

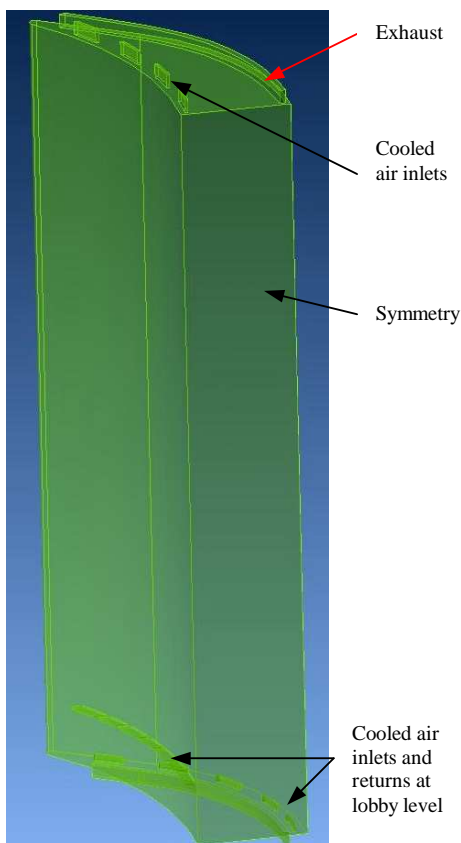
Airflow and Temperature Stratification in Buildings

Skyscraper Atrium

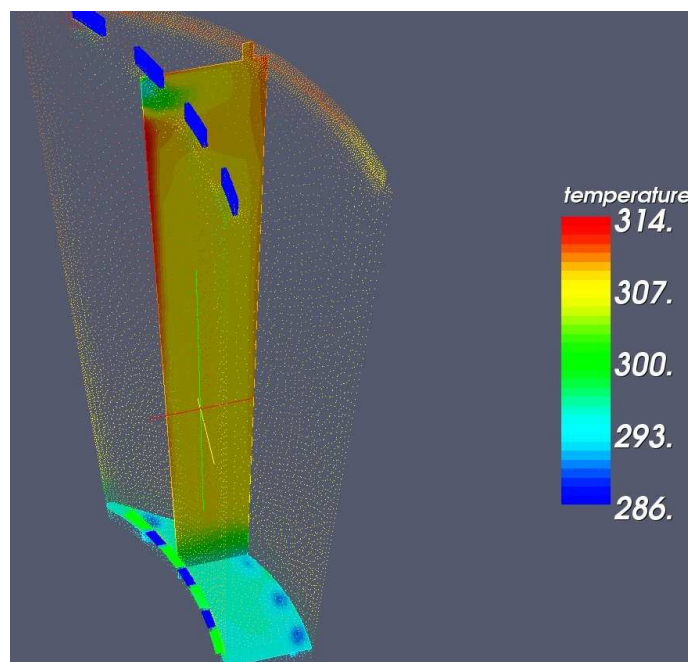
A pre-construction phase CFD analysis was conducted using AcuSolve for a skyscraper atrium to determine airflow and temperature levels during winter and summer conditions. Airflow requirements, vent locations and heating requirements were optimized to conform to building code standards for human comfort. The skyscraper “livable” area has a circular cross-section and houses retail, office, and hotel space at different levels. The atrium has a parabolic shaped cross-section with architectural glass external shell and energy efficient glass wall between the atrium and the livable area. The lower level of the atrium is an extended lobby level and has to meet human occupancy comfort levels.

Extreme conditions during summer and winter were analyzed. Daytime analysis included solar radiation model with optical parameters for both glass layers. The flow in this tall structure is significantly influenced by natural convection and buoyancy. The solutions were obtained with steady-state simulations using Spalart-Allmaras turbulence model.

Atrium Summer Model



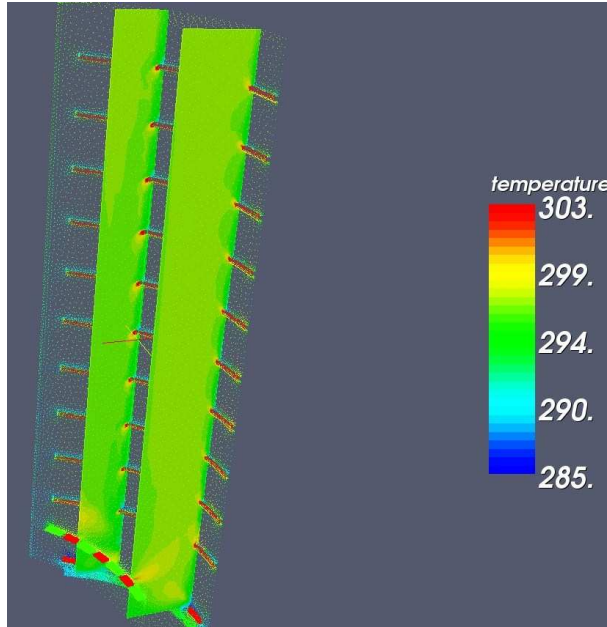
Temperature Stratification – Summer Sunny Day



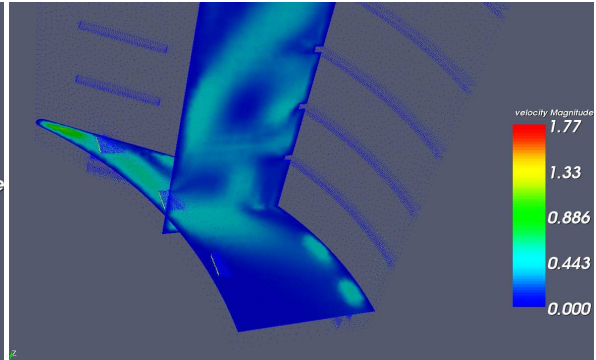
Lobby levels remain comfortable 73 °F with outside conditions at 95 °F and climate controlled interior at 78 °F. Cooled air at 56 °F is introduced at lobby level, and slightly above lobby level. Hot air at 98 °F is expelled through the exhaust. The analysis helped estimate cooled airflow rates thus supporting HVAC sizing requirements.

Atrium Winter Model

Temperature stratification – Winter Night



Velocity profile at lobby



Lobby levels remain comfortable 72 °F with outside conditions at 25 °F and climate controlled interior at 72 °F. Heated air at 85 °F is introduced at lobby level, and slightly above lobby level. Linear radiator elements positioned at several levels add heat to maintain the temperatures and prevent condensation on the exterior glass. The objective was to keep the lobby area comfortable with air velocities (draft) below 1 m/s.

Office Space

Airflow analysis was performed for an office space with curtain wall (insulative glass) on one side. Several winter night conditions were analyzed to determine minimum HVAC heating load. Heated air is supplied from sub-floor plenum through two linear floor vents along the curtain wall. The air is returned to the ceiling plenum through a square ceiling exhaust. A computer and multi-function copier/printer/fax station generates some additional heat. The model was created with solid zones with finite thickness for the glass and ceiling to model different U-values.

Temperature profile in the office exposed to 0 °F outside temperature with 64 °F conditioned air entering through floor vents

