and knowledge and absence of requisite skills. More over, there is world wide growing concern about the type of energy used for different purposes.

Research into building energy efficiency over the last decade has focused on efficiency improvements of specific building elements like the building envelope, including its walls, roofs and fenestration components (windows, daylighting, ventilation, etc.) and building equipment such as heating, ventilation, cooling equipment and lighting. Significant improvement have been made, and whilst most building elements still offer opportunities for efficiency improvements, the greatest future potential lie with technologies that promote the integration of responsive building elements and communication among building services. In this perspective Integrated Building Concepts are defined as solutions where responsive building elements together with energy systems are integrated into one system to reach an optimal environmental performance in terms of energy performance, resource consumption, ecological loadings and indoor environmental quality. Responsive Building Elements are defined as building construction elements which are actively used for transfer and storage of heat, light, water and air. This means that construction elements (like façades, floors, walls, roofs, foundation etc.) are logically and rationally combined and integrated with building service functions such as heating, cooling, ventilation and lighting. The development, application and implementation of responsive building elements are considered to be a necessary step towards further energy efficiency improvements in the built environment.

With the integration of responsive building elements and building services, building design completely changes from design of individual systems to integrated design of integrated building concepts, which should allow for optimal use of natural energy strategies (daylighting, natural ventilation, passive cooling, etc.) as well as integration of renewable energy devices. Among the other responsive building elements ventilated façades represent a promising technology that has started to be employed in these last years. So far, their actual performances and their thermofluidodynamic behaviour is, however, not well known and understood.

Research program objectives (intermediate and final) and expected results
The research activity of the PhD will be carried out by means of experimental and theoretical activities and it will be focused on thermal performance of the ventilated façades and on their capability to assure optimal conditions as far as the indoor thermal comfort, indoor air quality and energy saving potential are concerned.

In particular the activity will be developed along two lines: numerical simulations and laboratory measurements. This last type of investigation will be carried out by means of test cells (TWINS), which have recently (July 2004) been built at the DENER – Politecnico di Torino.

The main issue of the lab measurements will be to deepen the knowledge of physical phenomena involved in the façade thermal and fluid dynamic behaviour. Aim of this activity will be to highlight, by means of a sensitivity analysis, the effect of each façade element (i.e, the type of filter, shading device, glass) and/or working parameter (i.e, the ventilation strategy, air flow rate, strategy of integration between the building component and the HVAC system, …) on the global performance of the component.
This research phase will allow to identify the most appropriate way to optimise the component and to correctly integrate it with HVAC systems.

At the same time, a modelling activity will be carried out. It will be developed along three main lines:

1) Application of CFD codes to simulate the façade behaviour. First, the model will be validated through the comparison of the numerical results with the experimental data. Then, the model will be used to carry out analysis aimed at proposing and verifying new and more efficient façade configurations.

2) Development of zonal models (based on the "block algebra" technique) for thermal and fluid-dynamic analyses of the façade. Compared to the CFD codes, these tools are more suitable to perform sensitivity analysis, since they are simpler and quicker to use. In fact, even if they provide less information in comparison with CFD models, they are extremely effective to verify how the component performance changes changing the climatic conditions and the operative conditions (running the simulation, for example, for a complete test reference year – TRY). Moreover, after its validation, the zone model could be adopted as a design tools for architects and engineers, providing some simplified user interfaces.

3) Development of hybrid models, coupling the black-box inverse modelling techniques (based on the time profiles of the recorded data during the experimental campaigns) with deterministic models (simulating the behaviour of the HVAC system). This activity is aimed at implementing and verifying different integrated strategies for the façade and the HVAC system. Particular attention will be given to energy saving issues.

The activity of the PhD student will be connected with international research projects focused on analogous subjects (Annex 44 - Integrating environmentally responsive elements in buildings* of the International Energy Agency - IEA) and with a manufacturer (a private company who participate in the construction of the experimental apparatus TWINS) of glass façades.

List of publications of the proponents and/or specific references (with titles)


AAVV. 1998. La façade double-peau – mesures in-situ et en laboratoire* – Chapp. 5, 10, Institut de Technique du Batiment, Departement D'Architecture, EPFL, Lausanne


