ANALYSIS OF THE EFFECT OF HEAT COLUMN GENERATION ON ENERGY PERFORMANCE OF SPLIT AC UNITS IN HIGH-RISE RESIDENTIAL BUILDINGS

Vatharkhan Mohamed Harithkhan

208077G

Degree of Master of Philosophy

Department of Mechanical Engineering

Faculty of Engineering

University of Moratuwa

Sri Lanka

March 2026

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 except where the acknowledgement is made in the text. I retain the right to use this content in whole or part in future works (such as articles or books).

Signature: Date: 17/03/2026

The above candidate has carried out research for the MPhil under my supervision. I confirm that the declaration made above by the student is true and correct.

Name of Supervisor: Dr. N.A.I.D. Nissanka

Signature of the Supervisor: Date: 17/03/2026

Name of Supervisor: Dr. M.M.I.D. Manthilake

Signature of the Supervisor: Date: 17/03/2026

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to the University of Moratuwa for funding this research through the Senate Research Committee Grant (Grant number: SRC/LT/2021/05). I am deeply grateful to my supervisors, Dr. N.A.I.D. Nissanka and Dr. M.M.I.D. Manthilake, for their continuous support, invaluable guidance, and encouragement throughout this research, which was instrumental in its successful completion.

My heartfelt appreciation also goes to my father, Mr. S. Vatharkhan, for his unwavering support and motivation. Finally, I am profoundly thankful to my wife, M.T.F. Safrina, for her endless patience, understanding and unwavering support during the challenging moments of this journey.

ABSTRACT

In recent high-rise residential building constructions, air-cooled split-type air conditioners are popular due to their cost-effectiveness and installation flexibility. However, placing outdoor units in restricted building re-entrants creates heat columns along the height of the building. This phenomenon adversely affects energy efficiency and contributes significantly to the overall power consumption of the A/C units. I recent years, the escalating use of air conditioners due to global warming highlights the substantial energy dedicated to space cooling. Hence, improving air conditioning efficiency is vital in managing end-user electricity consumption. This research examines split air conditioning performance in a tropical high-rise residential building, focusing on heat column generation in re-entrants. The study assesses system efficiency under different loads and outdoor temperatures. A numerical framework was developed to optimize condenser layouts, allowing simulation of various scenarios. By analyzing outdoor wind conditions, individual usage, and room cooling loads, the research aims to predict the impact of heat columns generation on Split A/C performances in high rise residential buildings. The study reveals that elevated ambient temperatures in re-entrants significantly degrade performance due to heat column effects. CFD simulations demonstrated that condenser placement and re-entrant geometry critically influence temperature distribution, with upper-floor units experiencing severe accumulation, causing COP reduction up to 62% and elevating consumption by 75%. Simulations showed that under no-wind conditions, locating units 1.5 m from the exterior wall minimized heat column buildup, while 2.0 m proved optimal at 2 m/s outdoor wind conditions. Introducing a perforated slab improved thermal management, lowering peak temperatures from 64°C to 59.5°C at no-wind conditions. The findings underscore strategic importance in optimum layout of outdoor units in re-entrants to enhance efficiency and reduce costs, providing insights for architects and engineers. This study contributes insights into factors influencing heat column strength and emphasizes the mathematical framework for optimizing condenser arrangements.

Keywords: Condenser unit arrangement, Heat column generation, High-rise residential buildings, Computational Fluid Dynamics (CFD), Building cooling energy

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

Abbreviation	Description
A/C	Air Conditioning
CFD	Computational Fluid Dynamics
COP	Coefficient of Performance
HVAC	Heating, Ventilation and Air Conditioning
CGPI	Condenser Group Performance Indicator
GCPR	Group Condenser Performance Ratio
GCCR	Group Condenser Capacity Ratio
GCER	Group Condenser Energy Ratio
SDG	Sustainable Development Goals