Polytech network form for PhD Research Grants from the China Scholarship Council

This document describes the PhD subject and supervisor proposed by the French Polytech network of 14 university engineering schools. Please contact the PhD supervisor by email or Skype for further information regarding your application.

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PhD information	
Title	**Multi-functional and adaptive Façade Tool**
Main topics regards to CSC list (3 topics at maximum)	Multifunctional adaptive facades; numerical modeling; MATLAB tool

Required skills in science and engineering	Heat and mass transfer; numerical modeling; programming language (MATLAB and/or Python)

Subject description (two pages maximum)

1. Introduction

To respond to the worldwide new regulations on building energy performance, and to build a new generation of nearly zero energy buildings, a challenging issue is to allow buildings, and particularly the building facades, to have the ability to adapt with the outside and inside climate conditions in addition to the ability to generate power for electricity and air conditioning purposes. The integration of renewable energy resources into the building fabric is gaining more and more attention. There is an increasing interest over the last years for multi-functional facades incorporating advanced and renewable energy features for old building rehabilitation and for new buildings as well.

These envelopes are called multifunctional, power generating, and/or adaptive facades. These novel envelope systems allow answering the necessity to improve the indoor environmental quality and to facilitate the exploitation of renewable energy sources at the building scale.

In the recent years, a lot of research work is focusing on developing advanced multi-functional and adaptive envelopes that can store, release, produce energy and adapt their characteristics and/or performance depending on the inside needs and the outside conditions. Among these is the integration of nano-materials such as silica aerogels and phase change materials, the integration of power generating systems such as thermo-electrics and photovoltaic, the integration of adaptive materials such as thermo-chromic materials, the integration of porous materials for evaporative cooling applications, etc.

2. Problem statement and Research objectives

The numerical modeling of such advanced facades remain a complex issue. All building energy simulation computational and modeling tools available nowadays either don't include the capability to model such advanced facades, or do have but a few advanced features can be modeled. In addition, new emerging technologies cannot be modeled.

In addition, if users want to construct their own advanced façade, these softwares don't have the modularity feature to do so.

The research objective is to study the heat transfer and fluid flow phenomena of advanced envelopes. In order to develop numerical tools for adaptive, power generating and multi-functional envelopes incorporating renewable energy resources and other eco-concepts. These include but not limited to: photovoltaics, phase-change materials, multi-skin ventilated facades, super insulating dynamic facades, and other adaptive features.

The aim is to develop **a modular toolbox or library (in MATLAB/Simulink)** where the users can choose or construct their advanced façade based on the different sub-models present in the toolbox. The toolbox will be useful for new building design and old building retrofit interventions.

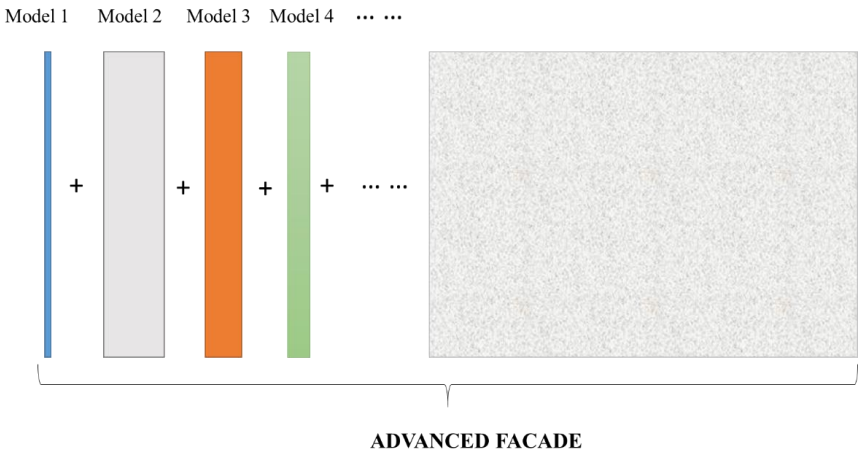
The importance of such toolbox is that it contains numerical models of advanced facades that are not included in the energy simulation tools available nowadays.
Users can run simulations as a “stand-alone” models/systems using this toolbox by implementing the necessary boundary conditions, or these models can be coupled to other simulation platforms such as the whole building energy simulation programs TRNSYS and EnergyPlus through run-time interoperability or co-simulation.
The users can then construct and test novel multifunctional and adaptive façade system concepts through the combination of different advanced models/features.

3. The Tool

The tool will be developed in MATLAB. It will be composed of several sub-models representing each technology/system/material. Each of which will be modeled as an object using the “CLASS” notion of the object-oriented feature of MATLAB. A graphical user interface will be developed. The importance of such a tool is its modular feature where a façade system can be constructed using any of the available sub-models. As illustration, the numerical models will include, but not limited to,

- Phase change materials
- Thermo-electrics
- Transparent silica aerogels
- Photovoltaic
- Solar thermal collectors
- Adaptive materials (such as thermo-chromic)
- Ventilated air layers
- Porous materials with water wetting systems (evaporative cooling systems)
- Multiple skin facades
- Dynamic insulation
- Other normal layers: glass, concrete, insulation, brick, …
- … …

Using the tool’s interface, the user can select and construct his/her own advanced façade as shown in the Figure below.



4. Validation

Each of the numerical sub-models will be validated using one or more of the following:

- using experimental published data found in the literature
- using software-to-software validation technique
- using numerical data published in the literature

5. Outcome

A modular numerical tool for multi-functional adaptive facades will be available for researchers and building (façade) engineers and architects.