

**A COMPUTATIONAL STUDY ON THE ENERGY
SAVING POTENTIAL OF UNDERFLOOR AIR
DISTRIBUTION SYSTEMS FOR SPACE COOLING IN
COMMERCIAL BUILDINGS**

Akurugoda Gamage Sama Jeewakanthi

208894 H

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Department of Mechanical Engineering

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Sri Lanka

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ABSTRACT

Demand for improved indoor air quality using low velocities and prevention of spread of air borne diseases has encouraged industry to focus more on the use of Under Floor Air Distribution (UFAD) systems in commercial buildings. Server rooms and communications centres have already adopted UFAD Systems as the most preferable cooling method due to its unique benefit over the overhead air distribution (OHAD) systems. However, only a handful of installations have been developed around the world with UFAD air conditioning systems for commercial buildings despite its ability to deliver key benefits of energy saving and air cleanliness. Accordingly, this research investigates the ability of UFAD system in delivering thermal comfort with respect to international standards: ASHRAE 55 and ISO 7730-2005.

A CFD simulation-based approach was employed for the analysis. The developed CFD model for an office environment was validated with published literature and subsequently utilized to predict thermal environment of different building and operating conditions.

The simulations were performed for OHAD systems and UFAD systems under different scenarios for an office building located in Colombo, Sri Lanka. The supply air temperature 17°C and 0.7, 0.5, 0.4 m/s inlet velocities of the OHAD system led to a temperature variation in the occupancy zone from 23 °C to 19.9 °C. For UFAD systems this was 23.3 °C to 18.6 °C. With the elevated 3 °C supply temperature UFAD system temperature range vary between 25.6 °C to 21.4 °C.

For other thermal comfort sensation criteria such as Draught rate, Percentage of dissatisfaction, inside mean air velocity and temperature effectiveness, the UFAD system showed better performance compared to OHAD systems. Further the UFAD performance was shown be quite sensitive to the outlet configuration. Thus, the outlet location of the UFAD system has to be carefully designed, with the help of CFD to obtain expected improved performance. Following such a CFD based well engineered design, it was shown here that the UFAD system could achieve 20.83% energy saving in tropical climate in comparison to similar capacity OHAD system.

Keywords:

Under Floor Air Distribution Systems, Computational Fluid Dynamics Simulation, Indoor air Quality, Thermal comfort, Air conditioning, Grid Independent Study.

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LIST OF NOMENCLATURE

Abbreviation	Description
ASHRAE	American Society of Heating and Air-Conditioning Engineers
UFAD	Under Floor Air Distribution
OHAD	Overhead Air Distribution (Overhead Mixing Ventilation)
HVAC	Heating, Ventilation and Air Conditioning
TDV	Traditional Displacement Ventilation
PMV	Predicted Mean Vote
PPD	Predicted Percentage of Dissatisfied
IAQ	Indoor Air Quality
CFD	Computational Fluid Dynamics
TVOC	Total Volatile Organic Compound
PM ₁₀	Particulate Matter of 10 Micrometres or less
RH	Relative Humidity
ACH	Air Changes per Hour
DAT	Dimensionless Air Temperature
T _a	Local Air Temperature
T _i	Mean Supply Air Temperature
T _o	Mean outlet Air temperature

Notations	Description
Occupied Zone	Region up to 6 ft height from floor level, 3.3 ft from sunlit walls/windows and 1 ft away from internal walls in an office space.
Plenum	separate space under the elevated floor of each level of the building where conditioned air supply through ducts. Normally this will be cover part or total floor are of the building.

Subscripts	Description
CO	Carbon Monoxide
CO ₂	Carbon Dioxide