CONFERENCE OF THE XVIII SPANISH-FRENCH SCHOOL *Jacques-Louis Lions*
ABOUT NUMERICAL SIMULATION IN PHYSICS AND ENGINEERING
Las Palmas de Gran Canaria, June 25-29, 2018

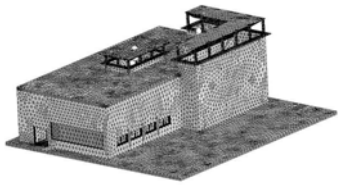
Some proposals on 3D Simulation of air velocity and temperature evolution in buildings

G. Winter*, J. Abdelfatah*, A. Ramos†, V. Henríquez†

Keywords: Nearly Zero-Energy Buildings (NZEBs), Finite Element Method,Computational fluid dynamics, Navier Stokes, Direct Sparse Solvers

Mathematics Subject Classification (2010): 65N30, 65N50, 68W10, 76-06, 76D05, 76F65, 76G25

It is important to use numerical tools, at the stage of design of buildings, to make them nearly zero-energy buildings. To improve the thermal quality of the building envelope, it is very useful the roof insulation and designs with natural ventilation. One target is to obtain a less energy-dependence building by studying different configurations of the courtyards to hold the confort inside the building [2]. We propose to calculate both velocity and temperature outside and inside buildings. The numerical simulation model consists of taking into acccount energy equation and Navier-Stokes equations. We include Boussinesq approximation linked to a modified Chorin algorithm [7] and we present comparative numerical results with other DNS solvers on several test cases [10, 11]. The advantage of using this model is that is appropriate for convergence, using for velocity polynomial approximation of grade one in finite elements. It is very important to get results in 3D with reasonable computational time cost. To compute the temperature over walls and roofs we consider nonlinear radiation-exchange flux at the outside and convection effects depending of the wind. The exterior roof surface is exposed to outdoor solar radiation, dry-bulb air temperature and the sky temperature. We consider a building with roof and walls consisting different layers as concrete, air cavity and expanded polystyrene, among others. To make mesh of the air domain and the solids mesh we use only free software[4, 5, 6]. We have implement the complete model and simulations carried out with the open source FreeFem++ language [1, 3] High Performance Computing(HPC) clusters and paralell sparse solvers.



References

[1] S. Auliac, A. Le Hyaric, J. Morice, F. Hecht, K. Ohtsuka, O. Pironneau, *FreeFem++*. Third Edition, Version 3.31-2, 2014. http://www.freefem.org/ff++/ftp/freefem++doc.pdf

[2] Juan M. Rojas, Carmen Galán Marín and Enrique D. Fernández-Nieto *Parametric Study of Thermodynamics in the Mediterranean Courtyard as a Tool for the Design of Eco-Efficient Buildings*. Energies 2012, 5, 2381-2403; doi:10.3390/en5072381 OPEN ACCESS energies ISSN 1996-1073

[3] F. Hecht, *New development in FreeFem++*. J. Numer. Math. **20** (2012), no. 3-4, 251–265, 65Y15.

[4] *FreeCAD Manual* https://www.freecadweb.org/wiki/Manual:Introduction

[5] C. Geuzaine and J.F. Remacle *Gmsh: a three-dimensional finite element mesh generator with built-in pre- and post-processing facilities.*. International Journal for Numerical Methods in Engineering 79(11), pp. 1309-1331, 2009

[6] *SALOME 8.2.0 Documentation* http://www.salome-platform.org/user-section/documentation/current-release

[7] R. Rannacher *On chorin's projection method for the incompressible Navier-Stokes equations.*. Institut Angewandte Mathematik. Universitat Heidelberg.1992. The Navier-Stokes Equations II - Theory and Numerical Methods. Oberwolfach, Germany, August 18-24, 1991.

[8] J. Abdelfatah, V. Henríquez, A. Ramos, G. Winter *3D Simulation with CFD of air speed and temperature evolution in a small commercial building. Application in Gran Canaria Island, Spain.July 2017.*. 2nd Global Conference on Applied Computing in Science and Engineering (ACSE2)

[9] Shanshan Tong, Hua Li, Kishor T. Zingre, Man Pun Wan, Victor W.-C. Chang, Swee Khian Wong,Winston Boo Thian Toh *Thermal performance of concrete-based roofs in tropical climate* Energy and Buildings 76 (2014) 392-401

[10] J.Connors *Convergence analysis and computational testing of the finite element discretization of the Navier-Stokes alpha model*. Numerical Methods for Partial Differential Equations, December 2008

[11] E.Chacón Vera *Buildings Flows with Freefem++*. Dpto. Ecuaciones Diferenciales y Análisis Numérico, Facultad de Matemáticas, University of Seville, Seville, Spain

*IUSIANI, Universidad de las Palmas de Gran Canaria, Campus Universitario de Tafira, 35017 Las Palmas de Gran Canaria (SPAIN). Email: gwinter@iusiani.ulpgc.es, jacoban90@outlook.es

†Departmento de Ingeniería de Procesos, Universidad de Las Palmas de Gran Canaria, Campus Universitario de Tafira, 35017 Las Palmas de Gran Canaria (SPAIN).Email:alejandro.ramos@ulpgc.es, vicente.henriquez@ulpgc.es