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Displacement Ventilation System for an Auditorium

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Abstract: This paper is the validation report for the performance of displacement ventilation with overhead conditioned air distribution system for an auditorium under a high cooling load. The validation is made out of a study carried out in an auditorium and with computational fluid dynamics (CFD) program. Displacement ventilation stratifies the temperature from the floor of the auditorium. Therefore, effective cooling is achieved in the occupant space in the auditorium. Since displacement ventilation need low blower speed, the energy spent on blower is reduced. This in turn gives an energy efficient system, without compromising the thermal comfort.
Index terms: Displacement ventilation, CFD, stratification, Thermal comfort, HVAC.

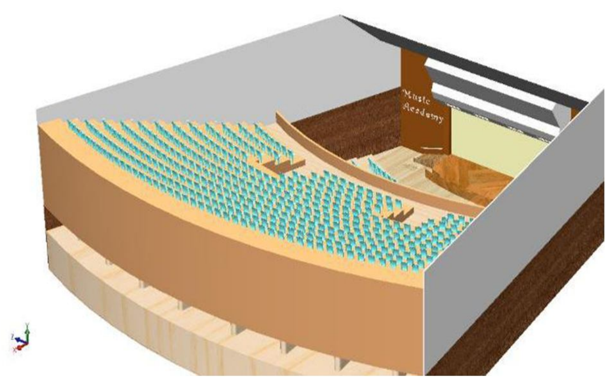
I. INTRODUCTION

Displacement ventilation systems are quieter than overhead conditioned air distribution system. They provide better indoor air quality, since ventilation efficiency is better than overhead systems. Displacement systems are appropriate in spaces where high ventilation is required, such as classrooms, conference rooms, and offices [3]. The main motive of the work is to perform a parametric study with overhead and displacement diffuser arrangements on thermal comfort and indoor air quality with a computational fluid dynamics (CFD) program.

II. DESIGN

The auditorium consists of 750 seating capacity in ground floor and 650 seating capacity in balcony. Total seating capacity of auditorium is 1400.

Fig 1. Design of auditorium



over head square cone diffusers for distributing conditioned air from air handling unit (AHU) and 5 over head square cone diffusers for return air. In balcony, 6 over head square cone diffusers for distributing conditioned air from AHU and 3 over head square cone diffusers for return air. And there are 4 rectangular diffuser over the stage for distribution and 4 return diffuser underneath the stage. HVAC system in the auditorium involve three mediums (refrigerant, water and air) for cooling. Forward curve blower blows the air to overhead diffusers. This air passes through the fin and tube condenser (cold water flowing through the tubes) before reaching blower. The cold water flowing through the fin and tube condenser is chilled by the refrigerant. This system is shown in the figure below.

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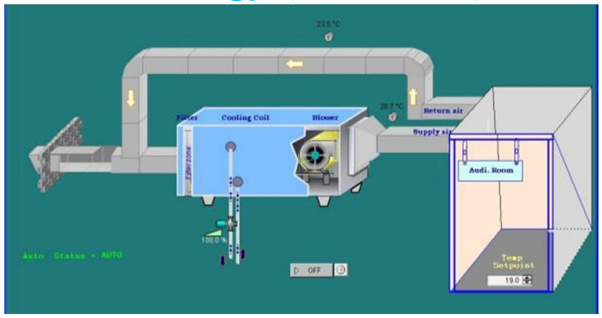

Fig 2. HVAC system of auditorium

From the dimensions of the auditorium where study is made, the auditorium 3D model was designed in solidworks as shown in the figure above. The HVAC system in the auditorium has overhead square cone diffusers for both inlet and return air ventilation. In the ground floor, there are 10 For displacement ventilation system, the displacement diffusers replaces the overhead diffusers. The auditorium is been designed with 10 semicircular displacement diffuser and 6 full circular displacement diffuser in ground floor. In balcony, 4 rectangular displacement diffuser, 6 semicircular displacement diffuser and 3 full circular displacement diffuser. For stage, 2 rectangular displacement diffuser and 2 semicircular displacement diffuser. The auditorium design with displacement ventilation system diffusers arrangement are shown in the figure below.

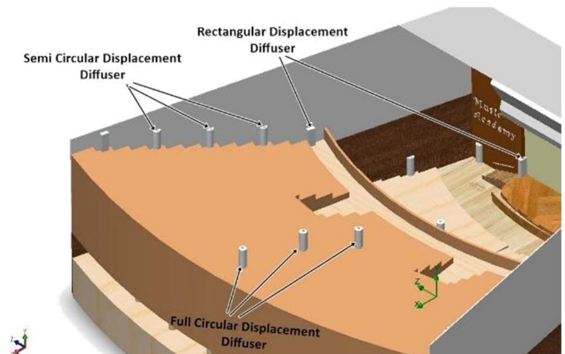

Fig 3. Auditorium with displacement ventilation system

III. CONSIDERATIONS

As for as computational fluid dynamics is concern, the inlet and outlet conditions are the basic boundary conditions. The flow given to the overhead diffusers are 350cfm with a temperature of 288K and a pressure of 0.8bar is given to return air diffuser. Similarly, the flow given to displacement diffusers are 350cfm with a temperature of 288K and considering same return diffusers as we considered for overhead diffuser analysis with pressure of 0.8bar. CFD analysis is performed in solidworks flow simulation program and the results were calculated. The fluid flow domain is given in the figure below.

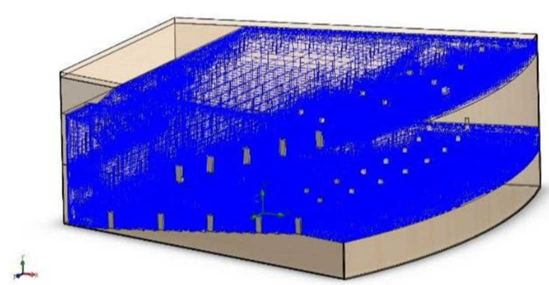

Fig 4. Fluid zone

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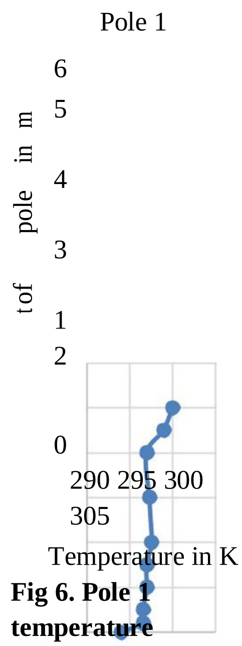


Fig 6. Pole 1 temperature

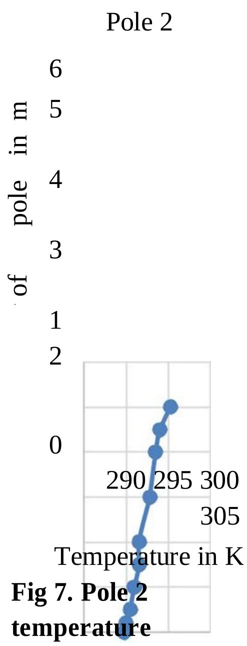
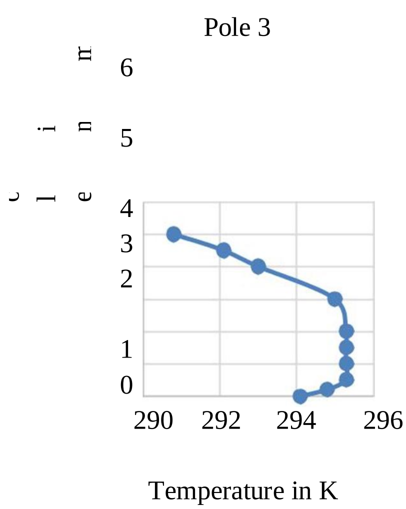


Fig 7. Pole 2 temperature



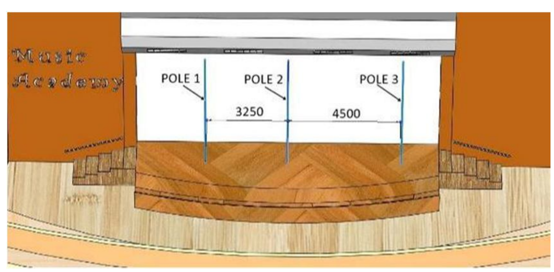


Fig 8. Pole 3 temperature

The cut plot of temperature distribution for overhead diffuser system is shown below.

Considering three imaginary poles in stage as shown in the figure for measuring temperatures in respective heights for both conventional and displacement ventilation system.

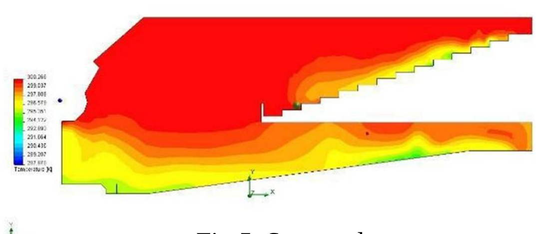


Fig 5. Stage pole arrangement

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IV. RESULTS AND COMPARISION

The temperature results of pole 1, 2 and 3 of the conventional overhead diffuser are shown below.

Figure 9: Cut plot of temperature distribution for overhead diffuser system

The temperature results of pole 1, 2 and 3 of the displacement ventilation system are shown below.

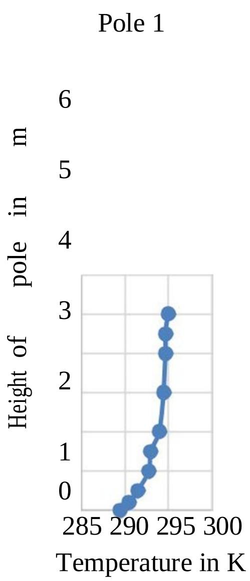

Fig 10. Pole 1 temperature

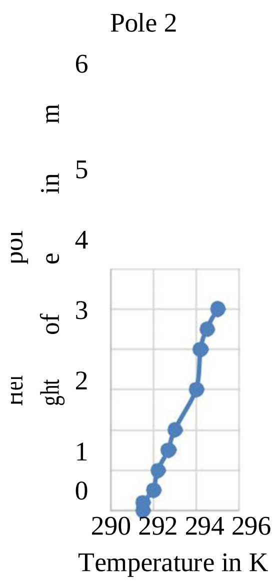

Fig 11. Pole 2 temperature

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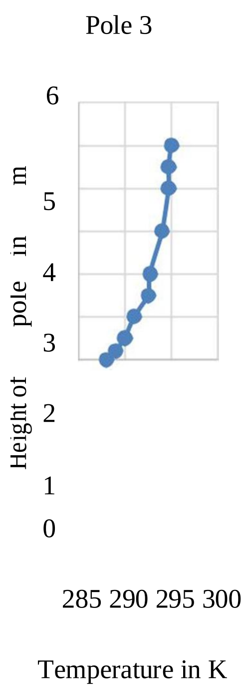

Fig 12. Pole 3 temperature

The contour results of temperature distribution for displacement ventilation system is shown below.

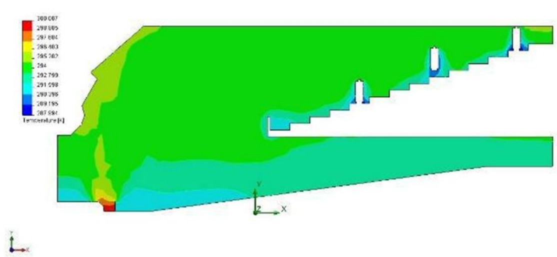

Figure 13: Cut plot of temperature distribution for displacement ventilation system diffuser

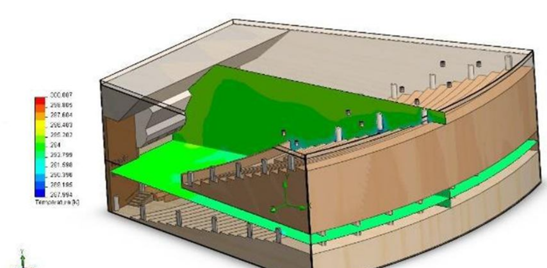

Figure 14: Cut plots of temperature distribution with auditorium model for displacement ventilation system diffuser

From the graphs and contour plots of both the systems, it is clear that overhead diffuser system has improper temperature distribution over the pole height. Whereas in displacement ventilation system, we could see uniform increase in temperature over pole height. This is due to the stratification of air temperature in the zone by 291K, 292K, 293K and 294K respectively.

V. CONCLUSION

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Displacement ventilation system considerably requires less blowing velocity compared to the overhead diffuser system. This in turn saves the energy to drive forward curve blower. This means, the displacement ventilation system is energy efficient. The thing happens in displacement ventilation system is, stratification of the air temperature as seen in the results. It is based on the fact that warmer the air, lesser the density. Less density air moves up and stratification of temperature occurs. From the results it is evident that displacement ventilation system is superior and energy efficient than overhead diffuser ventilation system without compromising thermal comfort. Hence displacement ventilation system is proposed for the auditorium.

REFERENCES

[1] Josephine Lau and Qingyan Chen, "Floor-supply displacement ventilation for workshops",2007

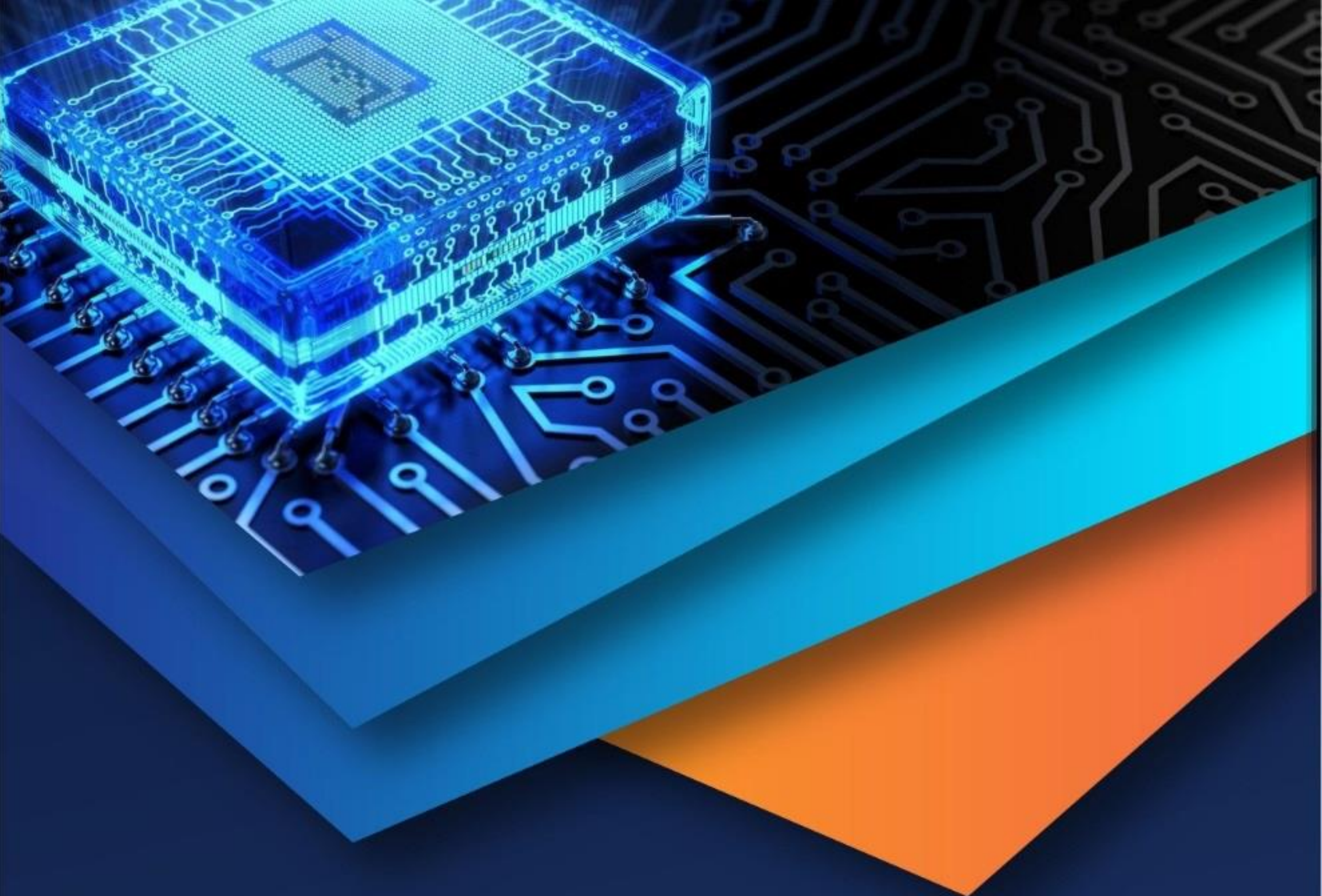
[2] Sephir D. Hamilton, Kurt W. Roth, Ph.D.,James Brodrick, Ph.D., "Displacement ventilation" ASHRAE Journal, September 2004.

[3] Soolyeon Cho, Piljae Im and Jeff S. Haberl "Literature review of displacement ventilation" May 2005.

[4] Lee, K.S., Zhang, T., Jiang, Z., and Chen, Q. 2009. "Comparison of airflow and contaminant distributions in rooms with traditional displacement ventilation and under-floor air distribution systems," ASHRAE Transactions, 115(2).

[5] Lee, K.S., Jiang, Z., and Chen, Q. 2009 "Air distribution effectiveness with stratified air distribution systems," ASHRAE Transactions, 115(2).

[6] Chen, Q., and L.R. Glicksman. 2003. System Performance Evaluation and Design Guidelines for Displacement Ventilation. Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.



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