# APPLICABILITY OF THE ADAPTIVE THERMAL COMFORT MODEL IN NATURALLY VENTILATED HIGH-RISE RESIDENTIAL DEVELOPMENTS IN COLOMBO, SRI LANKA

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218006B

Degree of Master of Science

Department of Architecture
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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 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: 2026/01/31

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

Name of Supervisor:

Signature of the Supervisor: ………………………….. Date: 31-01-2026

Dr. (Ms) Shaleeni Coorey

………………………….. Date: 31.01.2026

Prof. Narein Perera

# DEDICATION

To Dr. Shaleeni Coorey, Prof. Narein Perera, and Dr. Renganathan, whose wisdom illuminated my path and whose unwavering guidance transformed obstacles into stepping stones. Their scholarly rigor, patience, and belief in my potential have left an indelible mark on both this work and my growth as a researcher.

To my family, whose boundless love and steadfast support have been my anchor through every storm and calm. Their quiet sacrifices, encouraging words, and unwavering faith in me gave strength when mine waned, this achievement is as much theirs as it is mine.

Together, these extraordinary individuals have shaped not just this thesis, but the person I have become in the process.

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# ABSTRACT

This study investigates the applicability of the ASHRAE 55-2017 adaptive thermal comfort model in naturally ventilated high-rise residential developments in Colombo, Sri Lanka, where rapid urbanization and tropical climatic conditions pose unique challenges for low-income communities. While international standards like ASHRAE 55-2017 provide frameworks for thermal comfort, their relevance in resource-constrained, high-density tropical housing remains underexplored. To address this gap, the research employs a mixed-methods approach, combining longitudinal field measurements of indoor environmental parameters (temperature, humidity, air velocity) with detailed occupant surveys to capture subjective comfort perceptions and adaptive behaviors across five case-study buildings. The results reveal critical discrepancies between model predictions and lived experiences: occupants reported 94.5% dissatisfaction with indoor thermal conditions, despite employing adaptive strategies such as fan use and window adjustments. These differences are aggravated by vertical microclimatic variations, with upper-floor residents experiencing significantly different thermal conditions than lower floors, and socio-cultural constraints, such as privacy concerns that limit effective natural ventilation. Statistical analyses, including Spearman's rank correlation and ANOVA, further demonstrate that the ASHRAE model underestimates the adaptive capacity of residents in warm-humid climates, particularly during peak discomfort periods (e.g., midday, when 64% of respondents reported severe thermal discomfort). The study concludes that the ASHRAE 55-2017 model requires context-specific recalibration for tropical high-rises. It proposes revised adaptive comfort criteria and emphasizes targeted architectural interventions, such as optimized cross-ventilation and solar shading, alongside policy reforms to address thermal equity in low-income urban housing.

**Keywords**: Adaptive thermal comfort, naturally ventilated buildings, tropical architecture, high-rise housing, ASHRAE 55-2017, Sri Lanka.

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# LIST OF ABBREVIATIONS

| Abbreviation | Description |
|---|---|
| NV | Naturally Ventilated |
| PMV-PPD | Predicted Mean Vote-Predicted Percentage of Dissatisfied |
| ASHRAE | American Society of Heating, Refrigerating and Air-Conditioning Engineers |
| PMOT | Prevailing Mean Outdoor Temperature |
| UHI | Urban Heat Island |
| EN 15251 | European Standard for Indoor Environmental Input Parameters |
| CIBSE TM52 | Chartered Institution of Building Services Engineers Technical Memorandum 52 |
| IMAC | India Model for Adaptive Comfort |
| TCI | Tropical Comfort Index |
| CFD | Computational Fluid Dynamics |
| PCM | Phase-Change Material |
| AI | Artificial Intelligence |
| EH | Exceedance Hours |
| NMBE | Normalized Mean Bias Error |
| CV(RMSE) | Coefficient of Variation of Root Mean Square Error |
| IPMVP | International Performance Measurement and Verification Protocol |
| ISO 8996 (2004) | International Standard for metabolic rate estimation |
| ANOVA | Analysis of Variance |
| ICC | Interclass Correlation Coefficient |
| κ (kappa) | Cohen’s kappa (inter-rater reliability for categorical data) |
| SPSS | Statistical Package for the Social Sciences |
| R Studio | Programming environment for statistical computing |

# LIST OF APPENDICES