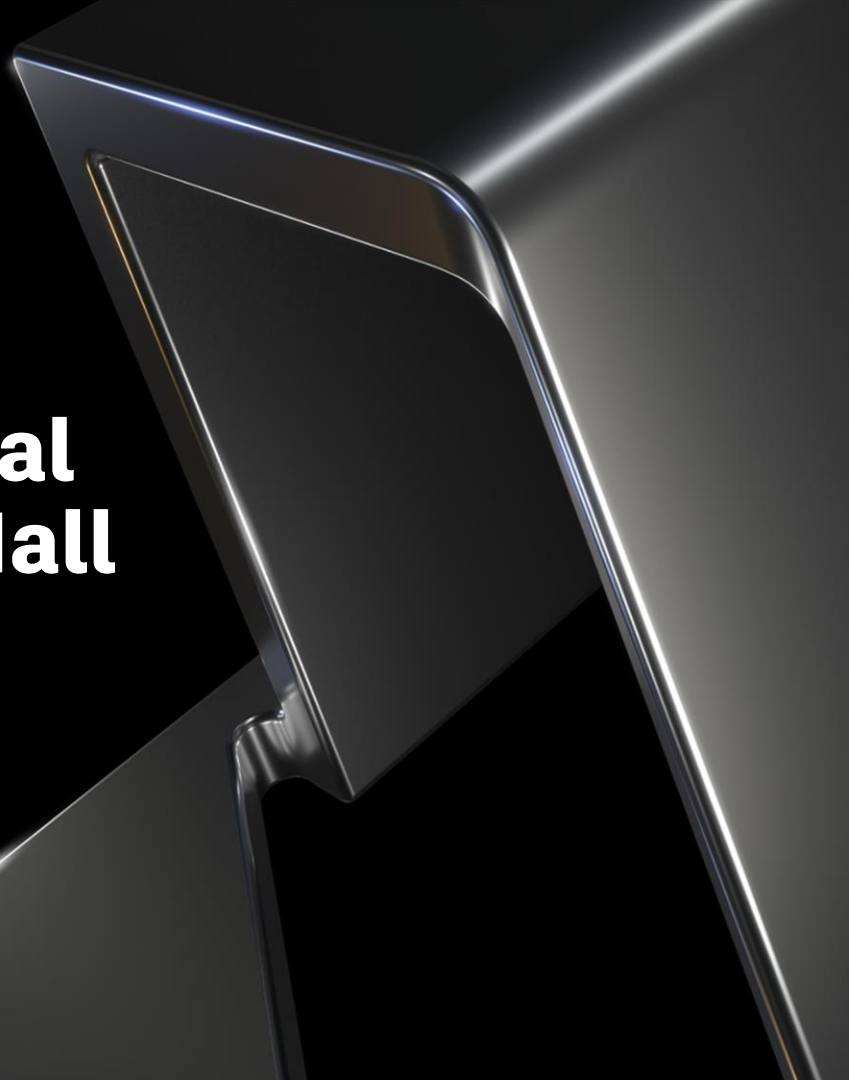
AUTODESK UNIVERSITY

Autodesk CFD for Thermal Comfort in Auditorium Hall

Dr. Munirajulu. M

HEAD - CFD | @m_munirajulu



About the Speaker

Dr. Munirajulu. M, Larsen & Toubro Limited

Passionate about performance-based design and use of simulation tools in design of buildings.

- 25+ years industry experience in CFD analysis
- Using Autodesk CFD Simulation for MEP design
- **Focus areas:** Data center cooling, Basement car park ventilation, DG room ventilation, Smoke simulation in buildings, Air-conditioning and thermal comfort analysis for large and complex buildings
- Speaker at AU 2017, 2018, 2019, 2020 US & AU2019 India

Role of Autodesk CFD Simulation

Performance based design

Design of large building spaces for human comfort is a challenge due to complex building geometry. Simple heat load based air-conditioning design may not suffice to ensure acceptable human comfort. Design based on such an approach would provide:

- Macro-level information
- Lack of local variation
- Over design /design failure

Alternatively, CFD simulation using Autodesk CFD provides a convenient way of evaluating human comfort throughout the building space.

- 3-D analysis / virtual design
- What-if scenarios
- Design effectiveness

Key Objectives

Key Learning Objectives

- Identify specific workflows in Autodesk CFD
- Implement workflows
- Assess CFD results
- Validate design for thermal comfort

Building – Auditorium Main Hall

Largest Hall in Asia

Auditorium hall is the principal component of events area in the convention center.

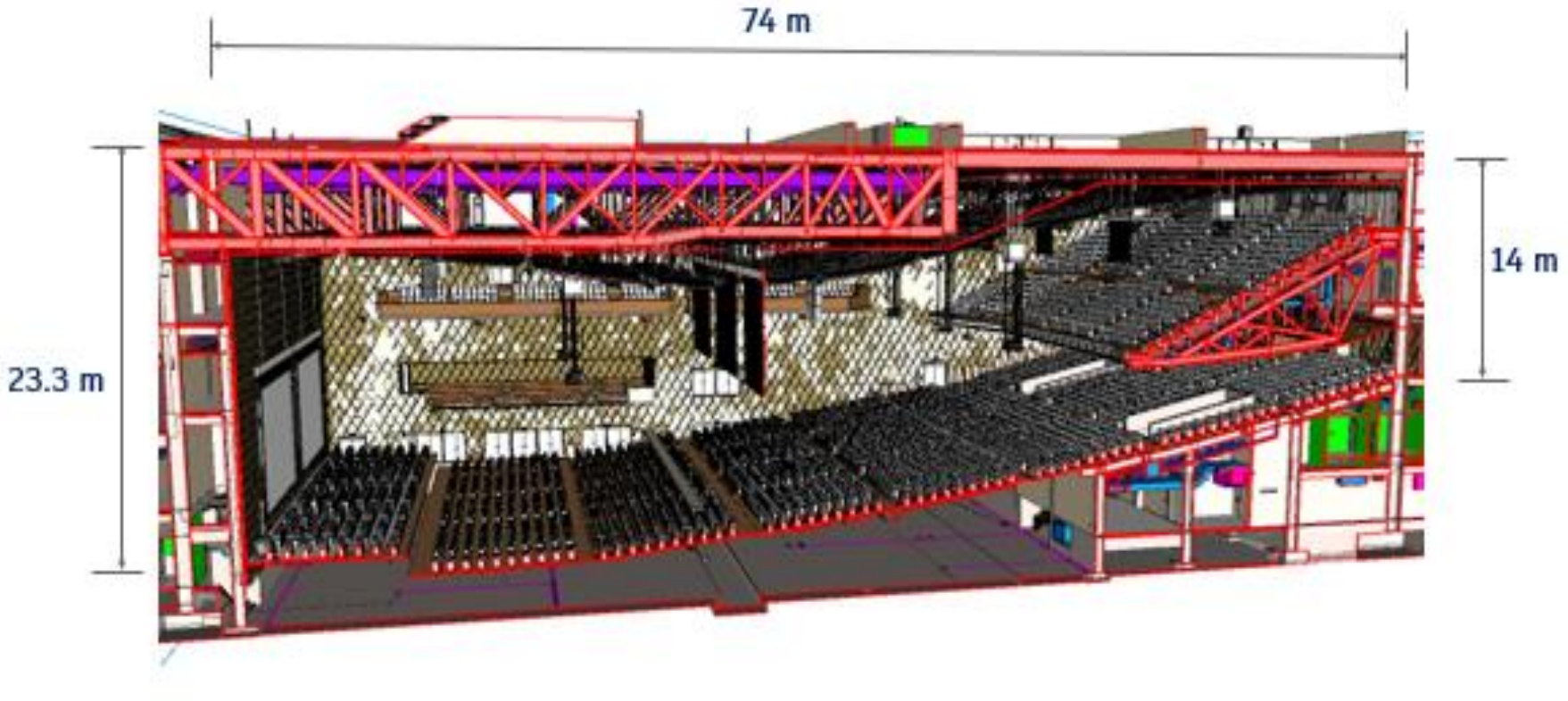
- Main component of events area
- 6000+ seater capacity
- Venue for plenary sessions, state/catered dinners, training, conferences, trade/corporate/cultural presentations

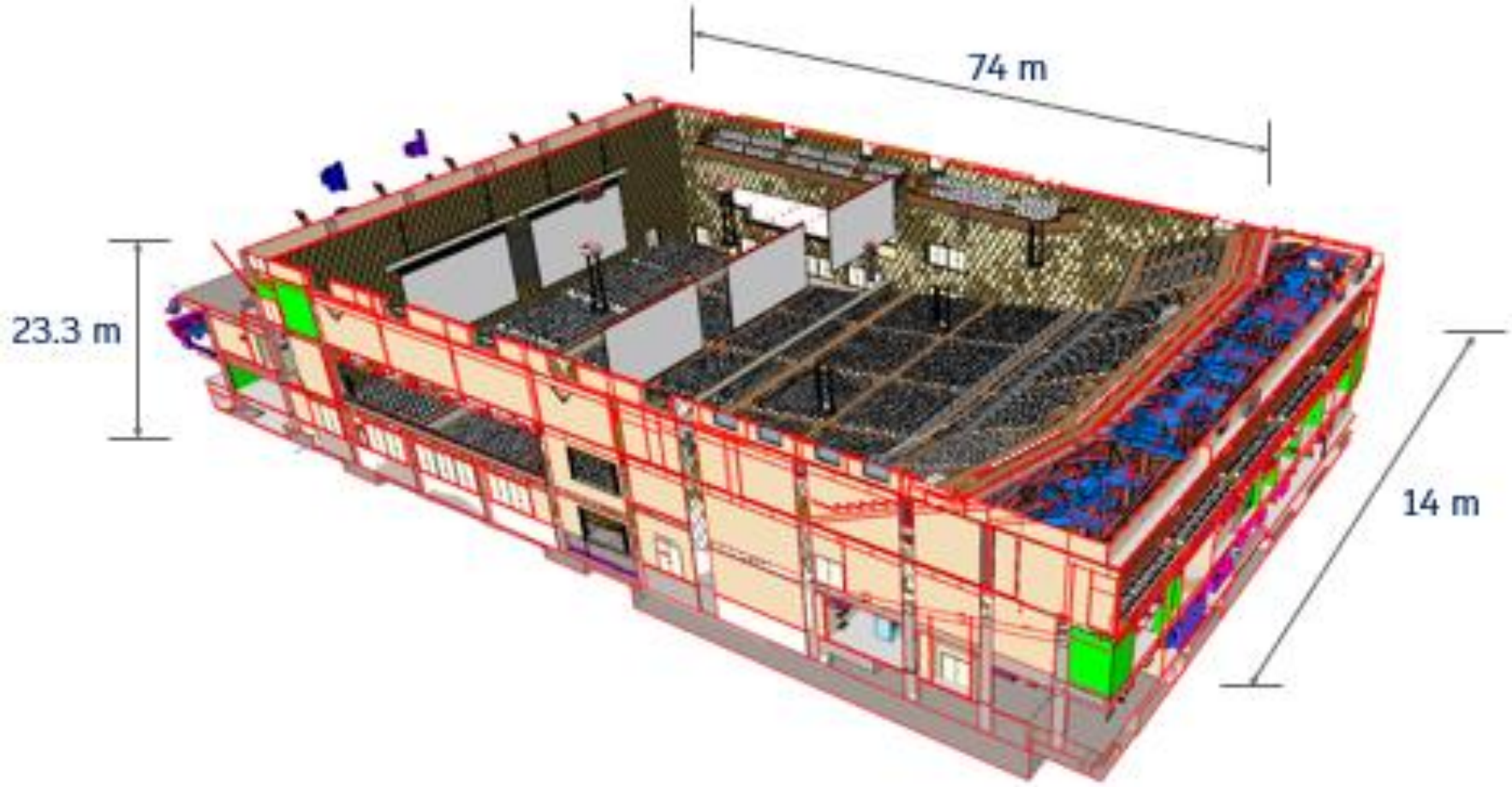
Auditorium has flexible design such that it can seat 6000+ people in one volume over several levels or be divisible into two halls of 4000 and 2000 capacity each by means of a vertical retractable/foldable acoustic partition.


Incredible India

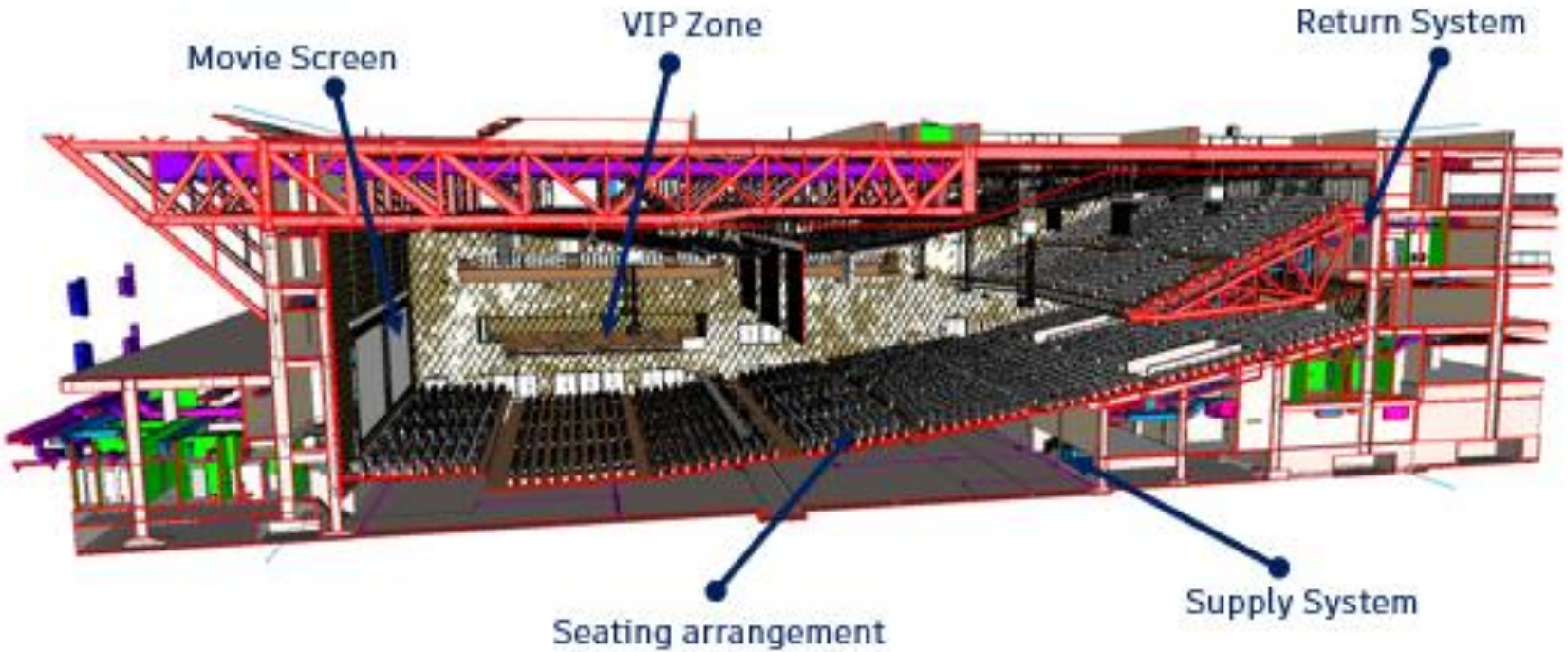
Thermal Comfort

Auditorium Main Hall Geometry

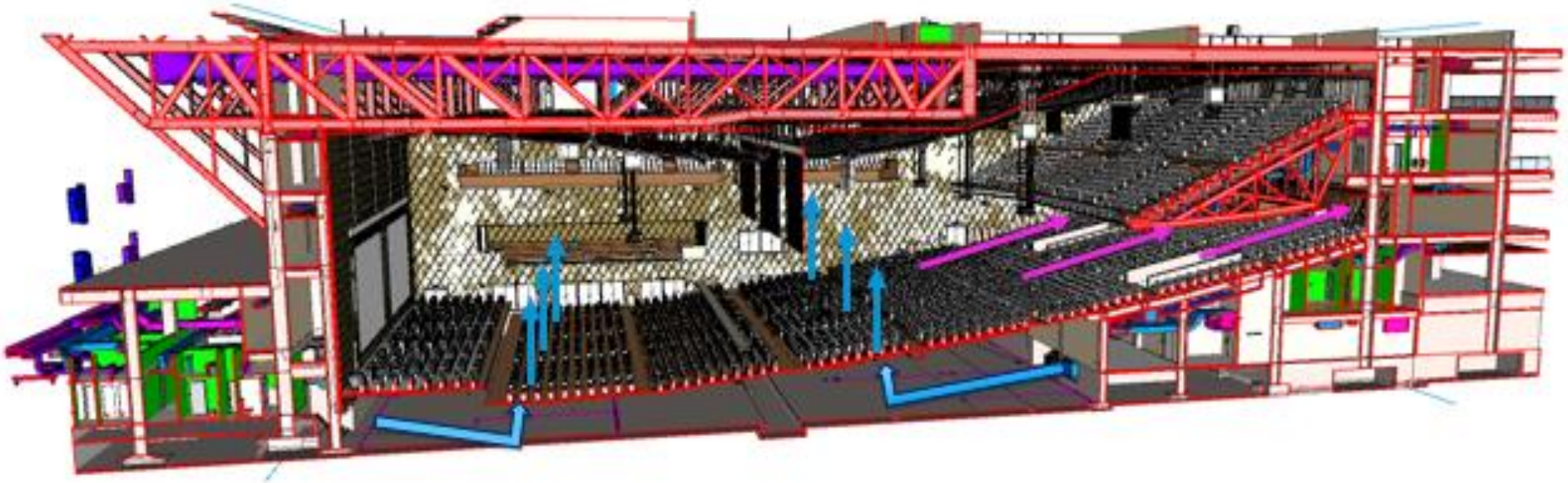



74 m
23.3 m
14 m

Air-Conditioning System



Air-Conditioning System

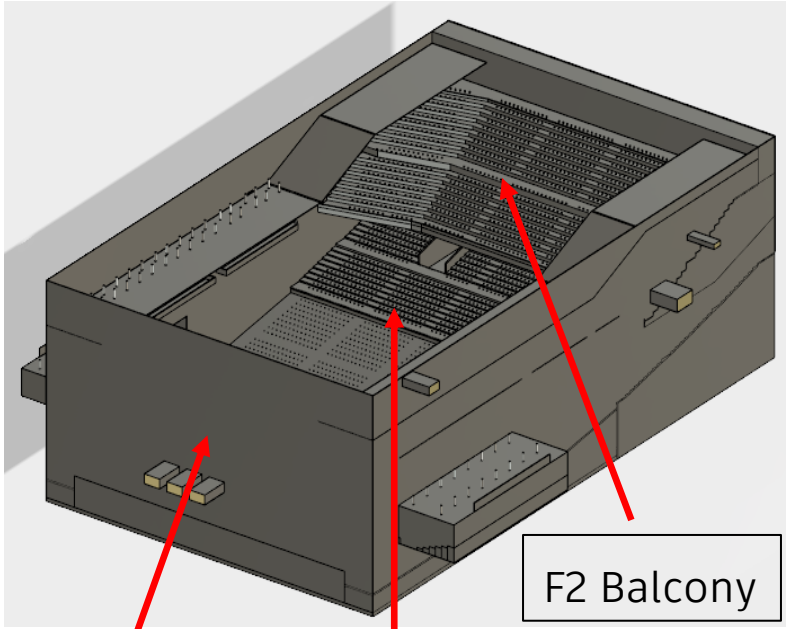


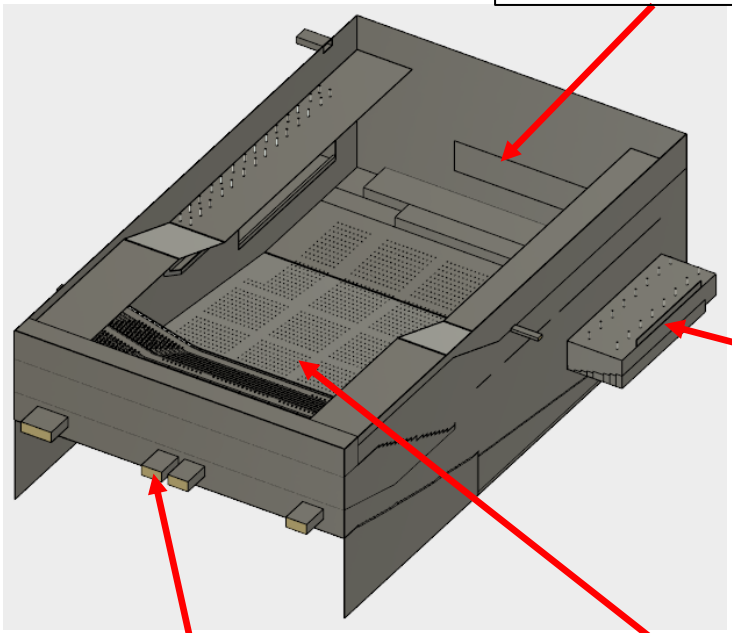
Conditioned air supplied through diffusers below the seat

Return air is drawn through various vents provided in the sides and back of the auditorium hall

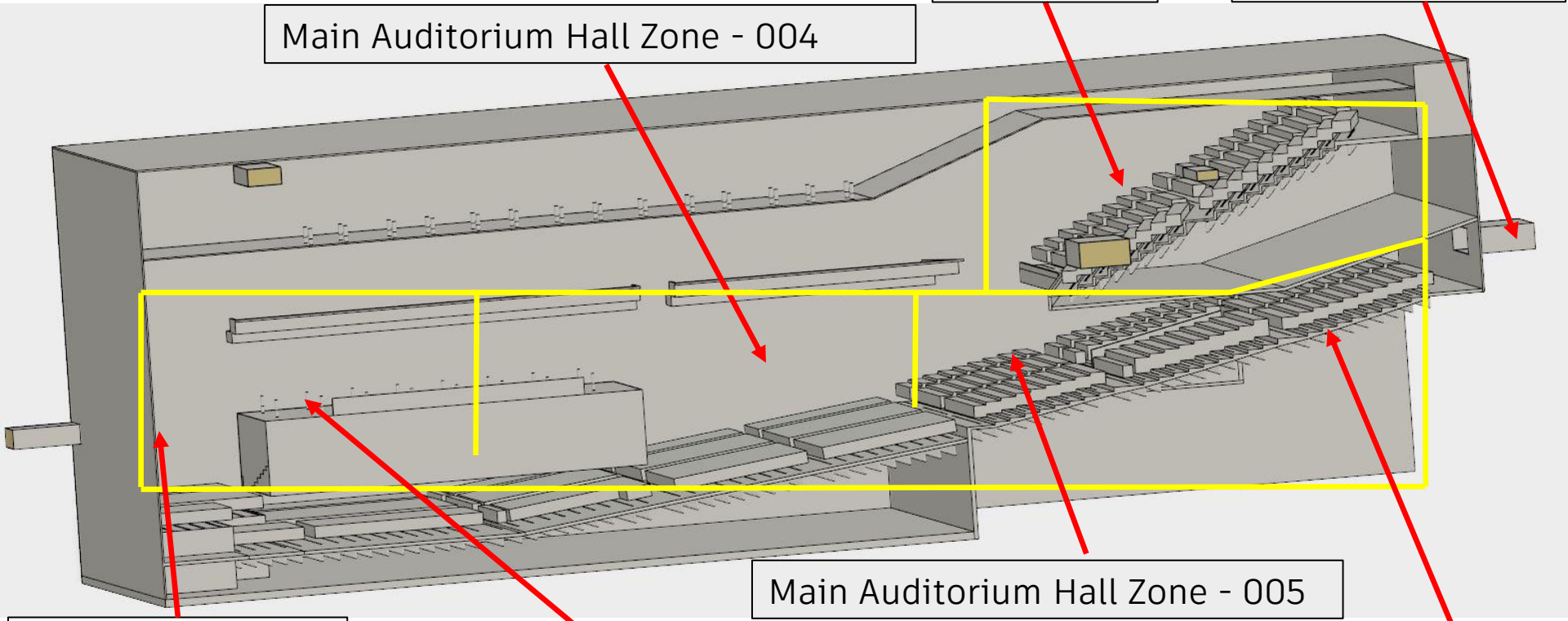
Component Characterization

Auditorium Hall CFD Model



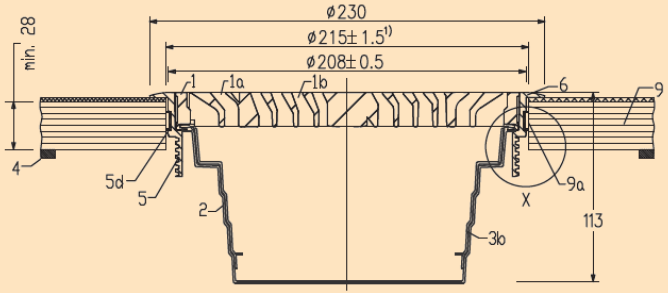


Auditorium Hall CFD model

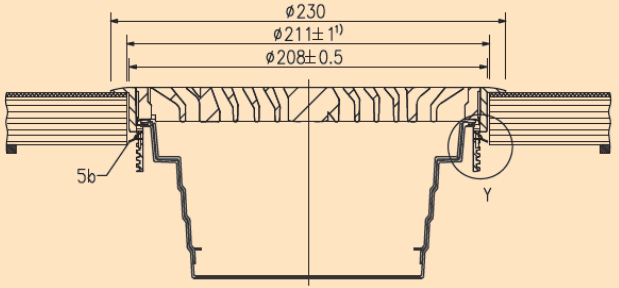


Auditorium Hall Supply Diffuser Specifications

Floor Outlet With Type BA2 Basket for Auditoria



Drawing 3: ASF-AD-DN200-BA2-RR

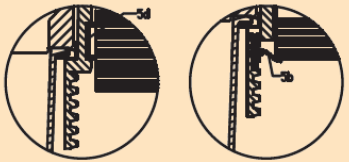


Drawing 4: ASF-AD-DN200-BA2-RC

Key

1	Swirl discharge element (core)	5	Mounting ring insert
1a	Swirl discharge slot	5b	Claw fastener
1b	Diagonal discharge slot	5d	Rubber wedge collar
1c	Indicator	6	Trim lip
1d	Symbols for configurations, airpattern and discharge rate	7	Connection box
1e	Pointer for diagonal pattern direction	8	Connection spigot
2	Dust receptacle basket	8a	V – damper (optional)
3	Outer damper	8b	Lever
3a	Inner damper	9	Access floor tile
3b	Damper	9a	Cylindrical penetration
4	Sealant (on site,by others)		

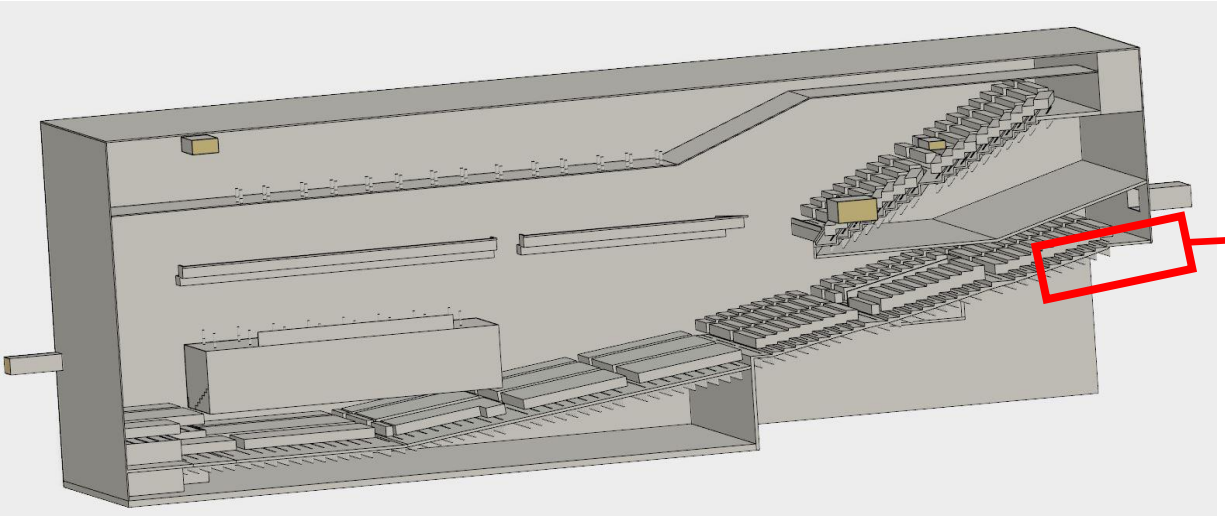
Detail

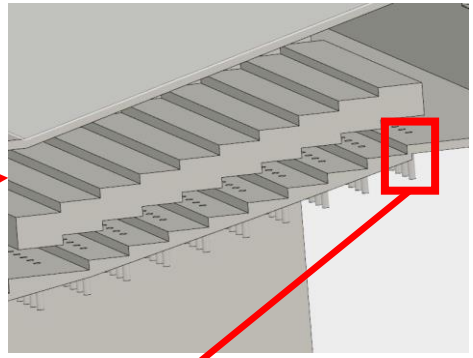


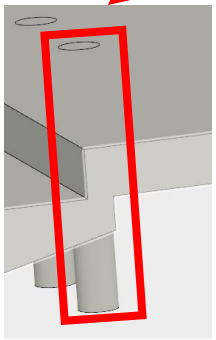
Detail X Detail Y

Note:
1) Ø of cylindrical floor penetration.
Dimensions in mm.

Auditorium Hall Diffuser Characterization

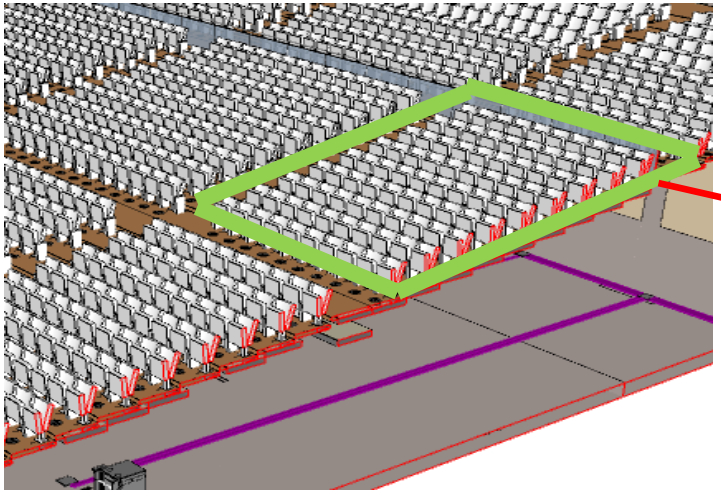




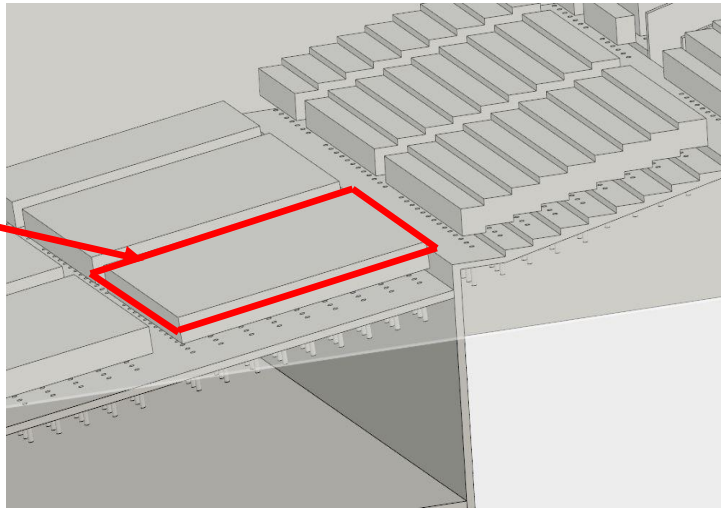


The diffuser is modelled as cylindrical body with circular opening indicating the shape of the diffuser. The outlet face is provided with resistance value of 0.5 (free area ratio) to depict the diffuser opening.

Auditorium Hall Human Occupant Characterization



CAD model



CFD model

The occupant chairs are modelled as block of air volume representing occupants as shown by the CFD model.

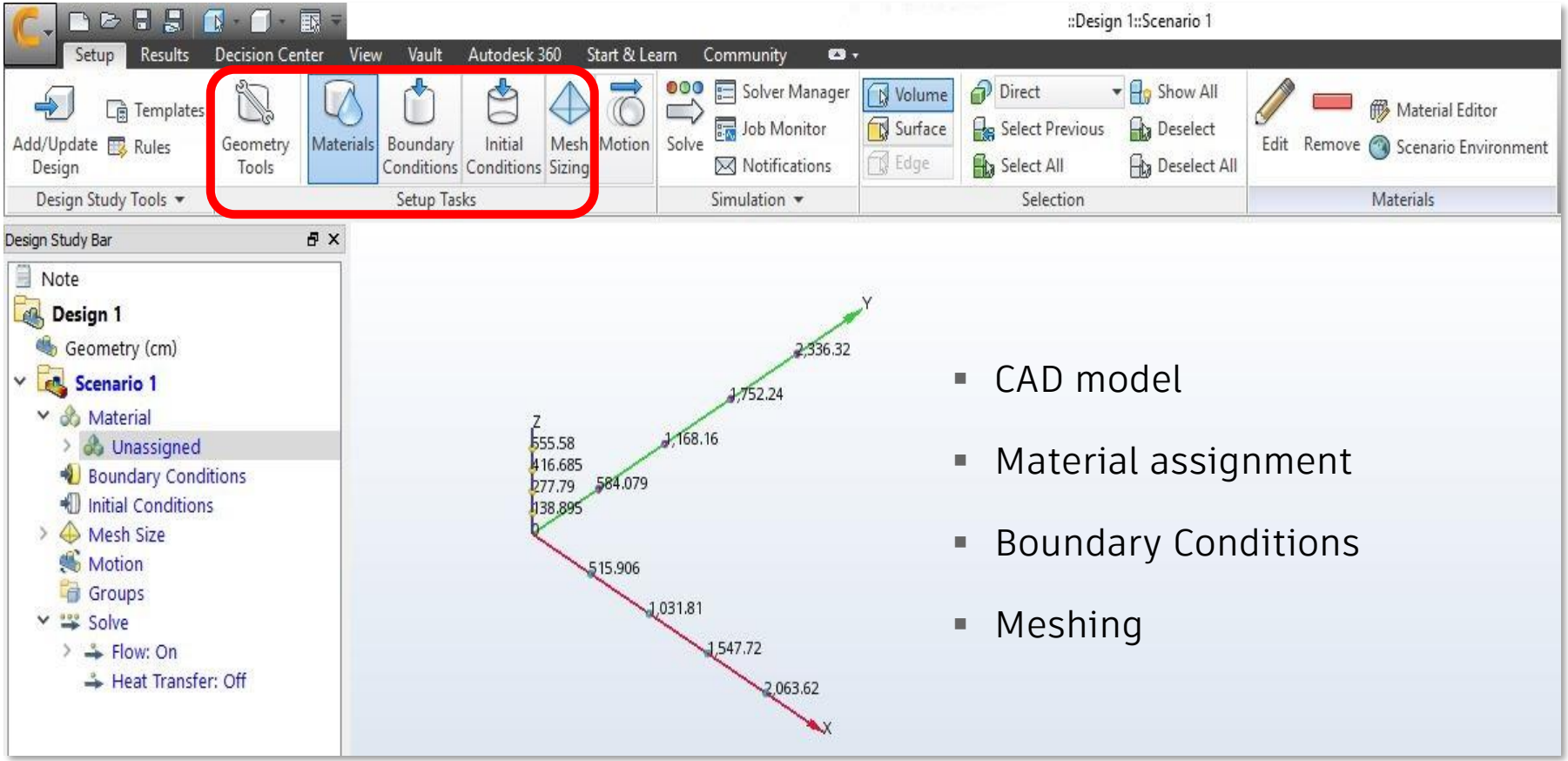
Auditorium Hall Design Details

S.No	Floor Region	People Capacity
1.	Main Auditorium Hall	4264
2.	F2 Balcony	1148
3.	VIP Box	112

1.	Lighting load	0.7 W/ft^2
2.	Equipment load	1.0 W/ft^2
3.	Sensible heat load	67.4 W/person
4.	Seated height	1.1 m
5.	Humidity	50%
6.	Inlet air temperature	16^0C

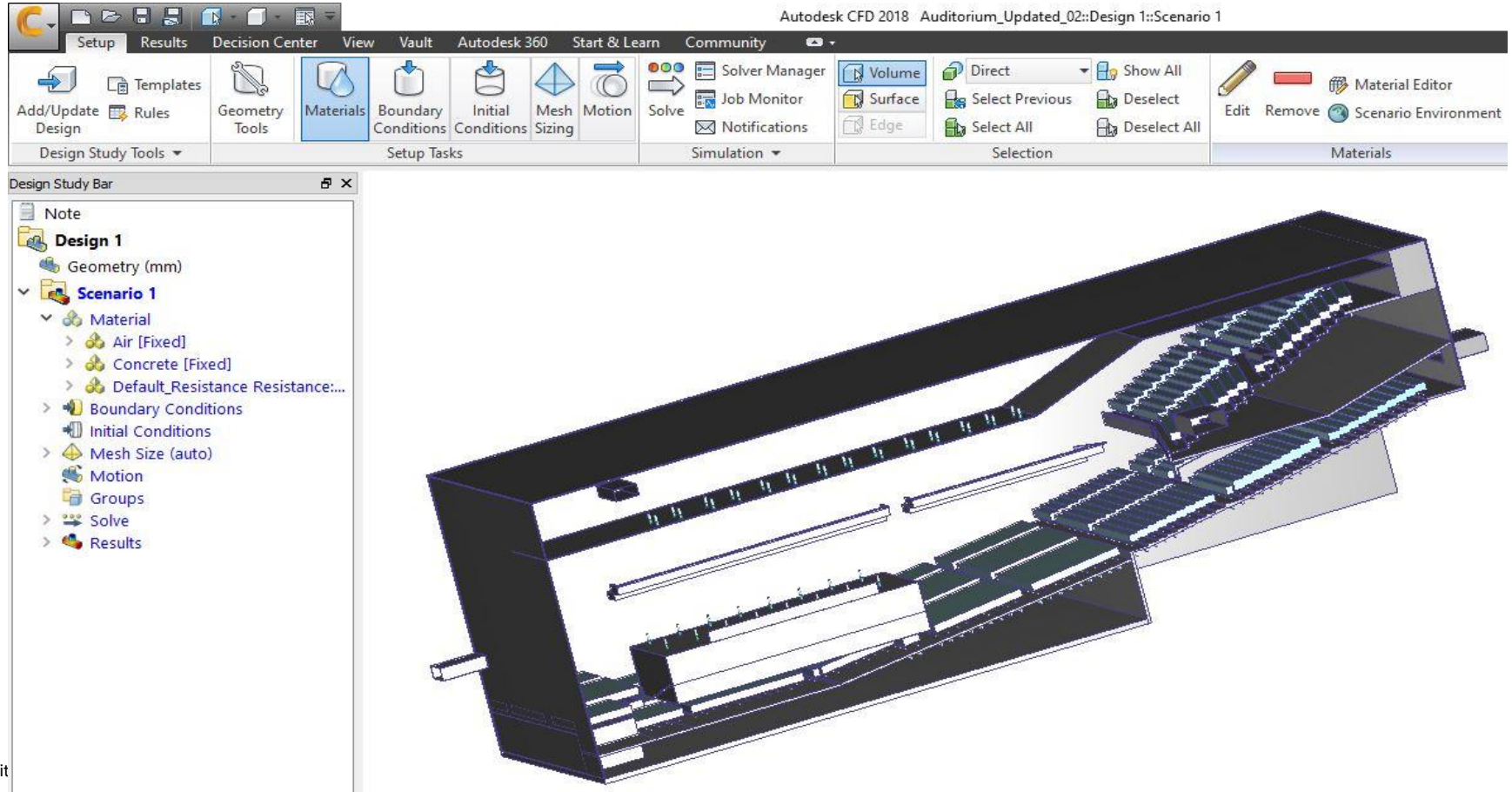
Modeling Strategies- Airflow and Heat Transfer

Autodesk CFD Set up Workflow

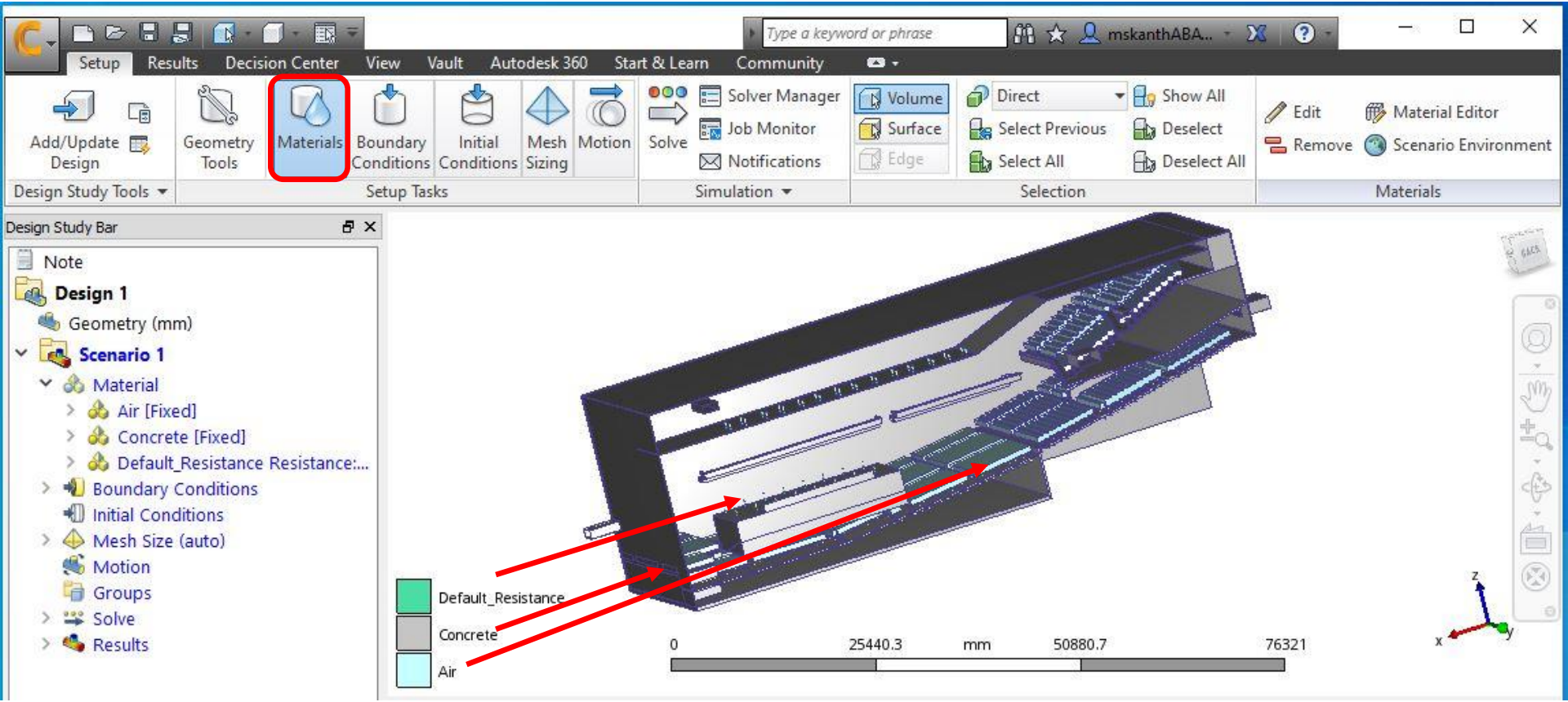


- CAD model
- Material assignment
- Boundary Conditions
- Meshing

Auditorium Hall CFD Model

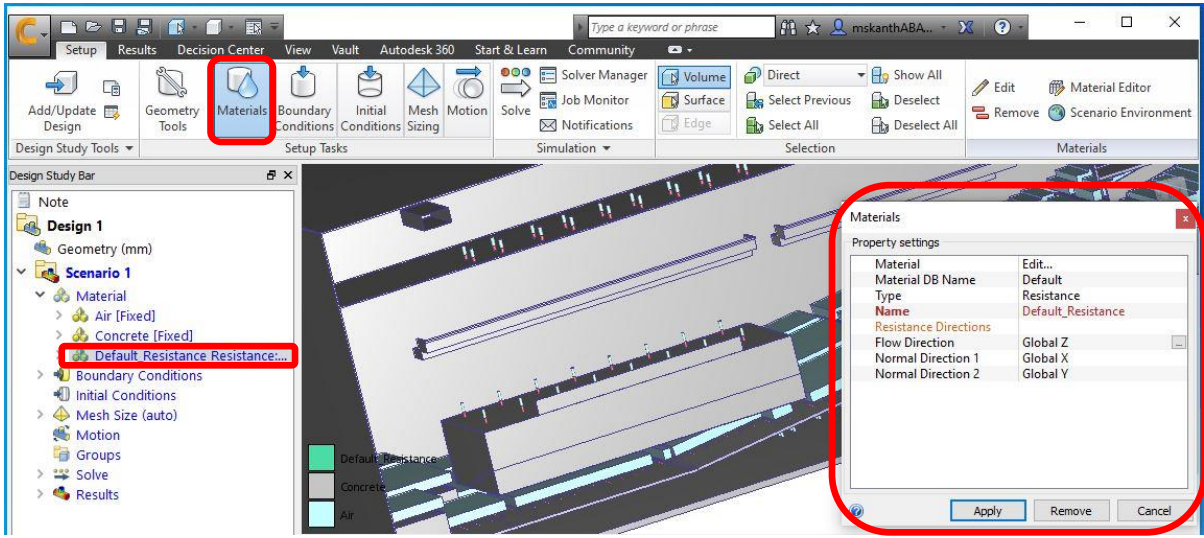


Materials

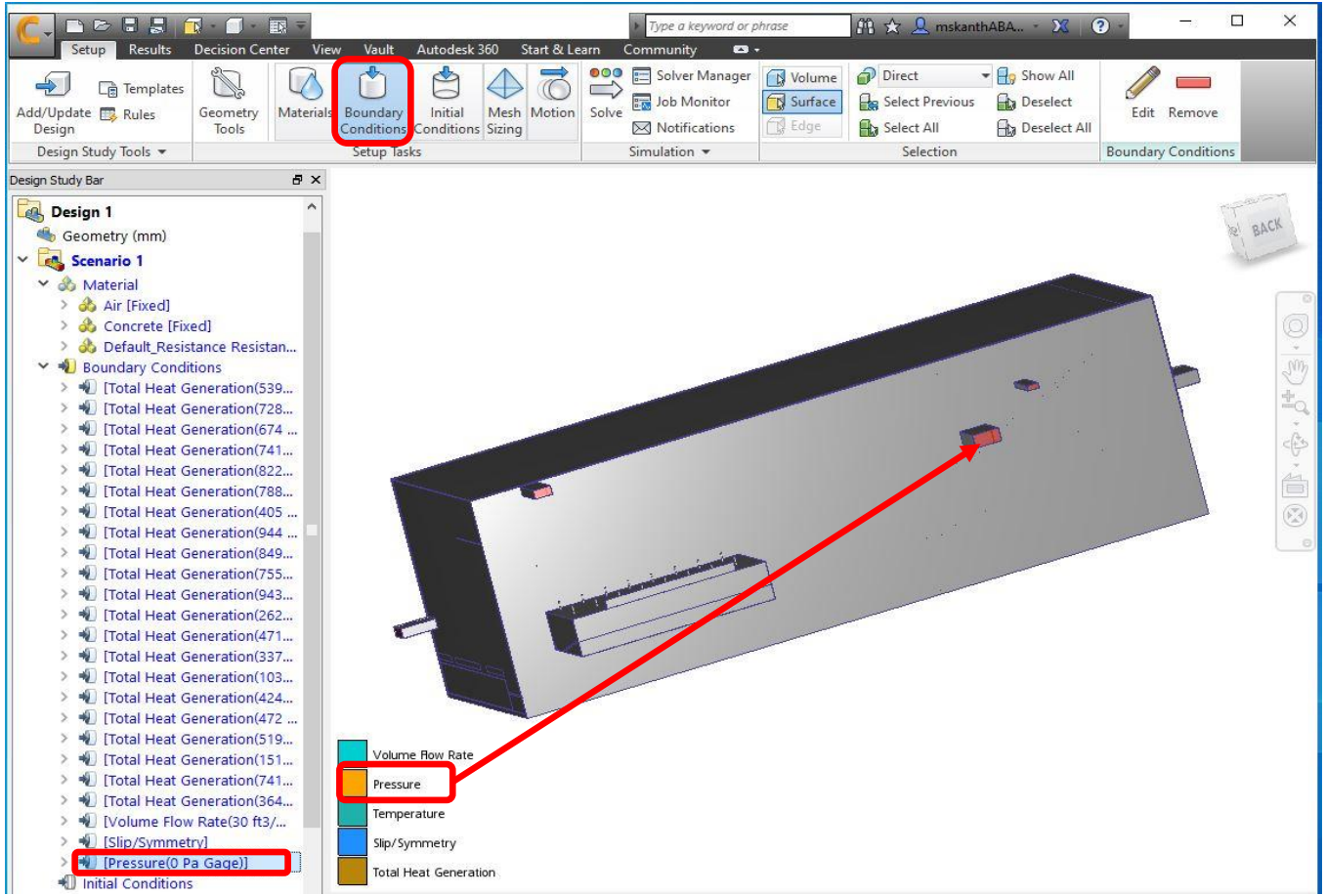


Materials

- The default resistance is provided to give resistance to the flow with a free area ratio of 0.5
- The structures are assigned as concrete material
- The fluid volume filling the room will be air material
- Humans are assigned as air volume with heat generation capacity mentioned in boundary condition

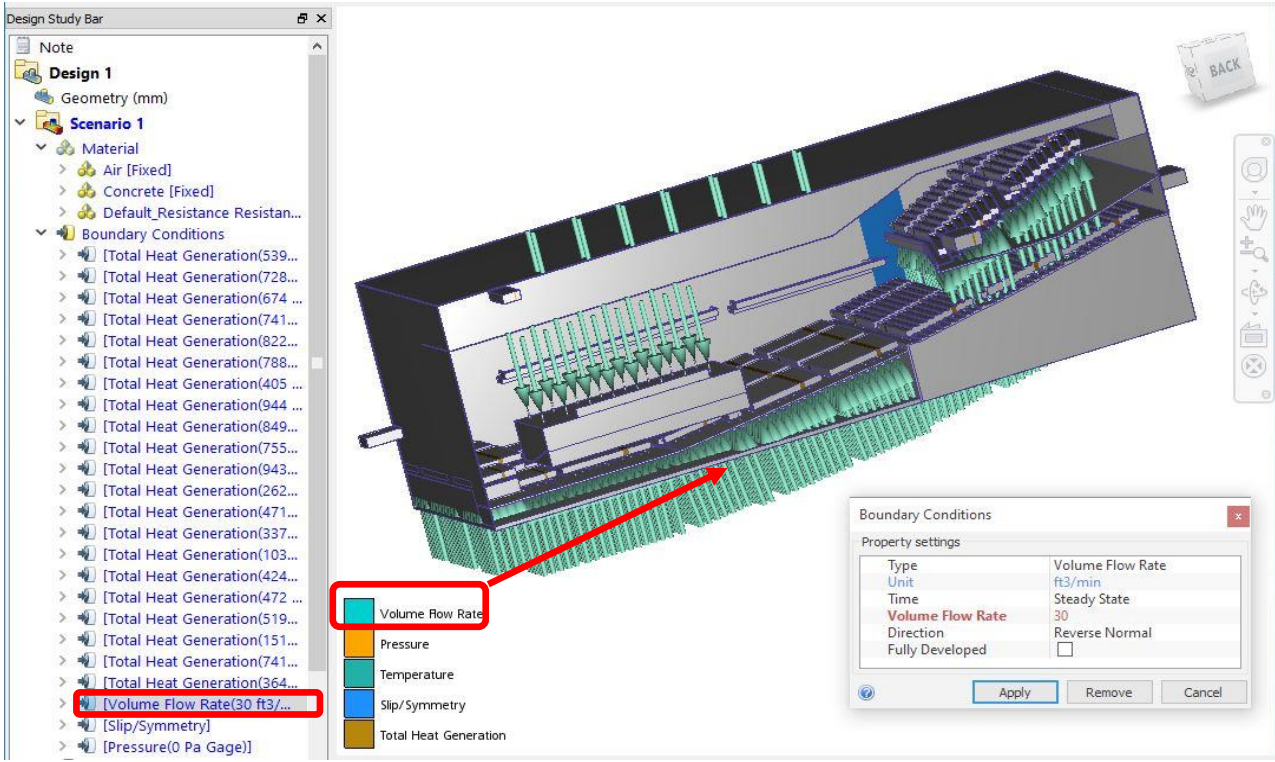


Boundary Conditions (BCs)- Outlets



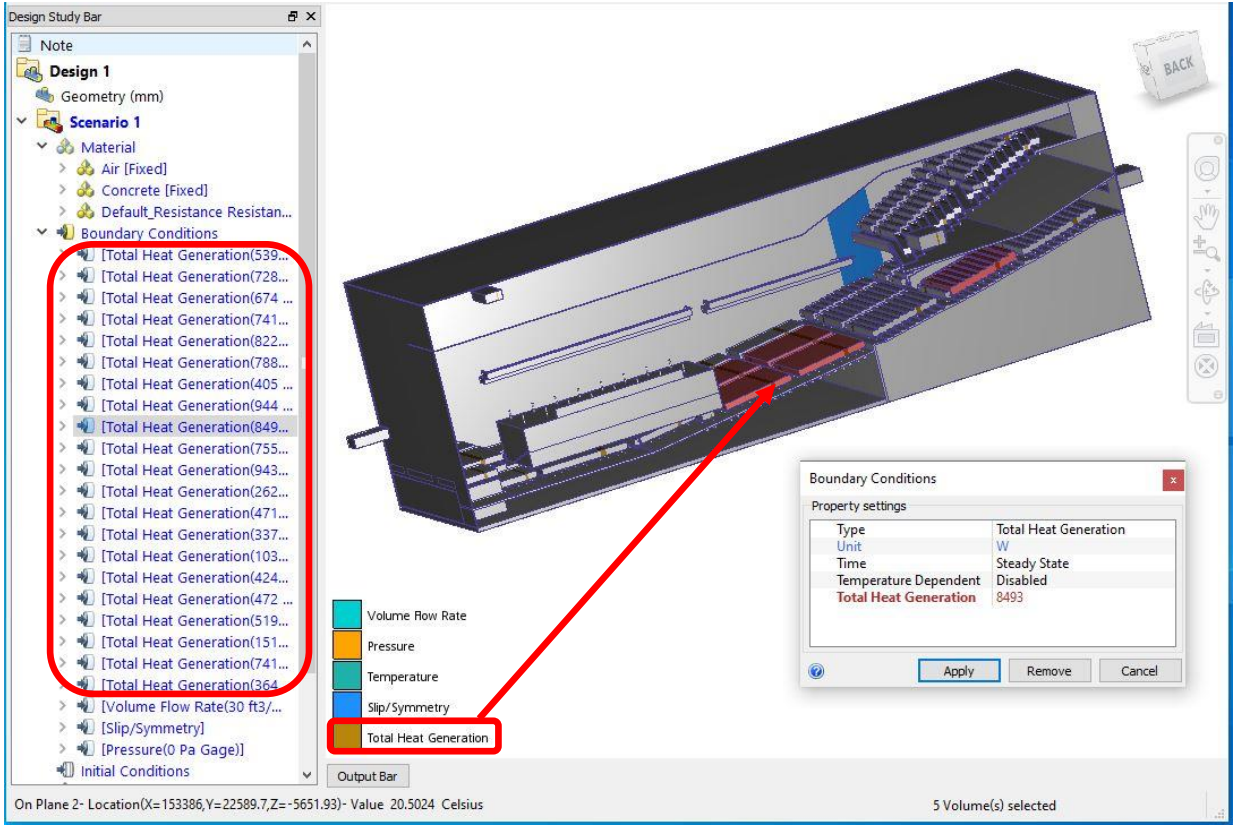
BCs - Inlets

30 CFM through each supply diffusers

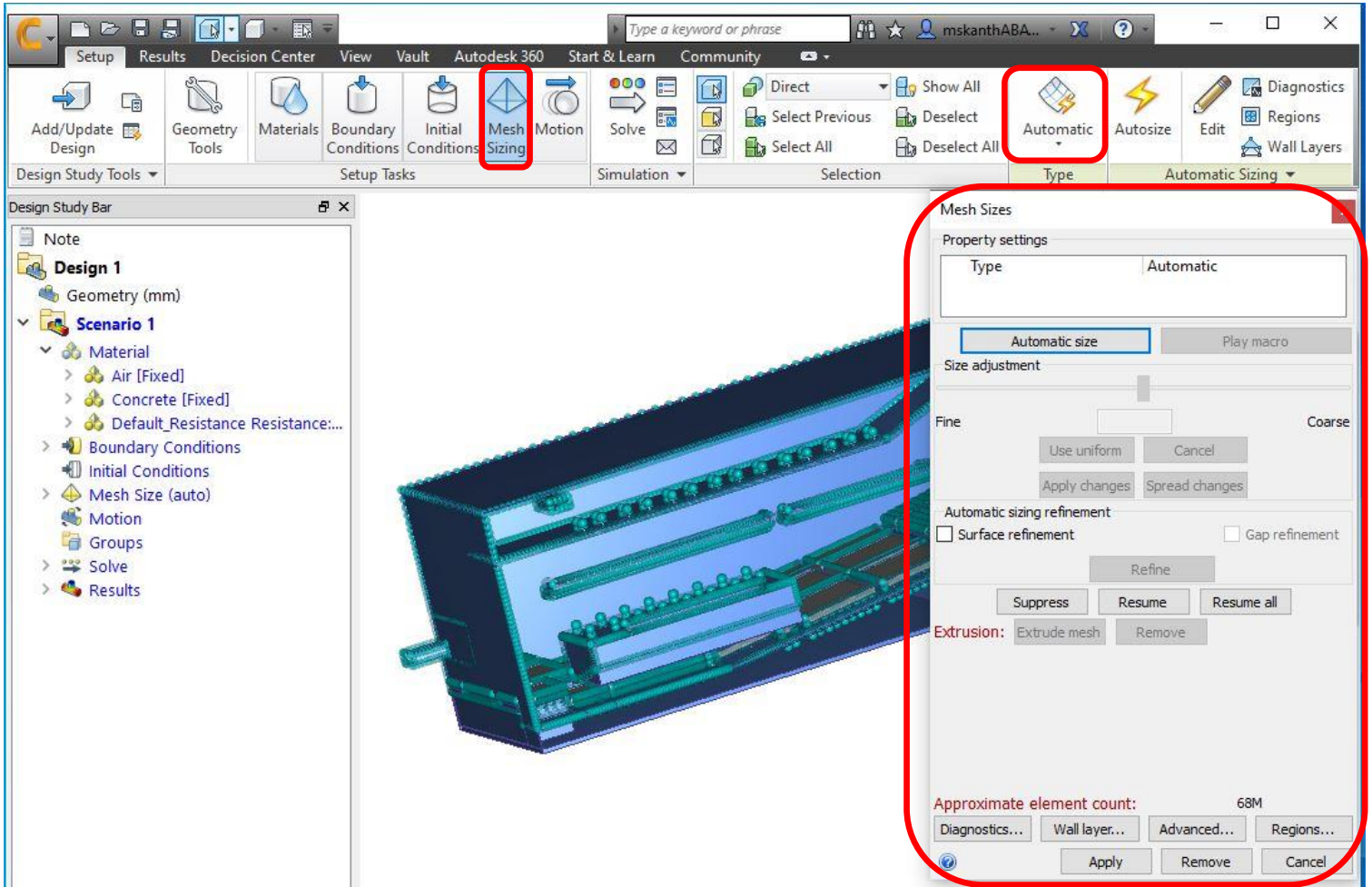


BCs – Heat Loads

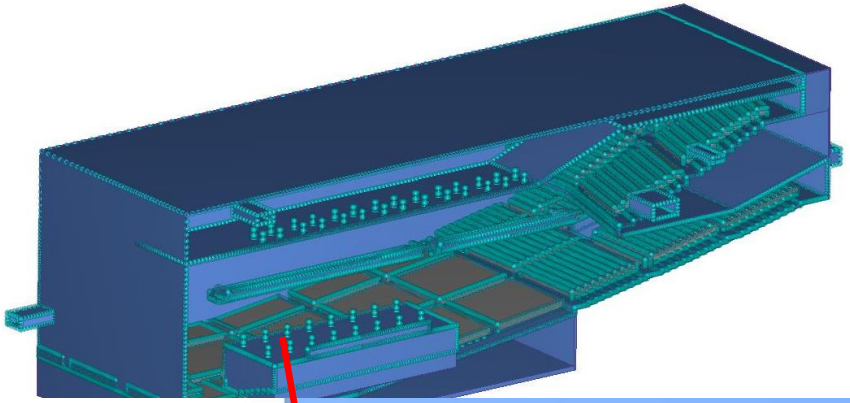
Total heat load was distributed to each air volume indicating occupants proportionate to the area.



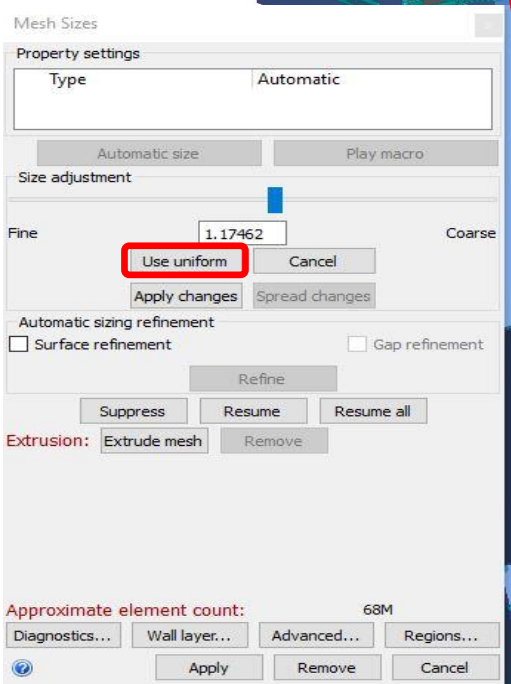
Automatic Meshing

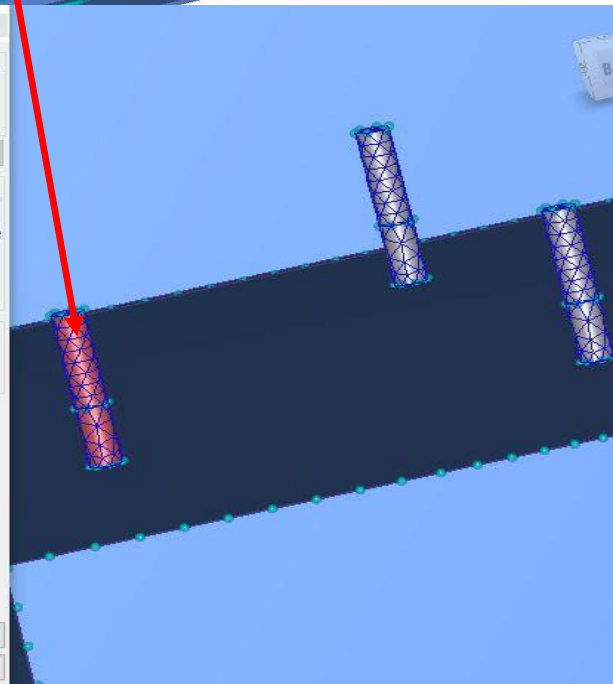


Uniform Meshing



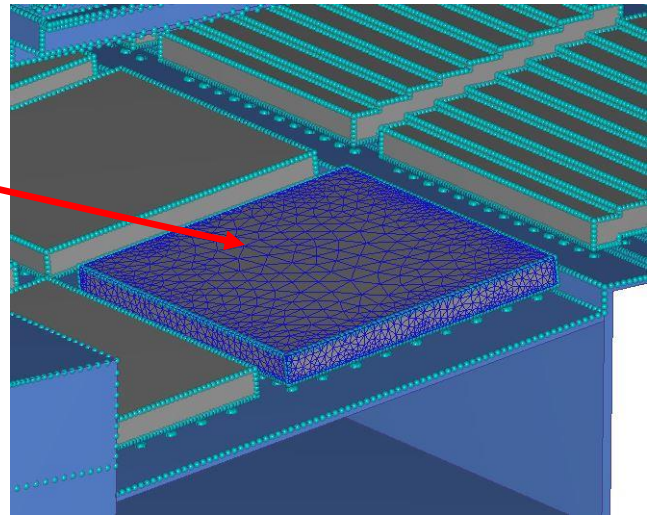
Uniform fine mesh (at least 4-5 elements) on diffusers to ensure proper air flow through the supply diffusers





Uniform Meshing

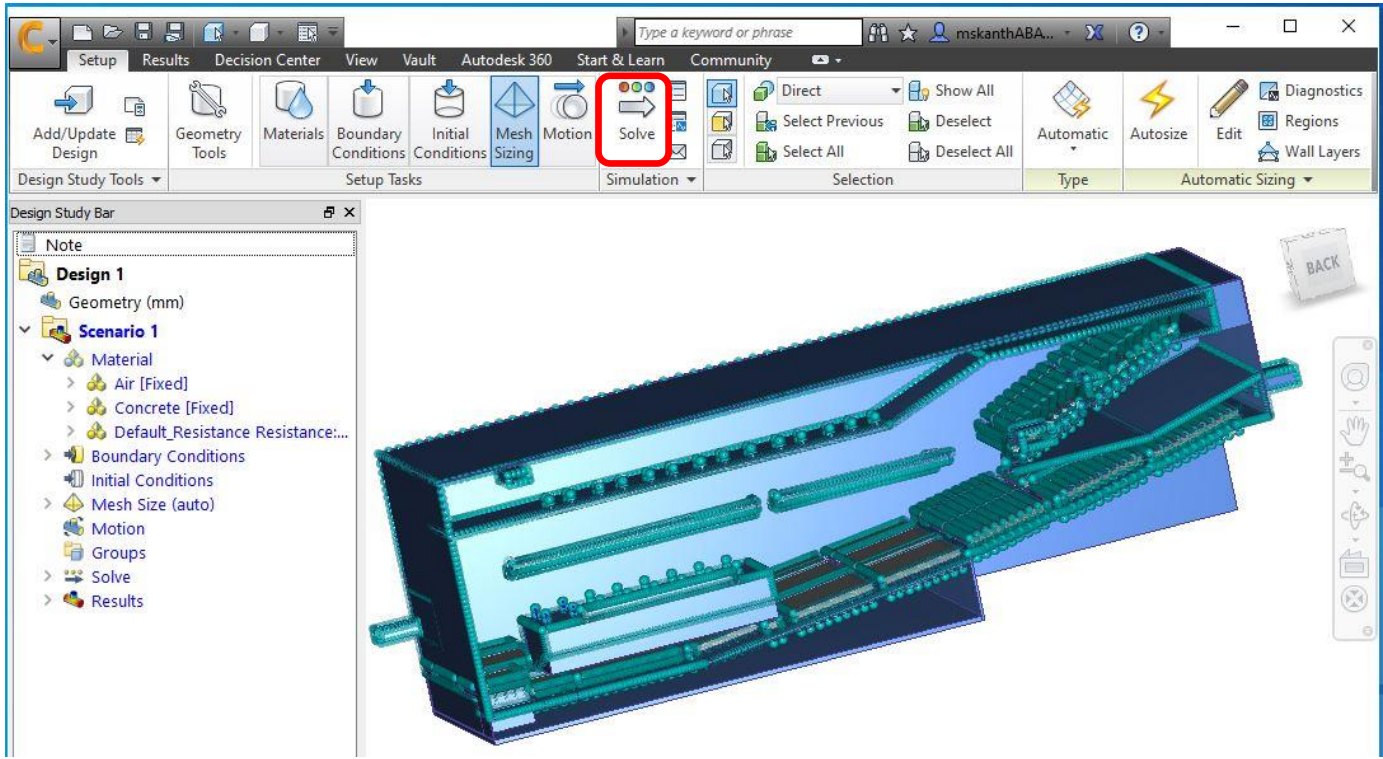
Uniform mesh (at least 4-5 elements) to capture effective heat absorption in air volume for occupants



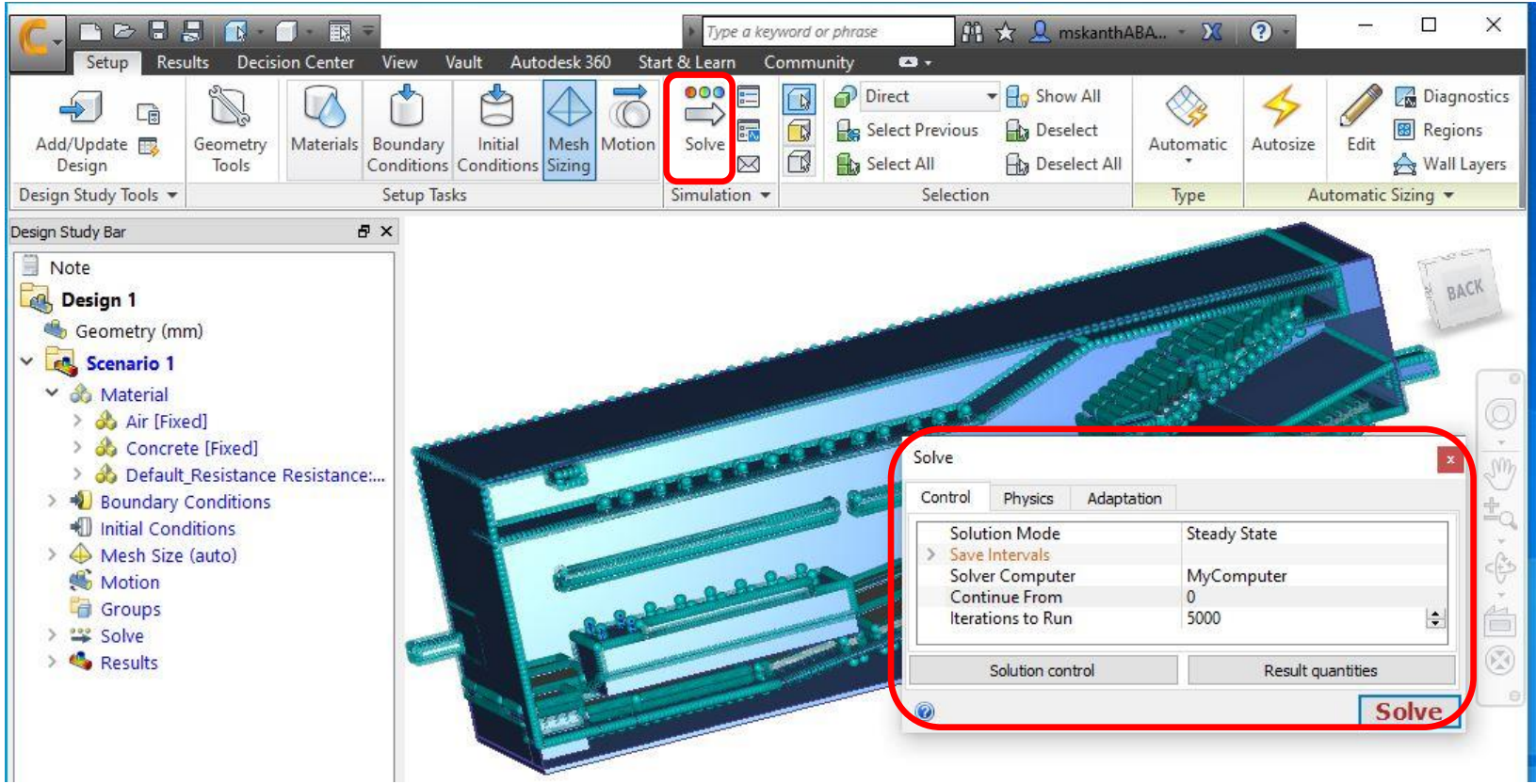
Set up Simulation and Visualize Results

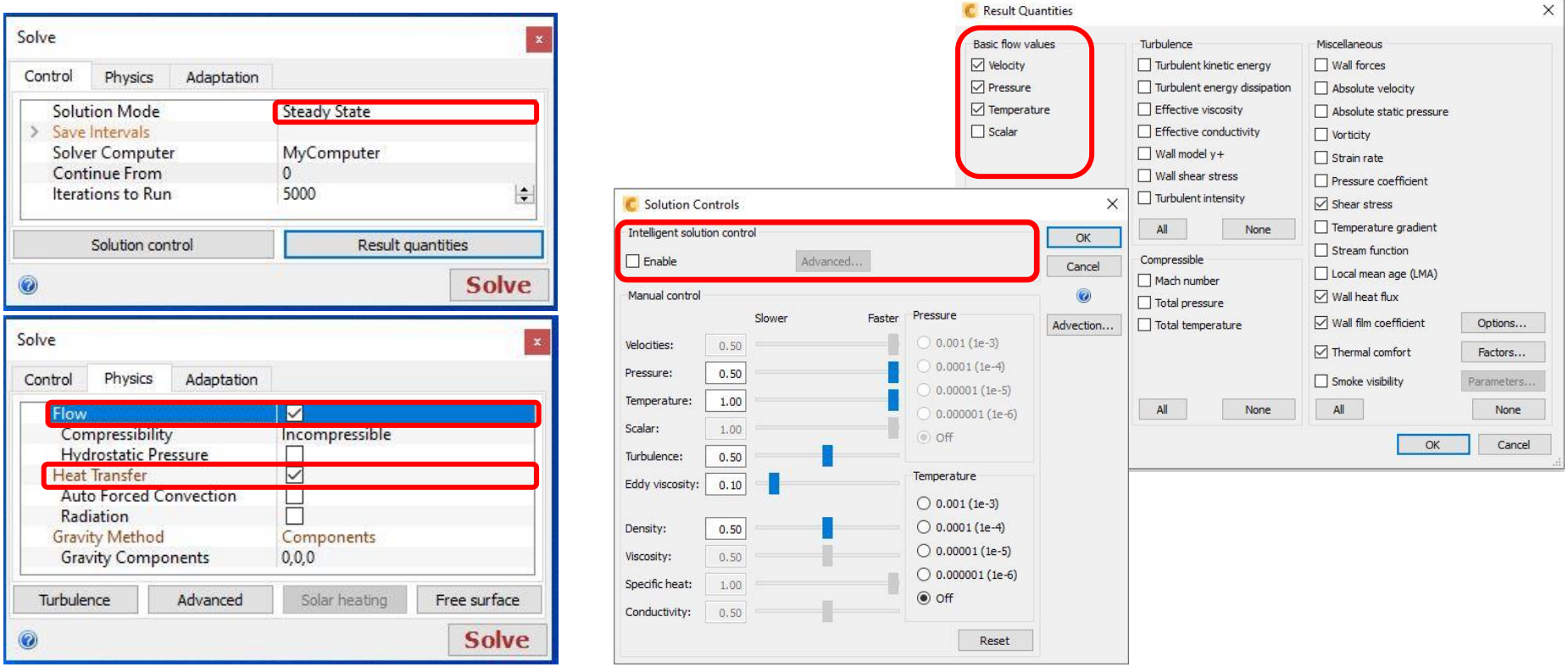
Simulation and results
Autodesk CFD Solve and Results Workflow

- Solver control
- Physics (Flow and Heat Transfer)
- Results – Global / Plane
- Results – Airflow Velocity and Temperature



Solve

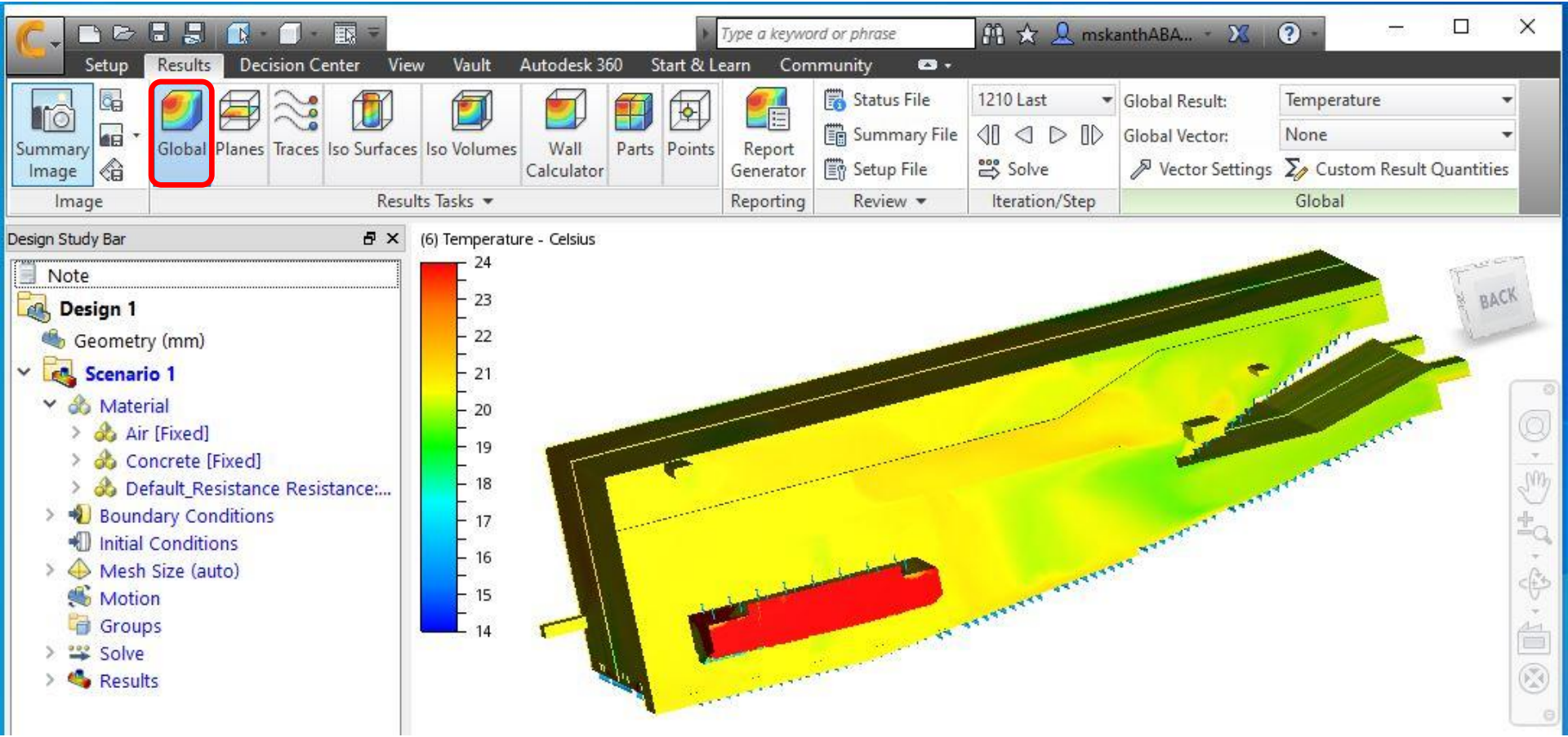




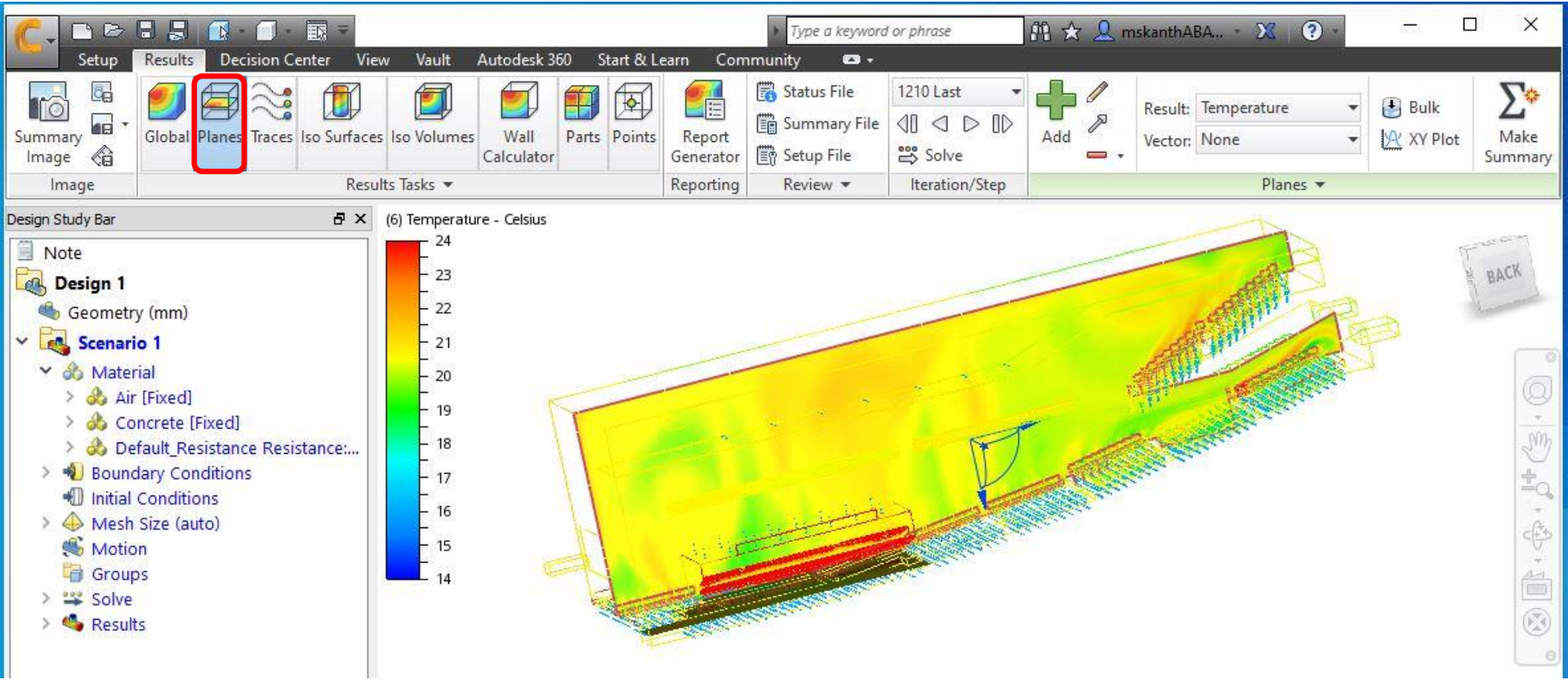
Solver settings

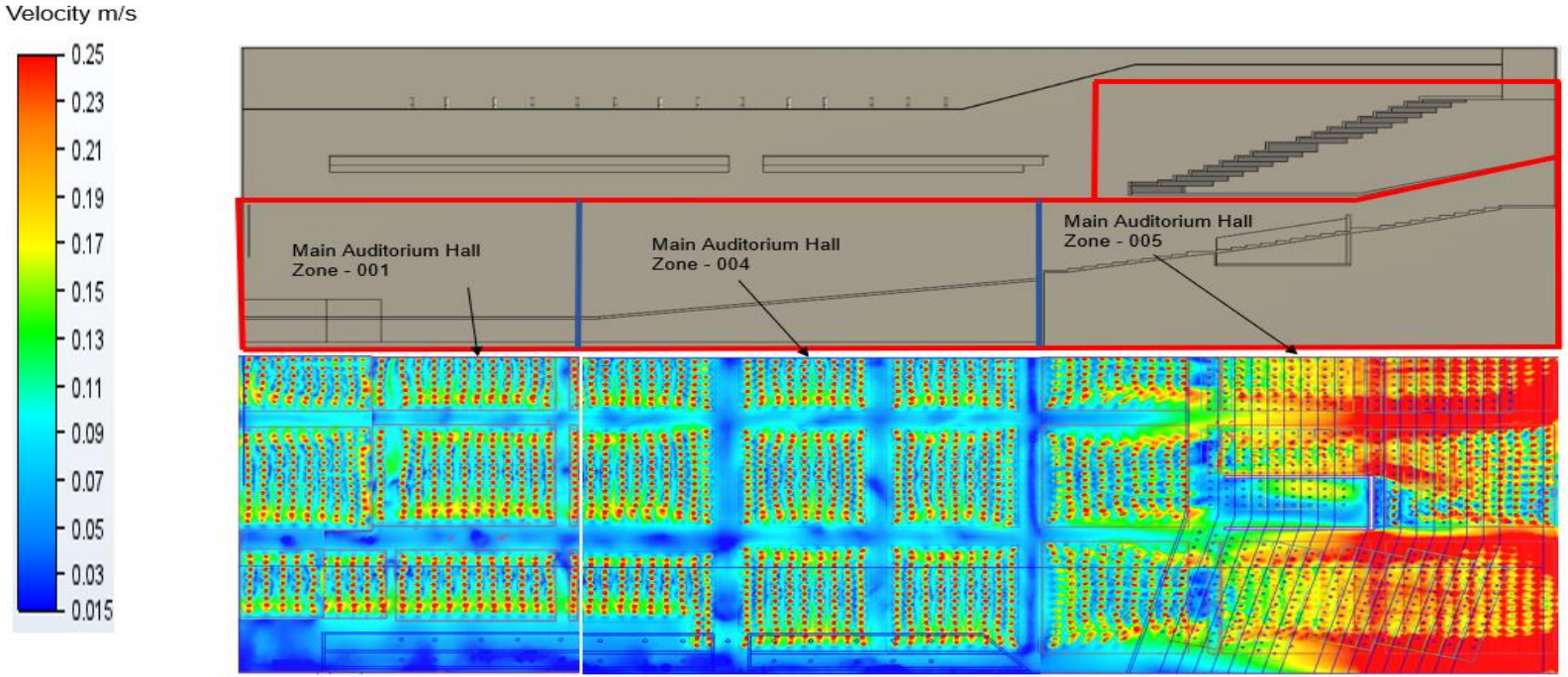
Steady state solution, Intelligent Solution Control, Flow and Heat Transfer, Forced Convection (Gravity method unselected)

Results- Global



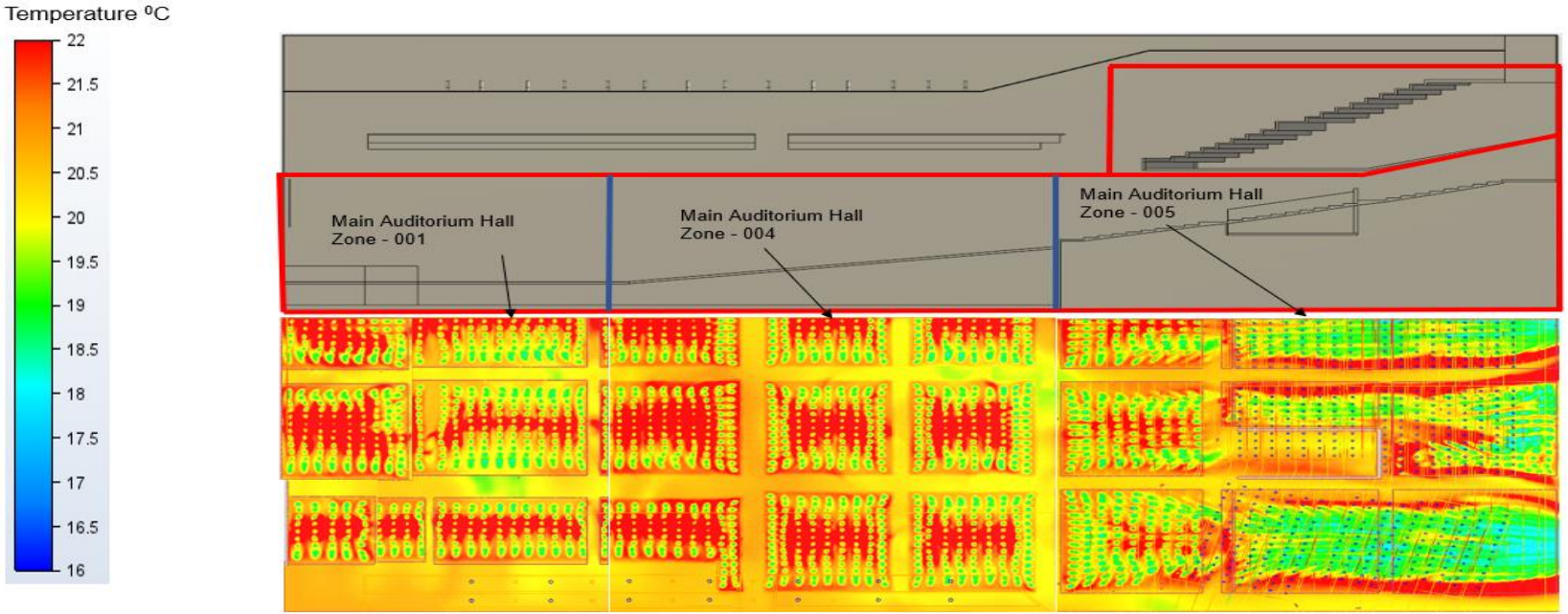
Results- Plane





Main Auditorium Hall -Results- Velocity at 1.7 m level

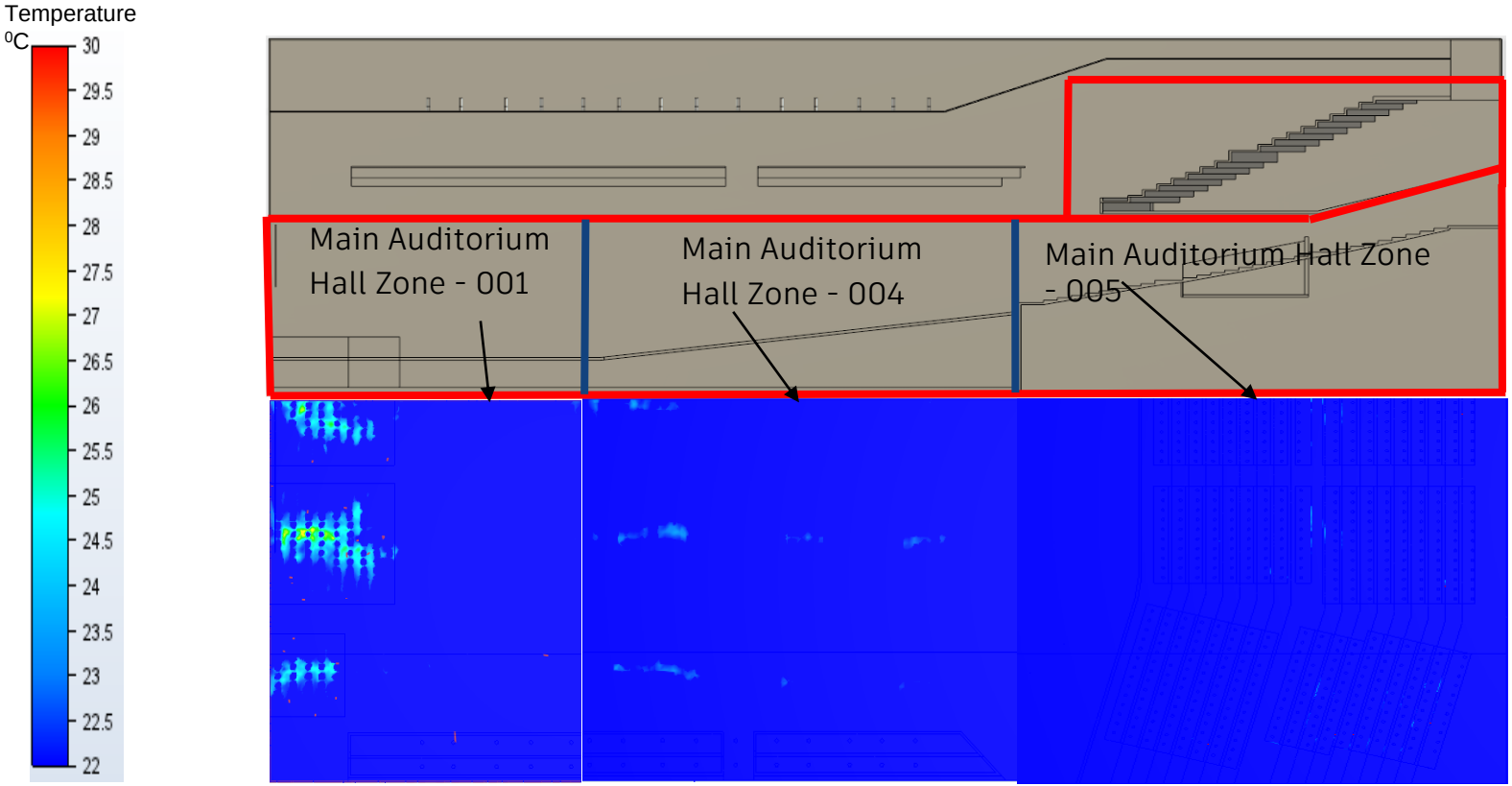
Results on Cut Planes are used to visualize velocity data on 3D model. Plan view shows high velocity through each diffusers indicated by red dots.



Main Auditorium Hall - Results- Temperature at 1.7 m level

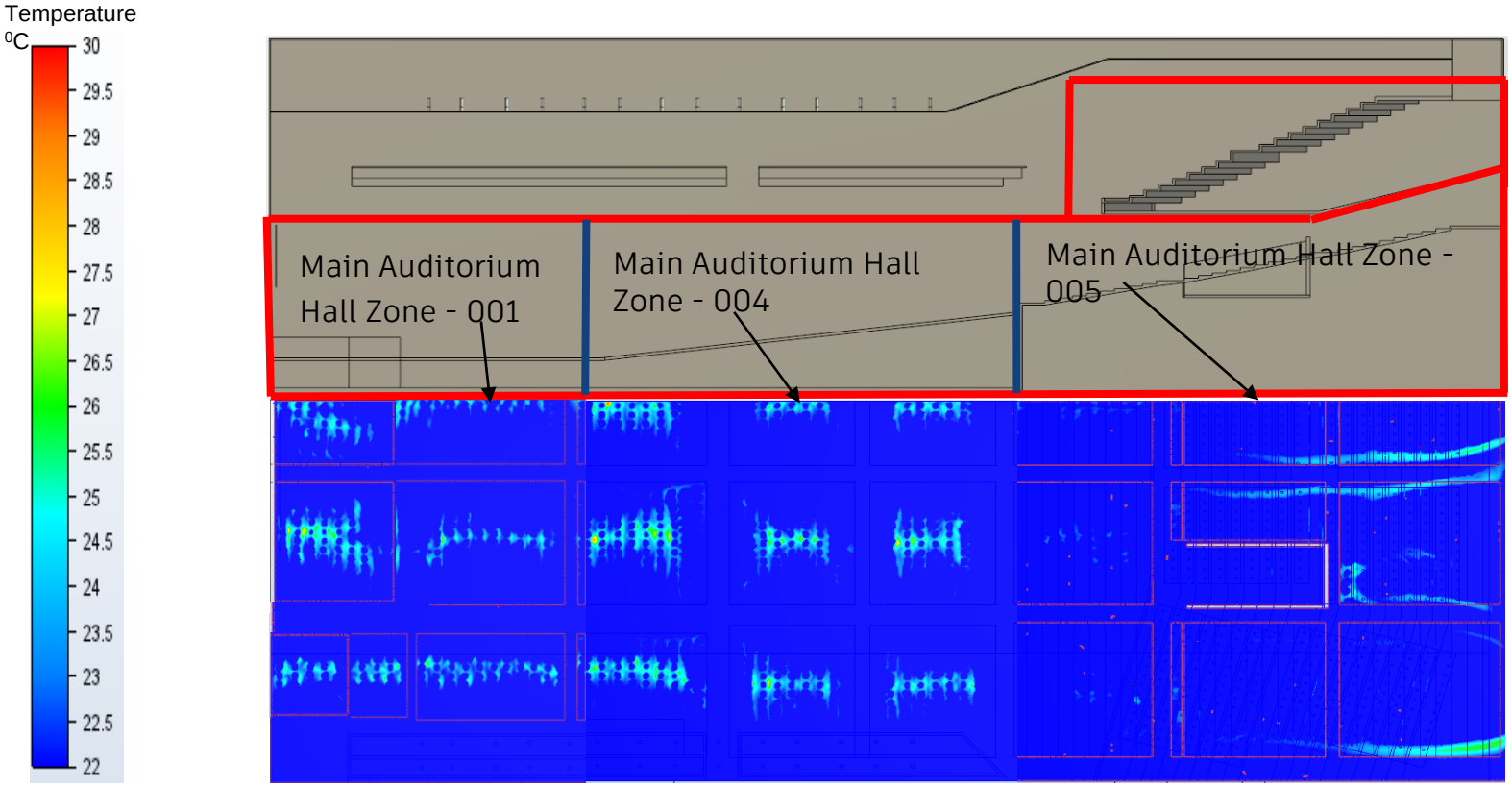
Results using Cut Plane at 1.7m level from FFL can be used to evaluate temperature for personnel comfort. In this case , 22^0 C.

Main Auditorium Hall - Results- Temperature at 1.7 m level



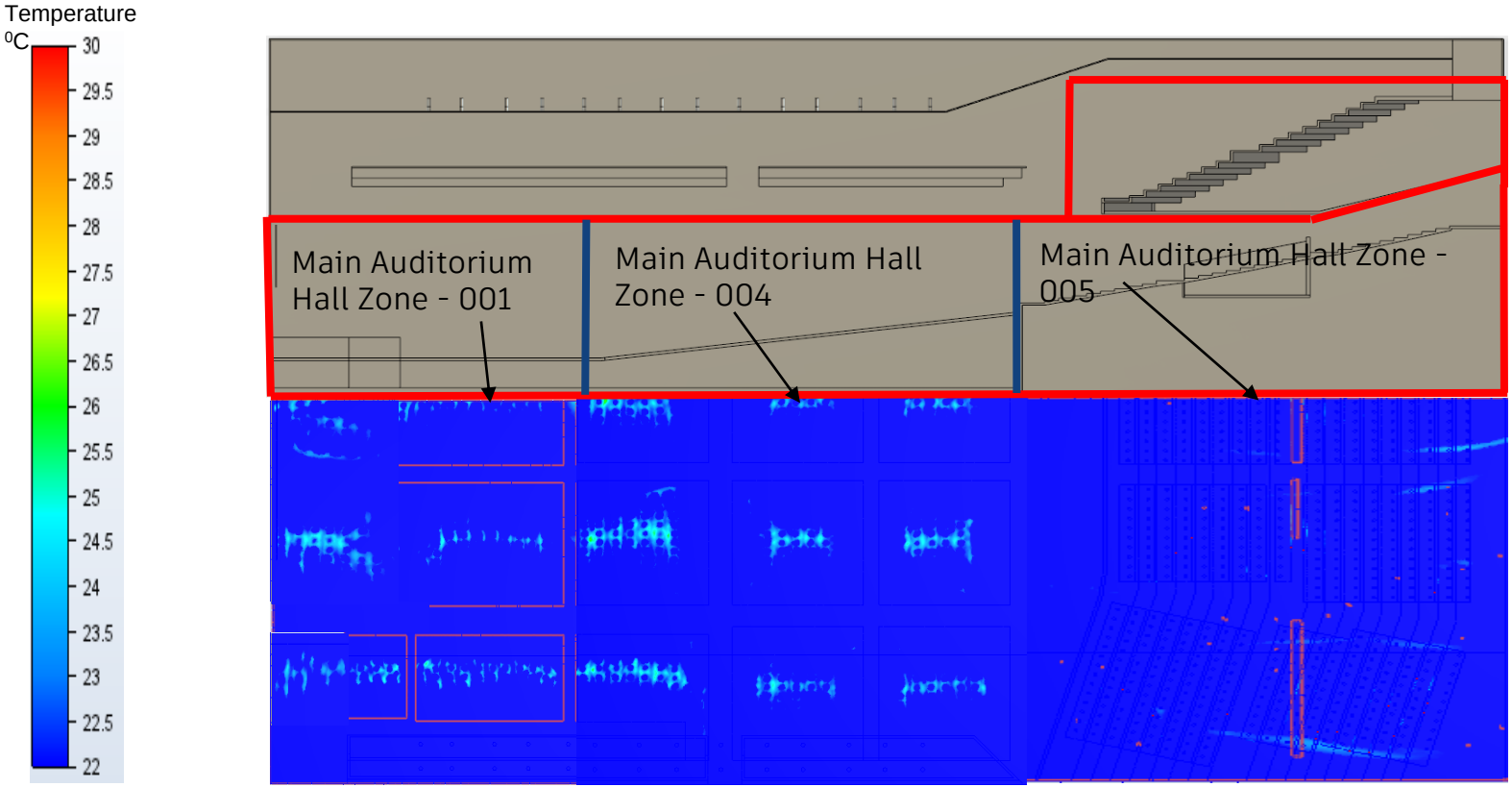
Temperature contour at 1.7 m from the floor

Main Auditorium Hall - Results- Temperature at 0.7 m level



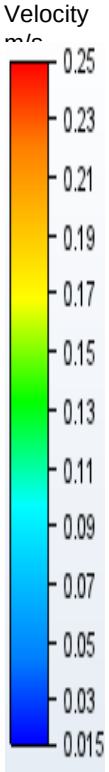
Temperature contour at 0.7 m from the floor

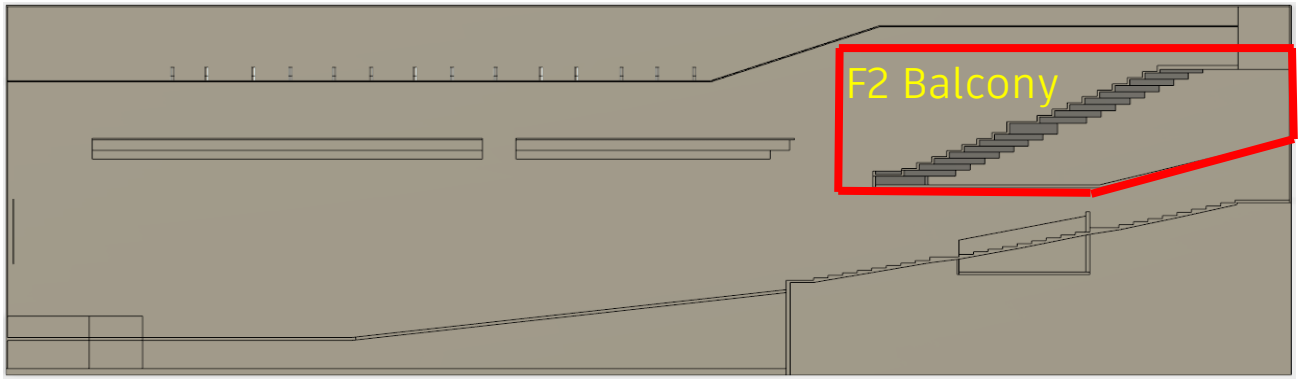
Main Auditorium Hall - Results- Temperature at 1.1 m level

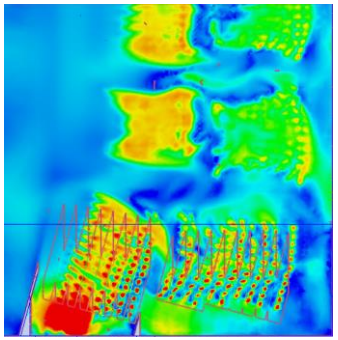


Temperature contour at 1.1 m from the floor

F2 Balcony CFD analysis results (Air flow pattern)

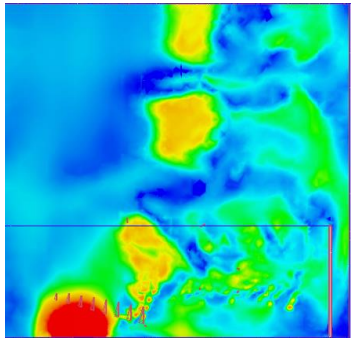






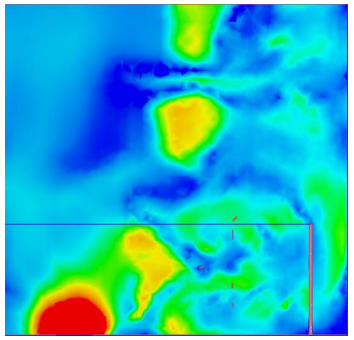
Towards Auditorium

Towards Wall



Towards Auditorium

Towards Wall

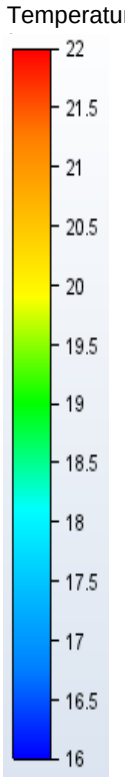


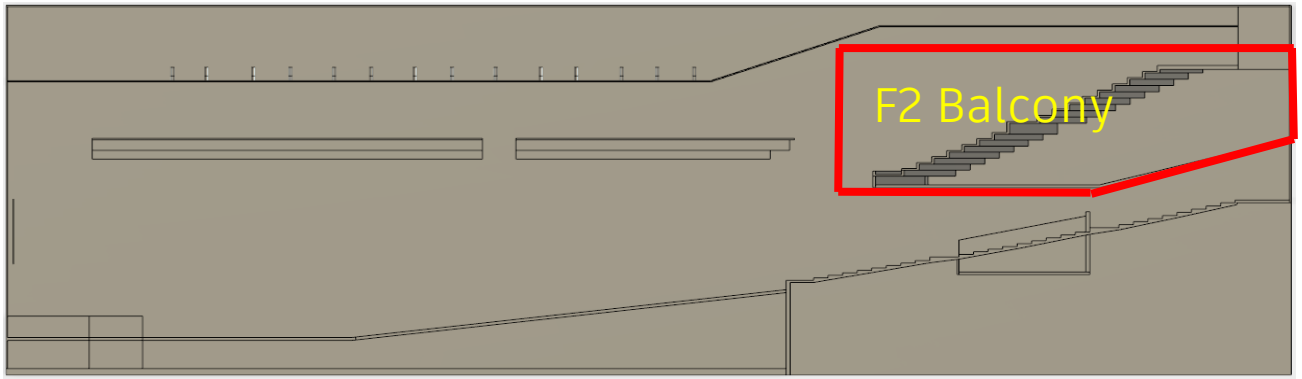
Velocity contour at 0.7 m from the floor

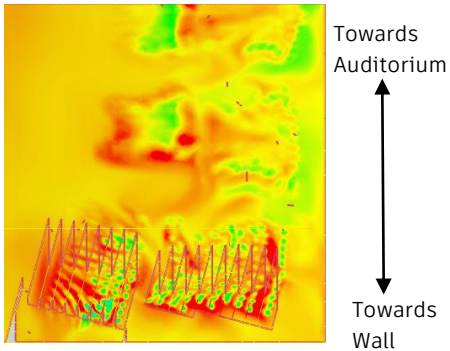
Velocity contour at 1.1 m from the floor

Velocity contour at 1.7 m from the floor

F2 Balcony CFD analysis results (Temperature)

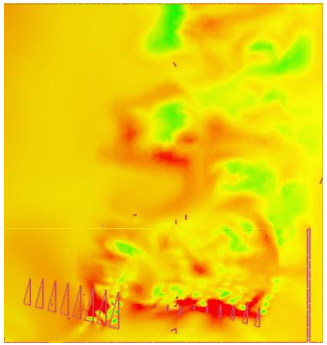






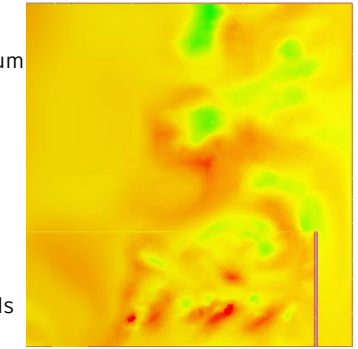
Towards Auditorium

Towards Wall



Towards Auditorium

Towards Wall

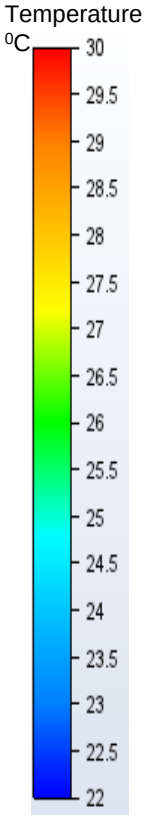


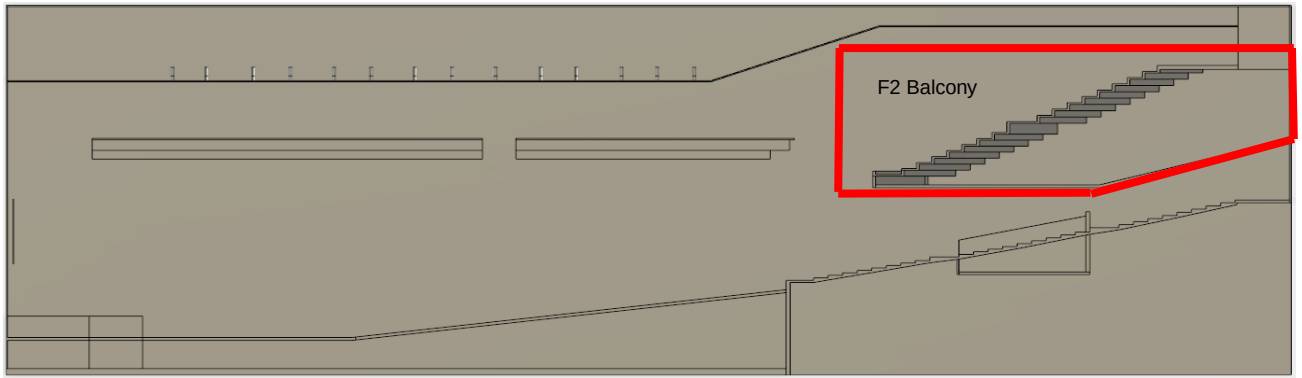
Temperature contour at 0.7 m from the floor

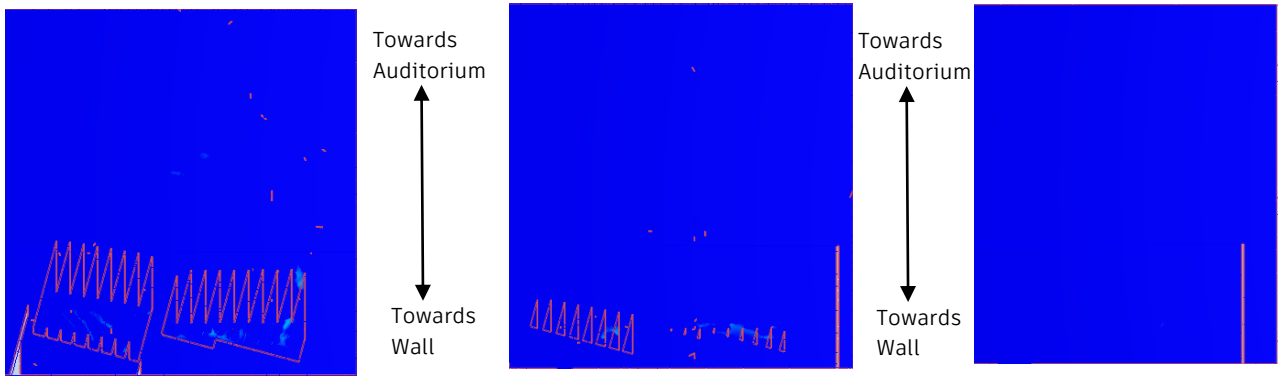
Temperature contour at 1.1 m from the floor

Temperature contour at 1.7 m from the floor

F2 Balcony CFD analysis results (Temperature)







Temperature contour at 0.7 m from the floor

Temperature contour at 1.1 m from the floor

Temperature contour at 1.7 m from the floor

Review results and evaluate design

Auditorium Hall- Thermal Comfort Evaluation

The velocity contour over the Main Auditorium Hall shows a uniform distribution of airflow.

The Temperature distribution in the Main Auditorium shows most of the occupied area within the recommended value of less than 22^{o} C.

The Temperature distribution in the F2 Balcony shows that most of occupied area has temperature in the range of 19^{o} C – 21.5^{o} C which is acceptable. Hence proposed air-conditioning system is adequate.

Wrap up

Key learnings:

- Identify specific workflows in Autodesk CFD
- Implement workflows
- Assess CFD results
- Validate design for thermal comfort in a large auditorium hall

Thank you for your attention and happy AU2021!

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