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FEM-based Heat Transfer Simulations on an Urban Scale

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Talk Abstract

Throughout the world, accelerated growth of cities, urban sprawl, energy issues related to climate change, fossil fuels depletion and renewable energy integration into increasingly complex networks, as well as all the problems related to mobility, to the different forms of pollution and to the balance to be found between different land uses (built, cultivated and left to nature) place decision-makers in front of great uncertainties.

It is especially difficult to choose between different scenarios of evolution of the city since this choice will likely have impacts on the very long term. If we look back, we can see that the average lifespan of buildings in Europe exceeds the century, that urban plots were often defined in the Middle Ages, and that the layout of the first streets, which goes back almost two millennia, for the cities of Roman foundation, is still perfectly visible in the city today.

So, sustainable urban planning must first take into account streets, then plots, then buildings, and lastly equipment, because new technologies, despite their appeal, provide only ephemeral solutions. Similarly, we must first work with the immutable (the solar paths), then with what varies slowly along the centuries (the climate, we hope), and finally with much more ephemeral phenomena such as uses and behaviors of the current inhabitants.

In the work shown here, we start observing the simultaneous arrival at maturity of Finite Element Methods (it is now possible to treat problems with millions of degrees of freedom) and infrared inspection (through the progress of thermal camera technology, but also drones and laser measurement). It has therefore become possible to realize an analysis of heat transfer across a street, this one being modeled with a satisfactory level of detail, and thus simulated thermography can be compared to temporal sequences of measured thermography.

We will discuss some first results, presenting the difficulties specific to both measurement and simulation, and we will show how their simultaneous realization allows to guide the simulation by the measurement, and to optimize the measurement by the simulation.

This work offers an original and stimulating field of application to the FEM community, useful results for architects and engineers concerned with urban buildings thermal efficiency and, more broadly, some first tracks to guide planners and decision makers towards a sustainable and more hospitable city.

Keywords
Urban Physics – Heat Transfer – Finite Element Method - Infrared

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Short biography

Born in 1969, Liège, Belgium, Benoit Beckers has obtained an Engineering Degree in Physics from University of Liège (ULg) in 1992. In 1993, he joined the Superior Architecture School of the Polytechnic University of Catalonia (UPC) in Barcelona, where he started personal researches on the following subjects: concert hall acoustics; daylight and solar radiation in architectural and urban projects; geometrical methods in numerical simulation; waves perception in their physical and cultural environment. In 2008, he moved to France as an associate professor in the Université de Technologie de Compiègne. Since 2016, he is appointed as a full professor in the civil engineering department (ISA BTP) of the Iniversité de Pau et des Pays de l'Adour (UPPA). In 2016, he organized the "First International Conference on Urban Physics" (FICUP), in Quito and Galapagos (Ecuador). Since 2017, he has been leading the "Urban Physics Joint Laboratory", a multidisciplinary structure envolving the UPPA, the Institute for Energy Transition Nobatek-INEF4, the Community of Agglomerations of the French Basque Country and the New Aquitaine Region.