

**ENERGY SAVING POTENTIAL OF
CEILING FAN-ASSISTED AIR CONDITIONING
IN TROPICAL CLIMATES**

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DECLARATION OF THE CANDIDATE AND SUPERVISOR

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ABSTRACT

The cost of air conditioning in tropical climates makes the biggest contribution to the energy bill in most domestic, commercial, and industrial settings. Improving the air circulation and thereby enhancing the thermal comfort of occupants pave the way to running the air conditioners (AC) at a higher temperature setting, which leads to lower power consumption. Accordingly, this research examines whether ceiling fan-assisted air conditioning systems can reduce the energy required for cooling in tropical environments.

The research is primarily based on field studies and was conducted in a typical office space in Kankesanturei, Sri Lanka, which has a year-round tropical climate with high temperatures and high levels of humidity. The office room is air-conditioned with a window-type AC, and air circulation is provided by a ceiling fan. 50 participants with almost identical clothing were selected. Testing was conducted for different AC temperature settings and different speed settings of the ceiling fan. Wind speed, temperature profiles within the room, and corresponding energy consumptions were recorded. Thermal sensation feedback from participants was also obtained via a questionnaire for each operating condition. Measurements and participant feedback were analyzed, using established ASHRAE standards to rate the thermal comfort level.

According to the findings, utilizing ceiling fan-assisted AC can result in a reduction in energy usage of up to 40% (depending on the AC type, temperature setting, and the nature of the occupants). As a result of the improved airflow generated by the ceiling fans, the hybrid system provides superior thermal comfort at moderate fan speeds. This is because the increased air movement improves air circulation and reduces temperature stratification within the room. Accordingly, this research highlights the potential benefits of adding this combined system to building design and HVAC system selection, providing significant information for building designers.

Keywords: Fan assisted AC, Thermal Comfort, Air Conditioner, Ceiling Fan, Office buildings.

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TABLE OF CONTENTS

DECLARATION OF THE CANDIDATE AND SUPERVISOR.....	i
ABSTRACT.....	ii
ACKNOWLEDGEMENTS.....	iii
TABLE OF CONTENTS.....	iv
LIST OF FIGURES.....	vii
LIST OF TABLES.....	ix
LIST OF ABBREVIATIONS.....	x
CHAPTER 1.....	1
1.0 INTRODUCTION.....	1
1.1 Problem Identification.....	1
1.2 Aim.....	3
1.3 Objectives.....	3
1.4 Methodology.....	3
1.5 Other Chapters.....	4
CHAPTER 2.....	6
2.0 THERMAL COMFORT ASSESSMENT.....	6
2.1 Analytical Approach to Assess Thermal Comfort.....	6
2.1.1 Rate of Metabolism.....	8
2.1.2 Insulation of Clothing.....	9
2.1.3 Air Temperature.....	10
2.1.4 Radiant Temperature.....	11
2.1.5 Air Velocity.....	12
2.1.6 Humidity.....	13

2.2	Thermal Comfort Evaluation Using Fanger’s Model.....	14
2.3	The Physiological Reaction of the Occupants to Hot and Humid Conditions	16
2.4	Acclimatization	17
2.5	Rating scale for subjective judgment	18
2.6	HVAC for Achieving Thermal Comfort	19
2.7	Ceiling fans.....	21
2.8	Wind Chill Effect	23
2.9	Fan Assisted Air Conditioning	23
2.10	Studies on Fan Assisted Air Conditioning	25
CHAPTER 3		30
3.0	Research Methodology.....	30
3.1	Standards	30
3.2	Test Chamber	30
3.2.1	Glass Fenestration	34
3.2.2	Room Lighting	34
3.2.3	Specifications of the Air Conditioner	35
3.2.4	Specifications of the Ceiling Fan	35
3.2.5	Ceiling.....	35
3.3	Test Subjects.....	36
3.4	Steps of the Experiment as Follows;	37
CHAPTER 4		42
4.0	RESULTS and DISCUSSION	42
4.1	Climate of Kankesanturei	42
4.2	Metrological data for Kankesanturei	44
4.3	Thermal Zone of Kankesanturei	46

4.4	The Iterative Method to Find Out T_{cl}	49
4.5	How To Get the Desired Level of Thermodynamic Comfort in Kankesanturei.....	57
4.6	Fan Assisted AC	57
4.7	Existing Capacity of The AC Unit for The Test Chamber	57
4.8	Indoor Temperature Distribution (Horizontal and Vertical Ways) When AC Incorporated with Ceiling Fan for Diverse Temperatures	58
4.9	Air Velocity Variation	66
4.10	Humidity Variation.....	70
4.11	Power Consumption for AC And Fan at Varied Temperatures	73
4.12	Effect of The Fan.....	74
4.13	PMV Values	77
4.14	PPD Values.....	78
4.15	Effect To the Power Consumption When the AC Incorporated With Ceiling Fan	81
4.16	Calculation of Payback Time	83
4.17	A Summary of Results	84
CHAPTER 5		88
5.0	CONCLUSIONS.....	88
References		89

LIST OF FIGURES

Figure 1.1 : Fan Assisted AC	2
Figure 2.1: Human Body Thermal Balance [51].....	7
Figure 2.2: Sensational Scale [49]	15
Figure 2.3: Index PPD and PMV variation [51]	26
Figure 3.1: Pictures of The Test Chamber	31
Figure 3.2: Appearance of The Test Chamber (Office Area)	32
Figure 3.3: Dimensions of The Test Chamber (Office Area)	33
Figure 3.4: Lighting Arrangement of The Room.....	34
Figure 3.5: Ceiling	36
Figure 3.6 : Sensational Scale	37
Figure 3.7: PMV vs PPD.....	38
Figure 3.8: Horizontal and vertical distribution.....	39
Figure 4.1: Variation of Relative Humidity Outdoor.....	45
Figure 4.2: Variation of Temperature Outdoor	45
Figure 4.3 : Existing Thermal Zone of Kankesanturei (In Blue Color) and ASHRAE Standard Comfortable Zone in Red Color	46
Figure 4.4 : Flow Chart for Iterative Method.....	50
Figure 4.5: PMV Variation Along the Year for Both Male and Female.....	52
Figure 4.6: PPD Variation Along the Year for Both Male and Female.....	53
Figure 4.7: PPD Variation Against PMV for Kankesanturei Area	54
Figure 4.8: Wind Chill Temperature Profile	56
Figure 4.9: Room Geometry (Locations).....	58
Figure 4.10:Vertical and Horizontal Temperature Distribution at Thermostat Setting 24°C	59
Figure 4.11:Vertical and Horizontal Temperature Distribution at Thermostat Setting 25°C	60
Figure 4.12:Vertical And Horizontal Temperature Distribution at Thermostat Setting 26°C	62
Figure 4.13:Vertical and Horizontal Temperature Distribution at Thermostat Setting 27°C	63

Figure 4.14: Vertical and Horizontal Temperature Distribution at Thermostat Setting 28°C	64
Figure 4.15: Vertical and Horizontal Temperature Distribution at Thermostat Setting 29°C	65
Figure 4.16: Room Geometry (Locations)	66
Figure 4.17: Vertical And Horizontal Air Velocity Distribution at No Fan Condition	67
Figure 4.18: Vertical And Horizontal Air Velocity Distribution at Fan Speed FS 1.	67
Figure 4.19: Vertical and horizontal air velocity distribution at fan speed FS 2	68
Figure 4.20: Vertical and horizontal air velocity distribution at fan speed FS 3	68
Figure 4.21: Vertical and horizontal air velocity distribution at fan speed FS 4	69
Figure 4.22: Vertical and horizontal air velocity distribution at fan speed FS 5	69
Figure 4.23: Vertical and Horizontal Relative Humidity Distribution at No Fan Condition.....	70
Figure 4.24: Vertical and Horizontal Relative Humidity Distribution at Fan Speed FS 1.....	71
Figure 4.25: Vertical and Horizontal Relative Humidity Distribution at Fan Speed FS 2.....	71
Figure 4.26: Vertical and Horizontal Relative Humidity Distribution at Fan Speed FS 3.....	72
Figure 4.27: Vertical and Horizontal Relative Humidity Distribution at Fan Speed FS 4.....	72
Figure 4.28: Vertical and Horizontal Relative Humidity Distribution at Fan Speed FS 5.....	73
Figure 4.29: Power Consumption For AC	73
Figure 4.30: Noisiness of The Fan	74
Figure 4.31: Air Flow Sensation of The Fan	75
Figure 4.32: Total Effect of The Fan	75
Figure 4.33: Thermal Sensational Vote Given by The Test Subjects (50 Personal) .	76
Figure 4.34: Behavior of PMV at 27°C	77
Figure 4.35: Behavior of PMV at 28°C	77
Figure 4.36: Behavior of PMV at 29°C	78

Figure 4.37: Behavior of PPD at 27°C.....	78
Figure 4.38: Behavior of PPD at 28°C.....	79
Figure 4.39: Behavior of PPD at 29°C.....	79
Figure 4.40: Subjects' Votes on Comfortability in The Particular Thermostat Setting and Fan Speed	80
Figure 4.41: Energy Savings at The Optimal Operating Point, Versus No Fan Thermostat Settings.....	82

LIST OF TABLES

Table 2.1: Seven Point Sensational Scale [49]	15
Table 3.1: Power consumed by ceiling fans at various speeds	35
Table 4.1: Metrological Data for Kankesanturei.....	44
Table 4.2: PMV and PPD Values for Outdoor Environment Kankesanturei.....	51
Table 4.3: Wind Chill Temperature Values	56
Table 4.4: PMV And PPD Values at Thermostat Settings 27°C, 28°C And 29°C....	77
Table 4.5: Payback Time of The AC With Fan System w.r.t. Operating Without Fan At 25 ⁰ C.....	84

LIST OF ABBREVIATIONS

Abbreviation	Description
AC	Air conditioner
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
HVAC	Heating and Ventilation Air Conditioner
PMV	Predicted Mean Vote
PPD	Predicted Percentage of Dissatisfied
CAPEX	Total cost of a building for financing and constructing
OPEX	Total cost of a building for financing and constructing
FS	Fan speed
NF	No fan operating
TEMP	Temperature
MRT	Mean radiant temperature
EER	Energy Efficiency Ratio
SEER	Seasonal energy efficiency ratio
COP	Coefficient of performance
TOE	Ton of oil equivalent
NZEB	Net Zero Energy Building
AM	Tropical monsoonal
POE	Post-occupation evaluation
RETs	Renewable energy technologies
GHG	Greenhouse gases
BMS	Building management systems
IAQ	Indoor air quality
BIPV	Building-integrated photovoltaics
TPES	Total primary energy supply
ODSM	Operation Demand Side Management

Nomenclature

C_p	-	Specific heat of air, J/(kgK)
f_{cl}	-	Ratio of clothed surface area to nude surface area of human body
h_c	-	Convective heat transfer coefficient, W/(m ² K)
I_{cl}	-	Thermal resistance of clothing, m ² K/W
K	-	Thermal conductivity of air, W/(mK)
M	-	Heat generation rate -Metabolic, W/m ² of area of the body
m	-	Water vapor Concentration, kg/kg of mixed air
p	-	Pressure, Pa
p_w	-	Water vapor Partial pressure in moist air, Pa
p_{ws}	-	Saturated water vapor Pressure, Pa
RH	-	Relative humidity
T	-	Temperature, °C
T_a	-	Mean air temperature, °C
T_r	-	Mean radiant temperature, °C
R_{cl}	-	Thermal resistance of clothing, m ² K/W
R_{cl}	-	Thermal resistance of clothing, m ² K/W
v	-	Mean speed of air relative to the body, m/s
V	-	Air speed, m/s
W	-	External work, W/m ² of naked body area
ρ	-	Density of air, kg/m ³