Exploring Exposed Brick Arrangements in Secondary Facades for Healthy Building in a Tropical Climate Corridor

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Abstract. Open spaces, mainly corridors, are influenced by natural ventilation and lighting. Exposed brick materials provide durability and permeability for supporting thermal comfort, but limited insulation impacts air quality and health. This study evaluates four exposed brick arrangements for campus corridor design alternatives in a tropical climate, focusing on natural ventilation, daylighting, and visual comfort. A quantitative approach was conducted through simulations using Computational Fluid Dynamics (CFD) in SimScale for ventilation and Honeybee for daylighting performance (UDI and DA) to meet the healthy building criteria for air, light, and comfort features. The study showed that the large square opening with two brick stacks (Alternative 1) and three brick stacks (Alternative 2) provided the best ventilation, but present glare and pollution risks. One brick stack (Alternative 3) offered balanced daylighting and ventilation. Overall, Alternative 2 emerged as the most sustainable option, while Alternative 3 offered the best long-term visual comfort. This research confirms the potential of exposed brick arrangements as a secondary facade in creating healthy and sustainable tropical campus corridors.

***Keywords**: Daylighting, Exposed Brick, Healthy Building, Natural Ventilation, Passive design*

Introduction

Campus buildings serve not only as formal learning spaces, but also as areas for social and informal interaction. However, many corridors or semi-open spaces are often overlooked in comfort and health evaluations [1]. These spaces are greatly affected by natural ventilation, heat exposure, and lighting. Bricks, with their high thermal capacity, absorb and store heat [2], while their porosity and air permeability help improve thermal comfort [3]. However, the important principles of Healthy Buildings: health, human needs, sustainability, resilience, and empowerment—are still not fully applied to semi-open areas [1]. Exposed brick offers durability and thermal benefits, but also poses risks related to moisture, insulation, and air quality [4]. In educational buildings, corridors support student mobility and activity, but many feel that they do not encourage social interaction [5]. Thermal and visual comfort, as well as air quality, greatly affect health, productivity, and cognitive performance [6]. Therefore, exposed brick has potential as a sustainable secondary wall material, but moisture and health risks must be managed to optimize its performance [7]. Evaluating the layout of exposed brick on secondary walls is crucial for creating healthy and sustainable tropical campus corridors.

Methods

The research began with a literature review on healthy buildings, façade materials, and the influence of physical environments on well-being, followed by the collection of secondary data on material properties and climate. Primary data were then obtained through measurements of air temperature, relative humidity, natural lighting, and spatial observations in the FH ILRC UI corridor. Temperature and humidity were recorded using HOBO devices and analyzed according to SNI thermal comfort standards.

To assess exposed brickwork as an alternative secondary exterior wall, the study used SketchUp modeling, CFD simulation in SimScale, and Honeybee (trial) for UDI and DA natural lighting analysis. Physical observations complemented the simulations. The results were used to evaluate ventilation, lighting, and visual comfort across three exposed brick configurations: two-layer with large holes (A1), three-layer with deeper holes (A2), and single-layer thin walls (A3)—leading to design recommendations to improve corridor comfort and health.

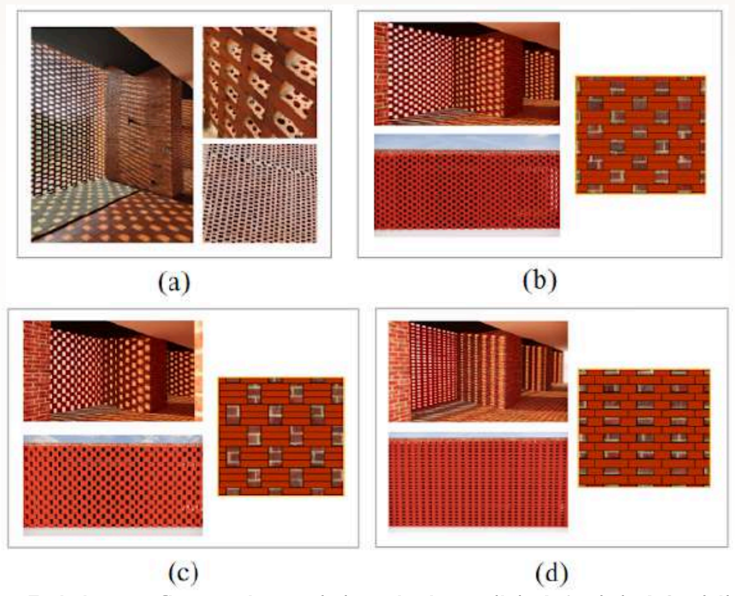

Figure 1. Brick configurations (a) existing; (b) A1; (c) A2; (d) A3; (e) A4

Result and Discuccion

Based on findings, A1 and A2 demonstrated the best ventilation performance, with the highest air velocity values (0.497 m/s and 0.571 m/s), supporting cross ventilation and healthier air circulation in accordance with SNI 03-6572:2001. However, the large number of openings in this option may also increase the risk of outdoor pollutants entering the corridor, and the high UDI value (>76%) indicates greater potential for glare. These results are in line with the research by Yuliana et al. [8], which confirms that roster blocks are a proven strategy for improving indoor air circulation, although excessive openness can compromise visual comfort. A3 offers a more balanced condition, with moderate natural lighting (UDI 58.11%), good airflow (0.485 m/s), and a CO_2 level (1005 ppm) close to the SNI threshold. These characteristics indicate a better combination of visual comfort and indoor air quality compared to other alternatives. This also reinforces the importance of geometric configuration, such as hole size and brick arrangement in determining the balance between wind speed and light intensity, as emphasized by Yuliana et al. [8].

Compared to existing conditions, A1, A2, and A3 show better airflow and better availability of natural light, supporting a healthier corridor environment.

Table 1. Results of Alternatives

	Existing	A1	A2	A3
Air velocity (m/s)	0,483	0,497	0,571	0,485
UDI (%)	70,49	76,90	76,33	58,110
DA (%)	28,784	38,960	38,330	31,710
CO_2 (ppm)	1022	1015	980	1.005

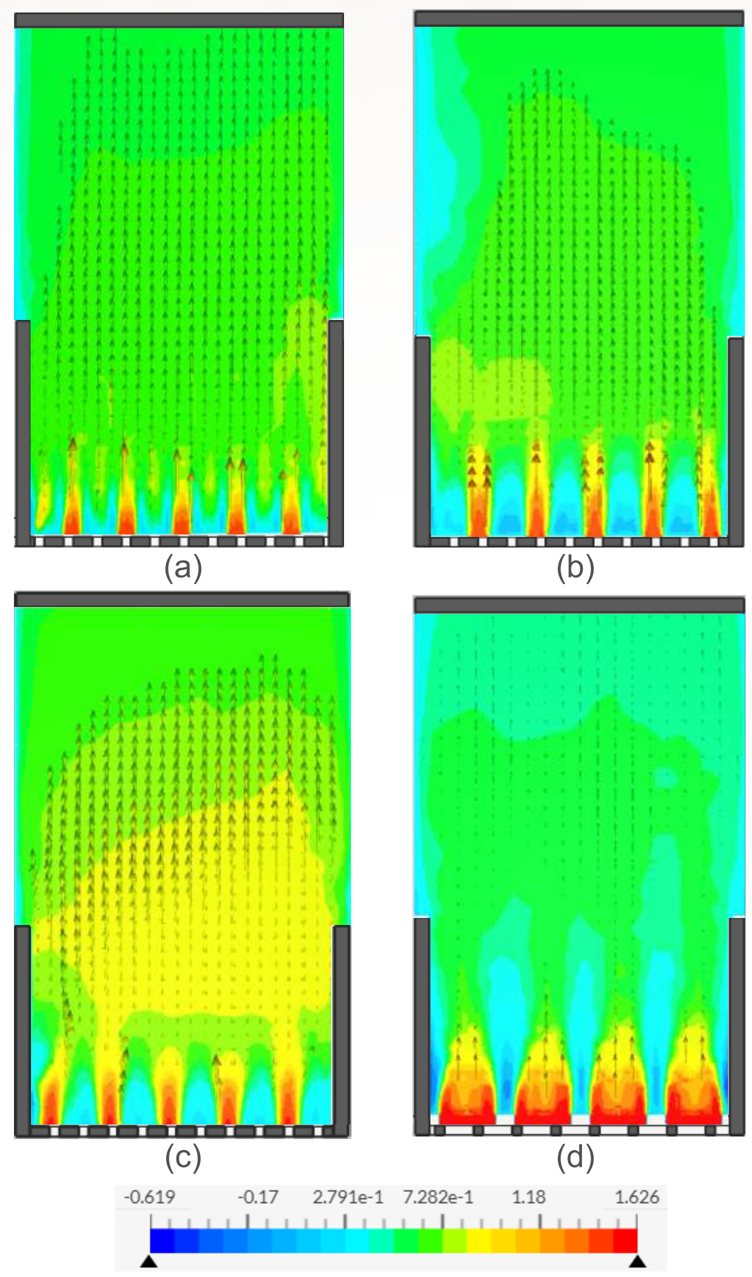

Figure 2. Velocity analysis (a) existing; (b) A1; (c) A2; (d) A3

Conclusion

This study aims to explore the potential of secondary facades with exposed brick in creating healthy and sustainable campus corridors. Alternative 2 is the best choice when air quality and natural lighting are priorities. With the lowest CO_2 level (980 ppm) based on preliminary findings and the highest UDI value (76.33%), this design supports optimal cross ventilation and energy efficiency in accordance with SNI and tropical passive principles. Alternative 3 offers a more balanced combination of ventilation, lighting, and visual comfort due to lower glare risk, making it suitable for areas requiring more stable shading. Compared to existing conditions, both Alternatives 2 and 3 provide better airflow and natural light distribution. Overall, Alternative 2 remains the most effective option for achieving a healthy and sustainable tropical corridor design.

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[3] Singh Rajput et al., 2024. doi: 10.1016/j.enbuild.2024.114480
[4] Elinwa et al., 2018. doi: 10.3390/buildings8050066
[5] Zewar, 2024. doi: 10.3390/buildings14092678
[6] Bluyssen, 2013.
[7] Díaz-Fuentes et al., 2020. doi: 10.1088/1742-6596/1708/1/012011
[8] Yuliana et al., 2023. doi: 10.1088/1755-1315/1267/1/012048

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Introduction

Campus buildings function as both learning spaces and social areas. However, many corridors and semi-open spaces are often overlooked in comfort and health assessments (Elnagar et al., 2024).

Brick material has high thermal capacity, allowing it to absorb and store heat (Aksamija, 2016). Its porosity and air permeability also allow airflow, which can improve thermal comfort (Singh Rajput et al., 2024).

In the context of Healthy Buildings, aspects of health, human needs, sustainability, resilience, and empowerment have not been fully applied to semi-open spaces (Elnagar et al., 2024).

Exposed brick offers durability and thermal benefits, but its moisture sensitivity, low insulation, and air-quality risks can affect user health (Elinwa et al., 2018).

Exposed brick can serve as a sustainable secondary façade, but moisture and related health risks must be managed to maximize its benefits (Díaz-Fuentes et al., 2020).

Corridors in educational buildings are important for student activities and mobility, but many students feel that current corridors do not support social interaction (Zewar, 2024).

Thermal, visual, and air quality comfort greatly affect health, productivity, and cognitive performance (Bluyssen, 2013).

Therefore, evaluating the exposed brick on the secondary façade is important for creating a healthy and sustainable tropical campus corridor

***Keywords**: Daylighting, Exposed Brick, Healthy Building, Natural Ventilation, Passive design*

Literature Review

Table 1. Related Studies

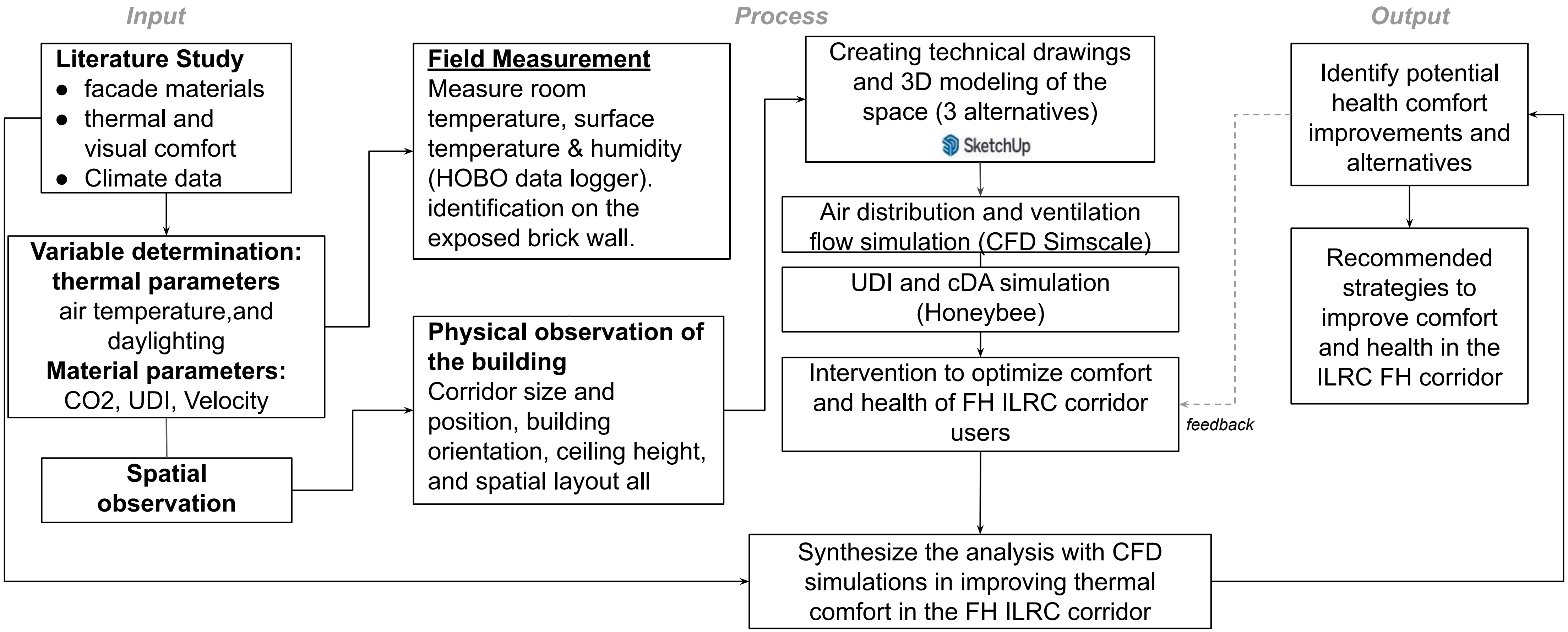
Title of Article	Optimization objective	Building type	Outcomes	Limitation
Development and optimization of a new **ventilated brick wall**: CFD analysis and experimental validation (Buratti et al., 2018)	Optimize ventilated wall with local materials via CFD for better airflow and thermal performance.	School	Determining optimal ventilation opening configuration (e.g., 1 opening 25×5.5 cm/m or 2 openings 12.5×5.5 cm/m) for uniform, optimal air velocity distribution.	Lab tests were done under controlled temperature and humidity, so results may vary in real climates.
Thermal Performance of Clay Bricks, Lime Bricks, and **Ventilation Blocks** as Building Walls (Wibisono, 2020)	Evaluate the thermal efficiency of clay, lime, and ventilated bricks in wall construction.	offices, residential houses, dormitory	Block ventilation materials reduce interior air temperature the most (up to 6.2°C), followed by clay (3.88°C) and limestone bricks (1.7°C); good ventilation and wide openings boost cooling effectiveness.	Study limited to temperature data in specific conditions; results not fully generalizable.
Investigating **roster brick** based on multi-objective optimization between daylighting, wind velocity and structural displacement (Yuliana et al., 2023)	Assessing roster brick configurations for lighting, ventilation, structural and comfort optimization in tropical buildings using a multi-objective approach.	Small northern room with roster brick façade for lighting and ventilation.	The roster brick design was optimized for 87.25% UDI, 1.98 m/s wind speed, and 0.36 mm displacement, ensuring privacy and aesthetics.	Tests used a small-scale model, not field implementation.

- Ventilation opening design and material form strongly influence thermal performance and comfort.
- Shading and corridor orientation significantly affect user comfort.
- Existing studies analyze ventilation, lighting, and air quality separately.
- No research evaluates exposed brick variations as secondary façades for educational corridors using a healthy building approach.

Objective: To identify which brick arrangement provides the most balanced performance between ventilation, daylighting quality, and visual comfort to support healthier corridor environments.

Hypothesis: Different exposed brick arrangements significantly affect ventilation performance and daylight availability in semi-open tropical corridors.

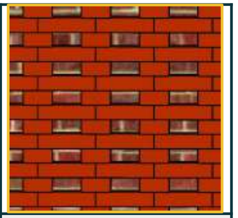
Method



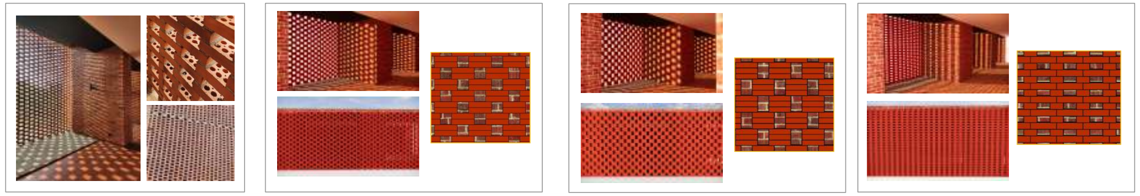
Input
Process
Output
Literature Study
facade materials
thermal and visual comfort
Climate data
Variable determination: thermal parameters
air temperature,and daylighting
Material parameters:
CO2, UDI, Velocity
Spatial observation
Field Measurement
Measure room temperature, surface temperature & humidity (HOBO data logger). identification on the exposed brick wall.
Physical observation of the building
Corridor size and position, building orientation, ceiling height, and spatial layout all
Creating technical drawings and 3D modeling of the space (3 alternatives)
SketchUp
Air distribution and ventilation flow simulation (CFD Simscale)
UDI and cDA simulation (Honeybee)
Intervention to optimize comfort and health of FH ILRC corridor users
feedback
Synthesize the analysis with CFD simulations in improving thermal comfort in the FH ILRC corridor
Identify potential health comfort improvements and alternatives
Recommended strategies to improve comfort and health in the ILRC FH corridor

Result and Discussion

Table 2. Results of Alternatives

Exploration of exposed brick arrangement pattern					
		Existing	A1	A2	A3
Air velocity	m/s	0.483	0.497	0.571	0.485
UDI	%	70.49	76.9	76.33	58.11
DA	%	28.784	38.96	38.33	31.71
CO_2	ppm	1022	1015	980	1005
		effectiveness	Air velocity +0.66% UDI +9.10% DA +35.31% CO_2 -0.69%	Air velocity +4.16% UDI +8.30% DA +33.10% CO_2 -4.11%	Air velocity +1.51% UDI -17.54% DA +10.14% CO_2 -1.66%

- A2 is the most compliant with air quality standards (CO_2 = 980 ppm) and has significant improvements in UDI and DA.
- A1 is also very good in terms of UDI and DA, but CO_2 slightly exceeds the upper limit (1015 ppm).
- A3 has a significant decrease in UDI, although CO_2 is relatively better than the baseline.
- The baseline is the worst in terms of illuminance (UDI/DA) and CO_2 levels.



(a) (b) (c) (d)

Figure 1. Brick configurations (a) existing; (b) A1; (c) A2; (d) A3; (e) A4

Result and Discussion

A1 and A2 - Maximize Ventilation

- A1 and A2 provide the highest ventilation (0.497 m/s; 0.571 m/s), supporting cross ventilation per SNI 03-6572:2001 and reducing mechanical reliance.
- However, their numerous openings increase pollutant infiltration risks, and UDI >76% indicates strong glare potential—consistent with Yuliana et al. [8], who found that overly open roster blocks reduce visual comfort.
- High-contrast glare may also cause visual discomfort (Tregenza & Wilson, 2011).

A3 - Balance Between Light and Ventilation

- Alternative 3 provides more balanced performance, with moderate daylight (UDI 58.11%), good ventilation (0.485 m/s), and CO_2 levels (1005 ppm).
- This supports better visual comfort and indoor air quality than the other options.

Compare to existing condition

- All three alternatives improve airflow and daylight availability, contributing to a healthier corridor environment.

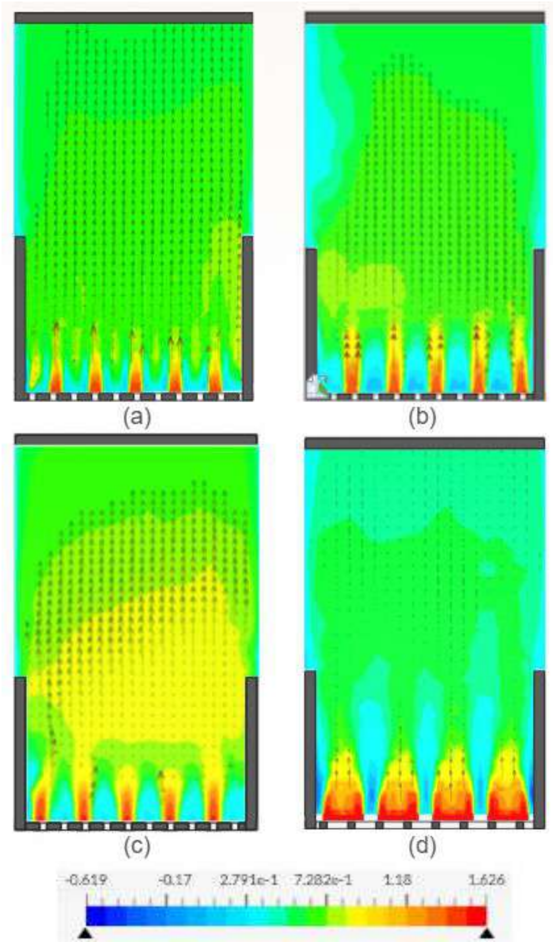


Figure 2. Velocity analysis (a) existing; (b) A1; (c) A2; (d) A3

Conclusion

- This study aims to explore the potential of secondary facades with exposed brick in creating healthy and sustainable campus corridors. A2 is the best choice when air quality and natural lighting are priorities. With the lowest CO_2 level (980 ppm) based on preliminary findings and the highest UDI value (76.33%), this design supports optimal cross ventilation and energy efficiency in accordance with SNI and tropical passive principles.
- A3 offers a more balanced combination of ventilation, lighting, and visual comfort due to lower glare risk, making it suitable for areas requiring more stable shading.
- Compared to existing conditions, both A2 and A3 provide better airflow and natural light distribution. Overall, Alternative 2 remains the most effective option for achieving a healthy and sustainable tropical corridor design.

This research promotes passive design strategies-especially using exposed brickwork to improve natural ventilation, daylighting, and thermal comfort. Sustainability in this research is an attempt to create healthy and passively adaptive campus corridors.

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