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Evaluation of Fabric Duct Air Conditioning System for a Large Exhibition Hall using OpenFOAM

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In a large occupancy such as an exhibition hall of a convention centre, where many people assemble, it is important to design an air-conditioning system to provide efficient, uniform and draught-free distribution of fresh air without “dead zone”. Fabric duct textile-based ventilation is one such system which can provide effective air changes and a good indoor climate without stale and stagnant spaces. A combination of low impulse and directional flow supply of air from fabric duct surface and from jet nozzles arranged along the length of the fabric duct is expected to provide comfortable environment for occupants. However, it is necessary to predict and ascertain airflow over the heat sources- such as people, equipment and solar gain and resulting temperature distribution in the occupied space. So CFD analysis has been carried out using OpenFOAM software to evaluate airflow and temperature in the exhibition hall. The arrangement of fabric duct air supply is such that cold air falls to the occupied zone by gravity from a height of around 17m from the floor and is heated by occupancy, equipment and external heat gains at the floor level and it rises due to buoyancy. In order to capture convection currents caused by density differences between cold supply air and warm room air, buoyancy effects are accounted for by using “buoyantSimpleFoam” solver in OpenFOAM.

Due to symmetry, one quadrant of exhibition hall geometry is considered to optimize CFD simulation efforts. Fabric duct air-conditioning system is placed above the false ceiling which consists of kite like elements, made of fabric with openings for airflow downwards. The kite ceiling is a complex feature and capturing fine details requires a mesh count that exceeded beyond 50 million but with the help of customization option in blockMesh and SnappyHexMesh, the cell count was restricted to 16 million with cell size ranging from 0.02 m to 1.3 m consisting of both pyramid and hexahedron. Heat loads are applied with the help of fvOptions by defining corresponding cellZones using topoSet tool.

CFD simulation is carried out for various scenarios- different nozzle sizes, nozzle orientation/angles, false ceiling design with and without stalls/exhibits and CFD results for air velocity and temperature distribution are extracted for occupied height. From these results, air-conditioning design options are evaluated for uniformity of airflow, draught and temperature and suitable design is recommended for implementation.

Sensitivity: Unclassified