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

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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 ventiation 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 uper 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

Pergerakan udara adalah salah satu faktor utama keselesaan termal. Dalam usaha mencapai keselesaan sambil memastikan penggunaan tenaga kekal rendah, pengudaraan semulajadi merupakan sandaran yang baik. Namun begitu, ketidaktentuan pergerakan udara di persekitaran kawasan bandar mungkin tidak mampu membekalkan aliran angin yang mencukupi untuk bangunan di kawasan berkenaan. Berdasarkan kajian terdahulu, didapati terdapat beberapa elemen bangunan yang menunjukkan potensi untuk menyumbang pengudaraan dalaman yang baik dalam persekitaran begitu. Menerusi kajian kes, penyelidikan ini telah mengenalpasti elemen-elemen tersebut. Ianya dikenali sebagai atribut pengudaraan semulajadi menerusi spesifikasi yang diberikan untuk setiap satunya. Hasil penyelidikan mendapati perangkap angin merupakan atribut terbaik yang menyumbang kepada pengudaraan semulajadi dalaman. Selain itu, bukaan luas dan susunatur ruang dalaman turut menyumbang kepada pengudaraan itu. Sementara bukaan dengan sisir angin didapati dapat mempertingkatkan kelajuan angin yang melaluinya memasuki bangunan. Dengan membangunkan sebuah prototaip rumah berskala sebenar, penyelidikan ini mengaplikasikan atribut-atribut tersebut untuk seterusnya dinilai kesannya terhadap pengudaraan semulajadi ruangan dalamannya. Perbandingan pergerakan udara dalaman terhadap pergerakan udara luaran bagi sesuatu ruang digunakan sebagai penentuan prestasi pengudaraan semulajadi ruangan tersebut. Hasil penyelidikan mendapati terdapat pergerakan udara yang tinggi memasuki bangunan menerusi perangkap udara bersisir aerofoil yang diaplikasi sebagai bukaan tinggi di ruang atrium bangunan. Ianya kekal tinggi di bahagian atas atrium tersebut sebelum turun mendadak apabila bergerak ke bawah. Kesan kedudukan aras tekanan neutral (NPP) yang rendah pada bangunan memberi kesan proses ini berterusan. Walaupun terasing dari ruang atrium, bukaan luas yang diaplikasi berkemungkinan memberi kesan pengudaraan pintas terutamanya di ruang dalaman tingkat atas. Sementara itu di ruang bawah, bukaan luas membenarkan pergerakan udara yang baik ke dalam bangunan walaupun pengudaraan lintang di persekitarannya adalah perlahan. Namun begitu dalam keadaan tiada angin lintang, rekabentuk ini masih berupaya mengekalkan pergerakan angin ruang dalaman menerusi kesan pengudaraan tindanan (*stack*).

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.

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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 hight between upper an 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.

NPP	-	Neutral pressure plane
PAM	-	Pertubuhan Akitek Malaysia
SAJ	-	Syarikat Air Johor
Ti	-	Indoor temperature (°Celcius).
To		Outdoor temperature (°Celcius).
UBBL 1984		Uniform Building By Law (1984)
V	-	Estimated air flow (m^3/s)
ZPS		Zero pressure spot

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