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Short Communication

Enhancement of induced natural ventilation using various ventilator configuration in single side ventilated building using CFD

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Need for natural ventilations are increasing because of demanding per capita energy consumption. Major challenges in natural ventilation are sufficient wind velocity throughout and providing cross ventilation building structure. Especially in urban area, possibility to provide cross ventilation is not possible as population factor is challenging. This lays emphasis on the significance of inducing natural ventilation in the buildings of urban areas to reduce energy consumption for human comfort. To visualize the performance of air ventilation of proposed models, simulation has been carried out using CFD. Proposal includes the new design in a residential room of urban building, which is having multiple opening with convergent and divergent nozzle structures in the pattern of window described below. For the boundary condition of CFD simulation, field study data were used. This paper investigates four different window patterns and is analyzed for better performance. In each pattern it has neutral axis horizontally and the structure used above are convergent type and bottom row are divergent type when it looks from inside of the buildings.

[**Keywords:** CFD; Natural ventilation, Ventilator configuration]

Introduction

In general, population rate is increasing and in urban areas, it is still affected by migration in the rural area. Over-consumption of resources results in adverse effects that influence in air pollution, ambient temperature, humidity and suffocation causing occupant's physical discomfort. Hence, improvement in sustainable ventilation drives focus. There are three types of ventilation systems available such as forced ventilation, natural ventilation and hybrid ventilation to replace the internal air by outside air through vents, windows and doors.

Building location, orientation and its window positions highly influence the performance of natural ventilation. The ventilation effect based on buoyancy was analyzed for various window-tilted configurations[1]. In this analysis, for a given wind direction ventilation performance is improved for high rise urban buildings. In a previous study, changes in window aperture structure result in increased airflow rate that draws in to the room thus cause improved air circulation rate[2]. For single side ventilated building airflow quantity and its velocity is controlled using different window opening angle for the lower and upper side[3]. Inducing natural ventilation using different window configuration is designed and analyzed in this study for the desire of reduced energy consumption using buoyancy as key factor.

Materials and Methods

The primary consideration of airflow diffusion, different geometric models of windows is designed in such a way to improve flow rate of air from atmosphere to building. Proposed design has convergent circular structure below the neutral line and divergent above the axis of neutral line. By its convergent nature draws air from outside with increased pressure, causing air to flow across the space. This method increases flow distance by covering maximum corners of a building when compared to conventional windows with square or rectangular opening. On the other end above neutral line due to divergent structure air, tend to flow outside and thus cause circulation inside the building space.

In general, temperature of building will be low if there is enough airflow as there is continuous exchange of heat inside building in contact with the atmospheric air[4-7]. Hence, aim of this investigation focuses only on mass flow of air inside the building by naturally inducing air to circulate better using the special structures proposed.

Environmental conditions

The area under analysis is in the southern region of India (Salem) with Latitude 11° N and Longitude 78° E and the average wind velocity of this region is 7.8 mph as referred from the Figure 1. This region belongs to tropical area with elevated temperature throughout the year.

Geometric Structure

Circular convergent and divergent structures are arranged in the patterns of Hexagon, Rectangle,

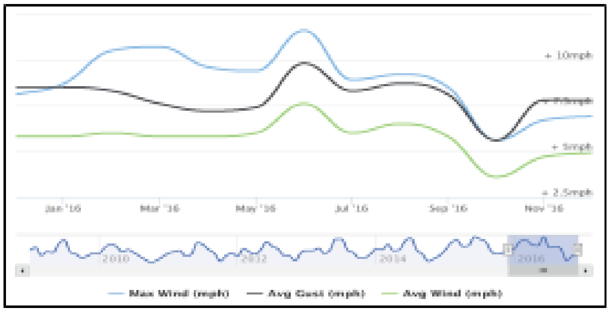

Fig. 1 — Maximum and average wind speed in Salem

Square and Triangle along its own mirror image with neutral line bisecting it horizontally. Convergent structures are placed at the node points if each pattern below the neutral line and divergent structures are placed above neutral line. The description of each structure is shown in Figures 2-5. Vertices length of square is in the proportion 1:3 (a:b) and for rectangle 1:2 (a:b) and for hexagon vertices length is equally distributed and for triangle it is 1:2 (a:b).

Mass Diffusion Analysis

By its principle, buoyancy changes with respect to height and it is used to find the velocity difference at different heights using Swiss power data circulation happens from lower end to higher (Fig. 6). Due to this reason, convergent structures are placed below neutral line so that it draws air in to the building with high velocity. Also divergent structure above neutral line induces air to drive away from the building, ending with the scenario of fresh air from down end wiping mass and temperature of existing particles and escaping through upper end.

Analytical

Air velocity is reduced just above the ground level by various objects and roughness. Once the height increases disturbances get rid of and its velocity will not change due to obstacles on the ground surface. These changes in air velocity at different heights can be calculated using the equation (1), considering the surface is flat and normal flow condition of air in the atmosphere.

V_1 = Wind velocity at reference height h_1.

V_2 = Wind velocity at reference height h_2.

Z_0 = Roughness length.

Using this equation inlet velocity is calculated as 0.98 m/s for reference height of the room.

$$v_2 = v_1 \frac{\ln\left(\frac{h_2}{z_0}\right)}{\ln\left(\frac{h_1}{z_0}\right)} \qquad (1)$$

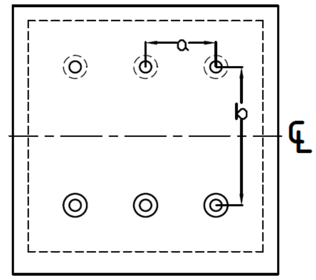

Fig. 2 — Square pattern

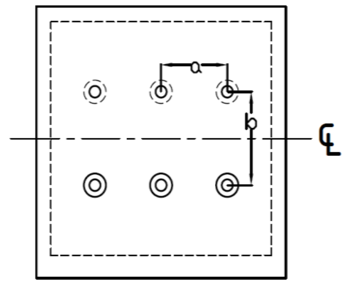

Fig. 3 — Rectangle pattern

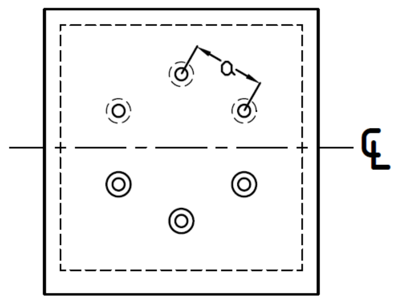

Fig. 4 — Hexagonal pattern

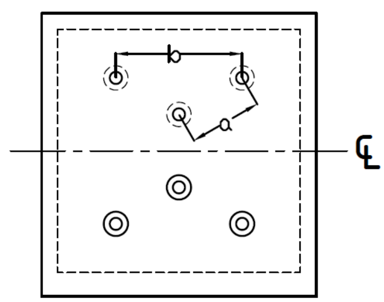

Fig. 5 — Triangle pattern

Simulation

Real case implementation of CFD is simulated using ANSYS Software. Input velocity from outer end of building is taken as 7.8 mph with the boundary conditions of isolated type building. In practical airflow is restricted by nearby buildings, trees and

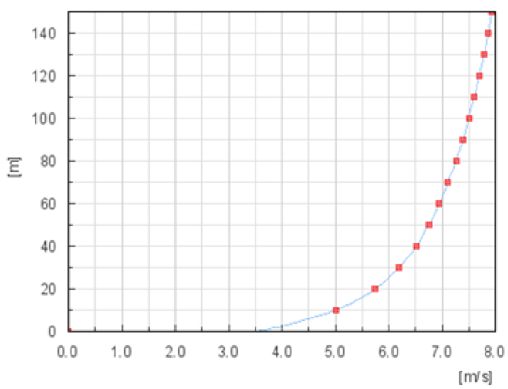

Fig. 6 — Wind speed profile

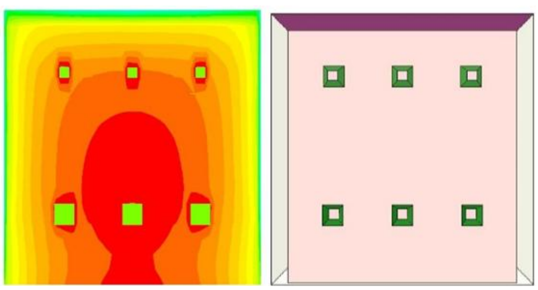

Fig. 7 — CFD velocity contour result with square pattern- Ventilator room

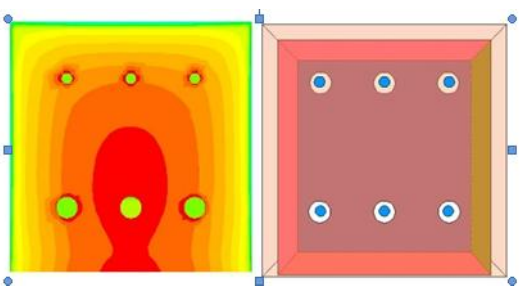

Fig. 8 — CFD velocity contour results for the room with Rectangular pattern- Ventilator

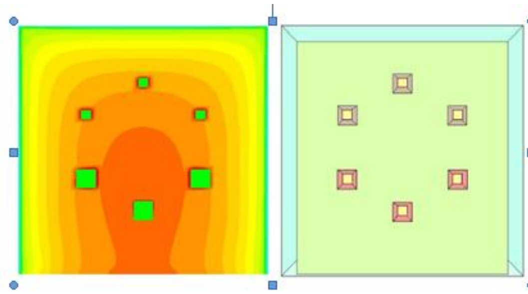

Fig. 9 — CFD velocity contour results for the room with Hexagon pattern- Ventilator

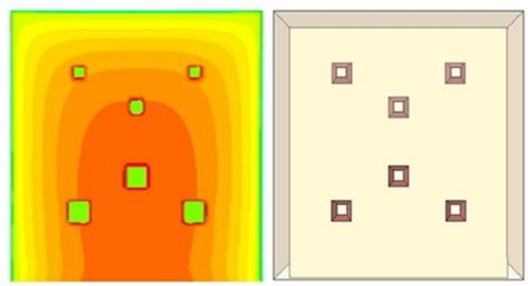

Fig. 10 — CFD velocity contour results for the room with Hexagon pattern- Ventilator

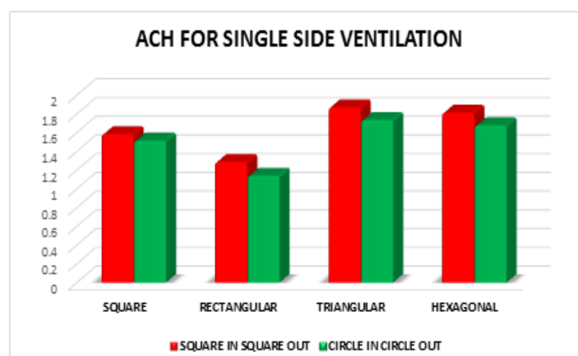

Fig 11 — ACH for Various configuration of ventilator pattern

similar obstacles. These occur mostly in lower part of building and there will be free flow at the outlet. For best case, building is considered isolated. Results of air circulation for four defined structures are given as follows.

i) Square pattern (Figure 7):

ii) Rectangle pattern (Figure 8):

iii) Hexagon pattern (Figure 9)

iv) Triangular pattern (Figure 10)

From the contour plots of stagnation pressure, it is understood that the strength of adverse pressure gradient is less pronounced in the triangular and hexagonal patterns. Thus, they provide less resistance to the fluid flow. The resistance offered by front wall to the air is getting diffused more. Uniformly in hexagonal and triangular patterns than other, two cases. This results in higher velocity of air in to the room and higher ACH comparably (Fig. 11). Out of all the configurations, triangular pattern with square inlet and square outlet has higher ACH value and it is found to the optimum single side ventilation configuration.

Results and Discussion

From the above simulation, air circulation is higher if the inlet and outlet structures are in triangular pattern. High air circulation results in increased mass diffusivity inside the building. Impact of air circulation at various heights is analyzed using the triangular pattern of ventilators and this can be depicted to any height using the buoyancy difference with respect to height using the expression.

Conclusion

Structural improvement for natural ventilation is made possible by the triangular pattern and convergent and divergent squared apertures. Moreover, the effect of air circulation has the impact of structure size and the angle of convergence can be generalized to 17.35° for better velocity.

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