

Fire
and Evacuation Modeling Technical Conference

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Fire and Evacuation Modeling for a Large Commercial Building

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L&T Construction

Speaker's Profile

Mr. R. Balakrishnan

- Vice President & HEAD – MEP Design, Buildings & Factories (B&F) IC, L&T Construction
- 38+ years of experience in all facets of industry.
- Well versed in codes & standards like NBC, IS, BS, IEC, IEEE, NFPA, ISHRAE, ASHRAE, UPC,..
- Extensive experience in MEP design for large and iconic projects – airports, stadiums, hospitals, commercial buildings , datacenters etc.
- Active member of IEEE, ISLE, IEE & FSAI.
- Chartered Engineer from IEI (F-114811-3) and has done many publications in various forums.



Speaker's Profile

Dr. Munirajulu. M

- HEAD – CFD, Buildings & Factories (B&F) IC, L&T Construction
- 28+ years in CFD analysis as applied to MEP and special systems including HVAC, Fire Engineering, PHE and Electrical systems.
- Responsible for performance-based design for design and build projects using CFD technology.
- Extensive experience in CFD applications for egress and smoke management for large projects – airports, stadiums, commercial buildings, high-speed rail stations, data centers... Global conference speaker on CFD and has presented in international forums



BUILDINGS & FACTORIES

COMMERCIAL & RESIDENTIAL

IT , OFFICE SPACES & DATACENTER

- IT & Software Parks
- Office Buildings
- Data Centers
- R&D Centers

RESIDENTIAL

- Elite Housing
- Affordable & Mass Housing

FACTORIES

- Light & Heavy Factories
- Cement Plants
- Warehouses

HEALTH, PUBLIC SPACES & AIRPORTS

AIRPORTS

- Passenger Terminal Buildings
- MRO Facilities
- Cargo Terminals

PUBLIC SPACES

- Convention Centers
- Metro Stations
- Shopping Malls
- Stadiums,
- Museums
- Educational Institutions
- Hotels,
- Mixed-use Developments

HEALTH

- Hospitals
- Medical Colleges

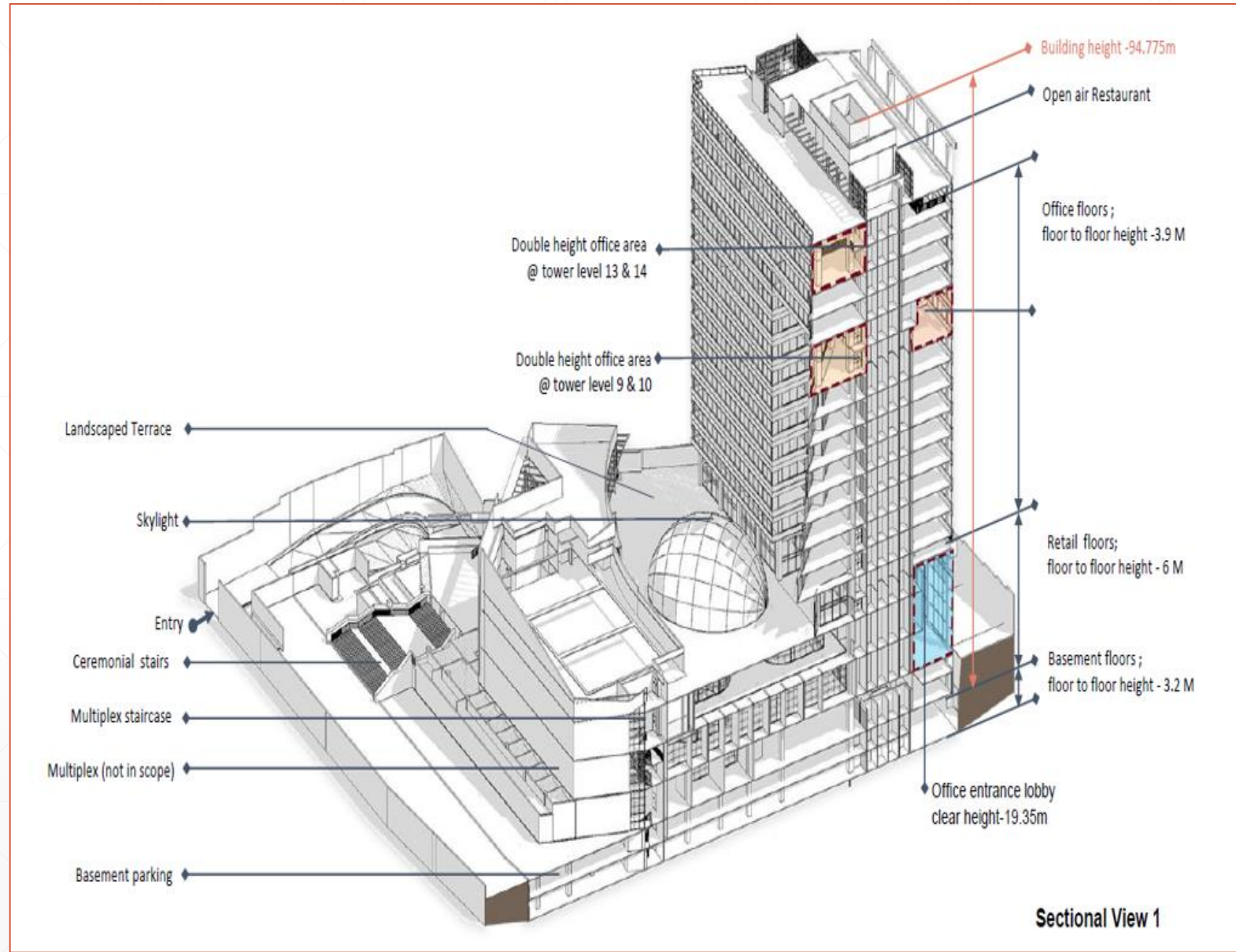
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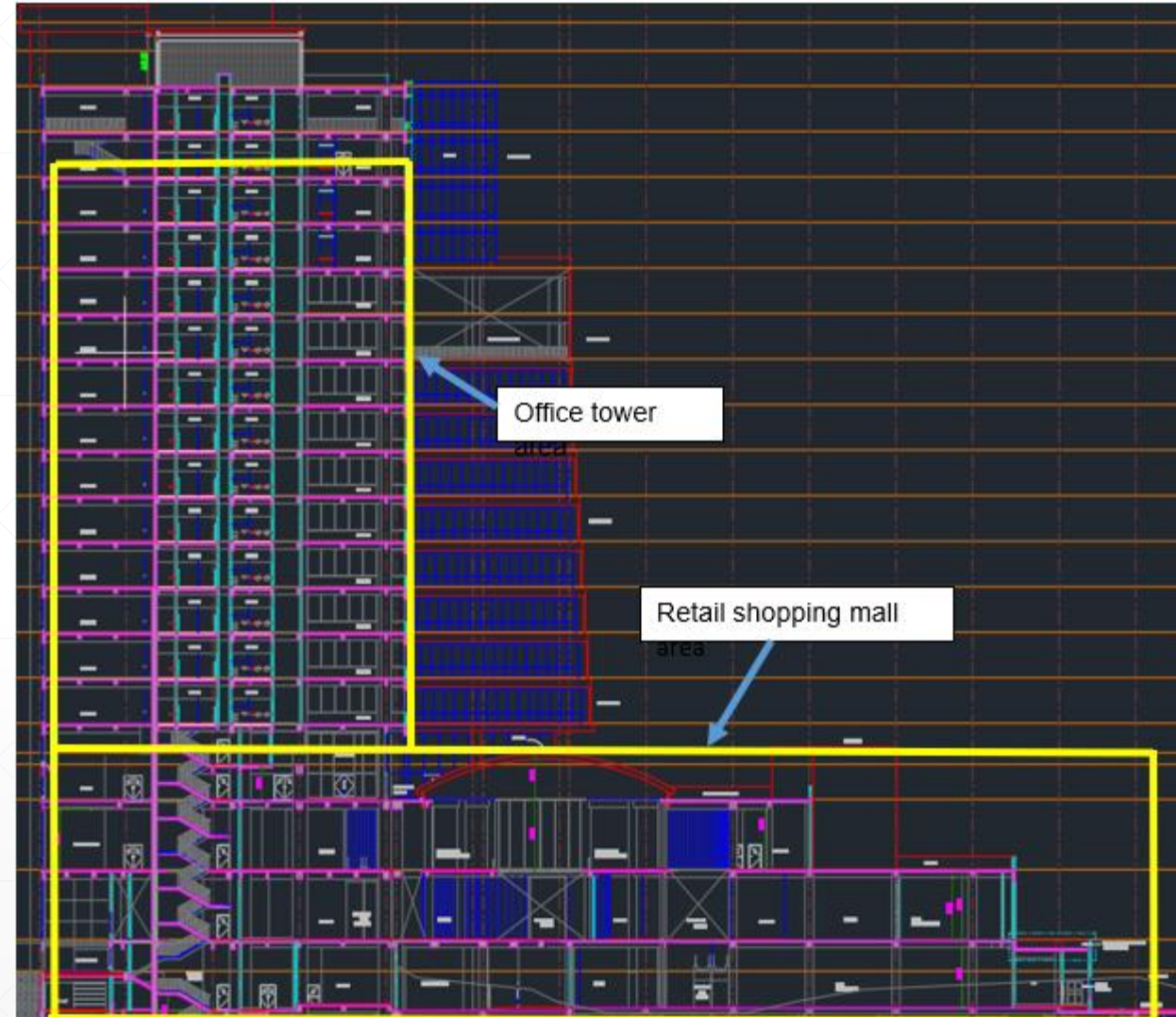
Introduction

- Building architecture – retail and office tower - staircases interlinked
- Local code (NBC 2016) – retail and office staircases – independent of each other
- Performance-based design for life safety
- Optimization?



Building Description

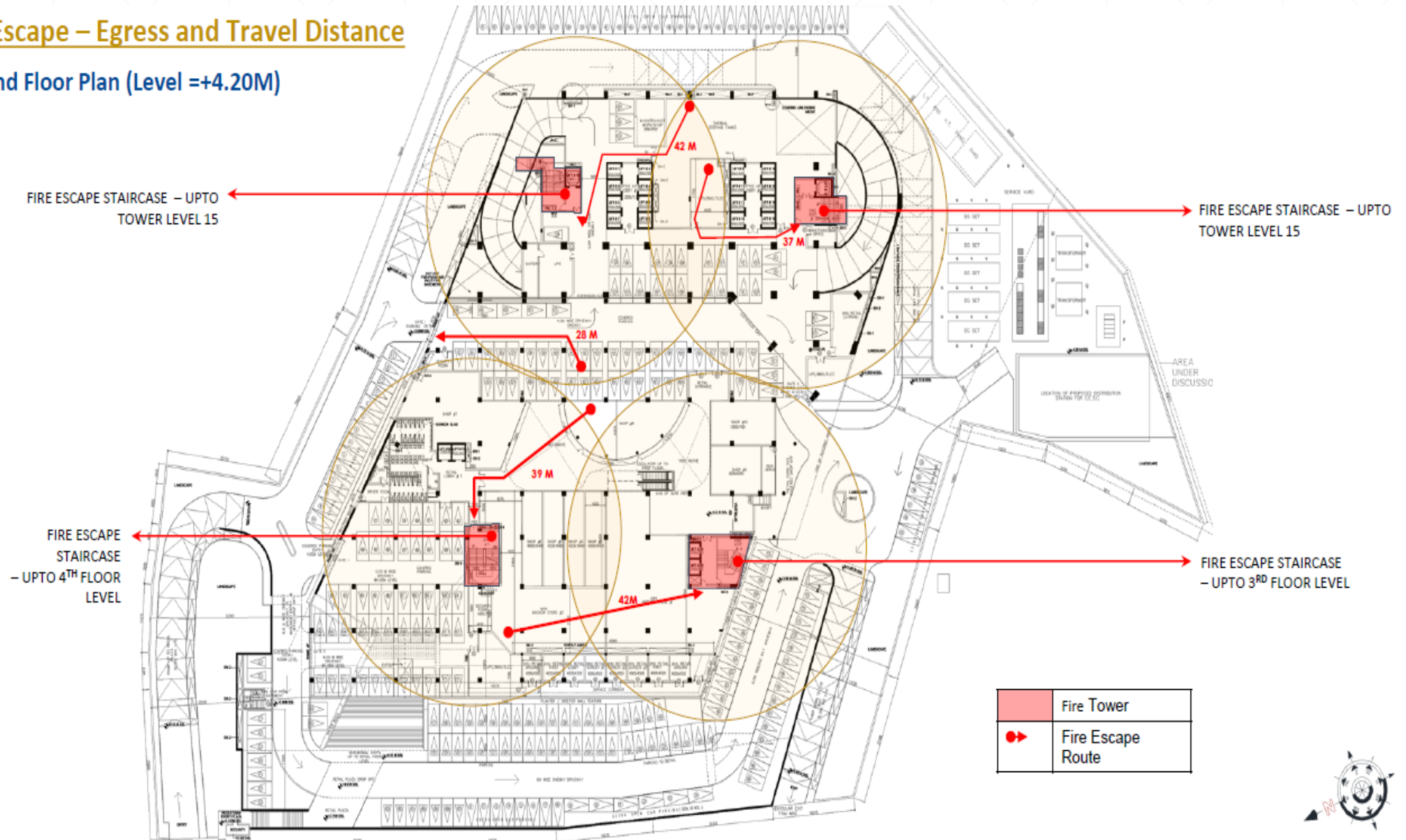
- Built up area– 76000 sq.m
- 1 office tower and 1 retail shopping mall area
- Retail shopping mall – G+4 Floors
- Office tower – 15 floors
- Fire escape staircases – 4nos.
- Refuge floors in office tower- 1st,5th,9th and 13th floor
- Final exits – at ground and 1st floor apart from 1 external staircase



Details of fire escape stairs

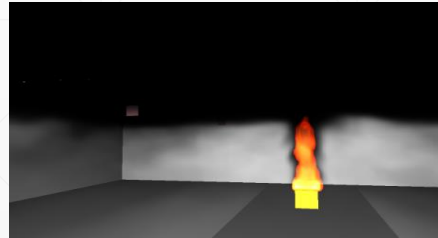
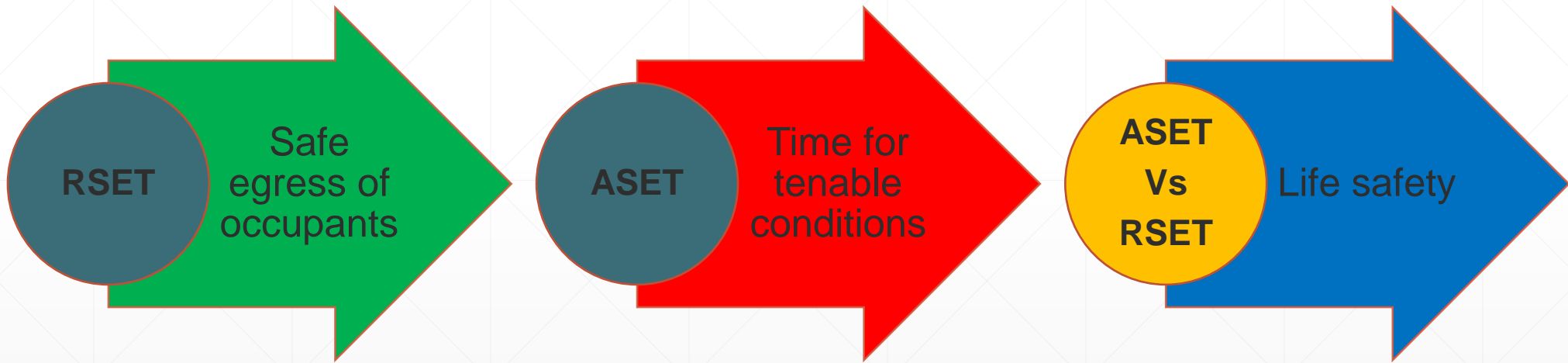
Fire Escape – Egress and Travel Distance

Ground Floor Plan (Level =+4.20M)



Project goal

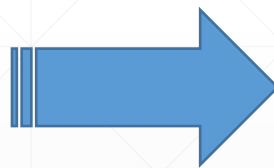
RSET - Required Safe Egress Time
ASET – Available Safe Egress Time



Methodology



Egress analysis is carried out for whole building except the basement B-1 & B-2



Smoke exhaust analysis is been carried out for 2nd floor in retail area and 14th floor office level

RSET

ASET

Pathfinder simulation

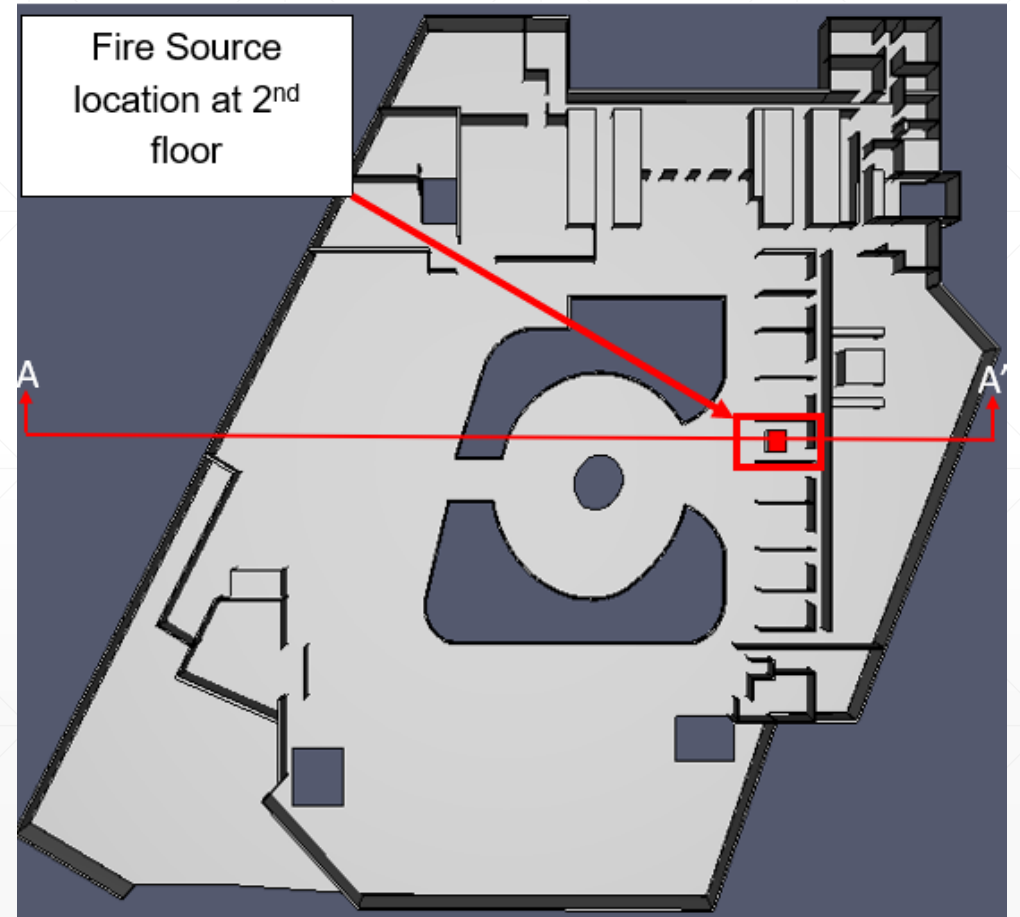
- Max velocity of occupants - 1.19 m/s
- Human occupant – cylinder (diameter = 0.45m and height = 1.7 m)
- Occupants will take nearest stairs or nearest exit from their respective positions

Floor	Function	Occupancy Considered	Total Occupants
Ground	Retail/Car Park/Common Area	Parking/Business/Assembly D-6	1327
1st	Retail	Assembly D-6	1056
2 nd	Retail/Multiplex/Food court	Assembly D-6	1587
3 rd	Retail	Assembly D-6	1082
4 th	Retail/Restaurant	Assembly D-6	278
Tower Level 1	Office/Refuge Area/Services	Business	270
Tower Level 2	Office/Refuge Area/Services	Business	273
Tower Level 3	Office/Refuge Area/Services	Business	273
Tower Level 4	Office/Refuge Area/Services	Business	259
Tower Level 5	Office/Refuge Area/Services	Business	258
Tower Level 6	Office/Refuge Area/Services	Business	259
Tower Level 7	Office/Refuge Area/Services	Business	259
Tower Level 8	Office/Refuge Area/Services	Business	259
Tower Level 9	Office/Cafeteria/Services	Business	187
Tower Level 10	Office/Cafeteria/Services	Business	231
Tower Level 11	Office/Refuge Area/Services	Business	267
Tower Level 12	Office/Refuge Area/Services	Business	267
Tower Level 13	Office/Refuge Area/Services	Business	173
Tower Level 14	Office/Refuge Area/Services	Business	182

FDS/PyroSim Simulation – Retail fire

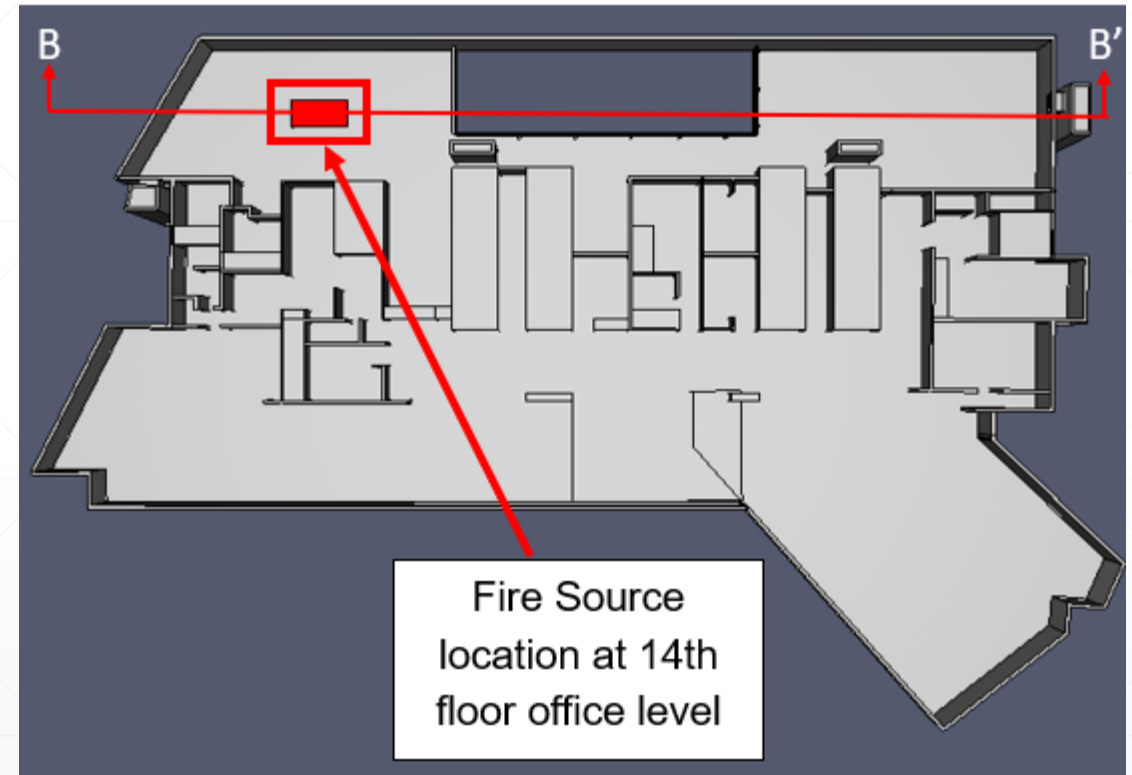
Fire Type	Retail
HRR	3.125 MW
HRR PUA	625 KW/sq.m
Fire area	5 sq.m
Fire size	2.236m x 2.236m x 2.0m
Soot yield	0.1 kg/kg

BS-7346-4:2003



FDS/PyroSim Simulation – Office fire

Fire Type	Workstation
HRR*	1.8 MW
HRR PUA	225 KW/sq.m
Fire area	8 sq.m
Fire size	4.0m x 2.0m x 0.8m
Soot yield	0.1 kg/kg



*Building and Fire Research Laboratory

FDS/PyroSim Simulation – Acceptance Criteria

VISIBILITY > 10 m
@ h=1.8 m

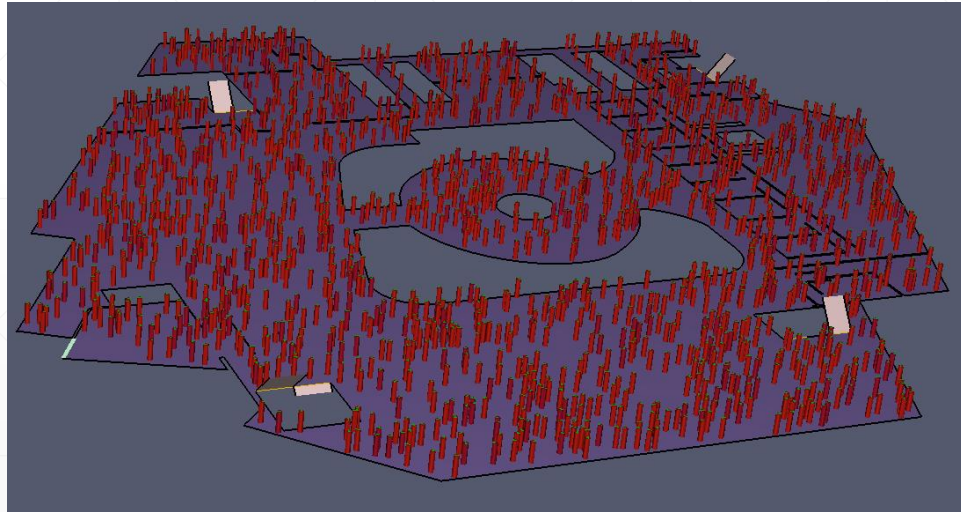
ASET

TEMPERATURE
< 60^o C @ h=1.8 m

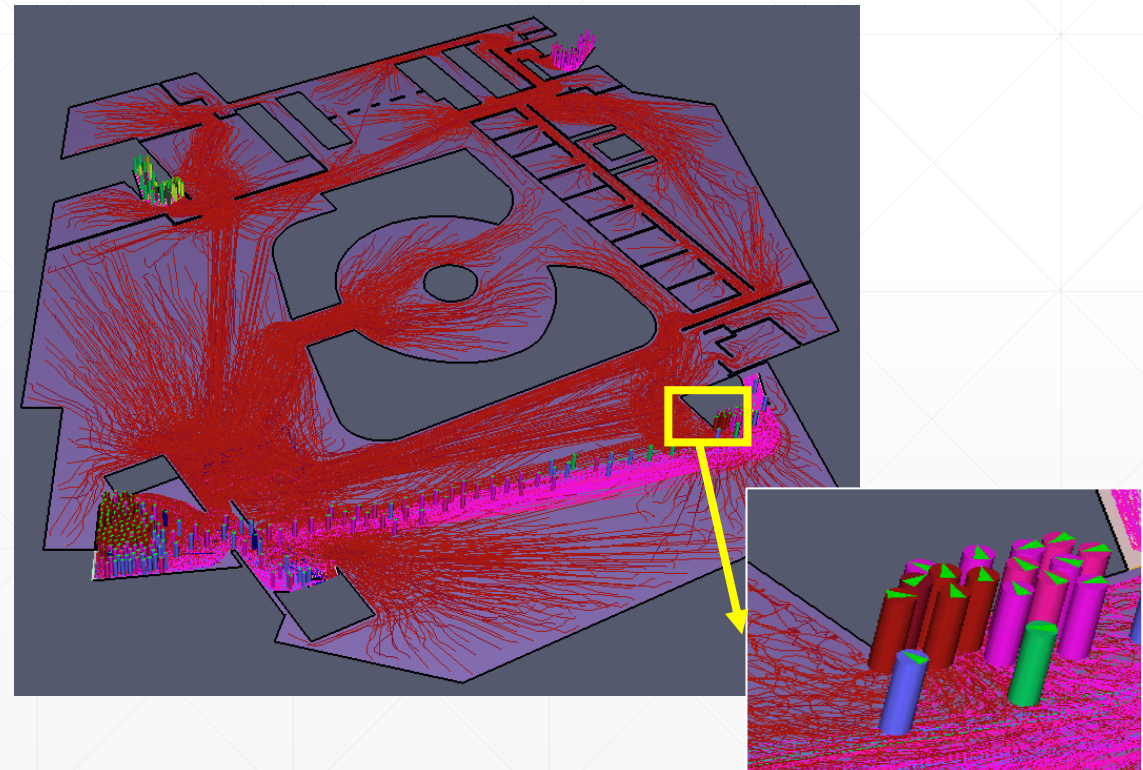
CIBSE Guide E & SFPE Handbook

Results - Pathfinder

Occupant distribution at 2nd floor at time = 0 seconds

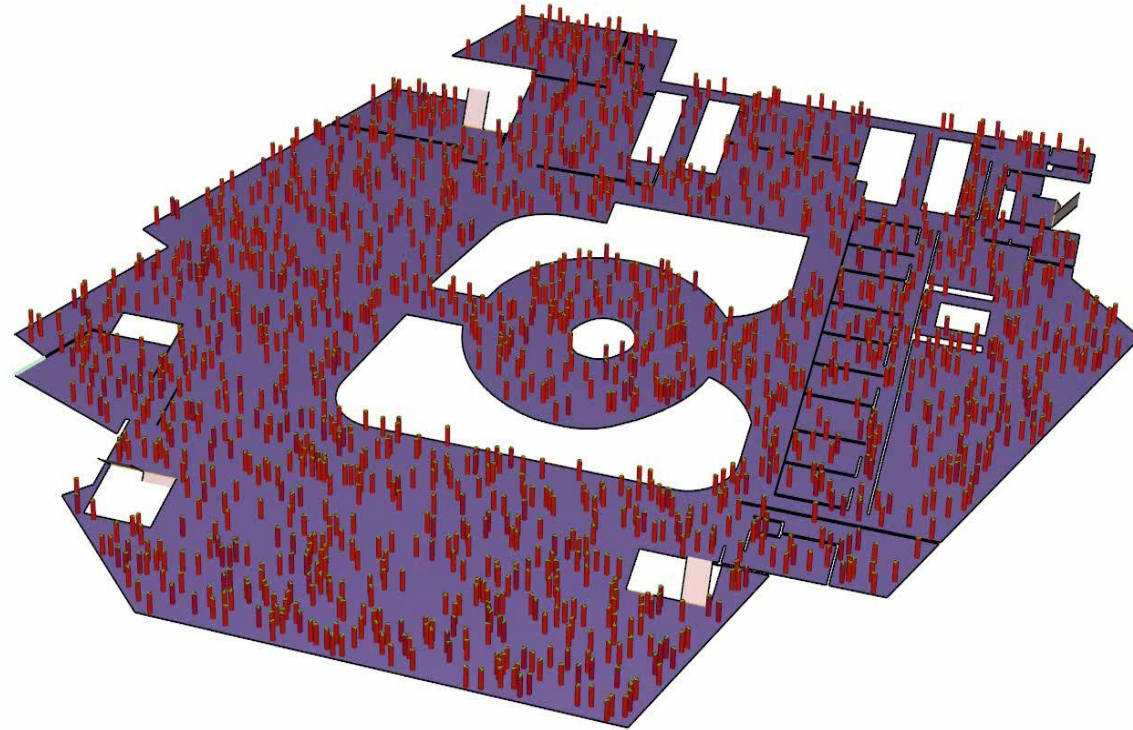


Occupant distribution at 2nd floor at time = 170 seconds



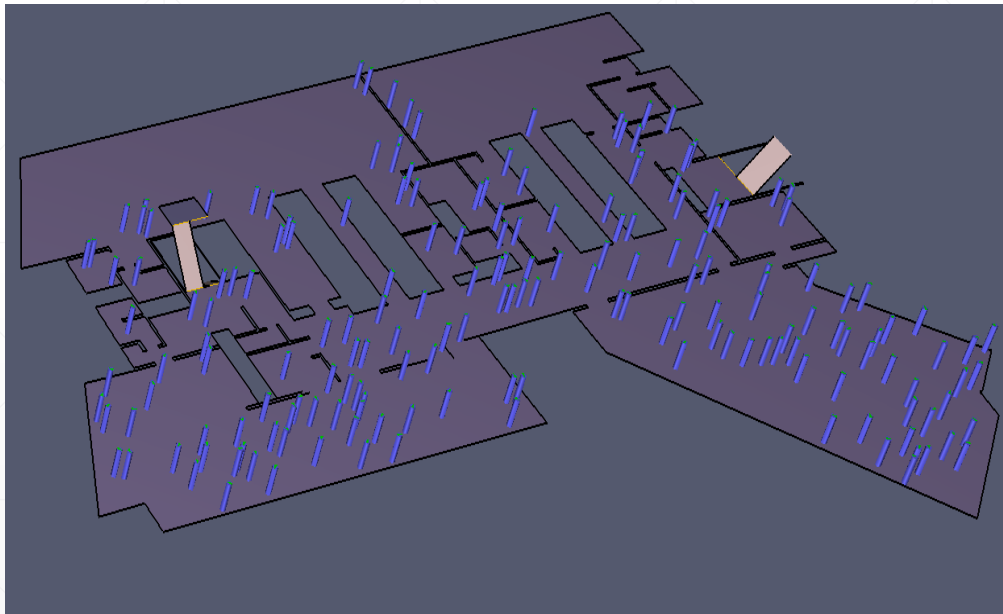
Occupant movement in 2nd floor retail area

Exited: 0/8717

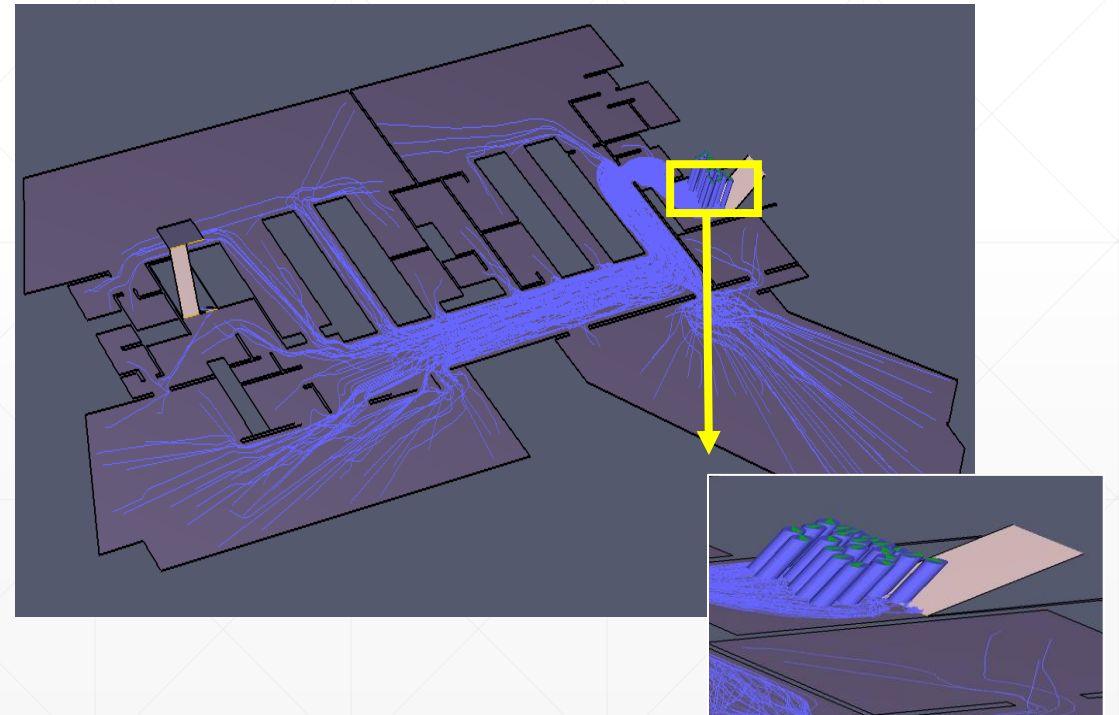


Results - Pathfinder

Occupant distribution at 14th office floor level at time = 0 second

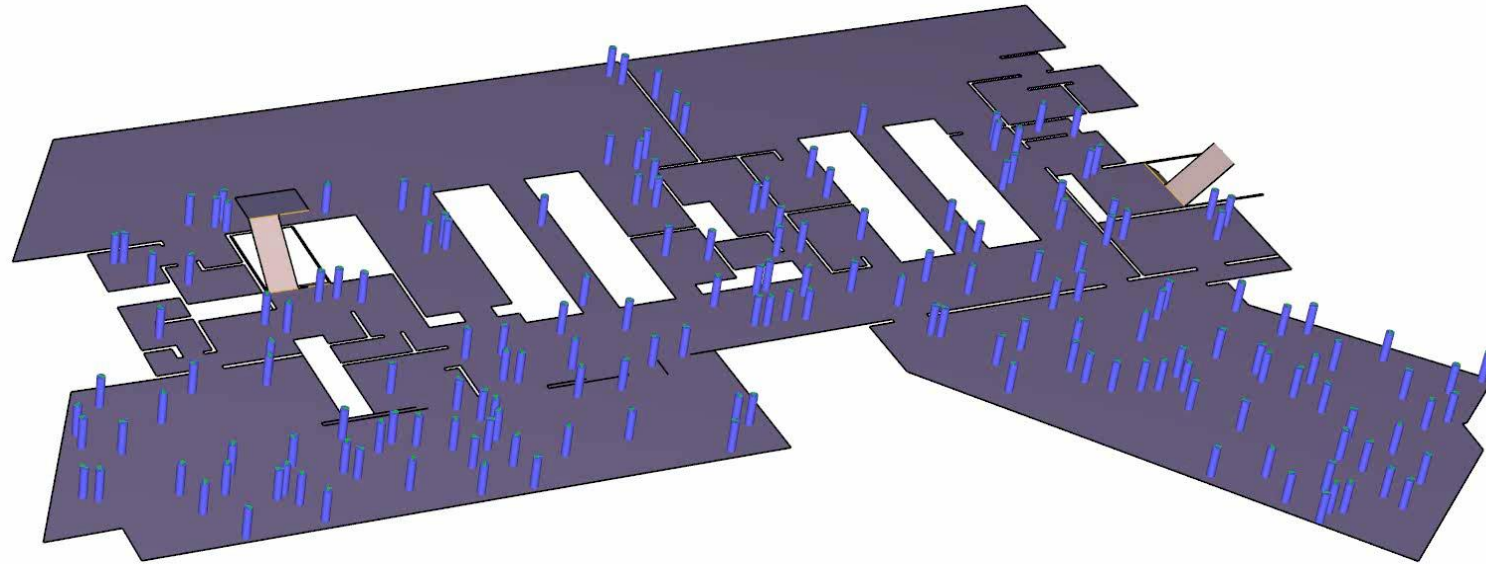


Occupant distribution at 14th office floor level at time = 108 seconds

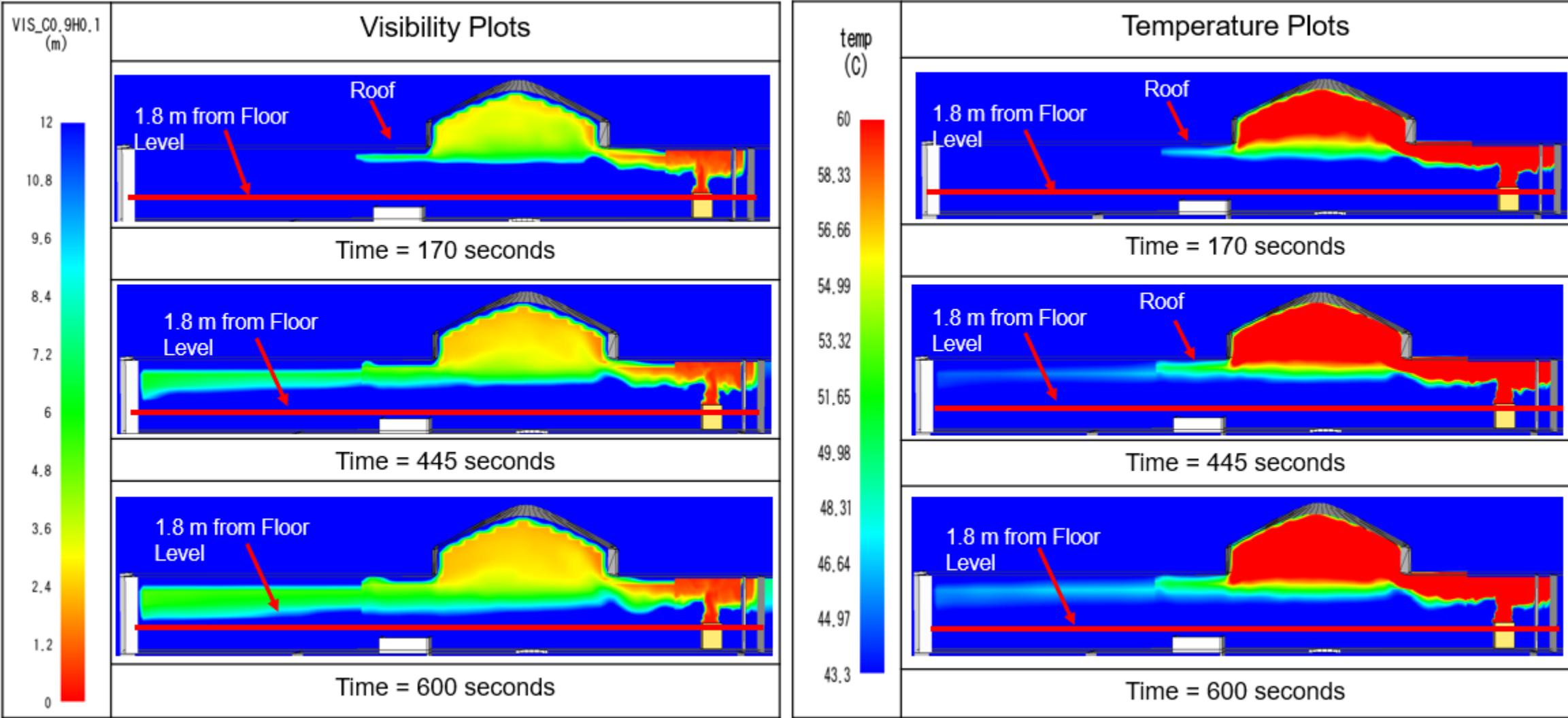


Occupant movement in 14th floor office area

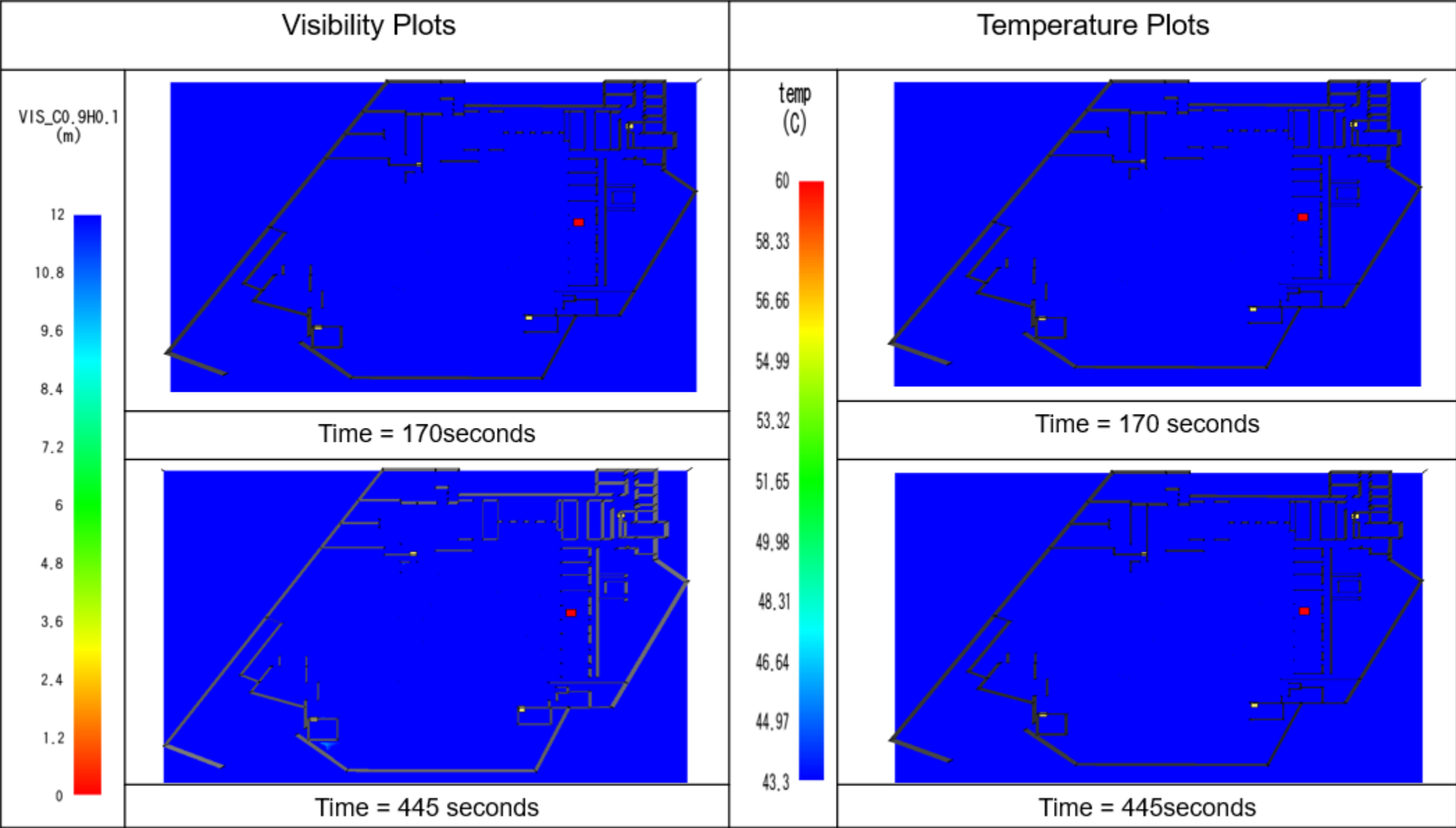
Exited: 0/8717



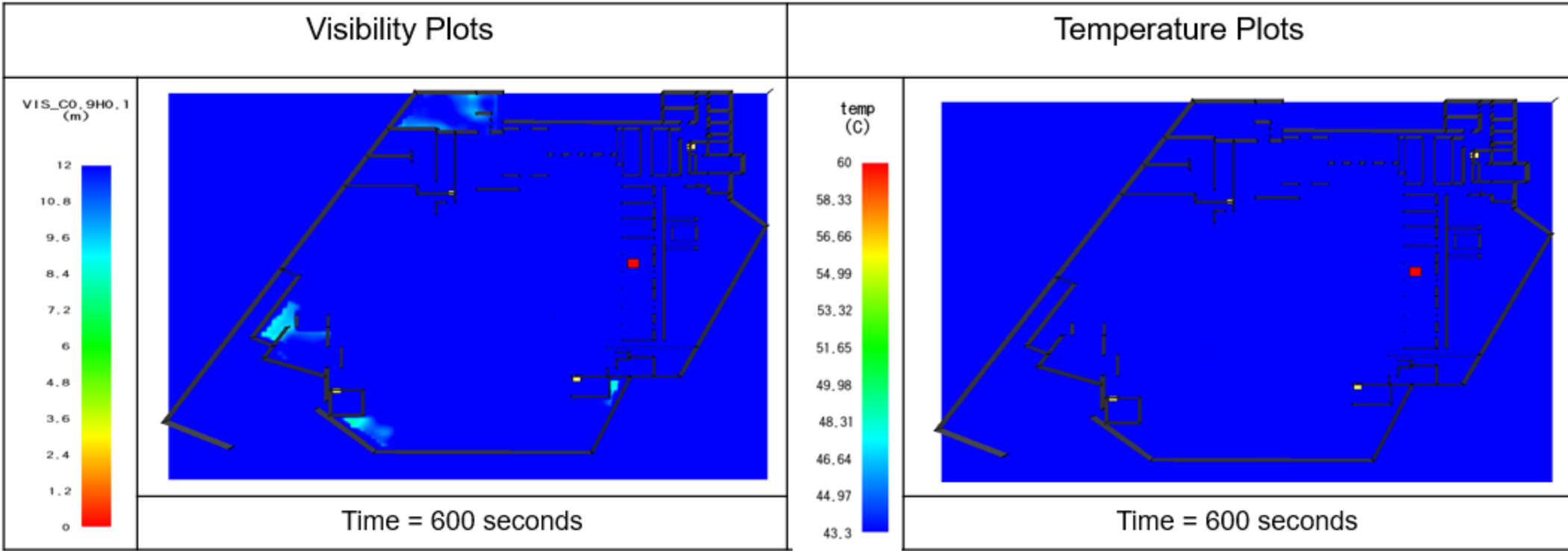
FDS/PyroSim Results - 2nd floor retail area (A-A')



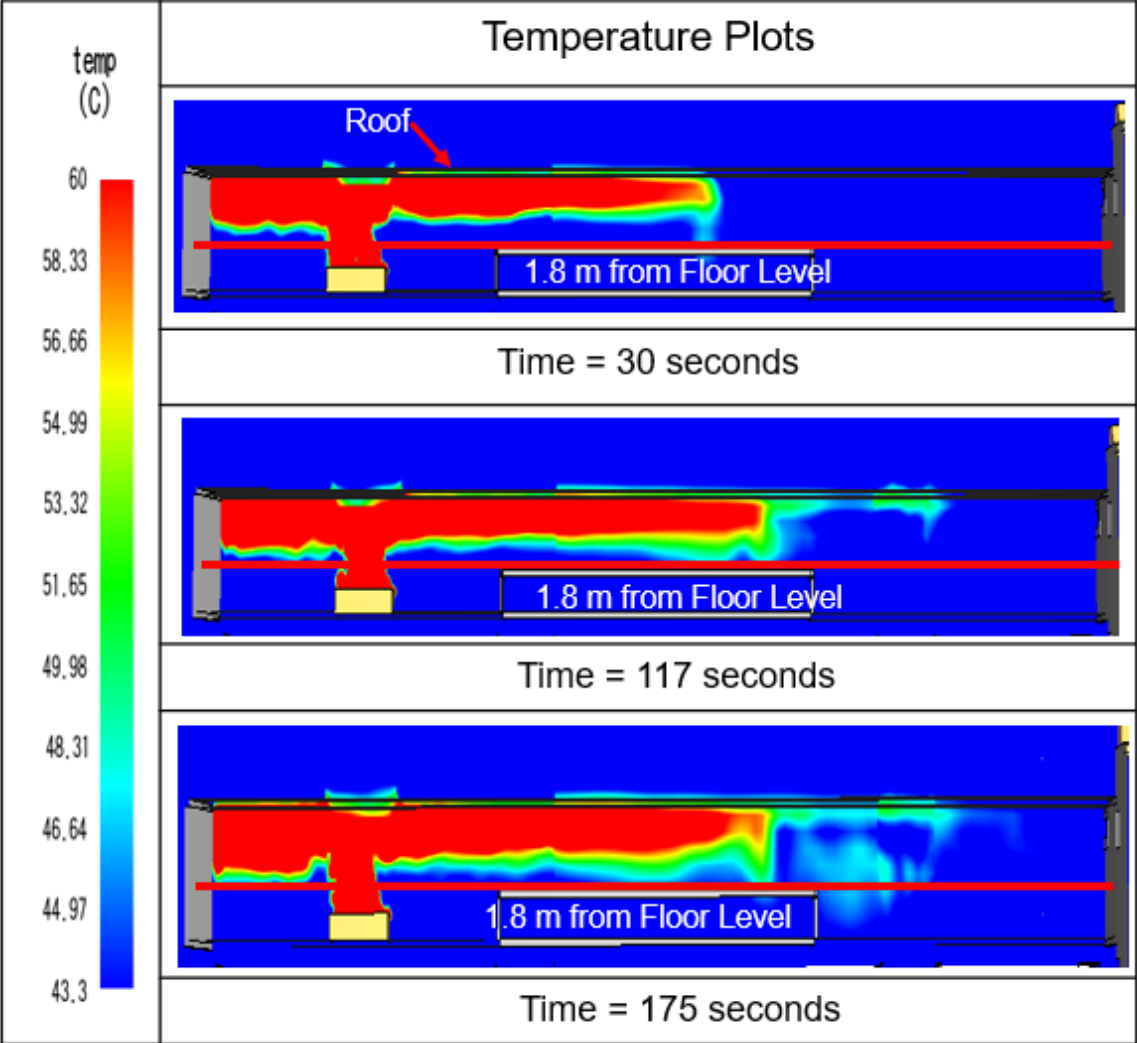
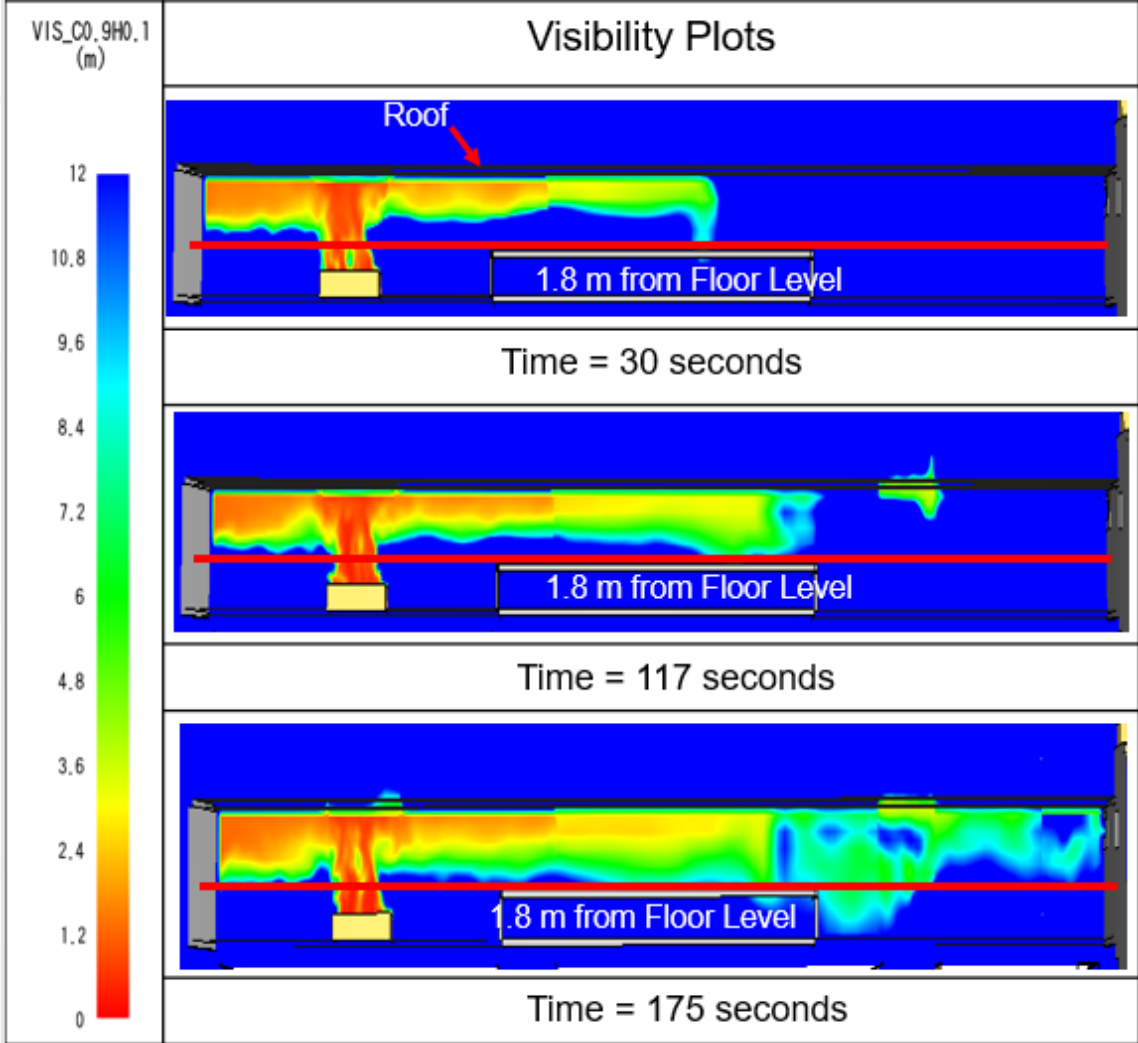
FDS/PyroSim Results - 2nd floor retail area (1.8m FFL)



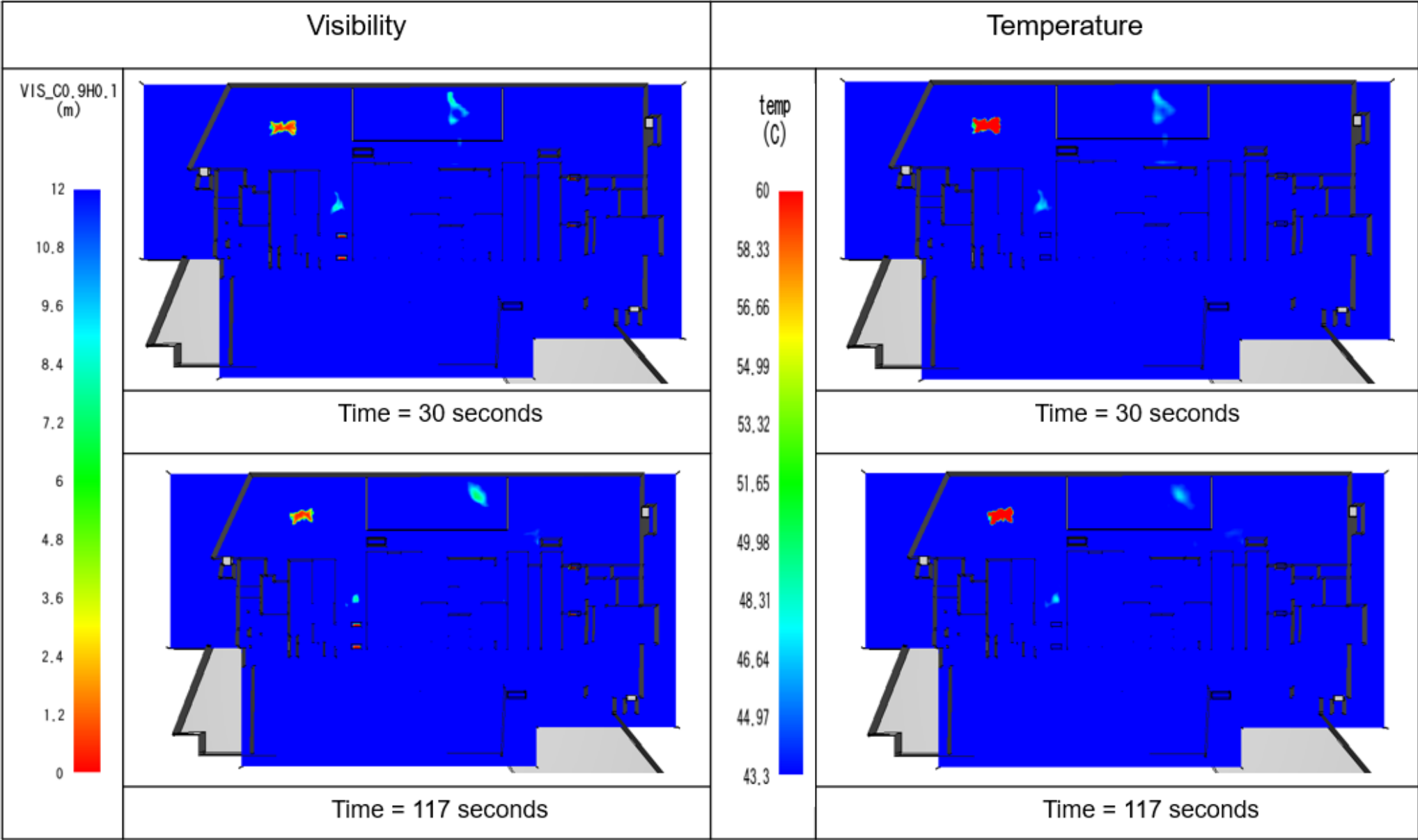
FDS/PyroSim Results - 2nd floor retail area (1.8m FFL)



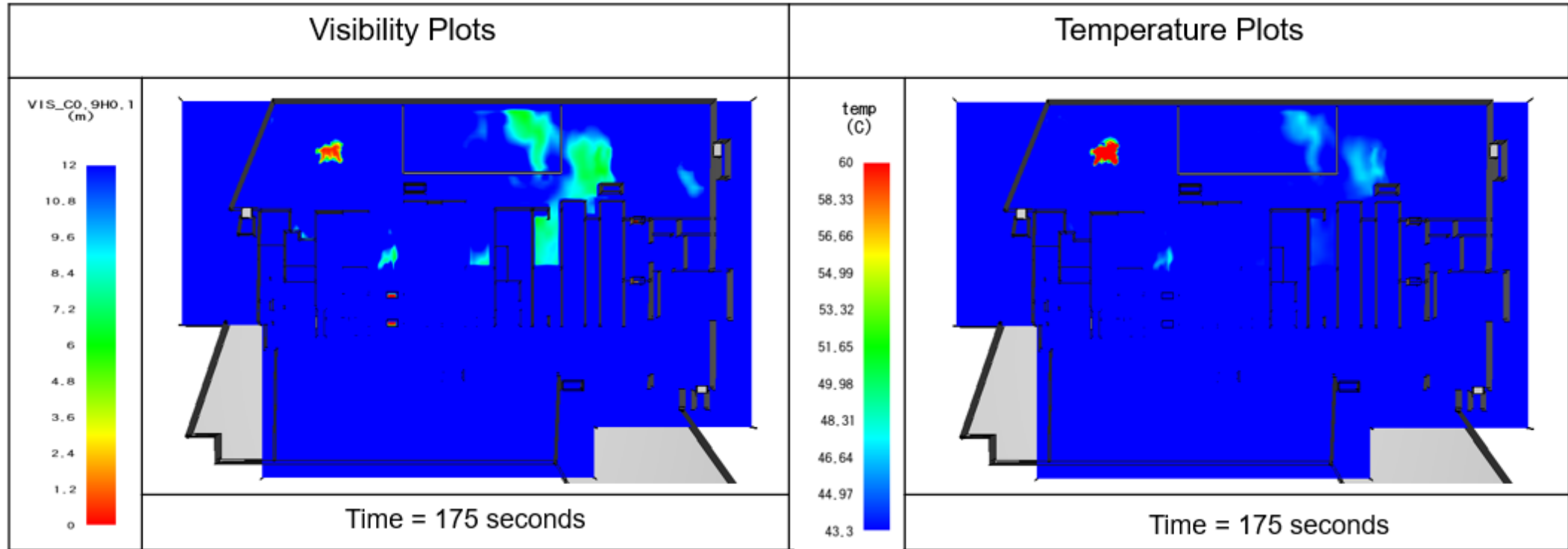
FDS/PyroSim Results – 14th floor retail area (B-B')



FDS/PyroSim Results – 14th floor retail area (1.8m FFL)



FDS/PyroSim Results – 14th floor retail area (1.8m FFL)



Conclusion: Retail floor

1. Smoke visibility is more than 10 m within the height of 1.8 m from the floor level for a duration of 10 minutes.
2. Smoke temperatures are less than 60⁰ C within the height of 1.8 m from the floor level except near the fire source region for a duration of 10 minutes.
3. Tenable conditions can be maintained for duration of 10 minutes, resulting in ASET (Available safe egress time) value of 600 seconds (10 minutes). RSET (Required safe egress time) value is 170 seconds as per egress time simulation
4. ASET >1.5 RSET. Therefore, provisions of staircases and smoke exhaust system is adequate for life safety for 2nd floor of retail area.
5. Total number of occupants = 1587. Requirement of staircase based on NBC 2016 = 15.87m. Only 5 staircases with total width of 12.5 m are sufficient as per egress analysis. So, based on the performance-based analysis of fire and egress in this project, total staircase width is reduced by 20%, resulting in a reduced number of fire escape staircases, thus providing opportunity for optimisation while ascertaining life safety.

Conclusion: Office floor

1. Smoke visibility is more than 10 m within the height of 1.8 m from the floor level except near the fire source region for the duration of 180 seconds.
2. Smoke temperatures are less than 60⁰ C within the height of 1.8 m from the floor level except near the fire source region for the duration of 180 seconds.
3. Tenable conditions can be maintained for duration of 175 seconds, resulting in ASET (Available safe egress time) value of 175 seconds. RSET (Required safe egress time) value is 117 seconds as per egress time simulation.
4. $ASET > 1.5 RSET$. Therefore, provisions of staircases and smoke exhaust system is adequate for life safety provided for 14th office floor level area
5. So, based on performance-based design analysis, 2 staircases with total width of 3 m is sufficient for egress of 182 occupants.

Thank you

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