NUMERICAL MODELING OF THE FLOW FIELD FOR INDOOR THERMAL COMFORT OF A BUILDING UNDER STACK EFFECT

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DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person expect where the acknowledgment is made in text.

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The above candidate has carried out research for the Masters Dissertation under my supervision.

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Prof. R.A. Attalage Date

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Prof. K.K.C.K. Perera Date

To My Beloved Parents

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Abstract

In recent years natural ventilation is widely recognised as excellent contributing towards in design low energy buildings. The main challenge in natural ventilation is identified as lack of knowledge in providing acceptable thermal comfort in an occupied space to meet the internal requirements against the prevailing climatic conditions variations. Numerical investigations of the indoor thermal comfort condition in a simple office space governed by the solar chimney stack effect have been undertaken using CFD techniques. A mathematical model was developed based on the relevant analytical framework governing the phenomena to simulate the velocity flow field and temperature distribution on the designated plane within the indoor space. Boussinesq approximation was incorporated to numerical scheme with realistic boundary conditions for flow simulation. The model was enriched by incorporating a sufficient fluid volume to represent environment surrounding the space and thereby eliminating the entry effect to the flow. Hexahedral cells were used in a non-uniform grid distribution to minimise numerical diffusion. A fine mesh is used near the walls to enhance the resolution and accuracy resolving the problems under the turbulent flow conditions. Grid independence analysis was carried out to ensure the accuracy of the numerical results. Under-relaxation factors 0.3, 1, 2, 0.8, 0.8, 1, 0.9 for pressure, density, momentum, turbulence kinetic energy, turbulence dissipation rate, turbulent viscosity, energy respectively were used. The model outputs were compared with the available experimental measurements taken under the same condition to calibrate the numerical scheme. A parametric study was carried out using the calibrated model to assess the distribution of thermal comfort index against the changes in geometrical and solar radiation parameters. The values of activity, metabolic rate for seated activity and clothing insulation were selected as 0, 60 W/m^2 and 0.5 Clo respectively for thermal performance analysis. The effect of each input parameter was investigated in terms of mean value and standard deviation corresponding to the flow velocity and the PPD_{NV} value. It can be concluded that the present model is capable of predicting the indoor thermal performance of a building under stack effect.

Keywords: *Natural ventilation, Solar chimney, Thermal comfort, CFD, Tropical climate*

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LIST OF ABBREVIATIONS

(ACH) - Air Changes per Hour

(ASHRAE) - American Society of Heating, Refrigerating and Air-conditioning Engineers

(ASM) - Algebraic Stress Model

(CFD) - Computational Fluid Dynamic

(DNS) - Direct Numerical Simulation

(LEED) - Leadership in Energy and Environmental Design

(LES) - Large Eddy Simulation

(MET) - Metabolic Rate

(MRT) - Mean Radiant Temperature

(PCG) - Preconditioned Conjugate Gradient

(PD) - Percentage of Dissatisfied

(PMV) - Predicted Mean Vote

(PMV_{NV}) - Predicted Mean Vote Natural Ventilation

(PPD) - Predicted Percentage of Dissatisfied

(PPM) - Parts Per Million

(PPD_{NV}) - Predicted Percentage of Dissatisfied under Natural Ventilation

(RANS) - Reynolds Averaged Navier-Stokes

(RNG) - Renormalisation Group

(RSM) - Reynolds Stress Model

(SIMPLE) - Semi-Implicit Method for Pressure-Linked Equations

(TMY2) - Typical Metrological Year 2

(USGBC) - United State Green Building Council