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Reduction of greenhouse gases by the effect of window position and its size in isolated building

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ABSTRACT

The physical comfort of the human entirely depends on the ventilation in the building. World getting hotter and hotter due to adverse climatic conditions so humans are in position to makes use of some forced system to make them cooler than atmosphere . The windows play a good role to provide ventilation naturally without burning energy, which leads to zero emission of greenhouse gases. This paper concentrates in enhancement of the natural ventilation by changing the orientation and size of the windows. The CFD approach is used to understand the physical mechanism of air circulating inside the building. This paper also provides the best windows design in terms of the flow phenomenon rate at the exit of the building. We also found the force and moment of the air passing through the isolated building with respect to gust and lull in order to get better understanding of the circulation. This paper mainly emphasizes to reduce the inclusion of forced system usage by implementing the proper design in civil structures, thereby global warming can be reduced.

KEY WORDS: Atmosphere, Natural ventilation, Gust, Forced system, Global warming, Air circulation.

1. INTRODUCTION

The natural ventilation works well in all climatic conditions when compared to some forced system. The windows help us to keep the temperature inside the room stable. The air ventilates the room by entering and leaving the windows of the building. The ventilation depends on the magnitude and humidity of the flowing air. The natural ventilation is enhanced or diminished by landscaping. When the size of the windows changes, inflow mass flow rate of the air is changes respectively. The indoor air quality can be improved in well placement of the windows which relates to the wealth and comfort of building occupants. Constructing any building with adequate ventilations reduces the heating of the building structure hence less energy required to cool the building by forced system. The good ventilation saves an enormous amount of energy which saves the earth from greenhouse gasses and global warming. Too much of inflow of cold or any type of air can upset the room atmosphere because of imbalance heating. If the airflow through the system is satisfactory, then gratified velocities through the doors and openings can be considered. The gust and lull effect taken in accountability for better understanding of the building aerodynamics. The study of human comfort with respect to air is sophisticated and very tedious. Human body undergoes vibration if the velocity of air is increased. The response of human towards the wind flow causes the human body to vibrate at certain natural frequency. If the air is flowing at acceptable range then the body can sustain vibration without any discomfort. The range of vibration in the body varies with respect to the sensitive and size of the parts. The eye will react to highest frequencies and big parts like stomach reacts to lower frequencies when the air impact at unstable atmosphere.

The computational approach has taken to solve this analysis since measuring of internal pressure in the wind tunnel is very complicated and we can't derive the accurate value of experimental calculation. The numerical formulas are used to evaluate the results based on the volume of air, hourly average speed, and volume of air flow.

2. EXPERIMENTAL

Assumption used in this problem: The room taken for the study is sealed, Except window opening there is no possibility of leakage, The velocity at the inlet is 5m/s which is constant throughout the entire process, Pressure is also remains constant (The internal pressure in the building used to calculate the structural loads), The effect of Galloping and Aerodynamic damping neglected.

Design of Ventilators: The windows are taken as the ventilator in this paper. We have modeled a room of size 20x15m which is placed with multiple windows in opposite sides of the building. The velocity of the air is taken as 5m/s which are considered to be acceptable range with the room temperature of 20^0C and 1.225 bar of pressure. We have designed around 8 models to find the optimized model of the window. The solution of the problem is studied based on the air leaving the room and air changes per hour. They arrived results are compared with each other to obtain the best window model. The model is designed and made as structured geometry for analysis. The K-Epsilon turbulence model with scalable wall function is chosen for the study of this isothermal process.

The initial values are choose based on the analytical approach and by using some numeric formulas for finding the appropriate flow property inside the building during the stable air flow.

Average time is defined as

$$T = 45 * (volume\ of\ building\ )^{\frac{1}{3}} * V$$

Volume of flow

$$Q = V * A$$

Mean velocity profile over a rough surface defined as

$$\frac{v}{v(ref)} = \{\frac{z}{z(ref)}\}^{1/7}$$

Turbulence intensity of the fluid which is passing inside the inlet is stated as

$$T_u = \frac{\sigma}{v}$$

Force and moment of the atmospheric air is given by

$$C_F = \frac{F}{q_\infty * L^2}$$

$$C_M = \frac{M}{q_\infty * L^3}$$

$$P = C_p * (0.5\rho) * V_m * V_m$$

The force and moment calculated with gust load and without gust loads in all 3 dimensional axis of the building (assuming there is no disturbance).

3. RESULTS AND DISCUSSION

We have taken nearly 8 models for cfd analysis approach. Each model is designed with constant location of outlet with varying location and orientation of the window inlet. The pressure and the velocity of the air entering the isolated building is remain constant throughout the analysis.

The mass flow, velocity, force and moment data are taken during analysis since we deal with the effectiveness of the natural ventilation and they are compared with each other effectively by using the graphical plots and tables.

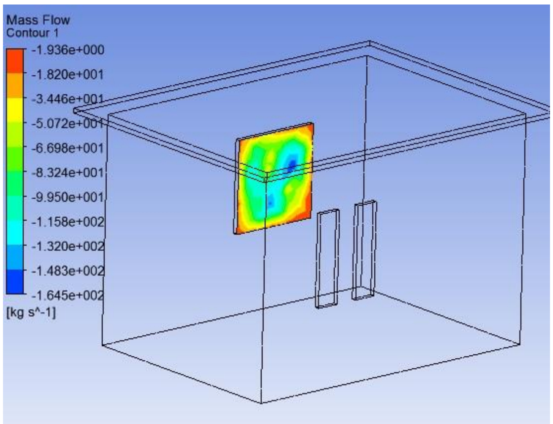

Fig.1. Mass flow of air at the exit of windows

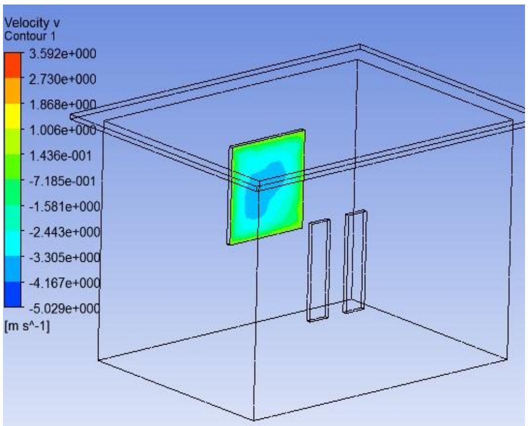

Fig.2. Velocity of air at the exit of the window

The mass flow rate at the outlet window has a maximum value of 1.9kg/s. At the center of the windows the value of mass flow rate is very minimum due to the linearity in the flow with 1.6kg/s. The value of the mass flow and velocity gradient depends on the location, size and position of the inlet. The inlet area is directly proportional to the mass flow rate inside the building.

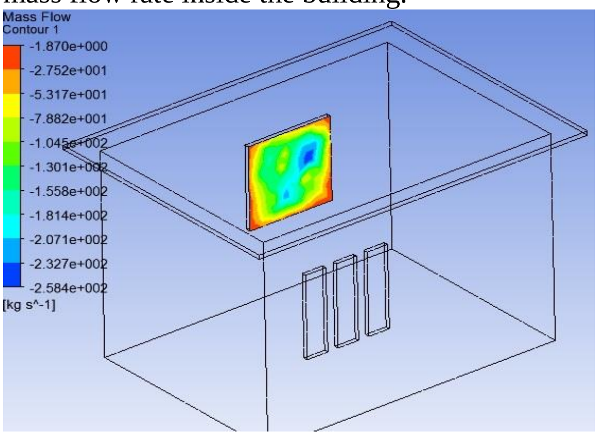

Fig.3. Mass flow of air at the exit of windows

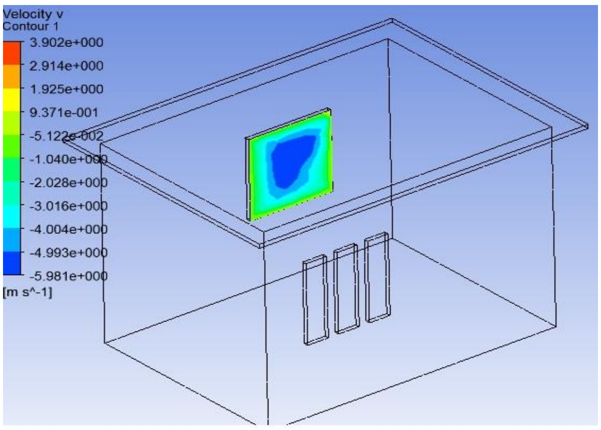

Fig.4. Velocity of air at the exit of the window

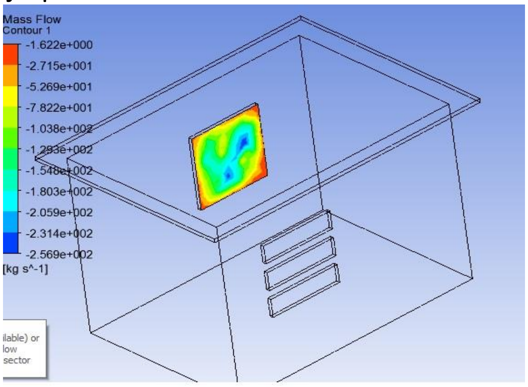

Fig.5. Mass flow of air at the exit of windows

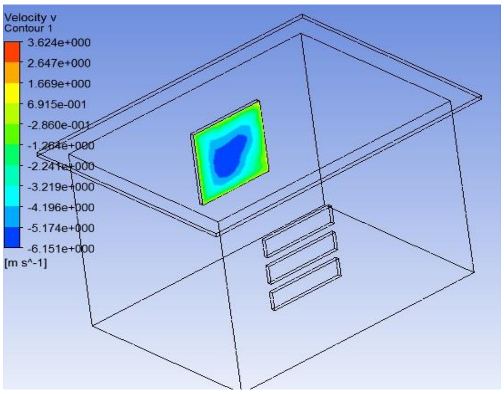

Fig.6. Velocity of air at the exit of the window

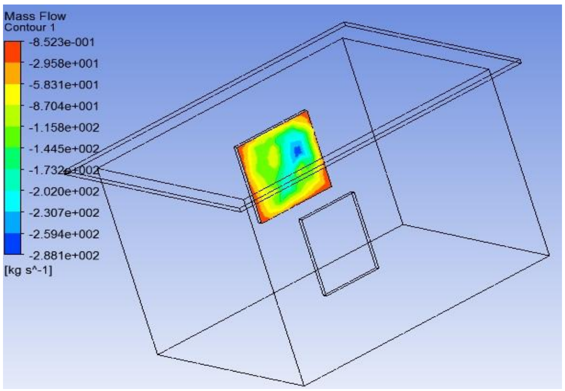

Fig.9. Mass flow of air at the exit of windows

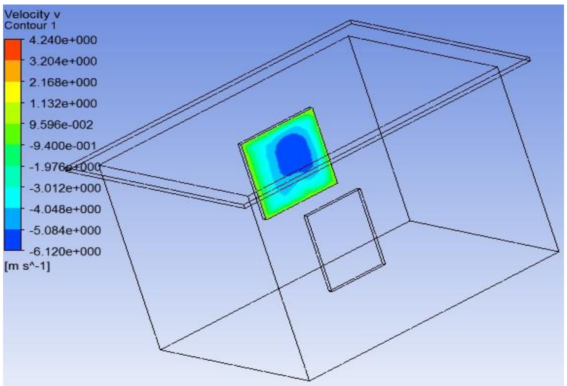

Fig.10. Velocity of air at the exit of the window

The data from the diagram representation are derived to make a comparative study of the all assumed models of the isolated building. The pressure inside the room remains constant for all the models however the mass flow and velocity of the outlet changes with respect to size and the orientation of the building structure.

Table.1. Comparative studies on the flow characteristics of the models

S.No	Case	Pressure (Pa)	Mass flow rate (kg/s)	Velocity (m/s)	Inlet Pattern
1.	Model 1	$1x10^5$	1.93	3.56	Vertical
2.	Model 2	$1x10^5$	1.29	4.4	Vertical
3.	Model 3	$1x10^5$	1.33	3.26	Vertical
4.	Model 4	$1x10^5$	1.87	3.9	Vertical
5.	Model 5	$1x10^5$	2.3	4.24	Vertical
6.	Model 6	$1x10^5$	1.6	3.6	Horizontal
7.	Model 7	$1x10^5$	1.83	3.5	Horizontal
8.	Model 8	$1x10^5$	1.92	3.9	Horizontal

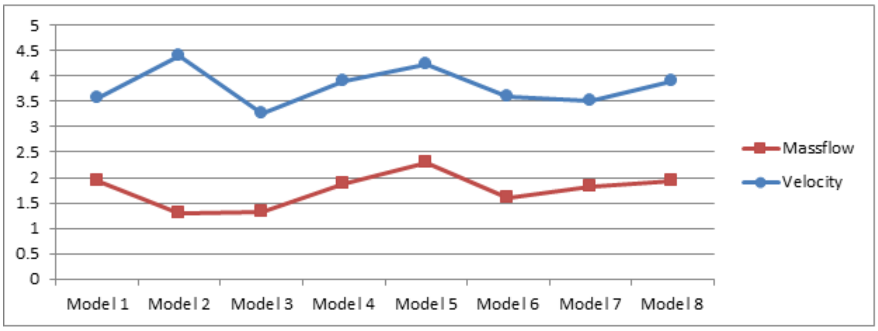

Fig.11. Representation of Mass flow rate and Velocity of all cases

The Gust and lull performance parameters of the model 5 are tabulated above since the model 5 provided us the best optimized results among other models. The results show that the force and moment at X-coordinate is very high when compared to other directions since the flow is unidirectional flow. The force and moment subjected to increase when the air is excited to the gust and cross winds.

Table.2. Gust and Lull representation of the Model 5

Force Direction	Total Force 10^3N	Moment Direction	Total Moment 10^5 N-m
FXG	53.6	FXZG	255.58
FXL	0.47	FXZL	10.25
FYG	-7.5	FYZG	95.2
FYL	-0.25	FYZL	53.5
FZG	0	FXYG	123.6
FYL	0	FXYL	9.8

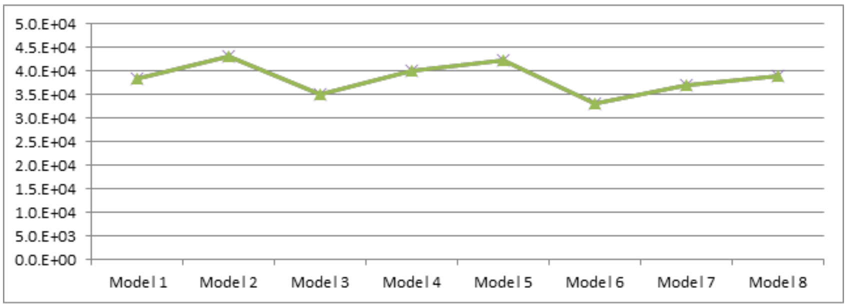

Fig.12. Reynolds number gradient for different models

4. CONCLUSION

Based on the computational approach in several models, it is evident that the conventional model (5) giving us better performance when compared to the other type of window model. We visualize that the force and momentum of the air increased drastically to enhance the natural ventilation in model 5.

The results prove that the natural ventilation not only depend on the size of the windows but also the position and orientation of the inlet as well as outlet.

We also conclude that by proper position of the window we can improve the natural ventilation which leads to the less burning of energy by forced systems. By implementing this approach in constructing any building we can reduce the emission of Greenhouse gases, thereby the global warming can be reduced nearly 10-15%. This methodology can be implemented to calibrate the velocity profile and spectrum of turbulence in future to enhance the natural ventilation utility.

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