PASSIVE DESIGN APPROACH IN ENHANCING NATURAL VENTILATION PERFORMANCE OF TWO STOREYS RESIDENTIAL BUILDINGS IN TROPICAL CLIMATE

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A thesis submitted in fulfillment of the requirement for the award of the Doctor of Philosophy.

Faculty of Civil and Environmental Engineering
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To Allah the Almighty,

For my beloved mother and father,

my wife and children,
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ABSTRACT

Air movement is one of the main factors contributing to thermal comfort. In achieving the comfort while maintaining low energy consumption, natural ventilation is the best source of air movement to relied on. However, inconsistency of surrounding air movement in urban areas may not provide sufficient air flow for building in the area. Based on previous research, there are building design elements that show potential in contributing good indoor natural ventilation within the surrounding. Throughout case studies, this research identifies the elements which further specified as natural ventilation attributes. Result shows, wind catcher attribute turn to be the most significant followed by wide openings and indoor layout. Whereas louvered openings show possibilities in enhancing the incoming air velocity by-passing them. Using a full-scale single unit double storey house prototype, this research applies the potential attributes to the design before being analyzed on the building indoor air movement effect. The ratio of the overall indoor air movement upon outdoor air movement at particular hours was used to indicate the space indoor natural ventilation performance for the building. The result shows significant high incoming air velocity through the aerofoil louvered wind catcher applied as the high opening for the building atrium. The high air velocity was maintained at the upper area inside the atrium before rapidly reduced along its way down. The low positioning of the neutral pressure plane (NPP) level in the building kept the process flows. Wide openings provided at upper level, even are not directly attached to the atrium may cause air short cut flowing out along the way down. However, wide openings at lower level, significantly contribute good air flow despite slower crossing ventilation flowing at the level. In a situation when the surrounding air is almost stagnant, the design was found still capable to keep the air movement flow via stack effect ventilation. The research also found that while it is important for the building to to enhance the incoming air flow, it is also important to provide a properly planned layout design to manage the indoor air flow.
ABSTRAK

Penyelidikan ini mendapati, selain memberi tumpuan untuk membawa pergerakan angin, merancang susunatur ruang dalaman juga adalah penting bagi memastikan pergerakan angin dalamannya adalah teratur dan berkesan.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>CONTENTS</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>TITLE</td>
<td>i</td>
</tr>
<tr>
<td>STUDENT DECLARATION</td>
<td>v</td>
</tr>
<tr>
<td>DEDICATION</td>
<td>vi</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>vii</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>viii</td>
</tr>
<tr>
<td>ABSTRAK</td>
<td>ix</td>
</tr>
<tr>
<td>TABLE OF CONTENTS</td>
<td>xi</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>vii</td>
</tr>
</tbody>
</table>

## CHAPTER 1 INTRODUCTION

<table>
<thead>
<tr>
<th>SECTION</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 Overview</td>
<td>1</td>
</tr>
<tr>
<td>1.2 Background of study</td>
<td>2</td>
</tr>
<tr>
<td>1.3 Problem statement</td>
<td>4</td>
</tr>
<tr>
<td>1.4 Research questions</td>
<td>7</td>
</tr>
<tr>
<td>1.5 Hypothesis</td>
<td>8</td>
</tr>
<tr>
<td>1.6 Aim and research objectives</td>
<td>9</td>
</tr>
<tr>
<td>1.7 Significance of research</td>
<td>10</td>
</tr>
<tr>
<td>1.8 Scope of study</td>
<td>11</td>
</tr>
<tr>
<td>1.9 Research methodology</td>
<td>12</td>
</tr>
<tr>
<td>1.10 Thesis outline</td>
<td>13</td>
</tr>
<tr>
<td>1.11 Conclusion</td>
<td>14</td>
</tr>
</tbody>
</table>

## CHAPTER 2 AIR MOVEMENT FACTORS FOR THERMAL COMFORT IN BUILDING

<table>
<thead>
<tr>
<th>SECTION</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 Introduction</td>
<td>15</td>
</tr>
<tr>
<td>2.2 Human comfort</td>
<td>17</td>
</tr>
<tr>
<td>2.2.1 Visual comfort</td>
<td>17</td>
</tr>
<tr>
<td>2.2.2 Acoustic comfort</td>
<td>18</td>
</tr>
</tbody>
</table>
2.2.3 Thermal comfort 18
2.3 Indoor air quality 20
2.4 Building ventilation 21
2.4.1 Cross ventilation. 23
2.4.2 Stack effect ventilation 24
2.4.3 Natural pressure plane effect on stack ventilation 26
2.5 Building ventilation opening 28
2.6 Window design 29
2.7 Louvers window design 31
2.8 Louvers design 32
2.9 Air jet 33
2.10 Summary of findings 34
2.11 Conclusion 35

CHAPTER 3 ARCHITECTURAL APPROACH FOR NATURAL VENTILATION STRATEGIES 37
3.1 Introduction 37
3.2 Architectural design 39
3.2.1 Architectural design development flow 39
3.2.2 Legal aspect on technical matters in architectural design 40
3.2.3 Construction process and project management 41
3.3 Factors effecting natural ventilation on building 42
3.4 Building design attributes identification 52
3.5 Ventilation strategies in vernacular architecture 61
3.5.1 Vernacular building layout and orientation 61
3.5.2 Vernacular building form 62
3.6 Ventilation strategies in contemporary architecture 65
3.6.1 Wind scoops or wind catcher element 65
3.6.2 Open plan concept 67
CHAPTER 4 RESEARCH METHODOLOGY

4.1 Introduction 72
4.2 Research approach 72
4.2.1 Qualitative method 73
  4.2.1.1 Case study method 74
  4.2.1.2 Design process method 75
4.2.2 Quantitative method 75
  4.2.2.1 On-field data measurement 76
  4.2.2.2 Indoor natural ventilation performance 78
  4.2.2.3 Wind tunnel simulation 78
4.3 Research method adopted 80
  4.3.1 Literature review 81
  4.3.2 Case Studies 82
    4.3.2.1 Preparation of the field study on case studies 88
    4.3.2.2 Data collection 91
    4.3.2.3 Data obtained 92
    4.3.2.4 Data analysis 92
  4.3.3 Design process 93
    4.3.3.1 Identifying the site 93
    4.3.3.2 Construction legislation matters 94
    4.3.3.3 Micro-climate of meteorological data of site 94
    4.3.3.4 Design development 94
    4.3.3.5 Wind tunnel experimental work 95
  4.3.4 Full scale prototype design development on site 96
4.4 Prototype analysis 96
  4.4.1 On-field data collection of the prototype 96
CHAPTER 5  NATURAL VENTILATION ATTRIBUTES IDENTIFICATION  101

5.1 Introduction  101
5.2 Objective of case studies  101
5.3 Case studies of vernacular house  102
5.3.1 Sri Banai house, Alor Setar, Kedah  102
5.3.2 Tok Su house, Alor Setar, Kedah  106
5.3.3 Kalimantan Tengah traditional house  109
5.3.4 Batak Toba house, the house of North Sumatera  112
5.4 Case studies on contemporary houses with vernacular elements  116
5.4.1 Sri Merlong house, Rengit, Johor  116
5.4.2 Sri Penggaram house, Batu Pahat, Johor  120
5.5 Case studies on contemporary house with natural ventilation design approach  123
5.5.1 Sekeping Seapark, Petaling Jaya  123
5.5.2 Skudai Box, Johor Bahru  129
5.6 Data analysis  132
5.6.1 Indoor natural ventilation performance  132
5.5.2 Significant natural ventilation attributes identification  134
5.5.3 Natural ventilation attributes contribution analysis  144
5.7 Summary finding of objective 1  147
5.8 Conclusion  148

CHAPTER 6  DESIGNING THE ATTRIBUTES COMBINATION ON A BUILDING  149

6.1 Introduction  149
6.2 Identifying the site  149
6.3 Construction legislation matters  150
6.4 Micro climate studies 152
   6.4.1 Meteorological district data 153
   6.4.2 Site studies on weather data 155
   6.4.3 Conclusion on weather data 162
6.5 Design process 163
   6.5.1 Setting the building footprint 163
   6.5.2 Space arrangement 164
   6.5.3 Natural ventilation attributes application 165
   6.5.4 Wind tunnel simulation of natural ventilation effect on the building form 171
6.6 Design development 178
6.7 Full scale prototype development on site 178
   6.7.1 Building plan approval from local authorities and technical departments 178
   6.7.2 Construction process 179
6.8 Summary finding of objective 2 180
6.9 Conclusion 182

CHAPTER 7 INDOOR NATURAL VENTILATION PERFORMANCE ENHANCEMENT 183
7.1 Introduction 183
7.2 Data collection 183
   7.2.1 Outdoor wind velocity and air temperature 185
   7.2.2 Comparison of outdoor wind velocity and indoor air movement 187
   7.2.3 Comparison of outdoor and indoor air temperature 192
7.3 Indoor natural ventilation performance 196
   7.3.1 Previous finding comparison 198
   7.3.2 Case studies comparison 199
7.4 Natural ventilation attributes application analysis 202
   7.4.1 Aerofoil louvered wind catcher atrium 202
   7.4.2 Opening design 205
   7.4.3 Centralized atrium indoor layout 209
7.4.4 Lowering the neutral pressure plane (NPP) level 210

7.5 Summary findings of objective 3 212

7.6 Conclucion 213

CHAPTER 8 CONCLUSION AND RECOMMENDATIONS 214

8.1 Introduction 214

8.2 Summary of research development. 214

8.3 Hypotheses review 216

8.4 Contribution to knowledge 217

8.5 Limitation of research 219

8.6 Recommendation for future research 220

8.7 Conclusion 221

REFERENCES

APPENDICES
LIST OF TABLES

2.1 Temperature, relative humidity and air velocity comfort range comparison 20
4.1 Building selected under the category of case studies 74
4.2 Sample of Matrix Comparison Table 76
4.3 Research methodology phases 81
4.4 Determination of field study period 89
4.5 Monthly average wind speed of Batu Pahat 97
4.6 Research methodology overview for Phase 1 98
4.7 Research methodology overview for Phase 2 99
4.8 Research methodology overview for Phase 3 99
5.1 Mean outdoor air velocity of case studies 133
5.2 Indoor Natural Ventilation performance on determined observed spaces 133
5.3 Analysis of natural ventilation building elements presence in determined case study spaces 145
5.4 Ventilation attributes significance on good indoor natural ventilation performance 147
6.1 Meteorological data of wind velocity in Batu Pahat 153
6.2 Matrix space interrelation 164
6.3 Matrix of attribute relation with other attributes 165
6.4 Matrix comparison of natural ventilation attributes and building spaces 166
7.1 The outdoor mean data of wind velocity and air temperature 187
7.2 Indoor natural ventilation performance of 7.00am to 6.00pm period 197
7.3 Indoor natural ventilation performance of 7.00pm to 6.00am period 198
7.4 Indoor natural ventilation performance of living hall comparison 200
7.5 Indoor natural ventilation performance of family hall comparison 201
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.6</td>
<td>Indoor natural ventilation performance of bedrooms comparison</td>
<td>201</td>
</tr>
<tr>
<td>7.7</td>
<td>Comparison of indoor and outdoor reading indicating buoyancy effect</td>
<td>204</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

1.1 Outdoor against indoor daily temperature of concrete house 5
1.2 Design requirements of cross ventilation and stack effect ventilation 6
1.3 The thesis structure 14
2.1 Location of tropical climates 16
2.2 Thermal comfort, visual comfort and acoustic comfort: 17
2.3 Diagram showing type of natural ventilation. 22
2.4 Cross ventilation diagram. 24
2.5 Stack ventilation diagram process in building. 25
2.6 Schematic diagram of stack ventilation in a workshop. 27
2.7 Purpose provided openings and adventitious openings. 29
2.8 Overall design impact on ventilation. 30
2.9 The average of air temperature without stack ventilation 31
2.10 The average of air temperature with stack ventilation 31
2.11 Ordinary shape of louvers 32
2.12 Vector flow for 45° angle louvers pointing down 32
2.13 Louvers window application on contemporary building design 33
2.14 Typical air jet distribution condition in room showing trajectory and gravity impact 34
3.1 Proposed adaptive comfort standard (ACS) for ASHRAE Standard 55, applicable for naturally ventilated buildings. 38
3.2 Knowledge exploration in design process 40
3.3 Building orientation towards the cardinal direction 43
3.4 Overheating temperature-indices for the 4 glazing system at various wall orientations (GL1-GL4) based on mediterranean region surrounding simulation 44
3.5 Bioclimatic tower 45
<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.6</td>
<td>Building form showing air supply strategy (left) and air exhaust strategy</td>
</tr>
<tr>
<td>3.7</td>
<td>Air movement of wind catcher study</td>
</tr>
<tr>
<td>3.8</td>
<td>Comparison study of side lit atrium (left) and top lit atrium (right) effect on indoor thermal condition</td>
</tr>
<tr>
<td>3.9</td>
<td>Large vortex due to higher angle attack</td>
</tr>
<tr>
<td>3.10</td>
<td>Computation Fluid Dynamic simulation showing velocity counters for aerofoil louvers model (a)25° (b)35° (c)45°</td>
</tr>
<tr>
<td>3.11</td>
<td>Building and landscape elements roles in directing the wind flow</td>
</tr>
<tr>
<td>3.12</td>
<td>Louvers windows application in building</td>
</tr>
<tr>
<td>3.13</td>
<td>Central level of high window opening at 2/3 of the floor to ceiling height</td>
</tr>
<tr>
<td>3.14</td>
<td>The example of Open Plan concept determined</td>
</tr>
<tr>
<td>3.15</td>
<td>The examples of Open Plan concept interior look</td>
</tr>
<tr>
<td>3.16</td>
<td>Low opening maximum height determination</td>
</tr>
<tr>
<td>3.17</td>
<td>Wind flow within 45 degree angle of direction to benefit the facing opening</td>
</tr>
<tr>
<td>3.18</td>
<td>Sample of Wind Rose Diagram to represent the surrounding pattern of wind flow</td>
</tr>
<tr>
<td>3.19</td>
<td>Determination of High Ceiling and Raised Floor</td>
</tr>
<tr>
<td>3.20</td>
<td>Building orientation study on a traditional house in Quang Nam</td>
</tr>
<tr>
<td>3.21</td>
<td>Air movement velocity of indoor spaces (No. 2 - 7) comparison with overall outdoor air movement velocity</td>
</tr>
<tr>
<td>3.22</td>
<td>Indoor cross ventilation at habitable level in Malay vernacular house</td>
</tr>
<tr>
<td>3.23</td>
<td>High ceiling for better indoor air movement (a) House in Tien Giang, Vietnam (b) House in Hanoi, Vietnam</td>
</tr>
<tr>
<td>3.24</td>
<td>Detail roof joint with opening gap allowing ventilation flow</td>
</tr>
<tr>
<td>3.25</td>
<td>Cross Sectional view and Ixometric sketches of Roof-Roof House showing the cross ventilation approaching the pool side</td>
</tr>
<tr>
<td>3.26</td>
<td>The shaded area by the pool side of Roof-Roof House with wide openings to allow the crossing ventilation flow through the interior spaces</td>
</tr>
</tbody>
</table>
3.27 The thin shaped building form with wide openings facing the direction of wind flow in Razorblade Pairs semi-detached 67
3.28 Chempenai House 68
3.29 Sekeping Serendah by Seksan Design 69
4.1 Research method flow 73
4.2 (a) Anemometer, (b) E-Sampler 77
4.3 Laser distance meter 77
4.4 Wind Tunnel at Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia 79
4.5 Wind Tunnel at Faculty of Civil and Environmental Engineering, Universiti Tun Hussein Onn Malaysia 80
4.6 Seri Banai House, Alor Setar, Kedah 83
4.7 Tok Su House, Alor Setar, Kedah 83
4.8 Kalimantan Tengah House, Indonesia 84
4.9 Batak Toba House of North Sumatera 84
4.10 Sri Merlong House, Rengit, Johor 85
4.11 Sri Penggaram House of Batu Pahat, Johor 86
4.12 Sekeping Seapark, Petaling Jaya, Selangor 87
4.13 Skudai Box, Johor Bahru 88
4.14 Process flow of Site Identification 93
5.1 Sri Banai house, Alor Setar, Kedah 102
5.2 Sri Banai house floor plan 103
5.3 Sri Banai house sectional view 1 103
5.4 Sri Banai house sectional view 2 104
5.5 Sri Banai house air velocity comparison Point 1 to Point 6 104
5.6 Sri Banai house air velocity comparison Point 7 to Point 12 104
5.7 Sri Banai house air velocity comparison Point 13 to Point 14 105
5.8 Sri Banai house air velocity comparison Point 15 to Point 20 105
5.9 Tok Su house, Alor Setar, Kedah 106
5.10 Tok Su house floor plan 107
5.11 Tok Su house sectional view Y-Y 107
5.12 Tok Su house air velocity comparison Point 1 to Point 5 108
5.13 Tok Su house air velocity comparison Point 6 to Point 8 108
5.14 Tok Su house air velocity comparison Point 9 to Point 11.  
5.15 Tok Su house air velocity comparison Point 12 to Point 15  
5.16 Kalimantan Tengah traditional house.  
5.17 Kalimantan Tengah house floor plan.  
5.18 Kalimantan Tengah house sectional view  
5.19 Kalimantan Tengah house air velocity comparison Point 1 to  
Point 6  
5.20 Kalimantan Tengah house air velocity comparison Point 7 to  
Point 15  
5.21 Kalimantan Tengah house air velocity comparison Point 16 to  
Point 21  
5.22 Kalimantan Tengah house air velocity comparison Point 10 to  
Point 12  
5.23 Batak Toba house, the house of North Sumatera.  
5.24 Batak Toba house floor plan.  
5.25 Batak Toba house sectional view  
5.26 Batak Toba house air velocity comparison Point 1 to Point 3  
5.27 Batak Toba house air velocity comparison Point 4 to Point 6  
5.28 Batak Toba house air velocity comparison Point 7 to Point 9  
5.29 Batak Toba house air velocity comparison Point 10 to Point 12  
5.30 Batak Toba house air velocity comparison Point 13 to Point 14  
5.31 Sri Merlong house of Rengit, Johor  
5.32 Sri Merlong house floor plan  
5.33 Sri Merlong house sectional view  
5.34 Sri Merlong house air velocity comparison Point 1 to Point 6  
at daytime  
5.35 Sri Merlong house air velocity comparison Point 7 to Point 9  
at daytime  
5.36 Sri Merlong house air velocity comparison Point 1 to Point 6  
at night  
5.37 Sri Merlong house air velocity comparison Point 7 to Point 9  
at night  
5.38 Sri Pengaram house of Batu Pahat, Johor
5.39 Sri Penggaram house sectional view.
5.40 Sri Penggaram house floor plan.
5.41 Sri Penggaram house air velocity comparison Point 1 to Point 4
5.42 Sri Penggaram house air velocity comparison Point 5 to Point 8
5.43 Sekeping Seapark of Petaling Jaya, Selangor
5.44 Sekeping Seapark sectional view Y-Y
5.45 Sekeping Seapark floor plan
5.46 Sekeping Seapark sectional view X-X
5.47 Sekeping Seapark air velocity comparison Pont 1 to Point 6 at daytime
5.48 Sekeping Seapark air velocity comparison Pont 7 to Point 10 at daytime
5.49 Sekeping Seapark air velocity comparison Pont 11 to Point 14 at daytime
5.50 Sekeping Seapark air velocity comparison Pont 1 to Point 6 at night
5.51 Sekeping Seapark air velocity comparison Pont 7 to Point 10 at night
5.52 Sekeping Seapark air velocity comparison Pont 11 to Point 14 at night
5.53 Skudai Box of Skudai, Johor Bahru
5.54 Skudai Box floor plan
5.55 Skudai Box sectional view
5.56 Skudai Box air velocity comparison Point 1 to Point 4
5.57 Skudai Box air velocity comparison Point 5 to Point 8
5.58 Sri Merlong floor plan showing the indoor natural ventilation high performance areas layout and the building elements.
5.59 Sri Banai floor plan showing the indoor natural ventilation high performance areas layout and the building elements.
5.60 Tok Su house floor plan showing the indoor natural ventilation high performance areas layout and the building elements.
5.61 Batak Toba house floor plan showing the indoor natural ventilation high performance areas layout and the building elements.
5.62 Kalimantan long house floor plan showing the indoor natural ventilation high performance areas layout and the building elements 141
5.63 Sekeping Seapark house floor plan showing the indoor natural ventilation high performance areas layout and the building elements 142
5.64 Skudai Box floor plan showing the indoor natural ventilation high performance areas layout and the building elements 143

6.1 Proposed site location and surrounding 150
6.2 Surrounding view; (a) Terrace houses at front, (b),(c),(d) Single unit houses at sides 151
6.3 Building setback lines indicating the building footprint on site 152
6.4 Batu Pahat monthly average wind velocity 154
6.5 Batu Pahat monthly mean temperature 154
6.6 Batu Pahat monthly relative humidity 154
6.7 Micro climate studies on site 155
6.8 Data measurement on site before the building construction 156
6.9 Data on wind velocity on site 157
6.10 Data on air temperature at site 158
6.11 Data on relative humidity at site 159
6.12 Wind velocity and direction on site 160
6.13 Building footprint 163
6.14 Bubble diagram of space arrangement. 165
6.15 Conceptual design of the central atrium. 167
6.16 Wide opening; (a) Positioning of the openings, (b) Detail of opening panel 168
6.17 Ground floor plan. 169
6.18 First floor plan. 169
6.19 Neutral pressure plane level effect on air flow. 170
6.20 Developing the scaled model and wind tunnel simulation. 171
6.21 Roof model analysis. 172
6.22 Graph of wind velocity on simulated roof design effect. 173
6.23 Air velocity measurement points of the louver blades simulation 175
6.24 Air velocity comparison of aerofoil and flat louver blades. 176
6.25 Wind flow and velocity simulation on angle attack of louver blades. 177
6.26 Louvers angle effect on wind velocity. 177
6.27 The finalized design of the building as the full scale prototype. 179
6.28 Construction progress. 180
6.29 Design process work scope and flow 181
7.1 Ground floor plan of Kebun Angin showing the points data measured. 184
7.2 First floor plan of Kebun Angin showing the points data measured. 184
7.3 Cross section view of Kebun Angin showing the points data measured. 185
7.4 Data collection using portable anemometer at various points 186
7.5 Data collection using Indoor Air Quality Data logger for the control data 186
7.6 (a)Outdoor mean wind velocity; (b)Outdoor mean air temperature. 187
7.7 Kebun Angin house air velocity comparison Point 1 to Point 5 from 7.00am to 6.00pm. 188
7.8 Kebun Angin house air velocity comparison Point 6 to Point 10 from 7.00am to 6.00pm 188
7.9 Kebun Angin house air velocity comparison Point 11 to Point 15 from 7.00am to 6.00pm 189
7.10 Kebun Angin house air velocity comparison Point 16 to Point 19 from 7.00am to 6.00pm 189
7.11 Kebun Angin house air velocity comparison Point 1 to Point 5 from 7.00pm to 6.00am 190
7.12 Kebun Angin house air velocity comparison Point 6 to Point 10 from 7.00pm to 6.00am 191
7.13 Kebun Angin house air velocity comparison Point 11 to Point 15 from 7.00pm to 6.00am 192
7.14 Kebun Angin house air velocity comparison Point 16 to Point 19 from 7.00pm to 6.00am 192
7.15 *Kebun Angin* house air temperature comparison Point 1 to Point 5 from 7.00am to 6.00pm

7.16 *Kebun Angin* house air temperature comparison Point 6 to Point 10 from 7.00am to 6.00pm

7.17 *Kebun Angin* house air temperature comparison Point 11 to Point 15 from 7.00am to 6.00pm

7.18 *Kebun Angin* house air temperature comparison Point 16 to Point 19 from 7.00am to 6.00pm

7.19 *Kebun Angin* house air temperature comparison Point 1 to Point 5 from 7.00pm to 6.00am

7.20 *Kebun Angin* house air temperature comparison Point 6 to Point 10 from 7.00pm to 6.00am

7.21 *Kebun Angin* house air temperature comparison Point 11 to Point 15 from 7.00pm to 6.00am

7.22 *Kebun Angin* house air temperature comparison Point 16 to Point 19 from 7.00pm to 6.00am

7.23 Atrium attributes combination

7.24 Indoor natural ventilation performance comparison against opening size percentage

7.25 Indoor natural ventilation performance comparison against opening orientation

7.26 Indoor natural ventilation performance comparison against opening level

7.27 Indoor natural ventilation performance comparison against louvers percentage upon opening size

7.28 The roof design acting as the wind catcher for the central atrium upper opening

7.29 Effect of cross ventilation on studying area

7.30 Air movement velocity in the atrium shaft
**LIST OF SYMBOLS AND ABBREVIATIONS**

- $p$ - air temperature.
- $P9$ - outdoor air temperature.
- $x$ - Independent variables
- $A$ - smallest value inlet (sqm)
- ACEM - Association of Consulting Engineers of Malaysia
- ASHRAE - American Society of Heating, Refrigerating and Air-Conditioning Engineers
- $CO_2$ - Carbon Dioxide
- $CO$ - Carbon Oxide
- $dB$ - Decibels
- $F1$ - area of lower opening (m$^2$)
- $F2$ - area of upper opening (m$^2$)
- $g$ - gravitational constant (9.81m/s)
- GBI - Green Building Index
- $H$ - total height between upper and lower openings (m).
- $h$ - stack height
- $h1$ - height of lower opening to the neutral pressure plane (m).
- $h2$ - height of neutral pressure plane to upper opening (m).
- HVAC - Heat, ventilation and air conditioning system
- IAQ - Indoor air quality
- JKR - Public Work Department.
- $K$ - factor that accounts for orifice characteristics (assumed = 0.65)
- MPBP - Majlis Perbandaran Batu Pahat.
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>NPP</td>
<td>Neutral pressure plane</td>
</tr>
<tr>
<td>PAM</td>
<td>Pertubuhan Akitek Malaysia</td>
</tr>
<tr>
<td>SAJ</td>
<td>Syarikat Air Johor</td>
</tr>
<tr>
<td>Ti</td>
<td>Indoor temperature (°Celsius).</td>
</tr>
<tr>
<td>To</td>
<td>Outdoor temperature (°Celsius).</td>
</tr>
<tr>
<td>V</td>
<td>Estimated air flow (m³/s)</td>
</tr>
<tr>
<td>ZPS</td>
<td>Zero pressure spot</td>
</tr>
</tbody>
</table>
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