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FIRE ENGINEERING REPORT

PROJECT/CLIENT:

UNIVERSITY OF WOLLONGONG - WESTERN BUILDING

NORTHFIELDS AVENUE WOLLONGONG NSW 2500

ARCHITECT:

HASSELL LIMITED

23 HICKSON ROAD, MILLERS POINT SYDNEY NSW 2000

PRINCIPAL CERTIFYING AUTHORITY:

GROUP DLA

SUITE 1202, LEVEL 12, 109 PITT STREET SYDNEY NSW 2000

DOCUMENT CONTROL & HISTORY

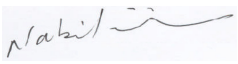
Revision	Issue	Date
-.	Consultant Advice for Stakeholders Discussion and Comments.	27/07/2017
0.	Fire Engineering Brief for PCA approval, Architect Comments and Client Information.	15/08/2017
1.	Draft FER for PCA Review/Comments and Stakeholders Information.	28/08/2017
2.	Revised Draft with updated architectural plans and updated BCA Compliance Report.	11/09/2017
3.	Revised Draft with updated architectural plans and information requested by PCA.	18/09/2017
4.	Final incorporates more details for fire safety measures.	04/10/2017
5.	Final for SSD submission.	01/11/2017

PREPARED BY:

ABS Fire Safety

ABS FIRE SAFETY PTY LTD.

32 LOVELL ROAD EASTWOOD NSW 2122



REPORTED BY:

NABIL GIRGIS.

MIFireE-UK, MEngNZ, MIEAust, RPEQ, NER, SFPE
CPEng (Civil, Structure & Fire Safety)
NSW Accredited Certifier Fire Safety -C10
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QLD Registered Civil / Fire Safety

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1 EXECUTIVE SUMMARY

1.1 FIRE SAFETY ENGINEERING BRIEF

The subject building is educational assembly building within University of Wollongong campus located at Northfields Avenue Wollongong NSW 2500.

Performance Solutions are developed for deviations to the DTS provisions of the NCC Volume One. These Performance Solutions must demonstrate compliance with the relevant Performance Requirements of the NCC Volume One. The proposed Performance Solutions to the DTS provisions of the NCC is summarised in **Table 1** below.

Table 1- Summary of DTS Provisions, Proposed Performance Solutions, Relevant Performance Requirements & Proposed Approach and Assessment Methods

NCC Clause Description of DTS Provision	Proposed Performance Solution or DTS Solution	Relevant Performance Requirements ClauseA0.7	Meeting NCC Performance Requirements	NCC Assessment Methods
Clause C2.2: The size of any fire compartment or atrium in Classes 5 to 9 must not exceed the relevant maximum floor area or the relevant maximum volume set out in Table C2.2.	The building floor area exceeds 8000m² and volume exceeds 48000m³. It is proposed to divide the building into two (2) separate fire compartments each of less than 8000m² floor area and less than 48000m³ volume	CP1 & CP2.	A0.2(b); by Deemed-to-Satisfy Solution.	A0.5 (d): Comparison with the Deemed-to-Satisfy Provisions. **SS: B & C.**
Clause 3.3: The distance between parts of eternal walls and any openings within them in different fire compartments separated by a fire wall must not be less than that set out in Table C3.3 unless walls have an FRL not less than 60/60/60 and any opening protected in accordance with C3.4.	No separation distance between non-fire-rated external walls and associated unprotected openings of different compartments in Level 3, based on sprinklered building	CP2.	A0.2(a): by Performance Solution.	A0.5 (b) (i): other verification method in the NCC
Clause D1.3 & D1.12: Stairs which connect or pass by more than 3 storeys is required to be fire-isolated.	The building contains non-fire-isolated required exit stairway and atrium open stair (is considered non-required exit). It is proposed to create glazed partitions and doors protected with drenchers, doors fitted	DP5.	A0.2(b); by Deemed-to-Satisfy Solution.	A0.5 (d): Comparison with the Deemed-to-Satisfy Provisions. **SS: B & C.**

NCC Clause Description of DTS Provision	Proposed Performance Solution or DTS Solution	Relevant Performance Requirements ClauseA0.7	Meeting NCC Performance Requirements	NCC Assessment Methods
	with self-closing devices and can be kept opened with magnetic tapes (stoper / holder) that automatically released with fire alarm. Drenchers to be controlled with separate valve.			
Clause D1.4: Exit travel distance should not exceed 20m to POC, 40m to alternative exit; and Clause D1.5 (a) & (b): < 60m, > 9m between alternative exits; and Clause D1.5 (c): alternative paths of travel do not converge at < 6m. D1.9: non-fire-isolated stairway must provide continuous means of travel to the level of egress to road or open space.	It is proposed, in some areas, to justify travel distance >20m to POC/single exit (up to 30m permitted), > 40m to alternative exit (≈ 45m) and minimum of 4m convergence of paths of travel, based on automatic fast-response sprinkler protection that is over and above NCC DTS Provisions, and demonstrate successful total building evacuation analysis ASET/RSET, including time to pass through doors, with acceptable life safety factor > 1.5. Stairway from plant room discharges at Level 3	DP4, DP6 & EP2.2.	A0.2(a): by Performance Solution.	A0.5 (b) (ii): other verification method as the appropriate authority accepts. **SS: E.**
Clause E1.3: Hydrant booster and pump in the sight of main entry.	It is proposed for hydrant booster and pump to be located not within sight of main entry with sufficient signage to be provided to fire brigade personnel.	EP1.3 & EP1.6.	A0.2(a): by Performance Solution.	A0.5 (b) (ii): other verification method as the appropriate authority accepts. **SS:F.**
Clause E2.2, Table E2.2a: Required exits serving an atrium to which Part G3 applies must be provided with automatic stair pressurisation	It is proposed to omit stair pressurisation system requirements for both north fire isolated stairway and east fire isolated stairway. Atrium open stair (is considered non-required exit, the atrium also has automatic smoke exhaust fans).	EP2.2.	A0.2(a): by Performance Solution.	A0.5 (b) (ii): other verification method as the appropriate authority accepts. **SS: E.**
Clause G3: Atrium Construction G3.2: Well cylinder 6m diameter; and G3 & G4: Bounding walls 60/60/60 at no	It is proposed not to comply with NCC DTS Provisions related to atrium construction and well size based on fast-response sprinkler protection plus automatic	EP2.2.	A0.2(a): by Performance Solution.	A0.5 (b) (ii): other verification method as the appropriate authority accepts. **SS: E.**

NCC Clause Description of DTS Provision	Proposed Performance Solution or DTS Solution	Relevant Performance Requirements ClauseA0.7	Meeting NCC Performance Requirements	NCC Assessment Methods
more than 3.5m from well perimeter.	smoke exhaust fan or smoke-and-heat vent activated by automatic smoke detection system and automatic sprinklers and demonstrate successful total building evacuation analysis ASET/RSET, including time to pass through doors, with acceptable life safety factor > 1.5.			
NSW Part H101: Entertainment Venues.	It is proposed not to provide fire separation to entertainment venue area and between stage and audiences seating based on fast-response sprinkler protection that over and above NCC DTS Provisions and smoke management, if required, with complying egress provisions.	EP2.2.	A0.2(a): by Performance Solution.	A0.5 (b) (ii): other verification method as the appropriate authority accepts. **SS: E.**

1.2 RECOMMENDATIONS/SCOPE OF WORK

1. This report is prepared for Western Building within University of Wollongong campus located at Northfields Avenue Wollongong NSW 2500, and not to be used for any other purpose.

2. All Fire Safety Measures required, are to be designed, installed and maintained in accordance with NCC Provisions and relevant Australian Standards, or otherwise as assessed, identified, determined and accepted by the relevant authorities.

3. The fire engineering assessment of this report based on the subject building population of 643 people, as advised by the UOW[1].

4. The proposed fire compartmentation walls, as detailed below, to be constructed with an FRL of 120/120/120.

   Where the proposed fire compartment boundary necessitate passing through line where no walls required from the Architectural prospect, a drencher-protected glazed partition to be used (drenchers installed in both sides of the glass).

   Where the proposed fire compartment boundaries necessitate passing through corridors a drencher-protected glazed partition and door leaves to be used. Drenchers protected glass

[1] UOW Western Building - Room Data Schedule

door can be held opened with magnetic tapes and automatically released to closed position with fire alarm (drenchers installed in both sides of the glass).

5. The proposed Eastern Stairway fire separation walls to be constructed with an FRL of 120/120/120.

   Where the proposed fire separation walls necessitate passing through line where no walls required from the Architectural prospect, a drencher-protected glazed partition to be used (drenchers installed in both sides of the glass)..

   Where the proposed fire compartment boundaries necessitate passing through doorways a drencher-protected glazed partition and door leaves to be used. Drenchers protected glass door can be held opened with magnetic tapes and automatically released to closed position with fire alarm (drenchers installed in both sides of the glass).

6. Illuminated exit signs to be placed in both sides above the horizontal exits between the atrium fire compartment and both north wing fire compartment & east wing fire compartment. Doors to swing in both directions.

7. Clear signage and block plan to AS2419 to be installed at the building main entrance and next to FIP indicating location of booster assembly, pump room and nearest fire-isolated stairway.

8. A pole signage to AS2419 to be provided at booster location towards the building main entry.

9. A signage to AS2419 to be provided on pump/valve room door.

10. Smoke test to be conducted, during final signoff inspection, to examine efficiency of atrium smoke fan with amount of makeup air provided with building geometry. Any recommendations raised from test, such as doors to be closed or opened with fire alarm or the like, to be included with the building AFSS, for regular inspection.

11. The building to be divided into three fire compartments of less than 8000m² floor area, (North Fire Compartment and East Fire Compartment and rooftop plants Fire Compartment), with north fire compartment to be served with fire-isolated stairway and east fire compartment to be served with fire-isolated stairway.

    Solid lines indicate fire walls with an FRL of 120/120/120.

    Dotted lines indicate drenchers-protected glazed partitions.

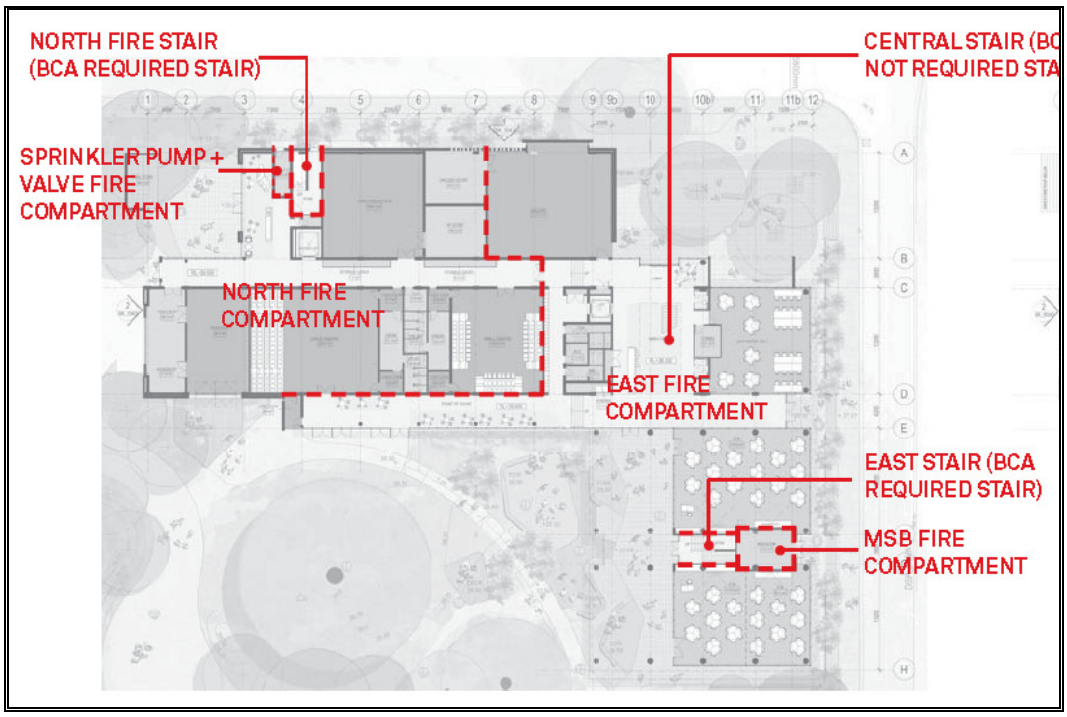

Figure 1 – Ground Level Fire Compartments.

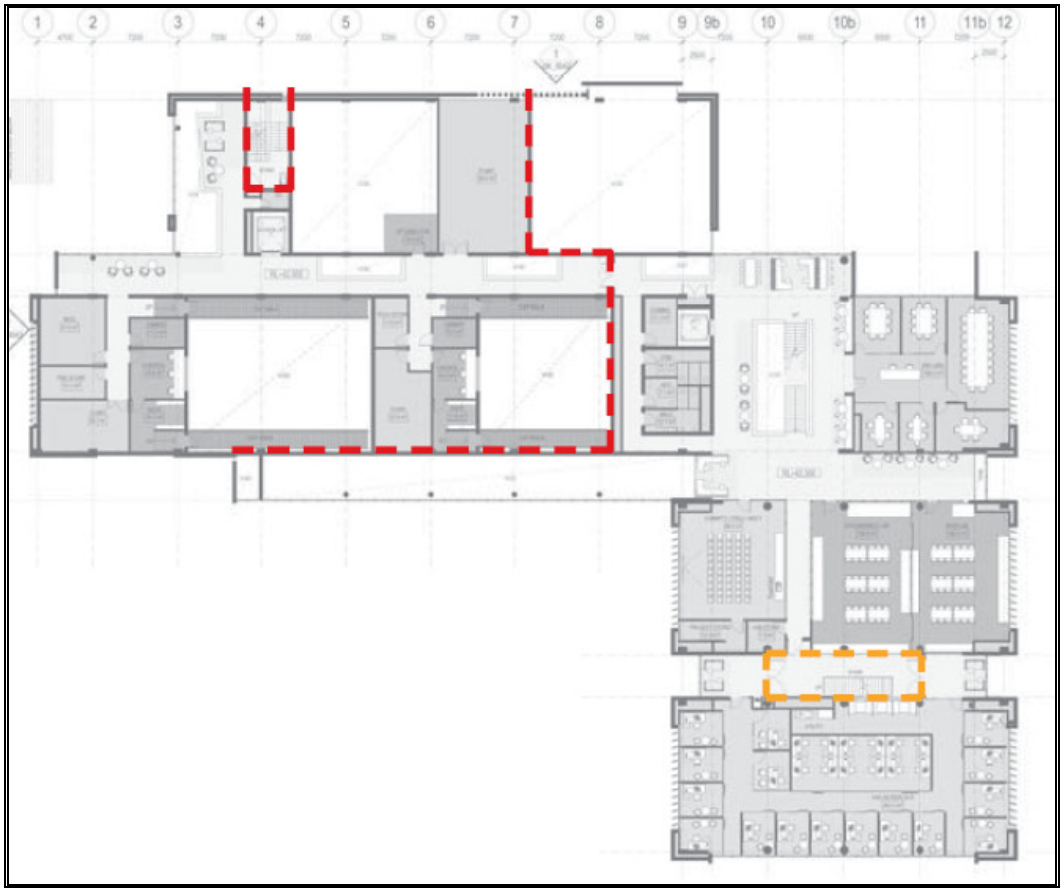

Figure 2 – Level 1 Fire Compartments.

Figure 3 – Level 2 Fire Compartments.

Figure 4 – Level 3 Fire Compartments.

Figure 5 – Level 4 (Plants) Fire Compartments.

12. The following fire safety systems are recommended to be provided throughout the building, as part of the completed fire safety systems identified by the Principal Certifying Authority:-

- Recommended provisions of automatic, fast response, sprinkler system to be installed to the entire building in accordance with NCC Clause E1.5 and AS2118-1999.
- Recommended side-wall drenchers to all glazed partitions/doors required as a fire separation walls for fire compartmentation (drenchers installed in both sides of the glass).
- The estimated response time from the activation of the sprinkler heads in the building to the activation of the pressure switch that activates the Addressable occupant warning system and signal to Fire Brigade monitoring system - as referenced in AS 2118.1-1999, Clause 8.10.1 - should be no greater than 90 sec.
- Fire hydrant system in accordance with NCC Clause E1.3 and Australian Standards AS2419.1-2005, except as permitted under this report (remote booster).
- Fire hose reel system in accordance with NCC Clause E1.4 and Australian Standards AS2441-2005 – (FHR coverage and flow to be confirmed).
- Portable fire extinguishers in accordance with NCC Clause E1.6 and Australian Standards AS2444 - 2001(To be inspected for compliance with AS2444).
- Automatic smoke detection and alarm system in accordance with NCC NSW Table E2.2B and NSW Specification E2.2a. Heat detectors to theatres spaces.
- Smoke management system; the activation of automatic sprinkler system and/or automatic smoke detection system to activate the automatic shutdown of the air-

handling system and automatic activation of stage smoke-and-heat vents (if required). System monitoring to be provided to AS1670.3-2004.

- Requirements of NSW Table E2.2b that requires that a stage with a floor area of more than 300m² must have a smoke exhaust system over the stage, is to be subject to an Performance Solution with heat and smoke vent to be installed and to be automatically opened with fire alarm.
- Emergency lighting in accordance with NCC Clause E4.2, E4.4 and Australian Standard AS2293.1 – 2005.
- Exit signage in accordance with NCC Clause E4.5, NSW E4.6 & E4.8 and Australian Standard AS2293.1 – 2005.
- All fire safety systems, including standby power supply, to be maintained in accordance with AS1851and relevant Australian Standards. The building Fire Safety Schedule and Annual Fire Safety Statement to include recommendations of this report with reference to this report and brief of the Performance Solutions.
- Sound systems and intercom systems for emergency purposes (system to be tested for compliance with NCC Clause E4.9). Recorded Message "Fire Alarm Evacuate Now"
- Atrium automatic mechanical smoke exhaust fan in compliance with NCC DTS Provisions (refer to mechanical design details).
- Horizontal exits between fire compartments to swing in both directions
- Doorways to north and east fire-isolated stairways to be fitted with smoke sealant and horizontal exits doorways between atrium fire compartment and north & east fire compartments to be fitted with smoke sealant.
- Lightweight Construction in accordance with Spec C1.8 (subject to confirmation of proposed construction method of internal fire walls)
- Fire Seals in accordance with AS1530.3
- Fire rated lift landing doors to AS1735.11
- Automatic Failsafe Devices to Part D2.21 of the BCA
- Smoke Curtain (or the like) to separate topmost floor to the atrium open well.
- Smoke sealant to all fire doors between fire compartments and to both fire-isolated stairways.

13. Emergency Organisations and Procedures are to be specifically developed, implemented and monitored for the subject building in accordance with AS 3745-2010, and to incorporate the following as a minimum:
    - The entire building to have a restricted non-smoking policy.
    - Clear exit paths of 1m minimum width (or greater where required for number of occupants).

- Hot-work to be carried out by minimum of 2 trained staff.
- Materials in compliance with Clause C1.10, Specification C1.10, NSW Clause C1,10 and NSW Specification C1.10 to be selected for all future finishes of renovation works and fittings, as an additional fire spread prevention measures.
- Separate controlling valve to sprinkler system and wall wetting drenchers system; so that isolation of building water supply during any maintenance works or the like, will not isolate sprinkler system water supply or wall wetting drenchers. Sprinkler valve and wetting drenchers' valve must be fitted with anti-tamper devices connected to a monitoring panel at building management or the location normally used by the staff such as staff room or offices.
- The following management procedure to be followed where any maintenance works is carried out inside the building and required sprinkler system or wall wetting drenchers to be isolated:
  - The sprinkler system to be re-charged at the end of each day
  - A written permission to be issued stating the length of isolation
  - The maintenance staff to sign off at the completion of work that the sprinkler system is re-charged and in a normal working order.

14. The fire engineering assessment shows that identified non-fire-rated external walls and associated openings at less than 6m from another fire compartment do not impose any additional risk for spread of fire and recommended to be permitted by relevant authorities.

15. The fire engineering assessment shows that identified extended travel distances (≈45m) and distance between alternative exits along are adequate, to the degree necessary, subject to recommendations of this report to be implemented, and recommended to be permitted by relevant authorities.

16. The fire engineering assessment shows that omission of north and east stairways pressurisation is adequate, to the degree necessary, subject to recommendations of this report to be implemented, and recommended to be permitted by relevant authorities.

17. The fire engineering assessment shows that proposed atrium well geometry is adequate, to the degree necessary, subject to recommendations of this report to be implemented, and recommended to be permitted by relevant authorities.

18. The fire engineering assessment shows that omission of stair pressurisation, fire separation of atrium area and internal fire separation within the entertainment venue part of the building is adequate, to the degree necessary, subject to recommendations of this report to be implemented, and recommended to be permitted by relevant authorities.

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END OF RECOMMENDATIONS/SCOPE OF WORK

2 INTRODUCTION

2.1 SCOPE OF PROJECT

The subject building is educational assembly building within University of Wollongong campus located at Northfields Avenue Wollongong NSW 2500.

2.2 SCOPE AND LIMITATIONS OF THIS REPORT

The BCA Preliminary Review Report Revision A, prepared by Group DLA and dated 17 July 2017 identified several non-compliances with the NCC DTS Provisions as detailed in Table 5, **Section 3.2** of this report and the Stakeholders have requested that Performance Solutions to be prepared in compliance with NCC Volume 1 DTS Provisions Part A Clause A0.2(a) meeting relevant Performance Requirements of the NCC where NCC DTS Provisions could not be met, The Client appointed ABS Fire Safety Pty Ltd as the Fire Engineering Consultants for this Project.

This Fire Engineering Brief (FEB) report is prepared for the project stakeholders' review; discussion and for the Principal Certifying Authority (PCA) approval. The FEB is prepared in accordance with Chapter 1.2 of the International Fire Engineering Guidelines Edition 2005, issued by the Australian Building Code Board (ABCB) to summarize the parameters and input data for the analysis to be carried out, which represent an agreement in principal between stakeholders and therefore, will form the basis for the Fire Engineered Performance Solution and the analysis of the Fire Engineering Report, which are required to assess and demonstrate that the development Performance Solution satisfies the relevant Performance Requirements of the Building Code of Australia (NCC).

The contents of this report are based on the following:

- The Building Code of Australia (NCC 2016) 'Volume 1.
- Relevant Australian Standards.
- NSW Environmental Planning & Assessment Act 1979.
- NSW Environmental & Assessment Regulation 2000.
- International Fire Engineering Guidelines, 2005 Edition.
- BCA Preliminary Review Report, prepared by Group DLA dated 17/07/2017.
- Consultant Advice, proposed approach and strategy by ABS Fire Safety on 27/07/17.
- Stakeholder's meeting on 02/08/2017, feedback provided on the Consultant Advice.
- Comments from the stakeholders on 28/08/2017 and 11/09/2017.
- BCA Compliance Report (Revision A), prepared by Group DLA dated 06/09/2017.
- Bushfire Protection Assessment Report by Eco Logical Australia dated 12/09/2017.
- Architectural drawings prepared by "*Hassell*" as detailed in **Table 2** below:-

Table 2 – Architectural Plans provided for Fire Safety Engineering Process.

Number	Title	Issue	Date
SK_0033.	Schematic Ground Layout.	G.	29.09.2017.
SK_0034.	Schematic Level 1 Layout	G.	29.09.2017.
SK_0035.	Schematic Level 2 Layout.	G.	29.09.2017.
SK_0036.	Schematic Level 3 Layout.	G.	29.09.2017.

Number	Title	Issue	Date
SK_0037.	Schematic Level 4 Layout.	G.	29.09.2017.
SK_0040.	Elevations North-South.	B.	08.09.2017.
SK_0041.	Elevations East-West.	B.	08.09.2017.

This Fire Engineering Report will not address the following issues:

- A detailed BCA assessment of the development.
- Access for people with disabilities.
- System or engineering design of any part of the existing / proposed development.
- Operational checks of fire safety equipment, verification of construction techniques, fire resistance levels or the witnessing of fire drills.
- Compliance or conformance audit for any fire safety system inside the building.
- Arson (other than single initial ignition), multiple ignition sources, acts of terrorism.
- Protection of property (other than adjoining property).
- Business interruption or losses or personal or moral obligations of the owner/occupier
- Occupational Health and Safety and Work Cover Authority Regulations.
- Health and amenity issues relating to heating, ventilation and air conditioning (HVAC), plumbing and drainage, artificial lighting, and weatherproofing.

2.3 RELEVANT STAKEHOLDERS

The project stakeholders and Fire Engineering Consultants Team are shown below in **Table 3**.

Table 3 - Fire Engineering Stakeholders &Consultants Team.

Name	Organisation	Role
Erika Garbayo.	UOW.	Client/Project Manager FMD.
N. Humphries, M. Todd, M. Copeland & J. Bokor.	Hassell Limited.	Architect.
Justin Jones-Gardiner.	Group DLA.	Principal Certifying Authority.
TBA.	FRNSW.	Regulatory Authority.
Stephen Gouge & Alicia Desgrand	Ethos Urban	Planning
Oliver Farrell & Samuel Hawdon.	Robert Bird Group.	Structural Consultant.
Anthony Whipps & Ryan Hammett	AJ Whipps.	Hydraulic Consultant.
Kheng-wyy Ip & Dev Selvar Ajah.	AECOM.	Mechanical Consultant.
Darren Hinds & Wesam Hyari.	Arup.	Electrical Consultant.
Francis Lenny.	McKenzie Group.	Access Consultant.
Chris Field, Cameron Hough, Kim Jones & Grant Cuthbert.	Arup.	Acoustic Consultant.
Mathew Ottley & Micah Johnson.	Marshall Day,	Performance & Theatre
John Thomson & Stephen Williams.	Thomson Elevator.	Vertical Transport.
Beres Dowdle & Jarrod Ross	Surface Design.	Facade.
Steven Houghton.	Eco Logical Aust.	Bushfire Protection.
Nabil Girgis.	ABS Fire Safety.	Fire Safety Consultant.

3 FIRE ENGINEERING DESIGN BRIEF

3.1 BUILDING DESCRIPTION AND CHARACTERISTICS

The new Western Building will be a landmark development for the University of Wollongong (UoW) campus. It will be located adjacent the campus Ring Road at the western end of the campus. The proposed project will accommodate the diverse functions of The Arts English and Media (TAEM) School and the Health and Society (HAS) School and the School of Geography and Sustainable Communities (SGSC) into a collaborative and engaging hub that will support the ambitions of next generation research and learning. Functions accommodated include specialist teaching spaces, academic and professional staff workplace, informal collaboration spaces as well as other support spaces. The proposed building will be circa 10,000sqm gross floor area across four levels plus a plant level.

The indicative construction materials are concrete skeleton, external brick walls or other modular solid cladding and glazed external openings are with Aluminium frame, along with some eternal steel/timber feature and colorbond metal roof.

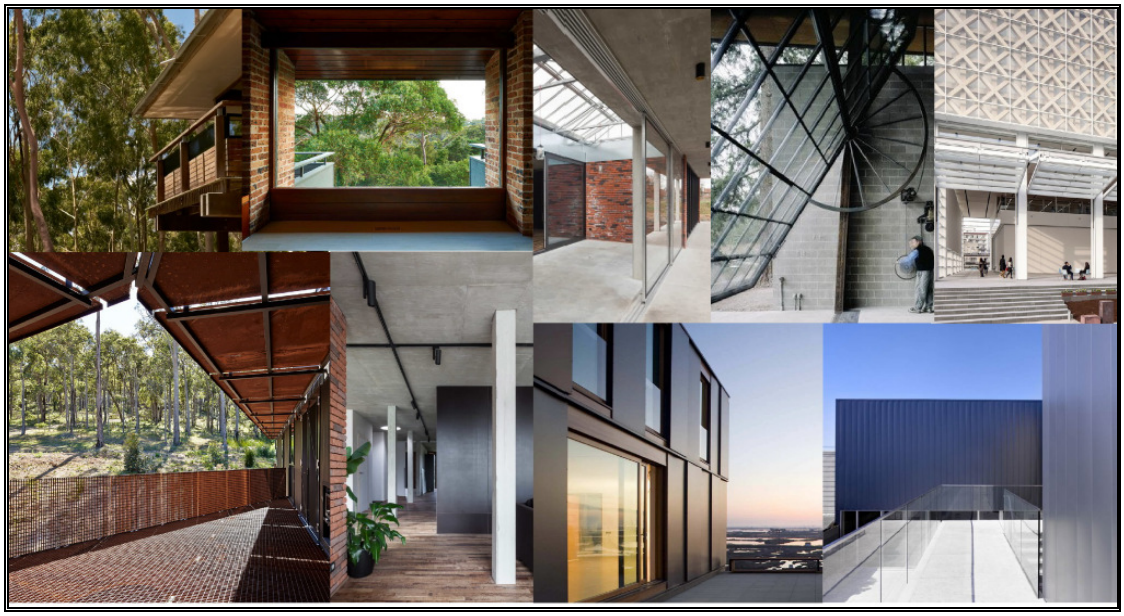

Figure 6 – Indicative proposed construction materials.

The building consists of Four (4) storeys and plants rooms on top, as shown below:-

Figure 7 – Ground Level.

Figure 8 – Level 1.

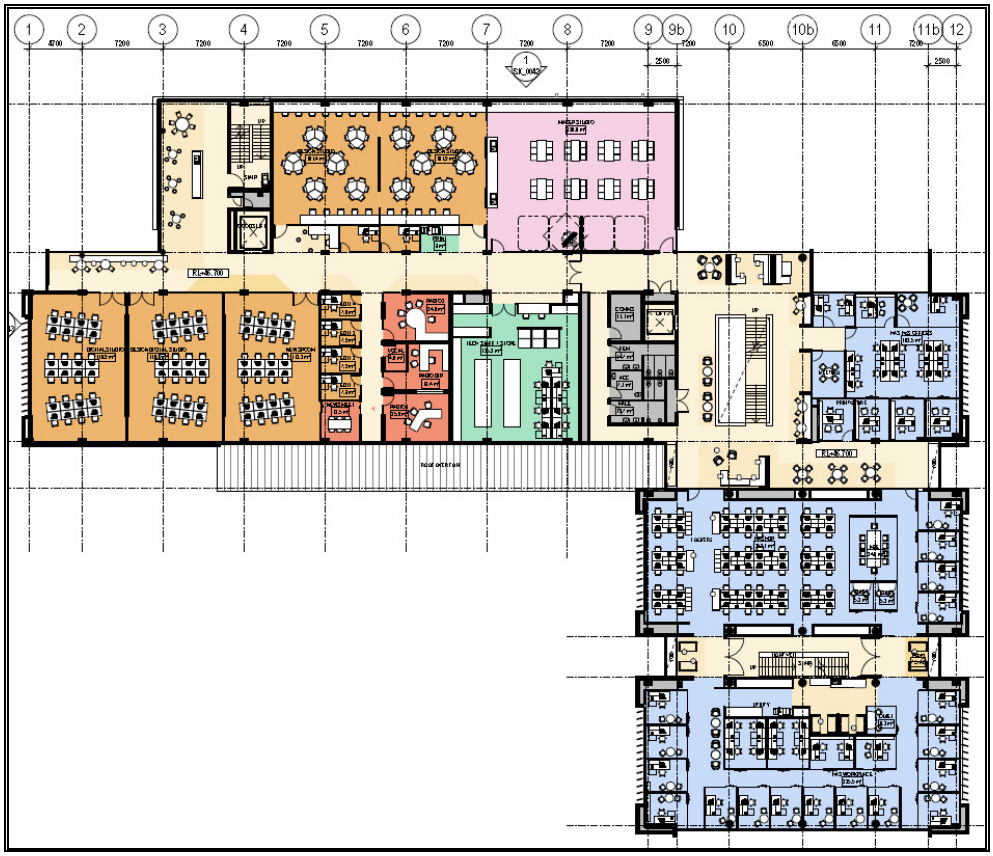

Figure 9 – Level 2.

Figure 10 – Level 3.

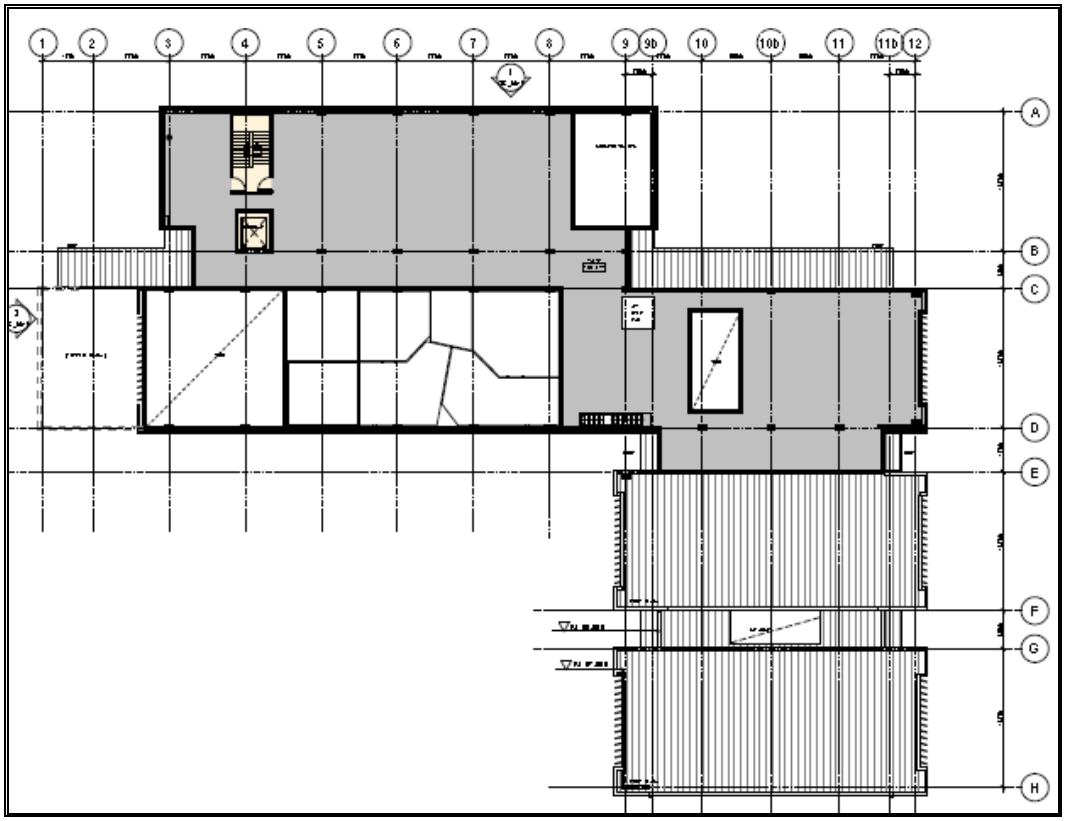

Figure 11 – Level 4 (Plants).

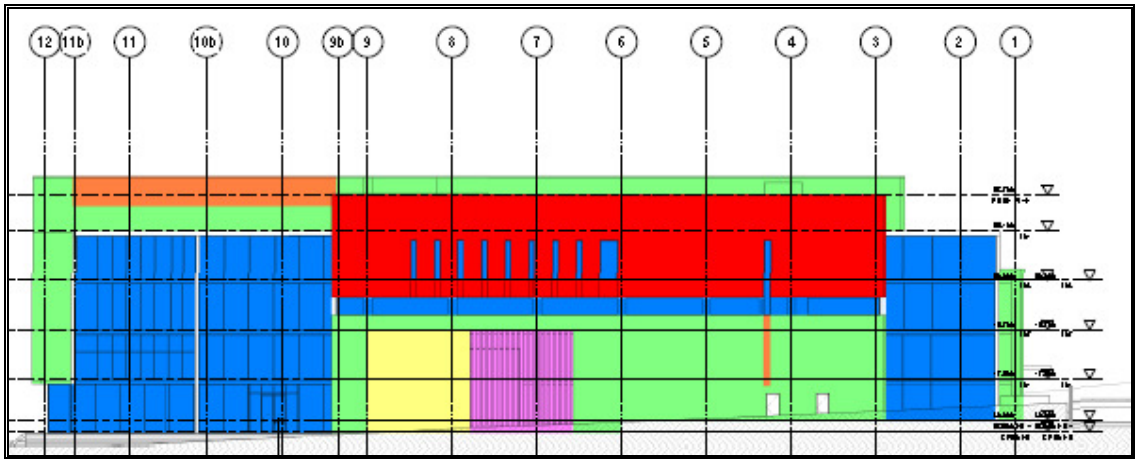

Figure 12 – North Elevation.

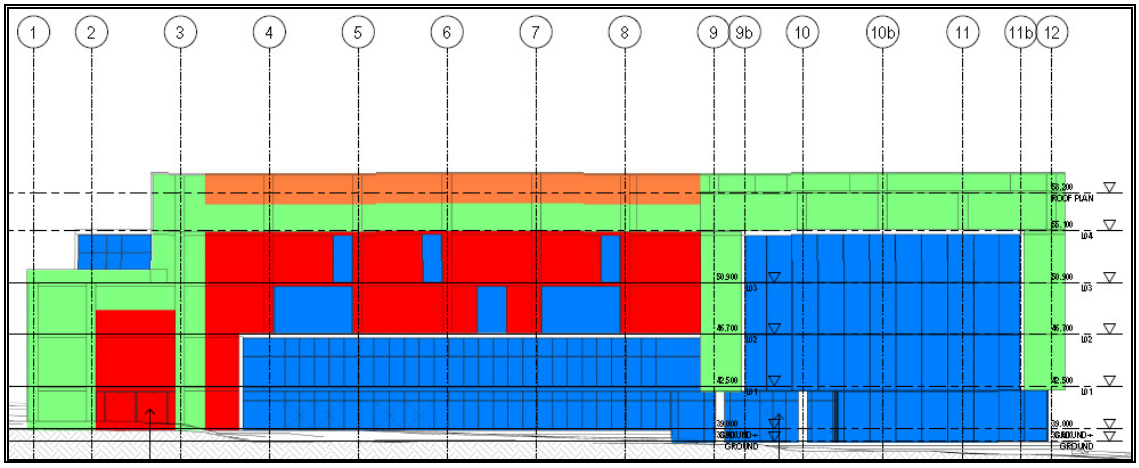

Figure 13 –South Elevation.

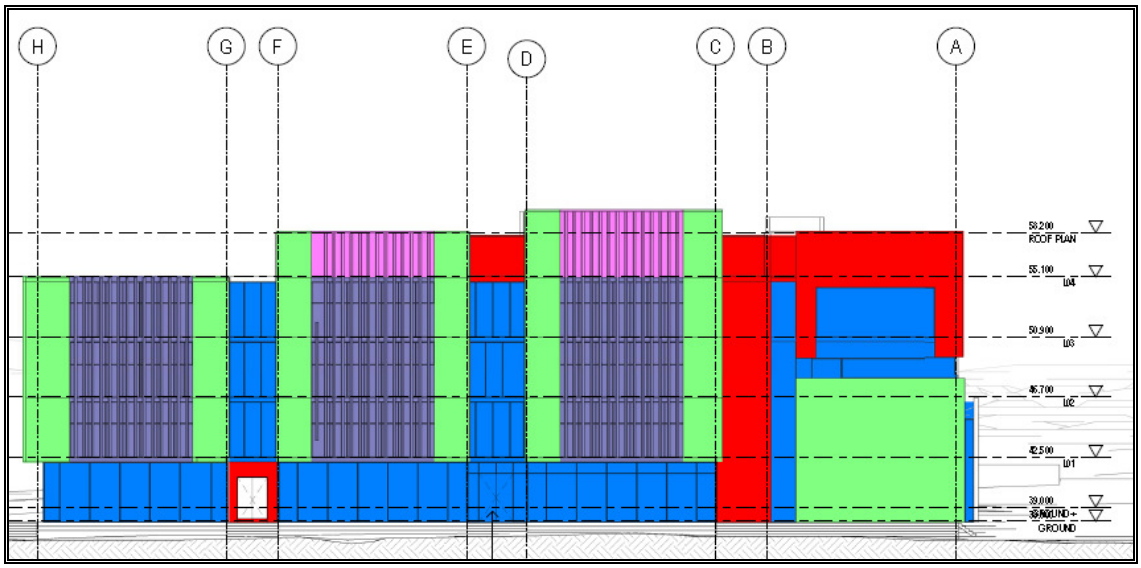

Figure 14 – East Elevation.

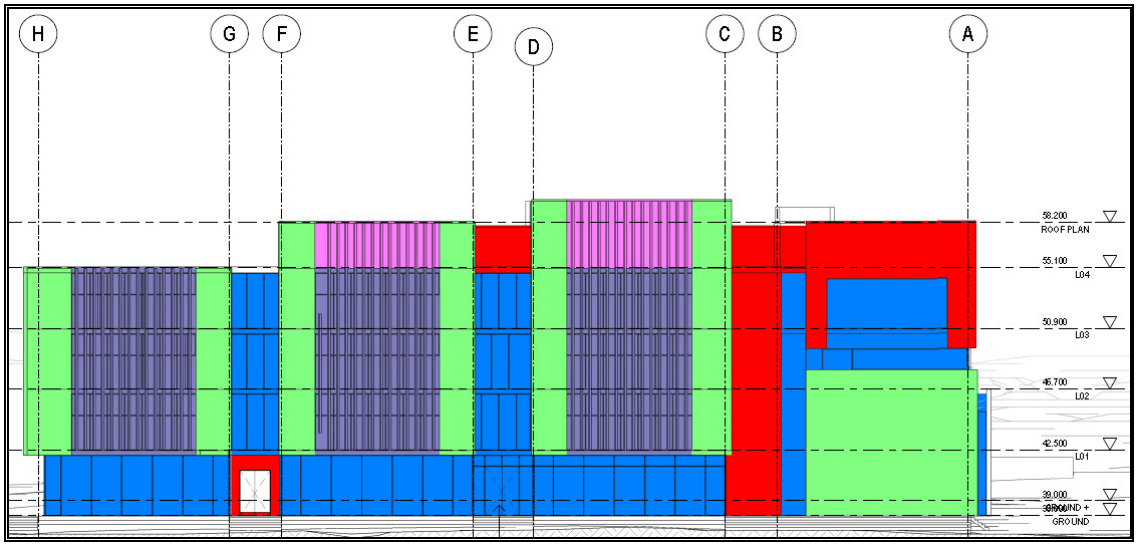

Figure 15 – West Elevation.

3.2 NCC ASSESSMENT

The Building Code Assessment for the building is listed in **Table 4** below.

Table 4 - Building Code of Australia (NCC 2016), Assessment for Fire Safety Engineering

NCC Reference		BCA Assessment
A3.2.	Classifications/Use.	Class9b: Educational Assembly & Entertainment Venue
C1.1.	Rise in storeys.	4.
C1.1.	Number of storeys.	5 (including Plants).
C1.1.	Type of Construction Required.	A.
C1.2.	Effective Height.	Less than 25m (> 12m).
C2.2.	Floor area and Volume.	Greater than 8000m² and greater than 48000m³

Performance Solutions are developed for deviations to the DTS provisions of the NCC Volume One. These Performance Solutions must demonstrate compliance with the relevant Performance Requirements of the NCC Volume One. The proposed Performance Solutions to the DTS provisions of the NCC is summarised in **Table 5** below.

Table 5- Summary of DTS Provisions, Proposed Performance Solutions, Relevant Performance Requirements & Proposed Approach and Assessment Methods

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Clause C2.2: The size of any fire compartment or atrium in Classes 5 to 9 must not exceed the relevant maximum floor area or the relevant maximum volume set out in Table C2.2.	The building floor area exceeds 8000m² and volume exceeds 48000m³. It is proposed to divide the building into two (2) separate fire compartments each of less than 8000m² floor area and less than 48000m³ volume	CP1 & CP2.	A0.2(b); by Deemed-to-Satisfy Solution.	A0.5 (d): Comparison with the Deemed-to-Satisfy Provisions. **SS: B & C.**
Clause 3.3: The distance between parts of eternal walls and any openings within them in different fire compartments separated by a fire wall must not be less than that set out in Table C3.3 unless walls have an FRL not less than 60/60/60 and any opening protected in	No separation distance between non-fire-rated external walls and associated unprotected openings of different compartments in Level 3, based on sprinklered building	CP2.	A0.2(a): by Performance Solution.	A0.5 (b) (i): other verification method in the NCC

NCC Clause Description of DTS Provision	Proposed Performance Solution or DTS Solution	Relevant Performance Requirements ClauseA0.7	Meeting NCC Performance Requirements	NCC Assessment Methods
accordance with C3.4.				
Clause D1.3 & D1.12: Stairs which connect or pass by more than 3 storeys is required to be fire-isolated.	The building contains non-fire-isolated required exit stairway and atrium open stair (is considered non-required exit). It is proposed to create glazed partitions and doors protected with drenchers, doors fitted with self-closing devices and can be kept opened with magnetic tapes (stoper / holder) that automatically released with fire alarm. Drenchers to be controlled with separate valve.	DP5.	A0.2(b); by Deemed-to-Satisfy Solution.	A0.5 (d): Comparison with the Deemed-to-Satisfy Provisions. **SS: B & C.**
Clause D1.4: Exit travel distance should not exceed 20m to POC, 40m to alternative exit; and Clause D1.5 (a) & (b): < 60m, > 9m between alternative exits; and Clause D1.5 (c): alternative paths of travel do not converge at < 6m. D1.9: non-fire-isolated stairway must provide continuous means of travel to the level of egress to road or open space.	It is proposed, in some areas, to justify travel distance >20m to POC/single exit (up to 30m permitted), > 40m to alternative exit (≈ 45m) and minimum of 4m convergence of paths of travel, based on automatic fast-response sprinkler protection that is over and above NCC DTS Provisions, and demonstrate successful total building evacuation analysis ASET/RSET, including time to pass through doors, with acceptable life safety factor > 1.5. Stairway from plant room discharges at Level 3	DP4, DP6 & EP2.2.	A0.2(a): by Performance Solution.	A0.5 (b) (ii): other verification method as the appropriate authority accepts. **SS: E.**
Clause E1.3: Hydrant booster and pump in the sight of main entry.	It is proposed for hydrant booster and pump to be located not within sight of main entry with sufficient signage to be provided to fire brigade personnel.	EP1.3 & EP1.6.	A0.2(a): by Performance Solution.	A0.5 (b) (ii): other verification method as the appropriate authority accepts. **SS:F.**
Clause E2.2, Table E2.2a: Required exits serving an atrium to which Part G3 applies must be provided with automatic stair	It is proposed to omit stair pressurisation system requirements for both north fire isolated stairway and east fire isolated stairway. Atrium open stair (is considered	EP2.2.	A0.2(a): by Performance Solution.	A0.5 (b) (ii): other verification method as the appropriate authority accepts. **SS: E.**

NCC Clause Description of DTS Provision	Proposed Performance Solution or DTS Solution	Relevant Performance Requirements ClauseA0.7	Meeting NCC Performance Requirements	NCC Assessment Methods
pressurisation	non-required exit, the atrium also has automatic smoke exhaust fans).			
Clause G3: Atrium Construction G3.2: Well cylinder 6m diameter; and G3 & G4: Bounding walls 60/60/60 at no more than 3.5m from well perimeter.	It is proposed not to comply with NCC DTS Provisions related to atrium construction and well size based on fast-response sprinkler protection plus automatic smoke exhaust fan or smoke-and-heat vent activated by automatic smoke detection system and automatic sprinklers and demonstrate successful total building evacuation analysis ASET/RSET, including time to pass through doors, with acceptable life safety factor > 1.5.	EP2.2.	A0.2(a): by Performance Solution.	A0.5 (b) (ii): other verification method as the appropriate authority accepts. **SS: E.**
NSW Part H101: Entertainment Venues.	It is proposed not to provide fire separation to entertainment venue area and between stage and audiences seating based on fast-response sprinkler protection that over and above NCC DTS Provisions and smoke management, if required, with complying egress provisions.	EP2.2.	A0.2(a): by Performance Solution.	A0.5 (b) (ii): other verification method as the appropriate authority accepts. **SS: E.**

3.3 OCCUPANTS NUMBER

The fire engineering assessment of this report based on the subject building population of 643 people, as advised by the UOW[2].

3.4 OCCUPANTS CHARACTERISTICS

The occupants characteristics within building are considered to be representing of the general population for typical teaching staff and educational institution students with no specific or unusual distributions and vary around the following parameters:-

- Sex: Males & Females.
- Age: Varied.
- Fitness Level: Average.

[2] UOW Western Building - Room Data Schedule

- Response: Average.
- Travel Speed: Average.
- Distribution: Occupants are distributed through all building floor levels as described above.
- State: Majority of occupants are considered permanent, awake, and conscious.
- Physical Attribute: Majority of occupants are considered of normal state similar to typical educational building occupants.
- Mental Attribute: Majority of occupants are considered able to evacuate the building with their own power.
- Level of Assistance: Students are considered to be groups and able to provide guidance to colleagues.
- Emergency Training: Occupants are considered to have some skills such as response, use of portable extinguisher and use of fire hose reels, have full understanding of house-keeping policy including avoidance of ignition and preventing fire initiation.
- Group Roles: Occupants are considered to have necessary emergency skills organisation roles especially to other colleagues.
- Activities at the outbreak of fire: during daytime staff / students might be busy with their normal teaching/learning process.

For the purpose of emergency evacuation majority of occupants are considered permanent, awake, conscious and familiar with the building egress routes, able to provide guidance to students.

Assessing requirements for people with disability, where needed, is considered to be planned by each building management; however it is recommended that implementation of emergency evacuation plan and policy for all occupants including people with disability in accordance with AS 3745-2002 and specifically for subject building. This is considered to reasonably address disabled egress in relation to fire safety strategy for subject building.

3.5 PROPOSED FIRE SAFETY SYSTEMS

The following fire safety systems are recommended to be provided throughout the building, as part of the completed fire safety systems identified by the Principal Certifying Authority:-

- Recommended provisions of automatic, fast response, sprinkler system to be installed to the entire building in accordance with NCC Clause E1.5 and AS2118-1999.

- Recommended side-wall drenchers to all glazed partitions/doors required as a fire separation walls for fire compartmentation (drenchers installed in both sides of the glass).

- The estimated response time from the activation of the sprinkler heads in the building to the activation of the pressure switch that activates the Addressable occupant warning system and signal to Fire Brigade monitoring system - as referenced in AS 2118.1-1999, Clause 8.10.1 - should be no greater than 90 sec.

- Fire hydrant system in accordance with NCC Clause E1.3 and Australian Standards AS2419.1-2005, except as permitted under this report (remote booster).

- Fire hose reel system in accordance with NCC Clause E1.4 and Australian Standards AS2441-2005 – (FHR coverage and flow to be confirmed).

- Portable fire extinguishers in accordance with NCC Clause E1.6 and Australian Standards AS2444 - 2001(To be inspected for compliance with AS2444).
- Automatic smoke detection and alarm system in accordance with NCC NSW Table E2.2B and NSW Specification E2.2a. Heat detectors to theatres spaces.
- Smoke management system; the activation of automatic sprinkler system and/or automatic smoke detection system to activate the automatic shutdown of the air-handling system and automatic activation of stage smoke-and-heat vents (if required). System monitoring to be provided to AS1670.3-2004.
- Requirements of NSW Table E2.2b that requires that a stage with a floor area of more than 300m² must have a smoke exhaust system over the stage, is to be subject to an Performance Solution with heat and smoke vent to be installed and to be automatically opened with fire alarm.
- Emergency lighting in accordance with NCC Clause E4.2, E4.4 and Australian Standard AS2293.1 – 2005.
- Exit signage in accordance with NCC Clause E4.5, NSW E4.6 & E4.8 and Australian Standard AS2293.1 – 2005.
- All fire safety systems, including standby power supply, to be maintained in accordance with AS1851and relevant Australian Standards. The building Fire Safety Schedule and Annual Fire Safety Statement to include recommendations of this report with reference to this report and brief of the Performance Solutions.
- Sound systems and intercom systems for emergency purposes (system to be tested for compliance with NCC Clause E4.9). Recorded Message "Fire Alarm Evacuate Now"
- Atrium automatic mechanical smoke exhaust fan in compliance with NCC DTS Provisions (refer to mechanical design details).
- .
- Horizontal exits between fire compartments to swing in both directions
- Doorways to north and east fire-isolated stairways to be fitted with smoke sealant and horizontal exits doorways between atrium fire compartment and north & east fire compartments to be fitted with smoke sealant.
- Lightweight Construction in accordance with Spec C1.8 (subject to confirmation of proposed construction method of internal fire walls)
- Fire Seals in accordance with AS1530.3
- Fire rated lift landing doors to AS1735.11
- Automatic Failsafe Devices to Part D2.21 of the BCA
- Smoke Curtain (or the like) to separate topmost floor to the atrium open well.

- Smoke sealant to all fire doors between fire compartments and to both fire-isolated stairways.

3.6 FIRE SAFETY DESIGN OBJECTIVES

3.6.1 NCC Objectives

The general objectives of the FEB and the subsequent FER are to demonstrate compliance with the relevant NCC Performance Requirements, associated with the areas of non-compliance with the DTS provisions of the NCC, in which the Performance Solutions must comply with.
The NCC requirements that must be achieved include:-

- Provide occupant's life safety where injury or suffering due to fire conditions is prevented.
- Provide safe intervention conditions for geared fire fighters.
- Prevent spread of fire between buildings and protect other properties.

3.6.2 Fire Brigade Safe Operations

Fire Brigades throughout Australia have a basic set of legal obligations which involve the protection of life, property and the environment. To enable the Fire Brigades to meet the obligations of the Fire Agency Act, the Act gives the Fire Brigades specific powers at the time of fire or other defined emergencies and includes:

- The ability to enter any land, building, or structure etc, using force if necessary.
- The ability to take possession, remove or destroy etc.
- The ability to access or shut down any water supply.
- The ability to close down any infrastructure, service, or waterway.
- The ability to remove persons, and to use force if necessary.
- To undertake any other measure to ensure the protection of life, property and the environment.

3.7 HAZARD IDENTIFICATION

One of the FEB processes is to identify potential fire hazards within and around the subject building, which forms the basis of developing individual worst-case fire scenarios, used within the Fire Engineering Assessment. The historical data is one of the major sources for hazard identification, along with academic researches and full-scale fire experiments.

3.7.1 Historical Data

A review of fires inside similar building from NSWFB Annual Statistical Report a Ten Year Review 1989/90 to 19998/99, ISSN 1035 9605 2003, and Marryatt Publication (Fire – A century of Automatic Fire Fast-response sprinkler protection in Australia and New Zealand) and listed below.

Table 6 – Potential Ignition Sources inside Entertainment Venues

Area	Ignition Sources
Offices / Function	Air-conditioning equipment, Blow lamps, Electrical, Electrical appliances, Explosions, Exposure, Flames, Flammable liquids, Fluorescent lights, Furnaces, Furnace "Blowback", Gas producers, Hot ashes, Incendiarism, Incinerators, Kerosene heaters, Overheating, Smoking, Sparks, Spontaneous ignition, Static, Welding, Unrecorded

Area	Ignition Sources
Stage / Entertainment Venue.	Electrical Exposure, Flames, Hot Ashes, Incinerators, Incendiarism, Overheating, Smoking, Sparks, Spontaneous ignition.

Table 7 – Fire Hazard inside Entertainment Venues.

Area	Fire Hazard (Combustible Materials)
Offices / Function	Air-conditioning Equipment, Vertical Ducts, Electrical Equipment, Elevators (Lifts), Escalators, Electrical Appliances, Plastics in Furniture, Synthetics Carpets, Rubbish Collection and Dispatch.
Stage / Entertainment Venue.	Air-conditioning Equipment, Costumes, Electrical Equipment, Heating Equipment, Temporary Wiring, Lighting, Scenery, Flammable Liquids, Rubbish Collection and Dispatch.

Table 8 – Historical data of possible ignition source inside universities buildings.

Cause.	No. Of Fires.	Location.	No. Of Locations.	Particular Hazard.
Electrical	4	ground	3	Air Conditioning Equipment, Flammable Liquids and Cases, Hazardous Chemicals, Heating Equipment, High-voltage Electrical Equipment, Laboratories,, Open Flames.
Electrical Appliances	4	1st Floor	7	
Flammable Liquids	37	3rd Floor	1	
Overheating.	40	10th Floor	1	
Spontaneous.	41			
Welding.	1			
Not recorded.	1			

3.8 TRIALS FIRE SAFETY MEASURES/DESIGN

The proposed fire safety strategy is to comply with the DTS provisions of the NCC 2016, except for those non-compliances identified below.

The Trial Design for the proposed fire safety strategy is detailed below.

Table 9- Summary of DTS Provisions, Proposed Performance Solutions, Relevant Performance Requirements & Proposed Approach and Assessment Methods

NCC Clause Description of DTS Provision	Proposed Performance Solution or DTS Solution	Relevant Performance Requirements ClauseA0.7	Meeting NCC Performance Requirements	NCC Assessment Methods
Clause C2.2: The size of any fire compartment or atrium in Classes 5 to 9 must not exceed the relevant maximum floor area or the relevant maximum volume set out in Table C2.2.	The building floor area exceeds 8000m² and volume exceeds 48000m³. It is proposed to divide the building into two (2) separate fire compartments each of less than 8000m² floor area and less than 48000m³ volume	CP1 & CP2.	A0.2(b); by Deemed-to-Satisfy Solution.	A0.5 (d): Comparison with the Deemed-to-Satisfy Provisions. **SS: B & C.**

NCC Clause Description of DTS Provision	Proposed Performance Solution or DTS Solution	Relevant Performance Requirements ClauseA0.7	Meeting NCC Performance Requirements	NCC Assessment Methods
Clause 3.3: The distance between parts of eternal walls and any openings within them in different fire compartments separated by a fire wall must not be less than that set out in Table C3.3 unless walls have an FRL not less than 60/60/60 and any opening protected in accordance with C3.4.	No separation distance between non-fire-rated external walls and associated unprotected openings of different compartments in Level 3, based on sprinklered building	CP2.	A0.2(a): by Performance Solution.	A0.5 (b) (i): other verification method in the NCC
Clause D1.3 & D1.12: Stairs which connect or pass by more than 3 storeys is required to be fire-isolated.	The building contains non-fire-isolated required exit stairway and atrium open stair (is considered non-required exit). It is proposed to create glazed partitions and doors protected with drenchers, doors fitted with self-closing devices and can be kept opened with magnetic tapes (stoper / holder) that automatically released with fire alarm. Drenchers to be controlled with separate valve.	DP5.	A0.2(b); by Deemed-to-Satisfy Solution.	A0.5 (d): Comparison with the Deemed-to-Satisfy Provisions. **SS: B & C.**
Clause D1.4: Exit travel distance should not exceed 20m to POC, 40m to alternative exit; and Clause D1.5 (a) & (b): < 60m, > 9m between alternative exits; and Clause D1.5 (c): alternative paths of travel do not converge at < 6m. D1.9: non-fire-isolated stairway must provide continuous means of travel to the level of egress to road or open space.	It is proposed, in some areas, to justify travel distance >20m to POC/single exit (up to 30m permitted), > 40m to alternative exit (≈ 45m) and minimum of 4m convergence of paths of travel, based on automatic fast-response sprinkler protection that is over and above NCC DTS Provisions, and demonstrate successful total building evacuation analysis ASET/RSET, including time to pass through doors, with acceptable life safety factor > 1.5.	DP4, DP6 & EP2.2.	A0.2(a): by Performance Solution.	A0.5 (b) (ii): other verification method as the appropriate authority accepts. **SS: E.**

NCC Clause Description of DTS Provision	Proposed Performance Solution or DTS Solution	Relevant Performance Requirements ClauseA0.7	Meeting NCC Performance Requirements	NCC Assessment Methods
	Stairway from plant room discharges at Level 3			
Clause E1.3: Hydrant booster and pump in the sight of main entry.	It is proposed for hydrant booster and pump to be located not within sight of main entry with sufficient signage to be provided to fire brigade personnel.	EP1.3 & EP1.6.	A0.2(a): by Performance Solution.	A0.5 (b) (ii): other verification method as the appropriate authority accepts. **SS:F.**
Clause E2.2, Table E2.2a: Required exits serving an atrium to which Part G3 applies must be provided with automatic stair pressurisation	It is proposed to omit stair pressurisation system requirements for both north fire isolated stairway and east fire isolated stairway. Atrium open stair (is considered non-required exit, the atrium also has automatic smoke exhaust fans).	EP2.2.	A0.2(a): by Performance Solution.	A0.5 (b) (ii): other verification method as the appropriate authority accepts. **SS: E.**
Clause G3: Atrium Construction G3.2: Well cylinder 6m diameter; and G3 & G4: Bounding walls 60/60/60 at no more than 3.5m from well perimeter.	It is proposed not to comply with NCC DTS Provisions related to atrium construction and well size based on fast-response sprinkler protection plus automatic smoke exhaust fan or smoke-and-heat vent activated by automatic smoke detection system and automatic sprinklers and demonstrate successful total building evacuation analysis ASET/RSET, including time to pass through doors, with acceptable life safety factor > 1.5.	EP2.2.	A0.2(a): by Performance Solution.	A0.5 (b) (ii): other verification method as the appropriate authority accepts. **SS: E.**
NSW Part H101: Entertainment Venues.	It is proposed not to provide fire separation to entertainment venue area and between stage and audiences seating based on fast-response sprinkler protection that over and above NCC DTS Provisions and smoke management, if required, with complying egress provisions.	EP2.2.	A0.2(a): by Performance Solution.	A0.5 (b) (ii): other verification method as the appropriate authority accepts. **SS: E.**

3.8.1 Proposed Fire Compartmentation

The building to be divided into three fire compartments of less than 8000m² floor area, (North Fire Compartment and East Fire Compartment and rooftop plants Fire Compartment), with each fire compartment to be served with fire-isolated stairway.

— Solid lines indicate fire walls with an FRL of 120/120/120.

- - - Dotted lines indicate drenchers-protected glazed partitions.

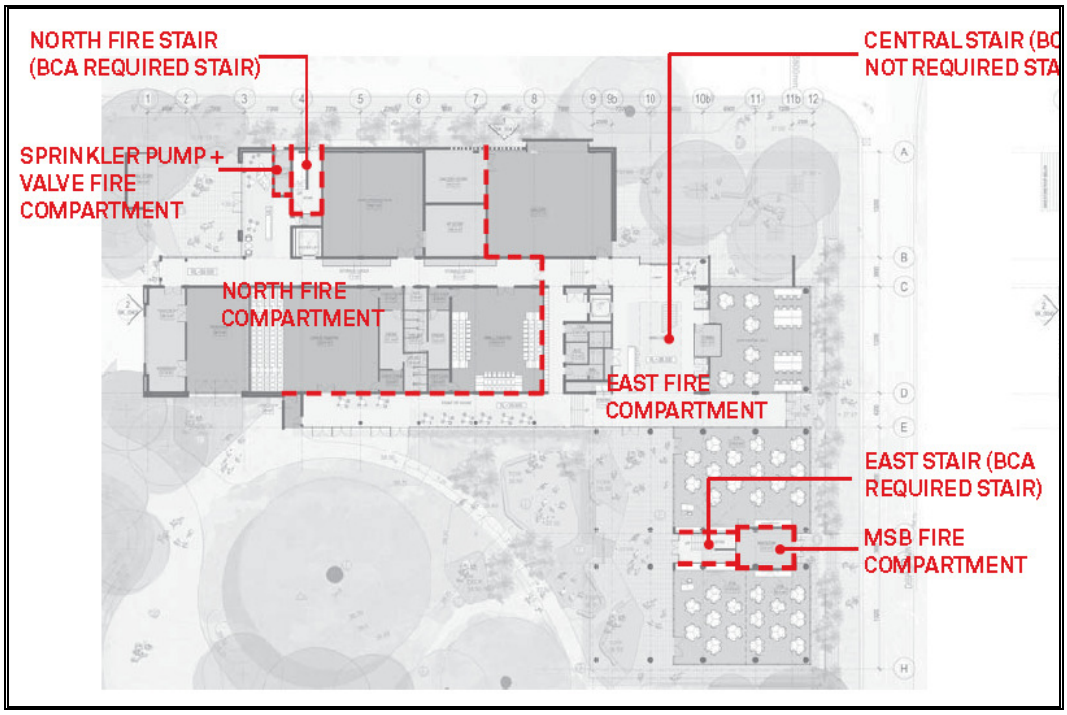

Figure 16 – Ground Level Fire Compartments.

Figure 17 – Level 1 Fire Compartments.

Figure 18 – Level 2 Fire Compartments.

Figure 19 – Level 3 Fire Compartments.

Figure 20 – Level 4 (Plants) Fire Compartments.

In order to meet the intent of the architectural design concept; the atrium opened stair not to be considered as a required exit where the atrium fire compartment has two horizontal exits to adjacent fire compartment then to fire-isolated stairs.

3.9 METHODS OF EVALUATION

The following Fire Engineering Tools are available to be utilised with Fire Engineering Analysis and computer modelling is one of the fire safety methodologies recommended within the International Fire Engineering Guidelines, along with fire safety engineering sciences/ principles to evaluate building performance in the event of a fire. It should be noted that only computer programs or Qualitative Assessment Methods suitable for the building geometry and the extent of analysis required will be selected.

3.9.1 Comparative Approach

The International Fire Engineering Guidelines Part 1, Section 1.2, Clause 12.9.1 states that; typically, the fire safety provided by one element, or a sub-system, or the complete fire safety system, is compared to the level of fire safety that would be achieved in an identical building in which that element, sub-system or system is designed in compliance with the deemed-to-satisfy or prescriptive provisions identified in Section 1.2.8. If the analysis is carried out on such a comparative basis, it will involve the same assumptions, models, calculations and input data for the proposed trial design and the deemed-to-satisfy or prescriptive design.
A comparative approach aims to determine whether the Performance Solution is equivalent to (or better than) the deemed-to-satisfy or prescriptive design. The comparative approach is often referred to as an “equivalence” approach.

3.9.2 Qualitative or Quantitative Approach

The International Fire Engineering Guidelines Part 1, Section 1.2, Clause 12.9.2 states that; in the minority of cases, qualitative analysis may be agreed during the FEB process to be sufficient for the consideration of a single non-compliance issue. The basis (logic) on which this approach is used should be documented with appropriate references.
A “Delphi” approach may also be appropriate in certain circumstances, i.e. where a group of suitably expert professionals reach consensus agreement regarding the suitability of a particular solution. It is also states that in the majority of cases the complexity of the non-compliances issues will require a quantitative approach. This entails the use of one or more of the many analysis methods available. The quantitative methods will often be supported by additional qualitative arguments.

3.9.3 Computer Programs for Simulation

C-FAST

The zone model[3] used to aid in the Fire Engineering Analysis is known as FAST. FAST is a collection of fire modelling tools, which uses the underlying fire model CFAST and adds the

[3] CFAST User's Manual

routines of Fireform to provide engineering calculations of fire phenomena in compartmented structures,

The algorithms, procedures, and computer programs within FAST have been compiled from the latest knowledge and understanding currently available, and distributed by the U.S. Department of Commerce, National Institute of Standards and Technology (NIST).

The CFAST model used in FAST is a two-zone model used to calculate the evolving distribution of smoke and fire gases and the temperature throughout a building during a fire. CFAST is based on solving a set of equations that predict state variables (pressure, temperature etc) based on the enthalpy and mass flux over small increments of time. These equations are derived from the conservation equations for energy mass, and momentum, and the ideal gas law.

Numerous verification tests have been carried out by various research organisations to validate the results predicted by FAST. In many instances, the results predicted by FAST have been conservative.

FIREWIND

FireWind[4] provides the facility for fast calculation of specific fire engineering problems from a range of areas. The results of these can then be used as part of an overall engineering solution to a particular design situation. In this regard it cannot be too strongly emphasised that the results from a particular calculation are exactly that results. These results are not complete answers but should be used as a guide to the final answer.

FireWind is an easy to use computer software package of 18 programs covering different aspects of fire technology and fire protection science. It includes:

- one-room and two-rooms zone models which take into account various ventilation conditions
- sprinkler activation calculations combined with a zone model
- model of evacuation from a multi-room and multi-storey building
- heat radiation calculations
- ... and more

FireWind developed from FireCalc which was created for CSIRO (Commonwealth Scientific and Industrial Research Organization) - leading Australian scientific institution. Now we have developed FireWind - Windows 32 package. FireWind includes all major programs of FireCalc and some new original programs. Convergence of old programs can be improved with a slower speed option. Original programs of FireWind and FireCalc are based on Fire Modelling and have been thoroughly validated. The results of validation work have been published in Fire Engineering journals and proceedings of international Fire Engineering conferences.

Program Limitations

[4] FireWind User's Manual Version 3.6 - 2003

The theoretical basis of radiation assessment is well understood and in this regard the program draws on a firm foundation. The limitations that arise in the use of the program are primarily concerned with its design.

Only rectangular openings are catered for as these constitute by far the most common form of building opening and hence, radiant heat hazard. Increasing the scope in this respect would once again lead to unnecessary complication.

The program does not calculate the effect of partial shading of the fire sources with some opaque objects. However, such situations can be handled by applying the program several times for different observation points and taking to account only radiation intensity at the observation point, ignoring the radiation map.

All of the above limitations result from finding a balance between practical application and computational complexity and are not envisaged as being too restrictive.

Radiation is acutely temperature dependent (T to the fourth power) and therefore some care needs to be taken when deciding on the source temperature. The effective black-body temperatures of flames have been measured in many full-scale building fires and these have ranged typically from about 900ºC to about 1100ºC. A value of 1000ºC (1273 K) is reasonably representative of building fires involving normal combustible materials.

The program “Conductivity” implements numerical integration of the one dimensional transient heat transfer problem, where considering that the member at the initial non-fire conditions (ambient temperature) is in thermal equilibrium with the environment.
During fire condition the program considers the radiant heat exchange with the flame at one side and environment at ambient temperature at the other side with convection is not considered, and the material of the member is assumed to be uniform, and water content is not considered which is conservative.

Program “Way Out” computes the evacuation time for a group of people from multi-room and multi-storey building and the two other components of emergency evacuation (detection time and pre-movement time) have to be evaluated separately.

The computational details of this program based on the work by Shestopal and Grubits “Evacuation Model for Merging Traffic in Multi-room and Multi-storey Buildings – Fire Safety Science- Proceeding of the 4th International Symposium, International Association for Fire Safety Science, Ottawa, Ont., 1994, p.625-632, which utilises experimental data from the book by Russian Scientists Predtechenskii and Milinskii and later Russian research implemented in Russian Standard GOST 12.1.004-91. Way Out is based on the data obtained with average street persons. It is not applicable to the hospitals or nursing homes where mobility of people is significantly lower.

3.10 ACCEPTANCE CRITERIA

Qualitative and Quantitative Analysis will be carried out to verify that the Performance Solutions presented for the identified areas of Deviations with the DTS provisions of the NCC 2016, will satisfy the relevant fire safety performance requirements of the NCC 2016.

Performance will be assessed for the building where occupant life safety factor provided with proposed design to be greater than (1.5) with all fire systems successfully operated, and greater than (1) with failure of any fire safety system.

3.10.1 Life Safety Criteria

The fundamental life safety criteria that will be applied to the existing building will include hot layer height, heat radiation, convection heat, visibility/optical density and toxicity, **Table 10** below details the limiting values for Life Safety Criteria.

Table 10 – Acceptance Criteria[5].

Life Safety Criteria	Limiting Value	Comments
Hot Layer Temperature	200°	Smoke at any level above 2.1m from the floor.
Hot Layer Height[6]	> 2.1m	Temperature < 200°
	< 2.1m	Temperature < 100° Tolerance Time is 11 minutes. Temperature < 60° Tolerance Time is > 30 minutes.
Heat Radiation	2.5kW/m2	At a minimum of 2.1m above the floor
Convection Heat	1000C	-
Visibility/Optical Density	1.2 m^{-1}	SFPE Handbook Second Edition
Toxicity (exposure to CO)	20% COHb	If exposure to CO results in a 20% COHb, incapacitation will occur. If optical density exceeds 1.0dB/m, the exposure dose for incapacitation by CO is 14 000 ppm. min.

It should be noted that should Element No. 1 (smoke layer at 2.1m above floor level with smoke temperature less than 200°C) satisfied in determining ASET, then the other elements of 2,3,4 & 5 may not be necessary to be considered and if element No.1 is not satisfied then elements 2,3,4 & 5 shall be considered collectively in determining ASET.

Toxicity tenability limits will not be considered for life safety analysis where the minimum exposure for incapacitation is 5 minute which is longer than the occupants movement time inside egress routes [Source: SFPE Handbook, Second Edition, Section 2, Chapter 8, Table 2-8B(a)] and tabulated in **Table 11** below.

Table 11 - Toxicity Tenability Limits

Toxic Product	5 minutes exposures		30 minutes exposures	
	Incapacitation	Death	Incapacitation	Death
CO	6000-8000ppm[7]	12000-16000ppm	1400-1700ppm	2500-4000ppm

[5] [5] Fire Engineering Design Guide; AH Buchanan; 2001
[6] SFPE Handbook 4th Edition, Section 2, Chapter 6, Page 2-145, Table 2-6.20 "Limiting Conditions for Tenability Caused by Heat.
[7] Part Per Million

HCN	150-200ppm	250-400ppm	90-120ppm	170-230ppm
Low O2	10-13%	<5%	<12%	6-7%
CO2	7-8%	>10%	6-7%	>9%

Visibility, when occupants forced to walk through smoke, depends on the density of smoke soot (carbon) yield (g/g)

Table 12 - Visibility Tenability Limits[8]

Location	Minimum Visibility (m)	Optical Density (1/m)
Small Rooms	5	0.2
Other Rooms	10	0.1

The life safety criteria adopted for fire fighters in full turn out gear are below, as detailed in the Fire Brigade Intervention Model and Identified in **Table 13** below

Table 13 – Life Safety Criteria for Fire Fighters[9].

Life Safety Criteria	Limiting Value
Radiant Heat Flux	3.5 kW/m2 @ 1.5m above the floor

3.10.2 Spread of Fire Criteria

As stated in the Guide to NCC; CV1 is a means to verify whether or not a building proposal achieves the requirements of CP2(a)(iii) in minimising the risk of fire spreading between buildings on adjoining allotments. A fire in one building should not cause the spread of fire to another building, because such fire spread potentially endangers public safety, health and amenity.

It is not compulsory for a designer to use CV1. The designer has the choice of using:

- CV1 to verify that a proposal achieves CP2(a)(iii);
- the Deemed-to-Satisfy Provisions of Part C3; or
- another means of verifying that CP2(a)(iii) will be achieved.

CV2 is essentially the same as CV1, except that it deals with the spread of fire between two buildings on the same allotment. It is not compulsory for a designer to use CV2.

The Fire Engineering Guidelines Second Edition 2002 provides guidance of the failure criteria for spread of fire to another building that assessed by the radiant heat flux necessary to ignite an item as addressed in, reference to SFPE Handbook Second Edition (1998) and Drysdale (1985). The radiant heat flux necessary to ignite an item is assumed to be as following:-

- 10 kW/m² for easily ignited items such as thin curtains and loose newsprint
- 20kW/m² for normal items such as upholstered furniture
- 40kW/m² for difficult to ignite items such as wood of 5 cm or greater thickness.

[8] Fire Engineering Design Guide, A. Buchanan, University of Canterbury New Zealand.
[9] AFAC; Fire Brigade Intervention Model; Version 2.2; Australian Fire Authorities Council; October 2004

3.11 DESIGN FIRE SCENARIOS

Refer to the hazard identification section of this report and possible causes of ignition inside the building.

The design fire considered for the above fire scenarios will consist of a t²-fire.

T²- fires are considered as a continuous growth curve in terms of the heat output of the fire, and are characterised by the following quadratic function:

$$Q = (t/k)_2$$

where:
Q = the rate of heat release (MW)
t = the time from the effective ignition time (sec)
k = the characteristic time of growth to 1MW (sec).

Selected fire size and growth rate based on the following small fire load intensity within subject building (as tabulated in the International Fire Engineering Guidelines Chapter 3.4):-

- Academy = 300MJ/m²
- Cinema = 300MJ/m²
- Laboratory (other than Chemicals) = 200MJ/m²
- Laboratory (Chemicals) = 500MJ/m²
- School = 300MJ/m²
- Theatre = 300MJ/m²

A medium growth rate fire profile is selected inside this building.

Table 14 – Design Fire Scenario for occupant life safety analysis and spread of smoke

Fire Scenario	Design Fire
Sprinkler-controlled fire scenario	Medium-growth Capped with sprinkler activation.
Uncontrolled fire (Sensitivity Analysis)	Medium-growth 5MW Fire within subject building.

3.12 PARAMETERS FOR EVACUATION

Occupants within subject building are characterised by their ability/inability to recognise an emergency condition within the building and their ability/inability to move to exits. The characterisations of evacuation parameters are-

3.12.1 Detection

Fire detection is automatic smoke detection and/or sprinkler system activates alarm system/occupants warning system for occupants away from room of fire origin.

For occupant within room of fire origin, a very short detection time is likely due to clear olfactory and visual fire cue.

For occupants away from room of fire origin, detection time is the time for smoke detector activation plus alarm verification delay, which will be used for life safety assessment and emergency evacuation analysis.

3.12.2 Pre-movement

For occupant inside room of fire origin a very short pre-movement time is likely due to clear olfactory and visual fire cue.

For occupants away from the room of fire origin, SFPE Handbook, Third Edition, Section 3 Chapter 13-Movement of People Table 3-13.1 recommends 180 sec (3 minutes) for pre-movement for occupants away from room of fire origin when an automatic cue is provided (Occupants Warning System). *Pre-movement time = 180 sec.*

3.12.3 Movement

Occupant Flow Rates (Research)-

The average velocities are based on the following research data-

Table 15 – Measured flow rates (person/sec/meter width).

Source	Level	Stairs Up	Stairs Down
British Data	0.8 – 1.4	1.0	0.9
French Data	1.1 – 2.7	1.4	0.9 – 1.6
American Data	1.4	0.9 – 1.7	1.0 – 1.5
Cinema Construction	0.9 – 2.1	-	-
North American Transit Authorities	1.5	0.9	1.1
Paris Metro	1.7	1.0	1.3
London Transport Board	1.5	1.1	1.1
Average	**1.5**	**1.1**	**1.15**

Occupant Velocity-
Occupant velocities for different aspects of the evacuation routes based on above research to be used for emergency evacuation analysis are as follows-

Table 16 – Mean occupant movement times

Part of Egress Route	Velocity
Level	1.19m/sec (SFPE Handbook Fourth Edition).[10]
Down stairs	1.1m/sec (SFPE Handbook Fourth Edition).
Specific flow through door	1.3person/sec/m (SFPE Handbook Fourth Edition).

For subject assembly building with crowd population; movement time is governed by the time required for occupants to pass through exits doorway rather than travelling time to exits.

Table 17 – The characterisations of assisted evacuation mean speed

Description of Subject Group	Mean Speed
All disabled	1 m/sec.
With locomotion disability.	0.8 m/sec.
No Aid.	0.95 m/sec.
Crutches.	0.94 m/sec.
Walking Stick.	0.81 m/sec.
Walking frame or rollator.	0.57 m/sec.
Without locomotion disability.	1.25 m/sec.
Electric wheelchair.	0.89 m/sec.

[10] SFPE Handbook, Fourth Edition, Section 3 Chapter 13.

Manual wheelchair.	0.69 m/sec.
Assisted manual wheelchair.	1.3 m/sec.
Assisted ambulant.	0.78 m/sec.

3.13 STANDARDS OF CONSTRUCTION, COMMISSION MANAGEMENT/ MAINTENANCE

The fire engineering analysis will be based on condition of completely constructed and fully occupied building with all fire safety systems has been designed, installed, commissioned, maintained and certified to the relevant Australian Standards.

3.14 FIRE SAFETY DURING CONSTRUCTION PHASE

Prevention of fire initiation during construction and suitable means of fire suppression systems during construction phase are the responsibility of the construction company (contractor/builder).

That is includes (but not limited to):-

- Avoidance of combustible material storage next to ignition source; and
- Hot works such as wilding and the like to be carried with minimum two competent licensed trades and under supervision; and
- Sufficient portable fire extinguishers to be available or similar means of suppression.
- Induction to all workers to have minimum skills for housekeeping, prevention of ignition and the use of portable fire extinguishers.
- All workplace health and safety provisions to be implemented.

4 ENGINEERING ASSESSMENT: EXCESSIVE FLOOR AREA AND VOLUME

4.1 GENERAL

This Performance Solution is to assess whether the proposed fire compartmentation, satisfying the NCC Performance Requirements CP1 & CP2 or not.

4.2 NCC DTS PROVISIONS

As stated in the BCA Compliance Report, the following NCC DTS Provisions are applicable to the subject building:-

Clause C2.2 The size of any Fire Compartment or Atria in Classes 5 to 9 must not exceed the relevant maximum floor area nor exceed the relevant maximum volume set out in Table C2.2.

NCC, Section C, Part C2, Clause C2.2, Table C2.2 limits the maximum size of Fire Compartments and Atria in Class 9b buildings of Type A construction to floor area of 8000m² and volume of 48000m³.

4.3 DEVIATION TO NCC DTS PROVISIONS

The subject building floor area and volume exceed maximum floor area and volume for Class 9b building with Type A Construction.

4.4 BASIS OF NCC DTS PROVISIONS

The Guide to NCC, in discussing Clause A0.2 states that; the intent of Clause A0.2 is to state how a solution would achieve compliance with the Performance Requirements, where Performance Requirements outline the levels of accomplishment different buildings must attain. The Performance Requirements are the only hierarchy levels must be satisfied. There are three options to comply with the Performance Requirements: Deemed-to-Satisfy Solutions, Performance Solutions or a combination of both.

The Guide to NCC states[11] that the fire compartment contains walls, floors and the like creating a compartment (or "box") of any shape used to limit the spread of fire to another compartment or part of building. If a Performance Solution is used, the building elements used to form a fire compartment must have appropriate fire separation from the remainder of the building as determined by fire engineering principles. Note that FRLs are only used in the Deemed-to-Satisfy Provisions.

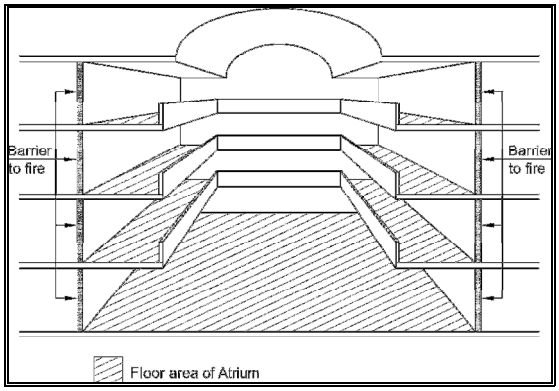

Figure 21 – NCC illustration of atrium floor area that should be bounded by fire barriers.

[11] Guide to NCC Page 28

The Guide to NCC in defining the safe pace states that a safe place provides a final refuge from a fire, such as a road or open space at the end of an exit. It can also be a temporary “haven” or “refuge” to protect people while they are evacuating during a fire. The term is only used in the Performance Requirements. Safe places can be inside or outside a building, and must provide a person with protection from a fire and then allow them to safely escape to a road or open space. Examples: fire-isolated stairways, ramps, passageway or an adjacent fire compartment.

The Guide to NCC states that the Objective of Section C based on the intention that a building should:

- provide people with an environment which, during a fire, will minimise the risk of them suffering illness or injury;
- provide people with an evacuation route which will minimise the risk of them suffering illness or injury while escaping a fire;
- facilitate the role of emergency services personnel, such as the fire brigade, if it becomes necessary for them to undertake such operations as fire-fighting and search and rescue;
- assist in minimising the risk of fire spreading from one building to another; and
- not to have a structural failure during a fire that results in damage to another building, allotment or road.

In relation to the Performance Requirements CP1 & CP2, The Guide states that; CP1 uses the term “to the degree necessary”. This word usage designed to provide flexibility in the way this provision implemented. The intended meaning of the term “to the degree necessary” in CP1 and other Performance Requirements, is explained in A1.7 of the NCC. It means that the NCC recognises that different building elements require differing degrees of structural stability during a fire. The expression intended to allow the appropriate authority to determine the degree of compliance necessary in each particular case. Any decision made in this context can extend to not requiring an item to be-installed or a particular level of performance to be achieved, if that is the appropriate action to be taken.

While assessment of a building proposal must have regard to the differing needs of each building element, the proposal must make sure that the elements have an appropriate structural stability during a fire, so that:

- the fire does not endanger the occupants by entering escape routes; and
- the fire does not endanger fire fighters while they are undertaking search and rescue operations.

If a Performance Solution to the Deemed-to-Satisfy Provisions in Section C is being used, it may be appropriate to assess it using the Section C Deemed-to-Satisfy Provisions for guidance purposes. It is stressed, however, that compliance with the Deemed-to-Satisfy Provisions is not compulsory if alternative means can be found to satisfy the appropriate authority that the Performance Requirements will be achieved. The building proponent should refer to A0.9 for guidance on acceptable assessment methods for determining compliance with the Performance Requirements.

4.5 ASSESSMENT & ANALYSIS

Fire and life safety engineering analysis in compliance with NCC Clause A0.4 a deemed-to-Satisfy solution which complies with the Deemed-to-Satisfy Provisions which is deemed to comply with The Performance Requirements.

4.5.1 Proposed Building Solution (Fire Compartments)

The building to be divided into three fire compartments of less than 8000m² floor area, (North Fire Compartment and East Fire Compartment and rooftop plants Fire Compartment), with north fire compartment to be served with fire-isolated stairway and east fire compartment to be served with fire-isolated stairway.

— Solid lines indicate fire walls with an FRL of 120/120/120.

- - - Dotted lines indicate drenchers-protected glazed partitions.

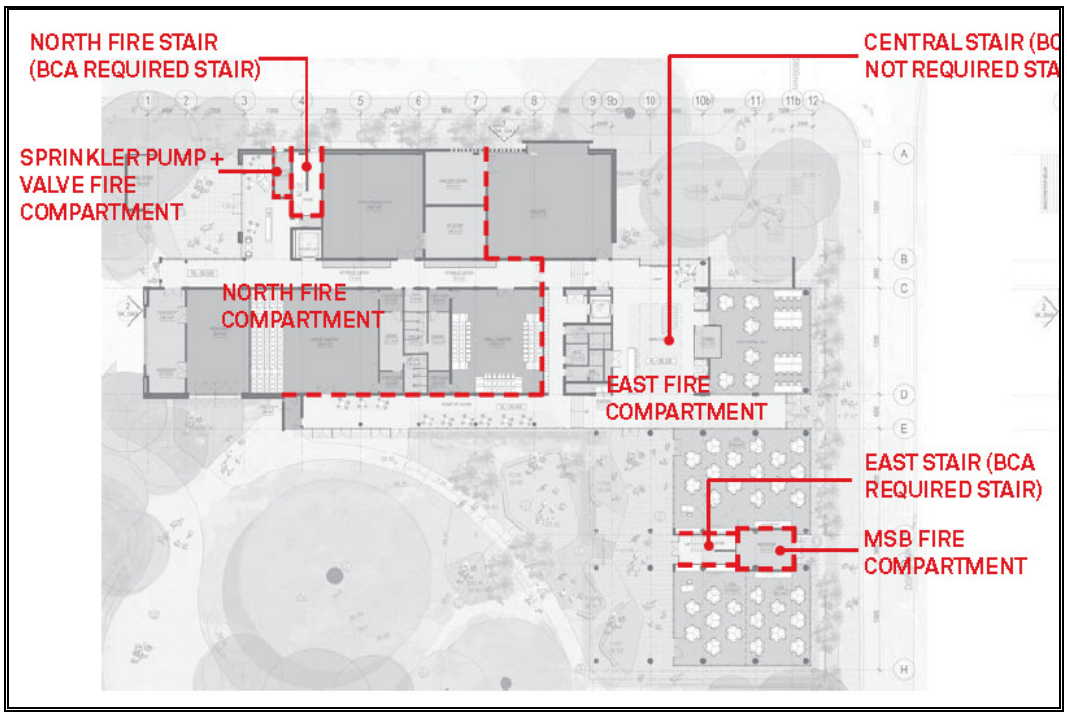

Figure 22 – Ground Level Fire Compartments.

Figure 23 – Level 1 Fire Compartments.

Figure 24 – Level 2 Fire Compartments.

Figure 25 – Level 3 Fire Compartments.

Figure 26 – Level 4 (Plants) Fire Compartments.

The proposed fire compartmentation walls to be constructed with an FRL of 120/120/120.

Where the proposed fire compartment boundary necessitate passing through line where no walls required from the Architectural prospect, a drencher-protected glazed partition to be used.

Where the proposed fire compartment boundaries necessitate passing through corridors a drencher-protected glazed partition and door leaves to be used. Drenchers protected glass door can be held opened with magnetic tapes and automatically released to closed position with fire alarm.

In order to meet the intent of the architectural design concept; the atrium opened stair not to be considered as a required exit where the atrium fire compartment has two horizontal exits to adjacent fire compartment then to fire-isolated stairs.

4.5.2 Assessment of Proposed Glazed Partitions and Doorways Part of fire Compartmentation

The Engineering Fire & Life Safety Assessment is based on demonstrating that the proposed drencher protected glass (Drenched glass is certified to achieve FRL 120/120/120) is adequate for occupant's safety during a fire and adequate to facilitate safe intervention conditions for geared fire fighters.

The proposed drencher-protected glass partitions and door leaves are required to be constructed in accordance with manufacturer specifications, such as Tyco system or any other equivalent, tested and certified system. Refer to **Appendix A,** design and installation certificates should be provided.

The alternative solution for proposed design incorporates the proposed drencher protected glass (Drenched glass is certified to achieve FRL 120/120/120, which is similar to FRL for the fire wall, with glass panel stability maintained for two hours, hence integrity and insulation,

The TYCO system is selected as being widely used in Australia and Model WS Specific Application Window Sprinklers are UL and C-UL Listed and NYC Approved (MEA 335-01-E) for use as "Specific Application Window Sprinkler" and as open sprinklers for "Outside" use (any other equivalent system can be used).

These sprinklers are also recognized by Underwriters Laboratories of Canada (ULC), and the Ontario Building Code for use in the Province of Ontario, Canada as providing a two-hour equivalency for a fire separation assembly when installed in accordance with this code.

When acceptable to the Authority Having Jurisdiction and unless modified by a local jurisdictional standard or code mentioned previously, the TYCO Model WS Window Sprinklers may be used in either a sprinklered or unsprinklered building to protect non-operable window openings that are part of a fire separation provided[12]:

- in an interior fire separation, the window sprinklers are installed on both sides of the window in the fire separation: or
- in jurisdictions where exterior spatial separation (that is, separation from adjacent space) is defined as protecting an adjacent building from a fire in a building, window sprinklers are installed on the interior side of the building; or
- in jurisdictions where exterior spatial separation is defined as protecting building from a fire in an adjacent building (that is, exposure protection), open window sprinklers are installed on the exterior side of the building.

[12] TYCO Technical Data Refer to Appendix A.

4.5.3 Assessment of Fire Brigade Intervention

With proposed fire compartmentation in compliance with DTS Provisions, fire brigade intervention to subject building is similar to DTS compliant building, the hydraulic design of subject building fire hydrant system in compliance with the Australian Standards AS2419.1-2005 and subject building has advantage of fast-response sprinkler protection that is over and above, therefore fire brigade intervention to subject building is facilitated to the degree necessary.

The fire engineering assessments of this report shows that simulated fire conditions provide tenability limits of at least 30 minute, with some fire scenarios occupants tenability limits extended to 60minutes (refer to Appendix B and Appendix C), with acceptable occupants life safety factor, therefore fire brigade search and rescue are minimised.

The simulated fire conditions within subject building show that tenability limits for geared fire brigade personnel do not arrive where smoke temperature do not reach 230°

The Fire Brigade Intervention Model, as detailed in Appendix E, shows that Required Safe Intervention Time (RSIT) is 24minute; therefore fire brigade personnel safety factor of greater than 1 is satisfied.

4.6 SATISFYING RELEVANT NCC PERFORMANCE REQUIREMENTS

Satisfying the relevant NCC Performance Requirements is achieved by building solution to comply with the Deemed-to-Satisfy Solutions[13], with fire compartments within the building have floor area of less than 8000m² and volume of less than 48000m³.

4.7 CONCLUSION

The above fire engineering assessment shows that proposed compartmentation in compliance with NCC Clause A0.2, is adequate to prevent spread of fire within the building or to adjacent properties, to the degree necessary, as required by Performance Requirements CP1 & CP2 of the NCC, therefore it is recommended to be permitted by relevant authorities.

[13] NCC Clause A0.2

5 ENGINEERING ASSESSMENT: EXTERNAL WALLS & OPENINGS

5.1 GENERAL

This Performance Solution is to assess whether the proposed Level 3, non-fire-rated walls and unprotected external openings in different fire compartments and located at less than 6m separation distance satisfying the NCC Performance Requirements CP2 or not.

5.2 NCC DTS PROVISIONS

As stated in the BCA Compliance Report, the following NCC DTS Provisions are applicable to the subject building:-

Clause C3.3: The distance between parts of external walls and any openings within them in different fire compartments separated by a fire wall must not be less than that set out in Table C3.3, unless-
(a) Those parts of each wall have an FRL of not less than 60/60/60; and
(b) Any openings protected in accordance with C3.4.

5.3 DEVIATION TO NCC DTS PROVISIONS

Non-fire-rated walls and unprotected external openings in different fire compartments at angle 90° and located at less than 3m separation distance (on Level 3).

5.4 BASIS OF NCC DTS PROVISIONS

The Guide to NCC states that the intent of Clause C3.3 is to limit the spread of fire between fire compartments through external walls and the openings in them.

The Guide also states that when the walls are at an angle of 180º or greater, the distance between them may be zero because the effects of radiant heat between the walls is negligible. In practice, the distance between such walls is likely to equal the width of the fire wall.

5.5 ASSESSMENT & ANALYSIS

Fire and life safety engineering analysis in compliance with NCC Clause A0.3: solution which complies with the Performance Requirements.

5.5.1 Proposed Building Solution (External Walls and Openings)

The proposed Performance Solution utilises the advantage of sprinkler-protection as discussed below.

5.5.2 Advantages of Sprinkler Protection

The entire building is proposed to be sprinkler-protected, which will mitigate the fire size and prevent the temperature of smoke inside the room of fire origin from reaching the critical

temperature for failure of structural members or protective membranes such as walls and ceiling lining, with the following advantages:-

(1) This Performance Solution utilising installation automatic standard sprinkler system is widely used and is generally very reliable, It is considered reasonable to assume that the intensity and extent of a fire will be reduced upon sprinkler activation and this would be expected to be achieved in the following ways:-

- Sprinklers are designed to limit the size of a fire or even suppress a fire by removing heat from the surrounding environment.
- Sprinklers are expected to prevent a fire developing to the stage where flames from a fire have projections outside external openings or reach the structural elements.
- Sprinklers may mitigate the impact of fire on the building structural elements by way of decreasing the temperature of the fire plume and combustion gases to temperatures less than the critical temperatures of the structural elements of the building.
- The Technical Memoranda TM19:1995[14], states that; "it may be assumed that the sprinkler activation cool most of the smoke layer to below that of the operating temperature of the sprinklers", and that, "it is considered that an average smoke layer temperature of 100^{o} may be assumed whilst the sprinklers are operating", the sprinkler-controlled fire will not have effect on the structural stability of the building elements, where average smoke temperature is smaller than the failure temperature of timber, steel or reinforced concrete.
- Statistics show that, in most cases, the fire usually extinguished before the fire brigade arrives at the building[15], with smoke temperature limited to only 100°, as discussed above.
- Sprinkler reliability reported in literature for correctly designed, installed, tested and maintained sprinkler systems. England and Young (1998) – Fire Australia Proceeding, Fire Risk Management for Buildings with Aged Accommodation estimated the reliability of automatic sprinkler systems to be approximately 95%, based on Australian Fire Incidents Statistics collected by the Australian Fire Authorities Council for the period 1989 -1994, this is consistent with data from United States where been reported that insurers consider the reliability of automatic sprinkler systems in the range of 92-97%

(2) The Guide to NCC discussing the Performance Requirements EP1.4 (recognised the benefit of sprinkler protection) states the following:-

- Life safety and fire suppression: Automatic fire suppression systems, such as sprinkler systems, are normally used in a building to contain and extinguish fire. When an automatic fire suppression system operates, it not only controls or limits the fire development, but statistics show that, in most cases, the fire is extinguished before the fire brigade arrives at the building.
- An automatic fire suppression system is regarded as part of a building's life safety package because:
  • if the system extinguishes the fire before it fully develops, the fire will not endanger the occupants; and

[14] Relationships for smoke control calculations; The Chartered Institution of Building Services Engineers, 1995 (CIBSE).
[15] Guide to NCC2016, Volume One, EP1.4, Page 312

• if the system limits or controls the spread of a fire, it allows occupants more time to evacuate to a safe place.

- "To the degree necessary" The use of the expression "to the degree necessary" in EP1.4 indicates that the NCC recognises that not all buildings need an automatic fire suppression system. Any decision made in this context can extend to not requiring an item to be installed or particular level of performance to be achieved, if that is the appropriate action to be taken.
- The NCC in several occasions (recognised the benefit of sprinkler protection) and reduced the FRL requirements.
- NCC Specification C1.1, 3.5 - allows the roof of certain building not to have a Fire Resistance Level (FRL) the NCC assumes that the sprinkler system will control prior to it breaking through the roof.
- NCC Specification C1.1, 3.9 - allows lower Fire Resistance Level (FRL) for sprinklered carpark.
- NCC Specification C1.1, 3.10 - Reference to Clause 2 of Specification E1.5 indicates that the required sprinkler system need only comply with AS 2118.4—Automatic fire sprinkler systems—Residential. This Standard has been specifically developed to provide a degree of life safety and property protection for occupants of low-rise Class 2 buildings.

5.5.3 Assessment of Fire Spread

The subject walls are entirely glazed with 90° angle between walls.

The NCC Verification Method CV2 is used to assess compliance with Performance Requirements CP2 (a) (iii) to avoid spread of fire between buildings in the same allotment, where radiant heat flux between the openings centrelines is simulated as detailed below:-

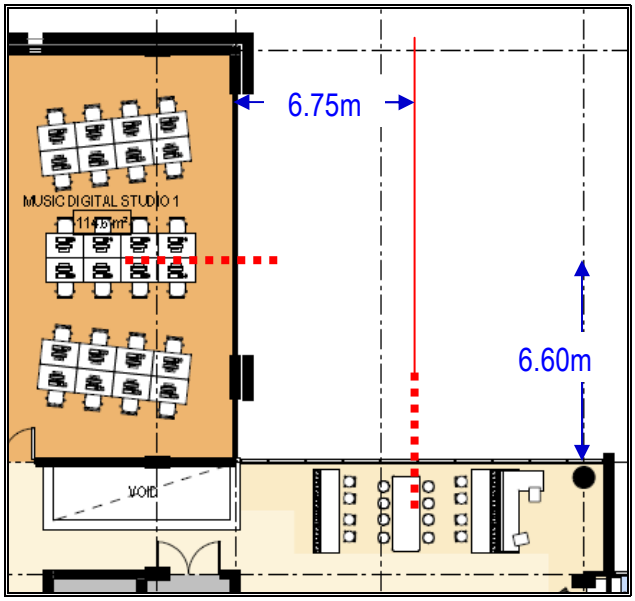

Figure 27 – Level 3 external walls and openings between fire compartments subject of this assessment.

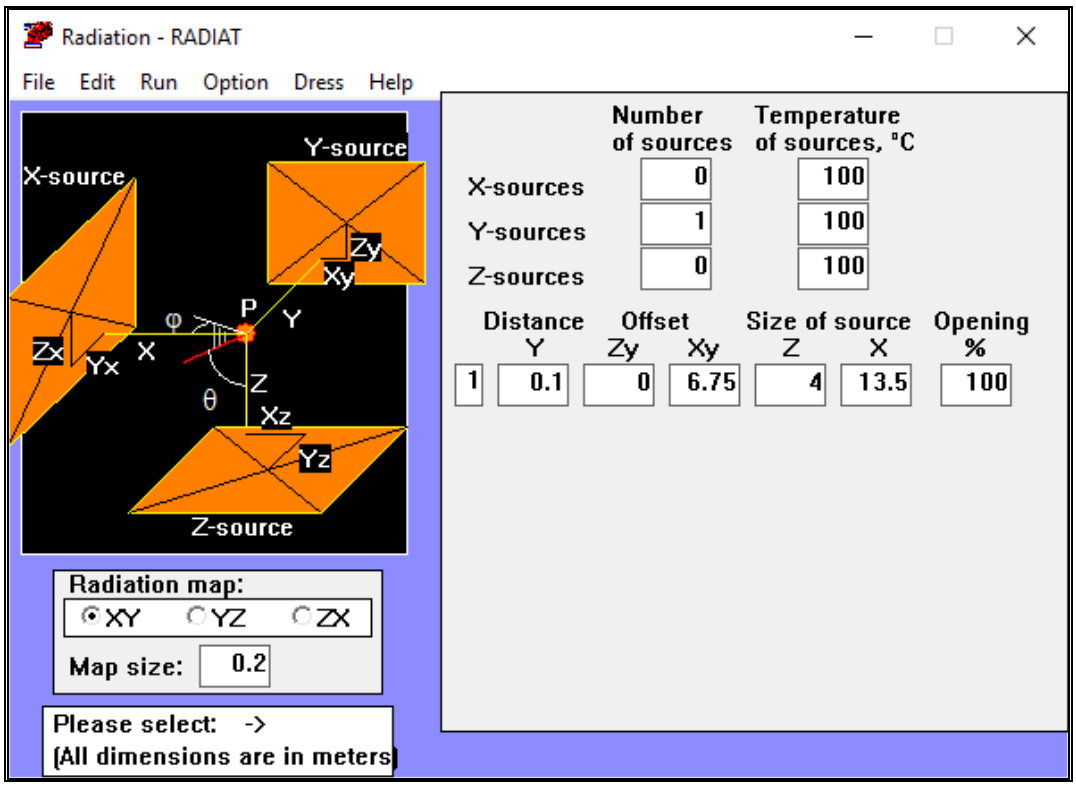

Figure 28 – Simulated omission during sprinkler-controlled fire scenario.

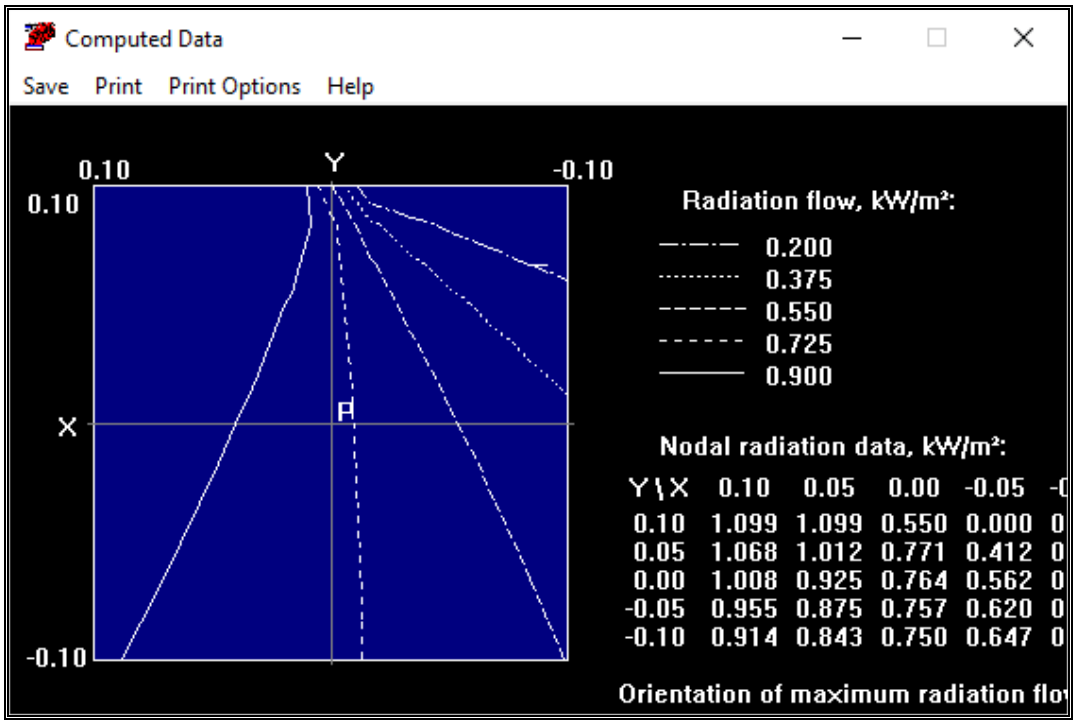

Figure 29 – Very small computed radiant heat flux.

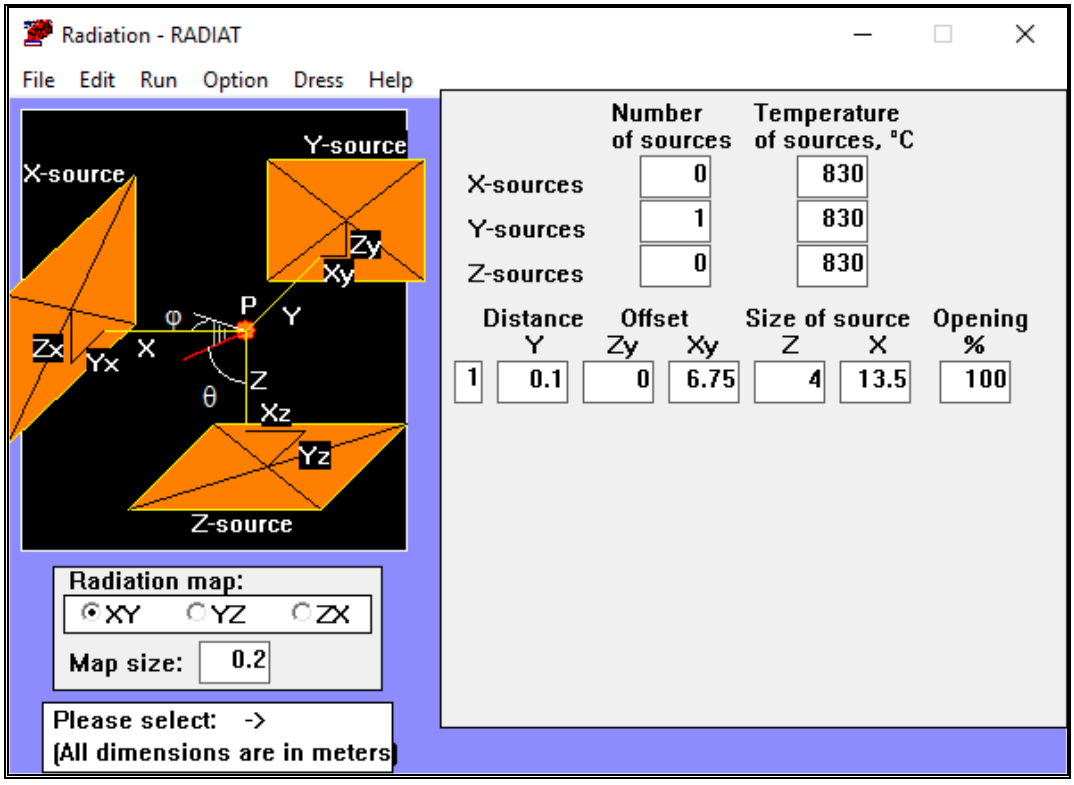

Figure 30 – Simulated omission during uncontrolled fire scenario.

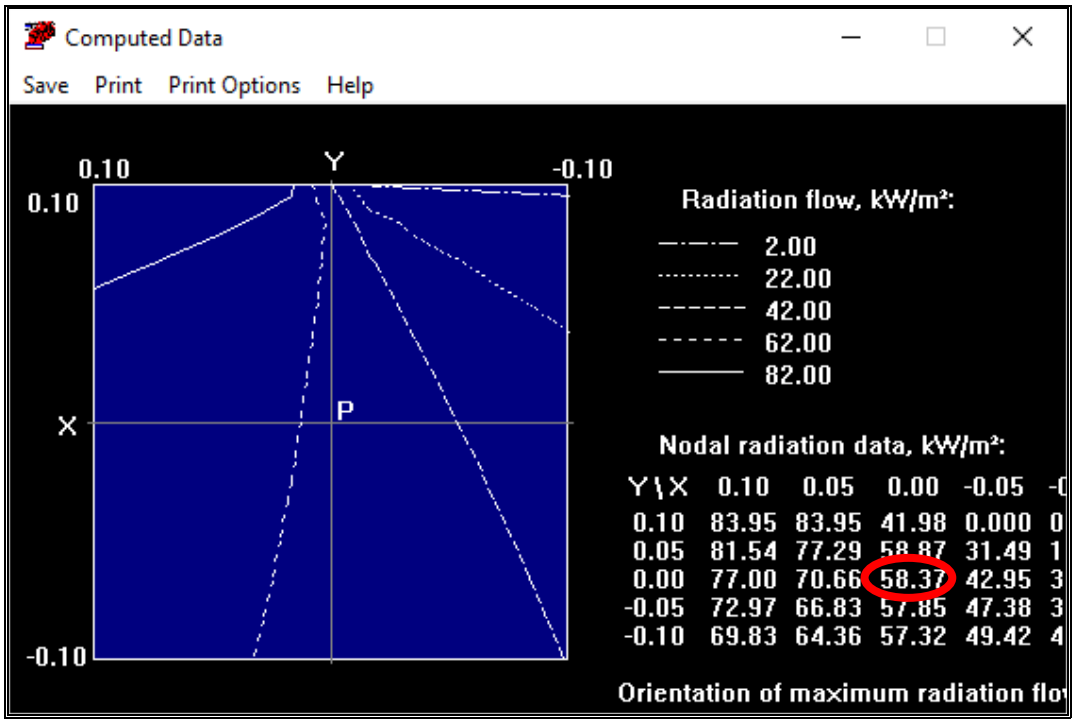

Figure 31 – Computed radiant heat flux at the centreline of the receiver is only 58.37kW/m² (< 80kW/m²).

The above simulations show that spread of fire between fire compartments is unlikely.

5.6 SATISFYING RELEVANT NCC PERFORMANCE REQUIREMENTS

The Performance Solution of non-fire-rated external walls and unprotected openings between two fire compartments is to be assessed against the relevant NCC Performance Requirements CP2, as shown below in **Table 18**

Table 18 - Assessment of Compliance with the BCA Performance Requirement CP2

CP2 Parameter	Discussion	Parameter Addressed
(a) A building must have elements which will, to the degree necessary, avoid the spread of fire -		
(i) to exits	N/A.	N/A.
(ii) to sole-occupancy units and public corridors	N/A.	N/A.
(iii) between buildings	The sprinkler protection maintained smoke temperatures lower than similar DTS complies building and also lower than failure temperature of the glass. The engineering analysis shows that spread of fire between fire compartments is unlikely with the sprinkler protection.	N/A.
(iv) in a building	N/A.	N/A.
(b) avoidance of spread of fire referred to in (a) must be appropriate to-		
(i) the function or use of the building	The function or use of the building is considered in relation to the proposed alternative solution, and considered equivalent to a similar DTS compliant building with low fire load intensity.	Yes.
(ii) the fire load	The fire load of the building is considered in relation to the proposed alternative solution, and considered equivalent to a similar DTS compliant building with low fire load intensity.	Yes.
(iii) the potential fire intensity	The potential fire intensity of the building is considered in relation to the proposed alternative solution, and considered equivalent to a similar DTS compliant building with low fire load intensity.	Yes.
(iv) the fire hazard	The fire hazard of the building is considered in relation to the proposed alternative solution, and considered equivalent to a similar DTS compliant building with low fire load intensity.	Yes.
(v) the number of storeys in the building	The building has a rise in storeys of 5 which considered equivalent to a similar DTS compliant building; however this issue has no significant effect on the spread of fire / smoke subject of this assessment.	Yes
(vi) its proximity to other property	The sprinkler protection maintained smoke temperatures lower than similar DTS complies building and also lower than failure temperature of the glass. The engineering analysis shows that spread of fire between fire compartments is unlikely with the sprinkler protection.	Yes.
(vii) any active fire safety systems	The sprinkler protection maintained smoke temperatures lower than similar DTS complies building and also lower than failure temperature of the	Yes

CP2 Parameter	Discussion	Parameter Addressed
installed in the building	glass. The engineering analysis shows that spread of fire between fire compartments is unlikely with the sprinkler protection.	
(viii) the size of any fire compartment	The size of fire compartments is considered in relation to the proposed alternative solution, and considered equivalent to a similar DTS compliant building	Yes
(ix) fire brigade intervention	N/A.	N/A.
(x) other elements they support	N/A	N/A
(xi) the evacuation time	N/A.	N/A

5.7 CONCLUSION

The above fire engineering assessment shows that proposed non-fire-rated external walls and unprotected openings between two fire compartments are adequate to prevent spread of, to the degree necessary, as required by Performance Requirements CP2 of the NCC, therefore it is recommended to be permitted by relevant authorities.

6 ENGINEERING ASSESSMENT: EASTERN & CENTRAL STAIR FIRE ISOLATION

6.1 GENERAL

This Performance Solution is to assess whether the proposed eastern stair fire isolation, and opened central atrium stair satisfying the NCC Performance Requirements DP5 or not.

6.2 NCC DTS PROVISIONS

As stated in the BCA Compliance Report, the following NCC DTS Provisions are applicable to the subject building:-

Clause D1.2 (d) (vi): In Class 9 buildings; in addition to any horizontal exit, not less than 2 exits must be provided from any storey or mezzanine that accommodates more than 50 persons, calculated under D1.3.

Cluse D1.3 (b): every stairway or ramp serving as a required exit must be fire-isolated unless, it connects, passes through, or passes by no more than 2 consecutive storeys and one extra storey of any classification may be included, if the building has a sprinkler system complying with Specifications E1.5 installed throughout, or the required exit does not provide access to or egress for, and is separated from the extra storey by construction having an FRL (-/60/60 if non-load-bearing), and an FRL (90/90/90 in Type A building or 60/60/60 in Type B building, if load-bearing) and no opening that could permit the passage of fire or smoke .

6.3 DEVIATION TO NCC DTS PROVISIONS

The central stair within atrium well connects more than 3 storeys and is opened (non-fire-isolated).

The eastern stairway connects more than 3 storeys (Ground, L1, L2 & L3); therefore it is required to be fire-isolated despite the building being sprinkler-protected.

6.4 BASIS OF NCC DTS PROVISIONS

The Guide to NCC in defining the safe pace states that a safe place provides a final refuge from a fire, such as a road or open space at the end of an exit. It can also be a temporary “haven” or “refuge” to protect people while they are evacuating during a fire. The term is only used in the Performance Requirements. Safe places can be inside or outside a building, and must provide a person with protection from a fire and then allow them to safely escape to a road or open space. Examples: fire-isolated stairways, ramps, passageway or an adjacent fire compartment.

The Guide to NCC, in discussing Clause D1.2 (d) (i) for Class 9 buildings states that **D1.2(d)(i)** recognises the emergency egress requirements for Class 9 buildings. Such buildings could contain large numbers of people who may be unfamiliar with the building’s egress provisions. They might also be confused and in various stages of immobility.

The Guide to NCC, in discussing Clause D1.2 (d) for Class 9 buildings states that; In **D1.2(d)(ii)–(vi)**, and **D1.2(e)** and **(f)**, the BCA recognises that some Class 9 buildings (patient care areas,

aged care buildings, early childhood centres, schools, spectator stands, storeys or mezzanines containing more than 50 people as calculated under **D1.13**) present difficult evacuation conditions (requiring two exits additional to any horizontal exits) because of such factors as:

- The age and nature of the occupants;
- The density of occupation (for example, occupants per m^2); and
- The unfamiliarity of occupants with the emergency evacuation requirements.

Discussing the purpose of fire-isolated exit; the Guide states that fire-isolated exits are required in multi-storey buildings to enable people to evacuate past a storey on fire. They also help the fire brigade carry out search and rescue and fire-fighting.

Such exits minimise the distance people need to travel in a fire-affected area before accessing a “safe place”, such as a fire-isolated stairway.

Fire-isolated exits may be:

- fire-isolated stairways;
- fire-isolated ramps; and
- fire-isolated passageways connected to fire-isolated stairways or ramps.

D1.3 sets out when stairways and ramps connecting storeys in a building are required to be fire-isolated. This only applies to a stairway or ramp serving as a required exit. Therefore, from the definition of "exit", **D1.3** only applies to those providing egress to a road or open space. Combined with the provisions of **D1.2** that exits are required from every storey, a stairway or ramp serving as an exit will generally be connecting storeys. However, the term "exit" could also apply to a stairway or ramp from a basement that exits vertically, directly to a road or open space and thus, does not technically connect storeys.

D1.3 only applies to stairways that are required exits and therefore does not apply to stairways between split levels of a single storey of a building or those leading from the front door of a building.

6.5 ASSESSMENT & ANALYSIS

Fire and life safety engineering analysis in compliance with NCC Clause A0.4 a deemed-to-Satisfy solution which complies with the Deemed-to-Satisfy Provisions which is deemed to comply with The Performance Requirements.

6.5.1 Proposed Building Solution (Required Fire Isolated Eastern Stairway)

The proposed Eastern Stairway fire separation walls to be constructed with an FRL of 120/120/120.

Where the proposed fire separation walls necessitate passing through line where no walls required from the Architectural prospect, a drencher-protected glazed partition to be used.

Where the proposed fire compartment boundaries necessitate passing through doorways a drencher-protected glazed partition and door leaves to be used. Drenchers protected glass door can be held opened with magnetic tapes and automatically released to closed position with fire alarm.

The eastern stairway fire compartment should be free of any fire load and ignition source, so that fire initiation is prevented.

6.5.2 Assessment of Proposed Glazed Partitions and Doorways Part of fire Isolation

Refer to Section 4.5.2 above,

6.5.3 Assessment of Central (Atrium) Open Stair

The fire safety strategy for the entire building is to provide fire compartmentation with floor area and volume in compliance with NCC DTS Provisions C2.2.

The central fire compartment accommodates the atrium is served with two horizontal exits leading to adjoining two fire compartments and two fire-isolated stairways, in compliance with NCC DTS Provisions Clause D1.2 "Number of Exits Required" and Clause G3.7 "Means of Egress".

Part of fire safety strategy therefore; not to assign the central atrium stairway as a required exit, hence this central stairway will not be fire-isolated in order to meet the intent of the architectural design.

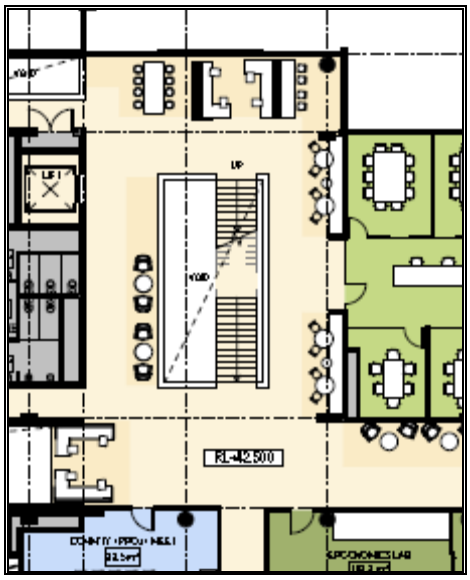

Figure 32 – Part of fire safety strategy is not to assign the central atrium stairway as a required exit, hence this central stairway will not be fire-isolated in order to meet the intent of the architectural design.

The intent of NCC, Part D1"Provision for Escape" where the Guide to NCC in discussing the DTS Provisions of Clause D1.2 (g) states that occupants must be able to access an exit. Where two or more exits are required, at least two exits (allowing for the fact that one of the exits may be made inaccessible by an emergency, such as a fire) should be accessible.

As discussed above; the NCC Provisions required at least one exit to be accessible during fire emergency where the other exits may be made inaccessible by the fire, and the proposed fire safety strategy for subject building provides two accessible exits during fire emergency.

The non-fire-isolated, opened, central atrium stairway is further assessed in relation to occupant life safety as following:-

- Occupants do not need to use the central atrium stairway during fire incident where other two alternative fire-isolated stairways are available, and subject stair is assigned as non-required exit.
- The upper levels atrium area around the central atrium stairway is circulation area free of fire load, combustible materials and ignition sources; therefore fire initiation or fire spread within subject circulation areas are very unlikely.
- Occupants within atrium area, that is open spaces have with clear visual and olfactory cue, therefore occupants will start moving away from fire and smoke affected area very quickly.
- The atrium is enclosed within separate fire-compartment with short travel distance to two alternative horizontal exits to adjacent fire compartment; therefore occupants have the facility to move away from atrium area in a very short time without exposure to smoke or radiant heat flux; and
- The atrium roof is fitted with automatic smoke exhaust fans with capacity of greater than 100m³/sec, therefore the hot smoke generated from atrium fire, if happened, will be automatically extracted to outside the building preventing occupant exposure and fire spread.
- The entire building, including circulation areas around the atrium stairway is protected with fast-response automatic sprinkler heads; therefore, with the sprinkler activation, the smoke temperature inside the building will be < 100°[16], this statement is further verified with several simulations of fire conditions during sprinkler-controlled fire scenarios as detailed in Appendix B.
- The simulated fire conditions inside the building including atrium area show that tenable conditions for geared fire fighter are maintained for sufficient time with acceptable safety factor for fire brigade personnel.

6.6 SATISFYING RELEVANT NCC PERFORMANCE REQUIREMENTS

Satisfying the relevant NCC Performance Requirements is achieved by building solution to comply with the Deemed-to-Satisfy Solutions[17], with fire isolation of eastern stairs of 120/120/120 FRL.

The Performance Solution of non-fire-isolated, opened, central atrium stairway is to be assessed against the relevant NCC Performance Requirements DP5, as shown below in **Table 18**

[16] The Technical Memoranda TM19:1995 (Relationships for smoke control calculations; The Chartered Institution of Building Services Engineers, 1995 (CIBSE)
[17] NCC Clause A0.2

Table 19 - Assessment of Compliance with the BCA Performance Requirement DP5

DP5 Parameter	Discussion	Parameter Addressed
To protect evacuating occupants from a fire in the building exits must be fire-isolated, to the degree necessary, appropriate to -		
(a) the number of storeys connected by the exits	The number of storeys connected by the exit is considered in relation to the proposed alternative solution and central atrium open stairway is assigned as non required stairway during emergency evacuation. The fire compartments provide alternative safe exits and the building sprinkler protection limits the smoke temperature with atrium automatic exhaust fan extract smoke away to outside the building.	Yes
(b) the fire safety system installed in the building	The relevant fire safety systems installed throughout the building, including fire compartments to provide alternative safe exits and the building sprinkler protection limits the smoke temperature with atrium automatic exhaust fan extract smoke away to outside the building..	Yes
(c) the function or use of the building	The function or use of the building is considered in relation to the proposed alternative solution, and considered equivalent to a similar BCA compliant building in terms of occupant life safety with advantage of smaller fire load intensity inside subject building. The fire compartments provide alternative safe exits and the building sprinkler protection limits the smoke temperature with atrium automatic exhaust fan extract smoke away to outside the building.	Yes
(d) the number of storeys passed through by the exits	The building has a rise in storeys of 4 and plant rooftop with the proposed alternative solution and central atrium open stairway is assigned as non required stairway during emergency evacuation. The fire compartments provide alternative safe exits and the building sprinkler protection limits the smoke temperature with atrium automatic exhaust fan extract smoke away to outside the building.	Yes
(e) fire brigade intervention	The simulated fire conditions inside the building including atrium area show that tenable conditions for geared fire fighter are maintained for sufficient time with acceptable safety factor for fire brigade personnel.	Yes

6.7 CONCLUSION

The above fire engineering assessment shows that proposed eastern stairway fire isolation in compliance with NCC Clause A0.2, and non-fire-isolated central atrium stairway are adequate to provide safe egress path for occupants to outside the building, to the degree necessary, as required by Performance Requirements DP5 of the NCC, therefore it is recommended to be permitted by relevant authorities.

7 ENGINEERING ASSESSMENT: EGRESS PROVISIONS

7.1 GENERAL

This Performance Solution is to assess whether the proposed design concept incorporates extended travel distances to POC(s) or to exits, satisfying the NCC Performance Requirements DP4, DP6 and DP2.2 or not.

7.2 NCC DTS PROVISIONS

As stated in the BCA Compliance Report, the following NCC DTS Provisions are applicable to the subject building:-

Clause D1.4 (c) (i): In Class 5, 6, 8 or 9 buildings; no point on a floor must be more than 20 m from an *exit*, or a point from which travel in different directions to 2 exits is available, in which case the maximum distance to one of those *exits* must not exceed 40 m

Clause D1.5: Exits that are required as alternative means of egress must be—

(a) distributed as uniformly as practicable within or around the *storey* served and in positions where unobstructed access to at least 2 exits is readily available from all points on the floor including lift lobby areas; and
(b) not less than 9 m apart; and
(c) not more than—
  (i) ..; or
  (ii) ..; or
  (iii) in all other cases — 60 m apart; and
(d) located so that alternative paths of travel do not converge such that they become less than 6 m apart.

Clause D1.9: A non-fire stairway or non-fire-isolated ramp serving as a required exit must provide a continuous means of travel by its own flights and landing from every storey served to the level at which egress to a road or open space is provided

7.3 DEVIATION TO NCC DTS PROVISIONS

The BCA Compliance Report identified the following exit travel distance non-compliances:-

- Ground level: Travel distance from the Gallery Store to point of choice exceeds 20m (approximately 30m)
- Level 3: The furthest point from the “Live Area” exceeds 40m to nearest exit (approximately **45m**).
- Level 3: The furthest point from the “Music Digital Studio” exceeds 40m to nearest exit (approximately **45m**).
- Level 4: The furthest point of the Plant Area (East corners) exceeds 20m to point of choice (approximately 29m worst case).
- Level 4: The secondary non- fire isolated stair from plant room, is discontinuous. In that it requires users to discharge at level 3 and re-enter another nearby stair to reach open space

The BCA Compliance Report, also, identified the following issue related to alternative paths of travel to a required exit must not converge within 6m of one another.

- Levels 1 & 3: Grid G-F – Travel from the furthest South East corners do not reach a compliant point of choice before alternative paths (leading to the central stair) converge.

7.4 BASIS OF NCC DTS PROVISIONS

The Guide to NCC states that the intent of D1.4 is to maximise the safety of occupants by enabling them to be close enough to an exit to safely evacuate.

The **D1.4** travel distances are based on an assumption of what is considered "reasonable" distances to be travelled by occupants in reaching an exit.

The Guide, also, states that the intent of D1.5 is to require that if an exit is inaccessible, access to any required alternative exit must be available within a reasonable distance. Where a building requires multiple exits, the exits maximise the choices of a person evacuating, in case one exit becomes blocked.

If alternative paths of travel converge too closely, both paths can be blocked by the same fire. The minimum distance between the paths of travel aims to negate this.

The minimum convergence distance only comes into operation when the paths of travel have already diverged to that distance. The paths can commence more closely together than the distance specified.

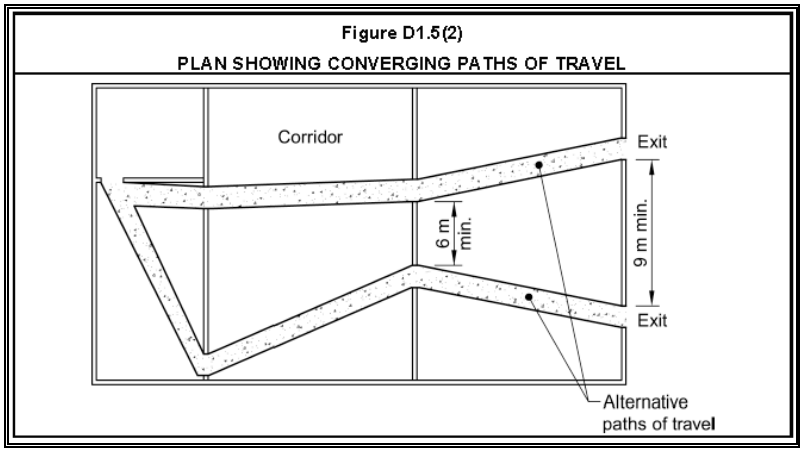

Figure 33 – From Guide to NCC 2016 - Illustrates the convergence prohibition on alternative paths of travel.

The Guide, also, states that the intent of D1.9 is to require that a person using a non-fire-isolated stairway or ramp be provided with a safe evacuation path. Also requires that occupants in a required non-fire-isolated stairway or ramp are able to continue all the way down to the level from which egress to a road or open space is available.

D1.9(a) refers to a continuous means of travel comprising flights of stairs and landings. It would generally not be acceptable for an entire or substantial proportion of a storey to be called a "landing".

The first diagram in Figure D1.9(1) illustrates non-compliance with D1.9(a) because the stair does not provide a continuous path of travel to the level providing egress to a road or open space. The second diagram in Figure D1.9(1) illustrates a method of compliance with D1.9(a).

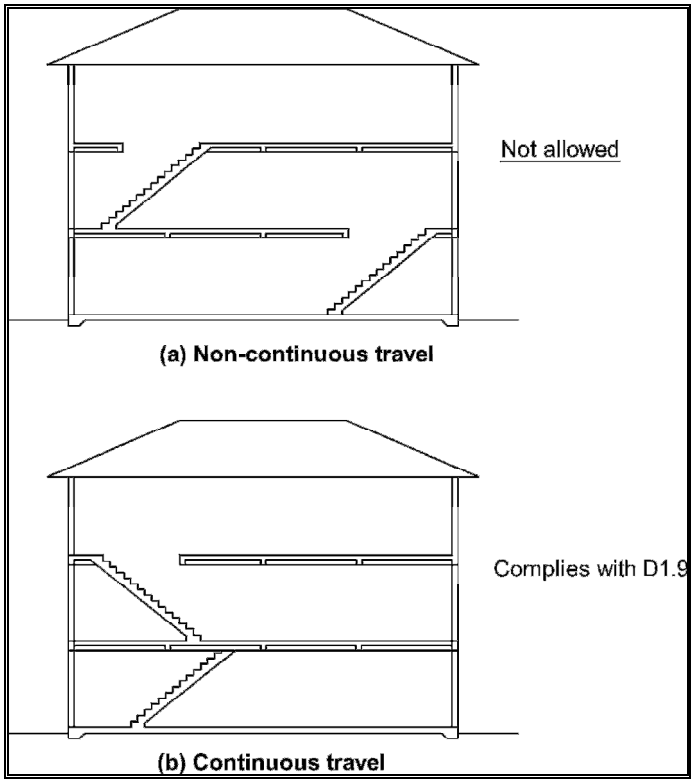

Figure 34 – From Guide to NCC 2016 - Illustrates compliance with D1.9a

7.5 ASSESSMENT & ANALYSIS

Fire and life safety engineering analysis in compliance with NCC Clause A0.2 is to use a performance solution that complies with the Performance Requirements.

7.5.1 Proposed Building Solution (Egress Provisions)

The proposed performance solution incorporates the following provisions:-

- Create fire compartmentation (as addressed in Section 4 above) to provide horizontal exits which reduce the travel distance to POC and alternative exits; and
- Create fire isolation to eastern stairway (as addressed in Section 5 above), along with north fire-isolated stairway which provide occupants with safe egress to outside the building, away from fire-affected area, also will improve the travel paths between alternative exits.
- Provide fast-response sprinkler protection, which is over and above NCC DTS Provisions, that control the fire and extend tenability limits in order provide safe evacuation conditions[18].
- Provide automatic mechanical smoke exhaust fan (capacity100m³/sec) to Atrium roof.

[18] The Technical Memoranda TM19:1995 (Relationships for smoke control calculations; Technical Memoranda TM19:1995, The Chartered Institution of Building Services Engineers, 1995 (CIBSE).

With the above fire safety measures; a life safety assessment (ASET[19]/RSET[20]) to be conducted with:-

- Sprinkler-controlled fire conditions simulated on Appendix B; and
- Sensitivity Analysis for uncontrolled fire scenario conditions simulated on Appendix C; and
- Total building emergency evacuation is detailed on Appendix D

ASET/RSET ratio of greater than1.5 should be satisfied during sprinkler-controlled fire scenario, and ASET/RSET ratio of greater than 1 should be satisfied during uncontrolled fire scenario associated with sprinkler failure.

Three fire locations selected for occupant life safety assessment during possible fire, where non-compliances are identified, as following:-

- Ground floor atrium fire; and
- Level 1 east wing fire; and
- Level 2 north wing fire.

7.5.2 Simulated Fire Conditions Inside the Building (ASET)

Following table is summary of simulated Available Safe Evacuation Time (ASET) during different fire scenarios.

The simulated fire conditions as detailed in Appendix B for design trial associated with successful operation of recommended fast response sprinkler system, while simulated fire conditions as detailed in Appendix C for sensitivity analysis associated with sprinkler system failure.

Table 20 – Summary ASET.

FIRE SCENARIO.	ASET (sec).
# 1A: Atrium sprinklers activated and smoke exhaust fan activated (100m³/sec).	3600.
# 1B: Atrium sprinkler activated and natural smoke ventilation (4 sides 4m height).	3600.
# 2: Eastern Wing - Sprinkler activated.	3600.
# 3: North Wing - Sprinkler activated.	3600.
# 4A: Atrium **sprinkler failure** and smoke exhaust fan activated (100m³/sec).	1800.
# 4B: Atrium **sprinkler failure** and natural smoke ventilation (4 sides 4m height).	1800.
# 5: Eastern Wing **sprinkler failure**.	3600.
# 6: North Wing **sprinkler failure**.	3000.

7.5.3 Emergency Evacuation Analysis (RSET)

Emergency Evacuation Analysis is detailed in Appendix C.

The occupant Required Safe Evacuation Time (RSET) is the time that all occupants need to evacuate the building to outside, and consists of the following components:

- Detection time.

[19] ASET: Available Safe Evacuation Time.
[20] RSET: Required Safe Evacuation Time.

- Pre-movement time.
- Movement time.

Detection Time

Occupant detection and awareness of fire via alarm activated by automatic smoke detection,

- Detection time = Automatic Alarm Activation Time + Alarm Verification Delay Time
  = 246sec + 60sec = 306sec.

Pre-movement Time

For occupant inside room of fire origin a very short pre-movement time is likely due to clear olfactory and visual fire cue.

For occupants away from the room of fire origin, SFPE Handbook, Third Edition, Section 3 Chapter 13-Movement of People Table 3-13.1 recommends 180 sec (3 minutes) for pre-movement for occupants away from room of fire origin when an automatic cue is provided (Occupants Warning System).

- Pre-movement time =180sec.

Movement Time

The available aggregate exit widths for stairways, as advised by the Project Architect are as following:-

Table 21- Summary available aggregate exit widths used for assessment (as advised by the Architect).

Stairway.	Width	Aggregate
Northern Stairway.	1450mm	4250mm (4.5m)
Central Stairway.	1450mm (or more)	
Eastern Stairway.	1350mm	

The fire engineering assessment of this report based on the subject building population of 643 people, as advised by the UOW[21].

Table 22- Summary Movement Time Calculations

Level	Occupants #	Walking Time.	Through Door.	On stairs	Total
Ground.	200 people.	60sec.	200 (2/3)/1.3/2m = 52sec.	-	112sec.
Level 1.	200 People.	60sec.	200 (2/3)/1.3/1.4m = 74sec.	16sec	150sec.
Level 2.	200 People.	60sec.	200 (2/3)/1.3/1.4m = 74sec.	32sec.	166sec.
Level 3.	200 People.	60sec.	200 (2/3)/1.3/1.4m = 74sec.	48sec.	182sec.
Level 4.	31 People.	60sec.	31 (2/3)/1.3/1.4m = 12sec.	64sec.	136sec.

The above table shows that Level 3 has longest movement time.

- Movement time = 182sec.

Total emergency evacuation time (RSET) = 306sec + 180sec + 182sec = 668sec.
= 11.1 minute

[21] UOW Western Building - Room Data Schedule

It should be noted that the above emergency evacuation calculations are very conservative, where movement time is calculated to outside the building while occupants are in safe place once they moved from fire affected area to adjacent fire compartment or to nearest fire-isolated stair.

Also conservative approach is used where 2/3 of the occupant number are assumed to pass through one exit with other 1/3 passing through the other door.

7.5.4 Occupants Life Safety Assessment (Occupant's Life Safety Factor)

The occupant's life safety during fire emergency within selected locations within subject building each fire compartment, as detailed in Appendix B and Appendix C, in order to determine the Available Safe Evacuation Time (ASET), then compared with time occupants need to evacuate the building to open space, as detailed in Appendix D, in order to determine the Required Safe Evacuation Time (RSET).

An occupant's Life Safety Factor is calculated as detailed in the following table.

Table 23- Summary occupant's Life Safety Factor

Fire Scenario	Description.	Cold Smoke Exposure	ASET. Sec.	RSET. Sec.	Calculated Safety Factor.	Required SF.
1A.	Atrium: Sprinkler, Fan.	No.	3600.	668.	5.4.	1.5.
1B.	Atrium: Sprinkler, Vent.	Yes.	3600.	668.	5.4.	1.5.
2.	North: Sprinkler.	No.	3600.	668.	5.4.	1.5.
3.	East: Sprinkler.	Yes.	3600.	668.	5.4.	1.5.
4A.	Atrium: Uncontrolled, Fan.	Yes.	1800.	668.	2.7.	1.
4B.	Atrium: Uncontrolled, Vent.	Yes.	1800.	668.	2.7.	1.
5.	North: Uncontrolled.	No.	3600.	668.	5.4.	1.
6.	East: Uncontrolled.	Yes.	3000.	668.	5.4.	1.

7.5.5 Assessment of Alternative Paths of Travel Reduced Convergence to 4m

The alternative paths of travel reduced convergence to 4m (in lieu of 6m) at Levels 1, 2 & 3 is assessed as being adequate based on the following:-

- The reduction occurs in the circulation area of the atrium that is free of fire load and ignition source; therefore fire initiation within this area is unlikely; and
- The reduction occurs in the circulation area of the atrium that is sprinkler-protected which extends the tenability limits by controlling the fire growth; and
- The reduction occurs in the circulation area of the atrium that is served with automatic smoke exhaust fan extracted the smoke, maintaining tenability limits.

7.5.6 Assessment of Plant Room Non-fire-isolated Required Stairway

The secondary non- fire isolated stair from plant room, discharges at level 3 with occupants need to re-enter another nearby stair to reach open space is assessed as being adequate based on the following:-

- The plant room has two exits; therefore another alternative exit via northern fire-isolated stairway is accessible should this exit not accessible. The Guide to NCC states that; D1.2(g) requires that occupants must be able to access an exit. Where two or more exits are required, at least two exits (allowing for the fact that one of the exits may be made inaccessible by an emergency, such as a fire) should be accessible; and
- The plant room, usually, used occasionally and for a limited time for maintenance purposes only ; and
- The plant room, usually, accommodates very small number of occupants, with very short evacuation time; and
- Entire building has automatic early fire detection system which significantly reduces RSET so occupants are able to evacuate prior to tenability limits arrive ; and
- Short travel distance from discharge point of plant stairway at Level 3 to two alternative sire-isolated exits from L3; and
- The plant room stairway discharge to Level 3 of atrium fire compartment that is protected with automatic smoke exhaust fans that extract the smoke maintains tenability limits sufficient for occupant's safe emergency evacuation; and
- The entire building is protected with automatic fast-response sprinkler system that limits the fire growth, and fire size, maintaining smoke temperature at less than 100 maintains tenability limits sufficient for occupant's safe emergency evacuation; and
- The fire conditions simulated during ground floor fire scenario (as a selected worst fire location) show that long tenable conditions during fire incident are available.

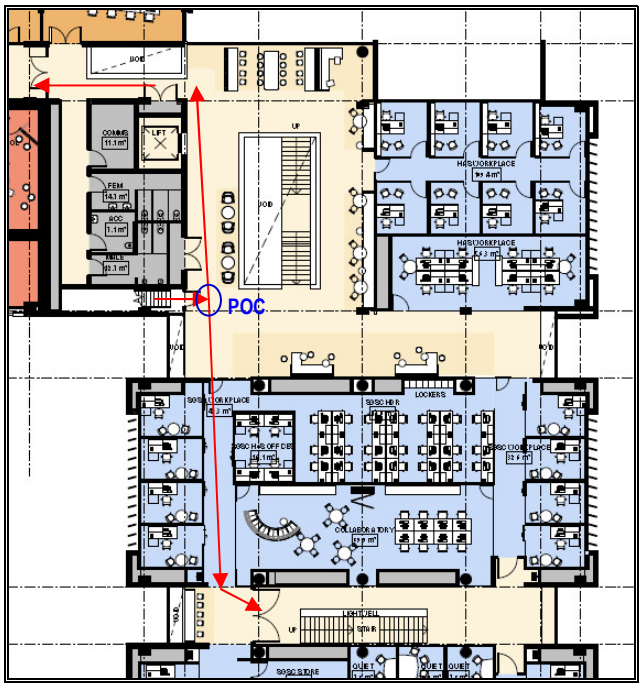

Figure 35 – Egress from plant room via non-fire-isolated stairway discharges at Level 3.

7.6 SATISFYING RELEVANT NCC PERFORMANCE REQUIREMENTS

The Performance Solution of extended exit travel distances, and distances between paths of travel alternative exits along with recommended compartmentation, fast-response sprinkler protection and recorded message during fire emergency is to be assessed against the relevant NCC Performance Requirements DP4, DP6 & EP2.2, as shown below in **Table** 24**, Table 25** & **Table 26** respectively.

Table 24 - Assessment of Compliance with the NCC Performance Requirement DP4

DP4 Parameter	Discussion	Parameter Addressed
Exit must be provided from a building to allow occupants to evacuate safely with their number, location and dimensions, being appropriate to-		
(a) the travel distance.	The travel distance is considered in relation to the performance solution and building evacuation time, the proposed fire compartment providing horizontal exits to adjacent fire compartment and the fire isolated stairs reduced travel distances, along with automatic, fast-response sprinkler that significantly extends tenability conditions. An acceptable life safety factor is calculated for occupants' emergency evacuation from upper levels; therefore extended travel distance has no effect on emergency evacuation.	Yes.
(b) the number, mobility and other characteristics of occupants.	The number, mobility and other characterisation of the occupants is considered in relation to the alternative solution and building evacuation time, the occupant number used in accordance with NCC DTS Provisions is greater than the client's advice, therefore conservative approach is used for life safety assessment. An acceptable life safety factor is calculated for occupants' emergency evacuation from upper levels; therefore extended travel distance has no effect on emergency evacuation.	Yes
(c) the function or use of the building.	The function or use of the building is considered in relation to the proposed alternative solution, and considered equivalent to a similar BCA compliant building in terms of occupant life safety. Subject building impose very low fire load intensity and small fire size.	Yes.
(d) the height of the building	The building has a rise in storeys of 4 which is considered equivalent to a similar BCA compliant building in terms of occupant life safety. It should be noted that with fire compartmentation, horizontal exits and fire-isolated stairs, height of the building has no effect as occupants reach safe place when move to adjacent fire compartment or fire-isolated stair,	Yes.
e) whether the exit from above or below ground level	The exits to outside are at the ground level and are considered as equivalent to a similar BCA compliant building.	Yes.

Table 25 - Assessment of Compliance with the NCC Performance Requirement DP6

DP6 Parameter	Discussion	Parameter Addressed
So that occupants can safely evacuate the building, paths of travel to exit must have dimensions appropriate to -		
(a) number, mobility and other characteristics of occupants; and	The number, mobility and other characteristics of occupants are considered in relation to the proposed Performance solution, with advantage of early automatic smoke detection, early sprinkler activation, compartmentation that provide horizontal exits to adjacent fire compartment with alternative fire isolated exits available. An acceptable life safety factor is calculated for occupants' emergency evacuation from upper levels; therefore extended travel distance has no effect on emergency evacuation.	Yes
(c) the function or use of the building	The function or use of the building is considered in relation to the proposed performance solution. An acceptable life safety factor is calculated for occupants' emergency evacuation from upper levels; therefore extended travel distance has no effect on emergency evacuation.	Yes
Limitation: *CP6 does not apply to the internal parts of a sole-occupancy unit in a Class 2 or 3 building or Class 4 part of a building.* *With respect of people with disabilities, DP6 does not apply to-* *(a) a Class 2 building;* *(b) a Class 7 car park associated with a Class 2 building.*		

Table 26- Assessment of compliant with the NCC Performance Requirement EP2.2

EP2.2 Parameter	Discussion	Parameter Addressed
EP2.2 (a) In the event of a fire in a building the conditions in any evacuation route must be maintained for the period of time occupants take to evacuate the part of the building so that-		
(i) the temperature will not endanger human life;	The fire engineering assessment and simulations show that smoke layer temperature within upper levels is very low whilst the sprinklers are operating, and during uncontrolled fire scenarios, therefore the temperature will not endanger human life, to the degree necessary.	Yes.
(ii) the level of visibility will enable the evacuation route to be determined;	The fire engineering assessment and simulations show that, visibility is maintained during all simulations therefore the smoke exposure will not endanger human life and visibility will enable the evacuation route to be determined, to the degree necessary.	Yes.
(iii) the level of toxicity will not endanger human life.	The fire engineering assessment and simulations show that, cold smoke toxicity is maintained with low concentrations of burning toxic products during all simulations, therefore the smoke exposure will not endanger human life and visibility will enable the evacuation route to be determined, to the degree necessary.	Yes.
EP2.2 (b) The period of time occupants take to evacuate referred to in (a) must be appropriate to-		
(i) the number,	The number, mobility and other characteristics of occupants are considered in relation to the proposed Performance solution, with advantage of early	Yes.

EP2.2 Parameter	Discussion	Parameter Addressed
mobility and other characteristics of the occupants; and	automatic smoke detection, early sprinkler activation, compartmentation that provide horizontal exits to adjacent fire compartment with alternative fire isolated exits available. An acceptable life safety factor is calculated for occupants' emergency evacuation from upper levels; therefore extended travel distance has no effect on emergency evacuation.	
(ii) the function or use of the building; and	The function or use of the building is considered in relation to the proposed performance solution. An acceptable life safety factor is calculated for occupants' emergency evacuation from upper levels; therefore extended travel distance has no effect on emergency evacuation.	Yes.
(iii) the travel distance; and	Extended exit travel distances and extended distances between alternative exits for subject building considered in relation to the proposed Performance Solution along with recommended compartmentation, fast-response sprinkler protection and recorded message. An acceptable life safety factor is calculated for occupants' emergency evacuation from upper levels; therefore extended travel distance has no effect on emergency evacuation.	Yes.
(iv) the fire load; and	The fire load within the building is considered in relation to the proposed Performance Solution, and considered equivalent to a similar NCC compliant building. An acceptable life safety factor is calculated for occupants' emergency evacuation from upper levels with 5MW uncontrolled fire scenario and sprinkler activation fire scenario; therefore extended travel distance has no effect on emergency evacuation.	Yes.
(v) the potential fire intensity; and	The potential fire intensity within the building is considered in relation to the proposed Performance Solution, and considered equivalent to a similar NCC compliant building. An acceptable life safety factor is calculated for occupants' emergency evacuation from upper levels with 5MW uncontrolled fire scenario and sprinkler activation fire scenario; therefore extended travel distance has no effect on emergency evacuation.	Yes.
(vi) the fire hazard; and	The fire hazard within the building is considered in relation to the proposed Performance Solution, and considered equivalent to a similar NCC compliant building. An acceptable life safety factor is calculated for occupants' emergency evacuation from upper levels with 5MW uncontrolled fire scenario and sprinkler activation fire scenario; therefore extended travel distance has no effect on emergency evacuation.	Yes.
(vii) any active fire safety systems installed in the building; and	The proposed fast-response sprinkler protection along with fire hydrants, fire hose reels, portable fire extinguishers and automatic fire detection and alarm system throughout the building is considered in relation to the proposed Performance Solution, which facilitates early occupant detection, control the fire and provide safer emergency evacuation for occupants and safer intervention conditions for fire brigade.	Yes.
(viii) fire brigade intervention.	The fire brigade intervention is considered in relation to the proposed Performance Solution and considered equivalent to a similar NCC complying building with smoke layer temperature within upper levels is very low whilst the sprinklers are operating, and during uncontrolled fire scenarios, which provide safe intervention conditions for fire brigade personnel.	Yes.

7.7 CONCLUSION

As detailed above, it is our considered opinion that; extended exit travel distances, and distances between paths of travel alternative exits along with recommended compartmentation, fast-response sprinkler protection and recorded message during fire emergency considered to be adequate for occupant safe emergency evacuation and brigade safe intervention conditions, to the degree necessary, as required by Performance Requirements DP4, DP6 & EP2.2 of the NCC.

8 ENGINEERING ASSESSMENT – HYDRANT BOOSTER LOCATION

8.1 GENERAL

This performance solution is to assess whether identified deviation of proposed location of fire hydrant booster is not in sight of the main building entry, satisfying the NCC Performance Requirements EP1.3 & EP1.6 or not.

8.2 NCC DTS PROVISIONS

As stated in the BCA Compliance Report, the following NCC DTS Provisions are applicable to the subject building:-

Clause E1.3: Fire Hydrant system must be installed in accordance with AS2419.1, in relation to performance, location and coverage-

The Australian Standards AS2419.1, states that fire authority booster connections located remote from the building must be:-

(a) At the boundary of the site;
(b) Adjacent to the principal vehicular access to the site;
(c) Located not less than 10m from the external wall of any building;
(d) Within sight of the main entrance of the building.

8.3 DEVIATION TO BCA DTS PROVISIONS

The proposed design incorporates fire authority booster connections is not located within sight of the main entrance of the building or at the boundary of the site.

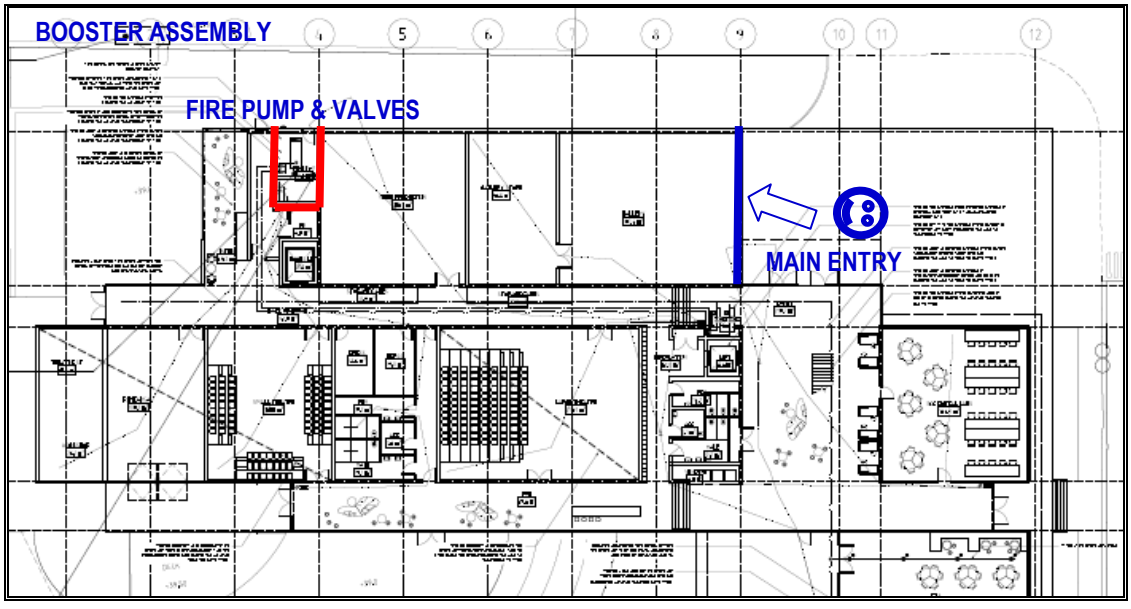

Figure 36 – location of booster subject of this performance solution.

8.4 BASIS OF BCA DTS PROVISIONS

The Guide to NCC states that the intent of E1.3 is to facilitate the fire brigade's fire-fighting operations and fire hydrants are needed to prevent the spread of fire between buildings and fire compartments. They are basically needed for fire brigade use and are not intended for use by occupants. Properly trained people and special equipment are needed for effective fire-fighting using a fire hydrant system.

Under E1.3(b)(i), the installation of a fire hydrant system, including the associated water supply, pipe work, pumps, and so on, must be in accordance with AS 2419.1. If any conflict exists between AS 2419.1 and the BCA, then the BCA takes precedence. Additional information can be obtained by reference to the Standard, including an informative Appendix titled "Guide to the Use of this Standard". AS 2419.1 provides the details for determining the number of fire hydrants required and where they should be located.

Under its Application provision, EP1.3 only applies to buildings located in an area serviced by a fire brigade. This is primarily because the pressures and flows from a fire hydrant are such that hydrants should only be used by the fire brigade. It is expected that designers will meet any special fire brigade requirements, which may cover such matters as the types of couplings and special flows and pressures to suit a particular nozzle.

The use of the expression "to the degree necessary" in EP1.3 indicates that the BCA recognises that not all buildings need fire hydrants.

Any decision made in this context can extend to not requiring an item to be installed or a particular level of performance to be achieved, if that is the appropriate action to be taken.

If an Alternative Solution is used, it may be appropriate to assess it using E1.3 for guidance purposes. However it is stressed that compliance with E1.3 is not compulsory if alternative means can be found to satisfy the appropriate authority that the Performance Requirements will be achieved.

8.5 ASSESSMENT & ANALYSIS

Fire and life safety engineering analysis in compliance with NCC Clause A0.2 is to use a performance solution that complies with the Performance Requirements.

8.5.1 Proposed Performance Solution

It is recommended to

- Install a clear signage and block plan to AS2419 at the building main entrance and next to FIP indicating location of booster assembly, pump room and nearest fire-isolated stairway.
- A pole signage to AS2419 to be provided at booster location towards the building main entry
- A sign to AS2419 to be provided on pump/valve room door.
- All other aspect of fire hydrant system shall comply with AS2419.

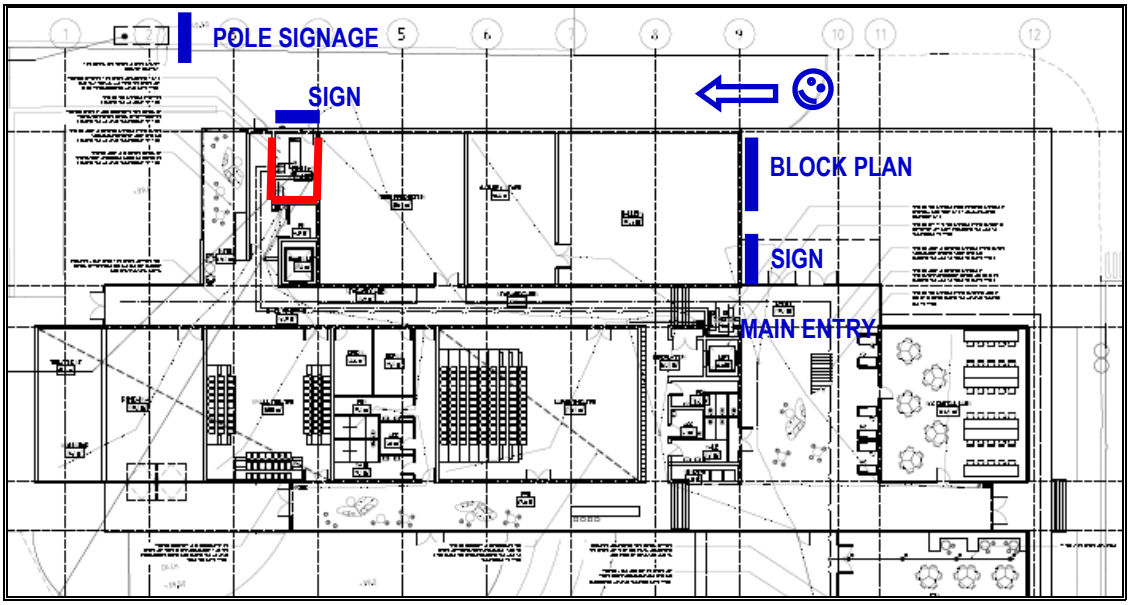

Figure 37 – Proposed performance solution.

8.5.2 Qualitative Assessment

The performance solution of proposed fire hydrant booster is not located in sight of the main building entry is assessed based on the following:-

- The proposed location adjacent carpark space with more space than any road, which facilitates fire brigade operation with wide space.
- The proposed location has short distance to access the fire-isolated stair that fire brigade should to reach upper level, if required, without the need to walk through smoke when using main entry to the atrium
- The building main entrance is located at intersection corner which is narrow and turning fire truck is not expected to be feasible, with any truck stopped in the intersection will prevent other vehicle to go through.
- The proposed signage in main entry, FIP, Booster location and pump/valves room locations provide sufficient information for fire brigade personnel.
- Recommended fast-response sprinkler protection, which is over and above NCC DTS Provisions that control the fire, reduce smoke generated and provide safe fire brigade personnel intervention conditions for longer period[22].

[22] The Technical Memoranda TM19:1995 (Relationships for smoke control calculations; Technical Memoranda TM19:1995, The Chartered Institution of Building Services Engineers, 1995 (CIBSE)

8.6 SATISFYING RELEVANT NCC PERFORMANCE REQUIREMENTS

The performance solution of fire hydrant booster location remote from the building main entry is to be assessed against the relevant NCC Performance Requirements EP1.3 & EP1.6, as shown below in **Table 27** & **Table 28** respectively.

Table 27 - Assessment of Compliance with the NCC Performance Requirement EP1.3

EP1.3 Parameter	Discussion	Parameter Addressed
A fire hydrant system must be provided to the degree necessary to facilitate the needs of the fire brigade appropriate to— **Application:** EP1.3 only applies to a building where a fire brigade is available to attend.		
(a) fire-fighting operations; and	The fire fighting operations is considered in relation to the proposed performance solution. Proposed fire booster location provides better fire ground operation in the car park and recommended signage, also better intervention condition via nearest fire-isolated stairway.	Yes.
(b) the floor area of the building; and	The fire floor area of the building is considered in relation to the proposed performance solution and considered equivalent to a similar NCC complaint building with compliant fire compartments sizes. Proposed fire booster location provides better fire ground operation in the car park and recommended signage, also better intervention condition via nearest fire-isolated stairway.	N/A.
(c) the fire hazard	The fire hazard within the building is considered in relation to the proposed alternative solution, and considered equivalent to a similar NCC compliant building with compliant fire compartments sizes. Proposed fire booster location provides better fire ground operation in the car park and recommended signage, also better intervention condition via nearest fire-isolated stairway.	Yes.

Table 28 - Assessment of Compliance with the BCA Performance Requirement EP1.6

EP1.6 Parameter	Discussion	Parameter Addressed
Suitable facilities must be provided to the degree necessary in a building to co-ordinate fire brigade intervention during an emergency appropriate to—		
(a)the function or use of the building; and	The function or use of the building is considered in relation to the proposed alternative solution and considered equivalent to a similar NCC compliant building. Proposed fire booster location provides better fire ground operation in the car park and recommended signage, also better intervention condition via nearest fire-isolated stairway.	Yes.
(b) the floor area of the building; and	The fire floor area of the building is considered in relation to the proposed alternative solution and considered equivalent to a similar NCC with compliant fire compartments sizes. Proposed fire booster location provides better fire ground operation in the car park and recommended signage, also better intervention condition via nearest fire-isolated stairway.	N/A.

EP1.6 Parameter	Discussion	Parameter Addressed
(c) the height of the building	The height of the building is considered in relation to the proposed alternative solution and considered equivalent to a similar NCC with compliant fire compartments sizes. Proposed fire booster location provides better fire ground operation in the car park and recommended signage, also better intervention condition via nearest fire-isolated stairway.	Yes.

8.7 CONCLUSION

As detailed above, it is our considered opinion that; proposed fire hydrant booster location remote from the building main entry is considered to be adequate to facilitate fire brigade intervention, to the degree necessary, as required by Performance Requirements EP1.3 & EP1.6 of the NCC.

9 ENGINEERING ASSESSMENT: OMISSION OF STAIRS PRESSURISATION

9.1 GENERAL

This Performance Solution is to assess whether the proposed design concept incorporates omission of stair pressurisation to north and east fire-isolated stairways, satisfying the NCC Performance Requirements EP2.2 or not.

9.2 NCC DTS PROVISIONS

As stated in the BCA Compliance Report, the following NCC DTS Provisions are applicable to the subject building:-

Clause E2.2 Table E2.2a (a) (iii): A required fire-isolated stairway, including any associated fire-isolated passageway or fire-isolated ramp serving an atrium must be provided with an automatic air pressurisation system for fire-isolated exits in accordance with AS/NZS 1668.1

9.3 DEVIATION TO NCC DTS PROVISIONS

Design concept incorporates omission of stair pressurisation to north and east fire-isolated stairways.

9.4 BASIS OF NCC DTS PROVISIONS

The Guide to NCC states that the intent of D1.4 is to maximise the safety of occupants by enabling them to be close enough to an exit to safely evacuate.

The **D1.4** travel distances are based on an assumption of what is considered “reasonable” distances to be travelled by occupants in reaching an exit.

The Guide, also, states that the intent of D1.5 is to require that if an exit is inaccessible, access to any required alternative exit must be available within a reasonable distance. Where a building requires multiple exits, the exits maximise the choices of a person evacuating, in case one exit becomes blocked.

D1.5 specifies the minimum and maximum permitted distances between alternative exits (for example, two exits may be located next to one another, so long as they are not each other’s alternative in an emergency). Where scissor stairs are used, the shafts will be adjacent and separated by fire-resisting construction. However, the access doors to the alternative scissor stairs must comply with the minimum separation distance. The minimum distance minimises the risk of fire spreading to block the alternative exit. The maximum distance between alternative exits minimises the need to travel too far to reach an exit.

If alternative paths of travel converge too closely, both paths can be blocked by the same fire. The minimum distance between the paths of travel aims to negate this.

The minimum convergence distance only comes into operation when the paths of travel have already diverged to that distance. The paths can commence more closely together than the distance specified.

The required exit and path of travel widths have been determined on the basis of an estimate of the width required to allow the safe exit of a given number of people expected in particular buildings.

9.5 ASSESSMENT & ANALYSIS

Fire and life safety engineering analysis in compliance with NCC Clause A0.2 is to use a performance solution that complies with the Performance Requirements.

9.5.1 Proposed Building Solution

The proposed performance solution incorporates the following provisions:-

- Qualitative Assessment.
- Create fire isolation to eastern stairway (as addressed in Section 5 above), along with north fire-isolated stairway which provide occupants with safe egress to outside the building, away from fire-affected area.
- Recommended fast-response sprinkler protection, which is over and above NCC DTS Provisions, that control the fire, reduce smoke generated and extend tenability limits in order provide safe evacuation conditions[23].
- Recommended atrium automatic mechanical smoke exhaust fan (capacity100m³/sec) to Atrium roof.
- Smoke sealant to eastern stair doorways

Figure 38 – North fire-isolated stairway and east fire-isolated stairway subject of this assessment.

[23] The Technical Memoranda TM19:1995 (Relationships for smoke control calculations; Technical Memoranda TM19:1995, The Chartered Institution of Building Services Engineers, 1995 (CIBSE)

9.5.2 Qualitative Assessment (Occupants Safe Emergency Evacuation)

The omission of stair pressurisation is assessed based on the following:-

- The two fire-isolated stairways not serving storey above 25m height.
- The two fire-isolated stairways do not serve two storeys below ground.
- The two fire-isolated stairways not serving the atrium fire compartment and located in a different fire compartments.
- The two fire-isolated stairways do not have more than 2 access doorways in the same storey [NCC Clause D1.7 (d)].
- All storeys served by subject fire-isolated stairways have another alternative exits being horizontal exits to adjacent fire compartments and atrium open stairs that is available in most fire incidents locations except fire incident on atrium fire compartment, where two horizontal exits are available for occupant to different fire compartments and to fire-isolated stairways.
- The entire building is sprinkler protected, which is over and above NCC DTS Provisions, that control the fire, reduce smoke generated and extend tenability limits in order provide safe evacuation conditions.
- Recommended provisions of Eastern stairway fire compartment to be kept free of any fire load or ignition source (this provision to be added to the building AFSS for regular inspection).
- Recommended provisions of doorways to north and east fire-isolated stairways to be fitted with smoke sealant.

9.6 SATISFYING RELEVANT NCC PERFORMANCE REQUIREMENTS

The Performance Solution of omission of stairway pressurisation to north and east fire-isolated stairways is to be assessed against the relevant NCC Performance Requirements EP2.2, as shown below in **Table 29**.

Table 29- Assessment of compliant with the NCC Performance Requirement EP2.2

EP2.2 Parameter	Discussion	Parameter Addressed
EP2.2 (a) In the event of a fire in a building the conditions in any evacuation route must be maintained for the period of time occupants take to evacuate the part of the building so that-		
(i) the temperature will not endanger human life;	The two fire-isolated stairways are fire isolated with doorways fitted with smoke sealant with fire and smoke movement into two stairs is prevented, to the degree necessary, therefore the temperature will not endanger human life.	Yes.

EP2.2 Parameter	Discussion	Parameter Addressed
(ii) the level of visibility will enable the evacuation route to be determined;	The two fire-isolated stairways are fire isolated with doorways fitted with smoke sealant with fire and smoke movement into two stairs is prevented, to the degree necessary, therefore the smoke exposure will not endanger human life and visibility will enable the evacuation route to be determined.	Yes.
(iii) the level of toxicity will not endanger human life.	The two fire-isolated stairways are fire isolated with doorways fitted with smoke sealant with fire and smoke movement into two stairs is prevented, to the degree necessary, therefore the smoke exposure will not endanger human life and visibility will enable the evacuation route to be determined.	Yes.
EP2.2 (b) The period of time occupants take to evacuate referred to in (a) must be appropriate to-		
(i) the number, mobility and other characteristics of the occupants; and	The number, mobility and other characteristics of occupants are considered in relation to the proposed Performance solution, with advantage of early automatic smoke detection, early sprinkler activation, compartmentation that provide horizontal exits to adjacent fire compartment with alternative fire isolated exits available. The two fire-isolated stairways are fire isolated with doorways fitted with smoke sealant with fire and smoke movement into two stairs is prevented, to the degree necessary.	Yes.
(ii) the function or use of the building; and	The function or use of the building is considered in relation to the proposed performance solution. The two fire-isolated stairways are fire isolated with doorways fitted with smoke sealant with fire and smoke movement into two stairs is prevented, to the degree necessary.	Yes.
(iii) the travel distance; and	Extended exit travel distances and extended distances between alternative exits for subject building considered in relation to the proposed Performance Solution along with recommended compartmentation, fast-response sprinkler protection and recorded message. The two fire-isolated stairways are fire isolated with doorways fitted with smoke sealant with fire and smoke movement into two stairs is prevented, to the degree necessary.	Yes.
(iv) the fire load; and	The fire load within the building is considered in relation to the proposed Performance Solution, and considered equivalent to a similar NCC compliant building. The two fire-isolated stairways are fire isolated with doorways fitted with smoke sealant with fire and smoke movement into two stairs is prevented, to the degree necessary.	Yes.
(v) the potential fire intensity; and	The potential fire intensity within the building is considered in relation to the proposed Performance Solution, and considered equivalent to a similar NCC compliant building. The two fire-isolated stairways are fire isolated with doorways fitted with smoke sealant with fire and smoke movement into two stairs is prevented, to the degree necessary.	Yes.
(vi) the fire hazard; and	The fire hazard within the building is considered in relation to the proposed Performance Solution, and considered equivalent to a similar NCC compliant building. The two fire-isolated stairways are fire isolated with doorways fitted with smoke sealant with fire and smoke movement into two stairs is prevented, to the degree necessary	Yes.

EP2.2 Parameter	Discussion	Parameter Addressed
(vii) any active fire safety systems installed in the building; and	The proposed fast-response sprinkler protection along with fire hydrants, fire hose reels, portable fire extinguishers and automatic fire detection & alarm system throughout the building along with recommended smoke sealant to doorways opened to stairways are considered in relation to the proposed Performance Solution, which facilitates early occupant detection, control the fire and provide safer emergency evacuation for occupants and safer intervention conditions for fire brigade.	Yes.
(viii) fire brigade intervention.	The fire brigade intervention is considered in relation to the proposed Performance Solution and considered equivalent to a similar NCC complying building with smoke layer temperature within upper levels is very low whilst the sprinklers are operating, and during uncontrolled fire scenarios, The two fire-isolated stairways are fire isolated with doorways fitted with smoke sealant with fire and smoke movement into two stairs is prevented, to the degree necessary which provide safe intervention conditions for fire brigade personnel.	Yes.

9.7 CONCLUSION

As detailed above, it is our considered opinion that; omission of stairway pressurisation to north and east fire-isolated stairways considered being adequate for occupant safe emergency evacuation and brigade safe intervention conditions, to the degree necessary, as required by Performance Requirements EP2.2 of the NCC.

10 ENGINEERING ASSESSMENT: ATRIUM PROVISIONS

10.1 GENERAL

This Performance Solution is to assess whether the proposed design concept incorporates atrium bounding walls do not separate all other parts of the building and located at more than 3.5m from the perimeter of the atrium, satisfying the NCC Performance Requirements EP2.2 or not.

10.2 NCC DTS PROVISIONS

As stated in the BCA Compliance Report, the following NCC DTS Provisions are applicable to the subject building:-

Part G3, Clause G3.2: An atrium well must have a width throughout the well that is able to contain a cylinder having a horizontal diameter of not less than 6m.

Clause G3.3: Atrium connects more than 2 storey or more than 3 sprinklered storeys (one of them is ground level) must be separated from the reminder of the building at each storey by bounding walls set back no more than 3.5m from the perimeter of the atrium well.

Clause G3.4: The bounding walls must have an FRL of not less than 60/60/60, extends from floor to underside of the floor above with any door opening protected with self-closing or automatic-closing fire doors with an FRL of -/60/30, or drenchers-protected toughen glass or wired safety glass and fire barrier within ceiling above walls having an FRL -/60/30.

10.3 DEVIATION TO NCC DTS PROVISIONS

Design concept incorporates width of atrium well of less than 6m and contains stairway that further reduces the width.

Design concept incorporates atrium bounding walls do not separate all other parts of the building and located at more than 3.5m from the perimeter of the atrium.

10.4 BASIS OF NCC DTS PROVISIONS

The Guide to NCC states that the intent of Provisions G3.2 "Dimensions of atrium well" is to minimise the risk that radiant heat from a fire will affect people or materials on the other side of an atrium well.

The Guide also states that an atrium well is not limited to having a maximum size, nor is there a limitation on its shape, except that it must contain a space throughout which could contain a cylinder with a diameter of 6 metres. This 6metres is equal to the minimum distance between unprotected openings in external walls of adjoining buildings required by **C3.2**. This diameter void is intended to reduce the effects of radiant heat from a fire:

- affecting occupants evacuating on the other side of the atrium well; and
- igniting materials on the other side of the atrium well.

The Guide to NCC states that the atrium provision is consistent with **D1.12**, which deals with the number of floors that can be connected by a non-required non-fire-isolated stairway, ramp or escalator.

The Guide, also, states that the intent of G3.2 "Dimensions of Atrium Well" is to minimise the risk that radiant heat from a fire will affect people or materials on the other side of an atrium well.

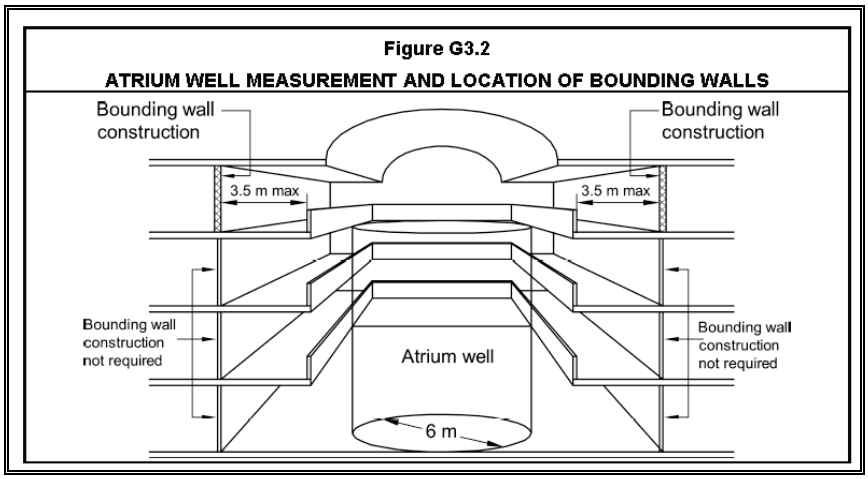

Figure 39 – Guide to NCC illustration of atrium bounding walls requirements.

The Guide states that the intent of G3.3 "Separation of Atrium by Bounding Walls" is to minimise the risk of spread of fire and smoke from or to the atrium or other parts of the building.

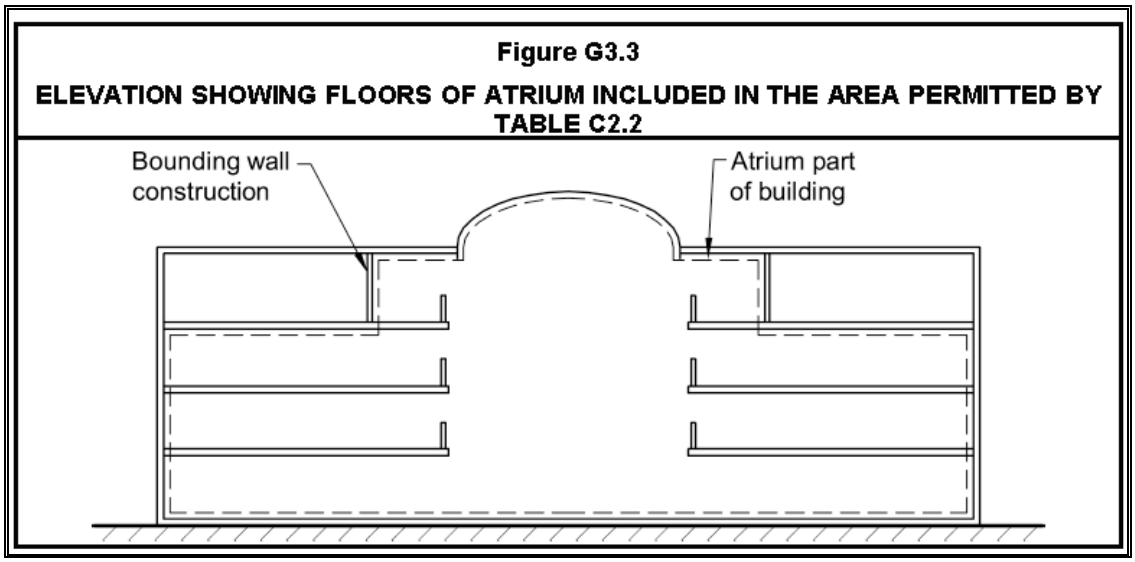

Figure 40 – Guide to NCC illustration of atrium floor area to be less than Table C2.2.

The Guide also states that; although the building may have an effective height of less than 25 metres, two exits are required from any area within an atrium. This is due to the additional fire hazard associated with atriums. There may be other parts of the BCA which permit buildings to have only a single exit, G3.7 overrides any such provisions insofar as they related to atriums. All other aspects of the means of access and egress from an atrium must comply with Section D.

10.5 Assessment & Analysis

Fire and life safety engineering analysis in compliance with NCC Clause A0.2 is to use a performance solution that complies with the Performance Requirements.

10.5.1 Proposed Building Solution

The proposed performance solution incorporates the following provisions:-

- Qualitative Assessment.
- Provide an FRL of 120/120/120 to atrium bounding walls in lieu of 60/60/60.
- Provide greater smoke extraction rate of the smoke to prevent occupant's exposure to the smoke where automatic smoke exhaust fan with capacity of more than 100m³/sec is recommended.
- An ASET/RSET analysis within subject atrium using simulated fire conditions for sprinkler-controlled fire scenario and uncontrolled fire scenario associated with sprinkler failure (ASET) compared to calculated emergency evacuation (RSET) as detailed in appendices B, C & D also discussed above in Section 6 above.

10.5.2 Qualitative Assessment (Atrium Well Reduced Dimensions)

The atrium well reduced dimensions is assessed based on the following:-

- The NCC Provisions for atrium well dimension is required for occupants life safety during fire incidents where it is intended to reduce the effects of radiant heat from a fire:
  - Affecting occupants evacuating on the other side of the atrium well; and
  - Igniting materials on the other side of the atrium well.

The above requirement intended to reduce the effect of radiant heat from fire is satisfied where:-

- The reduction of atrium well width less than 6m is small; and
- The upper levels atrium area around the well is circulation area free of fire load, combustible materials and ignition sources; therefore fire initiation or fire spread within subject circulation areas are very unlikely.
- Occupants within atrium area, that is open spaces have with clear visual and olfactory cue, therefore occupants will start moving away from fire and smoke affected area very quickly.
- The atrium is enclosed within separate fire-compartment with short travel distance to two alternative horizontal exits to adjacent fire compartment; therefore occupants have the facility to move away from atrium area in a very short time without exposure to smoke or radiant heat flux; and
- The atrium roof is fitted with automatic smoke exhaust fans with capacity of greater than 100m³/sec, therefore the hot smoke generated from atrium fire, if happened, will be automatically extracted to outside the building preventing occupant exposure and fire spread.
- The entire building, including circulation areas around the atrium well is protected with fast-response automatic sprinkler heads; therefore, with the sprinkler activation, the smoke temperature inside the building will be < 100°[24], this temperature of less than 100° will not cause radiant heat flux that might harm occupant or ignite any item at distance 5.6m, as been simulated below. The computed radiant heat flu of 0.286 in less than occupant's tenability limits of 2.5kW/m² and much less than 10kW/m² that cause ignition of easily ignited items such as thin curtains and loose newsprint.

[24] The Technical Memoranda TM19:1995 (Relationships for smoke control calculations; The Chartered Institution of Building Services Engineers, 1995 (CIBSE)

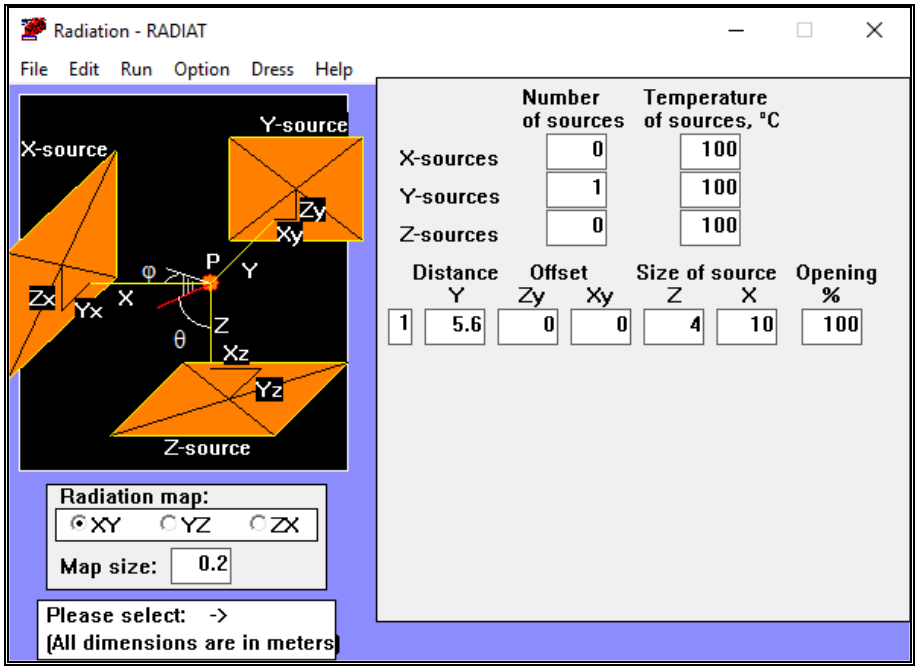

Figure 41 – Simulated atrium well complete side opening (10m x 4m) with well width of 5.6m and smoke temperature of 100° (sprinkler-controlled fire)

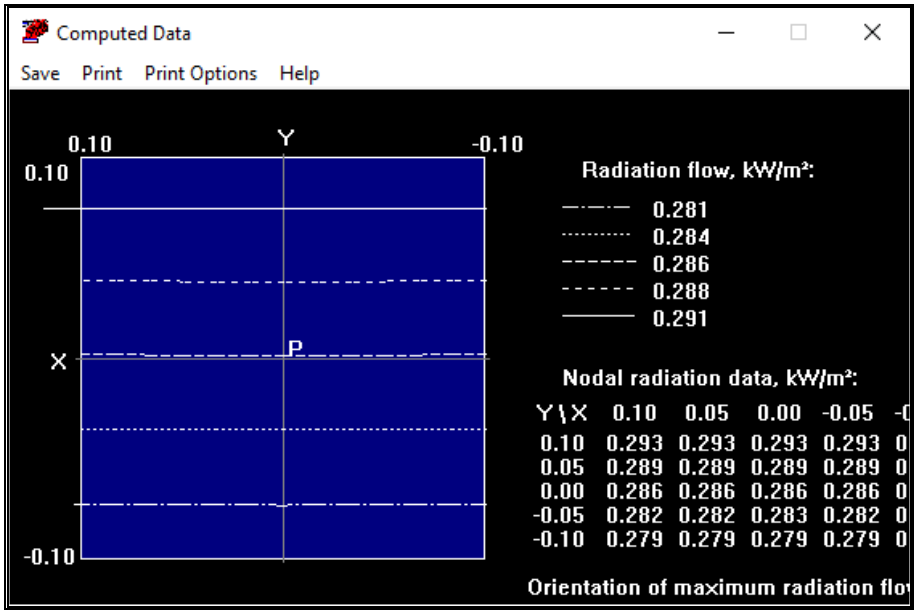

Figure 42 – Very small radiant heat flux of 0.286kW/m² (<< 2.5kW/m² for occupants and <<< 10kW/m² for ignition of easily ignited items such as thin curtains and loose newsprint)

The sensitivity analysis for uncontrolled fire (sprinkler failure), the maximum simulated smoke/compartment temperature is less than 140° and radiant heat flux simulated below.

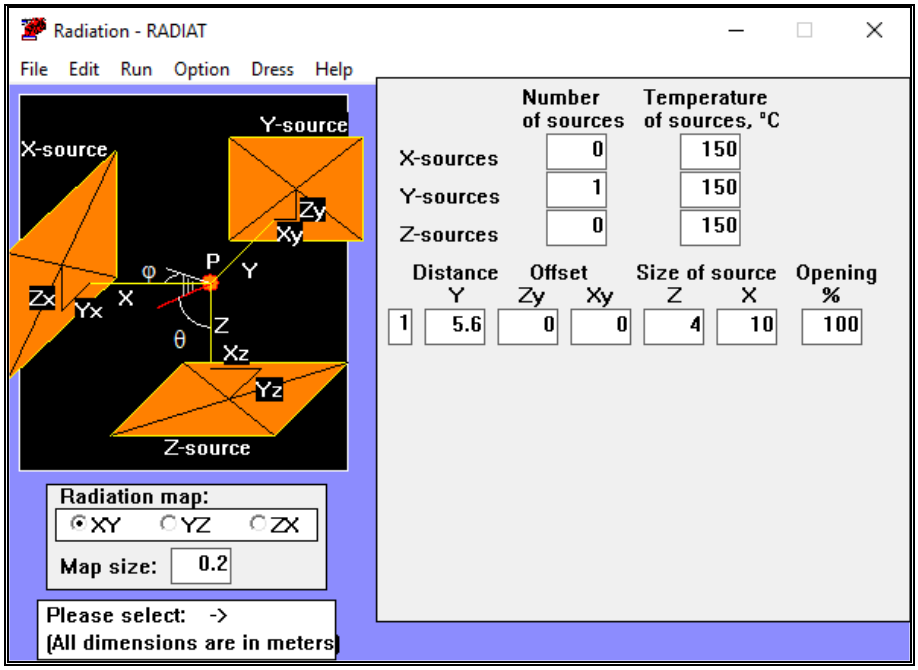

Figure 43 – Simulated atrium well complete side opening (10m x 4m) with well width of 5.6m and smoke temperature of 150° (un-controlled fire)

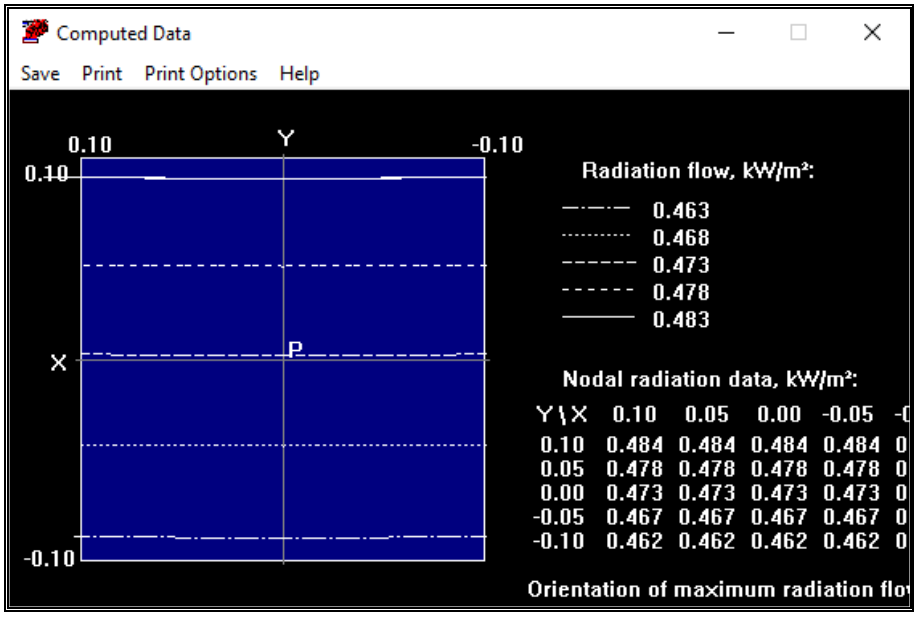

Figure 44 – Simulated atrium well complete side opening (10m x 4m) with well width of 5.6m and smoke temperature of 150° (un-controlled fire)

10.5.3 Qualitative Assessment (Atrium Geometry: Occupants Life Safe & Spread of Fire)

The proposed atrium geometry is assessed based on the following:-

- The bounding walls construction, in all levels, provide an FRL of 120/120/120 which is greater than the required FRL for bounding walls of 60/60/60; therefore greater protection is proposed for fire spread within building and occupant's life safety.

- The performance-based capacity of smoke exhaust fan within atrium with more than 100/m³/sec flow rate is recommended, which provide better fire conditions preventing occupants exposure to smoke.

- The simulated atrium geometry shown to provide acceptable occupant life safety factor of greater than 1.5 during design trial with automatic fast-response sprinkler protection and automatic smoke fan activation (calculated occupant's life safety factor is 4.29).
- The simulated atrium geometry shown to provide acceptable occupant life safety factor of greater than 1 during sensitivity analysis trial with failure of sprinkler and automatic smoke fan activation (calculated occupant's life safety factor is 2.15).

- The occupants have very short travel distance to two alternative horizontal exits to adjacent fire compartment reaching safe place prior to be overcome by the smoke.

- The entire building is sprinkler protected with fast-response sprinkler heads, which is over and above NCC DTS Provisions, that control the fire, reduce smoke generated and extend tenability limits in order provide safe evacuation conditions.

- Recommended provisions of doorways to north and east fire compartments to be fitted with smoke sealant, therefore spread of smoke to adjacent fire compartments and the reminder of the building is prevented to the degree necessary.

Table 30- Summary atrium occupant's Life Safety Factor

Fire Scenario	Description.	Cold Smoke Exposure	ASET. Sec.	RSET. Sec.	Calculated Safety Factor.	Required SF.
1A.	Atrium: Sprinkler, Fan.	No.	3600.	668.	5.4	1.5.
1B.	Atrium: Sprinkler, Vent.	Yes.	3600.	668.	5.4	1.5.
4A.	Atrium: Uncontrolled, Fan.	Yes.	1800.	668.	2.7	1.
4B.	Atrium: Uncontrolled, Vent.	Yes.	1800.	668.	2.7	1.

10.6 SATISFYING RELEVANT NCC PERFORMANCE REQUIREMENTS

The Performance Solution of atrium geometry is to be assessed against the relevant NCC Performance Requirements EP2.2, as shown below in **Table 31**.

Table 31- Assessment of compliant with the NCC Performance Requirement EP2.2

EP2.2 Parameter	Discussion	Parameter Addressed
EP2.2 (a) In the event of a fire in a building the conditions in any evacuation route must be maintained for the period of time occupants take to evacuate the part of the building so that-		
(i) the temperature will not endanger human life;	The atrium protected with automatic fast-response sprinkler heads, performance-based automatic mechanical exhaust fans, with short distance to adjacent fire compartments with an FRL of 120/120/120 and smoke sealant to doorways; therefore smoke exposure is prevented, to the degree necessary, and the temperature will not endanger human life.	Yes.

EP2.2 Parameter	Discussion	Parameter Addressed
(ii) the level of visibility will enable the evacuation route to be determined;	The atrium protected with automatic fast-response sprinkler heads, performance-based automatic mechanical exhaust fans, with short distance to adjacent fire compartments with an FRL of 120/120/120 and smoke sealant to doorways; therefore smoke exposure is prevented, to the degree necessary, and visibility will enable the evacuation route to be determined.	Yes.
(iii) the level of toxicity will not endanger human life.	The atrium protected with automatic fast-response sprinkler heads, performance-based automatic mechanical exhaust fans, with short distance to adjacent fire compartments with an FRL of 120/120/120 and smoke sealant to doorways; therefore smoke exposure is prevented, to the degree necessary, and toxicity will not endanger human life	Yes.
EP2.2 (b) The period of time occupants take to evacuate referred to in (a) must be appropriate to-		
(i) the number, mobility and other characteristics of the occupants; and	The number, mobility and other characteristics of occupants are considered in relation to the proposed performance solution, with advantage of early automatic smoke detection, early sprinkler activation, compartmentation that provide horizontal exits to adjacent fire compartment with alternative fire horizontal exits available and short travel distance. The doorways to adjacent fire compartments fitted with smoke sealant with fire and smoke movement is prevented, to the degree necessary. Acceptable occupant's life safety factor is achieved.	Yes.
(ii) the function or use of the building; and	The function or use of the building is considered in relation to the proposed performance solution, with advantage of early automatic smoke detection, early sprinkler activation, compartmentation that provide horizontal exits to adjacent fire compartment with alternative fire horizontal exits available and short travel distance. The doorways to adjacent fire compartments fitted with smoke sealant with fire and smoke movement is prevented, to the degree necessary. Acceptable occupant's life safety factor is achieved.	Yes.
(iii) the travel distance; and	Short travel distance from subject atrium to horizontal exits leading to adjacent fire compartments. Acceptable occupant's life safety factor is achieved.	Yes.
(iv) the fire load; and	The fire load within the building is considered in relation to the proposed Performance Solution, and considered equivalent to a similar NCC compliant building, with advantage of early automatic smoke detection, early sprinkler activation, compartmentation that provide horizontal exits to adjacent fire compartment with alternative fire horizontal exits available and short travel distance. The doorways to adjacent fire compartments fitted with smoke sealant with fire and smoke movement is prevented, to the degree necessary. Acceptable occupant's life safety factor is achieved.	Yes.
(v) the potential fire intensity; and	The potential fire intensity within the building is considered in relation to the proposed Performance Solution, and considered equivalent to a similar NCC compliant building, with advantage of early automatic smoke detection, early sprinkler activation, compartmentation that provide horizontal exits to adjacent fire compartment with alternative fire horizontal exits available and short travel distance. The doorways to adjacent fire compartments fitted with smoke sealant with fire and smoke movement is prevented, to the degree necessary. Acceptable occupant's life safety factor is achieved.	Yes.
(vi) the fire hazard; and	The fire hazard within the building is considered in relation to the proposed Performance Solution, and considered equivalent to a similar NCC compliant building, with advantage of early automatic smoke detection, early sprinkler activation, compartmentation that provide horizontal exits to adjacent fire compartment with alternative fire horizontal exits available and short travel distance. The doorways to adjacent fire compartments fitted with smoke	Yes.

EP2.2 Parameter	Discussion	Parameter Addressed
	sealant with fire and smoke movement is prevented, to the degree necessary. Acceptable occupant's life safety factor is achieved.	
(vii) any active fire safety systems installed in the building; and	The proposed fast-response sprinkler protection along with fire hydrants, fire hose reels, portable fire extinguishers and automatic fire detection & alarm system throughout the building along with recommended smoke sealant to doorways opened to stairways are considered in relation to the proposed Performance Solution, which facilitates early occupant detection, control the fire and provide safer emergency evacuation for occupants and safer intervention conditions for fire brigade.	Yes.
(viii) fire brigade intervention.	The fire brigade intervention is considered in relation to the proposed Performance Solution and considered equivalent to a similar NCC complying building with smoke layer temperature within upper levels is very low whilst the sprinklers are operating, and during uncontrolled fire scenarios, The two fire-isolated stairways are fire isolated with doorways fitted with smoke sealant with fire and smoke movement into two stairs is prevented, to the degree necessary which provide safe intervention conditions for fire brigade personnel.	Yes.

10.7 CONCLUSION

As detailed above, it is our considered opinion that; proposed atrium geometry considered being adequate for occupant safe emergency evacuation, prevention of fire and smoke spread within the building and brigade safe intervention conditions, to the degree necessary, as required by Performance Requirements EP2.2 of the NCC.

11 ENGINEERING ASSESSMENT: ENTERTAINMENT VENUE PROVISIONS

11.1 GENERAL

This Performance Solution is to assess whether the proposed design concept incorporates omission of fire separation of entertainment venue area and internal fire separation requirement for ground floor and first level entertainment venues spaces, satisfying the NCC Performance Requirements EP2.2 or not.

11.2 NCC DTS PROVISIONS

As stated in the BCA Compliance Report, the following NCC DTS Provisions are applicable to the subject building:-

NSW Part H101 (Clause NSW H101.5: Fire separation of stages, Clause NSW H101.7: Flying scenery, Clause NSW H101.12.1: Seating to be fastened, NSW Clause H101.15: Dressing rooms, NSW Clause H101.16: Storerooms & NSW Clause H101.17: Projection suites)

11.3 DEVIATION TO NCC DTS PROVISIONS

Design concept incorporates omission of fire separation of entertainment venue area and internal fire separation requirement for ground floor and Level 1 entertainment venues spaces.

11.4 BASIS OF NCC DTS PROVISIONS

The Guide to NCC states that Stages used for live performances can contain high fire loads due to the props, scenery, lighting, and the like used in such productions. Such props and scenery are often also stored in backstage areas, which add to the fire load.

The Guide, also, states that the intent of separation requirements within entertainment venues is to protect the audience in a theatre or public hall from a fire on the stage.

A stage and backstage area of a theatre or public hall has a high fire load. It is also a potential fire source due to stored props, scenery, lighting, special effects, and the like.

Because of the recognised fire hazard, proscenium walls and curtains are required to separate the stage and backstage areas from the audience.

To maintain this fire separation:

- an evacuation route from the stage side of a proscenium must not pass through the proscenium; and
- required exits from backstage must be independent of the audience evacuation routes.

11.5 ASSESSMENT & ANALYSIS

Fire and life safety engineering analysis in compliance with NCC Clause A0.2 is to use a performance solution that complies with the Performance Requirements.

11.5.1 Proposed Building Solution

The proposed performance solution incorporates the following provisions:-

- Qualitative Assessment.
- All other aspects of entertainment venue to comply with NCC DTS Provisions especially requirements related to egress provisions and smoke management provisions.
- Recommended fast-response sprinkler protection, which is over and above NCC DTS Provisions, that control the fire, reduce smoke generated and extend tenability limits in order provide safe evacuation conditions.

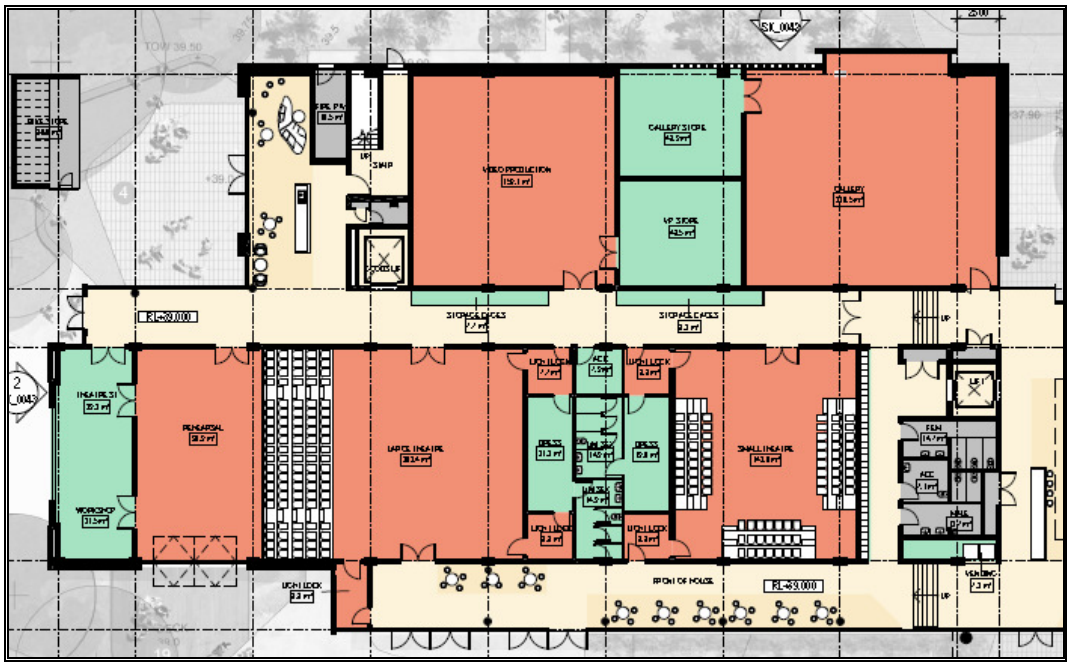

Figure 45 – Entertainment part of ground floor subject of this assessment.

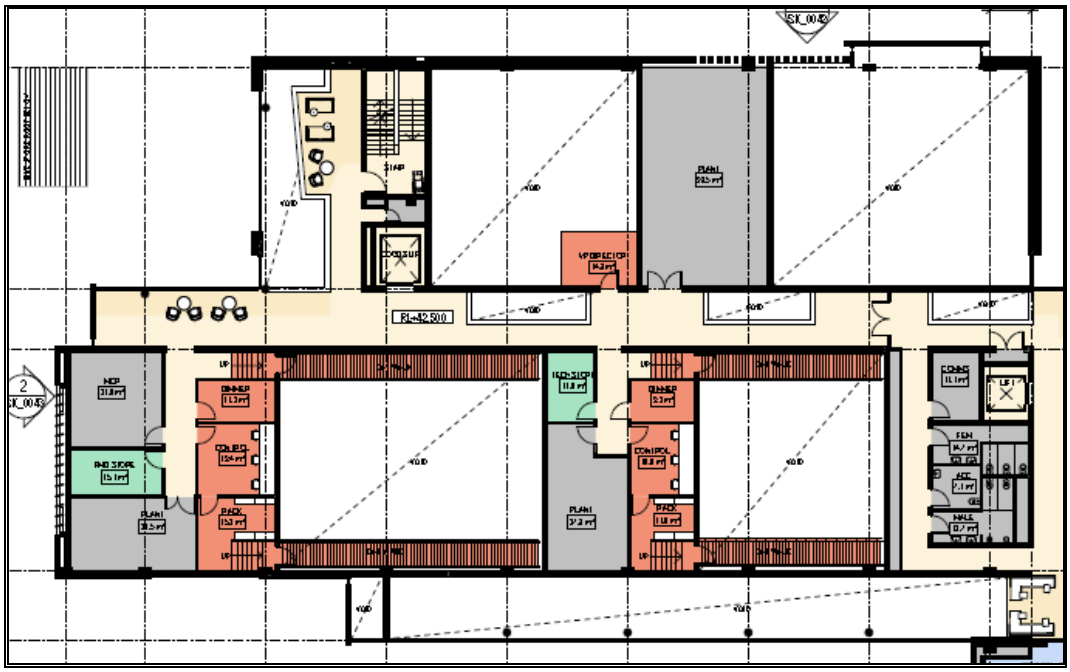

Figure 46 – Entertainment part of Level 1 subject of this assessment.

11.5.2 Qualitative Assessment (Entertainment Venue Omission of Fire Separation)

The omission of fire separation of entertainment venue area and internal fire separation within ground floor and Level 1 is assessed based on the following:-

- All other aspects of entertainment venue to comply with NCC DTS Provisions especially requirements related to egress provisions and smoke management provisions.
- Recommended fast-response sprinkler protection, which is over and above NCC DTS Provisions, that control the fire, reduce smoke generated and extend tenability limits in order provide safe evacuation conditions. The NCC, in several occasions recognised the advantage of fast-response sprinkler protection and permitted reduced FRL; further more non-fire-rated elements are permitted in some other occasions[25].
- The subject areas is used for educational purposes rather than public entertainment venue, therefore less fire loads and less fire hazard are presented compared to public services.
- The subject entertainment venue used for educational purpose, during daytime or early evening, which provide better emergency evacuation during daylight.
- The theatres areas are relatively small compared to public entertainment venue; therefore risk of fire and size of fire are less than public entertainment venue.
- Dislike, public entertainment venues, no alcohol consumption is allowed within the educational premises, which improve the occupants response to emergency and movement and reduces RSET compared to public entertainment venue.
- The number of occupants is relatively smaller than number of occupants in public entertainment venue; therefore the fire and life safety risk is less than public entertainment venue.
- The two theatres with crowd population that required to be protected are located on the ground floor with direct exit to outside the building; short exits travel distances and several alternative exits available.
- The theatres stages fitted with automatic smoke exhaust fans, along with fast-response sprinkler protection that reduces the fire size and volume of smoke generated, both together significantly eliminate occupants exposure to smoke and extend tenability limits (ASET).
- The entire building fitted with automatic smoke/heat detection and alarm system that provide early warning to occupants that significantly reduces RSET.

[25] NCC Specification C1.1

11.6 SATISFYING RELEVANT NCC PERFORMANCE REQUIREMENTS

The Performance Solution of omission of fire separation of entertainment venue area and internal fire separation requirement for ground floor and Level 1 entertainment venues spaces is to be assessed against the relevant NCC Performance Requirements EP2.2, as shown in **Table 32** below.

Table 32- Assessment of compliant with the NCC Performance Requirement EP2.2

EP2.2 Parameter	Discussion	Parameter Addressed
EP2.2 (a) In the event of a fire in a building the conditions in any evacuation route must be maintained for the period of time occupants take to evacuate the part of the building so that-		
(i) the temperature will not endanger human life;	The entertainment venue fire compartment and entire building is sprinkler protected to control the fire and smoke generated, with automatic fire detection to reduce RSET, along with automatic mechanical smoke exhaust fans, therefore smoke exposure is prevented, to the degree necessary, therefore the temperature will not endanger human life.	Yes.
(ii) the level of visibility will enable the evacuation route to be determined;	The entertainment venue fire compartment and entire building is sprinkler protected to control the fire and smoke generated, with automatic fire detection to reduce RSET, along with automatic mechanical smoke exhaust fans, therefore smoke exposure is prevented, to the degree necessary, therefore the smoke exposure will not endanger human life and visibility will enable the evacuation route to be determined.	Yes.
(iii) the level of toxicity will not endanger human life.	The entertainment venue fire compartment and entire building is sprinkler protected to control the fire and smoke generated, with automatic fire detection to reduce RSET, along with automatic mechanical smoke exhaust fans, therefore smoke exposure is prevented, to the degree necessary, therefore the smoke exposure will not endanger human life and visibility will enable the evacuation route to be determined.	Yes.
EP2.2 (b) The period of time occupants take to evacuate referred to in (a) must be appropriate to-		
(i) the number, mobility and other characteristics of the occupants; and	The number, mobility and other characteristics of occupants are considered in relation to the proposed Performance solution, with advantage of early automatic smoke detection, early sprinkler activation, along with automatic mechanical smoke exhaust fans. Ground floor has several alternative exits to outside the building with short exits travel distance.	Yes.
(ii) the function or use of the building; and	The function or use of the building is considered in relation to the proposed performance solution, with advantage of early automatic smoke detection, early sprinkler activation, along with automatic mechanical smoke exhaust fans. Ground floor has several alternative exits to outside the building with short exits travel distance.	Yes.
(iii) the travel distance; and	Ground floor has several alternative exits to outside the building with short exits travel distance	Yes.
(iv) the fire load; and	The fire load within the building is considered in relation to the proposed Performance Solution, and considered equivalent to a similar NCC compliant building. with advantage of early automatic smoke detection, early sprinkler activation, along with automatic mechanical smoke exhaust fans. Ground floor has several alternative exits to outside the building with short exits travel distance.	Yes.

EP2.2 Parameter	Discussion	Parameter Addressed
(v) the potential fire intensity; and	The potential fire intensity within the building is considered in relation to the proposed Performance Solution, and considered equivalent to a similar NCC compliant building, with advantage of early automatic smoke detection, early sprinkler activation, along with automatic mechanical smoke exhaust fans. Ground floor has several alternative exits to outside the building with short exits travel distance.	Yes.
(vi) the fire hazard; and	The fire hazard within the building is considered in relation to the proposed Performance Solution, and considered equivalent to a similar NCC compliant building, with advantage of early automatic smoke detection, early sprinkler activation, along with automatic mechanical smoke exhaust fans. Ground floor has several alternative exits to outside the building with short exits travel distance.	Yes.
(vii) any active fire safety systems installed in the building; and	The entertainment venue fire compartment and entire building is sprinkler protected to control the fire and smoke generated, with automatic fire detection to reduce RSET, along with automatic mechanical smoke exhaust fans,	Yes.
(viii) fire brigade intervention.	The fire brigade intervention is considered in relation to the proposed Performance Solution and considered equivalent to a similar NCC complying building The entertainment venue fire compartment and entire building is sprinkler protected to control the fire and smoke generated, with automatic fire detection to reduce RSET, along with automatic mechanical smoke exhaust fans, which provide safe intervention conditions for fire brigade personnel.	Yes.

11.7 CONCLUSION

As detailed above, it is our considered opinion that; omission of fire separation of entertainment venue area and internal fire separation within ground floor and Level 1 considered being adequate for occupant safe emergency evacuation and brigade safe intervention conditions, to the degree necessary, as required by Performance Requirements EP2.2 of the NCC.

12 RECOMMENDAIONS/SCOPE OF WORK

1. This report is prepared for Western Building within University of Wollongong campus located at Northfields Avenue Wollongong NSW 2500, and not to be used for any other purpose.

2. All Fire Safety Measures required, are to be designed, installed and maintained in accordance with NCC Provisions and relevant Australian Standards, or otherwise as assessed, identified, determined and accepted by the relevant authorities.

3. The fire engineering assessment of this report based on the subject building population of 643 people, as advised by the UOW[26].

4. The proposed fire compartmentation walls, as detailed below, to be constructed with an FRL of 120/120/120.

   Where the proposed fire compartment boundary necessitate passing through line where no walls required from the Architectural prospect, a drencher-protected glazed partition to be used (drenchers installed in both sides of the glass).

   Where the proposed fire compartment boundaries necessitate passing through corridors a drencher-protected glazed partition and door leaves to be used. Drenchers protected glass door can be held opened with magnetic tapes and automatically released to closed position with fire alarm (drenchers installed in both sides of the glass).

5. The proposed Eastern Stairway fire separation walls to be constructed with an FRL of 120/120/120.

   Where the proposed fire separation walls necessitate passing through line where no walls required from the Architectural prospect, a drencher-protected glazed partition to be used (drenchers installed in both sides of the glass)..

   Where the proposed fire compartment boundaries necessitate passing through doorways a drencher-protected glazed partition and door leaves to be used. Drenchers protected glass door can be held opened with magnetic tapes and automatically released to closed position with fire alarm (drenchers installed in both sides of the glass).

6. Illuminated exit signs to be placed in both sides above the horizontal exits between the atrium fire compartment and both north wing fire compartment & east wing fire compartment. Doors to swing in both directions.

7. Clear signage and block plan to AS2419 to be installed at the building main entrance and next to FIP indicating location of booster assembly, pump room and nearest fire-isolated stairway.

8. A pole signage to AS2419 to be provided at booster location towards the building main entry.

[26] UOW Western Building - Room Data Schedule

9. A signage to AS2419 to be provided on pump/valve room door.

10. Smoke test to be conducted, during final signoff inspection, to examine efficiency of atrium smoke fan with amount of makeup air provided with building geometry. Any recommendations raised from test, such as doors to be closed or opened with fire alarm or the like, to be included with the building AFSS, for regular inspection.

11. The building to be divided into three fire compartments of less than 8000m² floor area, (North Fire Compartment and East Fire Compartment and rooftop plants Fire Compartment), with north fire compartment to be served with fire-isolated stairway and east fire compartment to be served with fire-isolated stairway.

    Solid lines indicate fire walls with an FRL of 120/120/120.

    Dotted lines indicate drenchers-protected glazed partitions.

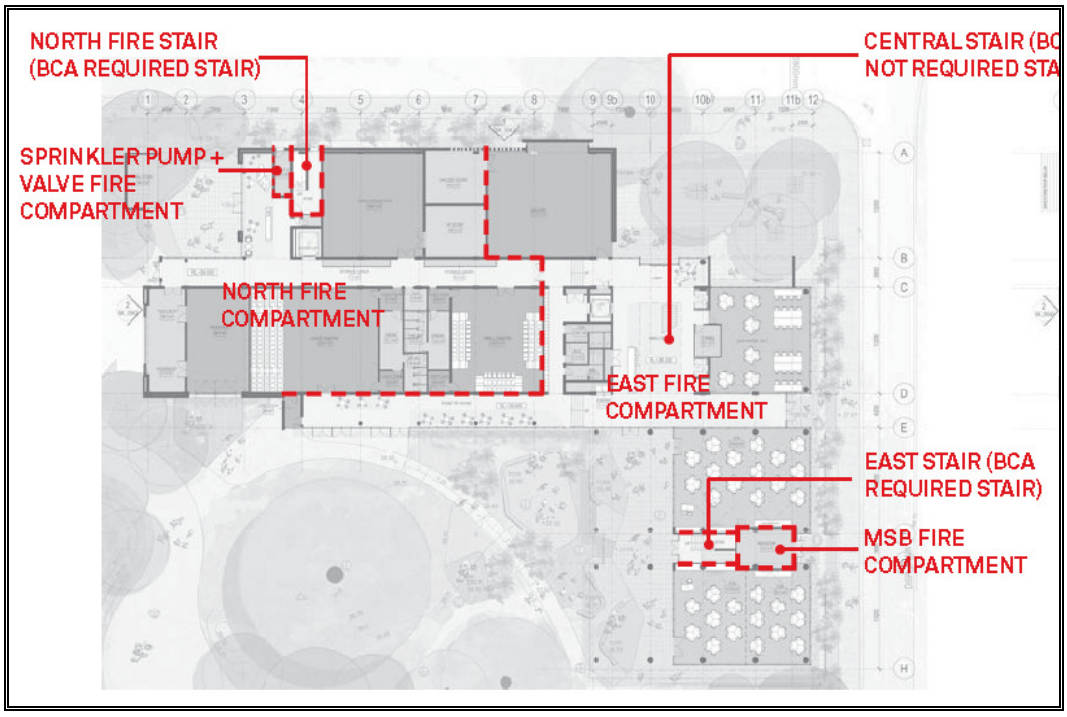

Figure 47 – Ground Level Fire Compartments.

Figure 48 – Level 1 Fire Compartments.

Figure 49 – Level 2 Fire Compartments.

Figure 50 – Level 3 Fire Compartments.

Figure 51 – Level 4 (Plants) Fire Compartments.

12. The following fire safety systems are recommended to be provided throughout the building, as part of the completed fire safety systems identified by the Principal Certifying Authority:-

- Recommended provisions of automatic, fast response, sprinkler system to be installed to the entire building in accordance with NCC Clause E1.5 and AS2118-1999.
- Recommended side-wall drenchers to all glazed partitions/doors required as a fire separation walls for fire compartmentation (drenchers installed in both sides of the glass).
- The estimated response time from the activation of the sprinkler heads in the building to the activation of the pressure switch that activates the Addressable occupant warning system and signal to Fire Brigade monitoring system - as referenced in AS 2118.1-1999, Clause 8.10.1 - should be no greater than 90 sec.
- Fire hydrant system in accordance with NCC Clause E1.3 and Australian Standards AS2419.1-2005, except as permitted under this report (remote booster).
- Fire hose reel system in accordance with NCC Clause E1.4 and Australian Standards AS2441-2005 – (FHR coverage and flow to be confirmed).
- Portable fire extinguishers in accordance with NCC Clause E1.6 and Australian Standards AS2444 - 2001(To be inspected for compliance with AS2444).
- Automatic smoke detection and alarm system in accordance with NCC NSW Table E2.2B and NSW Specification E2.2a. Heat detectors to theatres spaces.
- Smoke management system; the activation of automatic sprinkler system and/or automatic smoke detection system to activate the automatic shutdown of the air-handling system and automatic activation of stage smoke-and-heat vents (if required). System monitoring to be provided to AS1670.3-2004.
- Requirements of NSW Table E2.2b that requires that a stage with a floor area of more than 300m² must have a smoke exhaust system over the stage, is to be subject to an Performance Solution with heat and smoke vent to be installed and to be automatically opened with fire alarm.
- Emergency lighting in accordance with NCC Clause E4.2, E4.4 and Australian Standard AS2293.1 – 2005.
- Exit signage in accordance with NCC Clause E4.5, NSW E4.6 & E4.8 and Australian Standard AS2293.1 – 2005.
- All fire safety systems, including standby power supply, to be maintained in accordance with AS1851and relevant Australian Standards. The building Fire Safety Schedule and Annual Fire Safety Statement to include recommendations of this report with reference to this report and brief of the Performance Solutions.
- Sound systems and intercom systems for emergency purposes (system to be tested for compliance with NCC Clause E4.9). Recorded Message "Fire Alarm Evacuate Now"
- Atrium automatic mechanical smoke exhaust fan in compliance with NCC DTS Provisions (refer to mechanical design details).

- Horizontal exits between fire compartments to swing in both directions
- Doorways to north and east fire-isolated stairways to be fitted with smoke sealant and horizontal exits doorways between atrium fire compartment and north & east fire compartments to be fitted with smoke sealant.
- Lightweight Construction in accordance with Spec C1.8 (subject to confirmation of proposed construction method of internal fire walls)
- Fire Seals in accordance with AS1530.3
- Fire rated lift landing doors to AS1735.11
- Automatic Failsafe Devices to Part D2.21 of the BCA
- Smoke Curtain (or the like) to separate topmost floor at each of the open stairs.
- Smoke Curtain (or the like) to separate topmost floor to the atrium open well.
- Smoke sealant to all fire doors between fire compartments and to both fire-isolated stairways.

13. Emergency Organisations and Procedures are to be specifically developed, implemented and monitored for the subject building in accordance with AS 3745-2010, and to incorporate the following as a minimum:
    - The entire building to have a restricted non-smoking policy.
    - Clear exit paths of 1m minimum width (or greater where required for number of occupants).
    - Hot-work to be carried out by minimum of 2 trained staff.
    - Materials in compliance with Clause C1.10, Specification C1.10, NSW Clause C1,10 and NSW Specification C1.10 to be selected for all future finishes of renovation works and fittings, as an additional fire spread prevention measures.
    - Separate controlling valve to sprinkler system and wall wetting drenchers system; so that isolation of building water supply during any maintenance works or the like, will not isolate sprinkler system water supply or wall wetting drenchers. Sprinkler valve and wetting drenchers' valve must be fitted with anti-tamper devices connected to a monitoring panel at building management or the location normally used by the staff such as staff room or offices.
    - The following management procedure to be followed where any maintenance works is carried out inside the building and required sprinkler system or wall wetting drenchers to be isolated:
        - The sprinkler system to be re-charged at the end of each day
        - A written permission to be issued stating the length of isolation
        - The maintenance staff to sign off at the completion of work that the sprinkler system is re-charged and in a normal working order.

14. The fire engineering assessment shows that identified non-fire-rated external walls and associated openings at less than 6m from another fire compartment do not impose any additional risk for spread of fire and recommended to be permitted by relevant authorities.

15. The fire engineering assessment shows that identified extended travel distances (≈45m) and distance between alternative exits along are adequate, to the degree necessary, subject to recommendations of this report to be implemented, and recommended to be permitted by relevant authorities.

16. The fire engineering assessment shows that omission of north and east stairways pressurisation is adequate, to the degree necessary, subject to recommendations of this report to be implemented, and recommended to be permitted by relevant authorities.

17. The fire engineering assessment shows that proposed atrium well geometry is adequate, to the degree necessary, subject to recommendations of this report to be implemented, and recommended to be permitted by relevant authorities.

18. The fire engineering assessment shows that omission of stair pressurisation, fire separation of atrium area and internal fire separation within the entertainment venue part of the building is adequate, to the degree necessary, subject to recommendations of this report to be implemented, and recommended to be permitted by relevant authorities

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END OF RECOMMENDATIONS/SCOPE OF WORK

APPENDIX A: SIDE WALL SPRINKLER TECHNICAL DATA (INFORMATIVE)

tyco / Fire & Building Products

Technical Services: Tel: (800) 381-9312 / Fax: (800) 791-5500

Model WS™ — 5.6 K-factor Specific Application Window Sprinklers, Horizontal and Pendent Vertical Sidewall

General Description

The Model WS, 5.6 K-factor, Horizontal Sidewall and Pendent Vertical Sidewall, Specific Application Window Sprinklers are fast response, glass bulb type spray sprinklers.

These sprinklers are the first sprinklers ever to be specifically Listed to provide protection for heat strengthened or tempered glass windows using closed sprinklers. As part of the testing, the gas flow required to achieve the time/temperature relationship specified in ASTM E119 was established in a test furnace without sprinkler protection. A window assembly protected with Model WS Specific Application Window Sprinklers was then installed in the test furnace and the same gas flow conditions were maintained for a two hour test period. No cracking or visible damage to the window was permitted during the test period (even when a hose stream was directed at the window).

The success of the Model WS Specific Application Window Sprinkler is based on its specially designed deflector that ensures that the spray pattern wets the entire surface of the window, and its fast response thermal sensitivity.

Based on this successful testing, the Model WS Specific Application Window Sprinkler can be used as interior protection of windows or glazing in a sprinklered building or non-sprinklered building. Also, the Model WS Specific Application Window Sprinkler can be used as a open sprinkler for "Outside Sprinkler Protection against Exposure Fire", using the design requirements of NFPA.

As with any specific application sprinkler, the installation instructions included in this data sheet must be precisely followed. ICC Evaluation Service, Underwriters Laboratories of Canada (ULC), or Building Materials Evaluation Commission (BMEC) guidelines apply, consult the specific approval report.

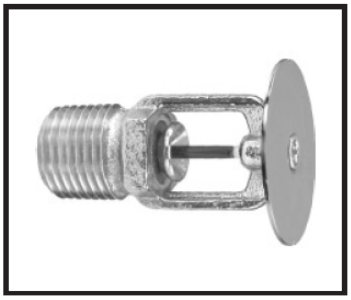
IMPORTANT

Always refer to Technical Data Sheet TFP700 for the "INSTALLER WARNING" that provides cautions with respect to handling and installation of sprinkler systems and components. Improper handling and installation can permanently damage a sprinkler system or its components and cause the sprinkler to fail to operate in a fire situation or cause it to operate prematurely.

WARNING

The Model WS Specific Application Window Sprinklers described herein must be installed and maintained in compliance with this document, as well as with the applicable standards of the National Fire Protection Association, in addition to the standards of any other authorities having jurisdiction. ***Failure to do so may impair the performance of these devices.***

The owner is responsible for maintaining their fire protection system and devices in proper operating condition. The installing contractor or manufacturer should be contacted with any questions.



Sprinkler Identification Number

TY3388 - Horizontal Sidewall
TY3488 - Pendent Vertical Sidewall

TY3388 is a redesignation for C3388.
TY3488 is a redesignation for C3488.

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Technical Data

Approvals
UL, C-UL, and ULC Listed.
NYC under MEA 289-04-E.
(The approvals only apply to the service conditions indicated in the Design Criteria section.)

Additional Recognition
- ICC Evaluation Service (ICC-ES Legacy Report NER-516)
- Building Materials Evaluation Commission (BMEC 01-11-263)

Pipe Thread Connection
1/2 inch NPT

Discharge Coefficient
K = 5.6 GPM/psi$^{1/2}$
(80,6 LPM/bar$^{1/2}$)

Temperature Rating
155°F/68°C & 200°F/93°C

Finish
Polyester Coated, Chrome Plated, or Natural Brass

Physical Characteristics
Frame . . . . . Brass
Button . . . . . Bronze/Copper
Sealing Assembly . . . . . Beryllium Nickel w/Teflon†
Bulb . . . . . Glass (3 mm dia.)
Compression Screw . . . . . Brass
Deflector . . . . . Brass/Bronze
† DuPont Registered Trademark

The glass bulb contains a fluid that expands when exposed to heat. When the rated temperature is reached, the fluid expands sufficiently to shatter the glass bulb, allowing the sprinkler to activate and water to flow.

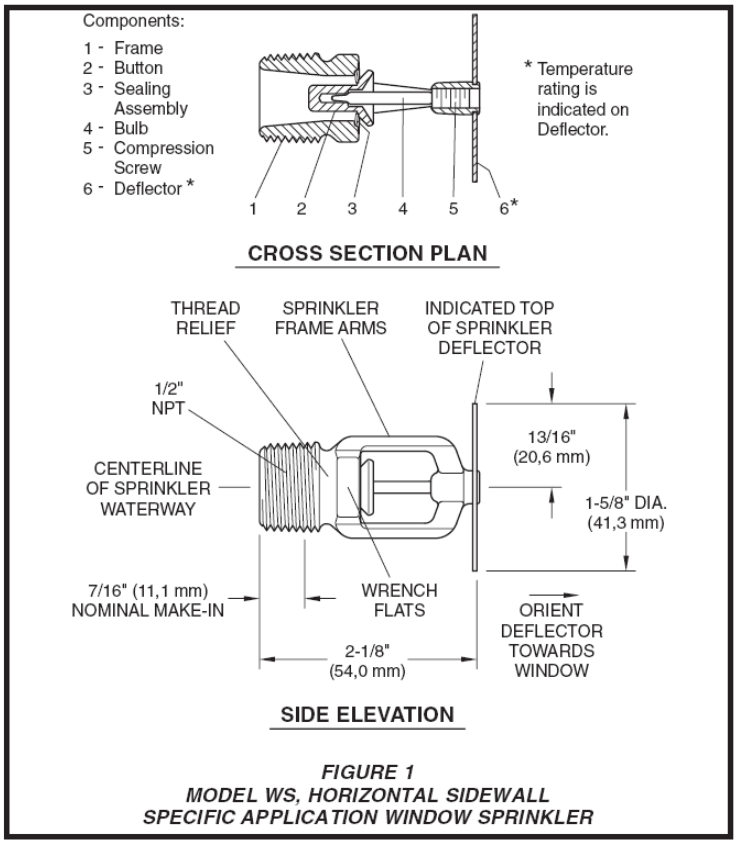


FIGURE 1
MODEL WS, HORIZONTAL SIDEWALL
SPECIFIC APPLICATION WINDOW SPRINKLER

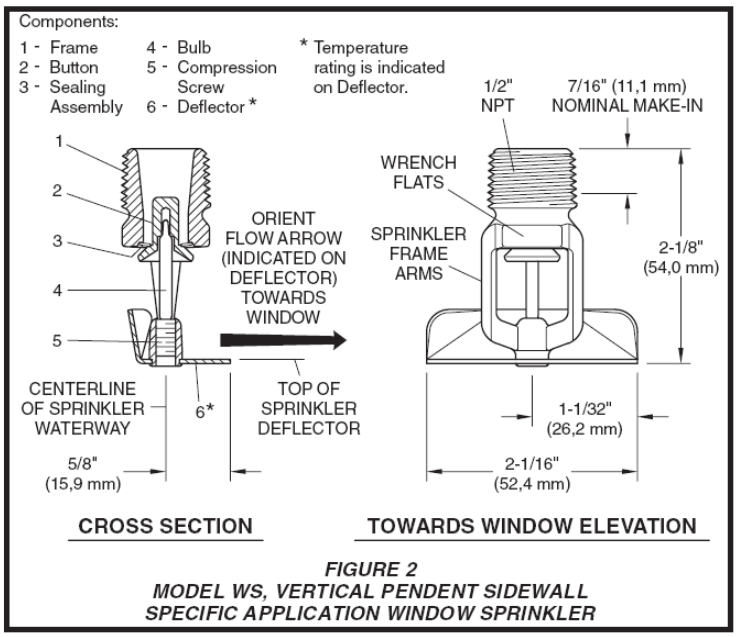


FIGURE 2
MODEL WS, VERTICAL PENDENT SIDEWALL
SPECIFIC APPLICATION WINDOW SPRINKLER

Design Criteria

The Model WS Window Sprinklers are listed by UL and C-UL, and NYC Approved (MEA 335-01-E) for use as a "Specific Application Window Sprinkler" and as open sprinklers for "Outside" use. These sprinklers are also recognized by the International Code Council Evaluation Service, Underwriters Laboratories of Canada (ULC), and the Building Materials Evaluation Commission (BMEC) for use in the Province of Ontario, Canada as providing a two-hour equivalency for a fire separation assembly, when installed in accordance with the NES Report (NER 516), ULC/ORD-C263.1 Appendix A, and BMEC Report (01-11-263).

NOTE

NER 516 can be obtained at www.icc-es.org. ULC/ORD-C263.1 Appendix A and BMEC 01-11-263 may be obtained by contacting Technical Services.

Area Of Use:

When acceptable to the Authority Having Jurisdiction and unless modified by one of the reports mentioned above, the Model WS Specific Application Window Sprinklers may be used in either a sprinklered or unsprinklered building to protect nonoperable window openings that are part of a fire separation provided:

a) in an interior fire separation, the window sprinklers are installed on both sides of the window in the fire separation. (Ref. Figure 3A-1),

b) in jurisdictions where exterior spatial separation (i.e., separation from adjacent space) is defined as protecting an adjacent building from a fire in your building, window sprinklers are installed on the interior side of the building (Ref. Figure 3A-2), or

c) in jurisdictions where exterior spatial separation is defined as protecting your building from a fire in an adjacent building (i.e., exposure protection), open window sprinklers are installed on the exterior side of the building (Ref. Figure 3A-3).

System Type:

Interior Protection - Wet Systems.

Outside Exposure Protection - Deluge.

Glass Type:

Non-opererable, heat-strengthened, tempered, single-glazed (single pane); non-opererable, heat-strengthened, tempered, double-glazed (double pane or insulated); or, non-opererable, stronger glass window assemblies. In all three cases, each individual pane of the window assembly is to be minimum 6 mm (1/4") thick.

Type of Window Frame/Mullion:

Noncombustible Frame with a standard EPDM rubber gasket seal. Vertical joints of glass panes must be connected by butt-joints sealed with a silicone sealant between the individual panes or by Noncombustible Mullions (Ref. Figure 3B-1 & 3B-2).

Maximum Length Of Window Assembly:

Unlimited.

Maximum Height Of Window Assembly:

13' (3,96 m) (Ref. Figure 3C & 3D).

Maximum Distance Between Window Sprinklers:

8' (2,44 m) (Ref. Figure 3B-1 & 3B-2).

Minimum Distance Between Window Sprinklers:

6' (1,83 m) (Ref. Figure 3B-1 & 3B-2), unless separated by a baffle or mullion of sufficient depth to act as a baffle. (A mullion will act as a baffle, when in the case of the Pendent Vertical Sidewall, the mullion extends to the back of the sprinkler deflector, and in the case of the Horizontal Sidewall, the mullion extends to the sprinkler wrench flat.)

Minimum Distance From Standard Sprinklers:

6' (1,83 m) unless separated by a baffle.

Sprinkler Location:

Mullioned Glazing Assemblies - Locate window sprinklers within each mullioned glazing segment (Ref. Figure 3B-1).

Butt Jointed Glazing Assemblies - Locate window sprinklers on maximum 8' (2,44 m) centers (Ref. Figure 3-B-2).

Maximum Distance From Vertical Mullion:

4' (1,22 m) (Ref. Figure 3B-1).

Minimum Distance From Vertical Mullions:

4" (101,6 mm) (Ref. Figure 3B-1).

Intermediate Horizontal Mullions:

Intermediate Horizontal Mullions were not tested with the window sprinkler. Their use is outside the scope of the "Specific Application" Listing for the window sprinklers (Ref. Figure 3B-3).

Deflector Location:

Sprinkler Deflectors must be located as described below in order to ensure that the entire surface of the glass window is covered. Sprinkler Deflectors are positioned with respect to the window frame, not the ceiling.

Horizontal Sidewall - Locate within the outside edge of the window frame from 1/2" to 4" (12,7 mm to 101,6 mm) away from the glass and 2" ± 1" (50,8 mm ± 25,4 mm) down from the top of exposed glass (Ref. Figure 3C).

Pendent Vertical Sidewall - Locate 4" to 12" (101,6 mm to 304,8 mm) from the face of the glass and 3" ± 1" (76,2 mm ± 25,4 mm) down from the top of exposed glass (Ref. Figure 3D).

Minimum Clearance From Face Of Glass To Combustible Materials:

All combustible materials shall be kept 2" (50,8 mm) from the front face of the glass. This can be accomplished by a minimum 36" (914,4 mm) pony wall or other method acceptable to the Authority Having Jurisdiction.

Escutcheon Assemblies:

The window sprinklers can be used with any metallic flush or extended escutcheon, provided the dimensions from the sprinkler deflector to the window frame and glass surface as specified in this data sheet are maintained. These sprinklers are not listed for recessed applications.

Recommended Hydraulic Requirements:

The Authority Having Jurisdiction should be consulted to determine the hydraulic requirements for each installation.

Interior Protection Sprinklered Building - Identify which compartmented area has the most hydraulically demanding window sprinklers. Calculate all of the sprinklers within a compartmented area or the number of window sprinklers required to cover a combined linear length of glass equal to 1.2 x the square root of the system area of operation, whichever is greater. For example if the building design area is 1500 ft^2 then 1.2 x $(1500\ ft^2)^{1/2}$ = 46.5 linear feet of glass or 1.2 x $(139\ m^2)^{1/2}$ = 14,2 linear meters of glass. Add the window sprinkler demand to your most demanding hydraulic design area.

Interior Protection Non-Sprinklered - Calculate all the sprinklers on the most demanding side of the glazing assembly within the enclosure.

Exterior Exposure Protection - Calculate all sprinklers controlled by the deluge valve using the design requirements of NFPA.

Duration Of Water Supply:

The duration of the water supply must comply with the requirements of NFPA. In the event the window sprinklers are being used to provide the equivalency of a fire rating, the water supply must be capable of supplying water for the required rating period.

Minimum Flow Per Sprinkler:

20 GPM (75,7 LPM) for sprinkler spacing of 6 to 8 ft. (1,83 to 2,44 m) or 15 GPM (56,8 mLPM) for sprinkler spacing less than 6 ft, (1,83 m).

Maximum Pressure Per Sprinkler:

Horizontal Sidewall = 70* psi (4,83 bar).

Vertical Sidewall = 175 psi (12,07 bar).

*The 70 psi is only for cold solder purposes. If there is a baffle or mullion of sufficient depth to act as a baffle, separating the sprinklers, the maximum pressure is 175 psi.

Installation

The Model WS Specific Application Window Sprinklers must be installed in accordance with the following instructions:

NOTES

Do not install any bulb type sprinkler if the bulb is cracked or there is a loss of liquid from the bulb. With the sprinkler held horizontally, a small air bubble should be present. The diameter of the air bubble is approximately 1/16 inch (1,6 mm).

A leak tight 1/2 inch NPT sprinkler joint should be obtained with a torque of 7 to 14 ft.lbs. (9,5 to 19,0 Nm). A maximum of 20 ft.lbs. (28,5 Nm) of torque is to be used to install sprinklers. Higher levels of torque may distort the sprinkler inlet with consequent leakage or impairment of the sprinkler.

Step 1. The pendent vertical sidewall sprinkler must be installed only in the pendent position with the centerline of the sprinkler parallel to the glass surface. The sprinkler must be orientated so that the direction of flow indicated on the sprinkler deflector is facing the window. The horizontal sidewall sprinkler must be installed only in the horizontal position with the centerline of the sprinkler perpendicular to the glass surface. The sprinkler must be orientated so that the word “Top” indicated on the sprinkler deflector is facing the top of window frame.

Step 2. With pipe thread sealant applied to the pipe threads, hand tighten the sprinkler into the sprinkler fitting.

Step 3. Wrench tighten the Sprinkler using only the W-Type 20 (End A) Sprinkler Wrench (Ref. Figure 4). The W-Type 20 (End A) Sprinkler Wrench is to be applied to the Sprinkler Wrench flats only.

When acceptable to the Authority Having Jurisdiction the Model WS Specific Application Window Sprinklers may be used in either a sprinklered or unsprinklered building to protect nonoperable window openings that are in an interior fire separation, the window sprinklers are installed on both sides of the window in the fire separation.

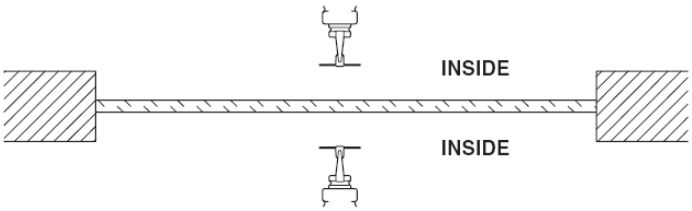


FIGURE 3A-1 — INTERIOR FIRE SEPARATION

When acceptable to the Authority Having Jurisdiction the Model WS Specific Application Window Sprinklers may be used in either a sprinklered or unsprinklered building to protect nonoperable window openings that are part of a fire separation provided in jurisdictions where exterior spatial separation is defined as protecting an adjacent building from a fire in your building, window sprinklers are installed on the interior side of the glass.

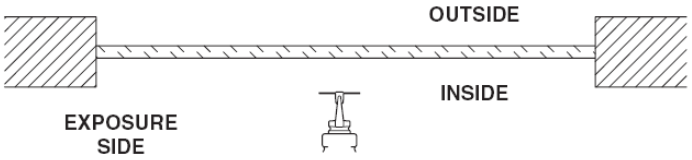


FIGURE 3A-2 — EXTERIOR FIRE SEPARATION — SPRINKLERS INSIDE

When acceptable to the Authority Having Jurisdiction the Model WS Specific Application Window Sprinklers may be used in either a sprinklered or unsprinklered building to protect nonoperable window openings that are part of a fire separation provided in jurisdictions where exterior spatial separation is defined as protecting your building from a fire in an adjacent building, open window sprinklers are installed on the exterior side of the glass.

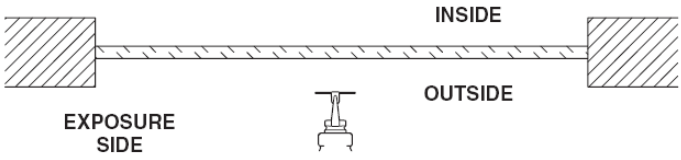
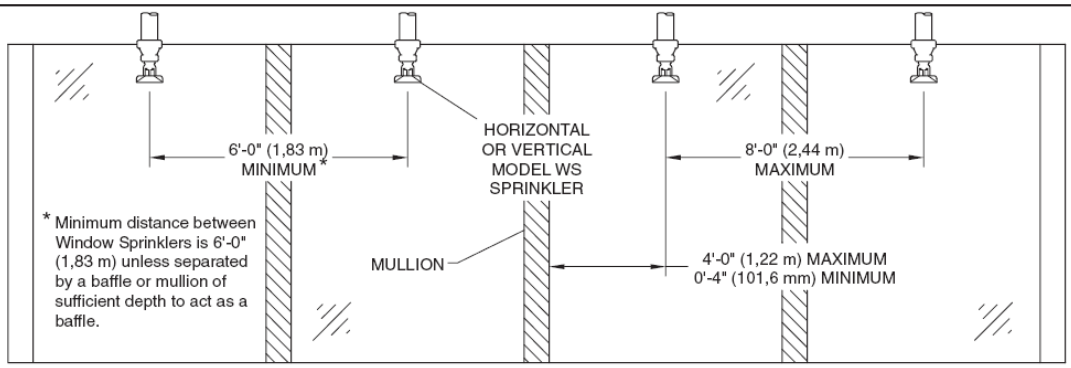


FIGURE 3A-3 — EXTERIOR FIRE SEPARATION — SPRINKLERS OUTSIDE

FIGURE 3A
TYPICAL NONOPERABLE WINDOW OPENINGS



A Window Sprinkler must be provided at each window glazing segment, regardless of width of segment. If segment is less than 6'-0". a baffle or mullion to act as a baffle must be provided.

FIGURE 3B-1 — MULTIPLE WINDOWS SEPARATED BY MULLIONS

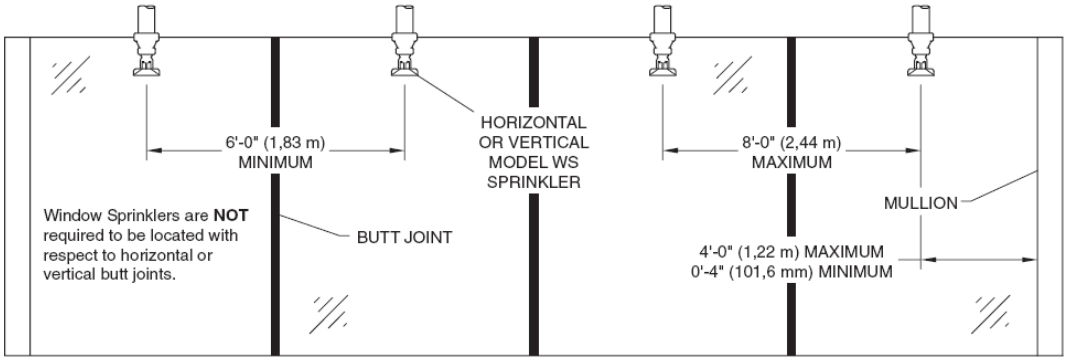


FIGURE 3B-2 — MULTIPLE WINDOWS SEPARATED BY BUTT JOINTS

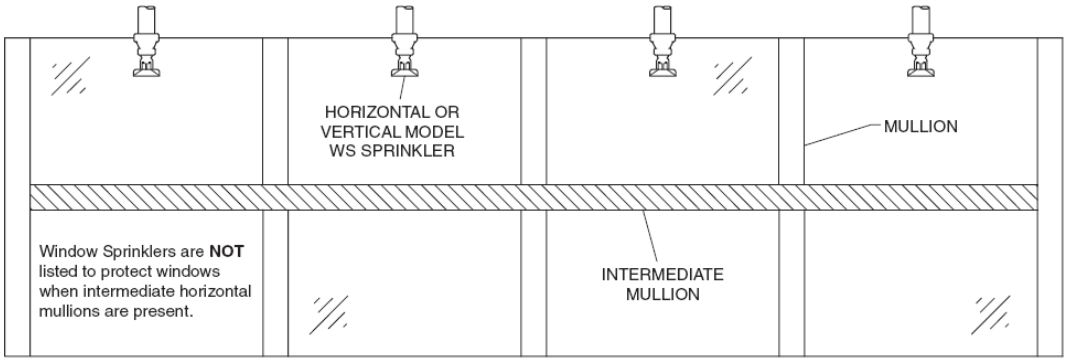


Figure 3B-3 — WINDOWS WITH HORIZONTAL MULLIONS

FIGURE 3B
WINDOW MULLIONS AND BUTT JOINTS

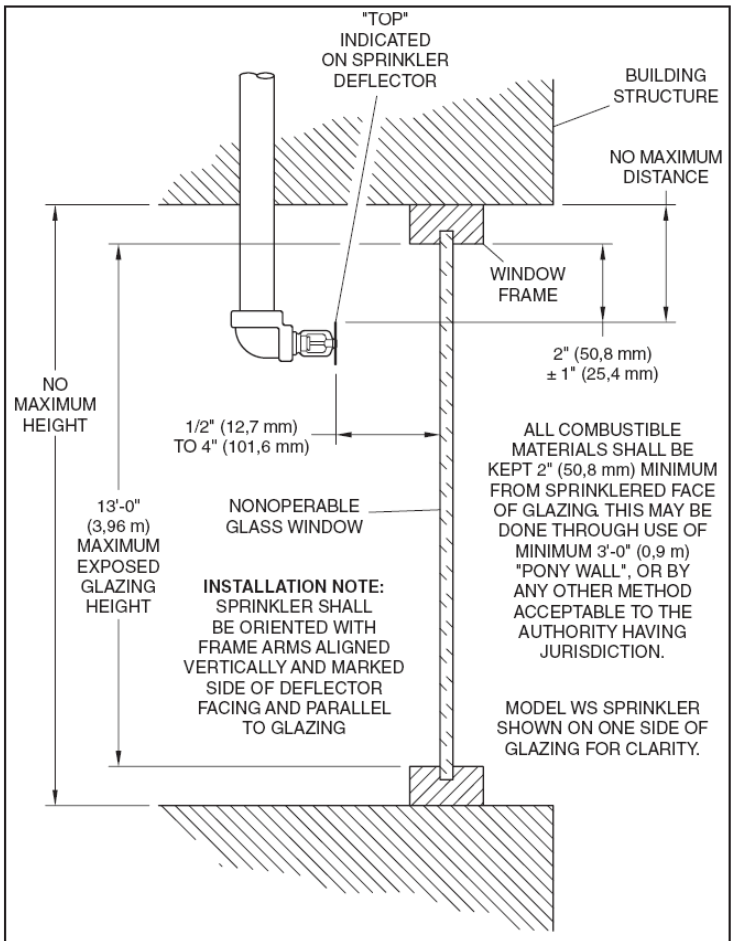


FIGURE 3C
MODEL WS HORIZONTAL SIDEWALL SPRINKLER
TYPICAL INSTALLATION

Care and Maintenance

The Model WS Specific Application Window Sprinklers must be maintained and serviced in accordance with the following instructions:

NOTE

Before closing a fire protection system main control valve for maintenance work on the fire protection system that it controls, permission to shut down the affected fire protection systems must be obtained from the proper authorities and all personnel who may be affected by this action must be notified.

Sprinklers that are found to be leaking or exhibiting visible signs of corrosion must be replaced.

Automatic sprinklers must never be painted, plated, coated, or otherwise altered after leaving the factory. Modified sprinklers must be replaced. Sprinklers that have been exposed to corrosive products of combustion, but have not operated, should be replaced if they cannot be completely cleaned by wiping the sprinkler with a cloth or by brushing it with a soft bristle brush.

Care must be exercised to avoid damage to the sprinklers - before, during, and after installation. Sprinklers damaged by dropping, striking, wrench twist/slippage, or the like, must be replaced. Also, replace any sprinkler that has a cracked bulb or that has lost liquid from its bulb. (Ref. Installation Section).

The owner is responsible for the inspection, testing, and maintenance of their fire protection system and devices in compliance with this document, as well as with the applicable standards of the National Fire Protection Association (e.g., NFPA 25), in addition to the standards of any other authorities having jurisdiction. The installing contractor or sprinkler manufacturer should be contacted relative to any questions.

It is recommended that automatic sprinkler systems be inspected, tested, and maintained by a qualified Inspection Service in accordance with local requirements and/or national codes.

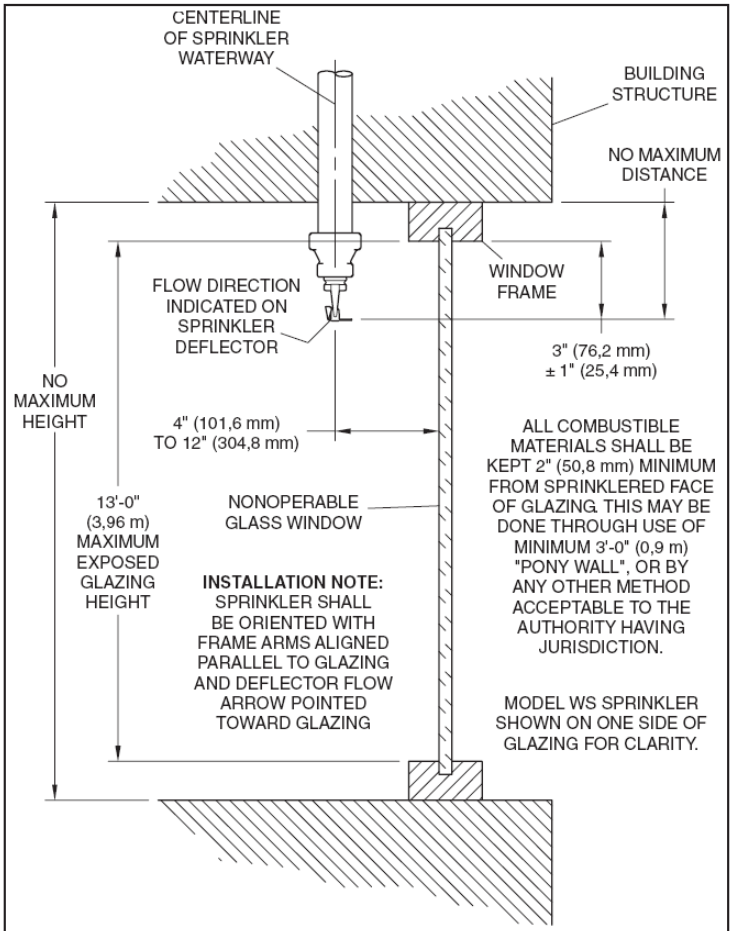


FIGURE 3D
MODEL WS VERTICAL PENDENT SIDEWALL SPRINKLER
TYPICAL INSTALLATION

Limited Warranty

Products manufactured by Tyco Fire & Building Products are warranted solely to the original Buyer for ten (10) years against defects in material and workmanship when paid for and properly installed and maintained under normal use and service. This warranty will expire ten (10) years from date of shipment by Tyco Fire & Building Products. No warranty is given for products or components manufactured by companies not affiliated by ownership with Tyco Fire & Building Products or for products and components which have been subject to misuse, improper installation, corrosion, or which have not been installed, maintained, modified or repaired in accordance with applicable Standards of the National Fire Protection Association, and/or the standards of any other Authorities Having Jurisdiction. Materials found by Tyco Fire & Building Products to be defective shall be either repaired or replaced, at Tyco Fire & Building Products' sole option. Tyco Fire & Building Products neither assumes, nor authorizes any person to assume for it, any other obligation in connection with the sale of products or parts of products. Tyco Fire & Building Products shall not be responsible for sprinkler system design errors or inaccurate or incomplete information supplied by Buyer or Buyer's representatives.

IN NO EVENT SHALL TYCO FIRE & BUILDING PRODUCTS BE LIABLE, IN CONTRACT, TORT, STRICT LIABILITY OR UNDER ANY OTHER LEGAL THEORY, FOR INCIDENTAL, INDIRECT, SPECIAL OR CONSEQUENTIAL DAMAGES, INCLUDING BUT NOT LIMITED TO LABOR CHARGES, REGARDLESS OF WHETHER TYCO FIRE & BUILDING PRODUCTS WAS INFORMED ABOUT THE POSSIBILITY OF SUCH DAMAGES, AND IN NO EVENT SHALL TYCO FIRE & BUILDING PRODUCTS' LIABILITY EXCEED AN AMOUNT EQUAL TO THE SALES PRICE.

THE FOREGOING WARRANTY IS MADE IN LIEU OF ANY AND ALL OTHER WARRANTIES EXPRESS OR IMPLIED, INCLUDING WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

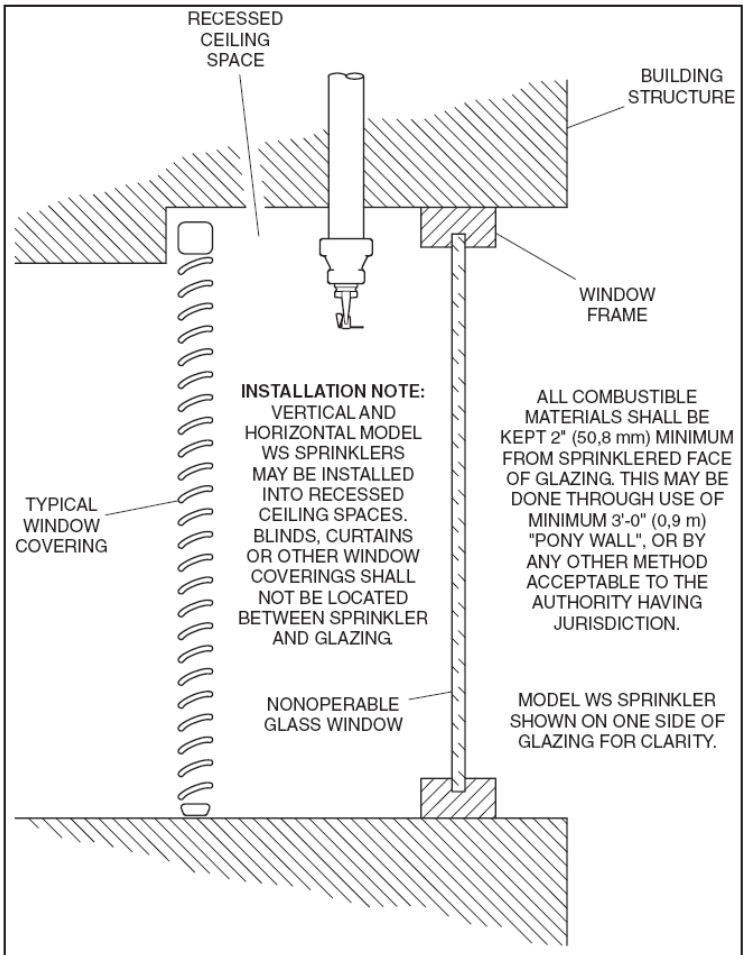


FIGURE 3E
MODEL WS VERTICAL PENDENT SIDEWALL SPRINKLER
RECESSED CEILING TYPICAL INSTALLATION

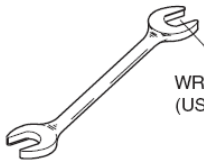


FIGURE 4
W-TYPE 20 SPRINKLER WRENCH

Ordering Procedure

Contact your local distributor for availability.

Sprinkler Assemblies with NPT Thread Connections:
Specify: Model WS, (Specify SIN), (specify Horizontal or Vertical Pendent) Specific Application Window Sprinkler, with (specify temperature rating), (specify finish), P/N (specify).

WS (TY3388) Horizontal Sidewall Window Sprinkler

155°F/68°C,
Natural Brass. . . . . P/N 50-305-1-155
155°F/68°C,
Chrome Plated . . . . . P/N 50-305-9-155
155°F/68°C,
White Coated. . . . . P/N 50-305-4-155
155°F/68°C,
White RAL9010* . . . . . P/N 50-305-3-155

200°F/93°C,
Natural Brass. . . . . P/N 50-305-1-200
200°F/93°C,
Chrome Plated . . . . . P/N 50-305-9-200
200°F/93°C,
White Coated. . . . . P/N 50-305-4-200
200°F/93°C,
White RAL9010* . . . . . P/N 50-305-3-200

WS (TY3488) Vertical Pendent Sidewall Window Sprinkler

155°F/68°C,
Natural Brass. . . . . P/N 50-304-1-155
155°F/68°C,
Chrome Plated . . . . . P/N 50-304-9-155
155°F/68°C,
White Coated. . . . . P/N 50-304-4-155
155°F/68°C,
White RAL9010* . . . . . P/N 50-304-3-155

200°F/93°C,
Natural Brass. . . . . P/N 50-304-1-200
200°F/93°C,
Chrome Plated . . . . . P/N 50-304-9-200
200°F/93°C,
White Coated. . . . . P/N 50-304-4-200
200°F/93°C,
White RAL9010* . . . . . P/N 50-304-3-200

* Eastern Hemisphere sales only.

Sprinkler Wrench:
Specify: W-Type 20 Sprinkler Wrench, P/N 56-000-1-106.

TYCO FIRE PRODUCTS, 451 North Cannon Avenue, Lansdale, Pennsylvania 19446

APPENDIX B: SPRINKLER-CONTROLLED FIRE CONDITIONS SIMULATIONS

12.1.1 Fire Scenario # 1A: Ground Floor Atrium - Sprinkler-controlled Fire and Smoke Fan

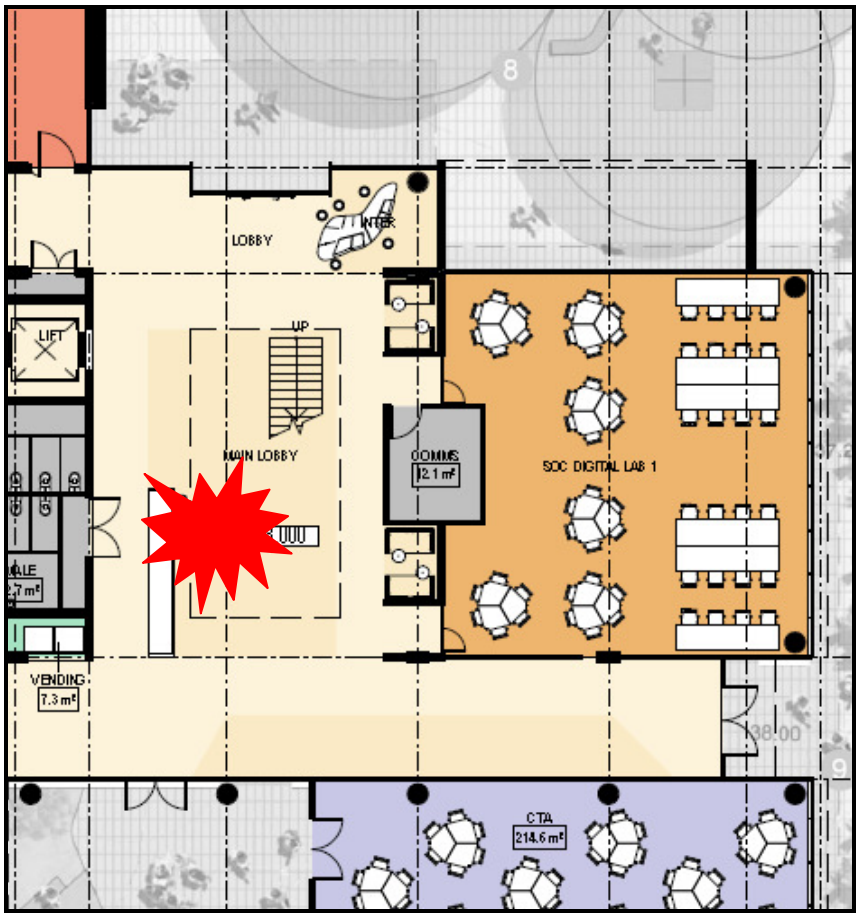


Figure 52 – Uncontrolled fire scenario inside ground floor Atrium.

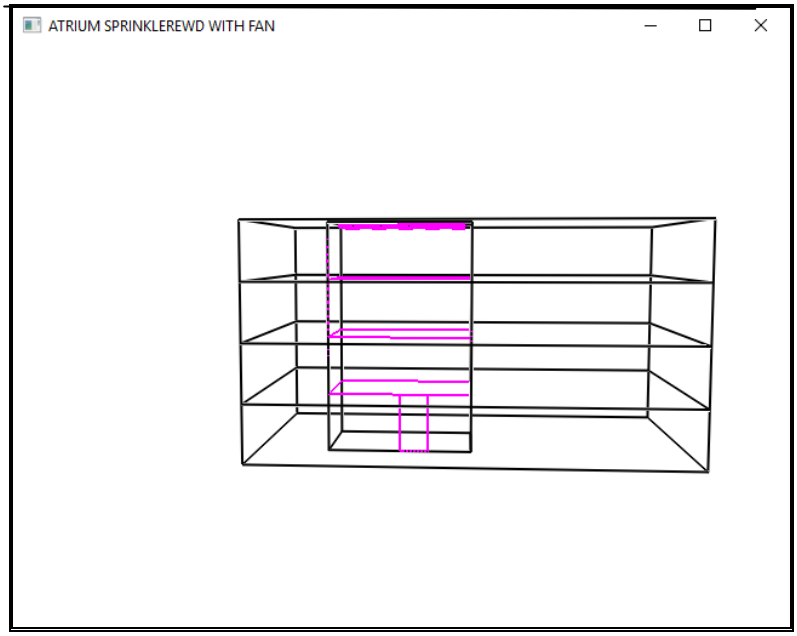


Figure 53 – View of simulated Atrium.

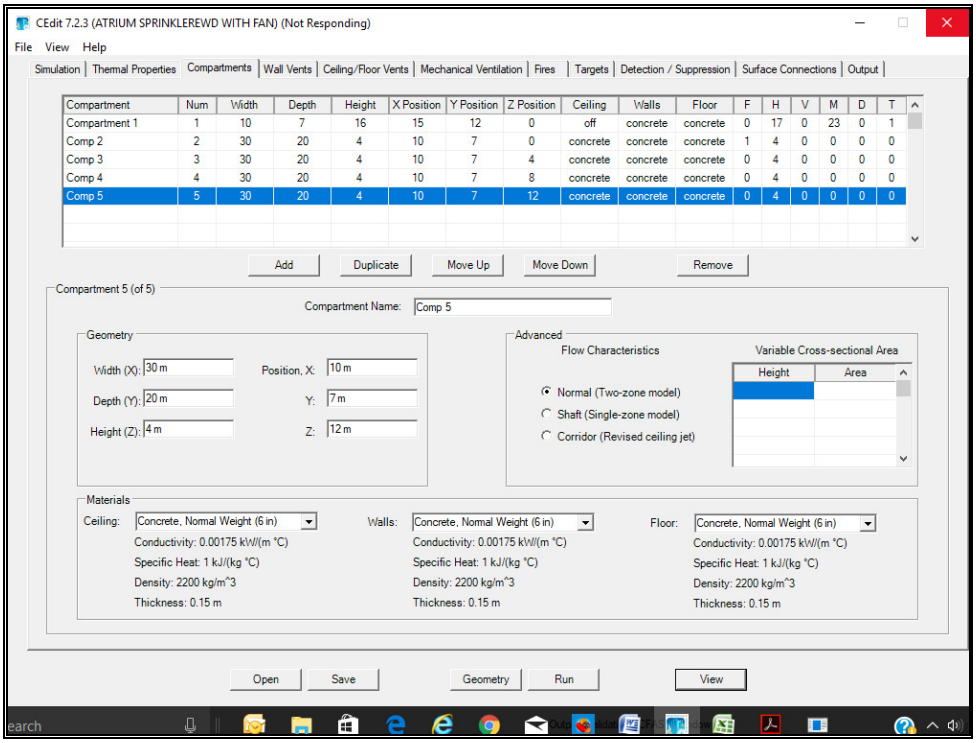


Figure 54 – Compartmentation input for simulation.

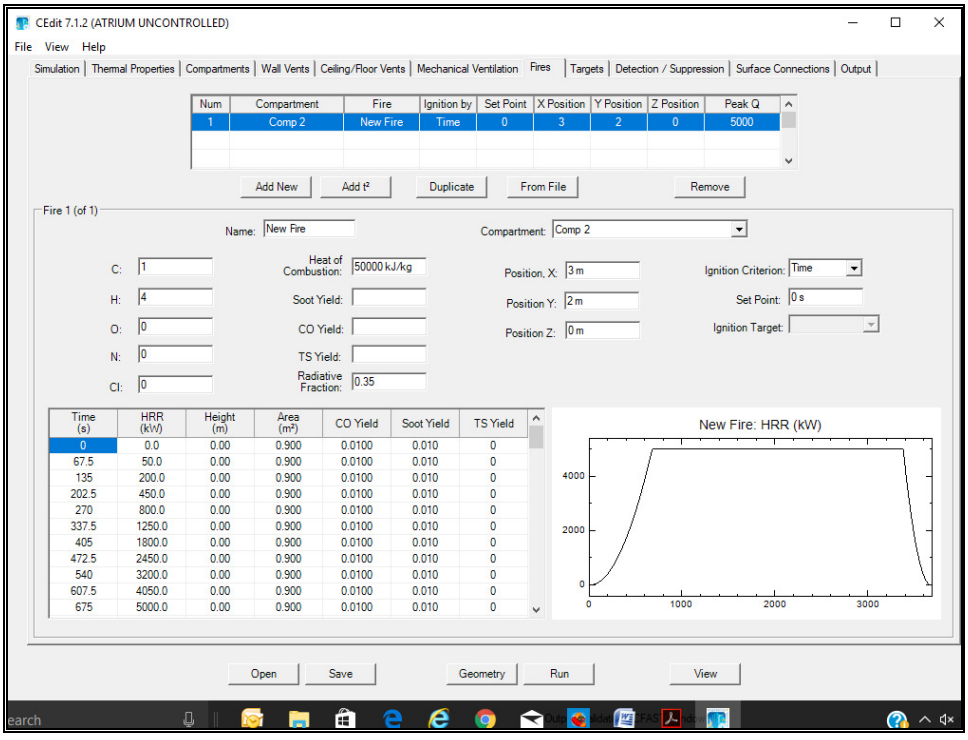


Figure 55 – Simulated 5MW Medium Growth Standard t²-Fire.

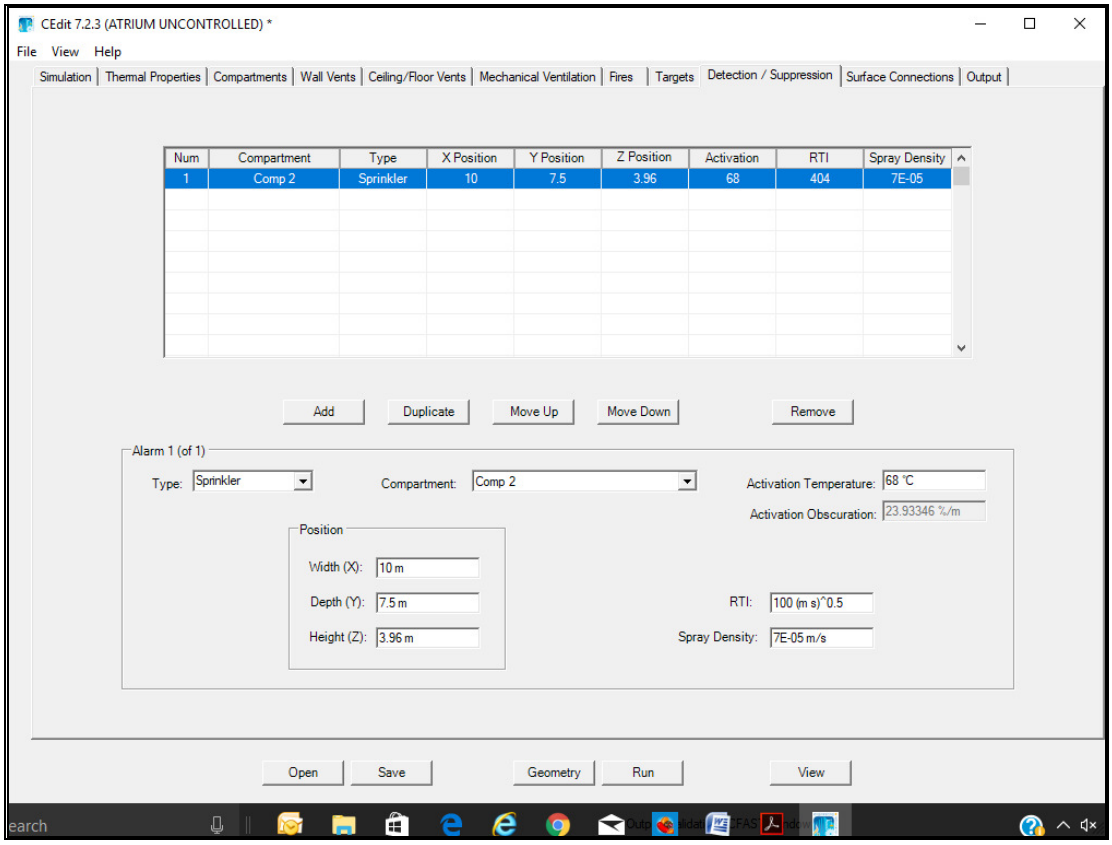


Figure 56 – Simulated fast-response sprinkler head in ground floor atrium.

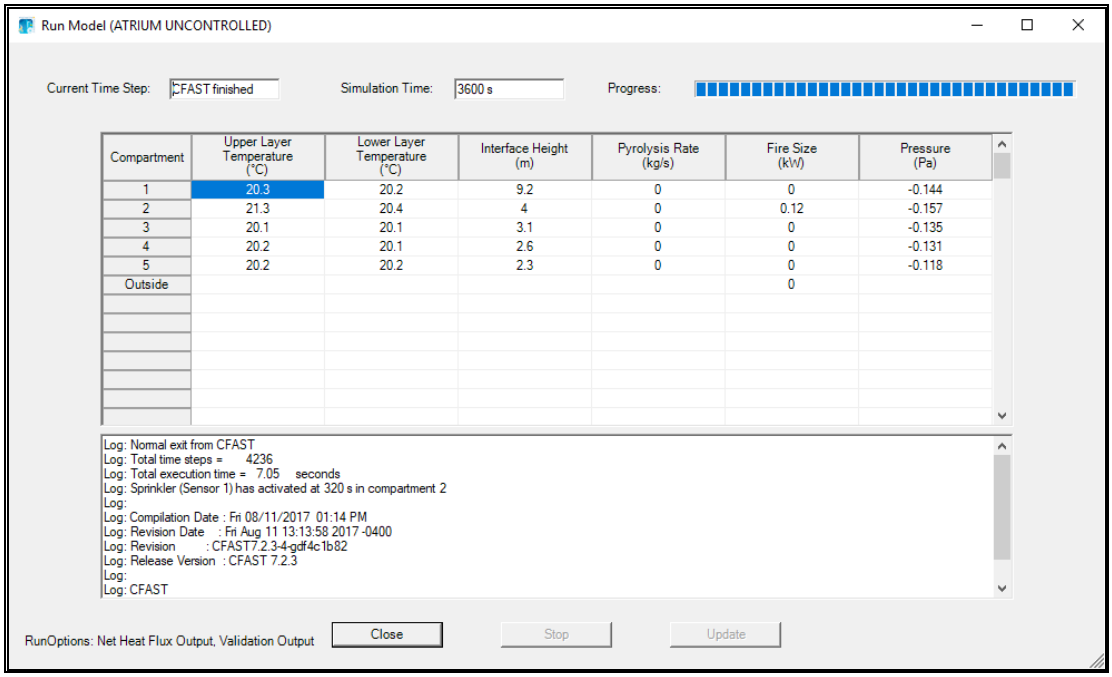


Figure 57 – Fast-response sprinkler head in ground floor atrium, activates at 320sec.

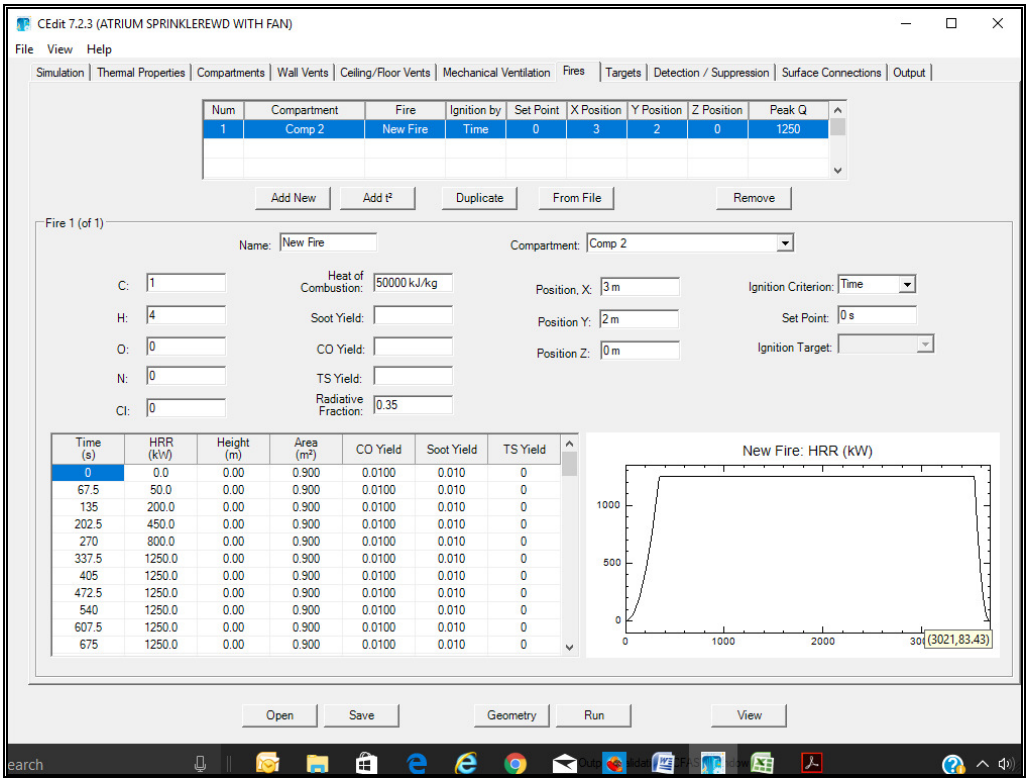


Figure 58 – Sprinkler-controlled fire profile.

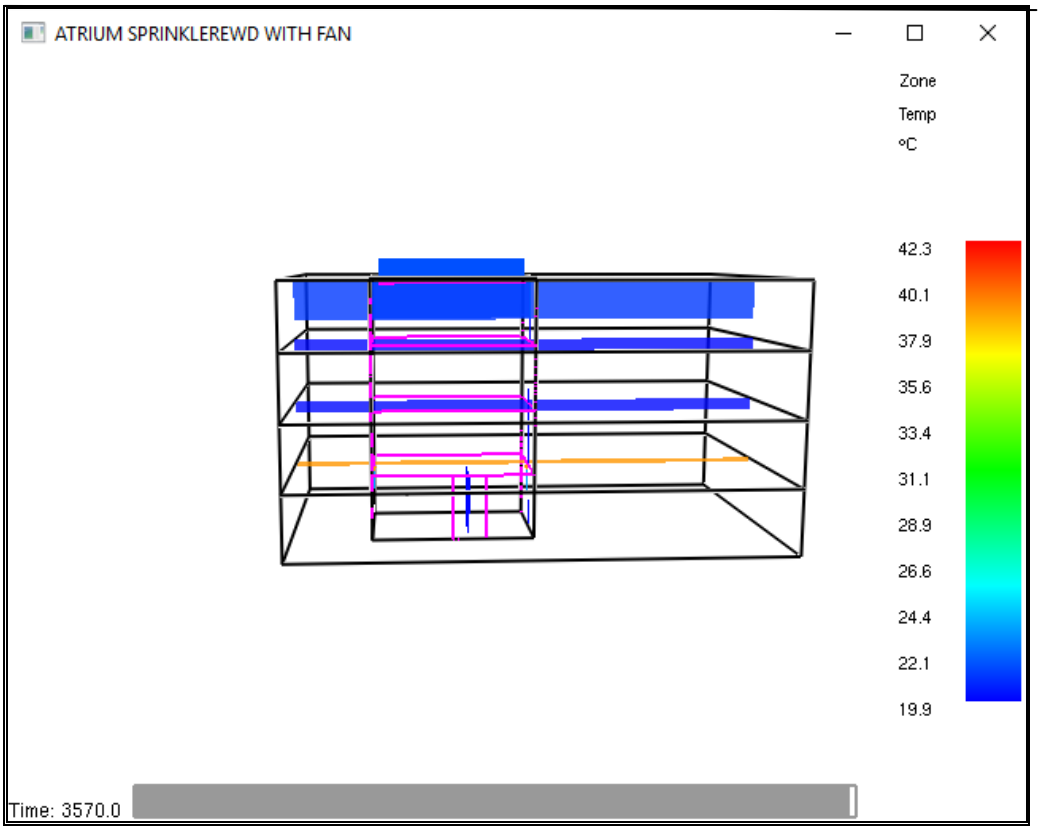


Figure 59 – Smoke view after one hour simulation of sprinkler-controlled fire scenario with smoke fan.

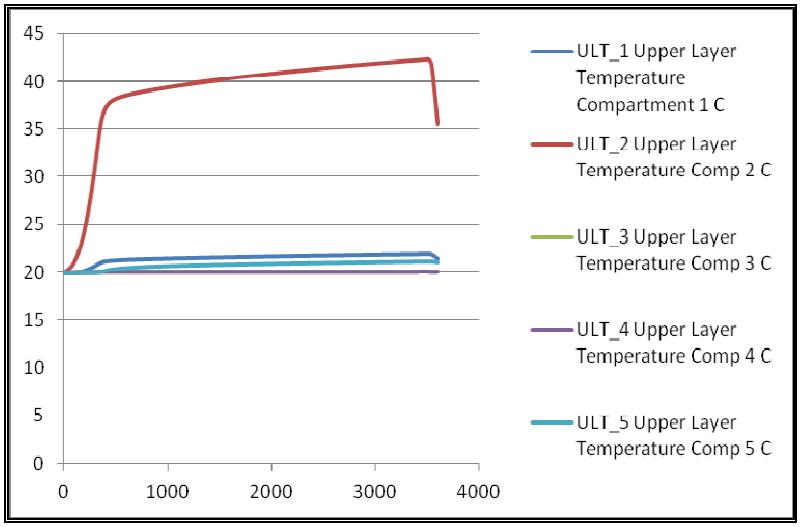


Figure 60 – Smoke temperature history during sprinkler-controlled fire scenario with smoke fan, smoke temperature inside upper floor does not reach 22° and smoke temperature inside ground floor (room of fire origin); does not reach 42°.

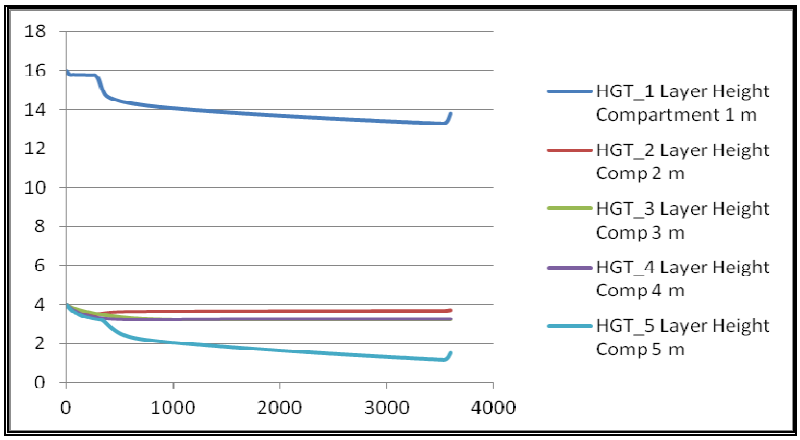


Figure 61 – Smoke layer height during sprinkler-controlled fire scenario with smoke fan; smoke layer higher than 2.1m above floor level (only Level 3 cold smoke reaches 2.1m above floor level at 80sec from ignition).

The above simulation shows that during sprinkler-controlled fire scenario; automatic mechanical smoke extraction fan.

Smoke temperature is very low and layer height greater than 2.1m above floor level

ASET (Atrium sprinkler-controlled fire scenario with smoke fan) = 60minute.

12.1.2 Fire Scenario # 1B: Ground Floor Atrium - Sprinkler-controlled Fire - Natural ventilation

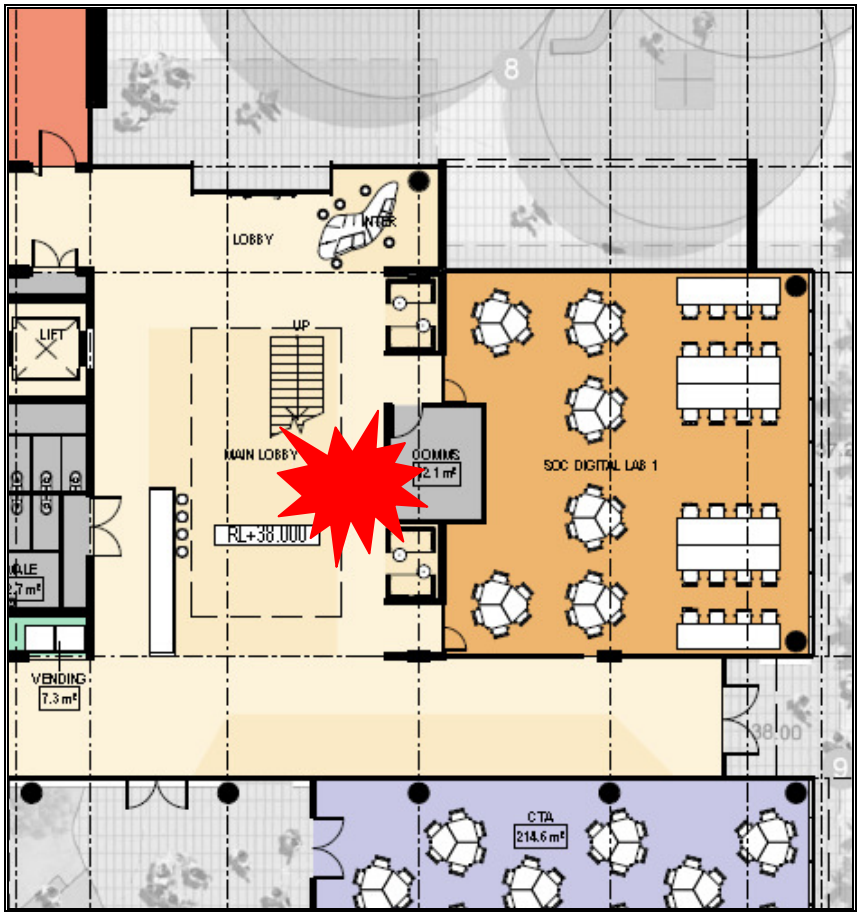


Figure 62 – Uncontrolled fire scenario inside ground floor Atrium.

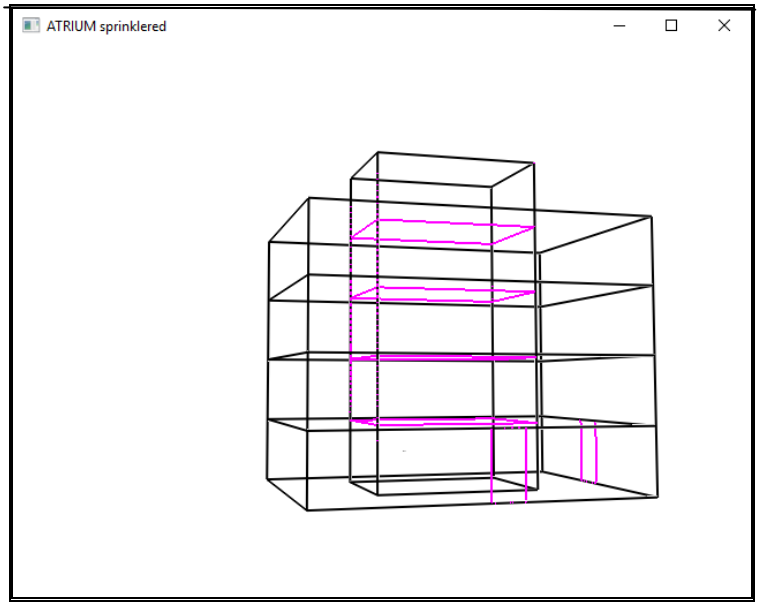


Figure 63 – View of simulated Atrium.

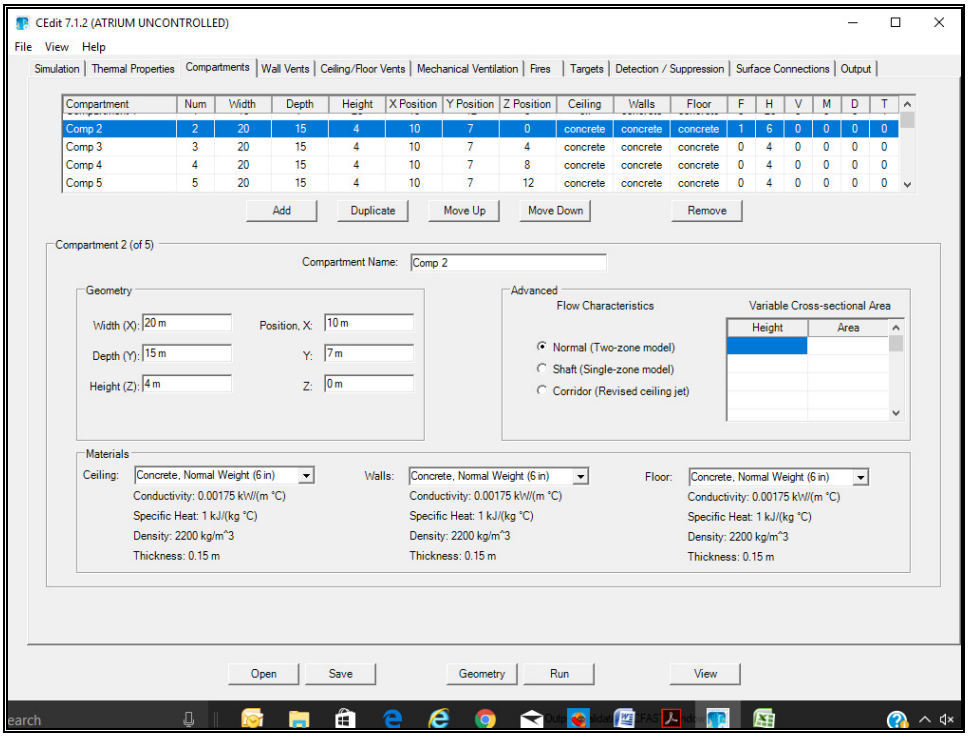


Figure 64 – Compartmentation input for simulation.

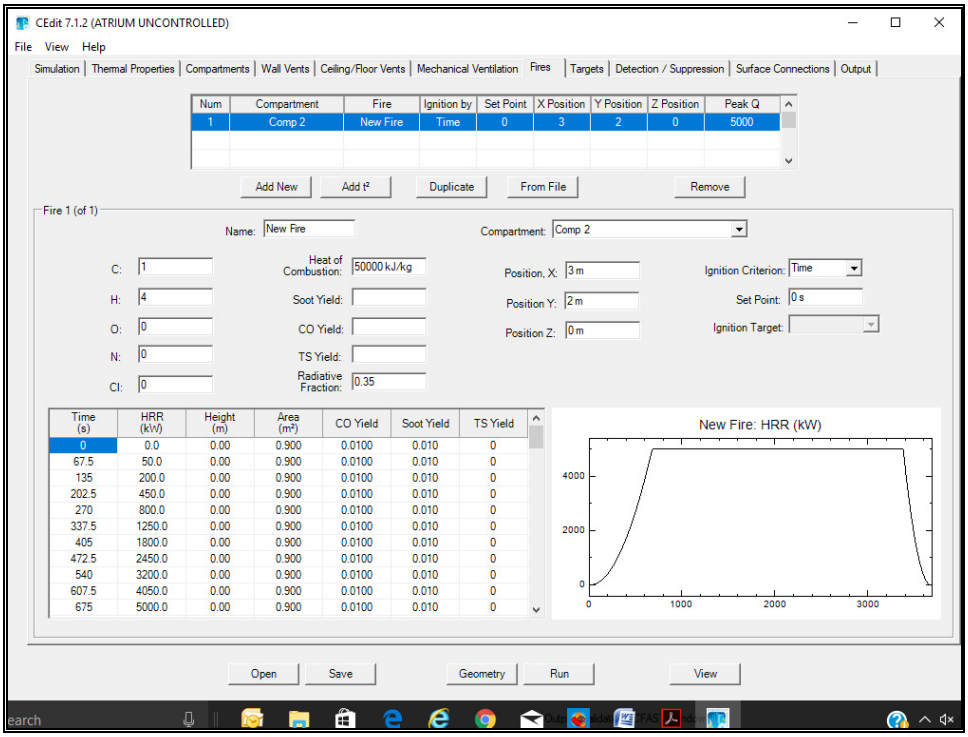


Figure 65 – Simulated 5MW Medium Growth Standard t²-Fire.

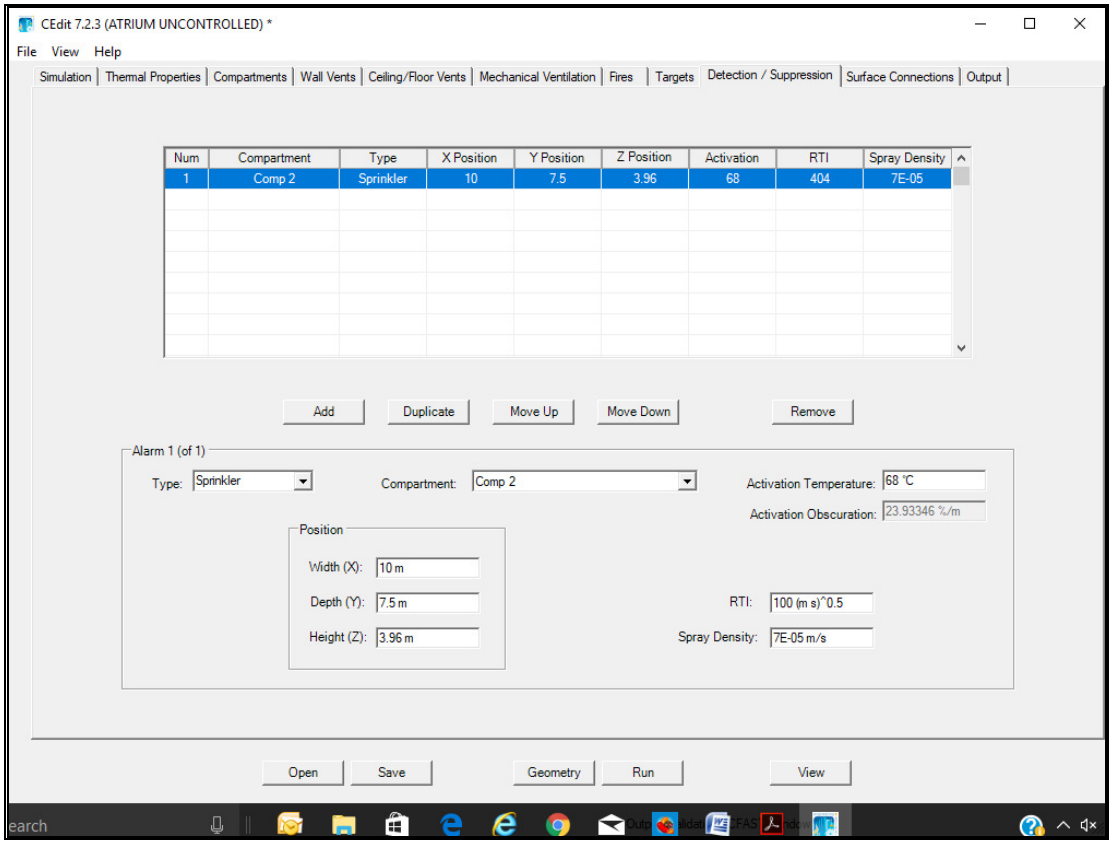


Figure 66 – Simulated fast-response sprinkler head in ground floor atrium.

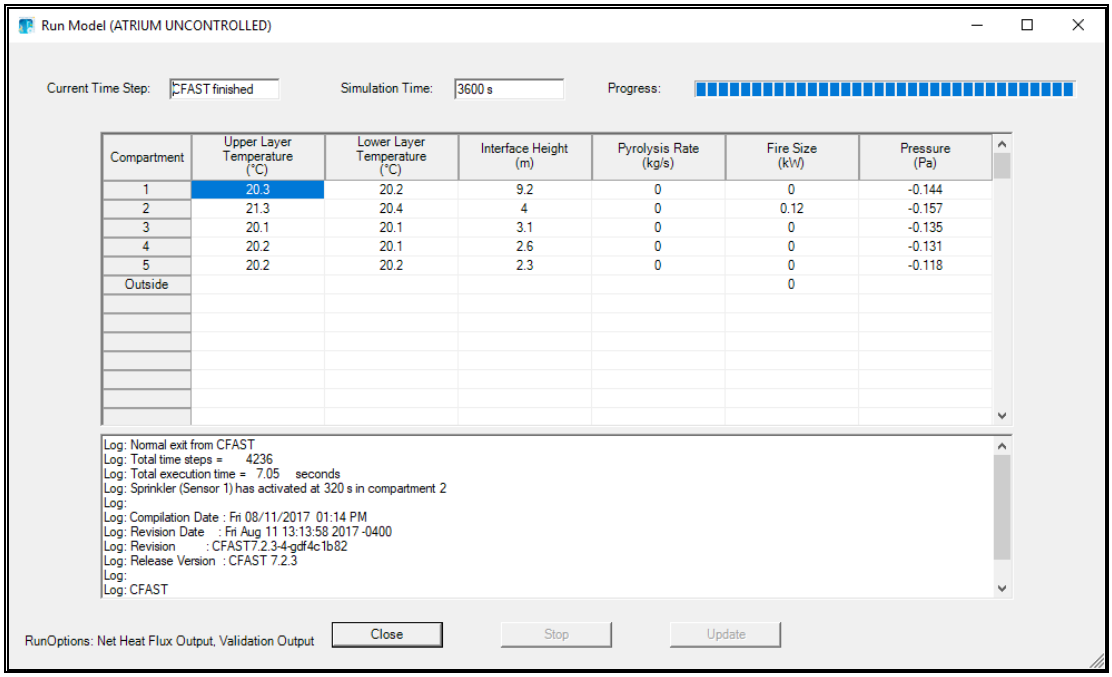


Figure 67 – Fast-response sprinkler head in ground floor atrium, activates at 320sec.

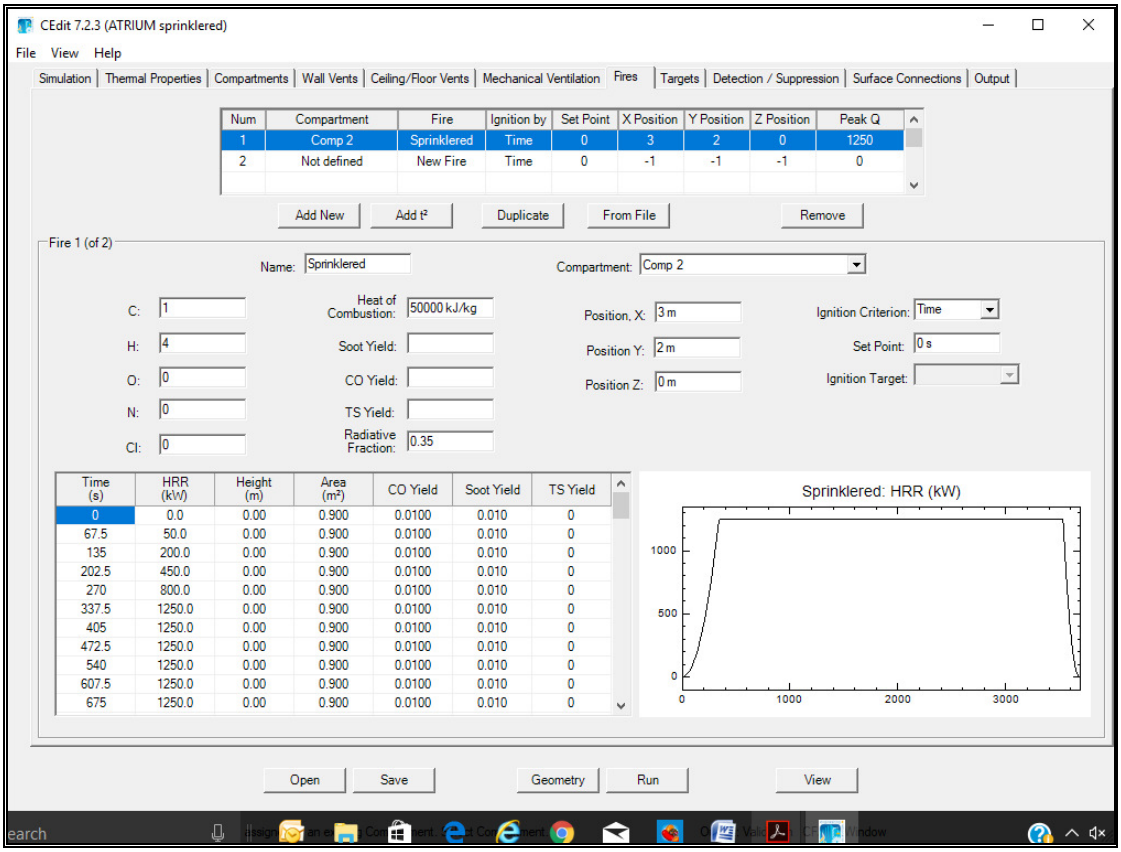


Figure 68 – Sprinkler-controlled fire profile.

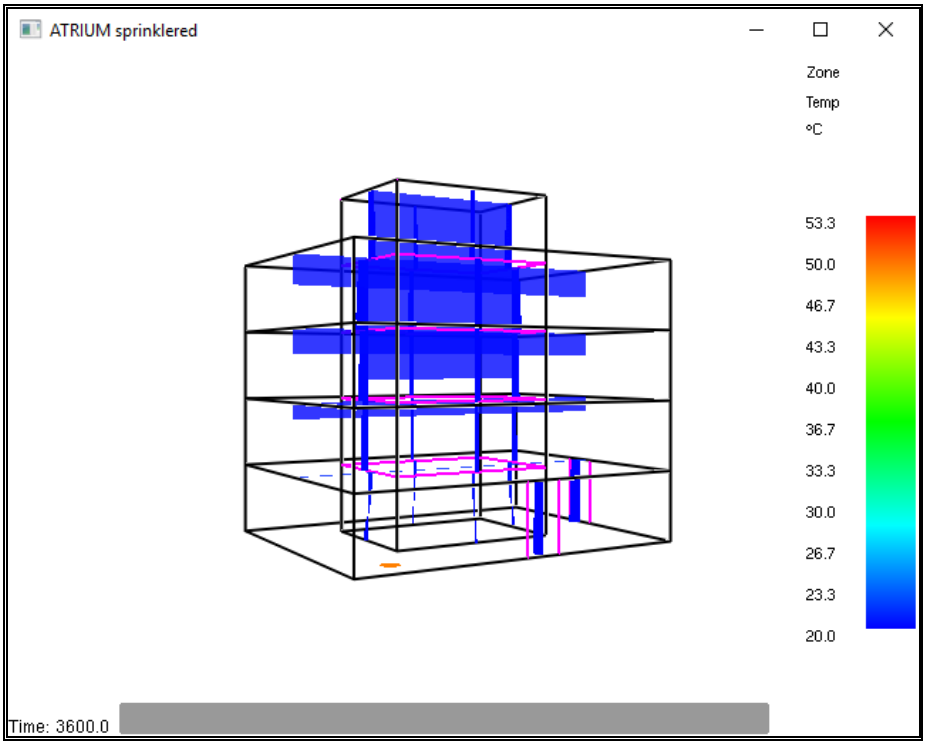


Figure 69 – Smoke view after one hour simulation of sprinkler-controlled fire scenario.

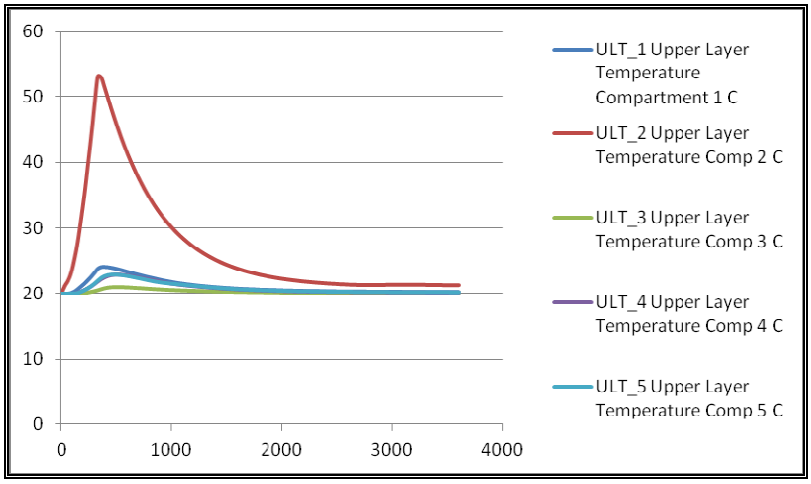


Figure 70 – Smoke temperature history during sprinkler-controlled fire scenario, smoke temperature inside upper floor does not reach 25° and smoke temperature inside ground floor (room of fire origin); does not reach 60°.

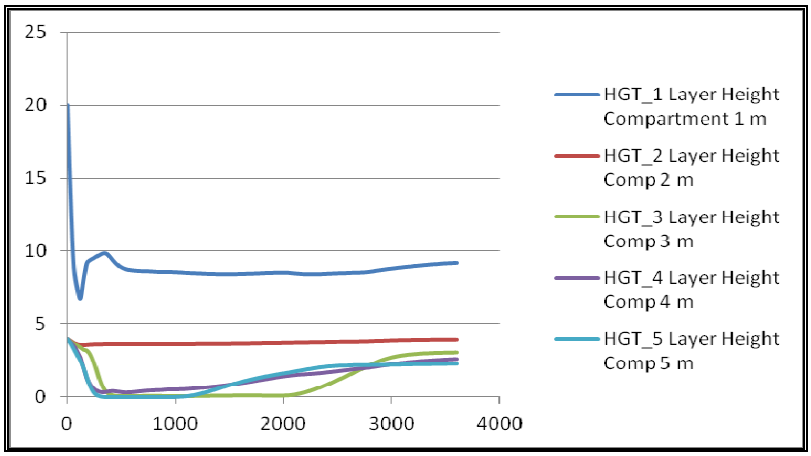


Figure 71 – Smoke layer height during sprinkler-controlled fire scenario; very cold smoke filled upper levels.

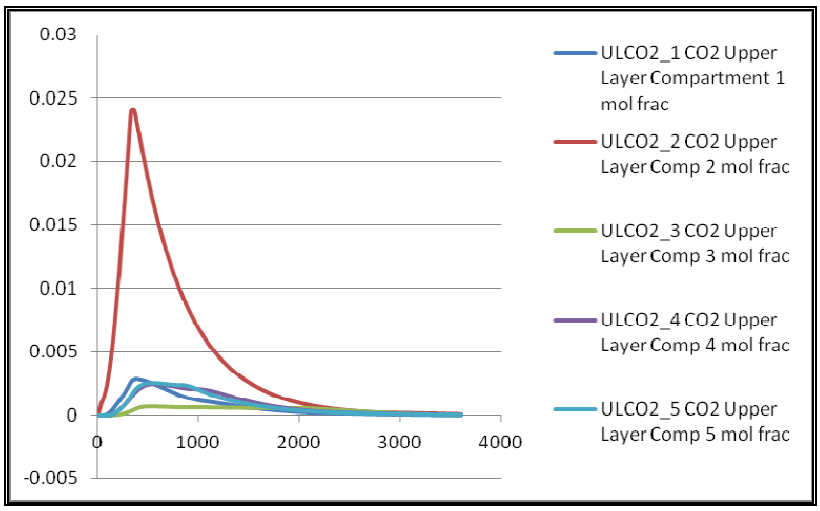


Figure 72 – Carbon Dioxide (CO2) concentration history.

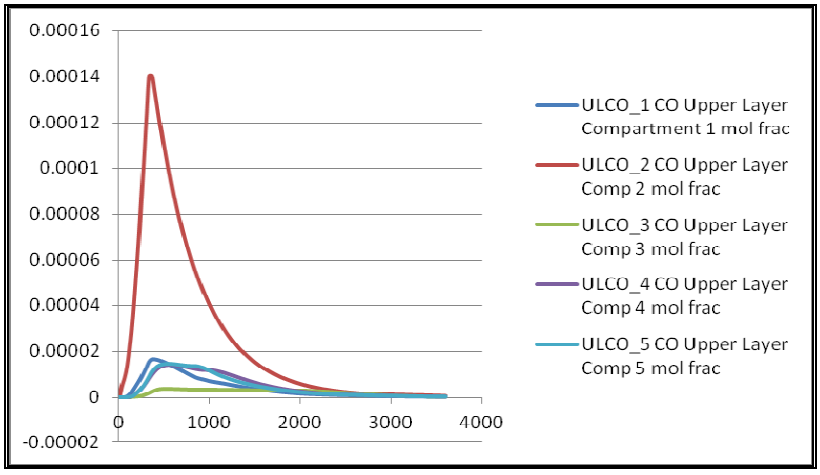


Figure 73 – Carbon Monoxide (CO) concentration history.

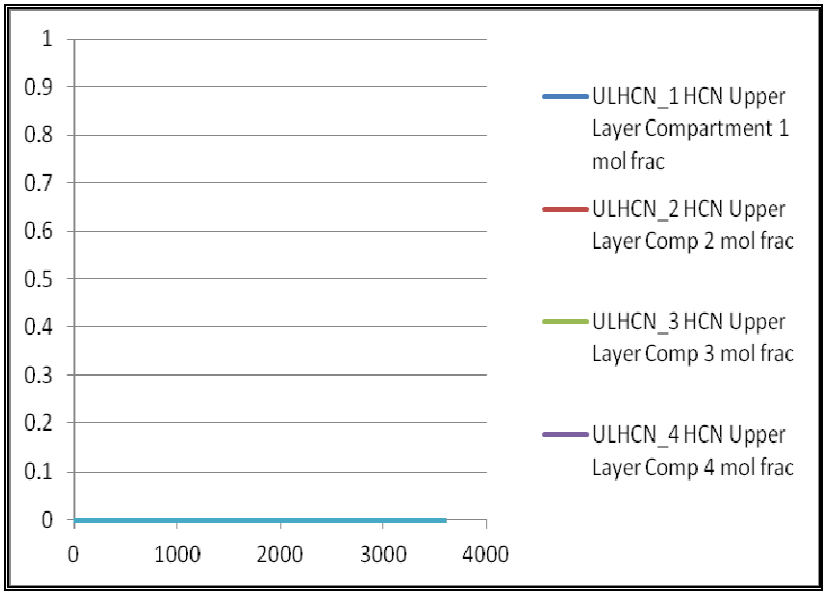


Figure 74 – There is no Hydrogen Cyanide (HCN) produced during fire.

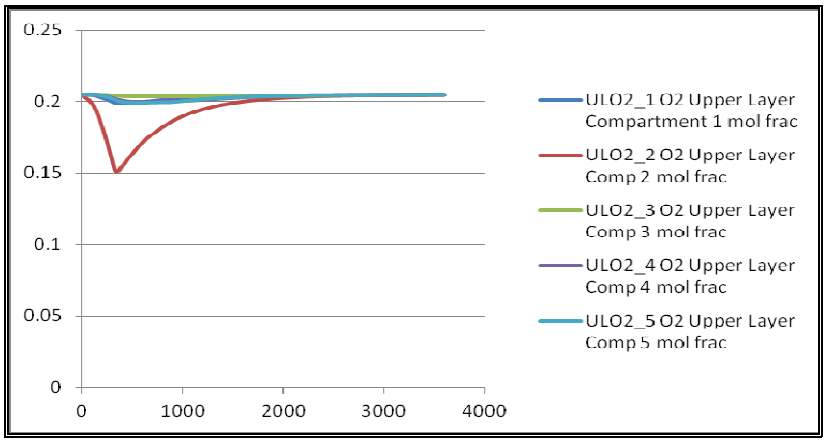


Figure 75 – Oxygen Concentration (O2) history during fire

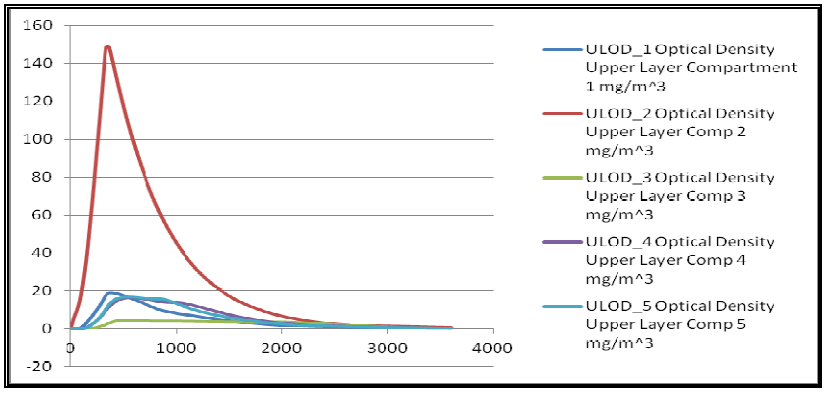


Figure 76 – Optical Density (OD) history during fire

The above simulation shows that during sprinkler-controlled fire scenario; smoke, naturally extracted through the Atrium smoke-and-heat roof vent, however all upper level filled with cold smoke of less than 24° and ground floor smoke layer height maintained at very high level with temperature of less than 55°.

Occupants in upper floor might expose to cold smoke of temperature of 24° and subject to toxicity tenability limits do not arrive, therefore upper level occupant's tenability limits do not arrive at full simulation of 60minute.

Tenability limits for ground floor occupants do not arrive where the smoke layer temperature do not reach 200° at 2.1m above floor level, only 55°, therefore ground floor tenability limits considered similar to upper floors tenability limits being 60minute.

The toxicity limits from exposure to Carbon Dioxide (CO2), do not arrive, where concentration of 24% simulated on all upper levels where occupants might walk through smoke, which is much less than tenability limits acceptance criteria (refer to Section 3.10.1 above, Table 13).

The toxicity limits from exposure to Carbon Monoxide (CO), do not arrive, where concentration of 20ppm simulated on all upper levels where occupants might walk through smoke, which is much less than tenability limits acceptance criteria (refer to Section 3.10.1 above, Table 13).

The simulation shows that there is no Hydrogen Cyanide produced during the simulation.

The Oxygen concentration of 20% in upper levels where occupants might walk through smoke, which is greater than the percentage required for tenability (refer to Section 3.10.1 above, Table 13).

The Oxygen concentration of 20gm/m³ (0.02 gm/m) is simulated in upper levels where occupants might walk through smoke, which is greater than the OD limits of 0.1 that is equivalent to 10m visibility.

ASET (Atrium sprinkler-controlled fire scenario with natural smoke vent) = 60minute.

12.1.3 Fire Scenario # 2: Eastern Wing Level 1 - Sprinkler-controlled Fire

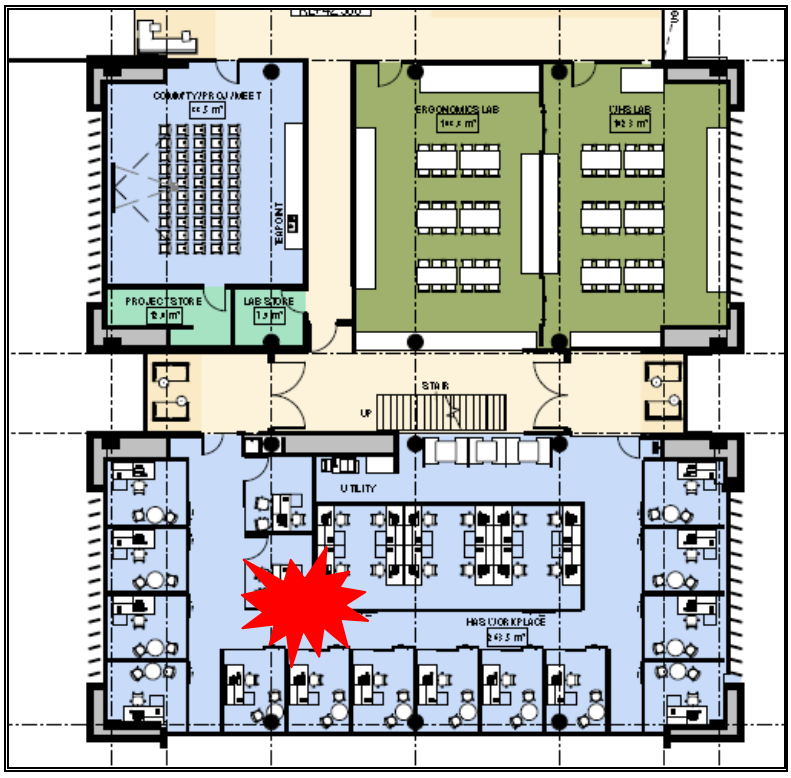


Figure 77 – Uncontrolled fire scenario inside Level 1 Eastern fire compartment.

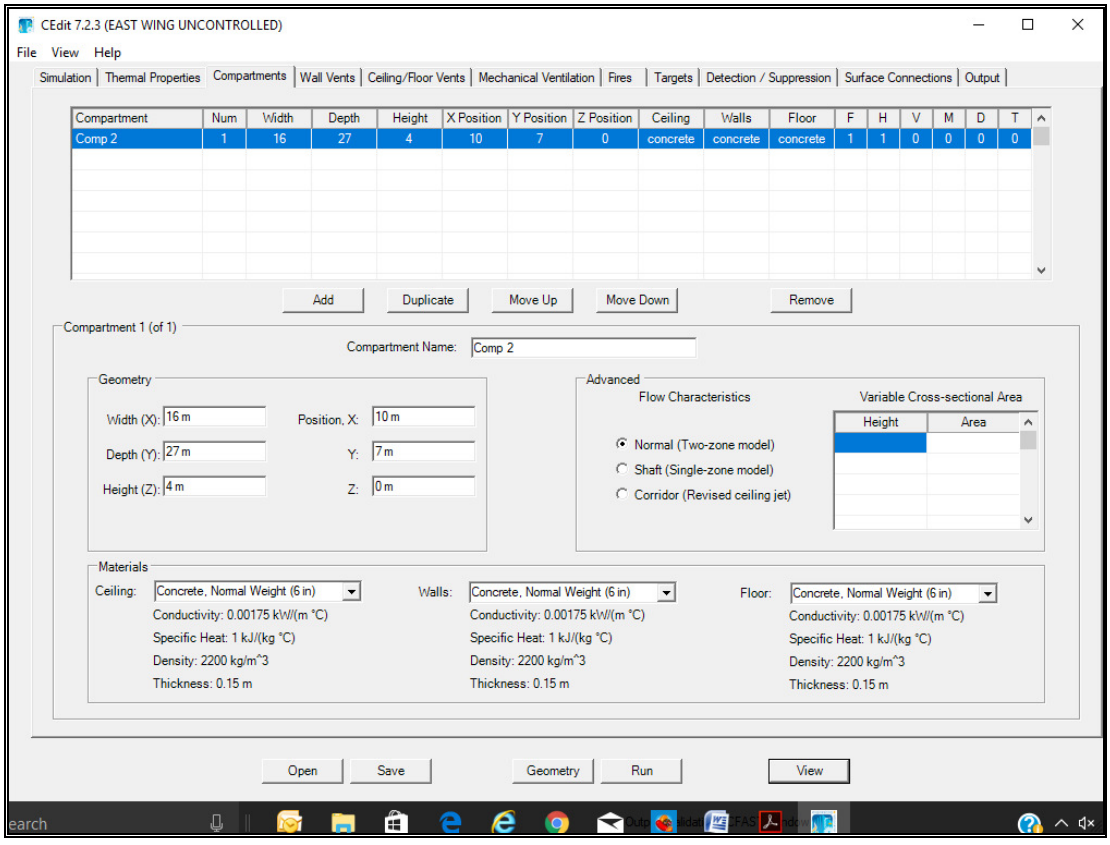


Figure 78 – Simulated Level 1 Eastern fire compartment.

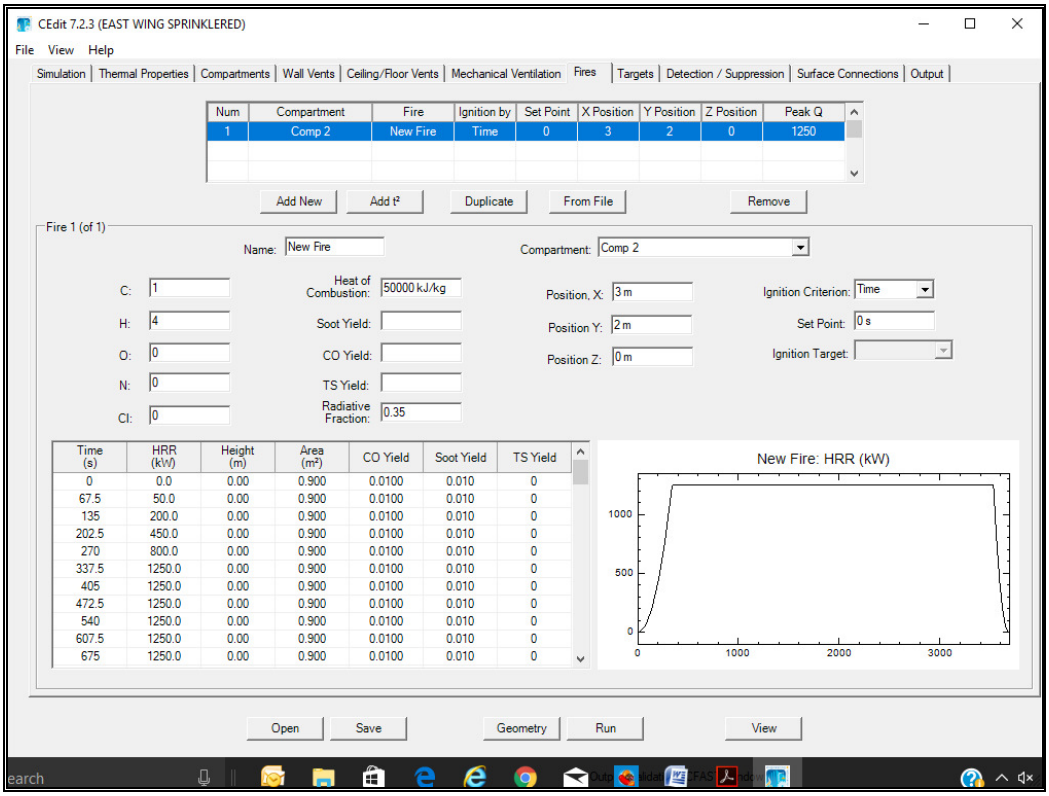


Figure 79 – Simulated sprinkler-controlled fire inside Level 1 Eastern fire compartment.

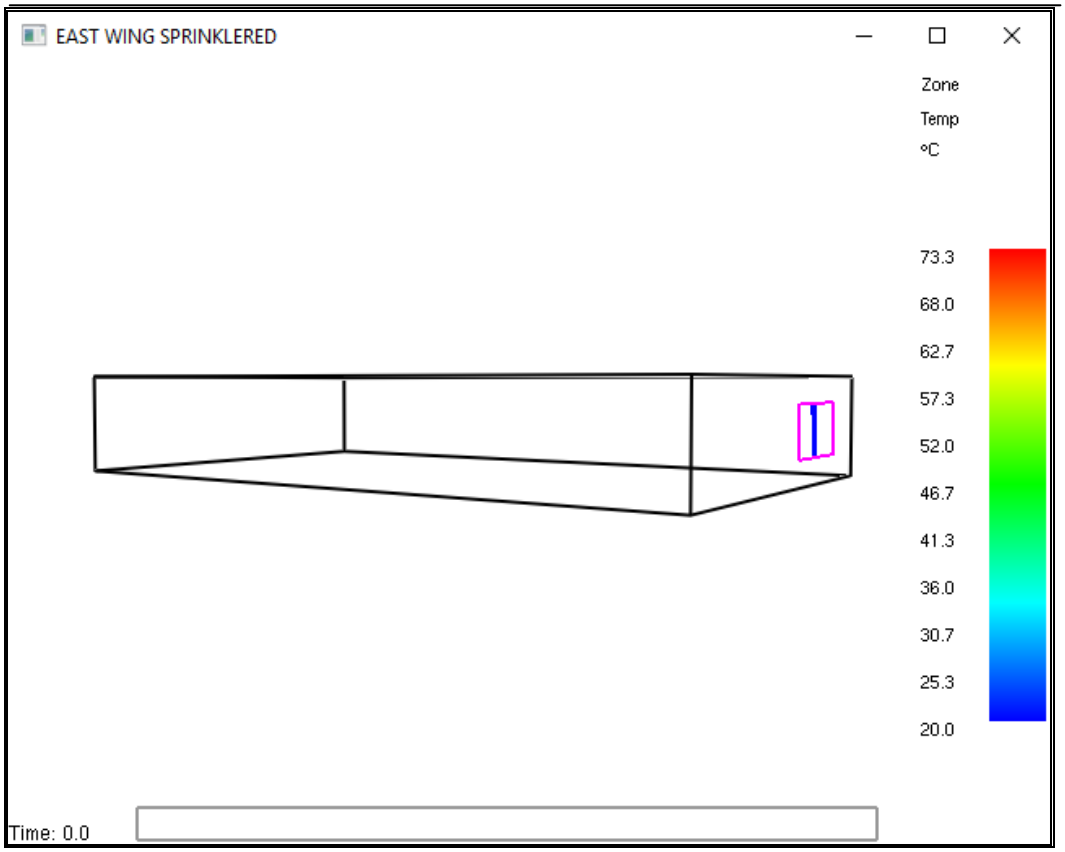


Figure 80 – Simulated smoke view for fire inside Level 1 Eastern fire compartment.

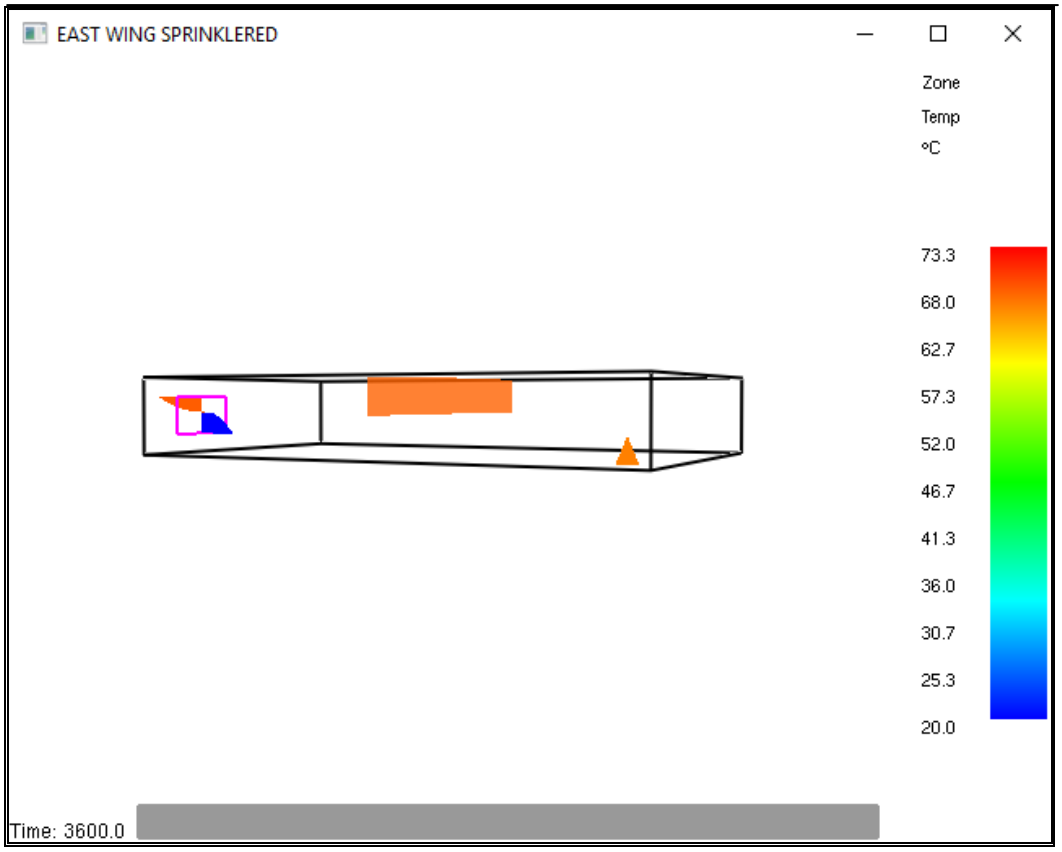


Figure 81 – Smoke view inside East Wing.

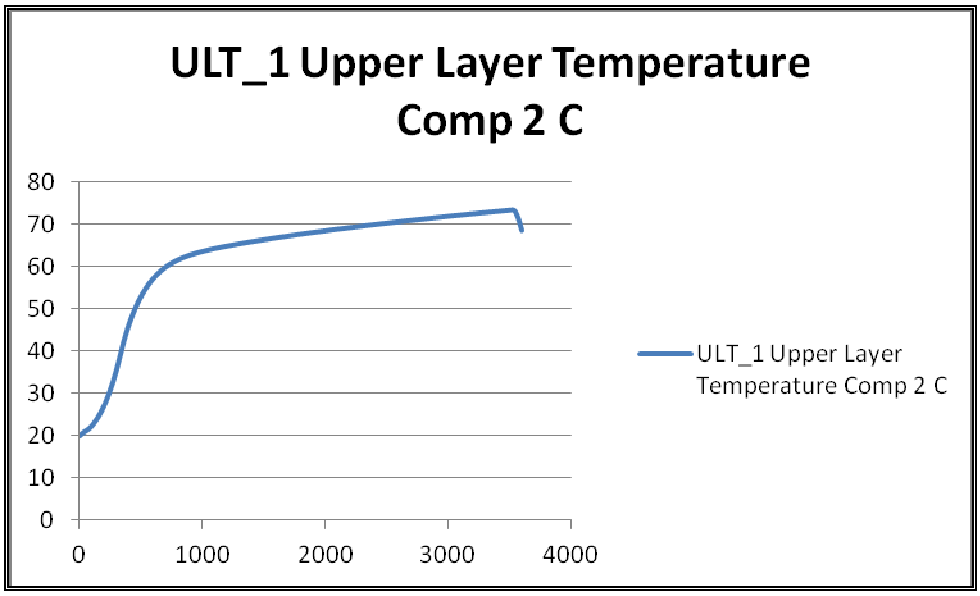


Figure 82 – Smoke temperature history.

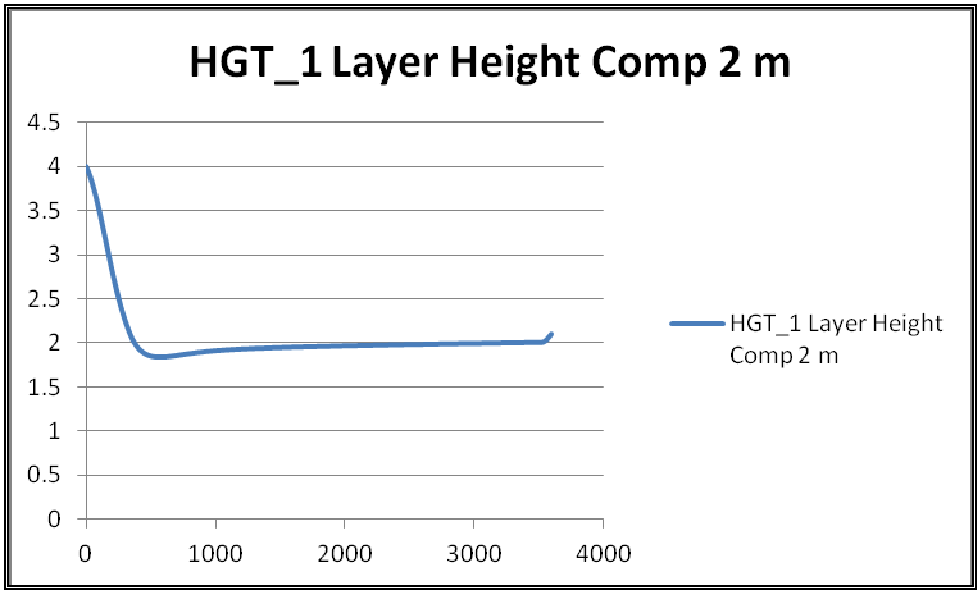


Figure 83 – Smoke height history.

Tenability limits do not arrive with smoke layer maintained at less than 75° at around 2m above floor level

ASET (East Wing Sprinkler-controlled Fire) = 3600sec = 60minute.

12.1.4 Fire Scenario # 3: North Wing Level 2 - Sprinkler-controlled Fire

Figure 84 –Sprinkler-controlled fire scenario inside Level 2 North fire compartment.

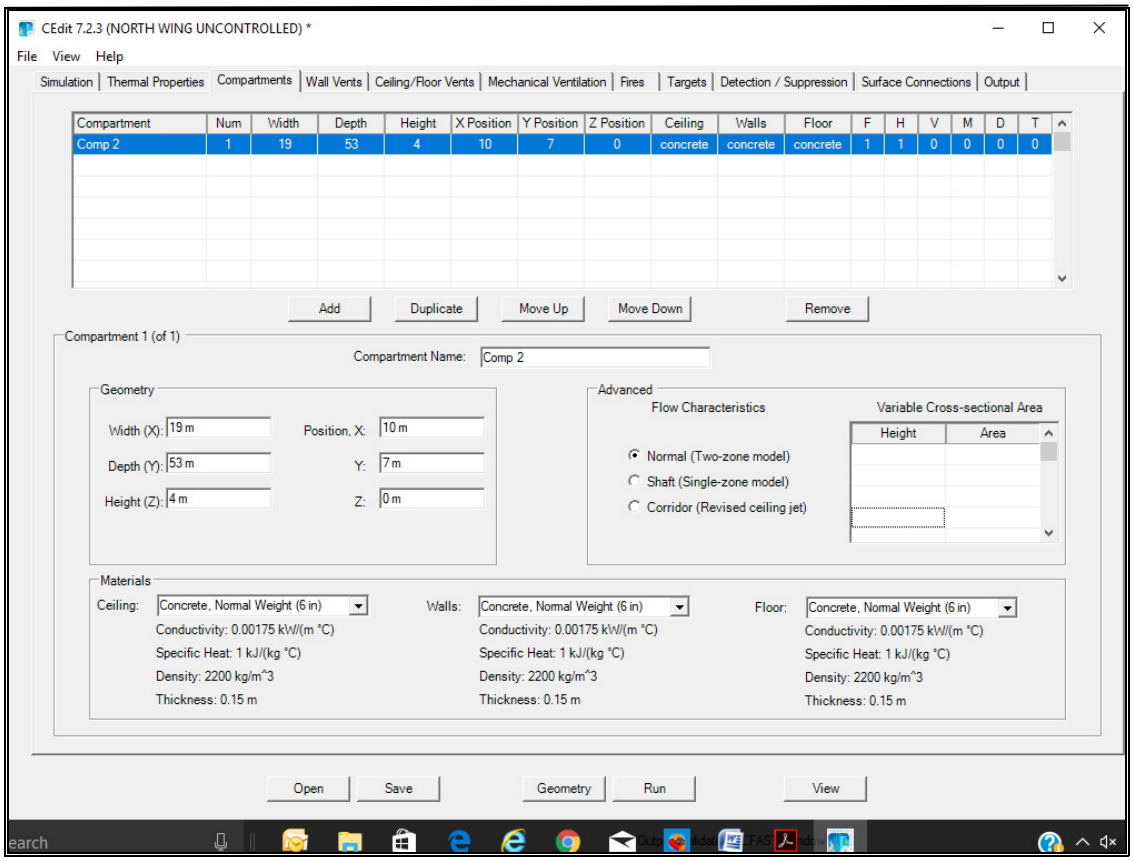


Figure 85 – Simulated Level 2 North fire compartment.

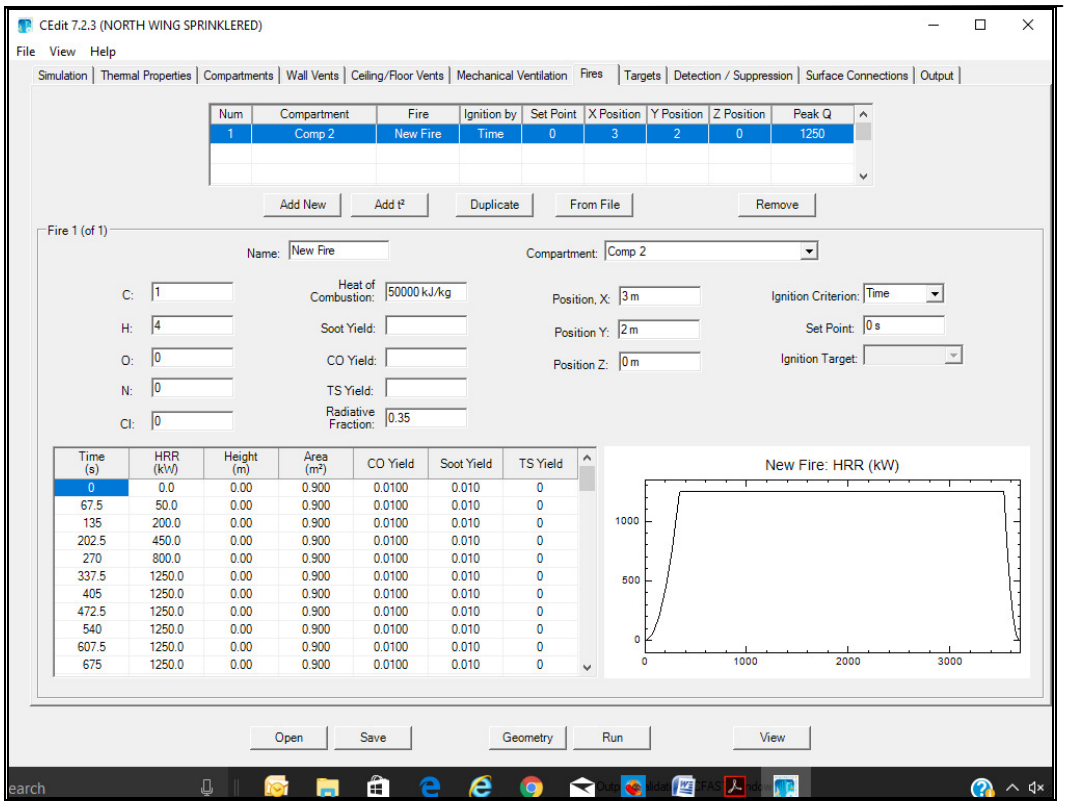


Figure 86 – Simulated sprinkler-controlled Fire inside Level 2 North fire compartment.

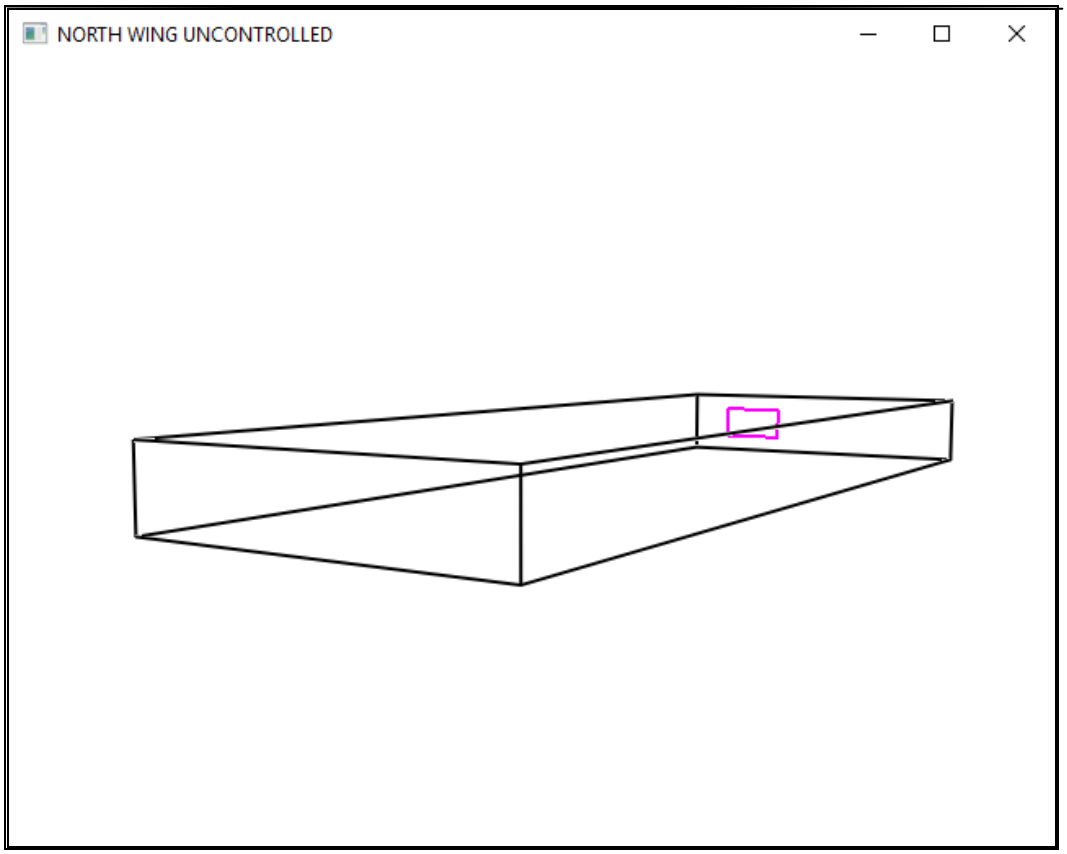


Figure 87 – Simulated smoke view for fire inside Level 2 North fire compartment.

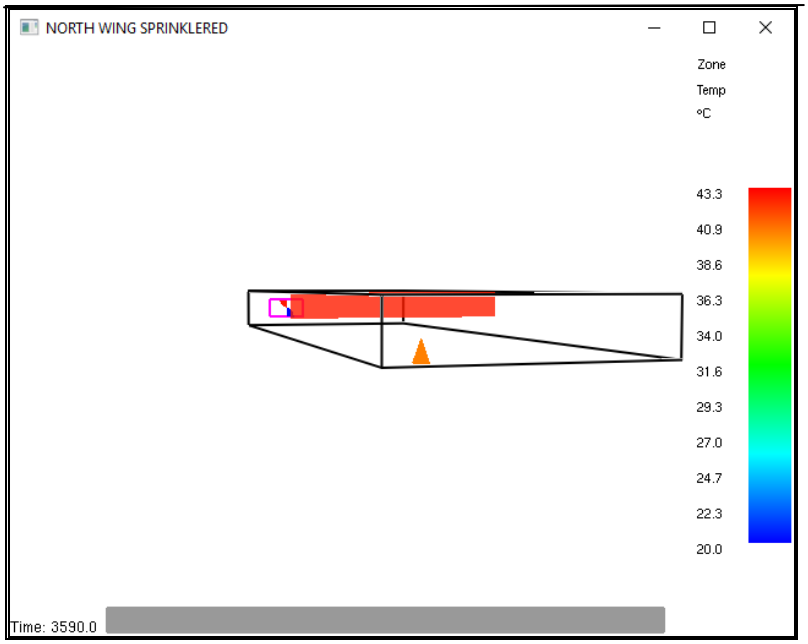


Figure 88 – Smoke view inside North Wing.

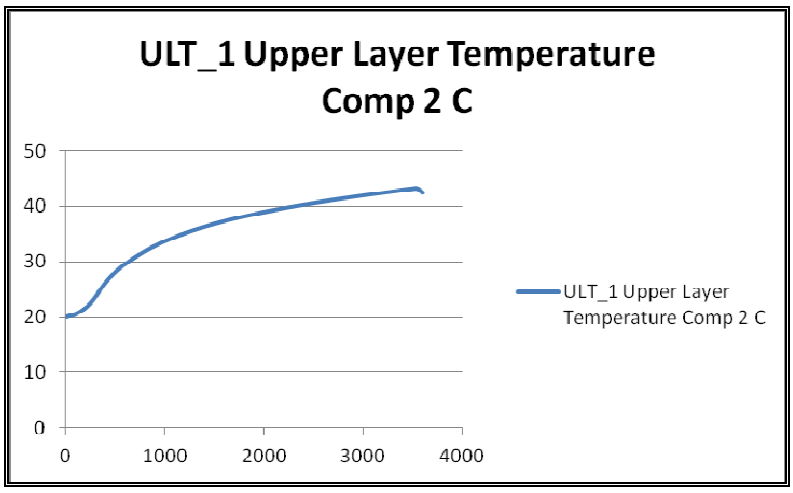


Figure 89 – Smoke temperature history.

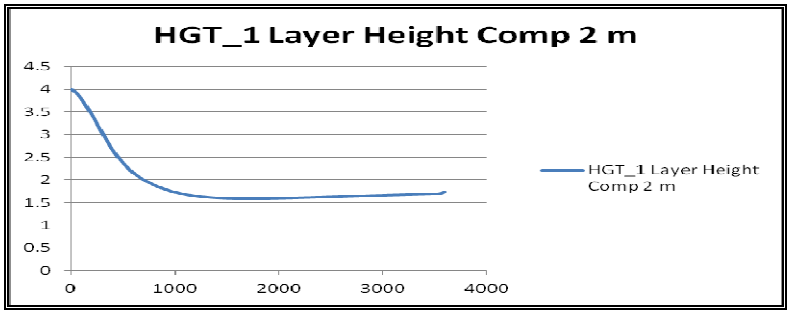


Figure 90 – Smoke temperature history.

Tenability limits do not arrive with smoke layer temperature 44° at less than 2.1m above floor level
ASET (East Wing Sprinklered Fire) = 3600sec = 60minute.

APPENDIX C: UNCONTROLLED FIRE CONDITIONS (SENISITIVITY)

12.1.5 Fire Scenario # 4A: Ground Floor Atrium - Uncontrolled Fire with Smoke Fan

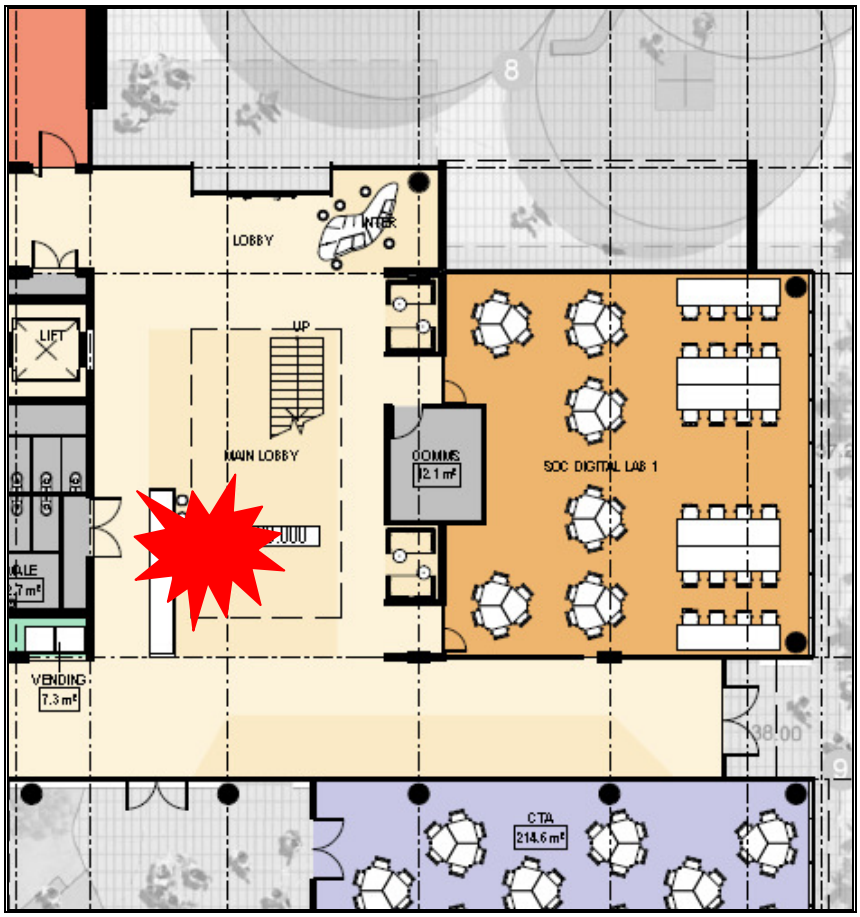


Figure 91 – Uncontrolled fire scenario inside ground floor Atrium.

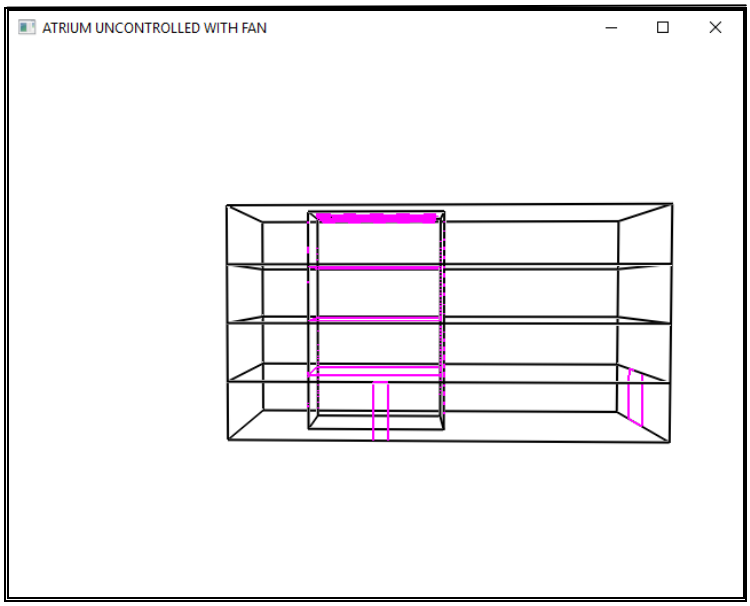


Figure 92 – View of simulated Atrium.

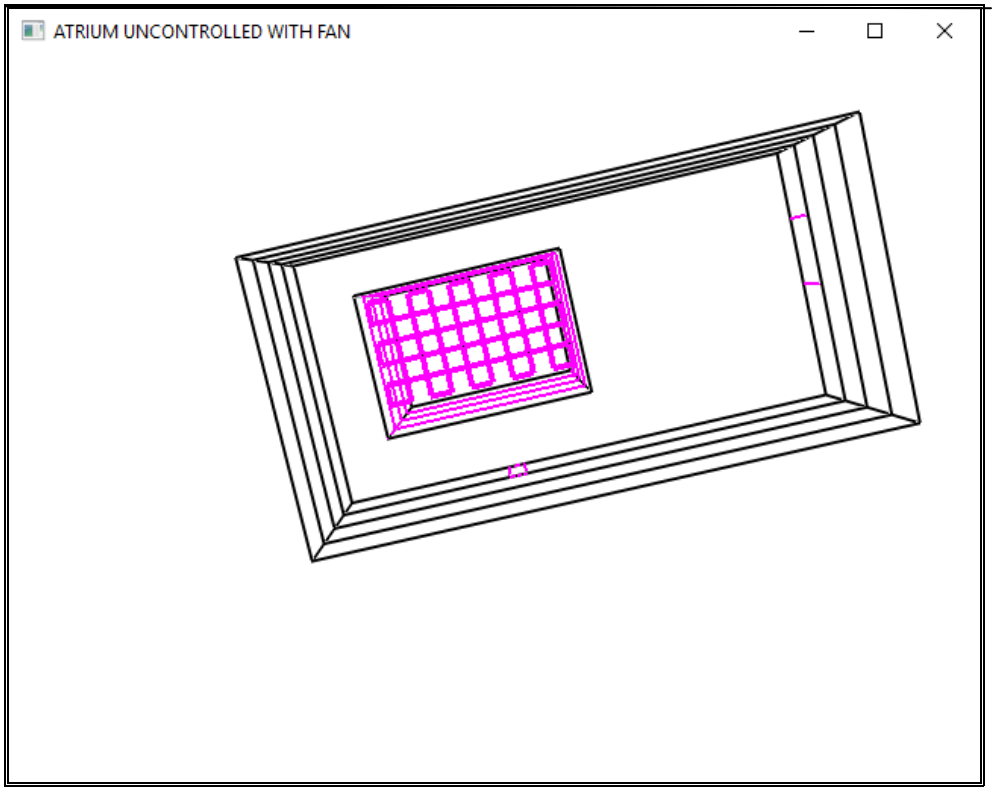


Figure 93 – View of simulated smoke exhaust fans with capacity 92m³/sec.

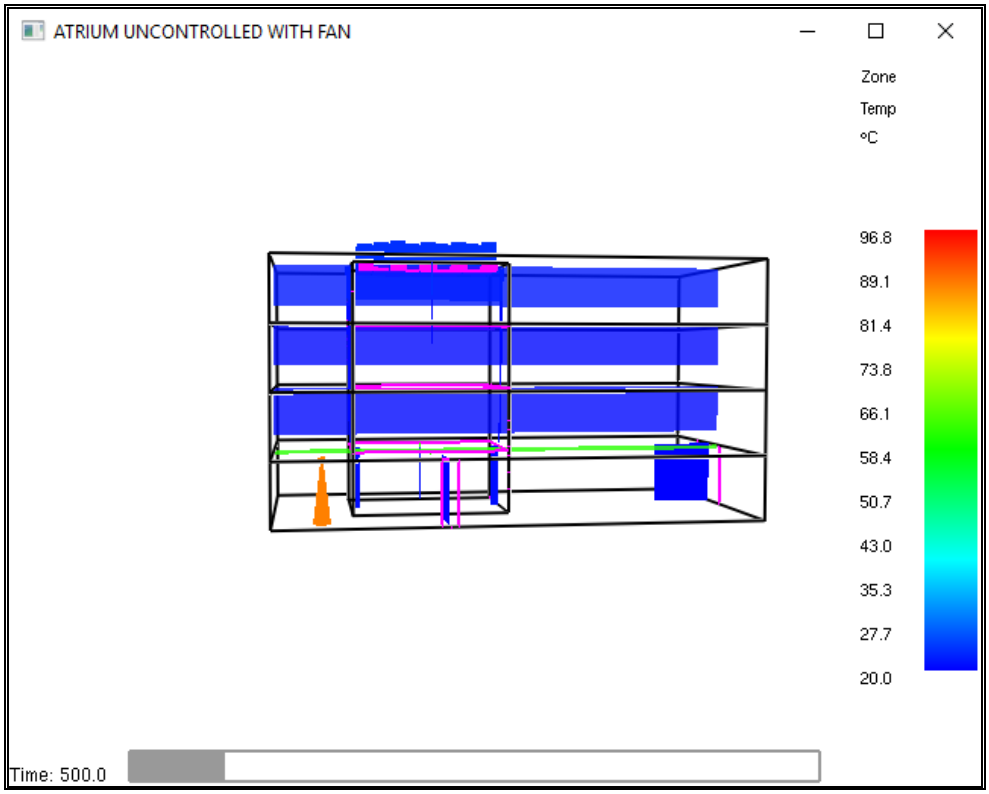


Figure 94 – View of simulated smoke layers at 500sec from ignition.

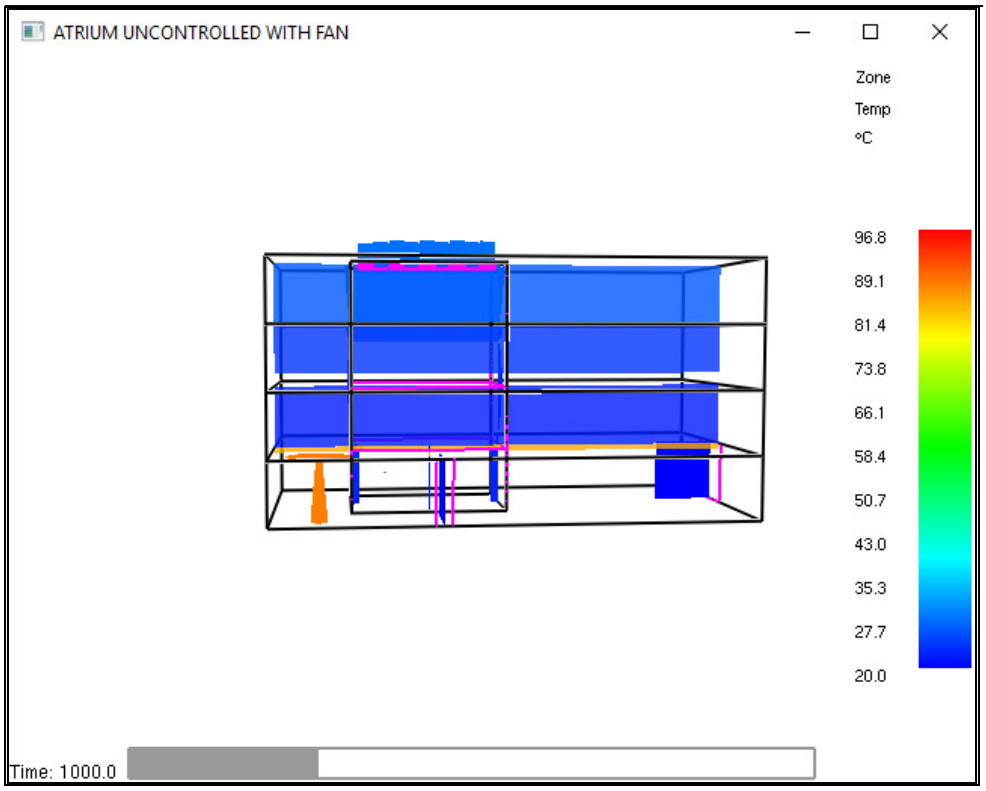


Figure 95 – View of simulated smoke layers at 1000sec from ignition.

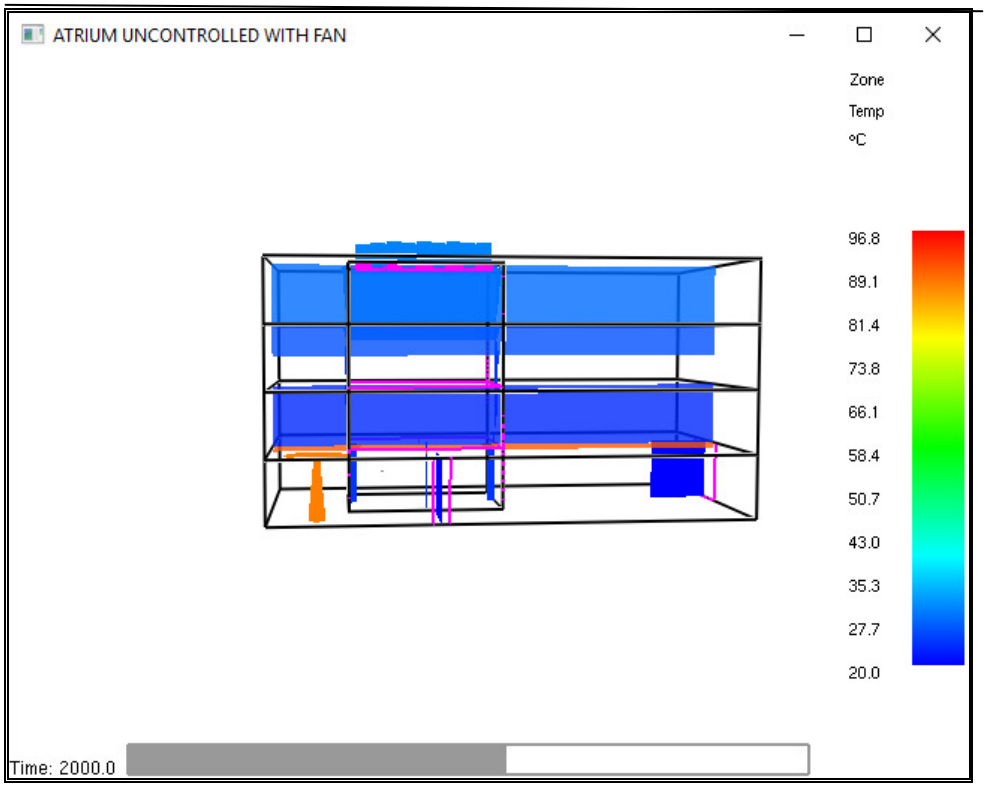


Figure 96 – View of simulated smoke layers at 2000sec from ignition.

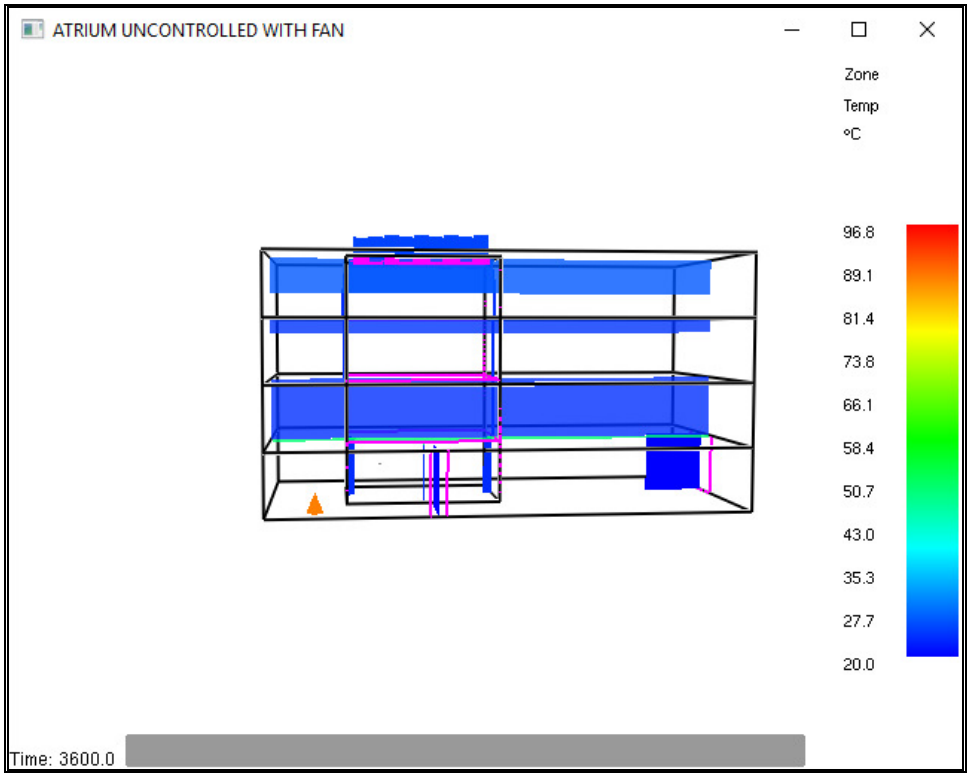


Figure 97 – View of simulated smoke layers at 3600sec from ignition.

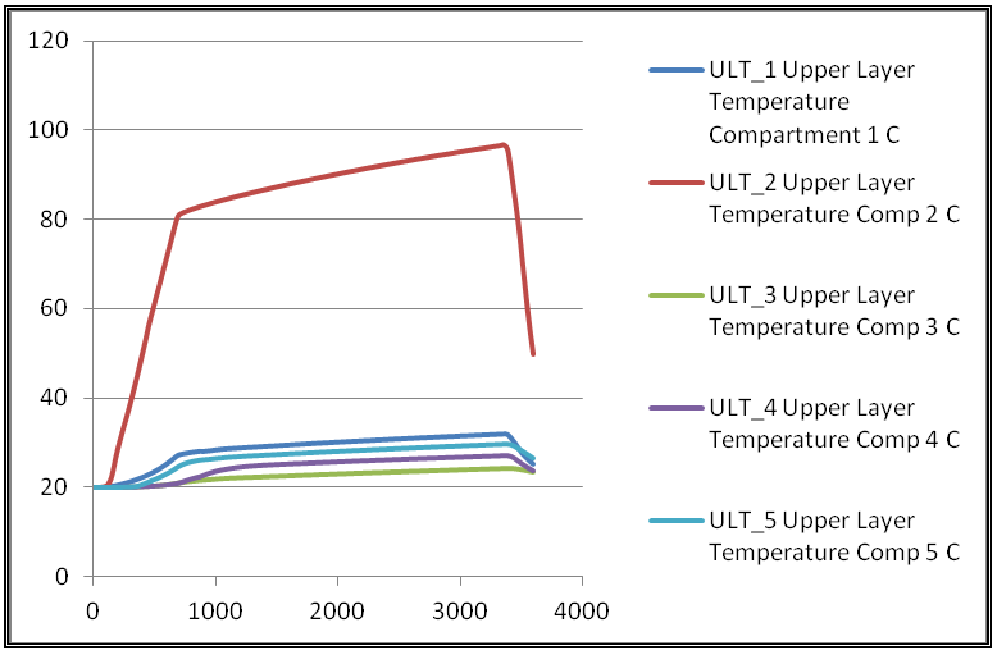


Figure 98 – Temperature history during atrium uncontrolled fire with smoke fans operated, smoke temperature do not reach 100° at ground floor (floor of fire origin), and average smoke temperature of 30° within all upper levels.

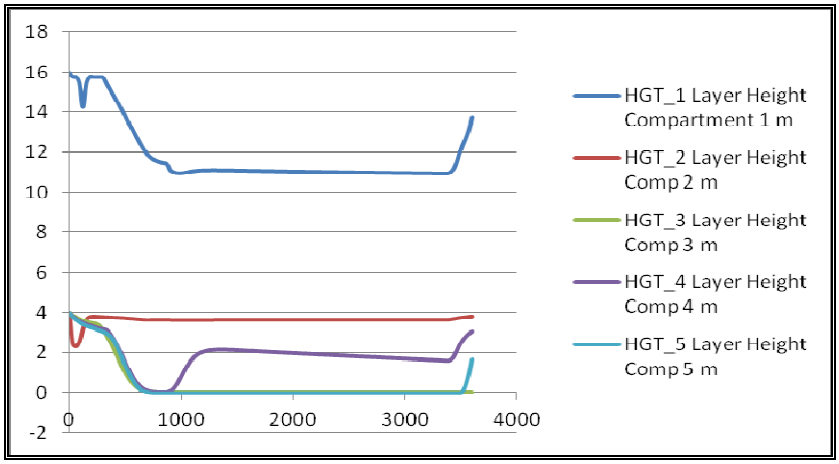


Figure 99 – smoke layer height history during atrium uncontrolled fire with smoke fans operated, smoke layer maintained high level within ground floor, while cold smoke filled upper levels, with only Level 3 smoke layer level maintained at around 2m above floor level after 1000 sec.

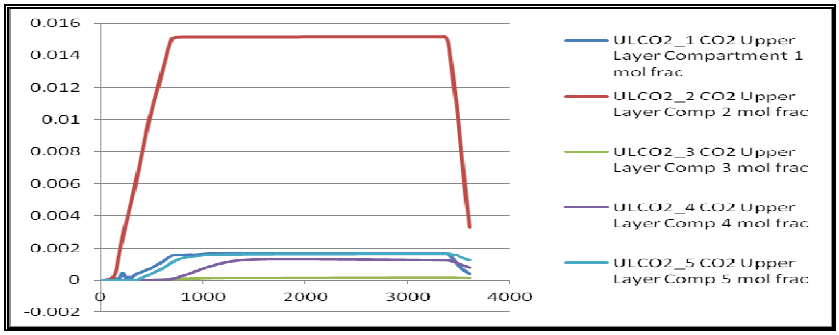


Figure 100 – Carbon Dioxide (CO2) concentration history.

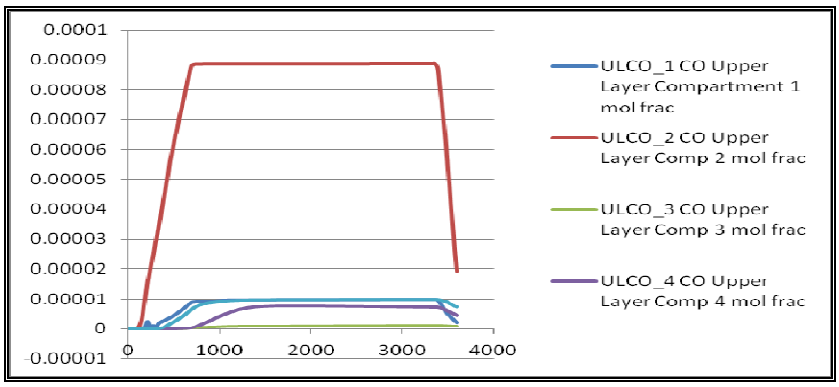


Figure 101 – Carbon Monoxide (CO) concentration history

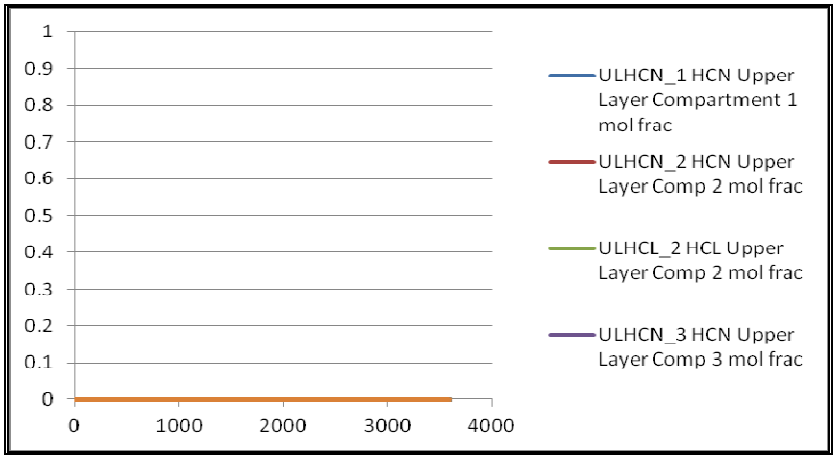


Figure 102 – There is no Hydrogen Cyanide (HCN) produced during fire.

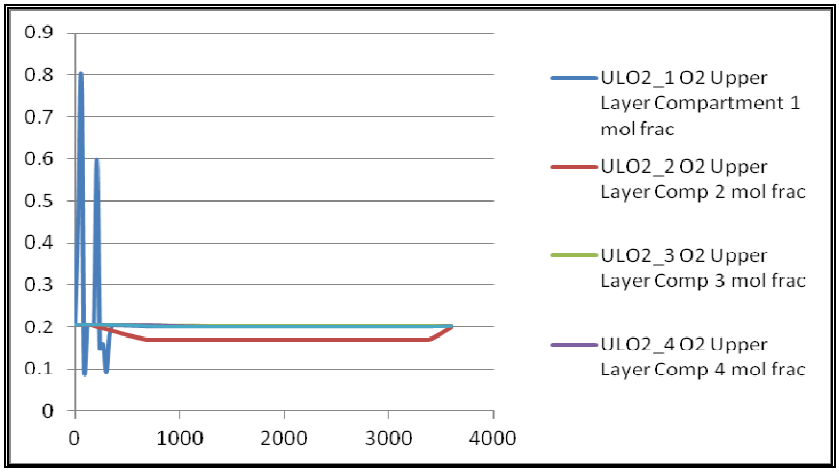


Figure 103 – Oxygen Concentration (O2) history during fire

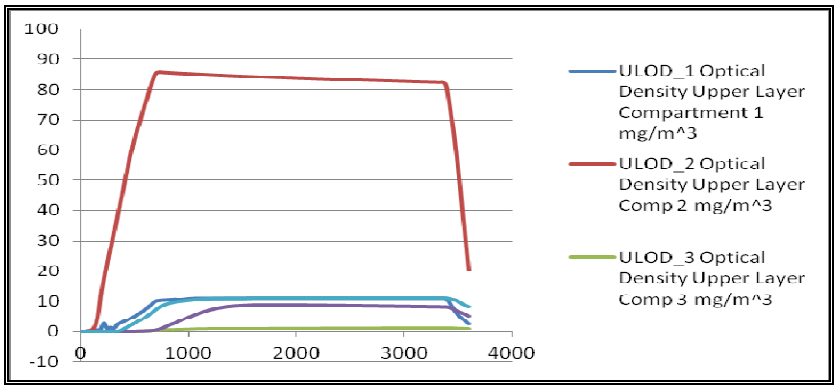


Figure 104 – Optical Density (OD) history during fire

The above simulation shows that during uncontrolled fire scenario with smoke exhaust fans operated, smoke layer maintained high level within ground floor, while cold smoke filled upper levels with average smoke temperature of 30° with only Level 3 smoke layer level maintained at around 2m above floor level after 1000 sec.

Occupants in upper floor might expose to smoke of temperature of 30° for up to 30minute (refer to Section 3.10.1 above, Table 12) and subject to toxicity tenability limits do not arrive, therefore upper level occupant's tenability limits arrive at 30 minute.

Tenability limits for ground floor occupants do not arrive where the smoke layer temperature do not reach 200° at 2.1m above floor level, therefore ground floor tenability limits considered similar to upper floors tenability limits being 30minute.

The toxicity limits from exposure to Carbon Dioxide (CO2), do not arrive, where concentration of less than 2% simulated on all upper levels where occupants might walk through smoke, which is much less than tenability limits acceptance criteria (refer to Section 3.10.1 above, Table 13).

The toxicity limits from exposure to Carbon Monoxide (CO), do not arrive, where concentration of 100ppm simulated on all upper levels where occupants might walk through smoke, which is much less than tenability limits acceptance criteria (refer to Section 3.10.1 above, Table 13).

The simulation shows that there is no Hydrogen Cyanide produced during the simulation.

The Oxygen concentration of 20% in upper levels where occupants might walk through smoke, which is greater than the percentage required for tenability (refer to Section 3.10.1 above, Table 13).

The carbon particles of 10gm/m³ (0.010 gm/m carbon) is simulated in upper levels where occupants might walk through smoke, which is less than the OD limits of 0.1 that is equivalent to 10m visibility.

ASET (Atrium uncontrolled fire scenario with smoke exhaust fans operated) = 30minute.

12.1.6 Fire Scenario # 4B: Ground Floor Atrium - Uncontrolled Fire with Natural Ventilation

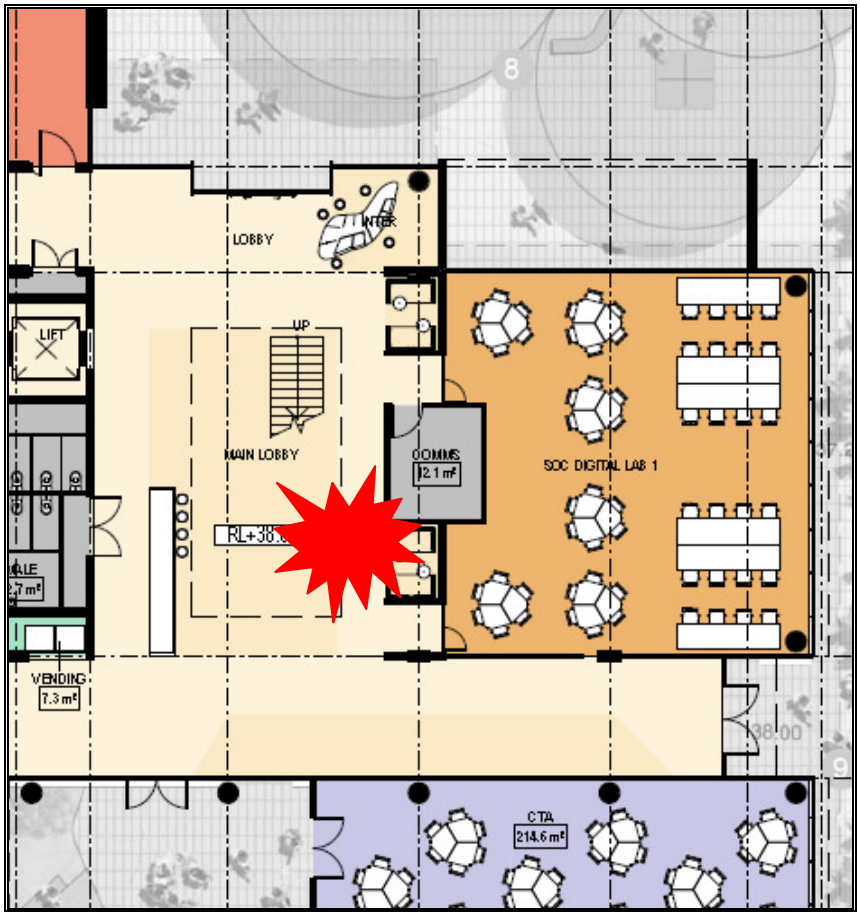


Figure 105 – Uncontrolled fire scenario inside ground floor Atrium.

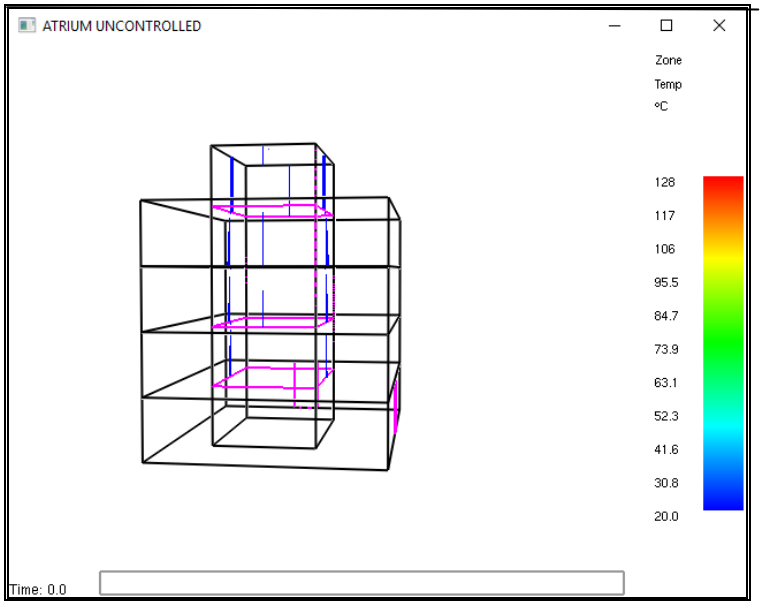


Figure 106 – View of simulated Atrium.

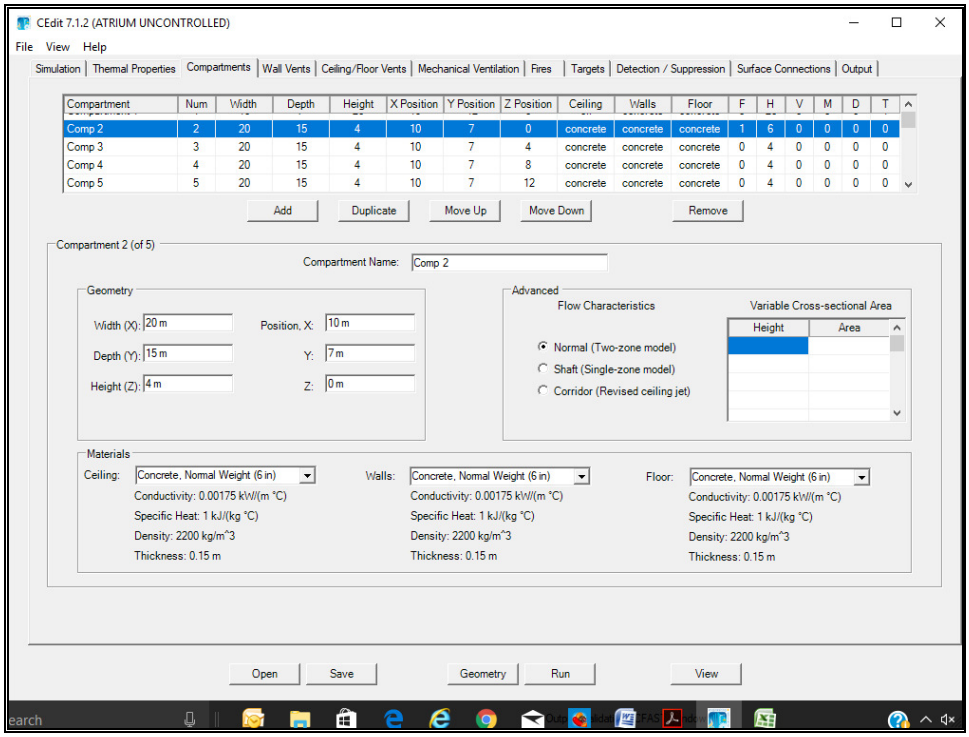


Figure 107 – Compartmentation input for simulation.

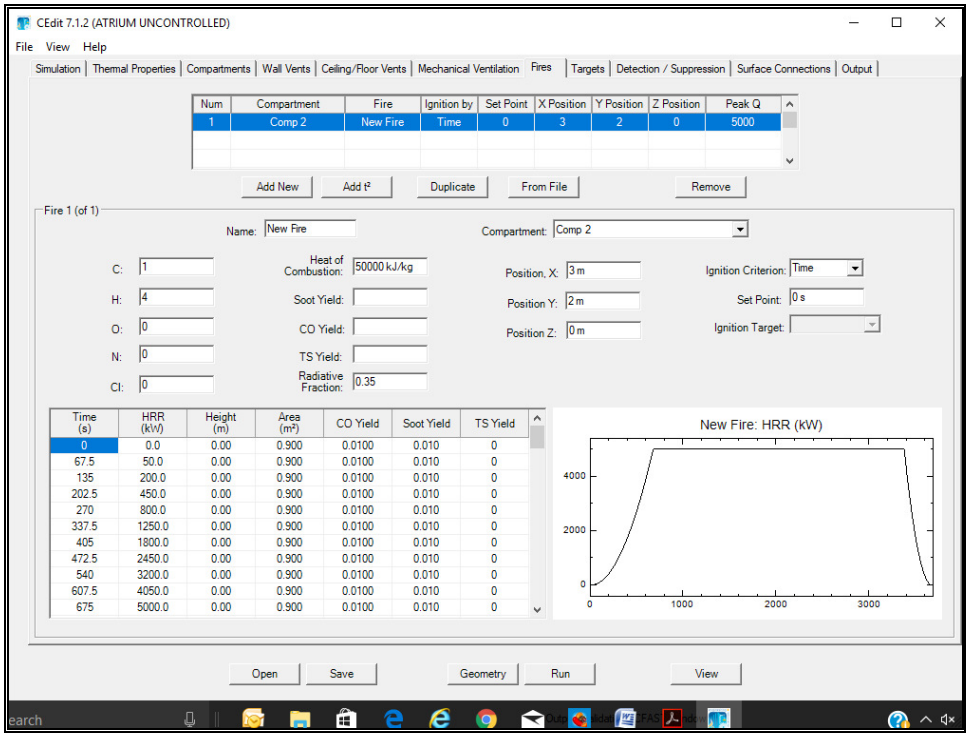


Figure 108 – Simulated 5MW Medium Growth Standard t²-Fire.

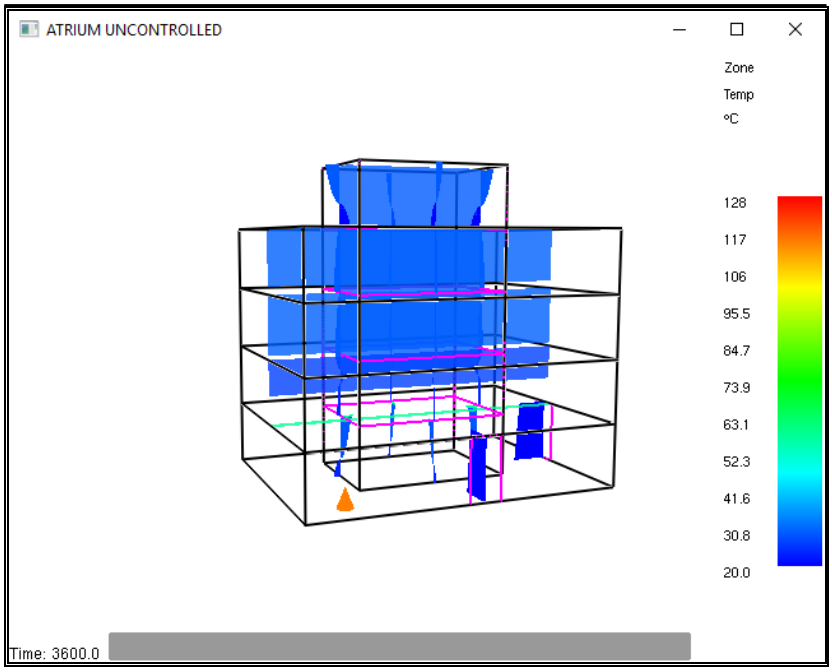


Figure 109 – All upper levels filed with cold smoke during uncontrolled fire scenario.

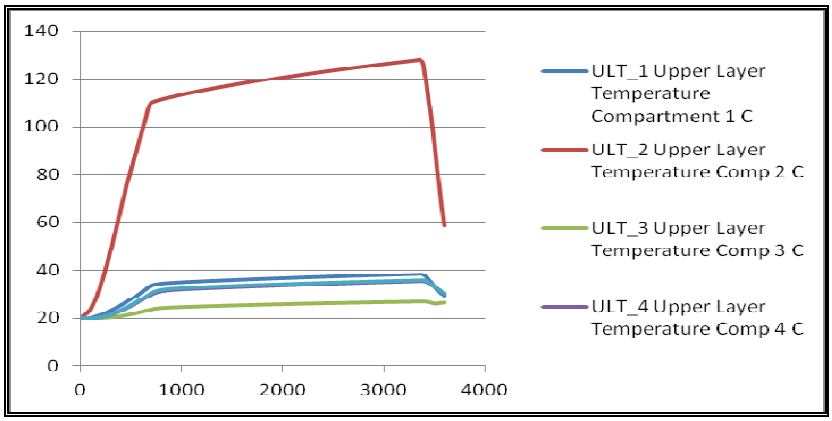


Figure 110 – Smoke temperature history inside the building, all upper floor smoke temperature will not reach 40°, ground floor smoke layer temperature will not reach 130° at high level.

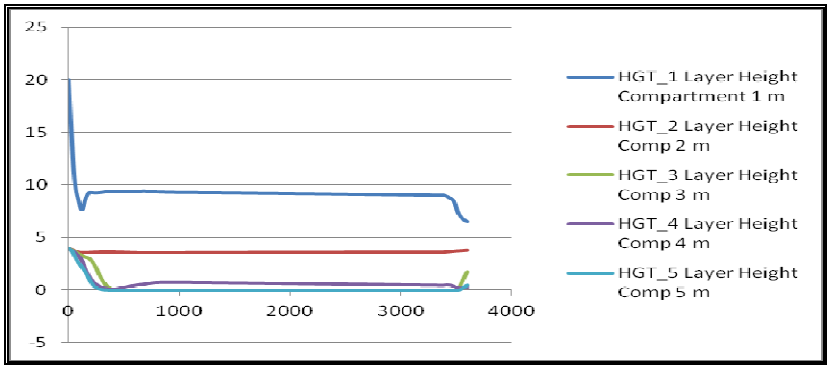


Figure 111 – Smoke level history inside the building, all upper floor filled with smoke with temperature less than 40°, ground floor smoke layer maintained at level higher than 2.1m with temperature less than 130°.

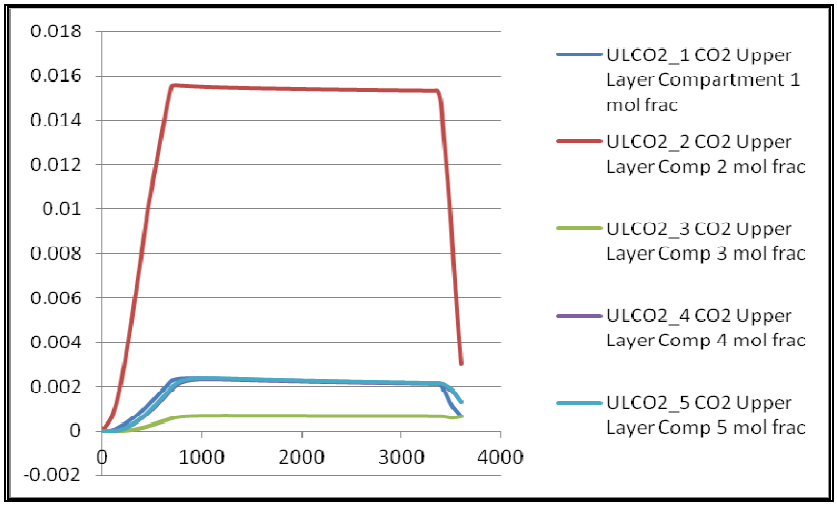


Figure 112 – Carbon Dioxide (CO2) concentration history.

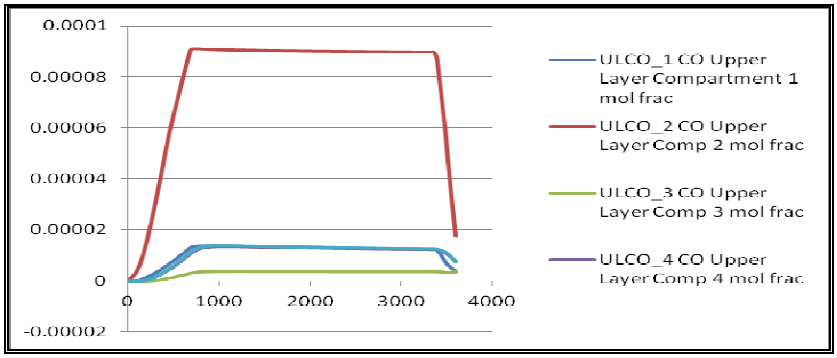


Figure 113 – Carbon Monoxide (CO) concentration history.

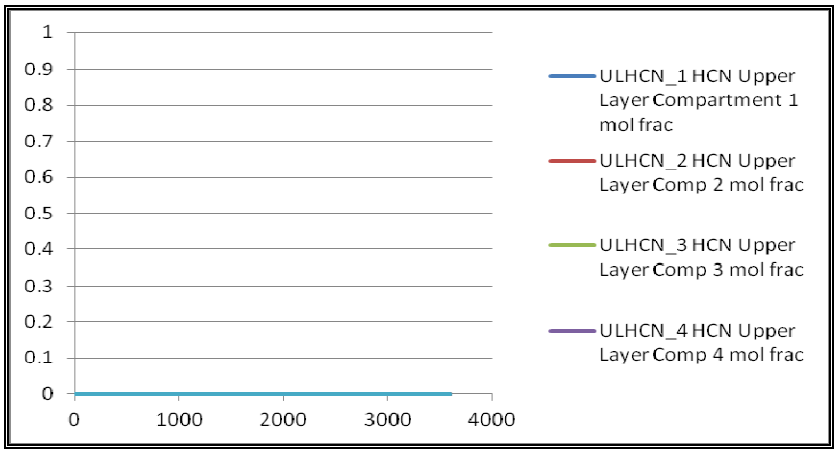


Figure 114 – There is no Hydrogen Cyanide (HCN) produced during fire.

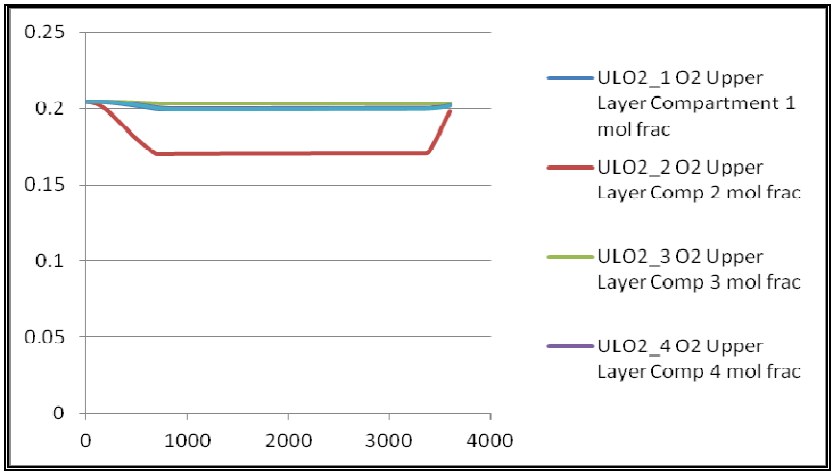


Figure 115 – Oxygen Concentration (O2) history during fire

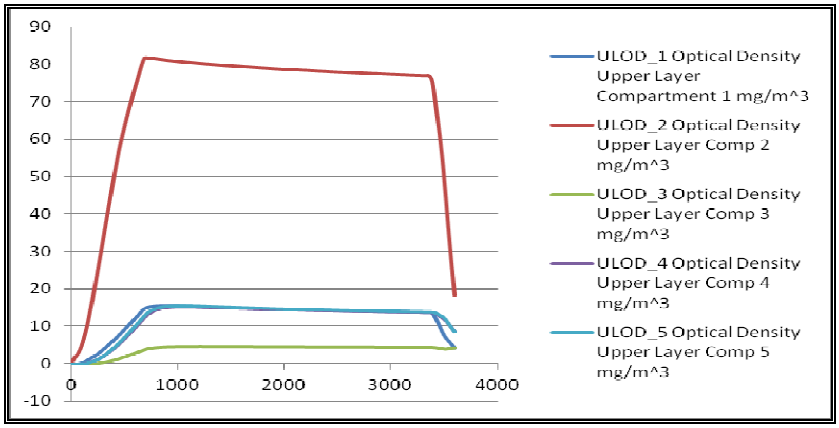


Figure 116 – Optical Density (OD) history during fire

The above simulation shows that during uncontrolled fire scenario; smoke, naturally extracted through the Atrium smoke-and-heat roof vent, however all upper level filled with cold smoke of less than 40° and ground floor smoke layer height maintained at very high level with temperature of less than 200°.

Occupants in upper floor might expose to smoke of temperature of 60° for up to 30minute (refer to Section 3.10.1 above, Table 12) and subject to toxicity tenability limits do not arrive, therefore upper level occupant's tenability limits arrive at 30 minute.

Tenability limits for ground floor occupants do not arrive where the smoke layer temperature do not reach 200° at 2.1m above floor level, therefore ground floor tenability limits considered similar to upper floors tenability limits being 30minute.

The toxicity limits from exposure to Carbon Dioxide (CO2), do not arrive, where concentration of 2% simulated on all upper levels where occupants might walk through smoke, which is much less than tenability limits acceptance criteria (refer to Section 3.10.1 above, Table 13).

The toxicity limits from exposure to Carbon Monoxide (CO), do not arrive, where concentration of 150ppm simulated on all upper levels where occupants might walk through smoke, which is much less than tenability limits acceptance criteria (refer to Section 3.10.1 above, Table 13).

The simulation shows that there is no Hydrogen Cyanide produced during the simulation.

The Oxygen concentration of 20% in upper levels where occupants might walk through smoke, which is greater than the percentage required for tenability (refer to Section 3.10.1 above, Table 13).

The carbon particles of 15gm/m³ (0.015 gm/m carbon) is simulated in upper levels where occupants might walk through smoke, which is less than the OD limits of 0.1 that is equivalent to 10m visibility.

ASET (Atrium uncontrolled fire scenario with natural ventilation) = 30minute.

12.1.7 Fire Scenario # 5: Eastern Wing Level 1 - Uncontrolled Fire (Sprinkler Failure)

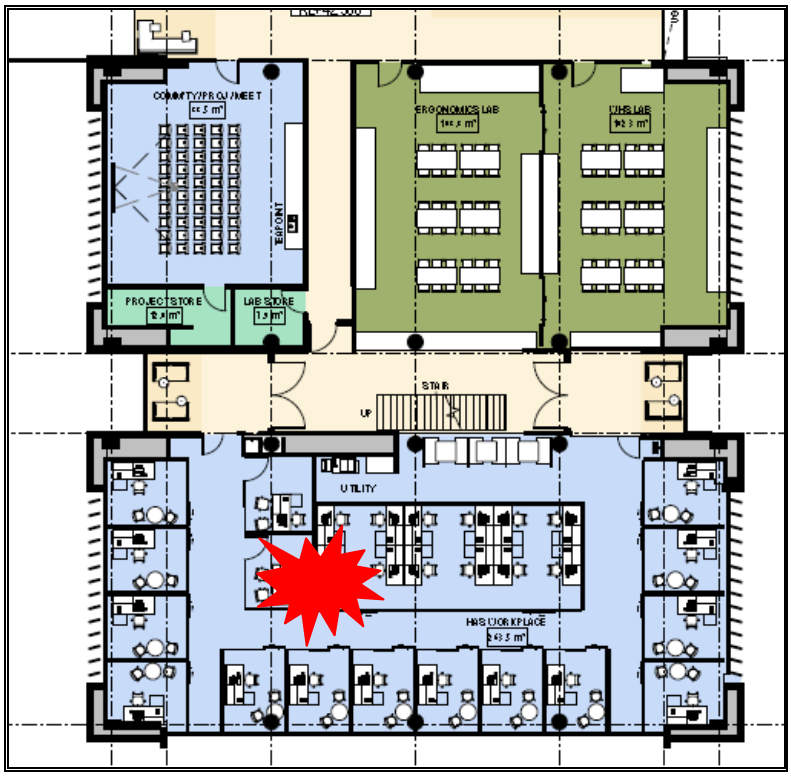


Figure 117 – Uncontrolled fire scenario inside Level 1 Eastern fire compartment.

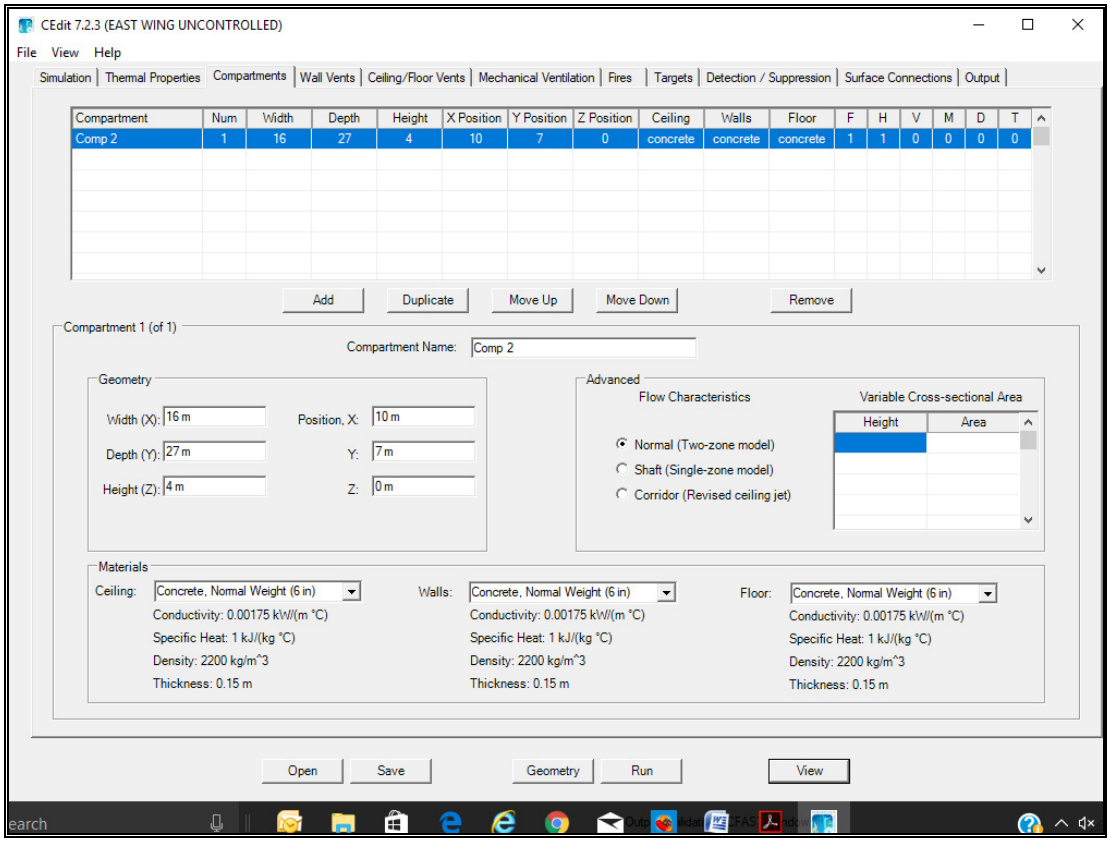


Figure 118 – Simulated Level 1 Eastern fire compartment.

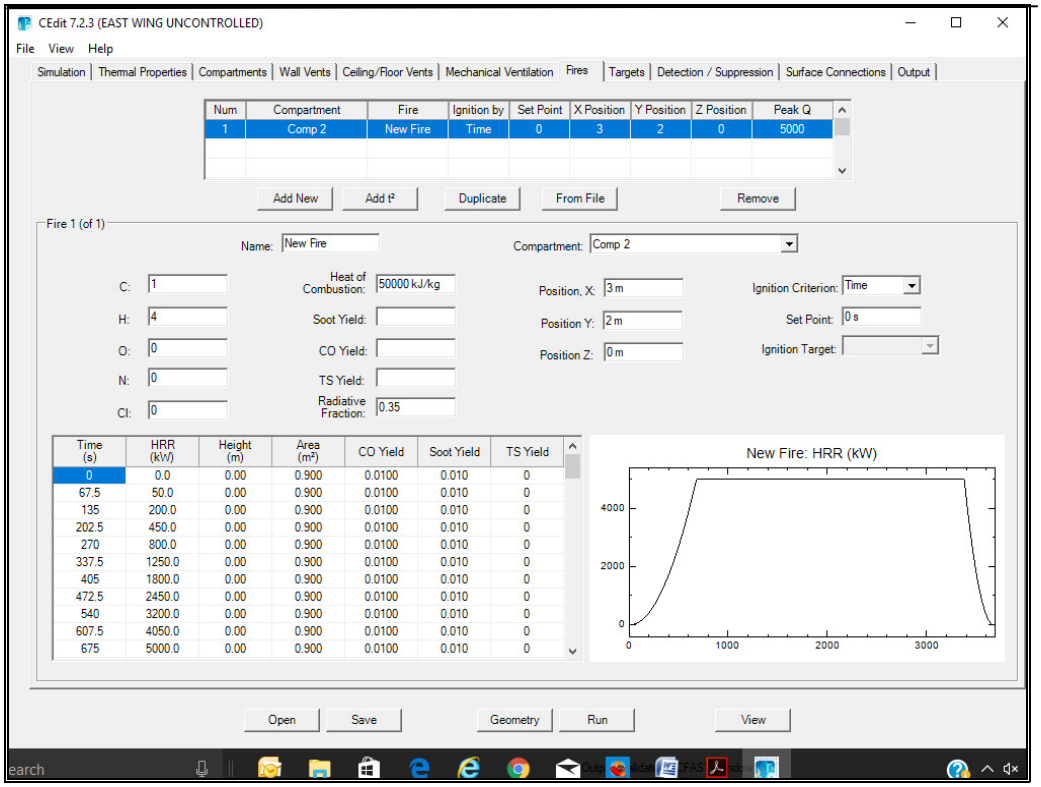


Figure 119 – Simulated 5MW Standard Medium Fire inside Level 1 Eastern fire compartment.

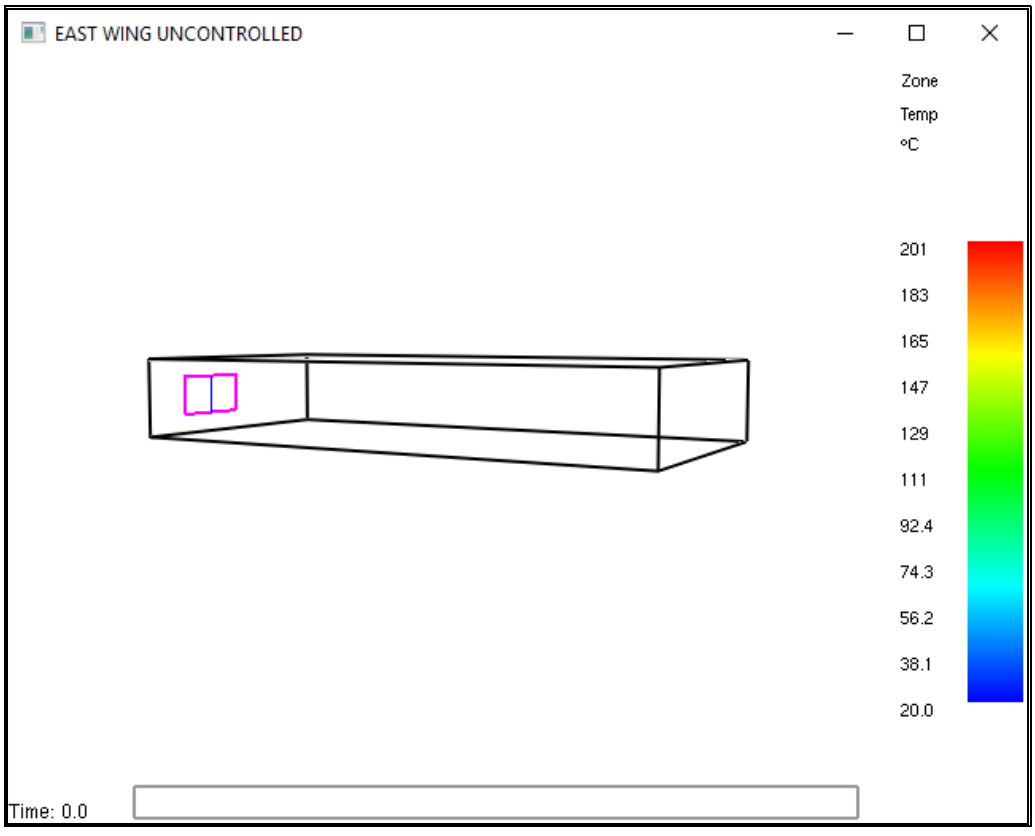


Figure 120 – Simulated smoke view for fire inside Level 1 Eastern fire compartment.

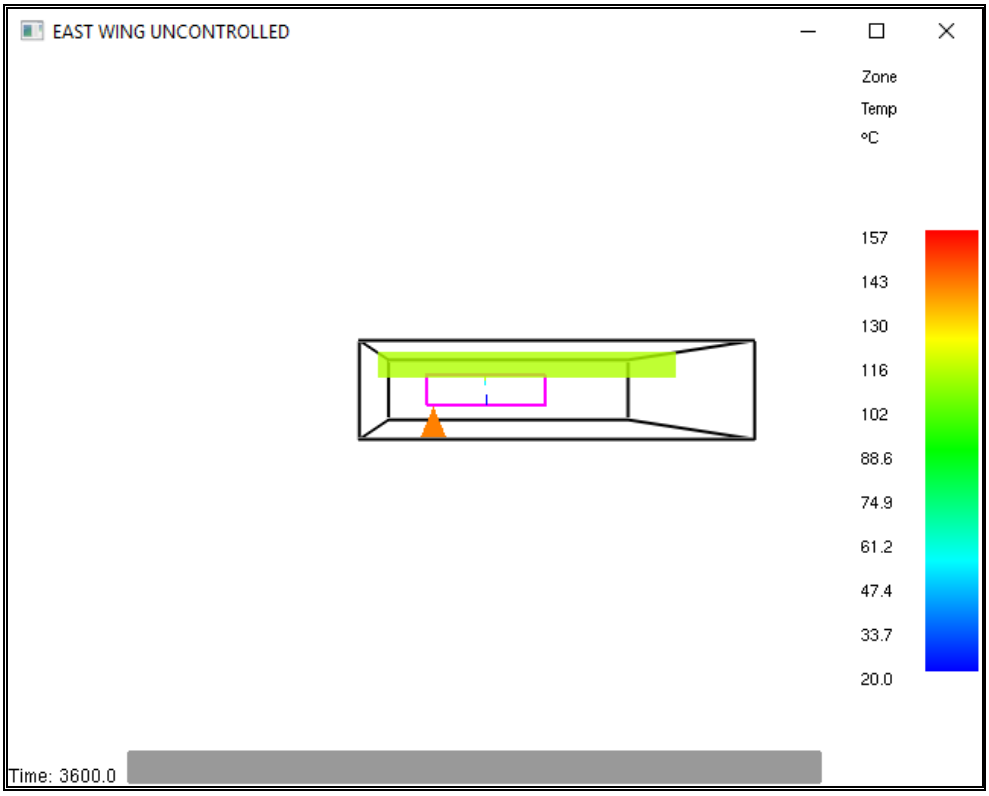


Figure 121 – Smoke view inside East Wing at 3600sec.

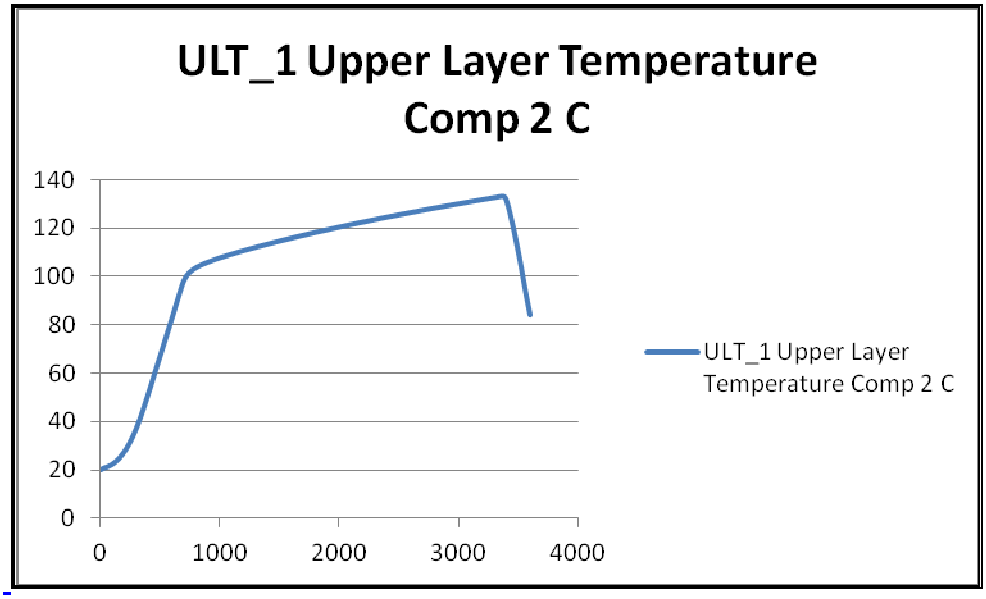


Figure 122 – Smoke temperature history.

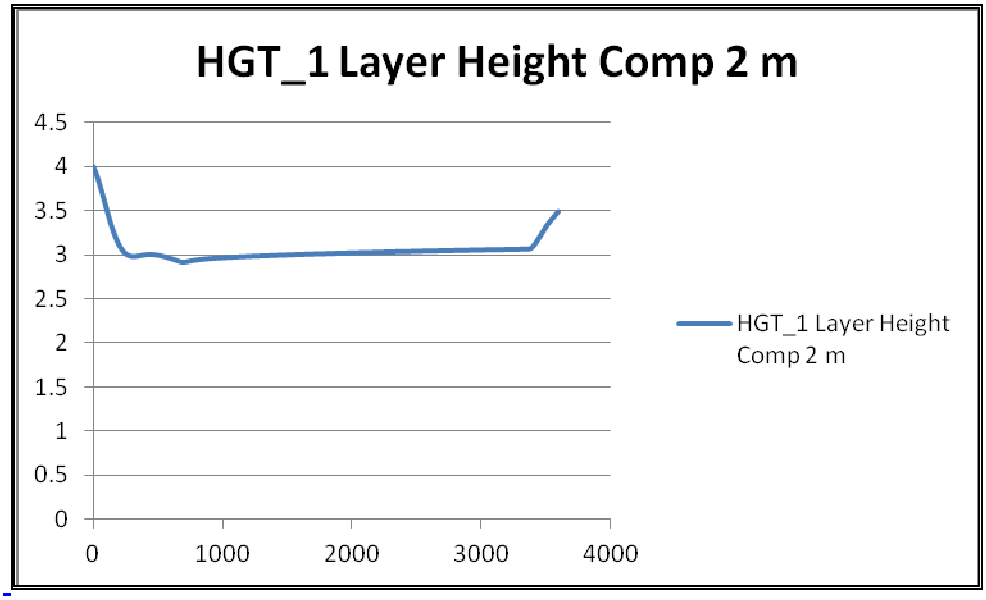


Figure 123 – Smoke height history.

Tenability limits do not arrive with smoke layer do not reach 200° at level higher than 2.1m above floor level
ASET (East Wing Uncontrolled Fire) = 3600sec.

12.1.8 Fire Scenario # 6: North Wing Level 2 - Uncontrolled Fire (Sprinkler Failure)

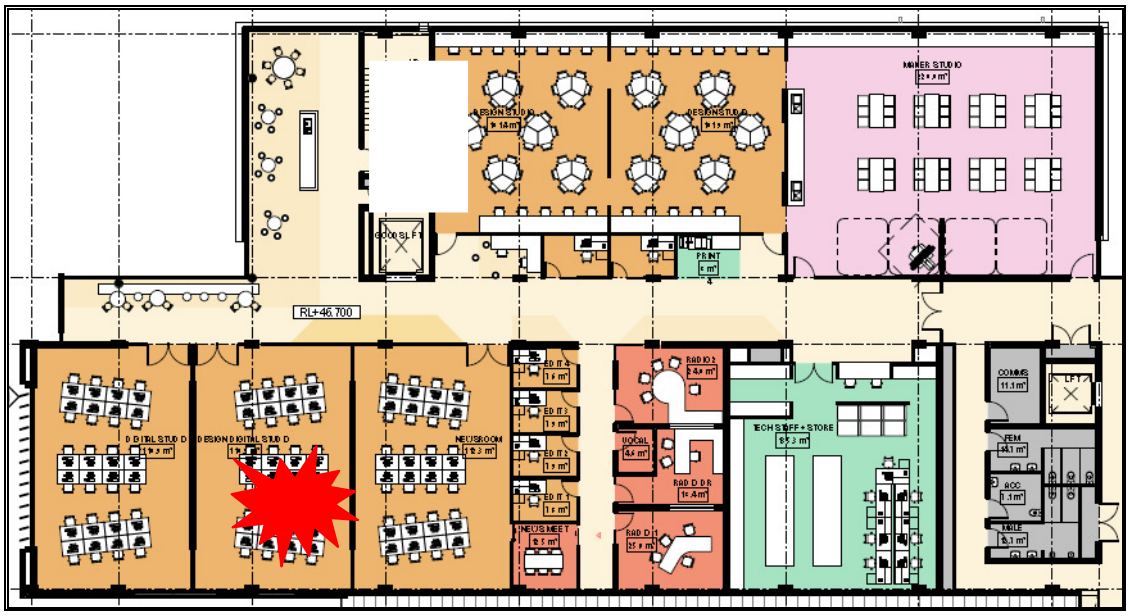


Figure 124 – Uncontrolled fire scenario inside Level 2 North fire compartment.

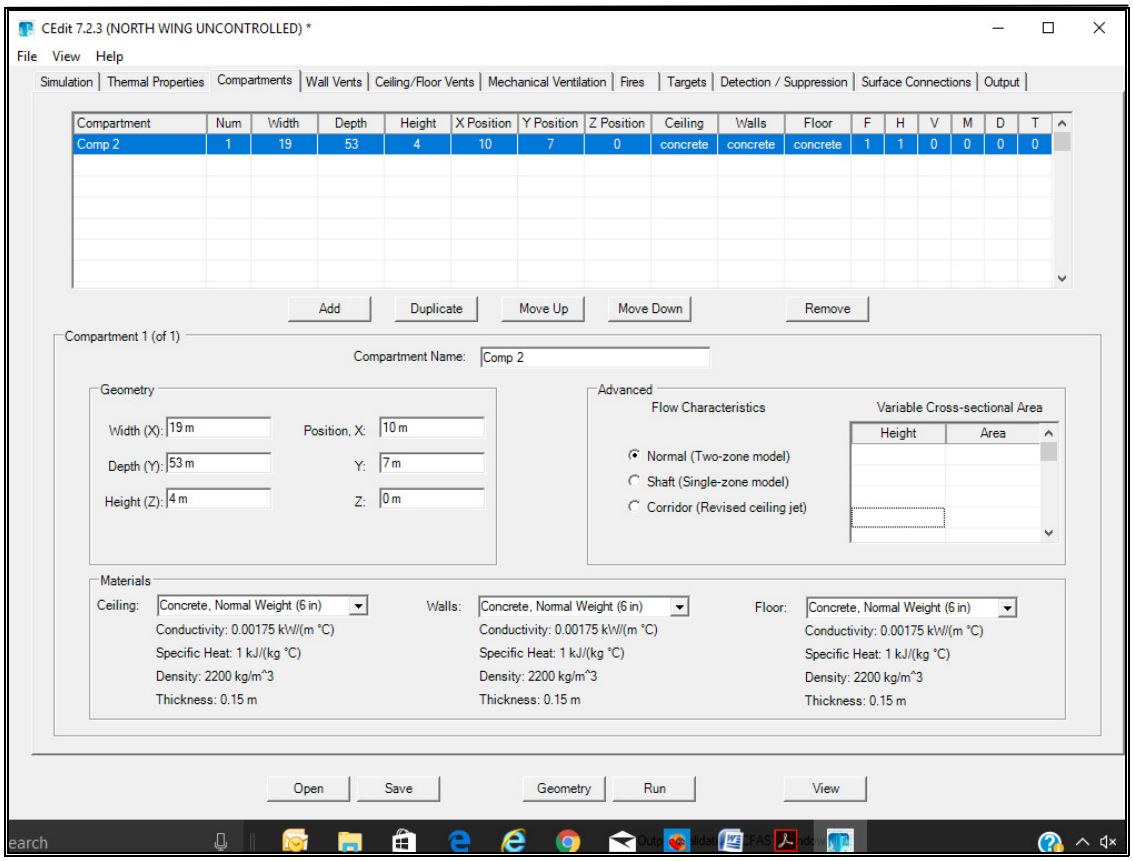


Figure 125 – Simulated Level 2 North fire compartment.

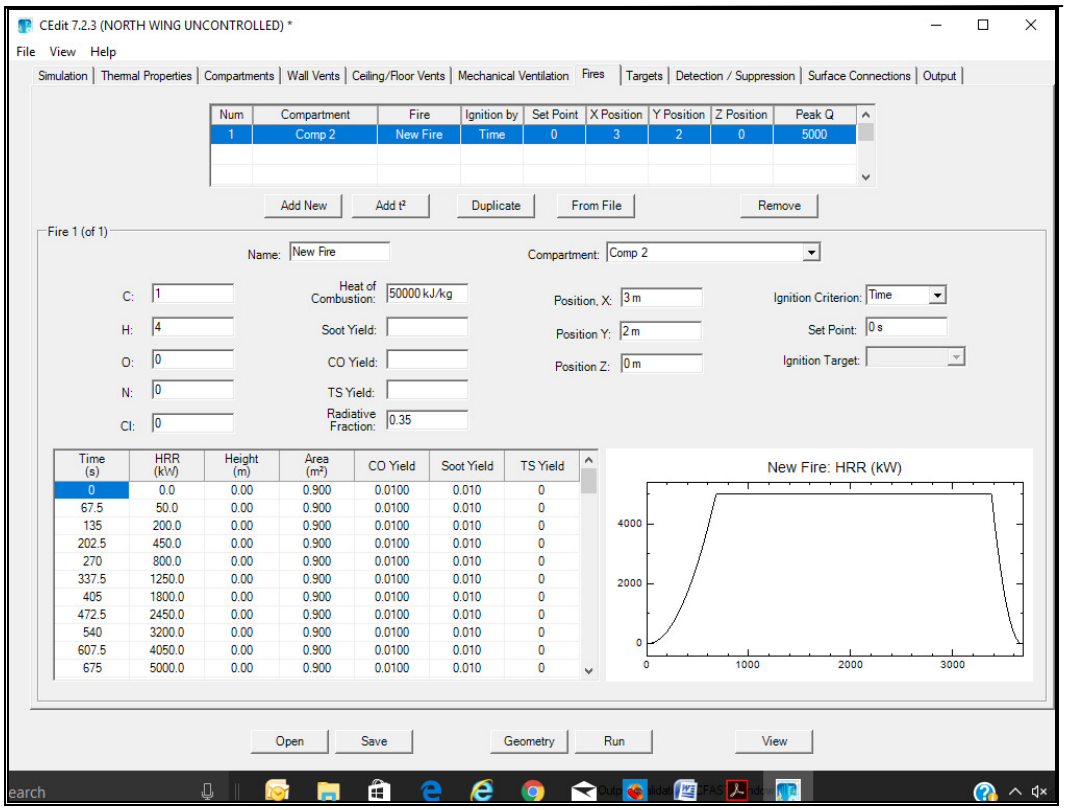


Figure 126 – Simulated 5MW Standard Medium Fire inside Level 2 North fire compartment.

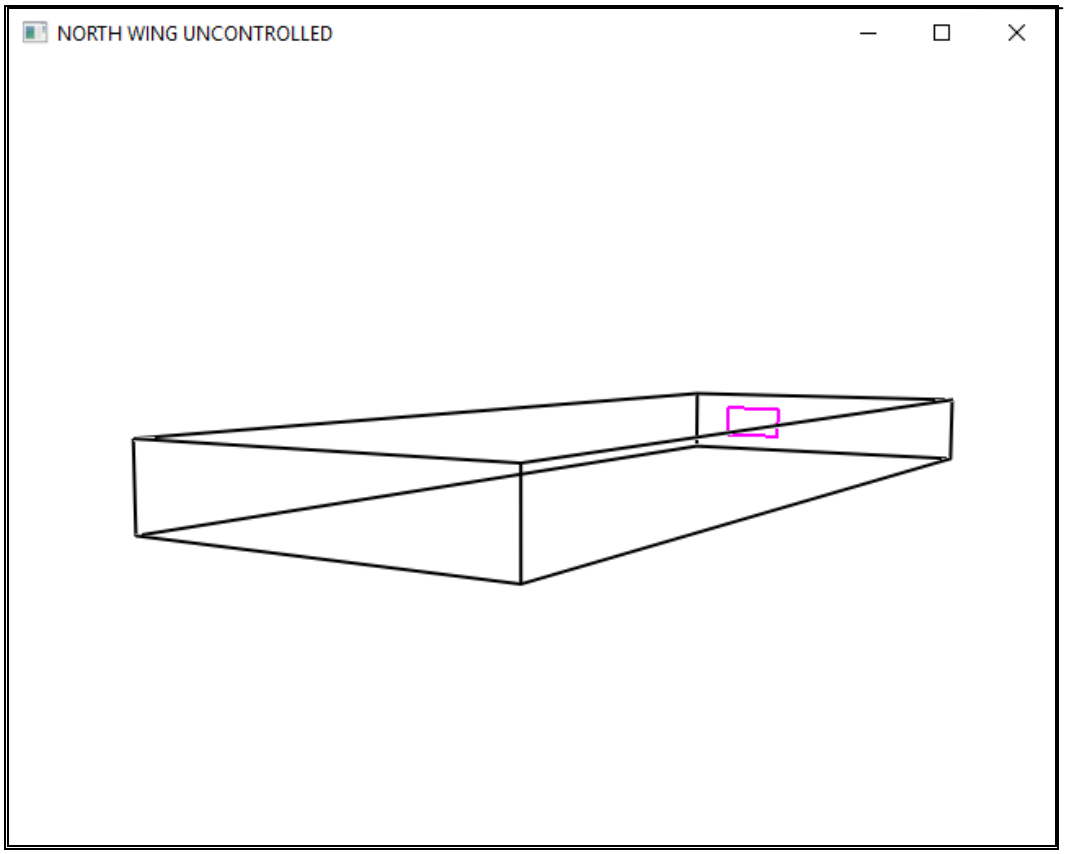


Figure 127 – Simulated smoke view for fire inside Level 2 North fire compartment.

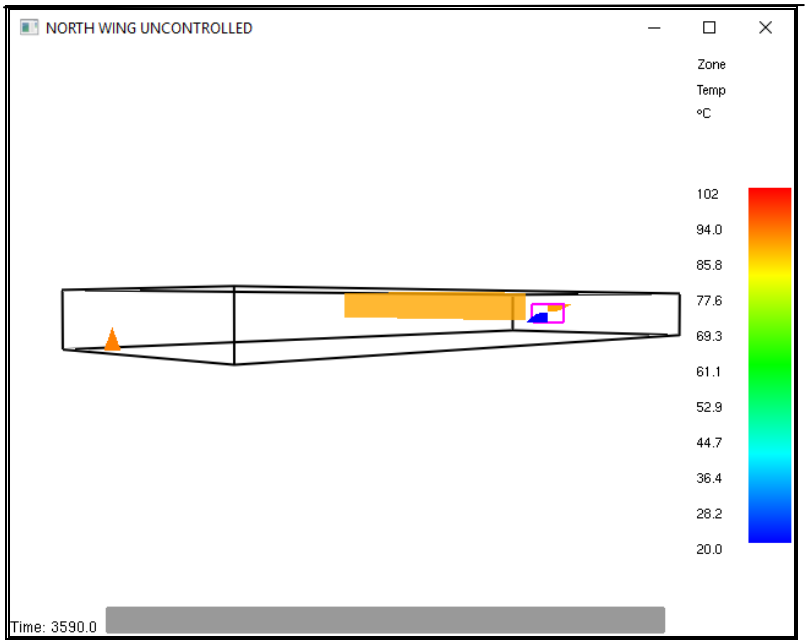


Figure 128 – Smoke view inside North Wing.

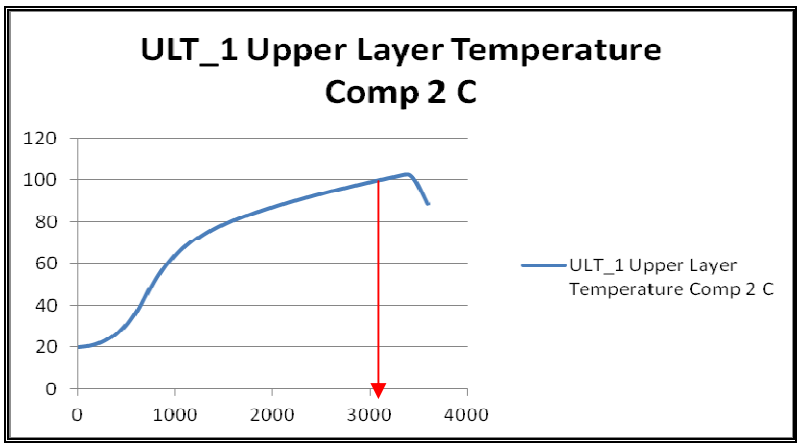


Figure 129 – Smoke temperature history.

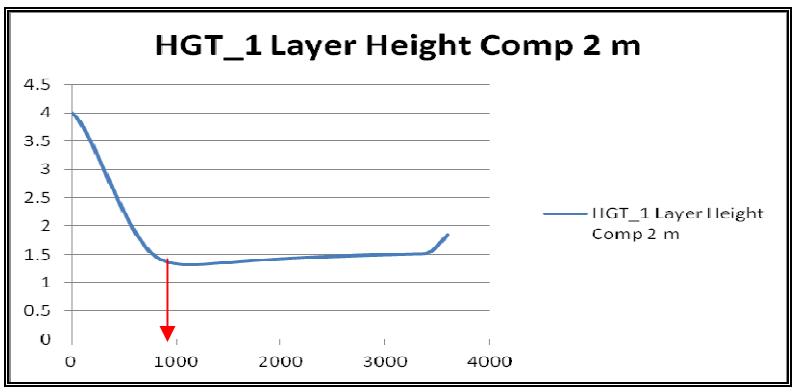


Figure 130 – Smoke temperature history.

Tenability limits arrive with smoke layer reaches 100° at less than 2.1m above floor level
ASET (East Wing Uncontrolled Fire) = 3000sec = 50minute.

Table 33 – Summary ASET.

FIRE SCENARIO.	ASET (sec).
# 1A: Atrium sprinklers activated and smoke exhaust fan activated (100m³/sec).	3600.
# 1B: Atrium sprinkler activated and natural smoke ventilation (4 sides 4m height).	3600.
# 2: Eastern Wing - Sprinkler activated.	3600.
# 3: North Wing - Sprinkler activated.	3600.
# 4A: Atrium **sprinkler failure** and smoke exhaust fan activated (100m³/sec).	1800.
# 4B: Atrium **sprinkler failure** and natural smoke ventilation (4 sides 4m height).	1800.
# 5: Eastern Wing **sprinkler failure**.	3600.
# 6: North Wing **sprinkler failure**.	3000.

APPENDIX D: EMERGENCY EVACUATION ANALYSIS

The occupant Required Safe Evacuation Time (RSET) is the time that all occupants need to evacuate the building to outside, and consists of the following components:

- Detection time.
- Pre-movement time.
- Movement time.

Detection Time

Occupant detection and awareness of fire via alarm activated by automatic smoke detection,

- Detection time = Automatic Alarm Activation Time + Alarm Verification Delay Time
  = 246sec + 60sec = 306sec.

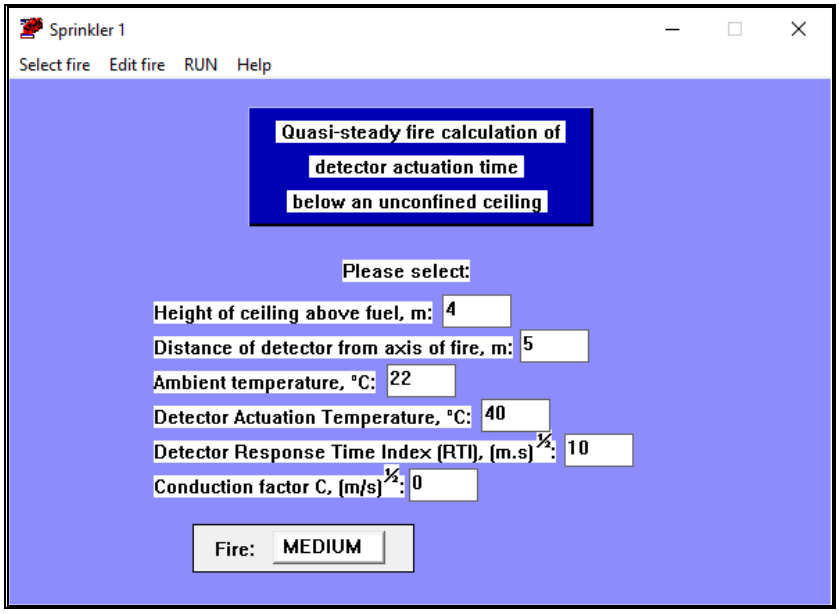


Figure 131 – Simulated smoke detector in ground level that has highest ceiling of 4m.

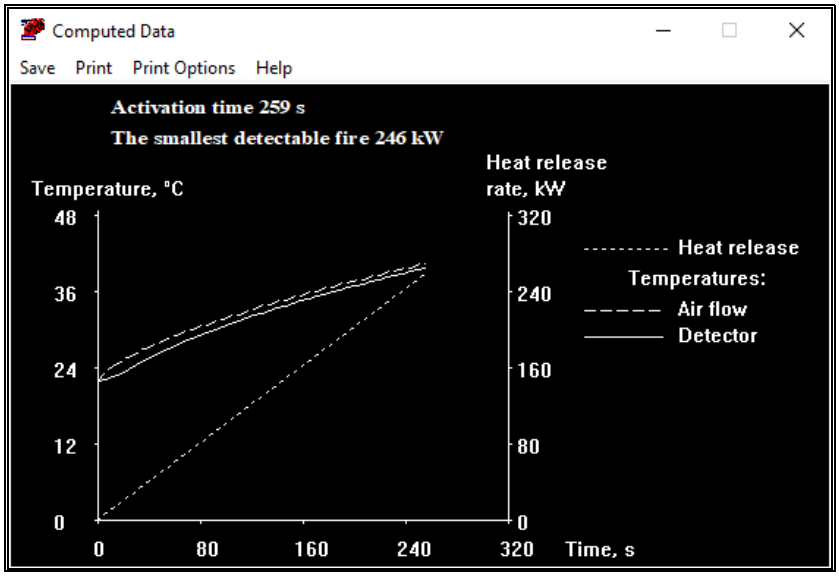


Figure 132 – Smoke detector simulated to activate at 246sec.

Pre-movement Time

For occupant inside room of fire origin a very short pre-movement time is likely due to clear olfactory and visual fire cue.

For occupants away from the room of fire origin, SFPE Handbook, Third Edition, Section 3 Chapter 13-Movement of People Table 3-13.1 recommends 180 sec (3 minutes) for pre-movement for occupants away from room of fire origin when an automatic cue is provided (Occupants Warning System).

- Pre-movement time =180sec.

Movement Time

With proposed fire compartmentation, during emergency occupants moving to adjacent fire compartment or nearest fire-isolated stairway are protected from fire for 2 hours where occupants considered to be reached a safe place. The horizontal exits between fire compartments will reduce the exit travel distances.

For subject assembly building with crowd population; movement time is governed by the time required for occupants to pass through exits doorway rather than travelling time to exits.

The movement time is based on average walking speed of 1m/sec and doorway flow rate 1.3person/sec.

Despite that the horizontal exits between fire compartments will reduce the exit travel distances; Walking distance to fire-isolated exit stairs or adjacent fire compartment is considered 60m, therefore travelling time for a person at the furthest point from fire-isolated stairs or adjacent fire compartment on upper levels level is 60sec.

The following figures show that minimum of 2 exits are available away from fire affected area. As a conservative approach 2/3 of occupants considered to use one exit and 1/3 will use the other exit. Stairway width of 1.4m is used for life safety assessment and emergency evacuation

As a conservative approach, travelling distance on stairs flights and landing considered double the effective vertical height of each level with reduced travel speed down stairs of 0.5m/sec in account for delay due to crowd population.

12.1.9 Emergency Movement Analysis for Each Fire Scenario

Ground floor occupants, during all fire scenarios, have several alternative exits leads directly to outside the building.

Upper levels occupants, within compartment of fire origin, will move away from the smoke to adjacent fire compartment or to nearest fire-isolated stairway, as analysed with the following figures.

Upper levels occupants, away from compartment of fire origin, will move away from the smoke to nearest fire-isolated stairway serving their fire compartment, as analysed with the following figures.

12.1.10 Upper Levels Movement during Fire Scenarios

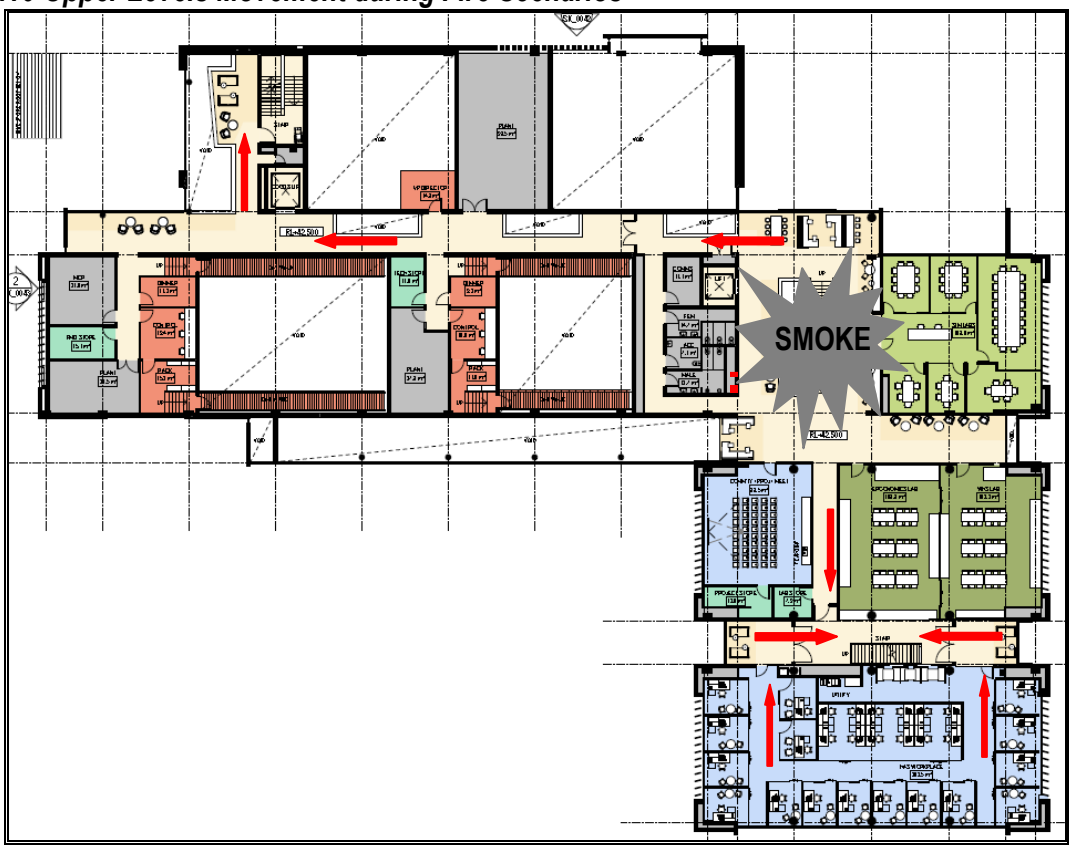


Figure 133 – Occupant's movement during atrium fire.

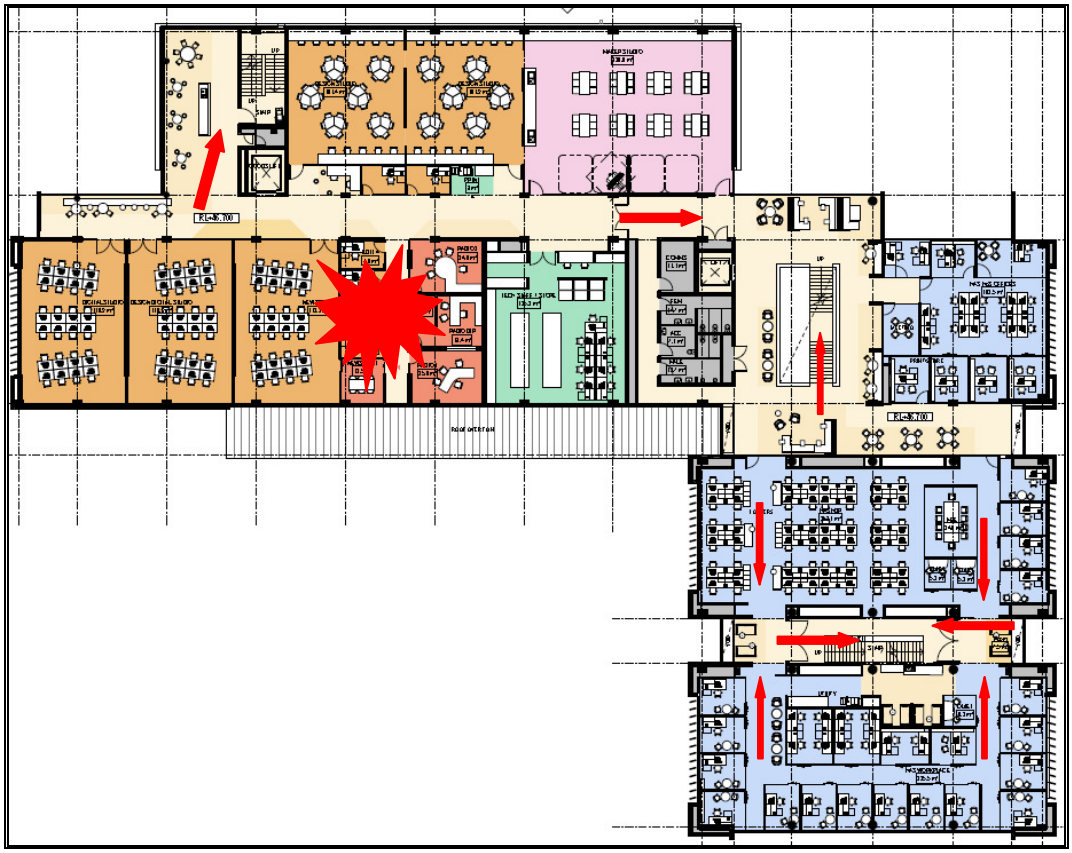


Figure 134 – Occupant's movement during north wing fire.

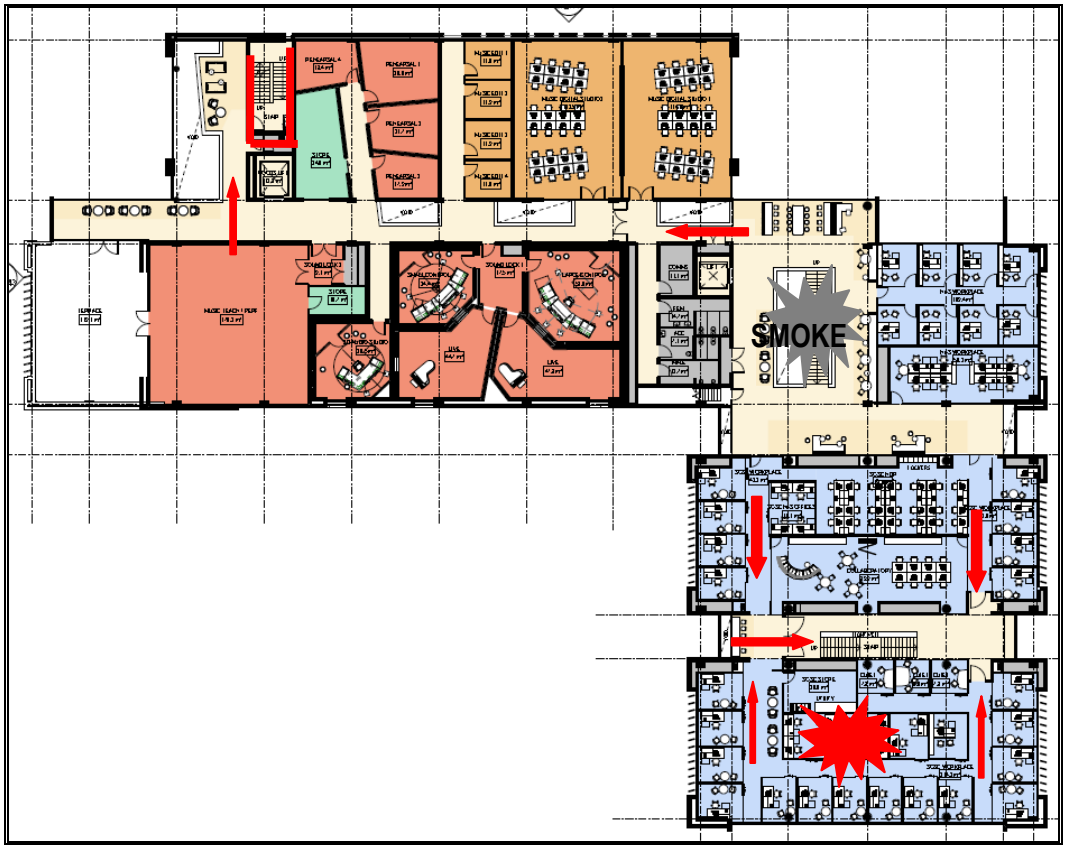


Figure 135 – Occupant's movement during east wing fire.

Table 34- Summary Movement Time Calculations

Level	Occupants #	Walking Time.	Through Door.	On stairs	Total
Ground.	200 people.	60sec.	200 (2/3)/1.3/2m = 52sec.	-	112sec.
Level 1.	200 People.	60sec.	200 (2/3)/1.3/1.4m = 74sec.	16sec	150sec.
Level 2.	200 People.	60sec.	200 (2/3)/1.3/1.4m = 74sec.	32sec.	166sec.
Level 3.	200 People.	60sec.	200 (2/3)/1.3/1.4m = 74sec.	48sec.	182sec.
Level 4.	31 People.	60sec.	31 (2/3)/1.3/1.4m = 12sec.	64sec.	136sec.

The above table shows that Level 3 has longest movement time.

- Movement time = 182sec.

Total emergency evacuation time (RSET) = 306sec + 180sec + 182sec = 668sec.
= 11.1 minute

It should be noted that the above emergency evacuation calculations are very conservative, where movement time is calculated to outside the building while occupants are in safe place once they moved from fire affected area to adjacent fire compartment or to nearest fire-isolated stair.

Also conservative approach is used where 2/3 of the occupant number are assumed to pass through one exit with other 1/3 passing through the other door.

APPENDIX E: FIRE BRIGADE INTERVENTION MODEL (RSIT)

Location of Subject Building

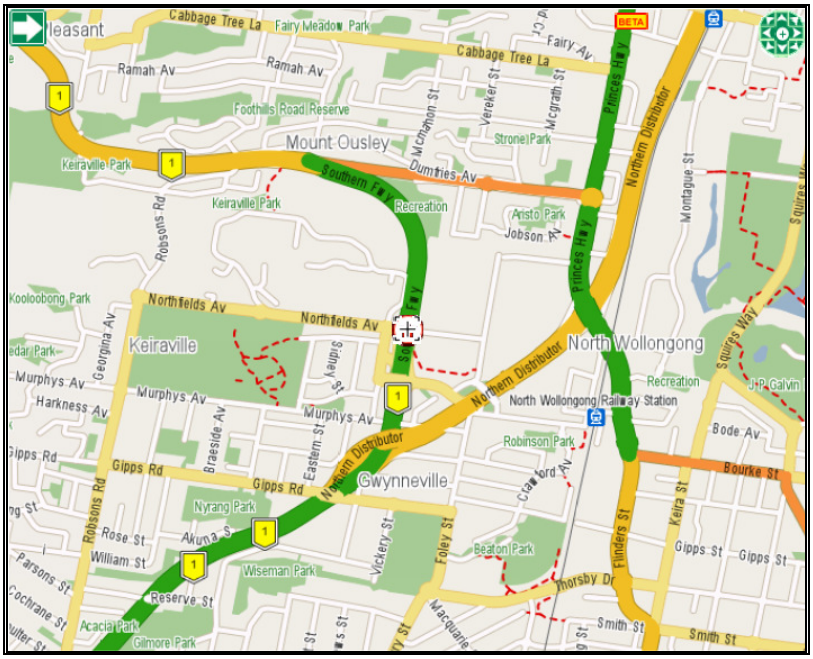


Figure 136 – Location of Subject Building.

Fire Stations close by Subject Location

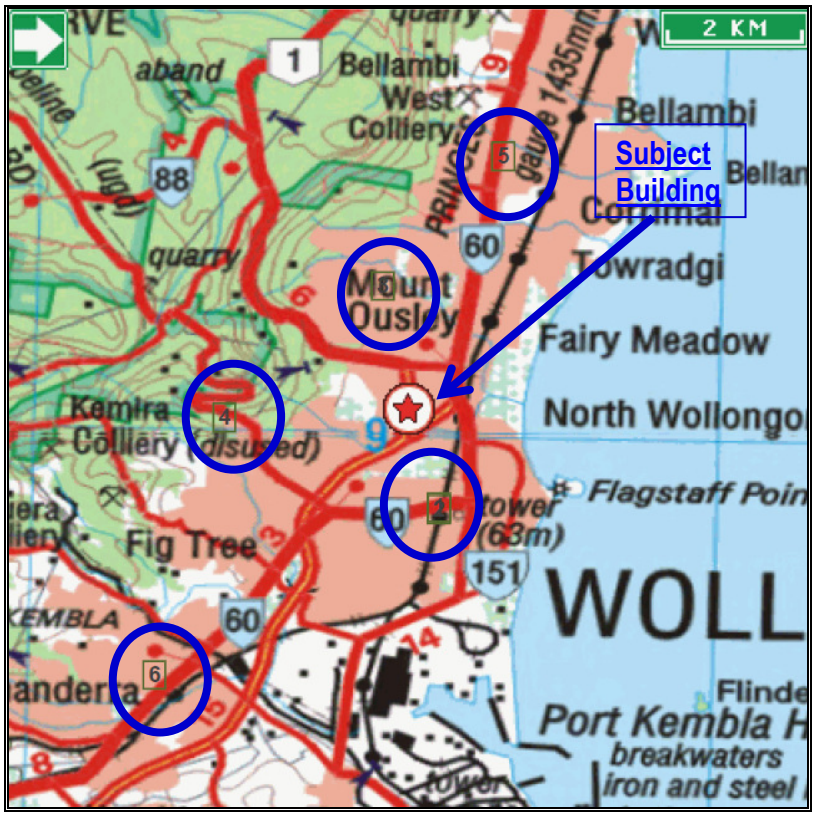


Figure 137 – Fire Stations within 6km from subject building.

Table 35 – Location and Radial Distance of Fire Stations within 6km from subject building

Fire Station	Address	Radial Distance
Wollongong	32-36 Denison Street, Wollongong NSW 2500	1.81 km
West Wollongong	**Wollongong NSW 2500**	**1.84 km**
Balgownie Fire Station	117 Balgownie Road, Balgownie NSW 2519	2.22 km
Mt Keira	Mount Keira NSW 2500	2.70 km
Corrimal Fire Station	124 Princes Highway, Corrimal NSW 2518	4.65 km
Unanderra Fire Station	80 Central Road, Unanderra NSW 2526	5.98 km

FBIM Calculations

Fire Brigade Intervention Model: University Of Wollongong			
Activity (module)	**Ref**	**Factor**	
Detection		80	s
Chart 1-Time taken for initial Brigade notification			
Automatic Smoke detection	**Yes**		s
Suppression system	**Yes**		s
Alarm verification delay	Table B	90	s
Automatic connection to Fire Brigade	Yes		
(Time to transmit information to fire brigade)		**170**	**sec**
Chart 2-Time taken to dispatch resources			
Call electric	Yes		
Call taken at central communications	Yes		
Time to relay dispatch information by phone or radio	Table D	0	s
Time for fire fighters to respond to call and	Chart 3	0	s
Time to respond		**0**	s
Chart 3-Time taken for fire fighters to respond to dispatch call			
Station manned full time	**Yes**		
Fire fighters in the fire station	**Yes**		
Percentile response time to be used	**No**		
Turnout from fire station	**Yes**		
Radial distance to fire station (West Wollongong Fire Station)	**km**	**0**	
Design Speed	**km/hr**	**0**	
Travel Time (West Wollongong Fire Station)		**0**	**sec**
Time to dress, assimilate information and leave station	Table E	90	s
Time to respond & depart fire station		**90**	s
Chart 4-Time taken to reach fire scene(kerb side)			
Percentile response time to be used	No		
Turnout from fire station	Yes		
Radial distance from fire station	km	**1.84**	
Design Speed	km/hr	26.3	
Travel Time (West Wollongong Fire Station)		**252**	**sec**
Chart 5-Time taken for initial determination of fire location			
(2) Road travel within site necessary	No		

(4) Fire visible on arrival	No		
(5) Premises occupied	Yes		
(6) Time to don safety equipment	Chart 6	298	s
(7) Hindrance Factor	Table S	0.8	
(8) Security Procedures	Table G	0	
(9) In accredited fire warden present	No		
(16) FB pre-planning documented	Yes		
(17) Time for internal travel to primary target	Chart 9	20	s
(19) Time for information gathering	Table L	30	s
(20) Time taken to determine fire location		**348**	**sec**
Chart 6-Time taken to don safety equipment and gather necessary tools			
(2) Time to dismount fire appliance and don BA	Table M	158	s
(3) Other safety equipment necessary	No		
(5) Time to conduct safety procedures	Table O	74	s
(6) Tools necessary for initial access and set up (hoses etc)	Yes		
(7) Time to remove necessary tools from appliance	Table P	69	s
(8) Time taken to don safety equipment and gather necessary tools		**301**	**sec**
Chart 7-Time taken to assess fire			
(2) Fire location and extent obvious without recon	Yes		
(3) Building greater then 3 storeys	Yes		
(5) Time for OIC to walk to floor below fire compartment		0	s
Vertical Travel Speed	Table T	0.9	steps/s
Horizontal Speed	Table Q	1.4	m/s
Vertical Travel Distance		0	steps
Horizontal Distance		0	m
Rest Breaks	Table T	1.9	steps/s
(6) Time for OIC to walk from floor below fire compartment to above		0	s
Vertical Travel Speed	Table T	0.9	steps/s
Horizontal Speed	Table Q	1.4	m/s
Vertical Travel Distance		0	steps
Horizontal Distance		0	m
Rest Breaks	Table T	1.9	steps/s
(7) Time for OIC to walk back to set up area		0	s
Vertical Travel Speed	Table T	1	steps/s
Horizontal Speed	Table Q	1.4	m/s
Vertical Travel Distance		0	steps
Horizontal Distance		0	m
Rest Breaks	Table T	1.9	steps/s
(8) Additional resources	Yes		
(9) Notify additional resources	Chart 2	0	s
(10) Time for fire assessment		0	s
Chart 8-Time taken to travel to set-up area			
(2) Road travel within site necessary	No		
(5) Safety equipment donned	Yes		
(7) Set up area inside the building	No		
(12) Time taken to travel to set-up area		0	s
Chart 9-Time taken for fire-fighter travel			

(2) Doors to be negotiated	No		
(6) Horizontal travel	No		
(7) Horizontal travel time		0	s
Horizontal Speed	Table Q	1.4	m/s
Horizontal Distance		0	m
(8) Vertical travel time		0	s
Vertical Travel Speed	Table T	0.9	steps/s
Vertical Travel Distance		0	steps
Rest Breaks	Table T	1.9	steps/s
(15) Travel time		0	s
Chart 10-Time taken to set up water for initial fire fighter protection			
(2) Fire attack from appliance	No		
(9) Time to set up water requirements	Chart 11	135	s
(10) Time taken to set up water for initial fire fighter protection		**135**	s
Chart 11-Time taken to set up water supply requirements			
(2) Appropriate hydrant system flow and pressure	Yes		
(12) Time taken to connect and charge hoses	Table V	135	s
(15) Time taken to set up water requirements		**135**	s
West Wollongong Fire Station Charts 1-4 (Arrival Time) – **Search & Rescue**		**512**	**sec**
West Wollongong Fire Station (Charts 5-12) (Preparation)		**919**	**sec**
West Wollongong Fire Station FBIM (Time to Apply Water)		**1431**	**sec**

24 minutes

APPENDIX F: CFD MODELLING BY DESANCO