Manchester City Council

THE FACTORY, MANCHESTER

Fire Strategy



MF-WSP-XX-XX-RP-YD-03-0004
APRIL 2023

CONFIDENTIAL

Manchester City Council

THE FACTORY, MANCHESTER

Fire Strategy

REPORT (REVISION 8 / C05) CONFIDENTIAL

PROJECT NO. 70014540

OUR REF. NO. MF-WSP-XX-XX-RP-YD-03-0004

DATE: APRIL 2023

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QUALITY CONTROL

Issue/revision	First issue	Revision 1	Revision 2	Revision 3	Revision 4 / C01
Remarks	Updated to RIBA Stage 4	Updated with design changes	Incorporated comments and design updates	Updated fire compartmentation around theatre. Minor updates to match coordinated design.	Incorporating design amendments and project team comments. Issued for Construction
Date	6th August 2018	24th May 2019	23rd July 2019	9th April 2020	12th June 2020
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Project number	70014540	70014540	70014540	70014540	70014540
Report number	MF-WSP-XX-XX-RP-YD-03-0001	MF-WSP-XX-XX-RP-YD-03-0002	MF-WSP-XX-XX-RP-YD-03-0003	MF-WSP-XX-XX-RP-YD-03-0004	MF-WSP-XX-XX-RP-YD-03-0004

Issue/revision	Revision 5 / C02	Revision 6 / C03	Revision 6 / C04	Revision 7 / C05	Revision 8 / C05
Remarks	Incorporating design amendments and project team comments. Issued for Construction	Incorporating design changes. Issued for Construction.	Incorporating design team comments and the latest evacuation model result. Issued for Construction.	Incorporating design team comments and the latest model result. Issued for Construction.	Incorporating minor as-built changes to the fire strategy report. Issued for Construction.
Date	30th September 2020	26th August 2021	7th June 2022	17th June 2022	4th April 2023
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Project number	70014540	70014540	70014540	70014540	70014540
Report number	MF-WSP-XX-XX-RP-YD-03-0004	MF-WSP-XX-XX-RP-YD-03-0004	MF-WSP-XX-XX-RP-YD-03-0004	MF-WSP-XX-XX-RP-YD-03-0004	MF-WSP-XX-XX-RP-YD-03-0004

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1 INTRODUCTION

1.1 GENERAL

WSP has been appointed to provide fire engineering advice on the proposed Factory development for Manchester City Council (MCC).

This document is confidential and for the exclusive benefit of Manchester City Council (the Client) and the design team. It may not be assigned to or relied upon by a third party without the agreement of WSP UK Limited (WSP) in writing.

WSP retains all copyright and other intellectual property rights in the document and its contents unless transferred by written agreement between WSP and the Client.

The findings and opinions expressed are based on the conditions encountered and/or the information reasonably available at the date of issue of this document and shall be applicable only to the circumstances envisaged herein.

No person except the Client shall have the benefit of this document by virtue of the Contracts (Rights of Third Parties) Act 1999.

1.2 OBJECTIVES

The objectives of this report are to:

- Demonstrate how the design can satisfy the requirements of Part B of the Building Regulations 2010 and in respect of the physical building requirements necessary for the building occupiers to fulfil their duties under the Regulatory Reform (Fire Safety) Order 2005.
- Provide fire safety engineering advice using the guidance given in British Standard 9999 Code of Practice for fire safety in the design, management and use of buildings (2017 Edition) and other supporting documentation.
- Highlight areas of the design that may deviate from the guidance given in the BS 9999 and its supporting documentation and provide associated justifications.

This fire strategy is concerned only with the life safety of occupants and the main text does not specifically include property protection measures. It is recommended that the client confirms any insurer's requirements that may need to be considered.

It has been assumed that all building work is carried out in accordance with Regulation 7 of the Building Regulations. Therefore, to ensure that the proposed fire safety systems detailed within this report achieve the appropriate fire performance, it is recommended that all products, components, materials or structures relating to the fire strategy are installed using competent companies/persons and, where applicable, third party accreditation/certification.

The principle content details in this fire strategy report have been discussed and agreed in principle with Building Control (Manchester City Council Building Control Department) subject to the details which will be provided by specialist designers for the fire safety systems.

1.3 DOCUMENTATION

This document is an update of the report previously issued and titled “MF-WSP-XX-XX-RP-YD-01-0001”. The report has been updated in order to incorporate all the changes during the construction phases. However, the principles of the previously agreed strategy will be maintained throughout.

This fire strategy report has been based upon the information contained within the general arrangement of drawings provided by OMA and Ryder Architects (refer to Table 1-1). This report should be read in conjunction with these drawings and other supporting documentation prepared and submitted by other consultants who are acting on behalf of the design team. As a result of the complex nature of this building several mechanical and electrical documents are relevant to the Fire Strategy, these are shown in Appendix F.

The level of detail provided in this report is aligned to RIBA Work Stage 5.

Table 1-1: Drawing and Document List

Level	Drawing No	Number	Revision
Ground Floor	MF-RYD-XX-GF-DR-A	32-0501	P01
Level 1	MF-RYD-XX-L1-DR-A	32-0502	P01
Level 2	MF-RYD-XX-L2-DR-A	32-0503	P01
Level 3	MF-RYD-XX-L3-DR-A	32-0504	P01
Level 4	MF-RYD-XX-L4-DR-A	32-0505	P01
Level 5	MF-RYD-XX-L5-DR-A	32-0506	P01
Level 6	MF-RYD-XX-L6-DR-A	32-0507	P01
Level 7	MF-RYD-XX-L7-DR-A	32-0508	P01
Level 8	MF-RYD-XX-L8-DR-A	32-0510	P01
Roof	MF-OMA-XX-RF-DR-A-10-0190		P11
Section AA	MF-OMA-XX-XX-DR-A-16-0010		P9
Section BB	MF-OMA-XX-XX-DR-A-16-0020		P9
Section ZZ	MF-OMA-XX-XX-DR-A-16-0030		P9
Section YY	MF-OMA-XX-XX-DR-A-16-0040		P3
Section East	MF-OMA-XX-XX-DR-A-17-0020		P3
Events Capacity	OMA - SCENARIOS AND CAPACITY DIAGRAMS	02-07-2021	TBC
Pearson Consult Ltd	Truck lift PCL - MCC -Draft Truck Lift PEEP	22-6-21	TBC

BDP Services Fire Strategy clarifications	MF-BDP-XX-XX-RP-MX-45-0004		C01
Smoke extract fans	MF-BDP-ZZ-ZZ-SH-M-68-0033		C05
Fire/Smoke dampers	MF-BDP-ZZ-ZZ-SH-M-68-0034		C16
Automatic opening vents	MF-BDP-ZZ-ZZ-SH-M-68-0035		C06
Smoke vent control panels	MF-BDP-ZZ-ZZ-SH-M-68-0037		C02
Damper control matrix	MF-BDP-XX-XX-SH-M-68-0041		C08
Access and Maintenance Strategy	MF-BDP-XX-XX-RP-MX-45-0003		C07
Emergency Lighting & Management Lighting Criteria	MF-BDP-XX-XX-SH-YX-70-8006		C03
Warehouse Emergency Lighting Containment	MF-BDP-XX-XX-DN-MX-11-0046		C01
Theatre & Warehouse Schematic Fire Detection and Alarm Systems	MF-BDP-XX-XX-DR-E-70-5002		C01
MIF Fire Safety management plan	TBC		TBC

Note: the above documents are live and therefore *reference should be made to the live project documents.*

The fire strategy drawings should be referred to in addition to this fire strategy, the references of the fire strategy drawings are shown in Table 1-2 below. No revision/ date is specified in this table and the latest version of these pdf mark-up drawings are intended to show the fire strategy principles. The latest of which are referred to on the online project document management system.

Table 1-2: Fire Strategy Drawings

Level	Drawing No	Rev
Ground	MF-WSP-XX-GF-SK-YD-10-0000	C06
Level 1	MF-WSP-XX-L1-SK-YD-10-0001	C05
Level 2	MF-WSP-XX-L2-SK-YD-10-0002	C05
Level 3	MF-WSP-XX-L3-SK-YD-10-0003	C04
Level 4	MF-WSP-XX-L4-SK-YD-10-0004	C05
Level 5	MF-WSP-XX-L5-SK-YD-10-0005	C06
Level 6	MF-WSP-XX-L6-SK-YD-10-0006	C06

Level	Drawing No	Rev
Level 7	MF-WSP-XX-L7-SK-YD-10-0007	C04
Level 8	MF-WSP-XX-L8-SK-YD-10-0008	C03
Roof	MF-WSP-XX-RF-SK-YD-10-0009	C04
Section AA	MF-WSP-XX-XX-SK-YD-16-0010	C05
Section BB	MF-WSP-XX-XX-SK-YD-16-0020	C03
Section ZZ	MF-WSP-XX-XX-SK-YD-16-0030	C04
Section YY	MF-WSP-XX-XX-SK-YD-16-0040	C02
Section East	MF-WSP-XX-XX-SK-YD-17-0020	C02

Note: Figures in this report are for explanatory purposes; for relevant details, reference should be made to the live project drawings.

1.4 VALIDITY

This report is formulated based on the above-listed drawings and information provided at the time of preparation of this report and is applicable to the project only.

1.5 ASSUMPTIONS

The underlying principles for this fire strategy are as follows;

- Fire is an accidental event and that there is a single seat of a fire;
- The measures in place detect a fire within the early stages of a fire growth;
- The measures in place alert occupants so that escape can be initiated;
- The measures in place should enable the fire service on their arrival to quickly gain access to the location of any incident;
- There is no reliance placed on the fire service for rescue from the building; the assumption being that people will be able to escape from the building using their own unaided efforts to a place of ultimate safety and disabled occupants will be assisted to safety by staff/building management;
- The design is for a single fire situation. The design does not cater for fire occurrence in numerous locations at one time as may be the case of an arson attack, nor does the design account for major catastrophic events;
- The design has been developed on the basis that the building will benefit from a high level of fire safety management through Manchester International Festival (MIF) who will provide sufficient staffing levels and training to support the various venue configurations through a fire risk assessment process.

1.6 REGULATORY REFORM (FIRE SAFETY) ORDER

Under the Regulatory Reform (Fire Safety) Order 2005 each and every owner, occupier and operator of a premises is required to adequately manage the safety of the areas under their control. Under this legislation a 'Responsible Person or Persons' is required to be appointed in order that the necessary level of safety can be implemented, with an inherent necessity for competence in the area of fire safety. The fire authority having jurisdiction has the power to inspect the premises to check that the Responsible Person(s) comply with the duties under the Order and will look for evidence that the Responsible Person(s) has carried out a suitable fire risk assessment and acted upon the significant findings of that assessment.

It is important therefore that the Responsible Person (the legal duty holder responsible for fire safety in the building) takes on board the information provided in this fire strategy and associated documents when preparing the fire risk assessment reports accordingly to reflect any changes that may need to be made to current fire safety policies and procedures.

1.7 THE CONSTRUCTION (DESIGN & MANAGEMENT) REGULATIONS 2015

Projects undertaken within the UK are subject to the requirements of the Construction, Design and Management Regulations (CDM).

This report defines the strategy for meeting the functional and performance requirements for fire safety in the finished building. Where any conclusions or recommendations have been arrived at which specify particular materials, products or forms of construction these will have been assessed, in accordance with CDM Regulation 9 (Duties for Designers). In the event that these involve significant residual risks or health and safety critical assumptions, this information will be made available, to the Principal Designer. Where the architect or other consultants use the standards put forward in this report to specify works, they are understood to be competent in alerting the Client, Principal Designer, Contractor and Building Occupiers of CDM issues.

1.8 REPORT AMENDMENTS

The following items have been amended in this revision.

The changes are minor and should not have any effects on the agreed fire strategy. The purpose of the update is to incorporate as built solutions and agreed measures into the fire strategy report.

Table 1-3: Fire Strategy Drawings

Section	Changes
Section 1	Table 1-1 Quality control to reflect the latest changes.
Section 1.8	The Factory WIP - List of Changes to Rev 7 / C05 Fire Strategy Report.
Section 4	Section 4.1.1 - paragraph 3 reflects the new flow chart, 4.1.3 - paragraph 2 incorporating the use of the aspirating system. paragraph 7 reworded to reflect the agreed C&E procedure (flow chart).

Section 4.2	Paragraph 2 and Note - to incorporate the use of an aspirating system which needs no investigation time.
Section 4.5	Smoke ventilation system – If any doors fail to open, (Theatre and North W) for South W, if two or more doors fails to open.
Section 4.5.2	Paragraphs 3, 6 & 7- To incorporate the as-built non-fire-rated duct for the smoke ventilation system.
Section 4.6	Update MSVS Criteria to reflect as built.
Figure 4.7.1	Make up air – FD openings principle to be incorporated.
Section 4.11	Reference - OMA extinguishers layout drawings.
Section 5.3.1	Update to incorporate the new flow chart, MIF vision to have a limited area of the building open to members of the public. (Excludes theatre and warehouse areas).
Section 5.7	The external escape route adjacent / immediate to the building proximity should be kept clear of obstructions during major events.
Section 6.9	To include the new stress test (width reduction) evacuation modelling detail and results.
Table 10-4	Note to be added to cover the engineering judgement (flue) submitted and approved by BCO.
Section 10.10.3.2 Ductwork	Notes are to be added on the use of non-fire-rated ductwork for the smoke ventilation system.
Section 11.1,2,3	Update to incorporate the updated external fire spread analyses and the as-built wall build-up.
Appendix E	Indicative cause and effect updated to the as-built C&E, Management Flow Chart etc.
Appendix G	The new stress test mode evacuation model has been added in Event mode I.

Note: The report is the same in principle as the previously issued and agreed fire strategy by WSP. The above table clearly lists where changes are proposed to be made and the details of the changes. Nonetheless, the principles of the previously agreed report remain the same.

2 DESIGN APPROACH

2.1 FIRE SAFETY GUIDANCE

The report provides a detailed account of the fire safety measures that are used to demonstrate compliance with Part B (Fire Safety) of the Building Regulations 2010.

The principle guidance documents to the Building Regulations 2010 adopted for the scheme is BS 9999 Edition 2017 and associated British Standards. It is noted that these guidance documents do not set out statutory requirements. They are intended to provide guidance only for generic building designs. An alternative solution can be applied to achieve an acceptable level of safety commensurate with the Functional Requirements of the Building Regulations 2010.

On the basis that the recommendations made within the guidance documents are followed, it is considered that the Requirements of the Building Regulations 2010 will be fulfilled; and that an adequate level of fire safety will be provided throughout the premises.

Note: Where reference is made to superseded or withdrawn documents in this report, the design team should adopt a subsequent revision or the latest equivalents standard. Furthermore, design team should ensure the Relevant Part is used to meets the design intents on this fire strategy report.

2.2 ALTERNATIVE FIRE ENGINEERING SOLUTIONS

Some specific areas of the design propose alternative solutions which are supported by a fire engineering approach in order to meet the Functional Requirements to the Building Regulations 2010. The use of a fire safety engineering approach is recognised within BS 9999 as an acceptable means of complying with the Functional Requirements:

> *"Fire safety engineering. This is the level for which BS 7974 is provided. This level provides an alternative approach to fire safety and can be the only practical way to achieve a satisfactory standard of fire safety in some large and complex buildings, and in buildings containing different uses." – Section Foreword*

The methodology for designing a fire safety engineering approach for the designs proposed follows the analytical framework outlined in BS 7974 'The application of fire safety engineering principles to the design of buildings'.

2.3 ABBREVIATIONS

The main abbreviations used throughout the report are summarised in Table 2-1 below.

Table 2-1: Abbreviations

Abbreviation	Meaning
AOV	Automatic Opening Vent
FD	Fire Door
MCC	Manchester City Council
MIF	Manchester International Festival

2.4 STAKEHOLDERS

For the purpose of this fire strategy report the following stakeholders are considered:

Table 2-2 – Relevant Stakeholders

Organisation	Role
WSP	Fire Safety Consultants
Manchester City Council	Authority Having Jurisdiction*
Manchester International Festival	Responsible Person**
Manchester International Festival	Clients venue operator
Manchester City Council	Client
OMA and Ryder Architects	Architecture
Ryder	Lead Consultant
BDP	MEP
Pearson Consult	Truck Lift
Buro Happold	Civil and Structural Engineering
Laing O'Rourke	Principle Contractor
Greater Manchester Fire and Rescue Service	Local Fire Service

**AHJ Role - The AHJ is the final deciding authority who may review and assess the proposal with the aim of approving, rejecting or impose additional requirements.*

***The responsible person in this instance could be the owner, end-users, or building management.*

3 PROJECT BACKGROUND

3.1 DESCRIPTION OF THE PROJECT

The Factory is a theatre and arts venue to be built on the former site of Granada Studios, in the St John's Quarter of Manchester and is to be the permanent home of the Manchester International Festival (MIF).

This large assembly building has been designed to provide a high degree of flexibility for the building operator MIF to provide a range of public/private events which includes uses such as theatre, music, dance, technology, film, TV, media and science. The building will cover 13,000m^2, the theatre has 1423 seated occupation and 1805 mixed seating and standing capacity when closed to the warehouse. When open to the warehouse the seated occupation can rise to 1604 and the mixed seated/ standing occupation can increase to 2200 as in Figure 3-2: MIF - Occupants Scenario and Capacity Diagrams below. In addition to the theatre, there is a 5,000 capacity space called the Warehouse to be used for art exhibitions, concert, mixed event etc.

The building includes the following key elements:

- **The Theatre** – a flexible Theatre space which includes a balcony level and retractable seating with a total capacity of up to 2,200 people when the theatre is open to the warehouse and the stage is in the warehouse.
- **The Warehouse** – a large 'multi-purpose' space with a standing capacity of up to 5,000.
- **The Towers** – offices, plant rooms and back of house areas associated with the Warehouse and Theatre.
- **The Foyer** – the ground floor of the building that is mainly used as the entrance to the Theatre and Warehouse but can also be used as an event space.
- **The Truck Lift and Loading Bay** – used to bring staging equipment to the level of the warehouse and theatre.

Moveable partitions will be provided to subdivide the Warehouse into two separate spaces as well as between the Theatre and the Warehouse. Note these partitions will include door openings to support egress in different modes of use. The key building elements and end-user capacity scenarios are shown in the figures below.

Figure 3-1: Key Building Elements

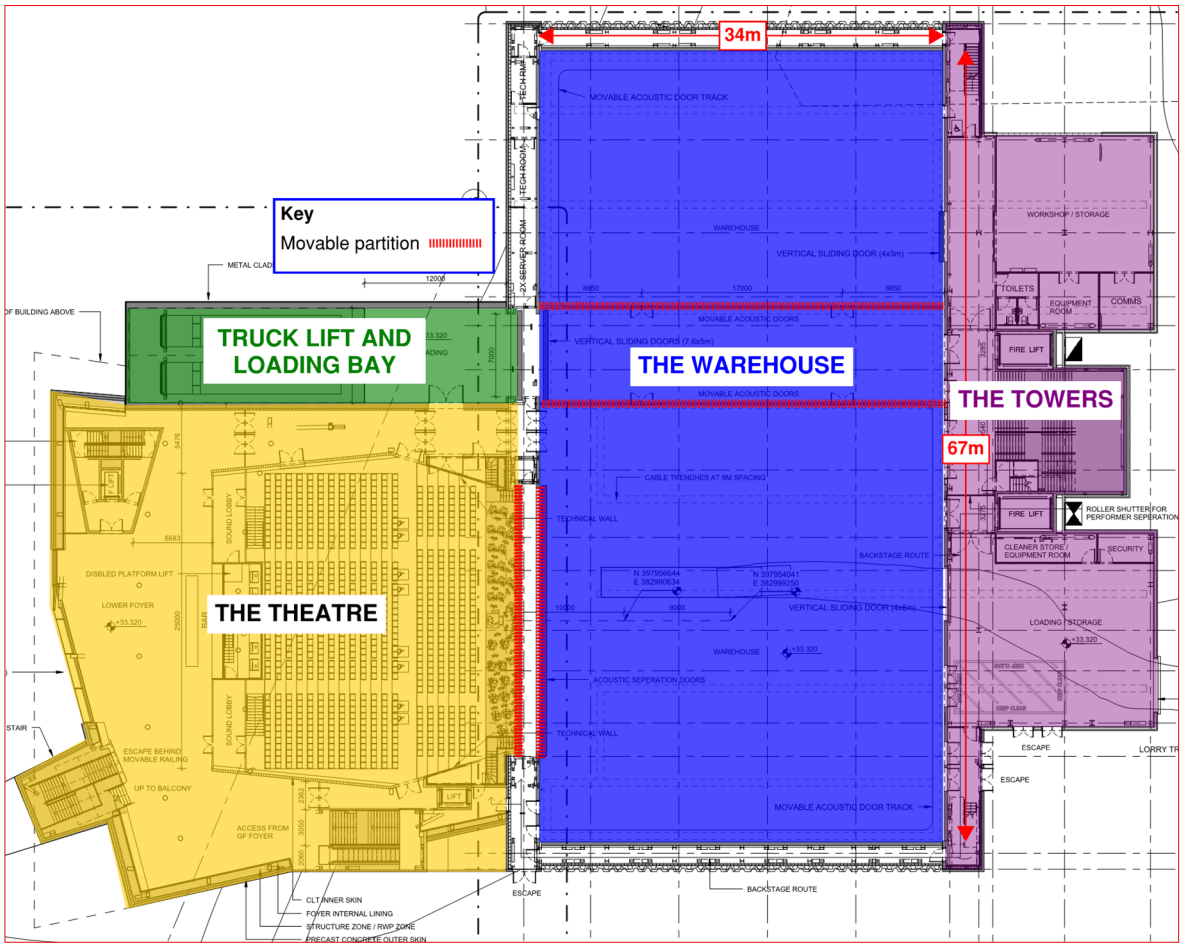


Figure 3-2: MIF - Occupants Scenario and Capacity Diagrams 26/04/2022


A
1200
5000
B
1190
1604
With proscenium open, it can be assumed the audience is dispersed across the adjoining spaces, utilising the ventilation systems from both TH and WH(S)
C
900
1604
With proscenium open, it can be assumed the audience is dispersed across the adjoining spaces, utilising the ventilation systems from both TH and WH(S)
D
1190
2200
640
1560
With proscenium open, it can be assumed the audience is dispersed across the adjoining spaces, utilising the ventilation systems from both TH and WH(S)
E
900
1423
2933
F
1190
1423
2933
F*
1423
G
Stalls only
640
H
900
1423
1500
I
1805
640
1183
5000

3.2 RISK PROFILE

BS 9999 is a risk-based document and requires a risk profile to be established to provide a basis upon which fire safety measures are developed. The risk profile is a function of the occupancy characteristic and the fire growth rate for the building.

3.2.1 OCCUPANCY CHARACTERISTICS

The majority of the areas can be accessed by members of the public that will be unfamiliar with their surroundings; as such an occupancy characteristic B (awake and unfamiliar with the building) will be applied for the overall building risk profile.

Spaces that can only be accessed by staff (e.g. plant rooms) will be classified as occupancy characteristic A (awake and familiar with the building).

3.2.2 FIRE GROWTH RATE

BS 9999 defines the fire growth rate as the rate at which it is estimated that a fire will grow. BS 9999 places the fire growth rates in the following categories:

- **Slow (1)** – evenly distributed low-level fire load, small discrete packets of fuel or material of limited combustibility.
- **Medium (2)** – Evenly distributed low to mid-level fire load comprising of a mix of combustible materials.
- **Fast (3)** – Stacked combustibles (on or off racking shelving but excluding high rack storage), some small quantities of materials other than materials of limited combustibility (or where larger quantities are stored in separate fire-resisting enclosures), process, manufacturing or storage of combustible materials.
- **Ultra-fast (4)** – Medium to large quantities of materials other than materials of limited combustibility, high racked storage, flammable liquids and gases or where rapid uncontrolled fire growth could occur.

As described in Section 3.1, the building can accommodate a wide range of events meaning that the fire growth rate may vary from one event to another.

However, for most of these events, a slow (1) or medium fire growth rate (2) is considered a reasonable rate. The Warehouse and the Theatre being very large spaces provided with smoke ventilation, a fast fire growth rate is unlikely to occur.

Rooms potentially containing a high fire risk such as places of special fire hazard will be classified as fire growth rate 3 (fast) and enclosed within a fire-resisting enclosure.

3.2.3 THE FACTORY RISK PROFILE

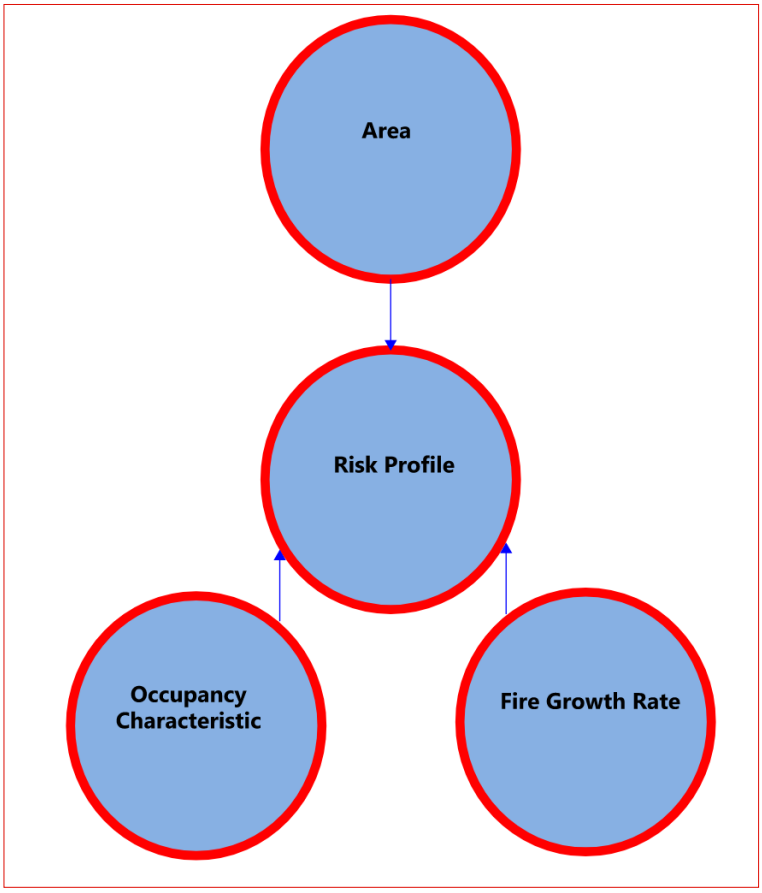
Based on the above, it is proposed to apply a risk profile B2 as the overall building risk profile (as this is applicable to the majority of areas). The Warehouse and Foyer have both additionally been considered with a B3 risk profile (as well as B1 and B2) to capture any events that may be managed by MIF in the future where there is a potentially higher fire growth rate. Prior to each event MIF's event manager or competent person appointed by the responsible person for the premises will be required to undertake a fire risk assessment to conform the risk profile of the venue and whether any additional measures are required

Table 3-1 – Fire Risk Profiles

Area	Occupancy Characteristic	Fire Growth Rate	Risk Profile
Staff areas Plants rooms	A - Occupants who are awake and familiar with the building	1 Slow **2 Medium** **3 Fast** 4 Ultra-fast	A1 **A2** **A3** A4
The overall building risk profile	B - Occupants who are awake and unfamiliar with the building	1 Slow **2 Medium** **3 Fast** 4 Ultra-fast	B1 **B2** **B3** B4

Where areas or rooms of high fire risk are present within a building, such as a plant room etc., these rooms will be separated from the remainder of the building by walls etc. having the appropriate degree of fire resistance based on the ancillary accommodation recommendations of this report. Whilst ancillary areas are part of the main risk profile, it is proposed to use exit widths and travel distances from an A3 risk profile for added conservativism in the design.

Figure 3-3 – Risk Profile



4 FIRE SAFETY SYSTEMS

4.1 FIRE DETECTION & ALARM SYSTEMS

4.1.1 SYSTEM CATEGORY

The overall risk profile in this building is B2; as such a category M fire detection and alarm system should be provided as a minimum (BS 9999, Table 7).

However, this risk profile may vary and a number of spaces are classified as fire growth rate 3; as such a category L2 fire detection and alarm system will be provided. This will also enable the end-user (MIF) to manage the evacuation and hence reduce the impact of a false alarm on business continuity.

The system will be a fully addressable analogue type designed and installed in accordance with BS 5839-1. An indicative fire alarm cause and effect flow chart is provided in Appendix E.

This category of the system requires detectors to be located in all escape routes, circulation spaces, all rooms accessed directly from an escape route and any other rooms considered to represent a high fire risk. In this instance, high-risk areas will include rooms containing a credible fire hazard such as plant rooms.

Type A (direct operation) manual call points, designed in accordance with BS EN 54-11 and installed in accordance with BS 5839-1, will be located at all storey and final exits between 1.2m and 1.4m from the finish floor level. A transparent hinged cover can be provided to the manual call points to minimise misuse of the system and false alarms.

Table 4-1 – Fire Detection and Alarm System

Areas	Minimum Acceptable System	Recommended System
All areas	M	L2

4.1.2 FIRE ALARM AND SMOKE CONTROL PANELS

The main fire alarm panel will be provided in a space manned during events, MIF confirmed that the preferred location would be in the front of house manager's office (room no. 215) at Level 02, as shown in the figure below.

In addition, repeater fire alarm panels shall be provided in the two fire-fighting lobbies at the ground floor (Fire Service access level), as shown in Figure 4-2 and Figure 4-3. Also, the fire-fighting Emergency controls for the fire-fighting shafts, Warehouse and Theatre ventilation systems and Fire Phones (Emergency Microphones) linked to the PA/VA system shall be provided at these locations for use by the Fire Service.

Figure 4-1: Illustration of the fire control panel at level 2 of the warehouse in the manager's office.

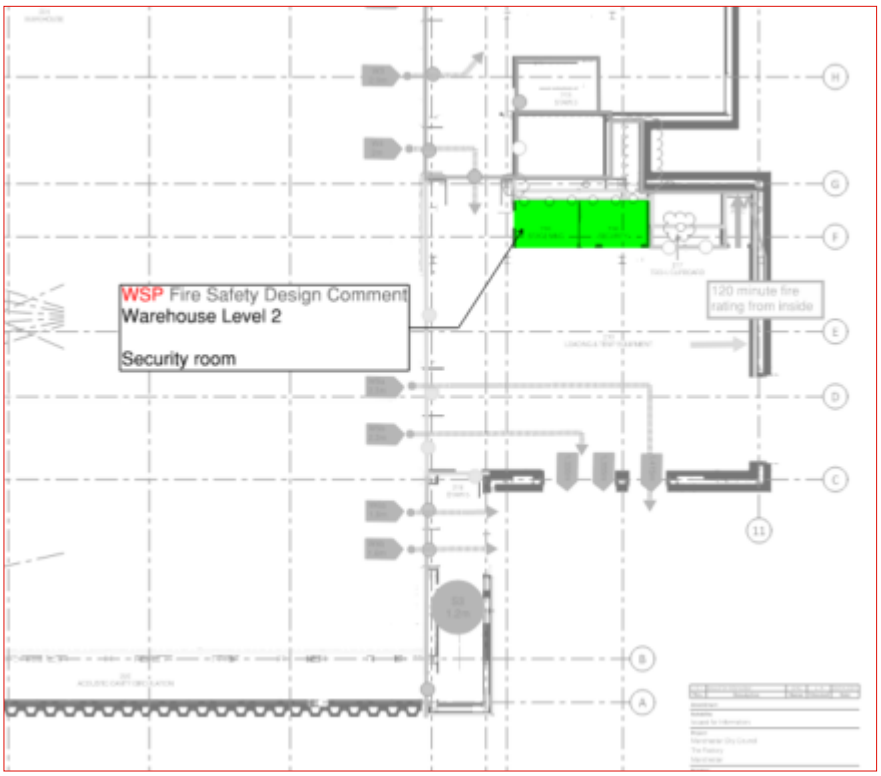


Figure 4-2: Illustration of fire service control panel at the ground level of the warehouse.

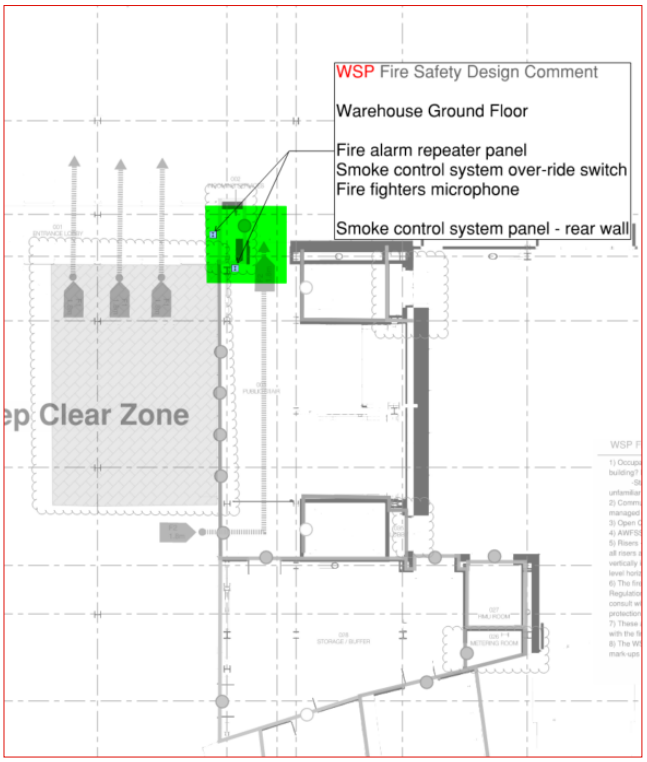
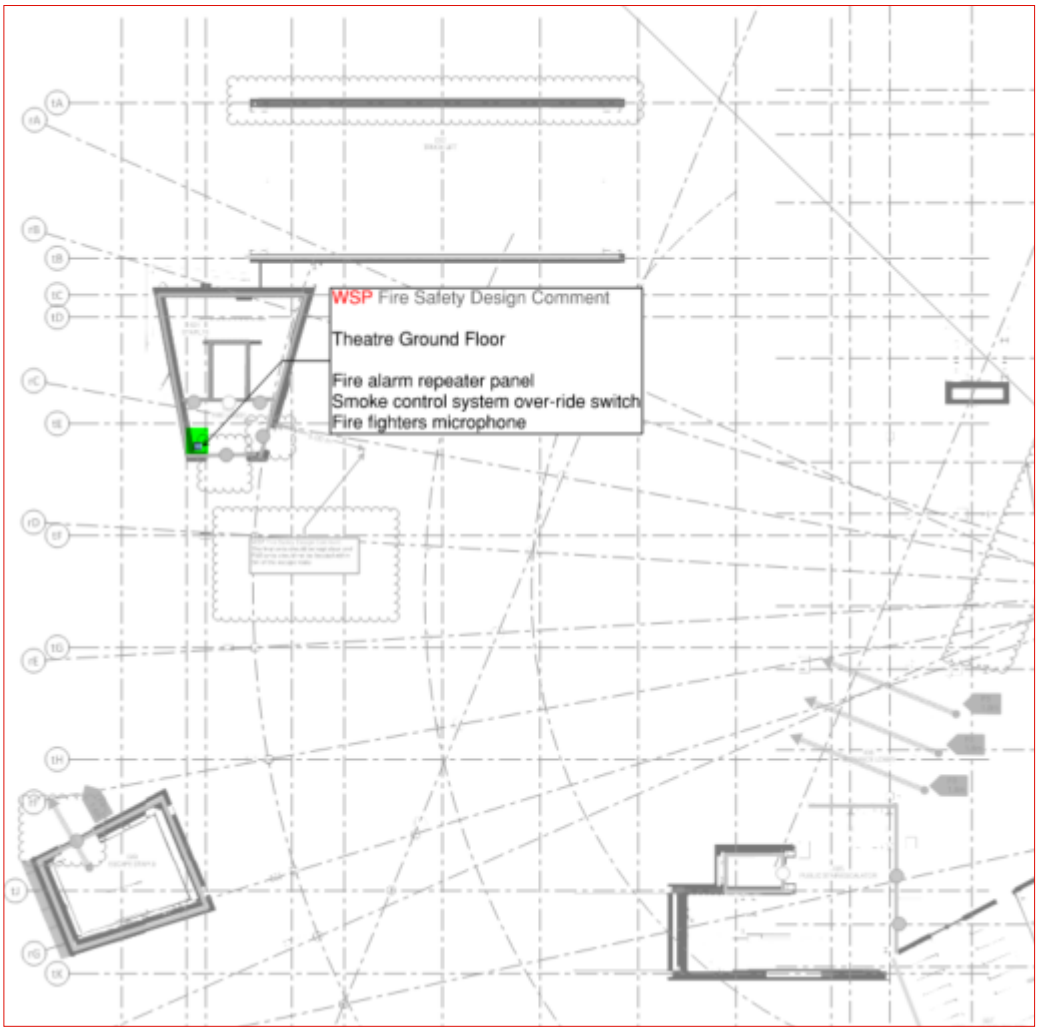


Figure 4-3: Illustration of fire service control panel at the ground level of the theatre.



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4.1.3 FIRE DETECTION

Automatic fire detection and manual call points will be provided as per the provisions of BS 5839-1 for an L2 system.

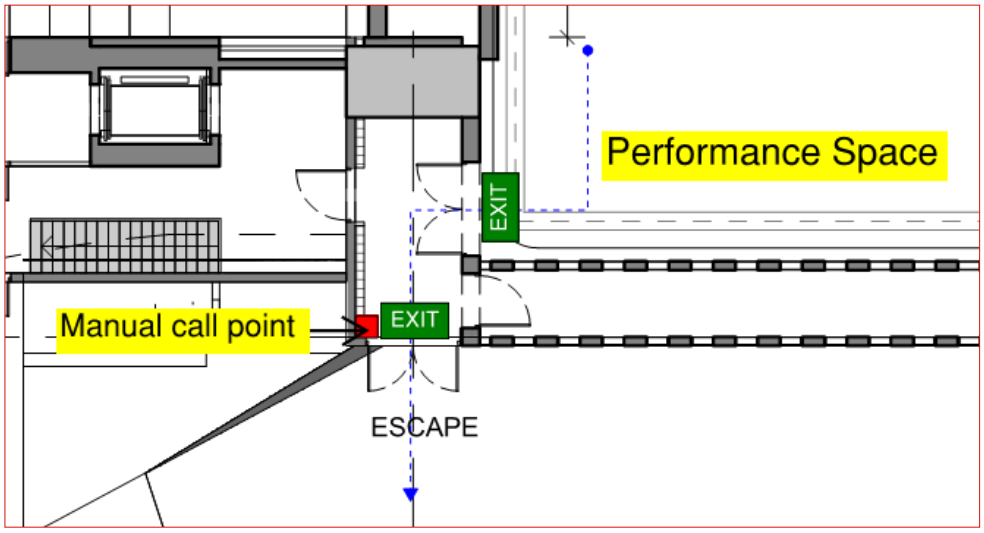
Automatic detection will comprise of either heat, aspirating detector system or optical smoke detectors system as appropriate for the area being protected. The fire alarm system will be interfaced as necessary (e.g. with mechanical ventilation systems, smoke actuated dampers, fire doors/ curtains etc.). The fire alarm panel will incorporate integral standby battery and charging facilities with power supplied from a separate dedicated circuit.

The fire alarm principal designer will give consideration to double-height spaces as recommended by BS 5839-1. Such spaces may require additional measures such as Optical beam or aspirating smoke detector system etc. The additional requirements for fire alarm system to be incorporated by specialist contractor (Crown House Technologies).

Dispositions are to be taken to limit the risk of false actuation of manual call points in event spaces. As agreed with MIF, these devices will be provided after the doors leading into a means of escape

from the event spaces. An example of this is shown for an exit from the warehouse in the figure below.

Figure 4-4: Example of Manual Call Points in Performance Spaces



The fire alarm system shall be arranged to allow for the alarm loop within a given performance space (e.g. Theatre, Warehouse) to be isolated during a performance where there is a risk of activation of the fire alarm system due to performance-related smoke effects. Management procedures will need to be in place to facilitate the isolation of the fire alarm system.

Where specific events create temporary enclosures, which would need fire detection to be provided to comply with BS 5839-1 for an L2 system, consideration will be given to providing wireless smoke detectors which can be interfaced with the building's fire alarm system to ensure continuity of coverage.

Due to the use of pyrotechnics for some events, the fire alarm system will be turned off to prevent false alarm, however, staff will be trained to manage the process. Furthermore, the control room will have a visual access to the stage area and the event space and will contain an emergency push button or manual call point to manually bring the system back on to live. As well as the ability to communicate with the security room using secured radio connection. A repeated emergency push button is also located in the security room where this can be activated and from where emergency can be managed.

4.1.3.1 Low Fire Risk Areas

There are a number of voids identified in the building that are considered to be low risk owing to the lack of ignition sources and combustible materials within these spaces. In addition, some of these spaces are inaccessible so as well as making fire detection maintenance impracticable, there is minimal risk of hidden spaces being used for storage in future. The following areas have been identified as not requiring fire detection (whilst also noting that fire detection to voids is not necessarily a requirement of the L2 detection system category required by this fire strategy):

- Theatre - void below seating at Level 3 (Figure 4-5).
- Theatre - void beneath Level 2 (Figure 4-6).

- Warehouse – above technical grid (Figure 4-7).

Figure 4-5 - Theatre void below seating at level 3, highlighted in green.

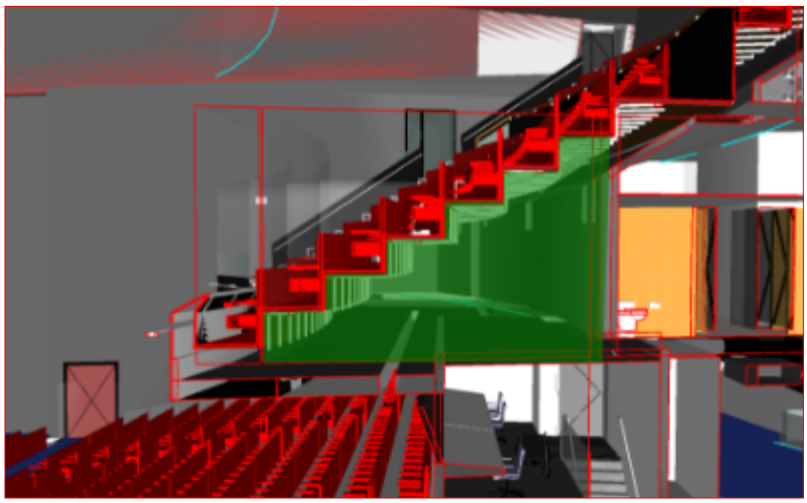


Figure 4-6 - Void beneath level 2, highlighted in green.

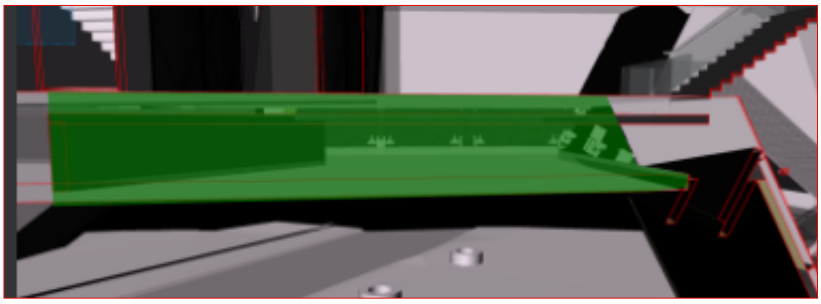
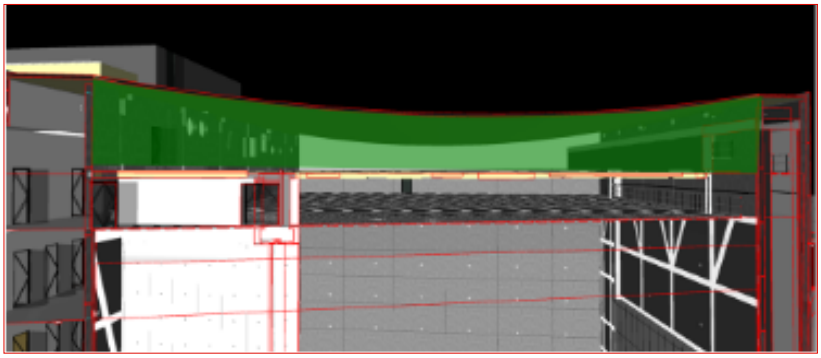


Figure 4-7 - Void above the warehouse, highlighted in green.



In addition to the omission of fire detection in the above voids, where the voids are inaccessible or will be infrequently accessed for maintenance purposes only do not require subdivision.

4.1.4 AUDIBLE AND VISUAL ALARM SIGNALS

An audible alarm signal will be provided throughout the building (including roof) as per the recommendations of BS 5839 – Part 1 to ensure that all occupants will be warned upon fire detection actuation. The alarm signal will be distinct from any other sounders or signals used in the

building and the sounder will not be less than 65db, this may increase appropriately in plant space where background noise is significantly higher.

On activation of the fire alarm system, the sound system used for music or other performance in the space should be silenced and the alarms sounders should take precedence.

Visual alarms will be provided in accordance with BS EN 54 Part 23. These will be installed in areas where persons with impaired hearing might be in relative isolation such as toilets areas and also in areas with high ambient sound levels.

Note: where full height WC cubicles are proposed in the toilet, each cubicle will be provided with VADs and the sounders calculation will ensure that sufficient sounder level can be heard in each cubicle.

In control rooms, the warning system for occupants in the control room will be a discrete type such that that once triggered it has limited impact on the public located in the performance space.

When evacuation is to be initiated by staff, the use of a public address system is considered the most appropriate.

As agreed with MIF, a management strategy will be in place to manually mute music in event spaces and turn on lights in the event of fire alarm actuation.

4.2 INDICATIVE FIRE ALARM CAUSE & EFFECT OUTLINE

This Section of the report is intended to provide an overview of how systems connected to the fire alarm system should operate upon detection of a fire in The Factory. The Factory has been designed as a flexible space and as such it is appropriate to assign three ‘modes’, to ensure that the fire safety systems operate as intended depending upon the use of the space.

In all modes, there is an investigation period of 6 minutes, during which time staff will have the opportunity to confirm if there is a fire and this time can also be used to allow staff time to prepare for the evacuation of the spaces. If this period elapses, or another detector is activated, or it is a manual call point that is activated then it shall be treated as a confirmed fire.

***Note**: the area where the fire alarm is actuated will go into evacuation immediately while investigation commences. Furthermore, all inner rooms associated with the room where the detector is activated will go into full evacuation as well. In addition, it is anticipated that the total premovement during the event mode in the warehouse and theatre area is 60 seconds. Due to the use of the space, it is likely that a fire will be detected by staff/attendees/or performers and therefore evacuation can commence immediately.*

***Note**: Where aspirating smoke detector is provided, it is not necessary to incorporate an investigation time.*

This system relies heavily on appropriate management procedures to select the correct performance mode for events taking place in The Factor. Therefore, it is recommended that a robust fire safety management plan is written for The Factory which covers the operation of the fire alarm and detection system.

The ground floor Foyer is included in the Warehouse and Theatre spaces as part of the C&E. The Warehouse escape from S1 shares an escape route with the foyer with exit F1 being used by persons escaping the Warehouse from S1 and persons escaping from the foyer also using exit F1

(shown in Figure 4-8 and Figure 4-9). The basis for the Foyer and Warehouse being able to escape at the same time, are the two following fire scenarios:

- A fire in the Foyer – exit F1 has been discounted in the foyer and there is sufficient capacity for occupants from the Foyer to escape. The exit capacity of the Warehouse has been calculated on the basis of S1 being blocked and therefore the exit capacity from the Warehouse without using F1 is sufficient.
- A fire in the Warehouse – Occupants from the Warehouse use S1 and they leave S1 through F2 and 3.6m of the width provided from F1. This leaves sufficient capacity for occupants of the foyer to escape through F1 and F3.

This demonstrates that the C&E does not require aligning for separate scenarios in the Foyer to the Warehouse and Theatre. Therefore, the Foyer has the capacity to host a 2,000 person event whilst the Warehouse is in maximum occupancy. Provided that exit S1 is available to those evacuating the Warehouse unless a fire blocks it. Section 7.4 of this report demonstrates that there are sufficient means of escape from the Warehouse and Foyer, based on the above scenario.

Figure 4-8 - Illustration if exits from the foyer.

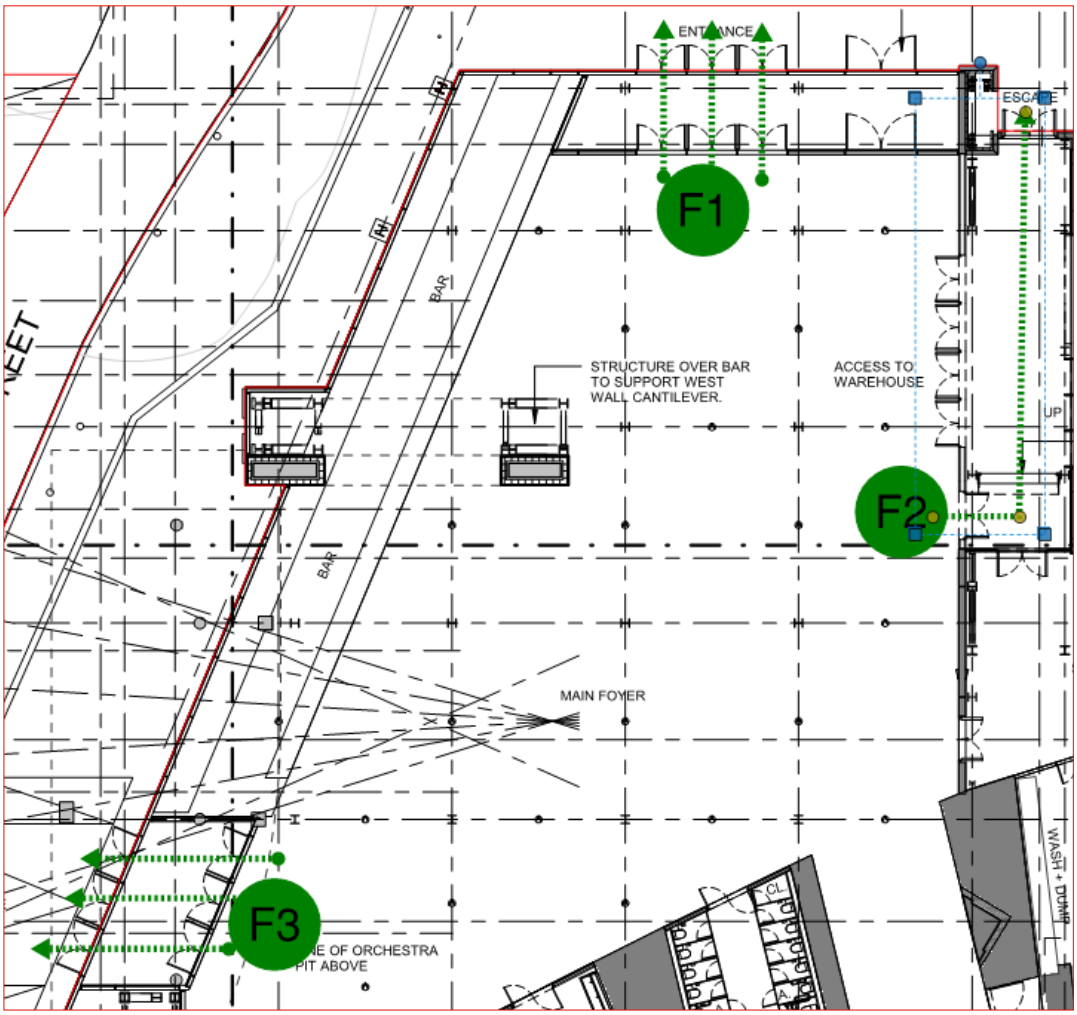
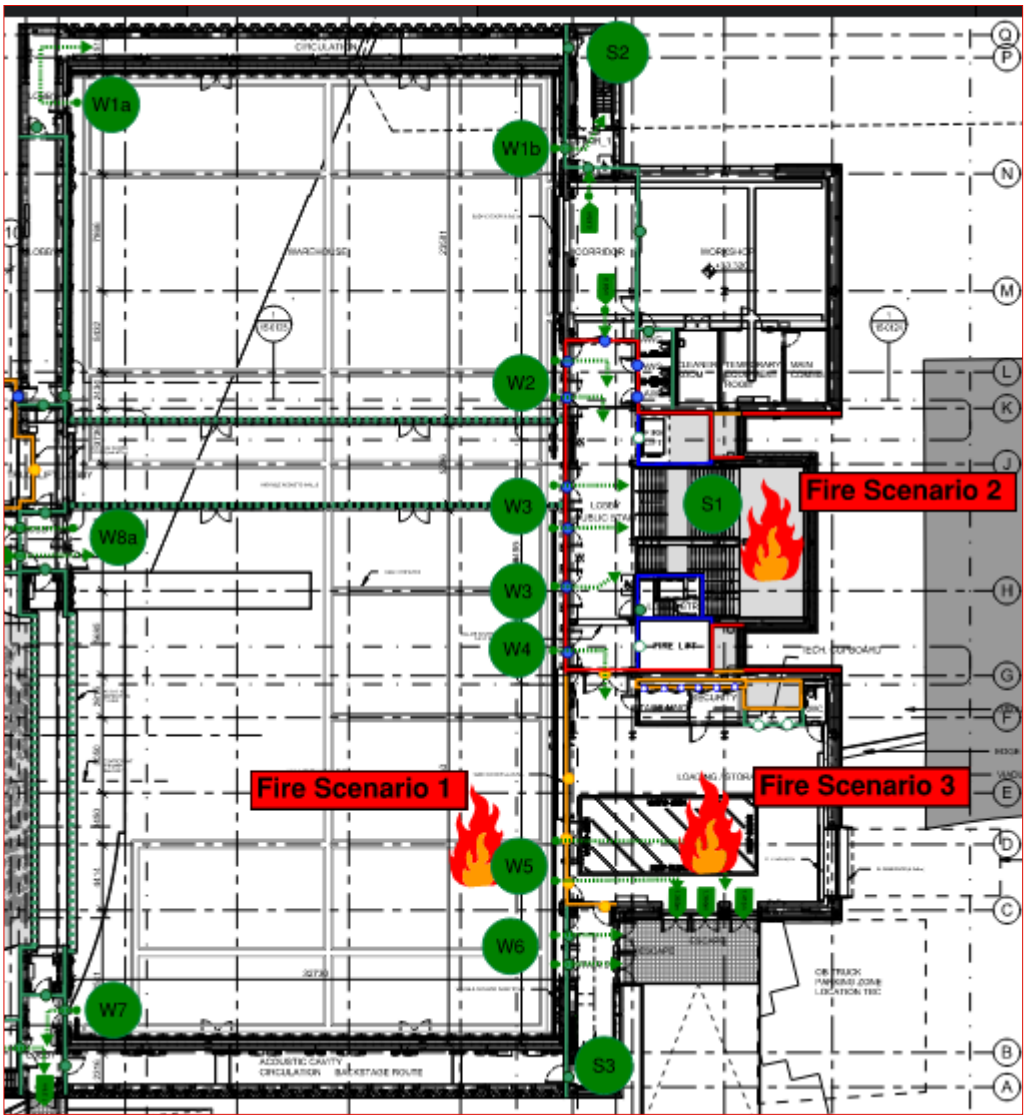


Figure 4-9 - Illustration of exits from the Warehouse.



4.3 AUTOMATIC WATER FIRE SUPPRESSION SYSTEM

In terms of height and size, the provision of a suppression system is not required for Building Regulations purposes under the guidance of BS 9999 and none will be provided.

4.4 DOOR FASTENINGS

Any doors on escape routes provided with a locking system will be provided with a fastening that can be easily and readily operated by the occupants evacuating without the use of a key and without having to manipulate more than one mechanism.

Where doors are provided with an electromagnetic lock, the device will return to the unlocked position upon:

- Activation of the fire detection and alarm system;
- Failure of the power supply or system error;

- Operation of a manual door release unit (Type A) conforming to BS EN 54-11:2001+A1:2006 located to the side of the door approached by occupants evacuating the building.

Specific doors will be used to provide make-up air for the ventilation system in the event of a fire, in line with the CFD reports for the warehouse and theatre in Appendix A & B respectively, an illustration of the doors used to provide the make-up air for both the warehouse and theatre are shown in Figure 4-10, Figure 4-11 and Figure 4-12 below.

Figure 4-10: Illustration of the make-up air provided for East of the Warehouse.

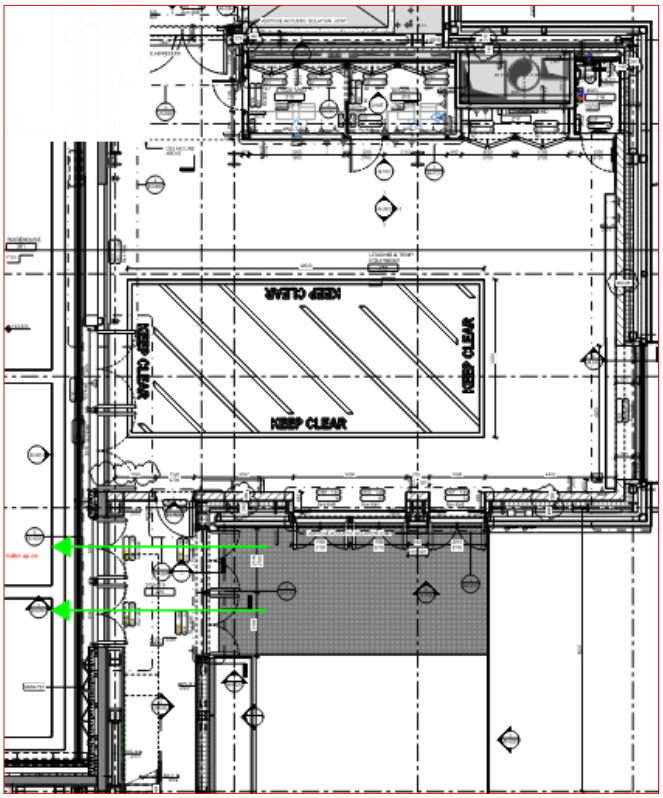


Figure 4-11: Illustration of the make-up air provided for the West of the warehouse.

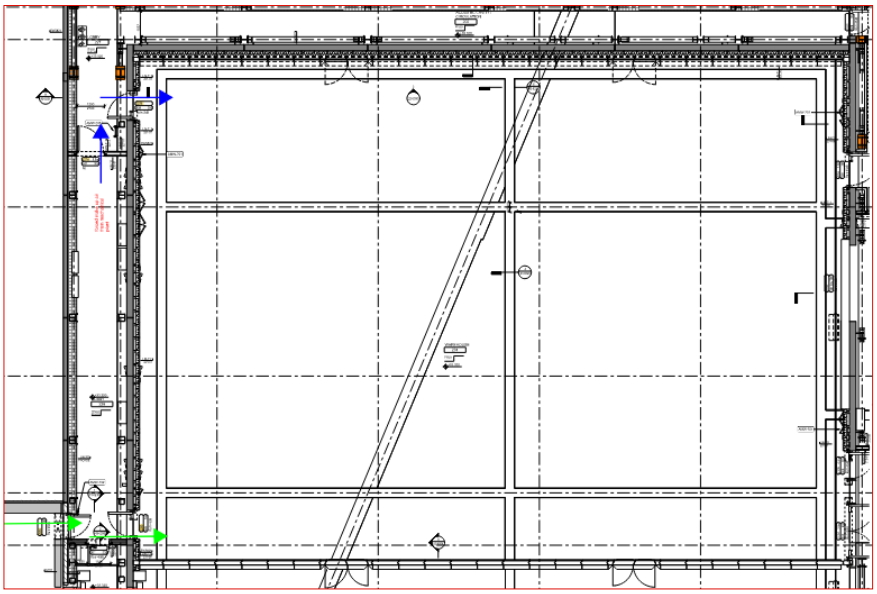
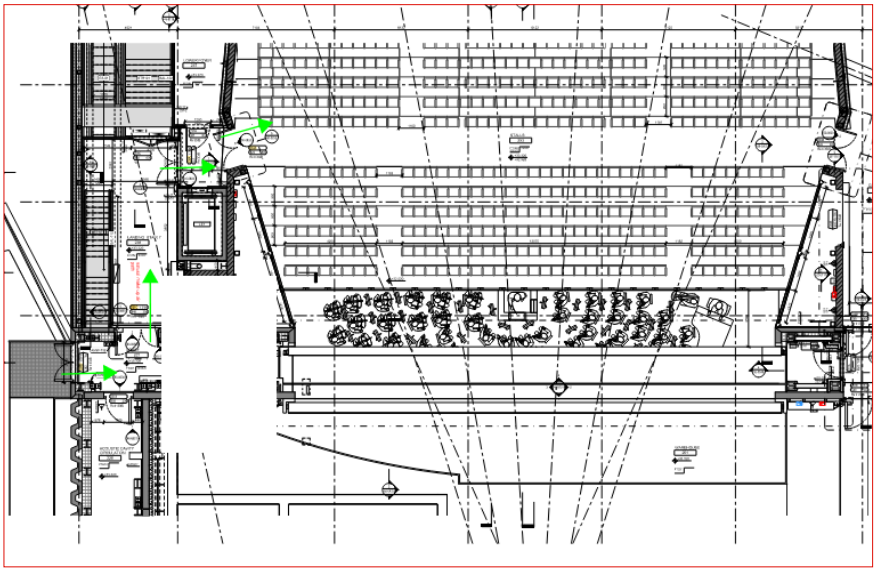


Figure 4-12: Illustration of the make-up air provided to the theatre.



The failure of the doors opening, required to provide make-up air, could result in the exit doors from the Warehouse and Theatre being 'pulled' closed by the ventilation system. To mitigate against this risk the worst-case single door failing to open (the door which provides the largest portion of inlet air) in each area has been considered and the ventilation for the smoke control system will be reduced by the proportion of this worse case, in the event that there is the failure of a door opening, the results of which are shown in Table 4-2 overleaf.

The access control and egress door schedule have been coordinated with the relevant design team to ensure that all doors on the escape route will be provided with adequate mechanisms to ensure that not more than one mechanism will be operated to open the doors from the escaping side. Furthermore, the access control document will be submitted to the statutory authority for approval.

4.5 SMOKE VENTILATION SYSTEMS

The areas provided with a smoke ventilation system are presented hereinafter. The operation of these systems is detailed in the MEP specifications and the BDP Fire Strategy Clarifications document (Ref: MF-BDP-XX-XX-RP-MX-45-0004).

The designed smoke ventilation systems for the smoke control system is provided with inlet air to operate. Some of this air is provided by the doors opening automatically, there is a risk that the failure of one of the leaves of these doors opening could mean there is not enough inlet air and the smoke control system essentially 'sucks' the doors closed.

To mitigate against this risk, each door leaf providing inlet air has been assessed and the leaves providing the largest amount of inlet air to each of the three areas (North Warehouse, South Warehouse and Theatre) has been identified. The smoke control fans are then to be reduced to a speed determined by the proportion of inlet air lost due to the largest door leaf not automatically opening. The following is a breakdown of how this works in each area of The Factory:

- Theatre – worst case is that the doors 221B, 221C, 238A and 234A fails to open which provides 54% of the total inlet air required. Therefore, it is proposed to have the extract fans in the theatre operate at approximately 46% of the total extract rate proposed, if the sensors determine that a door has failed to open.
- North Warehouse – In the north warehouse if any of the doors 226A, 226B, 227A or 227B fail to open the north warehouse smoke extract fan runs at 27%.
- South Warehouse - if two or more of the doors 219 D, E, F & G fail to open the south warehouse smoke extract fan runs at 50%.
- Warehouse undivided - if any of the doors 226A, 226B, 227A or 227B fail to open the north warehouse extract fan runs at 75% and if two or more of the doors 219 D, E, F & G fail to open the south warehouse smoke extract fan runs at 50%.

4.5.1 FIRE-FIGHTING SHAFT

Two fire-fighting shafts of this development (refer to Section 12.2.1) will be provided with the following systems:

- **Fire-fighting lobbies**: A mechanical smoke extraction system performance specification has been developed by BDP with smoke shafts of 0.6m^2 cross-sectional area. The AOVs from the firefighting lobbies to the smoke shaft of the Theatre firefighting shaft are specified as 0.8m^2 cross-sectional area. The AOV from the lobbies to the smoke shaft of the Towers firefighting shaft are specified as 0.65m^2 cross-sectional area. An initial CFD study has been carried out by WSP the details of which are in Appendix C. Further design details of the system will be specified by the manufacturer.
- **Fire-fighting stairs**: An automatic opening vent (AOV) designed in accordance with BS EN 12101-2 is provided in both firefighting stairs with the following free areas:
  - Theatre fire-fighting stair – 2.0m^2
  - Warehouse fire-fighting stair – 1.0m^2

Upon fire detection in a lobby, the smoke ventilation system provided in this lobby actuates (on the other floors the vents remain closed) and the vent provided at the head of the stair will automatically open.

4.5.2 THEATRE AND WAREHOUSE

Warehouse

Whilst a smoke ventilation system is not required for code compliance in a building of this type, it has been used to support the evacuation strategy from the area during high occupancy uses and is considered to be a life safety system. The Warehouse has the potential to be divided into two sections by the acoustic walls, with the sections referred to as Warehouse North and Warehouse South:

- Warehouse North – 16m^3/s mechanical exhaust with make-up air provided at low level (7.5m^2 or equivalent mechanical alternative);
- Warehouse South – 30m^3/s mechanical exhaust with make-up air provided at low level (7.5m^2 or equivalent mechanical alternative).

The above volumetric rates are understood to be sized based upon the 5,000 person music concert mode which is the largest occupancy mode for the Warehouse. Therefore, in the event of a fire during this mode, the ventilation system will be already running at the time of the fire. Smoke detection is provided at a high level within the Warehouse which will activate the ventilation system if it is not already running. In addition, emergency controls shall be provided on the ground floor in the fire-fighting lobbies for use by the fire service.

As outlined in Appendix A, a CFD analysis has been carried out for the Warehouse for a 5MW fire on the stage. The smoke layer temperatures observed for this reasonable worst-case scenario are 50°C and therefore the design of the ventilation system shall ensure these temperatures are manageable. It has been confirmed that the as-built non-fire-rated duct for the smoke ventilation system is capable of performing at 60°C, therefore, it is considered acceptable to meet the requirement of the CFD modelling.

In order to avoid depressurisation of the Warehouse space, the smoke extract fans' operation has been designed to require a confirmed open signal from the makeup air doors before they start. Whilst it is considered unlikely if properly maintained, in the case of one makeup air door failing to open, the smoke extract system will not run. To overcome this, it is recommended that the system is configured to partially run (at a proportional rate to the free area) on confirmed open signals from the makeup air doors. This will ensure that in the event that say 20% of the free area is unavailable due to a failed door opening, the smoke extract can still run at 80% and provide some protection. It is noted that this is considered extremely unlikely and also does not account for the fact that during the highest occupancy events, the majority of the doors will be held open by occupants during the evacuation from the space in the event of a fire.

It is recognised that the design of the system relies on natural make-up air by automatically opening some external doors. As the smoke control system is only required during the highest occupancy events (as justified in Section 6.11), it is acceptable in line with this fire strategy that during out of hours, the smoke control system is switched to a manual mode (or a separately configured fire alarm mode) whereby activation of a fire detector or manual call point does not initiate the smoke control system.

Theatre

A dedicated smoke extract system is proposed for the Theatre to justify the removal of a safety curtain and therefore forms part of a life safety system. The system consists of:

- 13m^3/s mechanical exhaust at a high level;
- 4m^2 make-up air at a low level.
- 3m^3/s make-up air at a low level

As outlined in Appendix B, CFD analysis has been carried out for the Theatre for a 5MW fire on the stage. The smoke layer temperatures observed for this reasonable worst-case scenario do not exceed 60°C and therefore the design of the ventilation system shall ensure these temperatures are manageable. It has been confirmed that the as-built non-fire-rated duct for the smoke ventilation system is capable of performing at more than 60°C, therefore, it is considered acceptable

It is recognised that the design of the system relies on natural make-up air by automatically opening some external doors. As the smoke control system is only required during public use of the theatre, it is acceptable in line with this fire strategy that during out of hours, the smoke control system is switched to a manual mode (or a separately configured fire alarm mode) whereby activation of a fire detector or manual call point does not initiate the smoke control system.

4.6 MECHANICAL SMOKE VENTILATION SYSTEM - GENERAL CRITERIA

- A mechanical smoke ventilation system will demonstrate equivalent or better conditions in the lobby and stairs than would be provided by a natural shaft conforming to 27.1.4.2.3 and as described in BRE Project Report 79204 [N1].

NOTE: *This is usually shown by a comparative computational fluid dynamics (CFD) analysis.*

- The smoke shaft or material will be constructed of materials classified as A1 in accordance with BS EN 13501-1:2007+A1, or of materials determined to be non-combustible when tested in accordance with BS 476-4, or of any material which when tested in accordance with BS 476-11 does not flame or cause any rise in the temperature on either the centre of the specimen or the furnace thermocouples.
- Fans should be capable of handling gas temperatures of 300°C for a continuous period of not less than 60 minutes and tested in accordance with BS EN 12101-3[1].
- It should operate automatically on activation of the automatic fire detection system in accordance with BS 5839-1.
- Provide the adequate extract rate per hour as specified for each area in this report.
- Where only a single mechanical extract is provided the fans should be duty/standby fans, as fan failure would result in failure of the system.
- The system should have a power supply in accordance with BS 8519.

Note[1]: An exemption has been agreed for the smoke ventilation duct based on the CFD in Appendix A allowing for the as-built to be a non-fire-rated duct for the smoke ventilation system.

Table 4-2: Ventilation speeds in failure mode sensitivity analysis.

Area	Required Ventilation from strategy		Inlet Ventilation Provided		Failure Affecting Natural air		Failure Affecting Forced air		Percentage of Total Required Fan Extract Rate- in Failure Mode (%)
	Forced Make-up air (m^3/s)	Make-up air (m^2)	Provided natural (m^2)	Provided Forced (m^3/s)	Area (m^2)	% of required	Flow rate (m^3/s)	% of required	
Theatre	3	4	4	3	2.5	54	3	-	**46**
North Warehouse	-	7.5	2	8	2	100	8	73	**27**
South Warehouse	-	7.5	9.8	-	2.45	2	-	-	**50**
Warehouse Overall	-	15	11.8	8	-	-	8	37	**50**

A summary of the results from the above Table are shown below:

- Theatre – worst case is that door 221C fails to open which provides 54% of the total inlet air required. Therefore, it is proposed to have the extract fans in the theatre operate at approximately 46% of the total extract rate proposed, if the sensors determine that a door has failed to open.
- North Warehouse – worst case is that doors 227A / 227B fail to open which provide 73% of the total inlet air required, therefore it is proposed to have the extract fans in the theatre operate at 27% of the total extract rate proposed if the sensors determine that a door has failed to open.
- South Warehouse - worst case is that doors 219F/G / 219D/E fail to open which provide 2% of the total inlet air required, therefore it is proposed to not reduce the extract fan rates from the South Warehouse, as alternative leak paths will provide some inlet air and 2% is unlikely to affect means of escape.
- Warehouse undivided - worst case is that doors 227A / 227B fail to open which provide 21% of the total inlet air required. It is proposed to have the extract fans in the Warehouse operate at 74% of the total extract rate proposed if the sensors determine that a door has failed to open. This will mean that there will be 79% of the required inlet air provided and 74.6% of the required extract rate operating – this slight difference in the proportion of inlet and extract air, is to account for the failure mode in the North Warehouse which is more onerous. The 74.6% extract rate for the Warehouse undivided is achieved through the reduction required for the failure mode of the North Warehouse extract rate, of 27% of the total extract rate in the North Warehouse.

The above is based on each of the extract fans being capable of one failure and a minimum operating speed of 25% of the total extract rate.

4.7 DOORS ON HOLD-OPEN DEVICES

Where a door is provided where they could be a hindrance for the day to day use and are therefore likely to be wedged or propped open, they will be fitted with hold-open devices incorporating an automatic release mechanism conforming to BS 5839-3 or BS EN 1155. The door will be released upon:

- Activation of the fire detection and alarm system; or
- Failure of the power supply or system error; or
- Operation of a manual switch located to the side of the door.

4.7.1 FIRE RATED SMOKE VENT DOORS

Doors 219 D-G are part of the stair 30 minutes fire resistance. These doors offer protection to the stairs, if there is no fire in the south warehouse, these doors will not need to open, and the 30 minutes integrity of the stairs is maintained. If the doors are open due to a fire in the south warehouse, it is anticipated that the negative pressure should be maintained to keep the stair smoke-free. However, in the event of smoke ingress into the stair and is unavailable for use, during the 10 minutes evacuation delay, the staff should coordinate the escape and ensure the tower occupants use the remaining two stairs available to them.

Similar to the above, the doors (234A, 238A, 221C, 221B and 226A, 226B, 227A 227B) complete the 30 minutes integrity of the space offering protection should a fire occur in another part of the building. and in the event of a fire in the space, the doors opening to provide makeup air should maintain negative pressure, therefore, mitigating the risk of smoke spreading to other parts of the building as well.

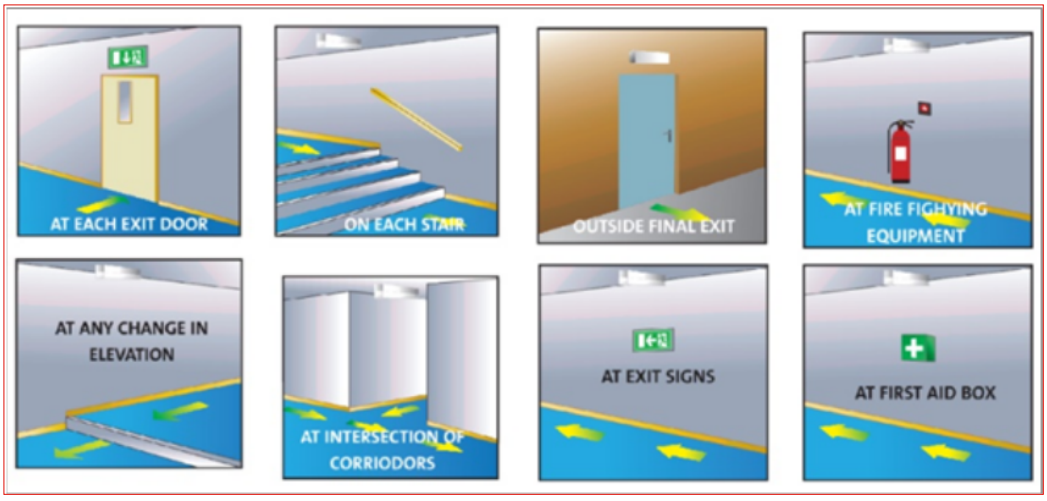
4.8 EMERGENCY ESCAPE LIGHTING

All escape routes, internal and external, must be adequately illuminated at all material times. Emergency escape lighting will be installed in accordance with the recommendations of BS 5266-1 and BS EN 1838 and provided in the areas listed below:

Table 4-3: - Emergency Escape Lighting

Occupancy Characteristic	Areas Requiring Emergency Lighting
B	All escape routes
Any use	All sanitary accommodation with a floor area over 8m^2
	Windowless sanitary accommodation with a floor area not more than 8m^2
	Electricity and generator rooms
	Switch room and battery room for the emergency lighting system
	Emergency control room

Figure 4-13 – Emergency Lighting Illustration



In event spaces, the system will be designed so that it can be blacked out during performances. However, on the failure of mains power, the system will activate automatically with manual override buttons located in strategic locations in the building such as the security room, control room, and entrance panel area to allow staff to manually bring on lighting to the event space in an emergency.

The detailed design of the system will be provided to the statutory authority by the specialist lighting designer.

4.9 EXIT SIGNS

All escape routes are to be distinctively and conspicuously marked by emergency exit signs following the recommendations of BS ISO 3864-1 and BS 5499-4. Escape route signage will be provided to include directions outside the building to the nominated assembly points. Each refuge area will be clearly marked by appropriate signs.

For the various event modes in some cases occupants will be required to escape in a specific direction and not use certain exits. In discussions with the design team as a controlled event, it is proposed to control these exit using staff to prevent use in lieu of additional fire do not enter signs. This is subject to building control approval.

Figure 4-14 – Illustration of Exit Signage



4.10 FIRE-FIGHTING LIFT

As specified in Section 12 of this report, the building will be provided with three firefighting lifts designed according to BS EN 81-72 and to BS EN 81-1 or BS EN 81-2 as appropriate for the particular type of lift. The fire-fighting lift installation includes:

- The lift car itself;
- The lift well; and
- The lift machinery space together with the lift control system and the lift communications system.

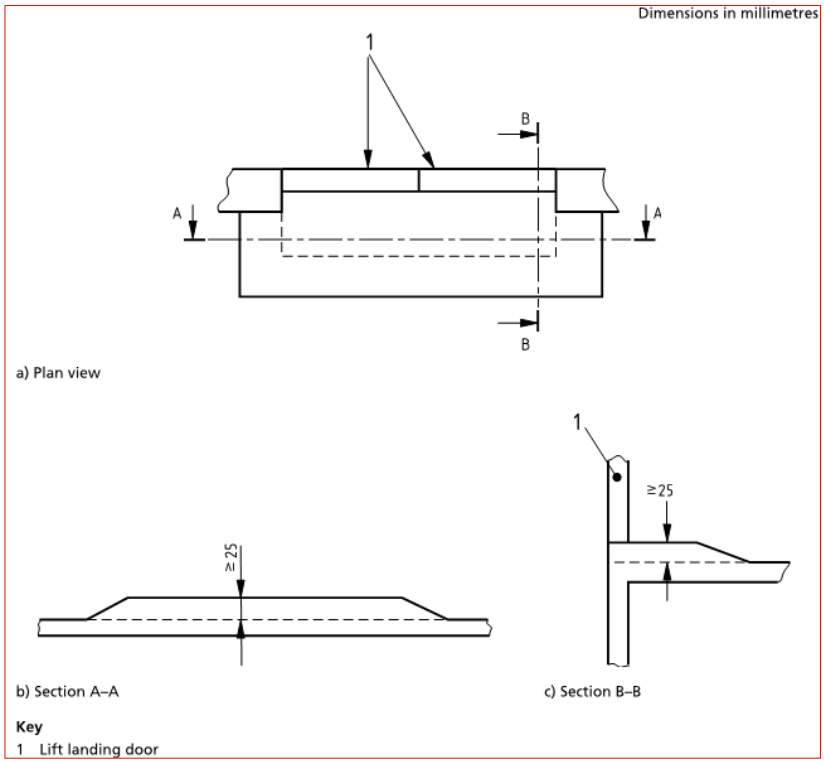
BS EN 81-72 provides guidance on water management into the lift well. Annex E in particular strongly recommends that the building is designed in such a way as to prevent ingress of water into the shaft in preference to measures to mitigate the impact of water in the shaft.

Section E.2 of Annex E provides the option of raising or ramping the floor to prevent water from entering the lift shaft and directing it to flow down the stairs or the smoke shafts. A 25mm step with a fall towards the stair is recommended in BS 9999. The standard clearly states that prevention (as outlined in E.2.) is strongly preferred to draining or pump solutions within the lift shaft (as outlined in E.3.).

Annex D of BS EN 81-72 provides requirements for the protection of electrical equipment against water.

Therefore, provided that the lift lobby is designed to prevent water ingress into the shaft (as per recommendations in E.2 BS EN 81-72) and the lift shaft and car electrical equipment is protected against water (as per recommendations in Annex D BS EN 81-72) then an additional sump/ pump will not be required.

Figure 4-15: Methods to Protect Fire-Fighting Lift Shaft from Water Ingress



4.11 FIRST-AID FIRE-FIGHTING

Hand-held first-aid fire-fighting provisions, which are not required under Building Regulations legislation, will be included to satisfy the requirements of the RR(FS)O in accordance with the end user's policies and fire risk assessment. Where provided, a fire point will be located towards each storey exit and suitable facilities associated with identified risks.

There is evidence that approximately two-thirds of fires are extinguished by the use of manual fire extinguishers. Availability of ample and appropriate fire extinguishers provides the means for this to occur. However, for this to be most effective, clear step by step signage on how to operate the fire extinguisher will be provided within the extinguisher storage area for trained staff members. The storage location will be clearly signed and readily accessible in an emergency.

Note; *This is cited in Annex B4 of BS 7974-2019 Application of Fire Safety Engineering Principles.*

Portable extinguishers will be deployed throughout the buildings in accordance with BS 5306-8 & AHJ (Building Control) requirements.

The type and size of extinguishers are to be selected based on the hazard being protected. The purpose of portable fire extinguishers is to control the growth and spread of fire in its early stages of development. Where Fire Extinguisher Cabinets are used these will be readily accessible and immediately available and will not be kept locked in any case within the facility. The extinguishers will be installed on hangers or in the brackets supplied by the manufacturer, mounted in cabinets, or placed on shelves.

Staff will be trained on the use of these extinguishers and will be familiar with their locations and emergency operation procedure.

For guidance on the provision of fire-fighting equipment, reference should be made to BS 5306-8 and OMA drawings – MF-OMA-XX-GF-SK-A-10-0200 to MF-OMA-XX-GF-SK-A-10-0270

Figure 4-16 – Types of Portable Extinguishers



4.12 SECONDARY POWER SUPPLIES

A secondary power supply is required for essential fire safety measures these measures are discussed in the BDP Fire Strategy Clarifications document (Ref: MF-BDP-XX-XX-RP-MX-45-0004). A summary of the provision of primary and secondary power supplies is shown below:

- Emergency lighting and signage
  - All emergency lighting cabling being 2 hours fire-rated and power shall be supplied by central battery units mounted at level 7 in the warehouse and level 4 in the theatre.
- Normal Lighting for fire-fighting shafts
  - All lighting in fire-fighting shafts shall have a secondary supply from the central battery.
- Fire-fighting lifts and evacuation lifts (including platform lift for control room)
  - Primary electrical supplies – provided via the main substation within the arches. For the Theatre, the supply is routed to a sub-switchboard which in turn feeds all primary supplies.
  - Secondary electrical supplies – provided from the roof top mounted generators and Life Safety Switchboards.
  - Both supplies are routed separately in 2 hours fire-rated cable to the Automatic Transfer Switch located in the head of the lift shaft.
- Smoke ventilation system
  - Primary electrical supplies for the Warehouse – provided via the main substation within the arches. For the Theatre, the supply is routed to a sub-switchboard which in turn feeds all primary supplies.
  - Secondary electrical supplies – provided from the roof top mounted generators and Life Safety Switchboards. For the Theatre, these are routed to a sub-switchboard before routing to all secondary supplies.
- Smoke ventilation system make up air damper/ door openers

- Automatic fire detection and alarm system
  - Primary electrical supplies – provided to the main fire alarm panel are a single feed from the main electrical switchboard.
  - Secondary electrical supplies – provided via the batteries integral to the panel.

These systems shall comply with their respective British Standards regarding alternative power supplies.

5 MEANS OF ESCAPE - GENERAL

5.1 INTRODUCTION

This section presents the general means of escape provisions applicable throughout the development. As the development is sub-divided into a number of areas having different levels of fire risk and evacuation strategies, specific provisions are detailed in the following sections:

Table 5-1: Specific means of escape provisions

Means of escape provisions related to	Report Section
Warehouse	Section 6
Theatre	Section 6.17
Foyer	Section 7
Towers	Section 8

5.2 EVACUATION PHILOSOPHY

The means of escape has been designed based on the following assumptions:

- Any fire in the building is assumed to be unintentional and therefore it is unlikely to start in two different locations at one time;
- The building will be evacuated by staged simultaneous evacuation in the event of a fire, the area affected will evacuate first followed by the rest of the areas.
- Each event mode will be provided with a sufficient number of trained staff/safety stewards.

In order to limit the impact of false alarms, a two-stage evacuation will be in place where there is an investigation period before the fire alarm sounders are activated. Also, the evacuation will be staged to allow for the performance areas (Theatre and Warehouse) to be evacuated separately to the Towers, as discussed in Section 4.2. The exact detailing of the alarm arrangements will depend on the events taking place and will be controlled in line with a Fire Safety Management Plan.

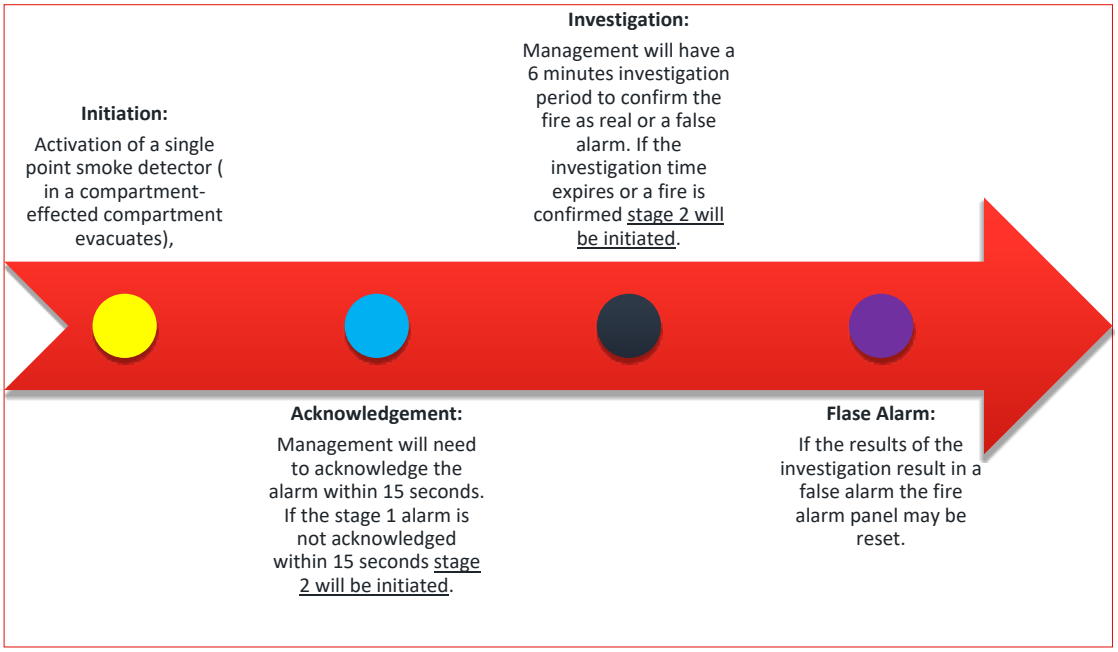
A typical sequence of events for two-staged evacuation is as follows:

- Initially, a coded staff alert is given.
- There is then an investigation period (Not exceeding 6 minutes)*.
- The evacuation signal is broadcast:

**Note: It is anticipated that in events mode, a fire on stage in the theatre or warehouse will be detected early by the occupant and therefore evacuation of the space will commence immediately.*

Stage 1 of the alarm sequence is outlined graphically below.

Figure 5-1 – Fire alarm stage 1

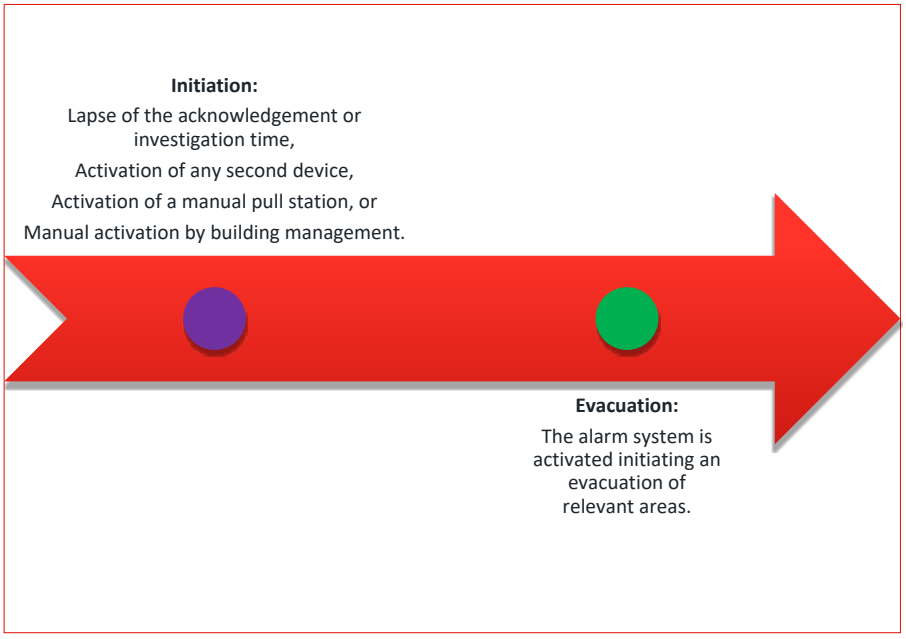


- If a fire is confirmed; or
- If an agreed investigation period lapses without the alarm being cancelled; or
- If a manual call point (break glass) or a second detector is activated during the investigation period.

Note that occupants in inner rooms will be immediately alerted in the event of fire detection in the access room (refer to Section 5.8.4).

Stage 2 of the evacuation sequence is outlined graphically below.

Figure 5-2 – Fire alarm stage 2



5.3 FIRE SCENARIOS

5.3.1 OUT OF NORMAL HOURS USE / PARTIAL USE OF THE PREMISES

It will be ensured that appropriate exit provisions can be maintained without compromising security and safety management.

Normal Mode

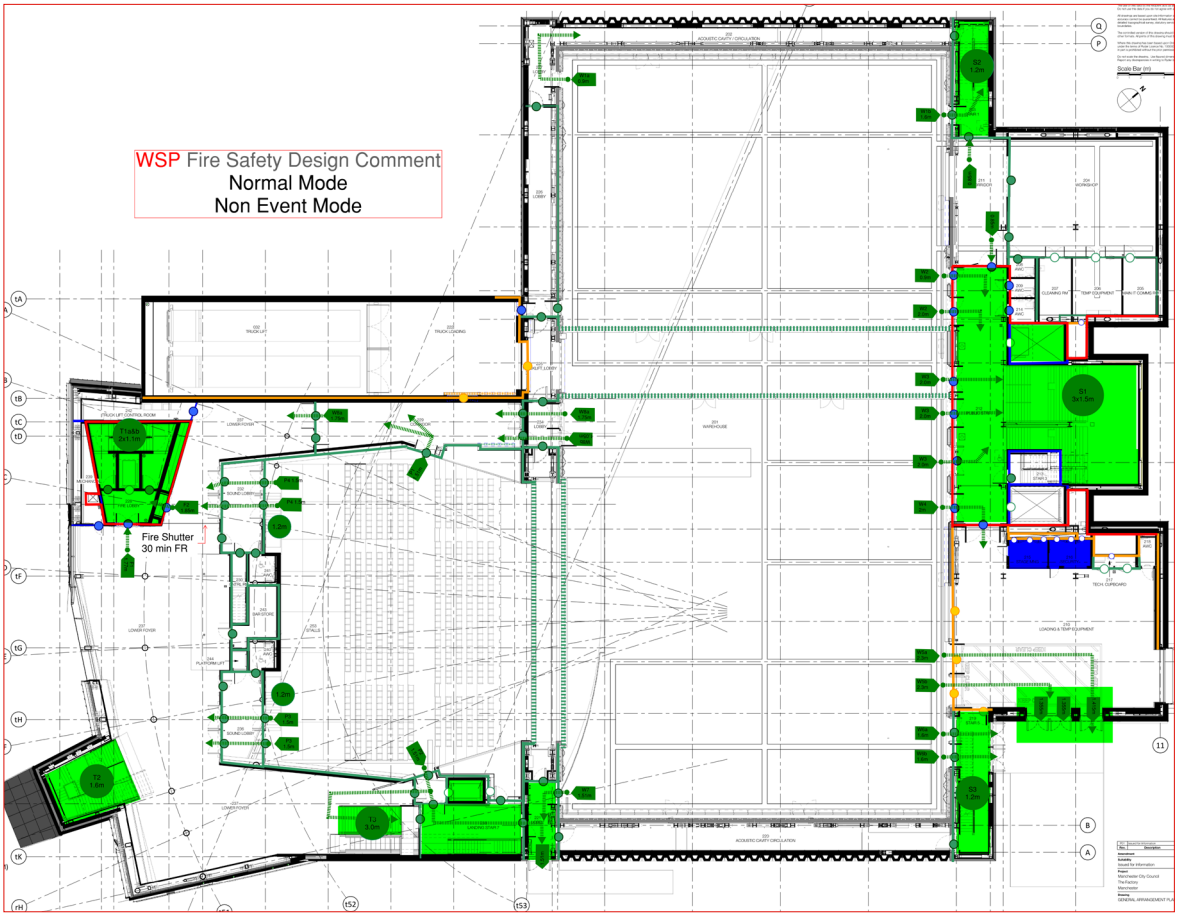
This mode is defined as including the following uses:

- Day-to-day usage, with no major events taking place;
- Out of hours usage;

Upon confirmation of a fire this mode operates with a simultaneous evacuation philosophy.

Note: During this mode, the smoke ventilation will not be activated for security and non-staff occupants in the building. Furthermore, this mode includes MIF vision to have limited areas of the building open to members of the public. (Excludes theatre and warehouse areas, events spaces)

Figure 5-3: Normal and non-event modes



The highlighted areas show the means of escape route available in this mode and fire scenario.

Occupants are provided with multiple escape routes, should one become unavailable due to the location of a fire, the others can be used in this mode.

5.3.2 EVENTS MODES – FIRE SCENARIOS

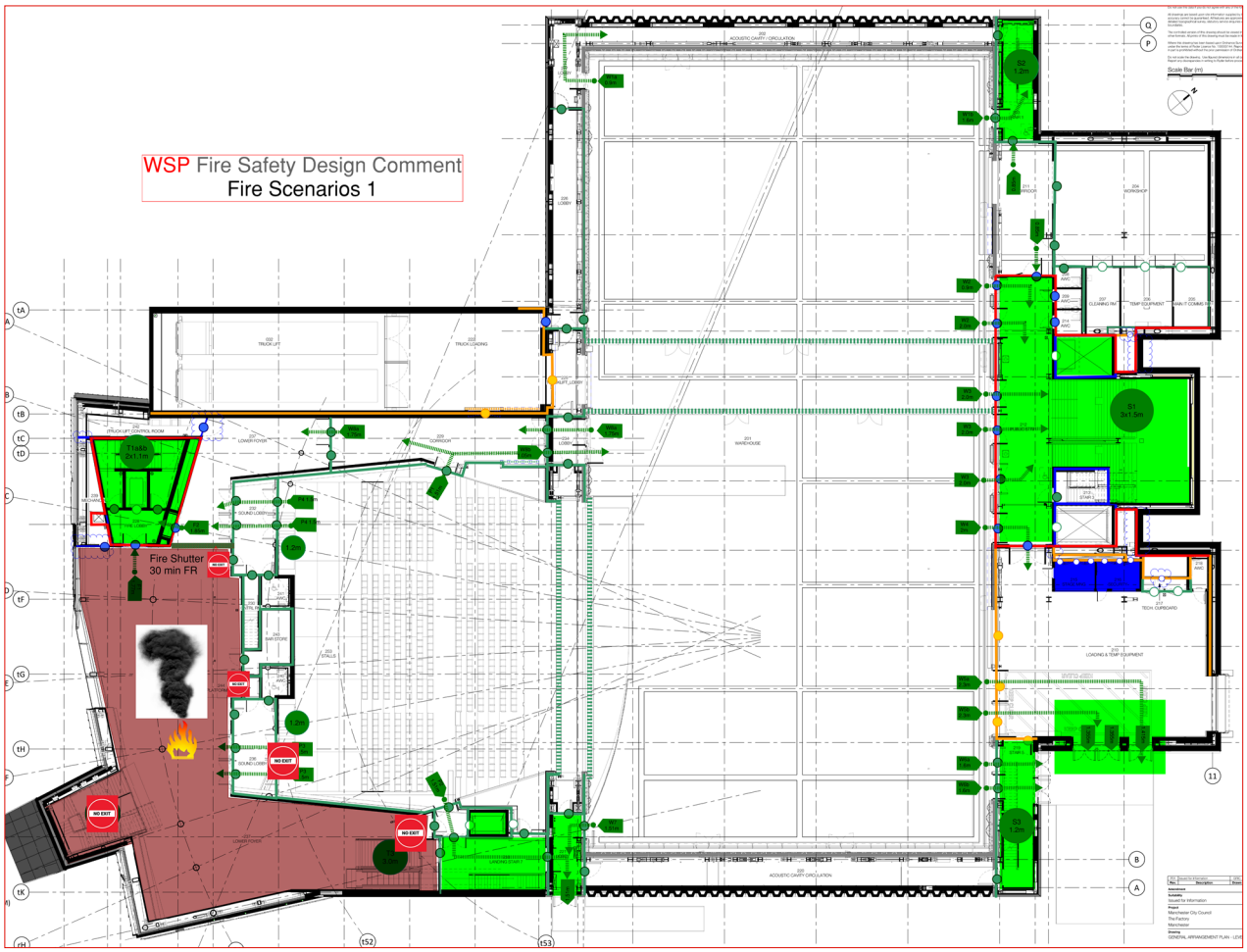
During all event modes, when evacuation is to be initiated by staff, the use of the public address voice alarm system is considered the most appropriate.

Staff must be adequately trained in the use of the system and it is presumed that the main control of the system will be coordinated from the security room and staff will be located at predetermined strategic locations to direct occupants to the most appropriate exit. The route will be coordinated with the staff using a two-way radio between the staff and the security room overseeing the building evacuation.

Fire Scenario 1

A fire in the lower foyer area on level two therefore, making stairs T2 and T3 and exits leading to this unavailable for use.

Figure 5-4: Fire scenario 1

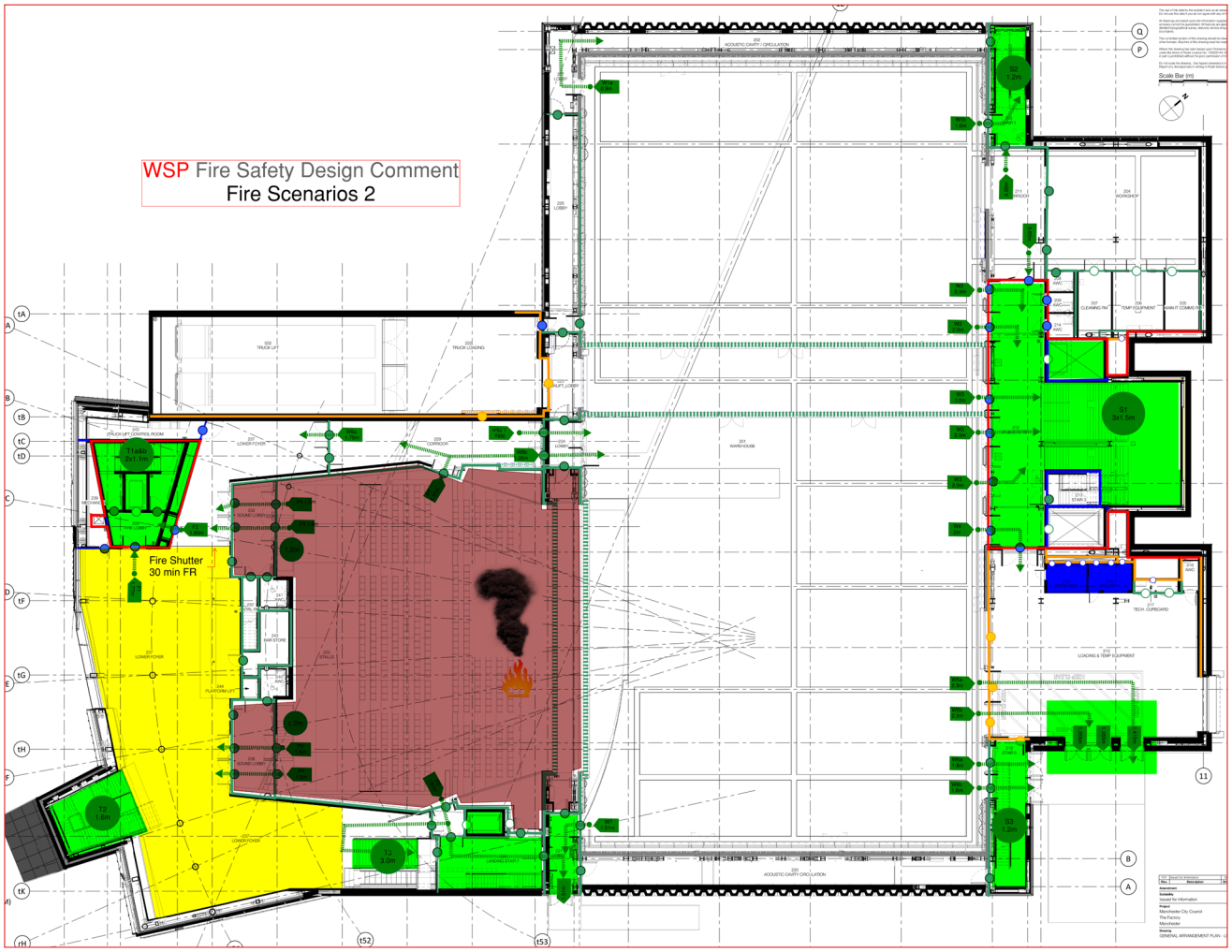


Fire Scenario 2

A fire in the theatre is most likely to occur on the stage, therefore, priority is given to evacuating theatre occupants away from the space at the earliest, the lower foyer can be used as a holding area while occupants evacuate in an orderly manner.

It is noted, that, occupants can also use the warehouse and all available exits to mitigate risk of crowds at exits. For more information see evacuation model F.

Figure 5-5: Fire scenario 2

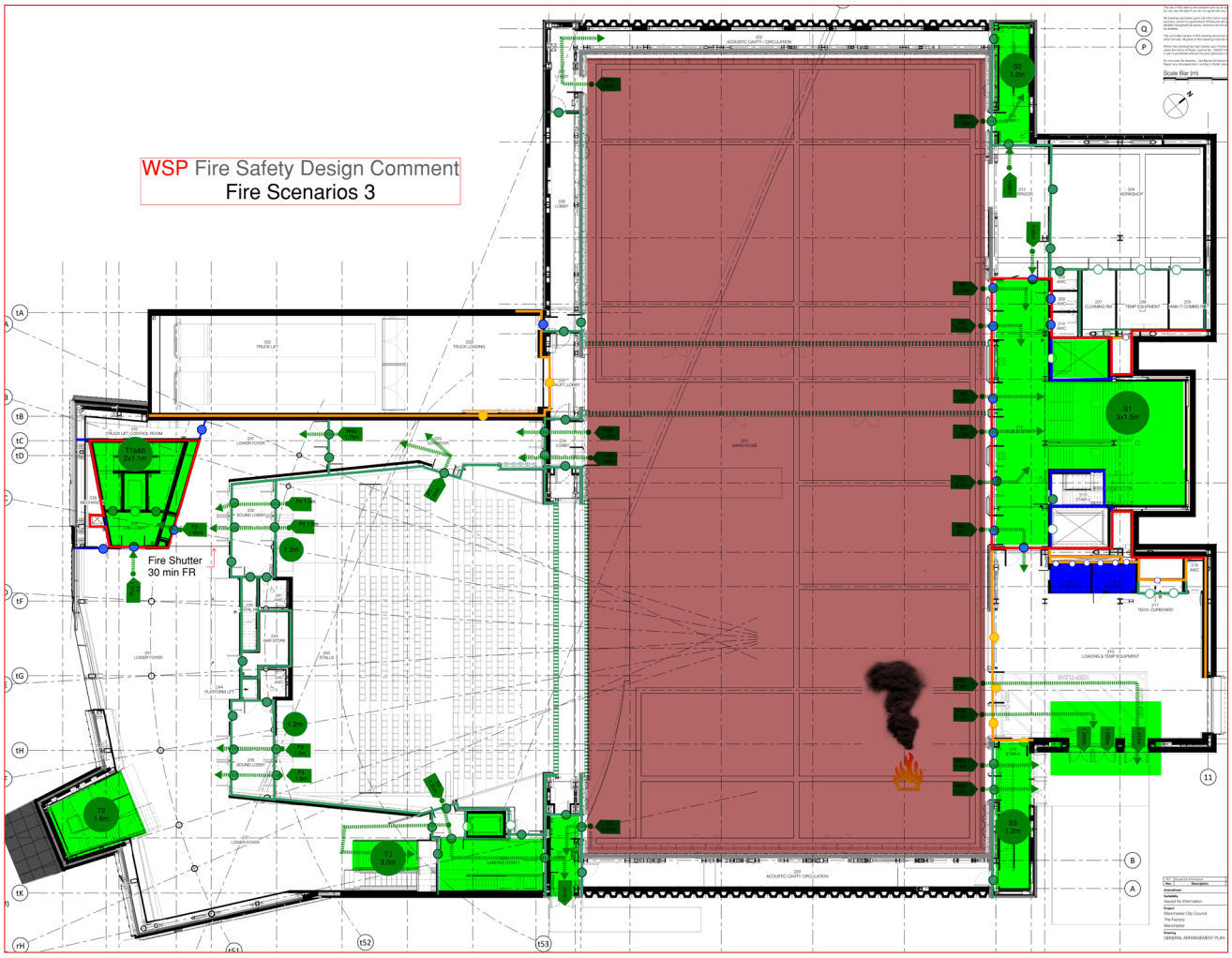


Fire Scenario 3

A fire in the warehouse is most likely to occur on the stage, therefore, priority is given to evacuating occupants away from the space at the earliest.

Occupants can also use the theatre escape route and all available exits to mitigate risk of crowds at exits. For more information see evacuation model G or I.

Figure 5-6: Fire scenario 3

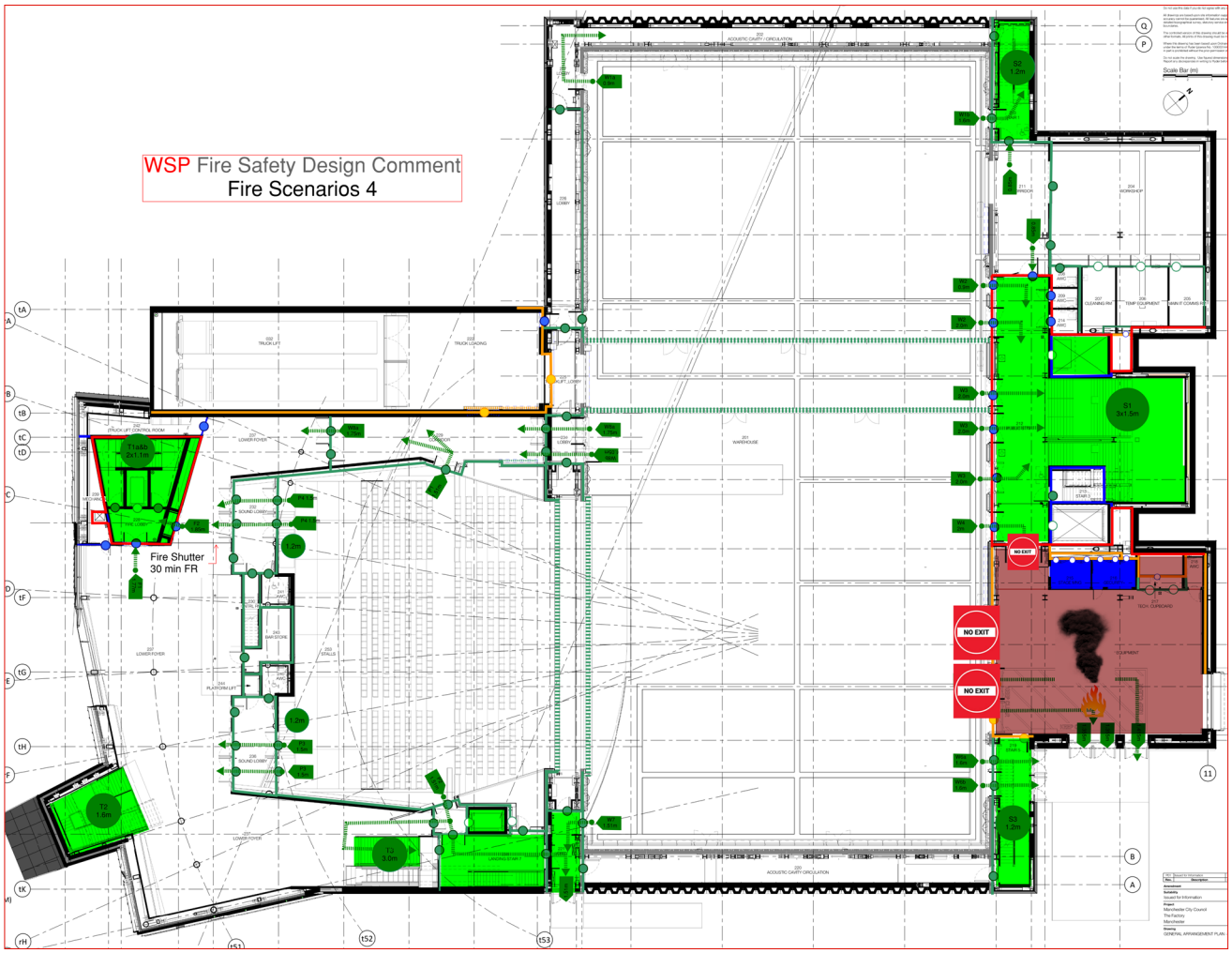


Fire Scenario 4

A fire in the loading bay area on level two makes exits W5a and b and other exits leading to this area unavailable for use.

Occupants can use the theatre escape route and all available exits to mitigate the risk of crowds at exits.

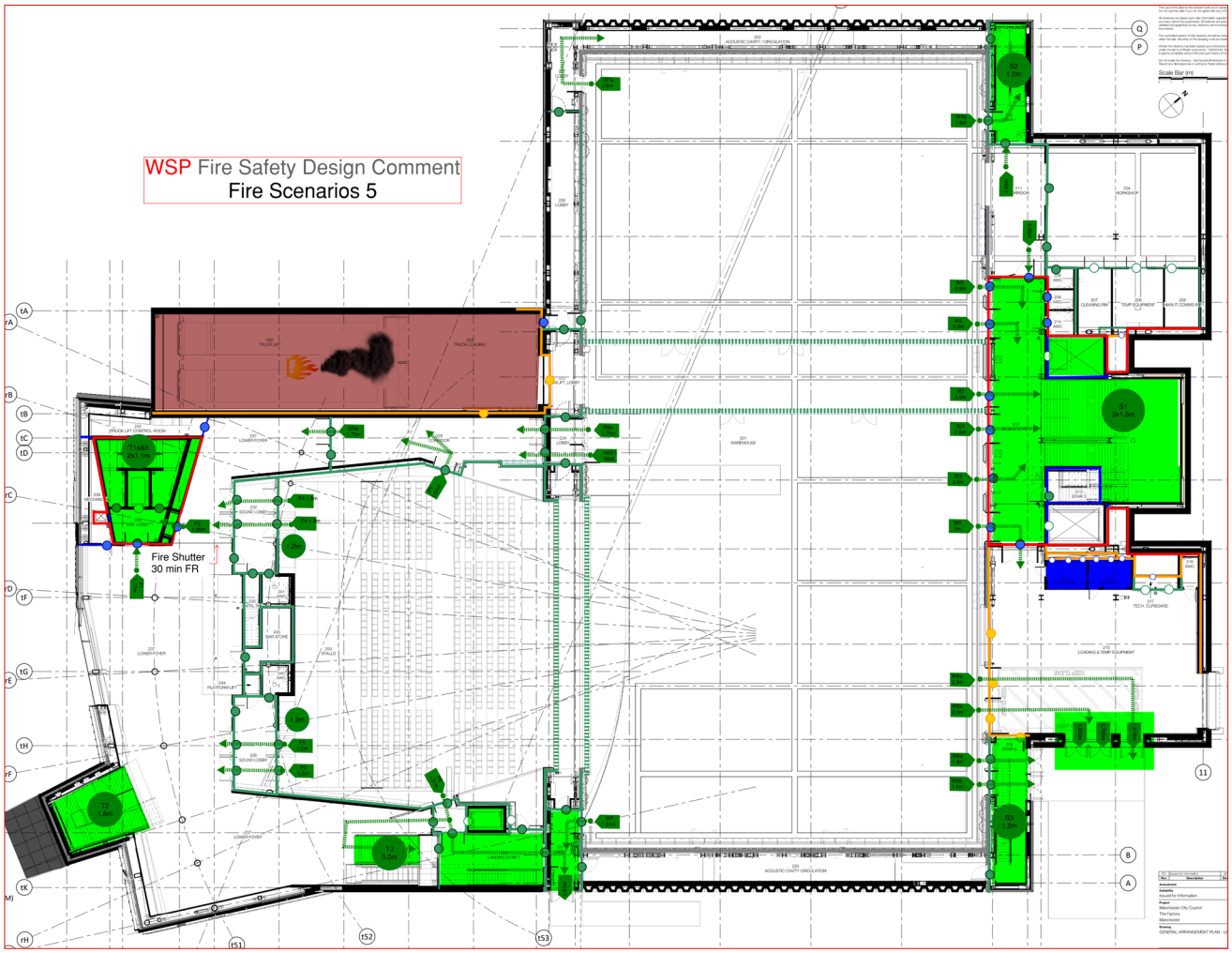
Figure 5-7: Fire scenario 4



Fire Scenario 5

A fire in the truck lift will follow the truck lift fire strategy produced by Pearson Consult Ltd (Truck lift PCL - MCC -Draft Truck Lift PEEP). and the building should be evacuated in an orderly manner using all the available exits.

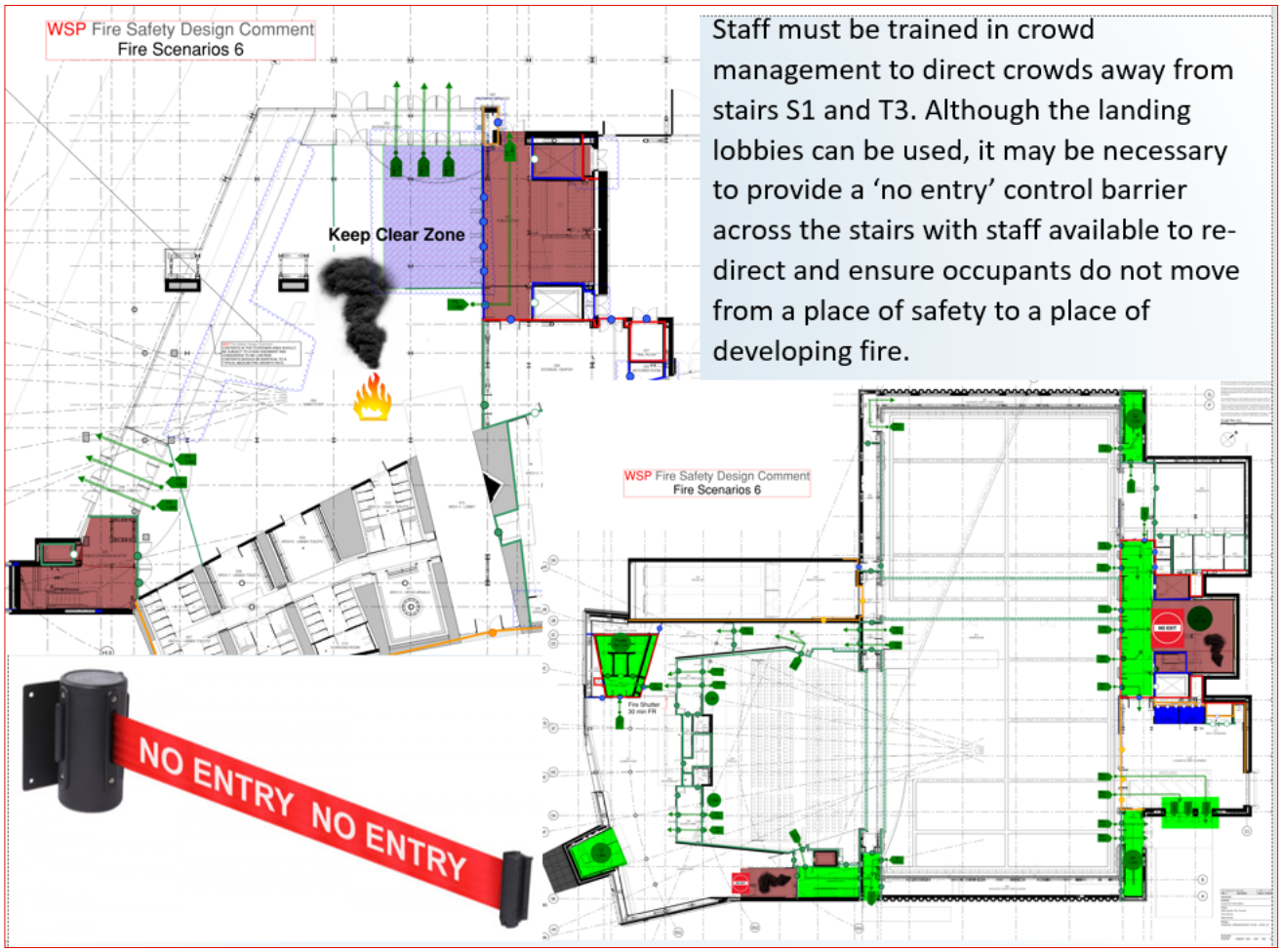
Figure 5-8: Fire scenario 5



Fire Scenario 6

A fire in the ground floor foyer area makes stairs S1 and T3 and exits leading to these unavailable for use.

Figure 5-9: Fire scenario 6

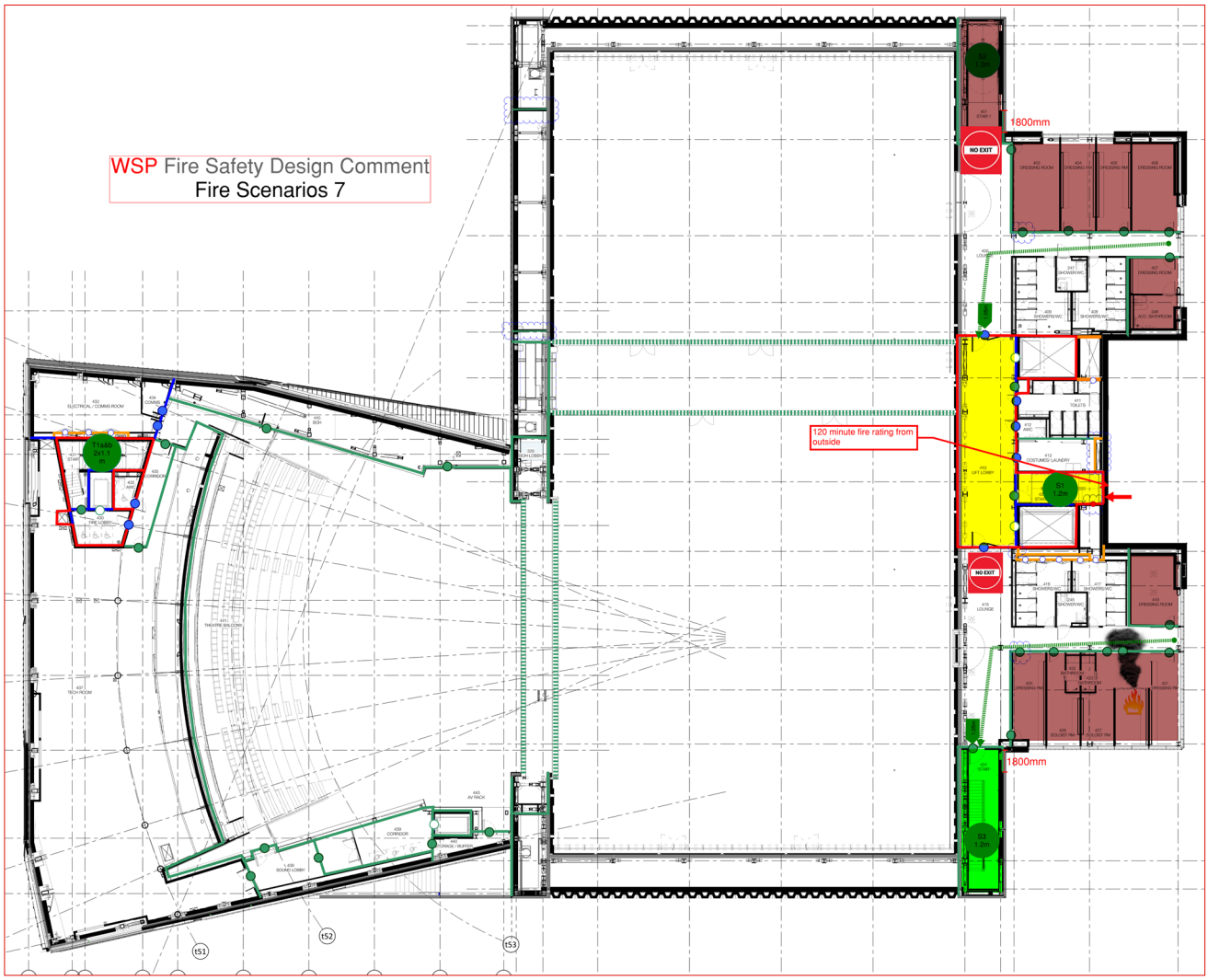


Fire Scenario 7

A confirmed fire in the tower or technical grid or non-event space area will result in the evacuation of the fire location as a priority, therefore, occupants of the tower will need to be evacuated at the same time as the associated warehouse.

During event mode, staff must be trained to recognise, that more occupants will be directed to use the theatre exits. It is recommended that tower occupants should use stairs S1 and S3 to mitigate the merging flow expected at stair S2 at level 02.

Figure 5-10: Fire scenario 7



5.4 MINIMUM HEIGHT OF ESCAPE ROUTES

A clear height of 2.0m will be maintained throughout the escape route.

5.5 MINIMUM NUMBER OF EXITS

Any room or storey will be provided with a minimum of:

- Two exits where the occupancy is greater than 60 people; and
- Three exits where the occupancy exceeds 600 people.

5.6 DIRECTION OF OPENING

Any doors used by more than 60 people will open in the direction of escape.

Doors will also not reduce the minimum width of the means of escape when open.

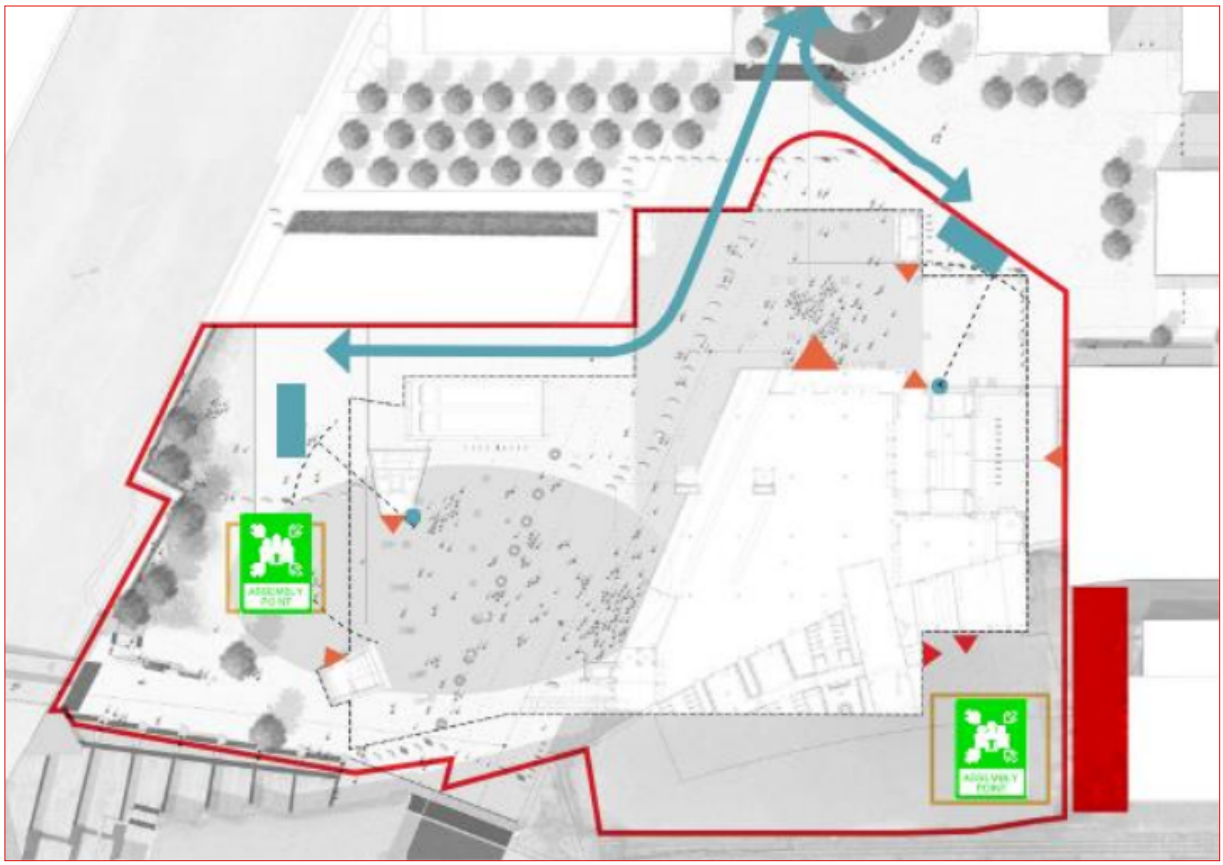
5.7 FIRE ASSEMBLY POINTS

Exterior assembly points will be provided for the building according to best practice and areas designated as exterior assembly points will be provided remotely from the exterior wall of the building served and provide a clear area of 0.5m^2 per occupant expected.

Following coordination with MIF, the following muster point locations and strategy have been agreed.

- Staff - staff muster point will be in the northern section of Festival Sq
- Visitors (<2,000) - for events with up to 2,000 attendees, visitors will be congregated in Factory Sq (the total capacity is approx.2,100)
- Visitors (<2,000) - for events with over 2,000 attendees, a dispersal - as opposed to a muster - strategy will be instituted

Figure 5-11: Indicative fire assembly points



MIF will undertake crowd movement modelling, with an ambition to increase the crowd size that could be 'mustered', utilising Factory Sq, Festival Sq, and Victoria St

Exterior exit discharge routes will be maintained clear of obstructions, furthermore, during major events, an exclusion zone will be employed by MIF in collaboration with MCC. The assembly points are to be coordinated with relevant stakeholders and located away from the emergency vehicle access route. Furthermore, it will be provided with both signage and lighting on either emergency power or on an alternate supply from the building.

5.8 HORIZONTAL MEANS OF ESCAPE

5.8.1 CAPACITY

The capacity of horizontal means of escape throughout the development will be estimated as described in the Table below.

Table 5-2: Horizontal Capacity Calculation

Step	Description
1	Determine the applicable risk profile (refer to Section 3.2)
2	Determine the minimum width per person based on the applicable risk profile using Table 12 of BS 9999
3	Consider additional fire safety measures provided (refer to Section 5.10)
4	Determine reduction percentage based on additional fire safety measures and calculate the width per person using this percentage
5	Calculate the capacity of each exit. Note that for doors less than 1050mm in width the capacity will be determined as follows: $\text{Capacity} = \frac{500}{Width\ per\ person}$
6	Calculate the total capacity of the storey/area exit assessed. When estimating the capacity of a storey/area having two or more exits discount the largest exit to assume that a fire might prevent the occupants from using one of them

In addition to the above, escape routes will comply with the minimum width:

- **Cross-corridor door:** minimum calculated corridor width minus 150mm or 1,050mm, whichever is greater;
- **Any other door:** 800mm;
- **Corridor:** 1,200mm;
- **Double doors:** the width of one of the leaves will be not less than 800 mm.

Note: wider escape routes may be required under Part M for use by mobility-impaired persons.

5.8.2 TRAVEL DISTANCE

Travel distances will comply with the recommendations of Section 16.4 of BS 9999 and will be measured to the nearest storey exit, to outside or to a separate compartment.

The travel distance limits depend on a number of parameters such as the risk profile applicable to the area (refer to Section 3.2) and the additional fire safety measures provided (refer to Section 5.10). They are specified in each specific section.

5.8.3 TRUCK LIFT

The truck lift means of warning and escape detailed design has been designed by Pearson Consult Ltd the specialist designer and their recommendations detailed within the truck lift design report will be adopted. For more information see Pearson Consult Ltd – Truck lift PCL - MCC -Draft Truck Lift PEEP Document.

Pearson truck-lift cause and effect will be coordinated to ensure alignment with the rest of the building cause and effect. therefore, ensuring that doors that are required to open to provide make up air for the theatre or warehouse smoke ventilation will function as required.

5.8.4 INNER ROOMS

In order to satisfy the recommendations in the BS 9999, the inner rooms will align with the following:

- Automatic fire detection will be provided within access rooms to provide early warning of fire to those occupants in the inner rooms. Detection of a fire in the access room will trigger the alarm in the inner room based on a single knock.
- The occupancy of the inner room will not exceed 60 people.
- They will be entered directly off the access room.
- The escape route from the inner rooms will not pass through more than one access room.
- The travel distance from any point in the inner room to the exit from the access room will not exceed the recommendations of relevant following sections.
- The access room will not be a place of special fire hazard.

5.8.5 CHANGES IN LEVEL

Single steps should be avoided. Where single steps are provided, they will be appropriately marked.

5.9 VERTICAL MEANS OF ESCAPE

5.9.1 CAPACITY

Table 5-3: Vertical capacity calculation

Step	Description
1	Determine the applicable risk profile (refer to Section 3.2)
2	Determine the minimum width per person based on the applicable risk profile using Table 13 of the BS 9999
3	Consider additional fire safety measures provided (refer to Section 5.10)
4	Determine reduction percentage based on additional fire safety measures and calculate the width per person using this percentage
5	Calculate the capacity of each stair
6	Calculate the total capacity of the storey/area exit assessed. When estimating the capacity of a storey/area having two or more exits discount the largest exit to assume that a fire might prevent the occupants from using one of them. This is not applicable where all staircases are provided with lobbies (note: lobbies are not required on the top floor-unless the stair also functions as a fire-fighting shaft).

In addition to the above, staircases will comply with the minimum width:

- Staircases serving staff areas only (risk profile A): 1.0m;
- Staircases serving public areas (risk profile B): 1.1m.

Note: wider staircases may be required under Part M and Part K.

Final exits from stairs will be at least as wide as the stair they serve.

5.9.2 METHODS OF VERTICAL ESCAPE FOR DISABLED PEOPLE

Where disabled people cannot evacuate directly to outside without assistance, provisions will be made so that they can reach a place of relative safety without assistance. In this development their evacuation will be addressed by providing refuges complying with the provisions of Annex G of BS 9999 summarised below:

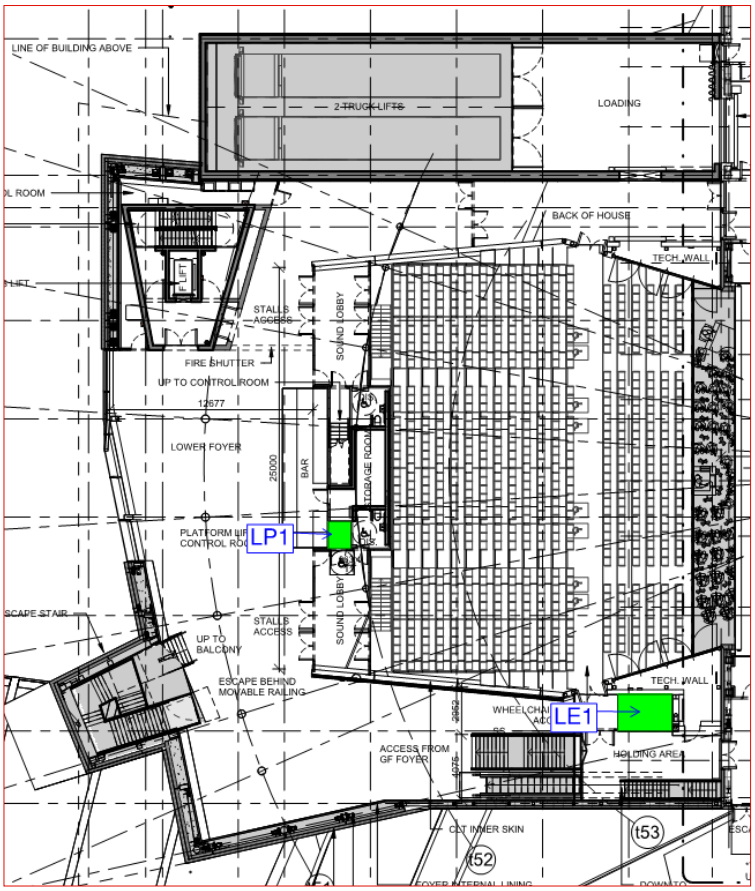
- Have a designated signed area of at least 900 mm x 1400 mm.
- Be located outside of the flow of evacuating occupants, so as not to cause an obstruction to the evacuating occupants.
- The door accessing the refuge area will have a clear width of not less than 850 mm.
- Be provided with an Emergency Voice Communication system complying with BS 5839-9.
- In addition, a number of lifts in the theatre will be designed as evacuation lifts in order to assist the evacuation of disabled occupants:
- Platform lift (LP1) serving the control room at level 02
- South lift (LE1) serving all floor of the Theatre.

The end-user will be required to develop a Personal Emergency Evacuation Plan (PEEP) for any person requiring assistance during a fire.

It is recommended that in addition to the lift, evacuation chairs should be provided in safe storage in two locations on the ground floor warehouse and theatre area for use by trained staff when evacuating any disabled occupants.

It is the responsibility of the building management to evacuate all persons. Adequate amount of staff should be made available for each event mode and all relevant staff should be trained to safely assist occupants to a place of ultimate safety (i.e. external assembly point) as reliance cannot be placed on the fire service to evacuate disabled occupants.

Figure 5-12: Evacuation lifts – Theatre



5.10 ADDITIONAL FIRE PROTECTION MEASURES

BS 9999 allows increasing travel distances and reducing escape widths where the fire protection measures provided in the building offer additional benefits in terms of life safety compared to a design strictly meeting the minimum recommendations of this guidance document.

In this development, a number of areas will be provided with additional fire protection measures:

- Automatic fire detection system: a number of areas only require the provision of a manual fire detection and alarm system (risk profiles A2, B1 and B2) but an automatic fire detection and alarm system (L2+M) will be provided within the premises. As such, this system will provide an early warning to the buildings' occupants in the event of a fire compared to a manual system. BS 9999 allows for:
  - A 15% increase in allowable travel distance and;
  - A 15% reduction in door width, corridor width and stair.
- Effect of ceiling heights: BS 9999 allows for increase in allowable travel distance and a reduction in door width, corridor width and stair width depending on the floor to ceiling height as described in Table 14 of BS 9999.

These variations will not exceed the maximum acceptable variations provided in Section 18.4 of BS 9999.

5.11 SEATING AND GANGWAYS ARRANGEMENT

The Theatre is provided with permanent fixed seating on the upper tier and temporary seating can also be provided in the lower tier as well as the Warehouse. These elements should comply with the recommendations of Annex D of BS 9999 summarised hereinafter.

5.11.1 FIXED SEATING ARRANGEMENT

5.11.1.1 SEATWAY WIDTH

The occupants within the seated area are required to have sufficient space available between their seat and the rear of the seat in front of them to be able to traverse to the gangway at the end of the row. This space is called the seatway, and is measured from the forward most projection of your seat to the rear of the seat in front as shown in Figure 5. If the seats automatically tilt up when the occupant stands up then the width may be measured to the forward most projection of the seat when it is in the raised position.

The required seatway width varies with increasing numbers of seats. The number of seats in a row is to be determined according to Table 6.

The ends of all rows of seats should be so aligned as to maintain a uniform width throughout the length of a gangway, unless the escape flow would be in one direction only (i.e. access to any alternative means of escape is along the rows), in which case the gangway may widen towards the storey exit.

Where exits are approached from a stepped gangway, there should be a landing the width of the exit and at least 1100 mm deep immediately in front of the exit doors.

Figure 5-13: Determination of seatway (BS 9999, Figure D.1)

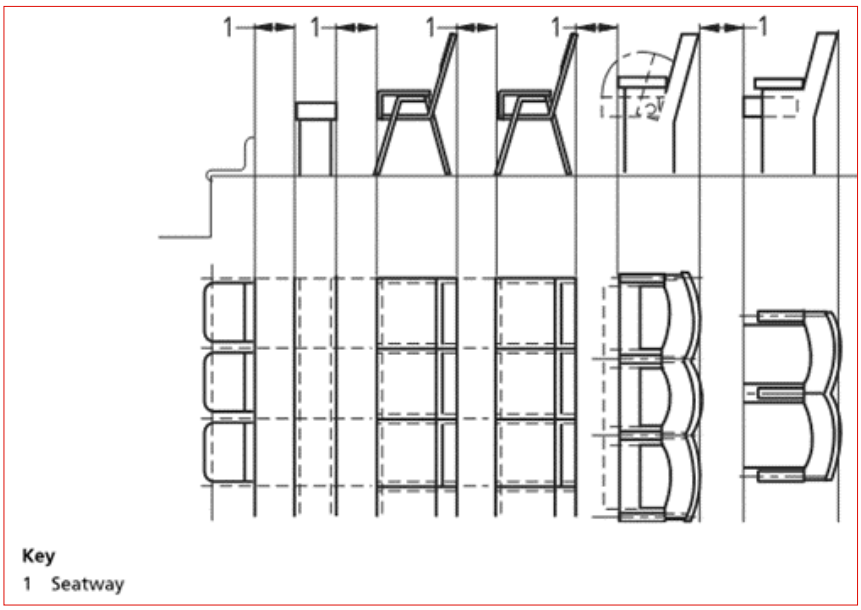


Table 5-4: Number of seats in a row

Seatway width	Maximum number of seats in a row	
	Gangway on one side	Gangway on two sides
300 to 324	7	14
325 to 349	8	16
350 to 374	9	18
375 to 399	10	20
400 to 424	11	22
425 to 449	12	24
450 to 474	12	26
475 to 499	12	28
500 or more	12	Limited by the travel distance

5.11.2 ADDITIONAL PROVISIONS FOR TEMPORARY SEATING

Temporary seating can be provided in the different event spaces of the development. The arrangement of the seating should comply with the recommendations of Appendix D of BS 9999 presented below:

- Seating for more than 50 persons laid out on the floor area should be secured together in lengths of not fewer than four seats.
- Seating for more than 250 persons, provision should be made for fixing to the floor the rows of seating flanking the front, the back and the cross gangways and the seats near exits, although only the end seats of the rows need to be fixed to the floor if all the seats are secured together.
- Where seats are secured together, it should not be possible to separate them, nor for a row to “snake”, merely by pushing one or more seats in a row.
- Access should be available beneath all temporary tiered seating to clear any accumulated rubbish.

The underside surfaces of all plywood decks to temporary seating should be Class 0. All surfaces of side panels, back panels and fascias to temporary tiered seating should be Class 0.

5.11.3 FURNITURE, SEATS, CARPET, MATS AND DRAPES (GENERAL)

General any upholstered seating, mats, flags, netting, carpets and other textile floor coverings and underlays should be resistant to ignition.

In terms of hazard category for the public spaces the seating shall meet a medium hazard category, which requires the following tests to be satisfied:

- Resistant to ignition source: smouldering cigarette as specified in BS EN 1021-1:2006.
- Resistant to ignition source: match flame equivalent as specified in BS EN 1021-2:2006.

- Resistant to ignition source 5 for upholstery composites as specified in BS 5852:2006.

Specifications for the fire performance and testing of furniture and furnishings can be found in the following standards:

- ignitability of upholstered furniture (including composites of cover material and infill) and loose covers: BS 5852;
- resistance to ignition of upholstered furniture for non-domestic use: BS 7176;
- flammability of fabrics for curtains and drapes(including nets and linings): BS 5872-2;
- burning behaviour (ignitability and flame spread) of curtains and drapes: BS EN 1101 (ignitability) and BS EN 1102 (flame spread);
- gymnasium equipment: BS 1892-2.9;
- assessment and labelling of textile floor coverings: BS 5287.88

All filling materials for all seating hazard categories shall pass the relevant test contained in the annexes given in the Furniture and Furnishings (Fire) (Safety) Regulations 1988.

FLAGS, BANNERS AND NETTING

Any flags and banners, to create a venue theme should be made from, or treated with, fire-retardant material and have a supporting fire certificate to an accepted fire testing standard.

STAGE MATERIALS

As an open theatre and stage venue design, the materials, props etc used for any performance should meet the fire safety requirement recommended in Association of British Theatre Technicians (ABTT) guides and any MIF fire safety standards.

6 MEANS OF ESCAPE – EVENT MODES

The building will be used in two modes, normal modes with no major event taking place and events mode which consists of eight different event modes as shown in the figure below.

Normal Mode

The first of these modes is called “Normal Operation Mode”, this mode is defined as including the following uses:

- Day-to-day usage, with no major events taking place;
- Out of hours usage;

Upon confirmation of a fire, this mode operates with a staged simultaneous evacuation philosophy and does not activate any smoke control systems. This is to prevent any security concern regarding doors automatically opening to provide inlet air and the smoke control is not required by the fire strategy for this level of occupancy.

Event Modes

There are multiple event modes, nine in total as shown in figure 6.1 of this report, the events vary from standing to seating modes, in order to make the use of the building as flexible as permitted.

It should be noted that a sufficient number of staff must be trained to operate and manage evacuation for each event mode. The number of occupants permitted for each event will be controlled by staff using ticketing. Furthermore, some of the event modes are identical and the only difference is seating mode or standing mode. Such as Event scenarios (A and I). (B, C and D). (E. F and H) and G.

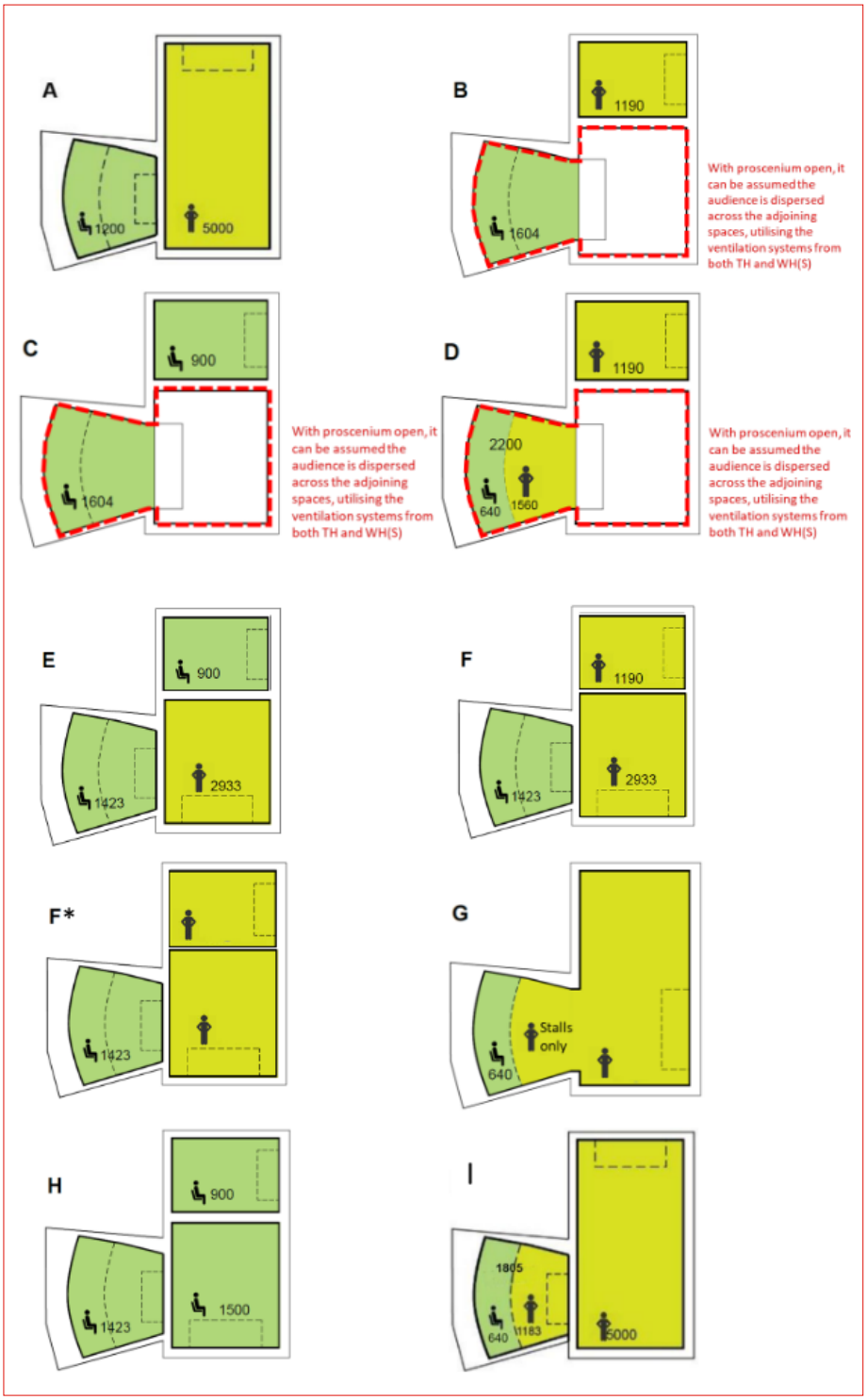
Table 6-1 – Proposed Event Modes Occupancy

Event mode	Theatre	Warehouse North	Warehouse South	Total Persons
A	1200	5000		6200 persons
B	1604	1190		2794 persons
C	1604	900		2504 persons
D	2200	1190		3390 persons
E	1423	900	2933	5256 persons
F&F*	1423	1190	2933	5546 persons
G	640	6165		6805 persons
H	1423	900	1500	3823 persons

I	1805	5000	6805 persons

Note: the total persons stated in the above table include staff and performers. Furthermore, the events with the most anticipated occupants are events modes G and I, having a total of 6,805 persons each.

Figure 6-1: Proposed Event Modes Diagram



6.1.1 TRAVEL DISTANCES

Travel distances vary according to the risk profile; they are summarized in Table 10. The travel distances in the Warehouse comply with the most onerous distances (B3 risk profile). However, these will have to be reassessed prior to any events where equipment/partition/furniture are provided that may have an impact on the travel distances.

For events with a large number of people, travel distances are irrelevant as the evacuation time will be driven by queuing through doors.

Table 6-2: Travel distance recommendations

Risk profile	Maximum travel distance (m)(1)	
	One direction	More than one direction
B1	24	60
B2	20	50
B3	16	40
Area with seating in a row	15	32
A3 (Plant areas)	18	45
A2 (Staff areas)	55	22

(1) It may be possible subject to a risk assessment to increase these travel distances where additional fire protection measures are provided (refer to Section 5.10).

In all areas, the travel distances are compliant with the above.

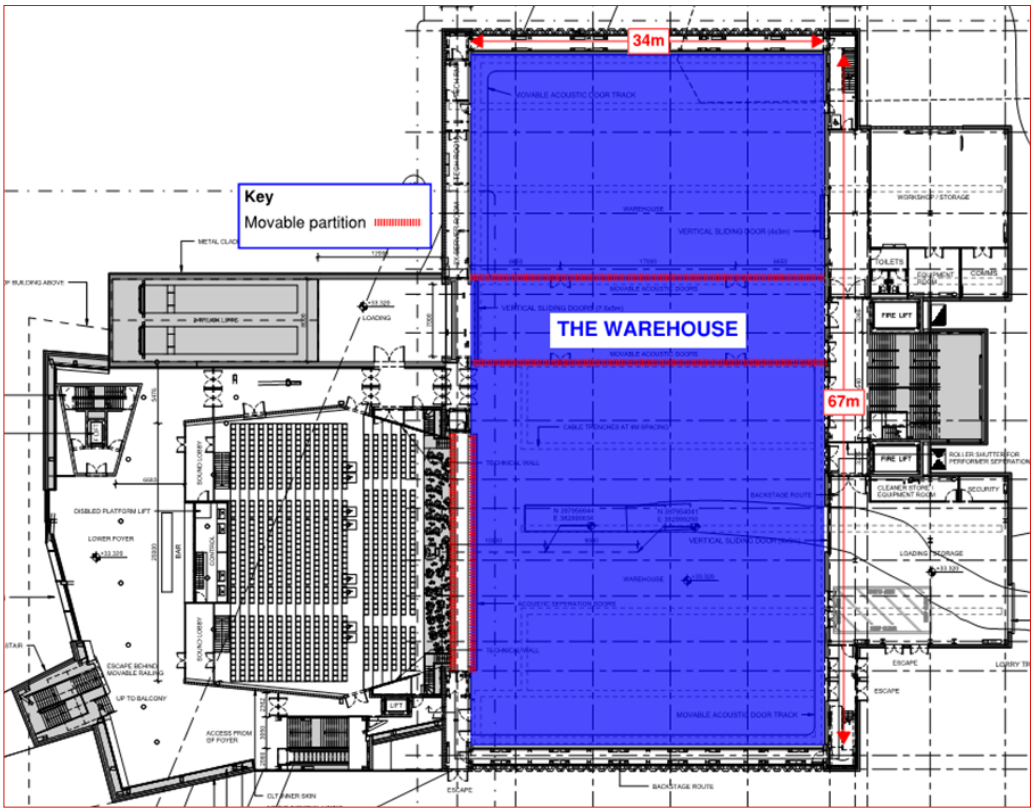
6.2 THE WAREHOUSE

The Warehouse consists of the area highlighted in the Figure below located on Level 2 of the building and is the space intended to accommodate the largest events.

This area will be designed in order to provide the maximum flexibility to the end-users (MIF) in order to organise any type of event and can be subdivided into two separate areas when necessary using moveable acoustic partitions. The south area can also be used as a large stage for the Theatre by removing the moveable partitions provided between these two areas.

Its dimensions when fully open will be circa 34m x 67m (2,278m²) with a height measured from the finished floor of Level 2 to the roof of circa 23m. The maximum expected occupancy will be 5,000 people (pop concert mode).

Figure 6-2: The Warehouse



6.3 THE THEATRE

The Theatre consists of the area located on the west of the development, starting at Level 2 with the foyer and the lower tiers, and with the upper tiers from Levels 3 to 5. There are two theatre control rooms, one at level 2 mezzanine and one at level 5 mezzanine.

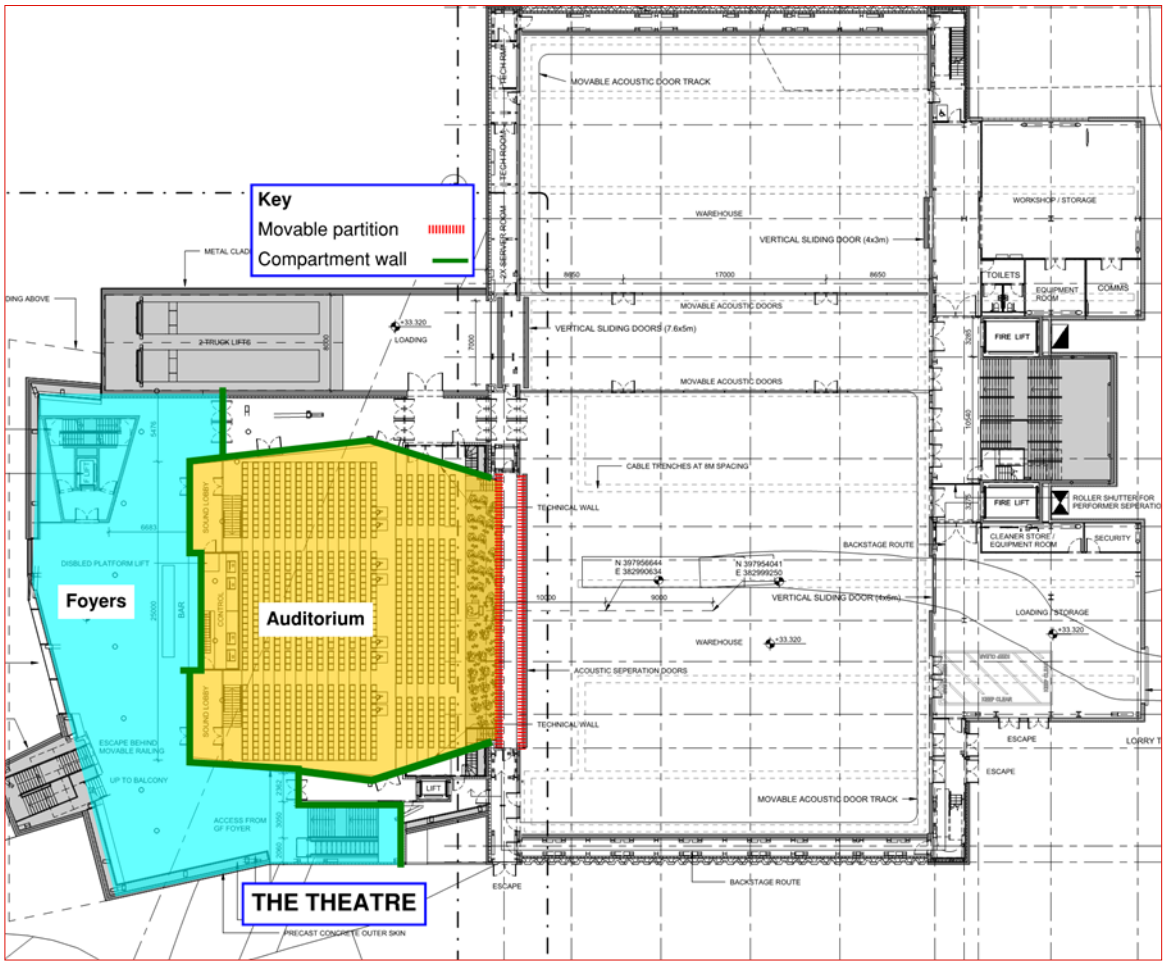
This area will be designed in order to provide maximum flexibility to the end-users (MIF) in order to organise various types of events. As such several of the layouts of this space can be modified in order to provide temporary seating and a sloping floor. This will have an impact on the occupancy of the premises and the available means of escape. The main modes are described in the following Table.

Table 6-3: Theatre – Summary of the different arrangements

Mode No	Description	
	Lower tiers	Upper Fixed Balcony Tier
1	Sloping floor and fully occupied – 785 seating	Fully occupied - 640 seating
2	Flat floor with stage within Theatre - Standing	Fully occupied - 640 seating
3	Flat floor with stage within Warehouse - Standing	Fully occupied - 640 seating

Note: In seating mode at full capacity, the theatre will accommodate a maximum of 1,425 persons.

Figure 6-3: The Theatre



Evacuation modelling has been carried out to validate the above event modes occupancies to demonstrate that sufficient exits are available for all occupants to leave the building within the available safe egress time for the warehouse (12-minutes without smoke ventilation and >20-minutes with smoke ventilation) and theatre (Thrust Stage Configuration with smoke ventilation 4.5-minutes for the top layer and 7.6-minutes at level 4 mid auditorium layer).

A summary of the evacuation modelling has been provided in appendix G of this report.

For more information on the fire engineering principle of the model and ASET vs RSET, see section 6.11 and Appendix A and B of this report.

The evacuation model has been carried out for the most onerous of the events mode stated in the table below.

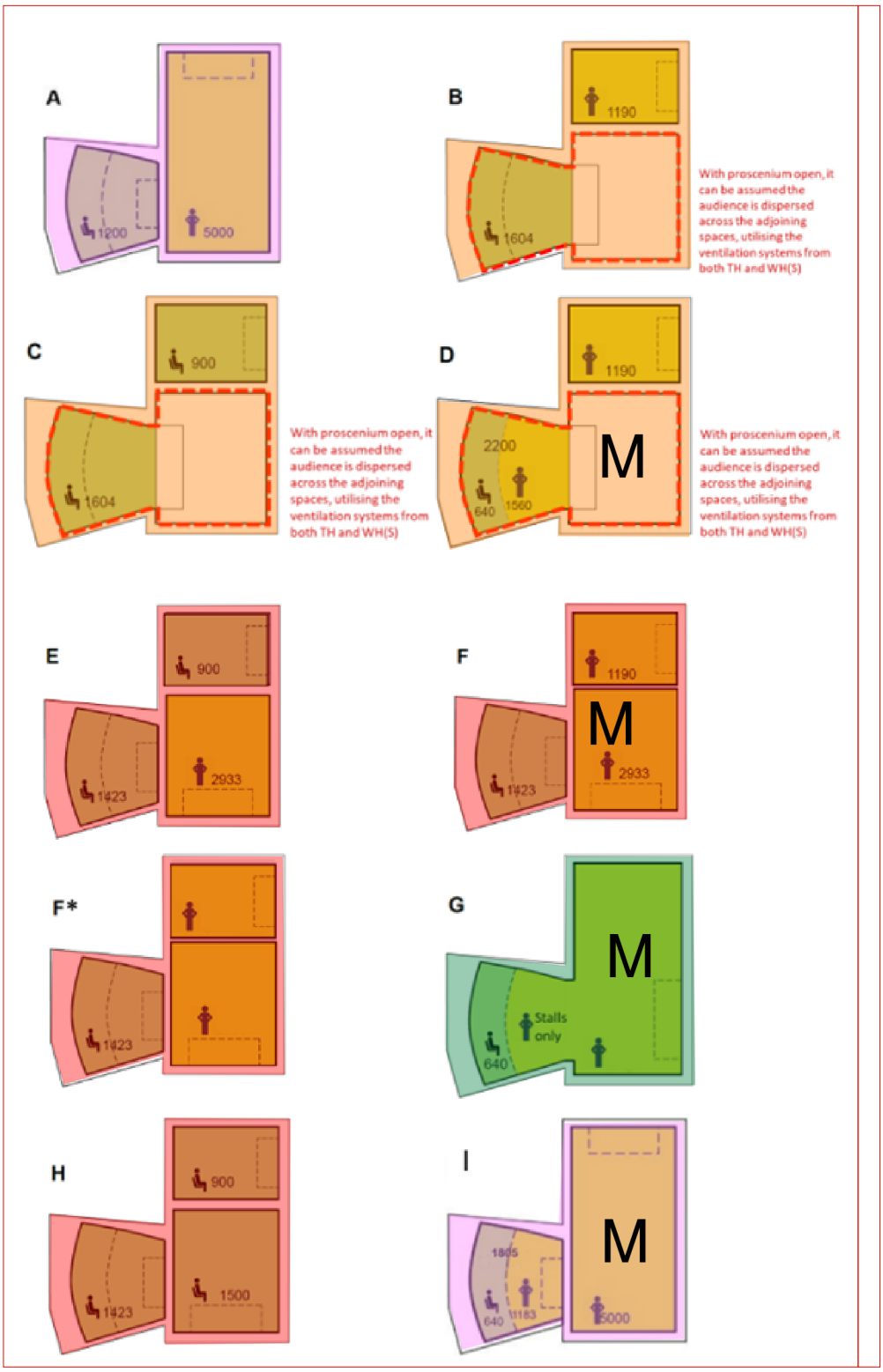
Table 6-4 – Event validated by evacuation modelling

Event mode	Theatre	Warehouse North	Warehouse South	Total Persons
D	2200 persons	1190 persons		3390 persons
F	1425 persons	1190 persons	2933 persons	5546 persons
G	640 persons	6360 persons		7000 persons
I	1805 persons	5000 persons		6805 persons

The result of the above events models are detailed below

Some of the event modes are identical and the only difference is seating mode or standing mode, as well as occupancy capacity. Such as Event scenarios (A and I). (B, C and D). (E. F and H) and G. Therefore, the most onerous of the three identical events modes and mode G have been modelled and detailed within this report. It is considered that, if the onerous event modes' results are within the acceptable timing, i.e the RSET is still less than ASET, then these event modes and the less onerous should be considered acceptable.

Figure 6-4 - Each event mode that is deemed to be similar has been highlighred in the same colour and the mode modelled marked with 'M'.



***Note**: The occupancy numbers are provided by the end-users and do not include staff.*

6.4 EXIT WIDTH CALCULATIONS

The width of doors, corridors and stairs are sized to accommodate the maximum number of occupants. Due to the provision of an enhanced detection system, a 15% reduction is permitted in accordance with BS 9999. Therefore, the following capacity factors have been used to calculate exit widths:

Table 6-5 – Capacity Factors for Doors, Corridors and Escape Routes

Risk Profile	Capacity Factor	Permitted Reduction	Revised Capacity Factor
B1	3.6 mm / person	15%	**3.06 mm / person**
B2	4.1 mm / person	15%	**3.485 mm / person**
B3	6.0 mm / person	15%	**5.1 mm / person**
A2 (Plant)	3.6 mm / person	15%	**3.06 mm / person**

In addition to the door capacity, the available safe egress time is based on the following with further details provided in Appendix A and B of this report.

Table 6-6 – ASET timing

Areas	ASET (sec)	ASET (mins)
Warehouse	720 Seconds	12 minutes
Theatre top row of seating	270 Seconds*	4.5 minutes
Theatre main exit level for the upper-tier	460 Seconds	7.6 minutes

Note: Due to the provision of smoke ventilation in the warehouse area, the tenable condition (ASET) remains longer than 20-mininutes until the CFD ended.

* This is for the thrust stage configuration which is worst-case. Compared to End stage format.

6.5 EVENT MODE D

North Warehouse Mode D

Table 6-7 – Event Mode D – Minimum Required Clear Width

Risk Profile	Capacity Factor	Anticipated Occupants	Required Clear Width After Discounting
B1	3.06 mm / person	1190 persons	**3,641 mm**
B2	3.485 mm / person	1190 persons	**4,147 mm**

Assuming the largest exits is unavailable due to the location of a fire, the remaining **5,500mm** wide exits are sufficient for **1190** occupants under **B2** events mode.

Theatre Mode

Table 6-8 – Event Mode D – Minimum Required Clear Width

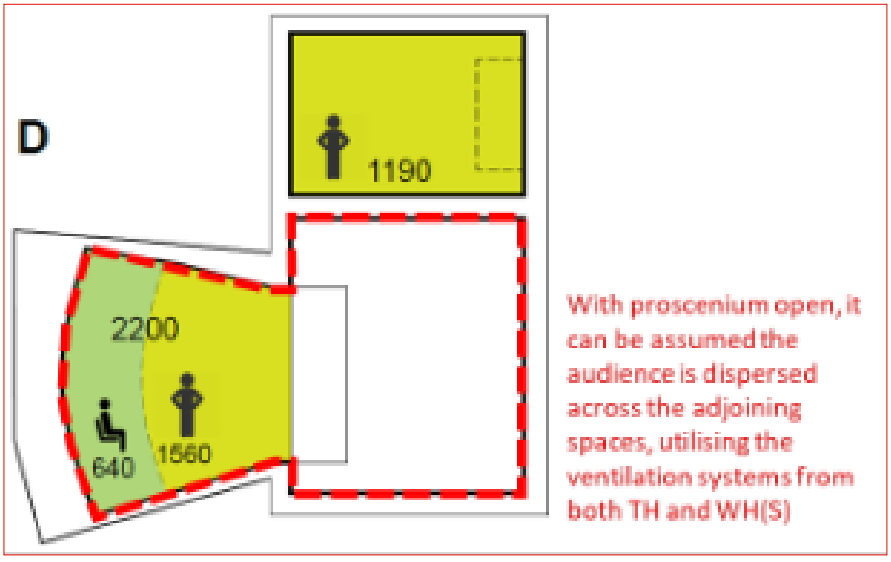
Risk Profile	Capacity Factor	Anticipated Occupants	**Required** Clear Width After Discounting
B1	3.06 mm / person	1560 persons*	**4,774 mm**
B2	3.485 mm / person	1560 persons*	**5,437 mm**

The theatre is provided with four exits, assuming one of the widest exits is unavailable due to the location of a fire, **3000 mm** see discounted location in the figure below. The remaining exits combined are **6000 mm** wide which is more than the minimum calculated required clear width of **5,437 mm**

*The 1,560 persons exclude the 640 persons in the upper balcony area of the theatre. The upper theatre level is provided with four exits, assuming one of the exits is unavailable, the remaining is sufficient for the 640 persons on the upper theatre levels.

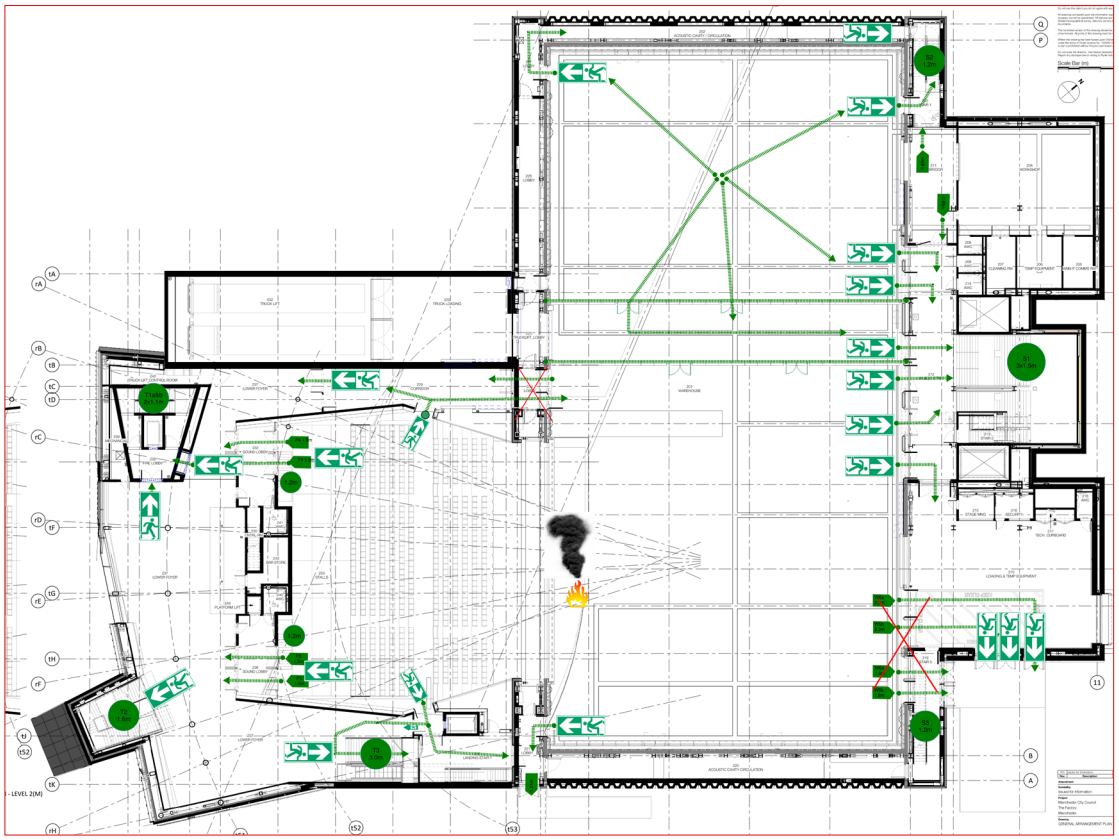
Note: the divider and other exits via the south warehouse will be made available to occupants in an emergency.

Figure 6-5: Event Mode D



The figure below shows the direction of escape available to the occupants. It should be noted that only a single fire is expected for both events, for example, a fire may occur in the theatre stage area or in the north warehouse. But not in two locations at the same time. Nonetheless, It is assumed that a fire is located in the theatre stage area. i.e., warehouse south because this is considered to be the most onerous of the fire scenarios.

Figure 6-6: Event Mode D – Fire in the Theatre Stage Area



As shown in the table below, the ASET is greater than the RSET for Event mode D. An additional 60 seconds premovement time (detection and start of evacuation) has been added to the evacuation modelling times, therefore, giving it a total of 497 seconds (8.3 mins). Henceforth the event mode is considered acceptable to provide time for occupants to choose to escape.

Table 6-9 – Event Mode D – Evacuation Modelling Result

Areas	ASET (sec)	ASET (mins)	RSET (sec)	RSET (mins)
Warehouse North	1200 seconds	20 minutes	363 seconds	**6.05 minutes**
Theatre top row of seating	240 seconds	4 minutes	199 seconds	**3.3 minutes**
Theatre top tier clearance	290 seconds	4.8 minutes	287 seconds	**4.7 minutes**
Theatre main exit level for the upper-tier	390 seconds	6.5 minutes	373 seconds	**6.2 minutes**
Theatre lower-level full evacuation	600 seconds	10 minutes	497 seconds	**8.3 minutes**
The whole building	N/A	N/A	697 Seconds	**11.6 minutes**

Table 6-10 – Event Mode D – RSET Safety Margin

Areas	ASET (mins)	RSET (mins)	Safety Margin
Warehouse North	20 minutes	**6.05 minutes**	70%
Theatre top row of seating	4 minutes	**3.3 minutes**	20%
Theatre top tier clearance	4.8 minutes	**4.7 minutes ***	2%
Theatre main exit level for the upper-tier	6.5 minutes	**6.2 minutes**	5%
Theatre lower level full evacuation	10	**8.3 minutes**	17%

Based on the above table, Event mode D tenable condition can be maintained. An additional 60 seconds premovement time (detection and start of evacuation) has been added to the result timing and the RSET is less than ASET. Based on the result, the occupants should be able to escape to a place of relative safety prior to the condition been untenable. Henceforth the event mode is considered acceptable.

6.6 EVENT MODES F

North Warehouse Mode F

Table 6-11 – Event Mode F – Minimum Required Clear Width

Risk Profile	Capacity Factor	Anticipated Occupants	Required Clear Width After Discounting
B1	3.06 mm / person	1190 persons	**3,641 mm**
B2	3.485 mm / person	1190 persons	**4,147 mm**

Assuming the largest exits is unavailable due to the location of a fire, the remaining **5,500mm** wide exits are sufficient for **1190** occupants under **B2** events mode.

South Warehouse Mode F

Table 6-12 – Event Mode F – Minimum Required Clear Width

Risk Profile	Capacity Factor	Anticipated Occupants	Required Clear Width After Discounting
B1	3.06 mm / person	2933 persons	**8,975 mm**
B2	3.485 mm / person	2933 persons	**10,222 mm**

Assuming the largest exits is unavailable due to the location of a fire, the remaining **13m** wide exits are sufficient for **2933** occupants under **B2** events mode.

Theatre Mode

Table 6-13 – Event Mode F – Minimum Required Clear Width

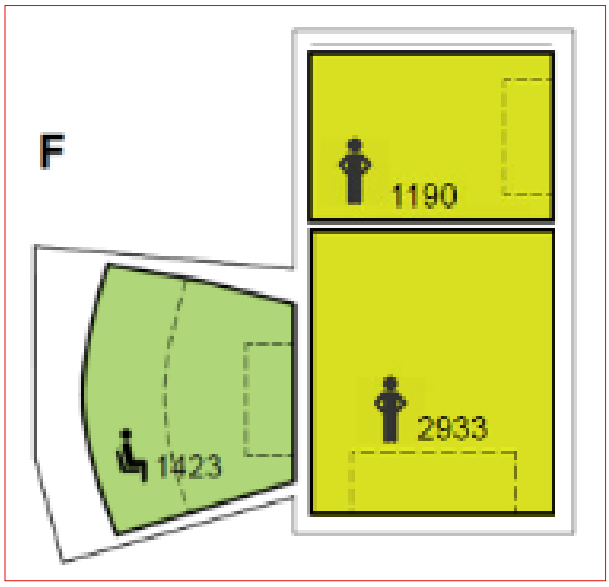
Risk Profile	Capacity Factor	Anticipated Occupants	**Required** Clear Width After Discounting
B1	3.06 mm / person	1423 persons	**4,774 mm**
B2	3.485 mm / person	1423 persons	**5,437 mm**

The theatre is provided with four exits, assuming one of the widest exits is unavailable due to the location of a fire, **3000 mm** see discounted location in the figure below. The remaining exits combined are **6000 mm** wide which is more than the minimum calculated required clear width of **5,437 mm**

The upper theatre level is provided with four exits, assuming one of the exits is unavailable, the remaining is sufficient for the 640 persons on the upper theatre levels.

Note: the divider and other exits via the south warehouse will be made available to occupants in an emergency.

Figure 6-7: Event Mode F



The figure below shows the direction of escape available to the occupants. It should be noted that only a single fire is expected for both events, for example, a fire may occur in the theatre stage area or in the warehouse. But not in two locations at the same time. Nonetheless, It is assumed that a fire is located in the south warehouse area because this is considered to be the most onerous of the fire scenarios.

Figure 6-8: Event Mode F – Fire in the Warehouse

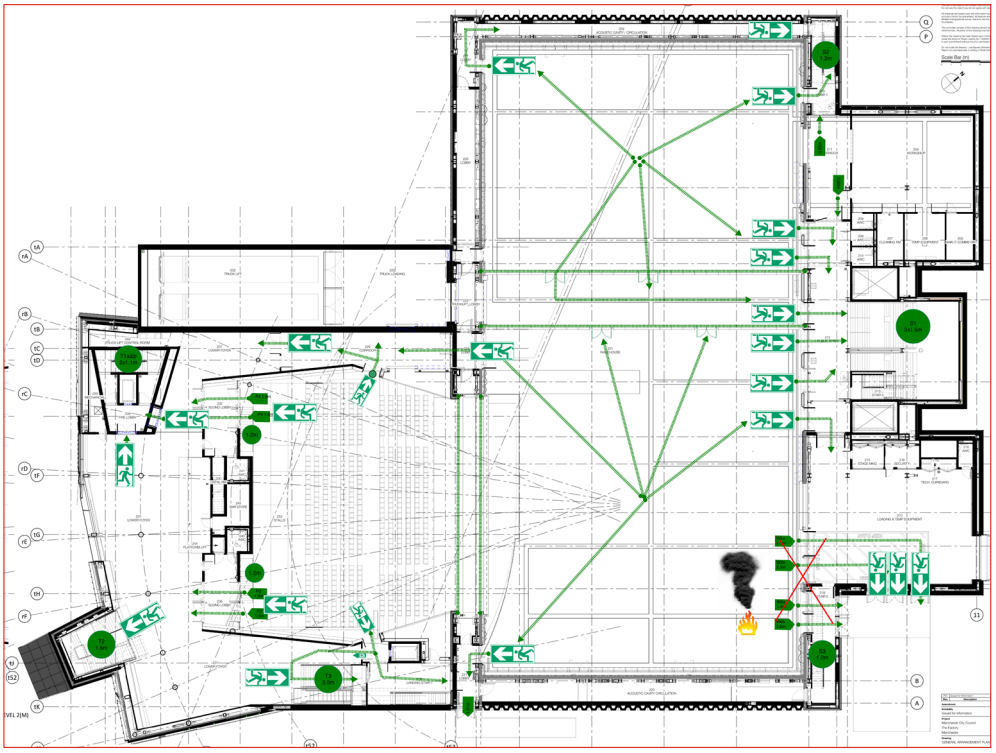


Table 6-14 – Event Mode F – Evacuation Modelling Result

Areas	ASET (sec)	ASET (mins)	RSET (sec)	RSET (mins)
Warehouse Area	1200 seconds	20 minutes	528 seconds	**8.8 minutes**
Theatre top row of seating	240 seconds	4 minutes	203 seconds	**3.3 minutes**
Theatre top tier clearance	290 seconds	4.8 minutes	279 seconds	**4.6 minutes**
Theatre main exit level for the upper-tier	390 seconds	6.5 minutes	356 seconds	**5.9 minutes**
Theatre lower-level full evacuation	600 seconds	10 minutes	425 seconds	**7 minutes**
The whole building	N/A	N/A	731 Seconds	**12.1 minutes**

Table 6-15 – Event Mode F – RSET Safety Margin

Areas	ASET (mins)	RSET (mins)	Safety Margin
Warehouse Area	20 minutes	**8.8 minutes**	58%
Theatre top row of seating	4 minutes	**3.3 minutes**	15%
Theatre top tier clearance	4.8 minutes	**4.6 minutes**	5%
Theatre main exit level for the upper-tier	6.5 minutes	**5.9 minutes**	30%
Theatre lower-level full evacuation	10 minutes	**7 minutes**	30%

Based on the above table, Event mode F tenable condition can be maintained. An additional 60 seconds premovement time (detection and start of evacuation) has been added to the result timing and the RSET is less than ASET. Based on the result, the occupants should be able to escape to a place of relative safety prior to the condition been untenable. Henceforth the event mode is considered acceptable.

6.7 EVENT MODES G

Warehouse Mode G

Table 6-16 – Event Mode F – Minimum Required Clear Width

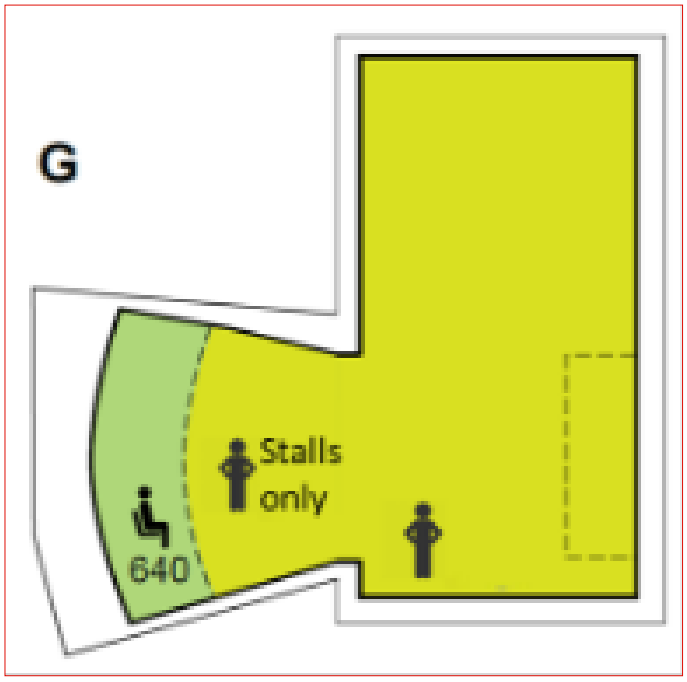
Risk Profile	Capacity Factor	Anticipated Occupants	Required Clear Width After Discounting
B1	3.06 mm / person	6360 persons	**19,462 mm**
B2	3.485 mm / person	6360 persons	**22,165 mm**

Assuming the largest exits is unavailable due to the location of a fire, the remaining **29,100mm** wide exits are sufficient for **6360** occupants under **B2** events mode.

The upper theatre level is provided with four exits, assuming one of the exits is unavailable, the remaining is sufficient for the 640 persons on the upper theatre levels.

Note: the divider and other exits via the south warehouse will be made available to occupants in an emergency.

Figure 6-9: Event Mode G



The figure below shows the direction of escape available to the occupants. It should be noted that only a single fire is expected, furthermore, the fire is likely to occur on the stage area located away from egress doors. Nonetheless, it is assumed that a fire is located in the south warehouse area because this is considered to be the most onerous of the fire scenarios.

Figure 6-10: Event Mode G – Fire in the Warehouse

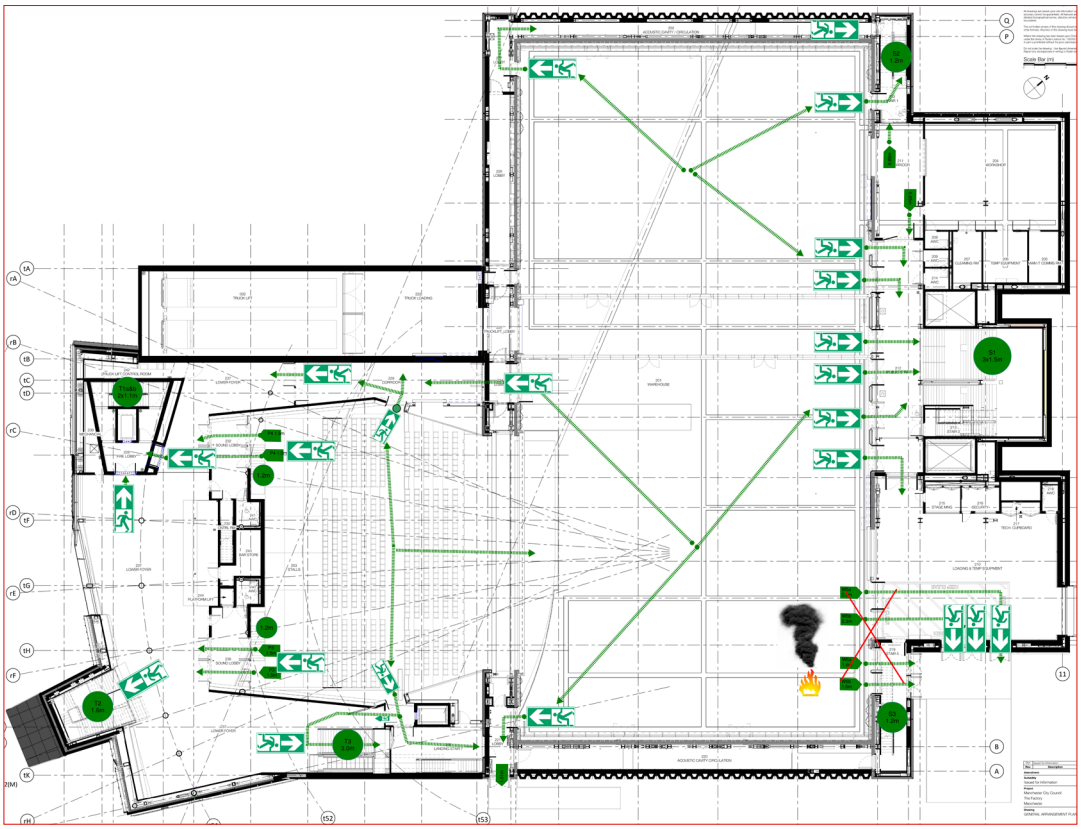


Table 6-17 – Event Mode G – Evacuation Modelling Result

Areas	ASET (sec)	ASET (mins)	RSET (sec)	RSET (mins)
Theatre top row of seating	240 seconds	4 minutes	204 seconds	**3.4 minutes**
Theatre top tier clearance	290 seconds	4.8 minutes	274 seconds	**4.5 minutes**
Theatre main exit level for the upper-tier	390 seconds	6.5 minutes	349 seconds	**5.8 minutes**
Warehouse and Theatre Stall Areas	1200 seconds	20 minutes	710 seconds	**11.8 minutes**
The whole building	N/A	N/A	928 Seconds	**15.4 minutes**

Table 6-18 – Event Mode G – RSET Safety Margin

Areas	ASET (mins)	RSET (mins)	Safety Margin
Theatre top row of seating	4 minutes	**3.4 minutes**	15%
Theatre top tier clearance	4.8 minutes	**4.5 minutes**	7%
Theatre main exit level for the upper-tier	6.5 minutes	**5.8 minutes**	12%
Warehouse and Theatre Stall Areas	20 minutes	**11.8 minutes**	40%

Based on the above result, the occupants should be able to escape to a place of relative safety prior to the condition been untenable. Henceforth the event mode G is considered acceptable.

6.8 EVENT MODES I

North Warehouse Mode I

Table 6-19 – Event Mode I – Minimum Required Clear Width

Risk Profile	Capacity Factor	Anticipated Occupants	Required Clear Width After Discounting
B1	3.06 mm / person	5000 persons	**15,300 mm**
B2	3.485 mm / person	5000 persons	**17,425 mm**

Assuming the largest exits is unavailable due to the location of a fire, the remaining **20,100mm** wide exits are sufficient for **5000** occupants under **B2** events mode.

Theatre Mode

Table 6-20 – Event Mode I – Minimum Required Clear Width

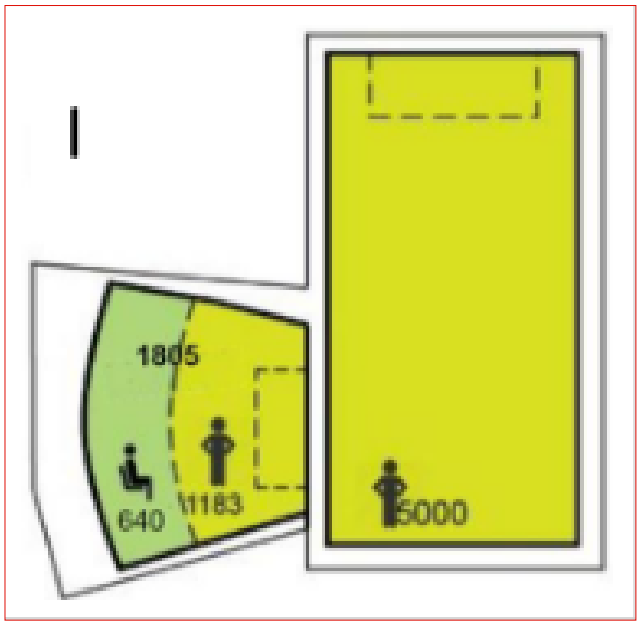
Risk Profile	Capacity Factor	Anticipated Occupants	**Required** Clear Width After Discounting
B1	3.06 mm / person	1183 persons	**3,620 mm**
B2	3.485 mm / person	1183 persons	**4,123 mm**

The theatre is provided with four exits, assuming one of the widest exits is unavailable due to the location of a fire. The remaining exits combined are **6000 mm** wide which is more than the minimum calculated required clear width of **4,123 mm**

The upper theatre level is provided with four exits, assuming one of the exits is unavailable, the remaining is sufficient for the 640 persons on the upper theatre levels.

Note: the divider and other exits via the south warehouse will be made available to occupants in an emergency.

Figure 6-11: Event Mode I



The figure below shows the direction of escape available to the occupants. It should be noted that only a single fire is expected for both events, for example, a fire may occur in the theatre stage area or in the warehouse. But not in two locations at the same time.

Figure 6-12: Event Mode I – Fire in the Warehouse

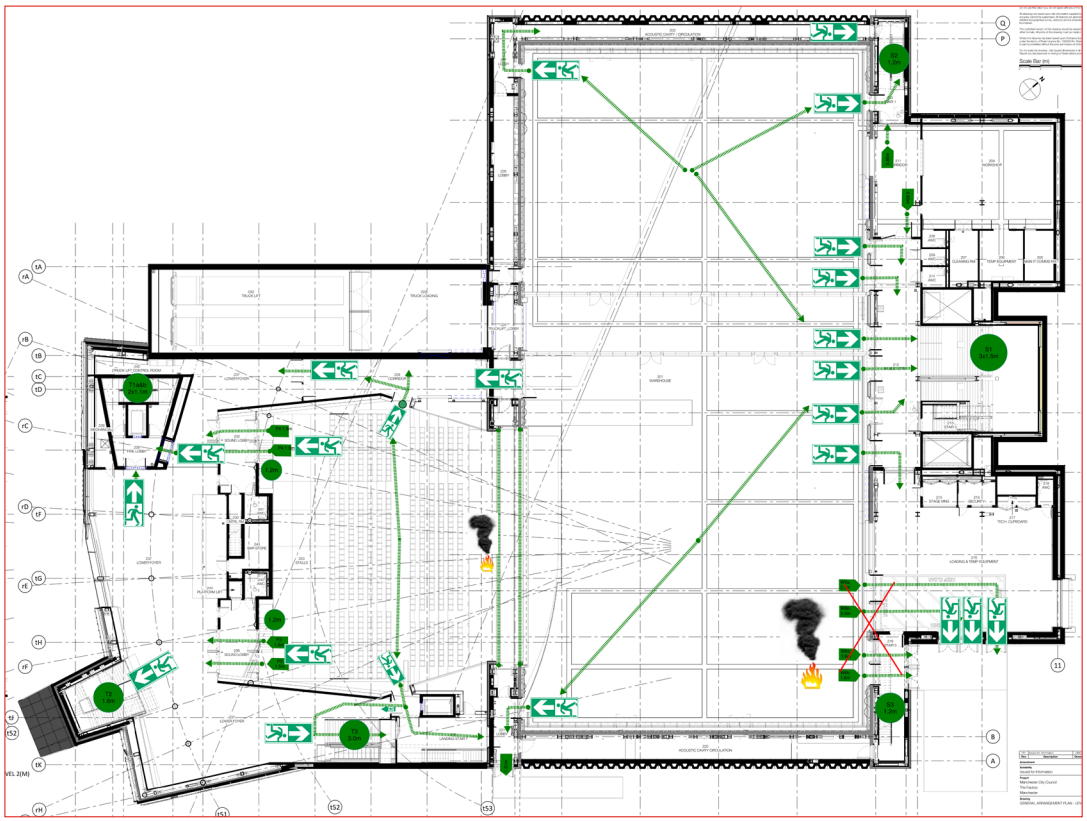


Table 6-21 – Event Mode I – Evacuation Modelling Result

Areas	ASET (sec)	ASET (mins)	RSET (sec)	RSET (mins)
Warehouse Area	1200 seconds	20 minutes	852 seconds	**14.2 minutes**
Theatre top row of seating	240 seconds	4 minutes	198 seconds	**3.3 minutes**
Theatre top tier clearance	290 seconds	4.8 minutes	286 seconds	**4.7 minutes**
Theatre main exit level for the upper-tier	390 seconds	6.5 minutes	365 seconds	**6 minutes**
Theatre lower-level full evacuation	600 seconds	10 minutes	437 seconds	**7.2 minutes**
The whole building	N/A	N/A	1083 Seconds	**18 minutes**

Table 6-22 – Event Mode I – RSET Safety Margin

Areas	ASET (mins)	RSET (mins)	Safety Margin
Warehouse Area	20 minutes	**14.2 minutes**	30%
Theatre top row of seating	4 minutes	**3.3 minutes**	20%
Theatre top tier clearance	4.8 minutes	**4.7 minutes**	2%
Theatre main exit level for the upper-tier	6.5 minutes	**6 minutes**	4%
Theatre lower level full evacuation	10 minutes	**7.2 minutes**	28%

Based on the above table, Event mode I tenable condition can be maintained. An additional 60 seconds premovement time (detection and start of evacuation) has been added to the result timing and the RSET is less than ASET. Based on the result, the occupants should be able to escape to a place of relative safety prior to the condition been untenable. Henceforth the event mode is considered acceptable.

6.9 EVENTS MANAGEMENT IS KEY

Fire safety management is an essential factor in achieving and maintaining suitable fire safety measures in the building. The fire safety design strategy relies on a suitable level of fire safety management will be put in place by MIF.

It is assumed that MIF has an adequate management structure which means that the management will conform with the minimum requirements to comply with this fire strategy and relevant the legislation.

Prior to each event, the following must be observed;

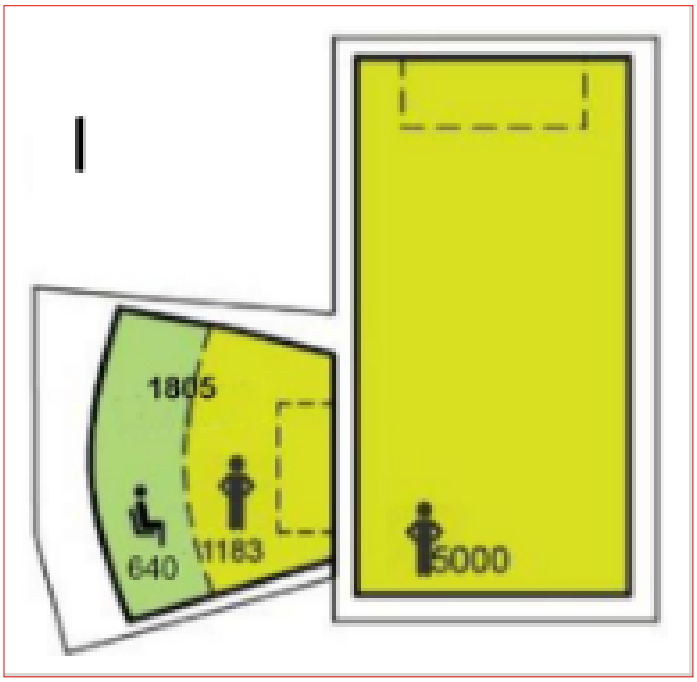
- A risk assessment has been carried out by a competent person.

- The events set-up does not impair the ability of the occupants to egress the building in an emergency.
- The assessment takes into account the evacuation of semi ambulant persons.

Revised Door Width Egress Modelling

In addition to the above, WSP carried out a requested stress test scenario as agreed with the statutory authority limiting the exit widths leading to stairs to the width of the stairs and the width of the final exit they are leading to.

Figure 6-13: Event Mode I Revised 230213



The figure below shows the direction of escape available to the occupants. The storey exits widths have been restricted to the width of the stairs and the width of the final exit they are leading to.

This scenario has been carried out to provide a stress test for the client, therefore allowing the end user the flexibility to close off some exit doors to allow direct flow to the staircase.

In this scenario, it is assumed that an emergency or a fire is located in the non-events space. therefore, all exits are available from the event areas.

Figure 6-14: Event Mode I – Fire in non-events space

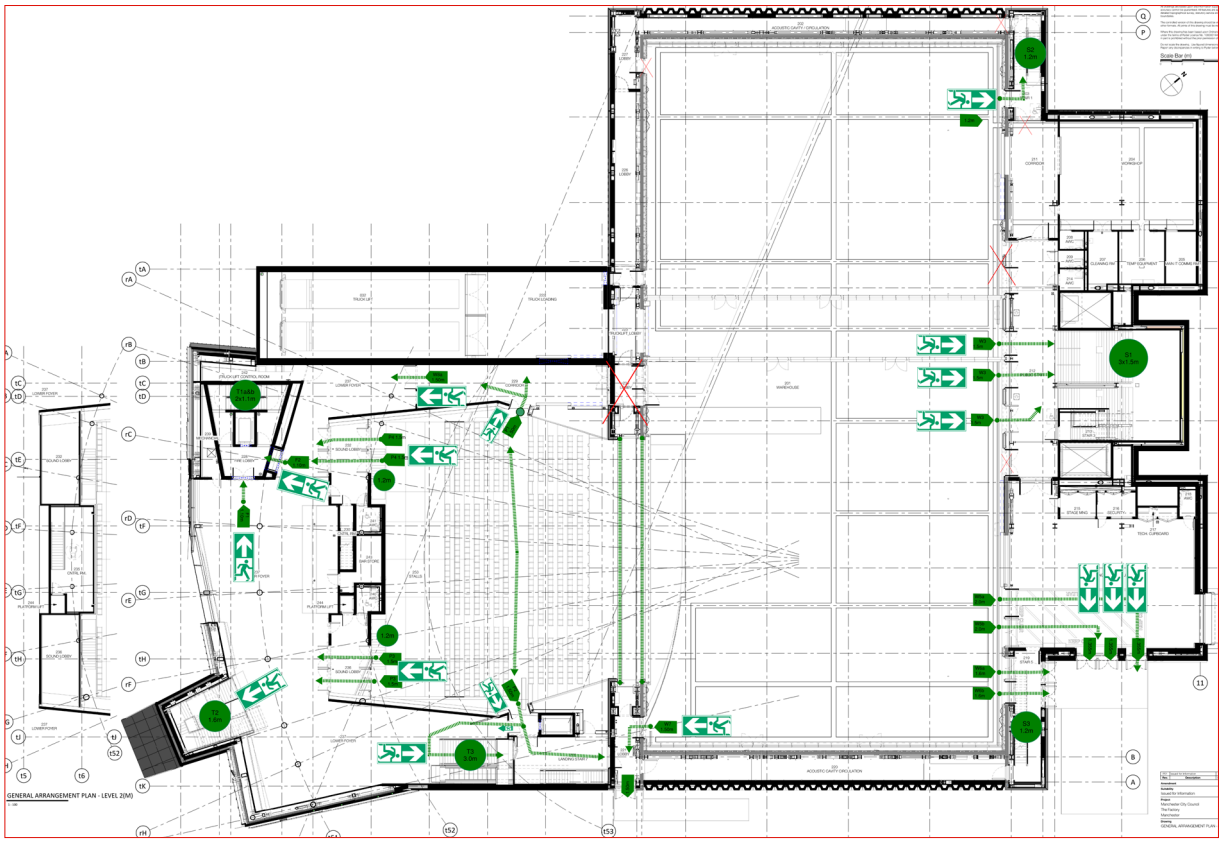


Table 6-23 – Event Mode I Revised 230213 – Evacuation Modelling Result

Areas	ASET (sec)	ASET (mins)	RSET (sec)	RSET (mins)
Warehouse Area	1200 seconds	20 minutes	445 seconds	**7.4 minutes**
Theatre top row of seating	240 seconds	4 minutes	199 seconds	**3.3 minutes**
Theatre top tier clearance	290 seconds	4.8 minutes	283 seconds	**4.7 minutes**
Theatre main exit level for the upper-tier	390 seconds	6.5 minutes	367 seconds	**6.1 minutes**
Theatre lower-level full evacuation	600 seconds	10 minutes	430 seconds	**7.1 minutes**
The whole building	N/A	N/A	655 Seconds	**10.9 minutes**

Table 6-24 – Event Mode I Revised 230213 – RSET Safety Margin

Areas	ASET (mins)	RSET (mins)	Safety Margin
Warehouse Area	20 minutes	**7.4 minutes**	63%
Theatre top row of seating	4 minutes	**3.3 minutes**	19%
Theatre top tier clearance	4.8 minutes	**4.7 minutes**	3%
Theatre main exit level for the upper-tier	6.5 minutes	**6.1 minutes**	6%
Theatre lower level full evacuation	10 minutes	**7.1 minutes**	2.9%

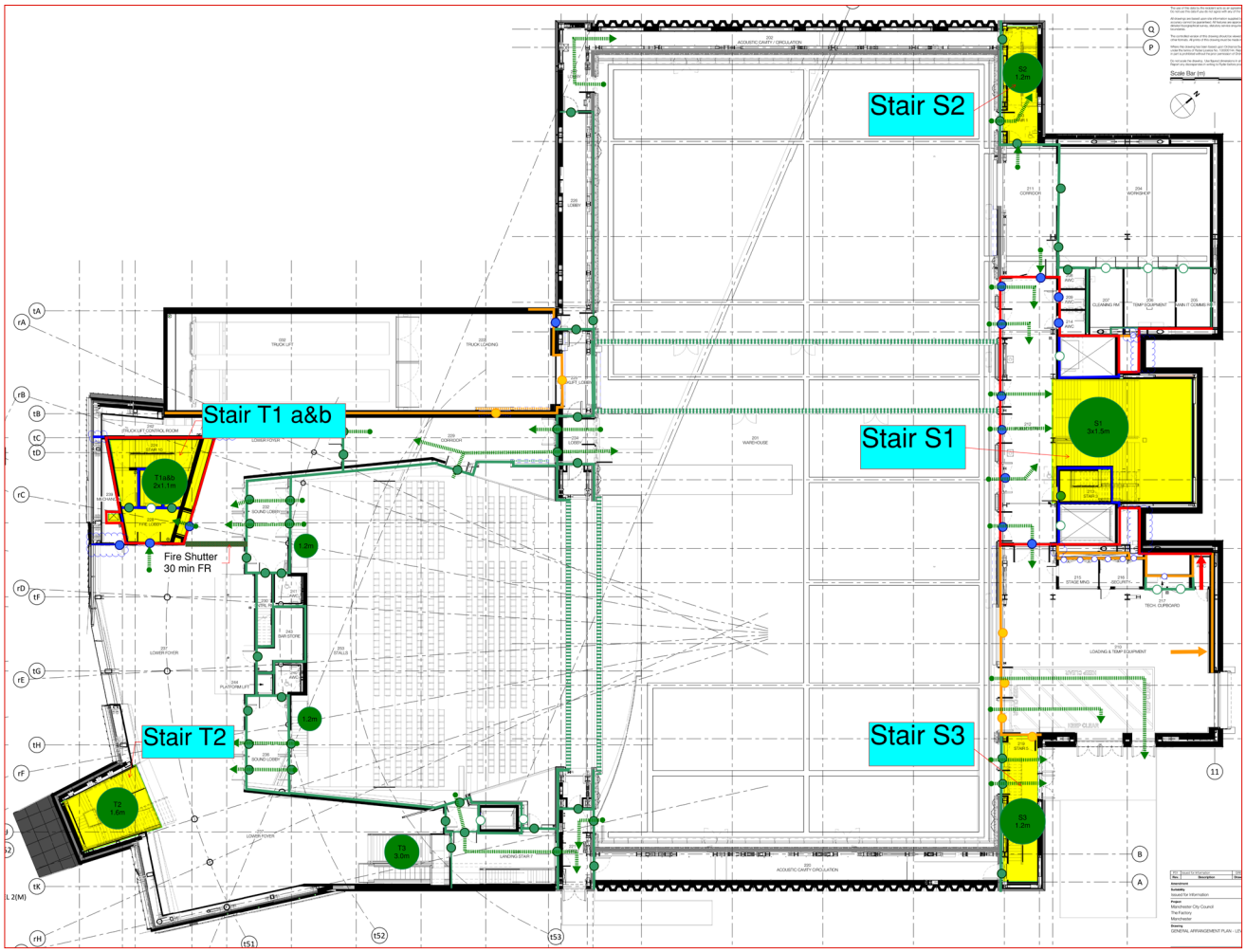
Based on the above table, Event mode I tenable condition can be maintained. An additional 60 seconds premovement time (detection and start of evacuation) has been added to the result timing and the RSET is less than ASET. Based on the result, the occupants should be able to escape to a place of relative safety prior to the condition been untenable. Henceforth the event mode is considered acceptable.

6.10 VERTICAL CAPACITY

Each area of the building is provided with multiple staircases for egress.

- The theatre is served by stairs T1 a&b, T2, T3 as well as access to the other stair via the warehouse.
- The tower is served by stairs S1, S2, and S3.
- The warehouse is served primarily by stairs S1, S2, and S3 as well as access to the other stair via the theatre's egress corridors.

Figure 6-15: Stairs Locations



The evacuation modelling was carried out to demonstrate that the available stairs are sufficient for the building occupants and the most onerous events modes.

The egress modelling has been undertaken using Pathfinder developed by Thunderhead Engineering. Version 2021, Revision 2021.2.0525 has been used for this analysis.

In summary, the walking speed in Pathfinder depends on the density, maximum speed of the occupants and the evacuation speed constant. This include taking into account merging flow occurring at stairs entrances and final exit. The walking speed distributions available are constant, uniform, standard normal and constant.

The walking speed used in this assessment is constant and set to a conservative 1.2 m/s speed while Steering Mode has been used to achieve a more natural evacuation. See Appendix G of this report for more information.

Table 6-25: Event Modes Final Evacuation Time to Place of Safety

Event mode	The whole building evac time	Evac time + 60 (min)
D	697 Seconds	**11.6 minutes**
F	731 seconds	**12.1 minutes**
G	928 seconds	**15.4 minutes**
I	1,083 seconds	**18 minutes**

As shown in the table above, the maximum evacuation time in the building is 18 minutes from detection time to occupants leaving the building to a place of relative safety. Therefore, the current stairs are considered to be sufficient for means of escape. For more information on the Evacuation modelling, see Appendix G of this report.

6.10.1 DISABLED REFUGES

Disabled refuges will be provided in each staircase in order to provide a place of relative safety for people that cannot evacuate the building without assistance. These will comply with the provisions described in Section 5.9.2.

The number of refuges is to be determined by the responsible person according to the numbers of wheelchair users likely to be present in the building. The upper tiers being provided with four spaces dedicated to wheelchair users the two stairs serving this area will be sized to accommodate four wheelchair users.

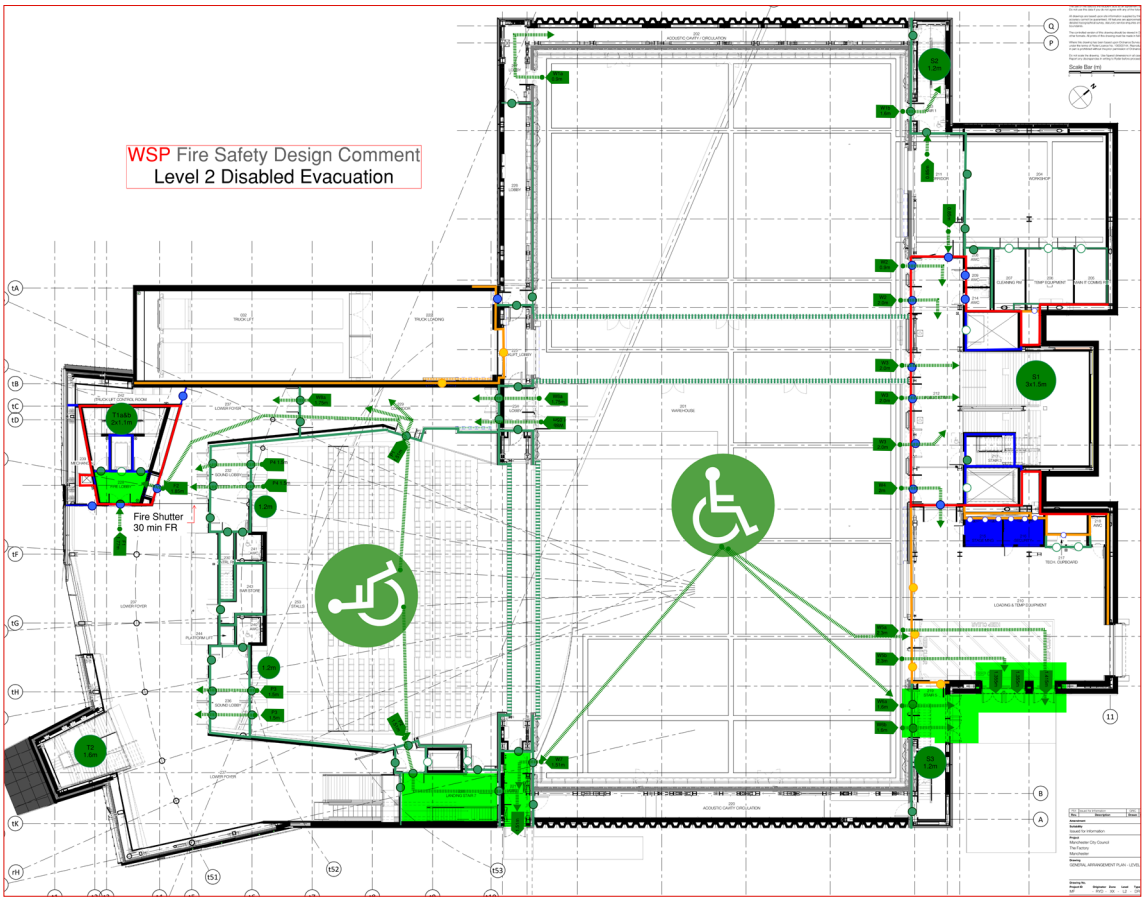
The number of disabled people that can access the lower tiers is not defined. However, refuges are not considered as necessary as disabled users can use the two following escape routes without assistance:

- The escape route leading to the Warehouse. Once in this space, the occupants will be in a place of relative safety; and
- The escape route leading directly to outside.

The Foyer at Level 2 will be provided with:

- Disabled refuge spaces in the fire-fighting stair;
- One escape route leading to the Warehouse;
- One escape route leading to outside.

Figure 6-16: Theatre – Level 2 disabled means of escape



Note: Disable refugee is not provided in stair S2 on level 2 due to the availability of other alternatives leading directly to a place of safety.

6.11 FIRE ENGINEERED ASSESSMENT OF WAREHOUSE MEANS OF ESCAPE

6.11.1 METHODOLOGY

An analysis has been undertaken to demonstrate that the 5,000 occupants will have sufficient time to exit the Warehouse floor before the onset of untenable conditions in the Warehouse. This compares Available Safe Egress Time (ASET) with the Required Safe Egress Time (RSET).

- The **ASET** is the time available from ignition before untenable conditions occur at Level 02 of the Warehouse which could prevent occupants from exiting the building.
- The **RSET** is the time which is required for occupants of the building to be alerted to a fire and to safely evacuate.

Full details of this analysis can be found within Appendix B.

6.11.2 AVAILABLE SAFE EGRESS TIME (ASET)

The Warehouse is provided with a ventilation system which will operate during a fire to remove smoke from the Warehouse. The ASET is taken as the point at which visibility drops to less than 10m at a height of 3m above the floor of Level 02. For the purposes of this analysis, two scenarios have been considered:

- One where the smoke ventilation system activates; and
- One without smoke ventilation.

This ASET has been calculated using a Computational Fluid Dynamics (CFD) software called Fire Dynamics Simulator (FDS). Full details of the CFD simulation and modelling assumptions can be found in Appendix A.

For both scenarios considered, the ASET has been determined as shown in Table 6-26: .

Table 6-26: Summary of ASET

Smoke ventilation	Fire Location	Fire Size	ASET (mins)
Yes	Fire on stage	5MW (Medium Growth)	>20(1)
No	Fire on stage	5MW (Medium Growth)	12

(1) CFD analysis terminated at 20 minutes – untenable conditions had not occurred at this point. Actual ASET is greater than 20 minutes.

A 5MW fire is considered to be a reasonable estimate of the fire size on a stage in this building during the highest occupancy events (music concert type event). For other scenarios where the fire risk may be different (e.g. exhibitions), the escape capacity for the maximum anticipated occupancy is adequate and therefore additional modelling is not necessary to demonstrate compliance with the recommendations of BS 9999.

6.11.3 REQUIRED SAFE EGRESS TIME (RSET)

The RSET consists of several components, these are:

- Time for detection of fire and raising of the alarm.
- Pre movement time: the time between that when occupants become aware of the emergency and that when they begin to move towards the exits. This consists of the time required to recognise the emergency and then carry out a range of activities before travelling to exits.
- Travel time: the time required for the occupant to walk to a place of relative safety.

DETECTION AND ALARM TIME

The building is fitted with an automatic detection system at high level within the Warehouse technical grid area. The activation time of the smoke detectors has been derived from the CFD analysis at 3 minutes. This time is considered as onerous as a fire is likely to be detected by staff or public members before the automatic fire detection given that during concert events the space will be all open and provided with a high level of management.

PRE-MOVEMENT TIME

Pre-movement times can vary considerably for different individuals or groups of individuals with the distribution of pre-movement times dependent upon a range of factors including the occupants' proximity to, and knowledge of the fire. In an open-plan setting such as the music concert mode of the Warehouse, the distribution of pre-movement times is likely to be very narrow with the majority of occupants starting to move at similar times.

A conservative pre-movement time of 1 minute has been applied. In music concert mode, the occupant density will be very high and therefore the escape time will be flow dominated. As shown in the next section, the flow time of occupants through the exits is 6 minutes. Therefore, any

occupants whose pre-movement time exceeded 1 minute would simply join the queue of occupants flowing through the exits and hence their pre-movement time would not affect the overall escape time.

ESCAPE TIME

In music concert mode with an occupancy of 5,000 persons, the occupant density will be in the region of 0.3m^2/person. At such high densities, the time taken for occupants to exit the space will be dominated by the time to flow through the exit doors rather than the time it takes occupants to walk to the exits.

Several scenarios have been considered as detailed throughout Section 6 of this report to consider that a number of exits are not available due to the fire. The flow rate has been applied to the remaining exits to determine an average flow rate and an approximate escape time. The results are shown in Table 6-27: .

Table 6-27: Calculation of Total Flow Time of Occupants through Exits

Scenario	Total Exit Width (m)	Flow Rate (persons/m/s)	Flow rate (persons/s)	Flow Time (s)	Flow time (mins)
1	8.46	1.33	11.25	301.03	5.02
	5.7	0.94	5.36		
2	10.59	1.33	14.08	328.67	5.48
	1.2	0.94	1.13		
3	6.46	1.33	8.59	358.43	5.97
	5.7	0.94	5.36		

(1) Available exit width after exit is discounted, based on fire scenario.

(2) Flow rate recommended in Table D3 of BS 7974-6 as all the exits from the Warehouse are larger than 1.05m.

REQUIRED SAFE ESCAPE TIME

The required escape time is calculated in Table 6-28: based on the previous sections.

Table 6-28: Required Safe Escape Time

Scenario	Detection and Alarm Time (mins)	Pre-Movement time (mins)	Escape Time (mins)	Required Safe Escape Time (mins)
1	3	1	5.02	9.02
2			5.48	9.48
3			5.97	9.97

ASET VS RSET ASSESSMENT

The comparison of ASET and RSET is shown in Table 6-29: .

Table 6-29: ASET vs RSET

Scenario	Smoke ventilation	ASET (mins)	RSET (mins)	Safety Margin
1	Yes	>20	9.02	>100%
	No	12		33%
2	Yes	>20	9.48	>100%
	No	12		27%
3	Yes	>20	9.97	>100%
	No	12		20%

CONCLUSION

The prescriptive methodology in BS 9999 suggests that the Warehouse has insufficient exit capacity for scenarios 2 and 3 based on the proposed worst-case occupant load of 5,000 people.

A fire engineered analysis, based upon the ASET vs RSET methodology in BS 7974, demonstrates that for the worst-case fire scenarios considered, occupants will have sufficient time to escape before subject to untenable conditions on escape routes.

The RSET time detailed in the table above demonstrate the conservative time, nonetheless, this time is less than the result from the evacuation modelling. Therefore, the most onerous (Evacuation Model Result) RSET will be adopted

6.12 FIRE ENGINEERED ASSESSMENT OF THEATRE MEANS OF ESCAPE

6.12.1 DESCRIPTION

The means of escape strategy from Level 2 varies according to the arrangement adopted as described in the above section of this repor. The width and distribution referred to in this Section are taken from the drawings referenced in Table 1-1.

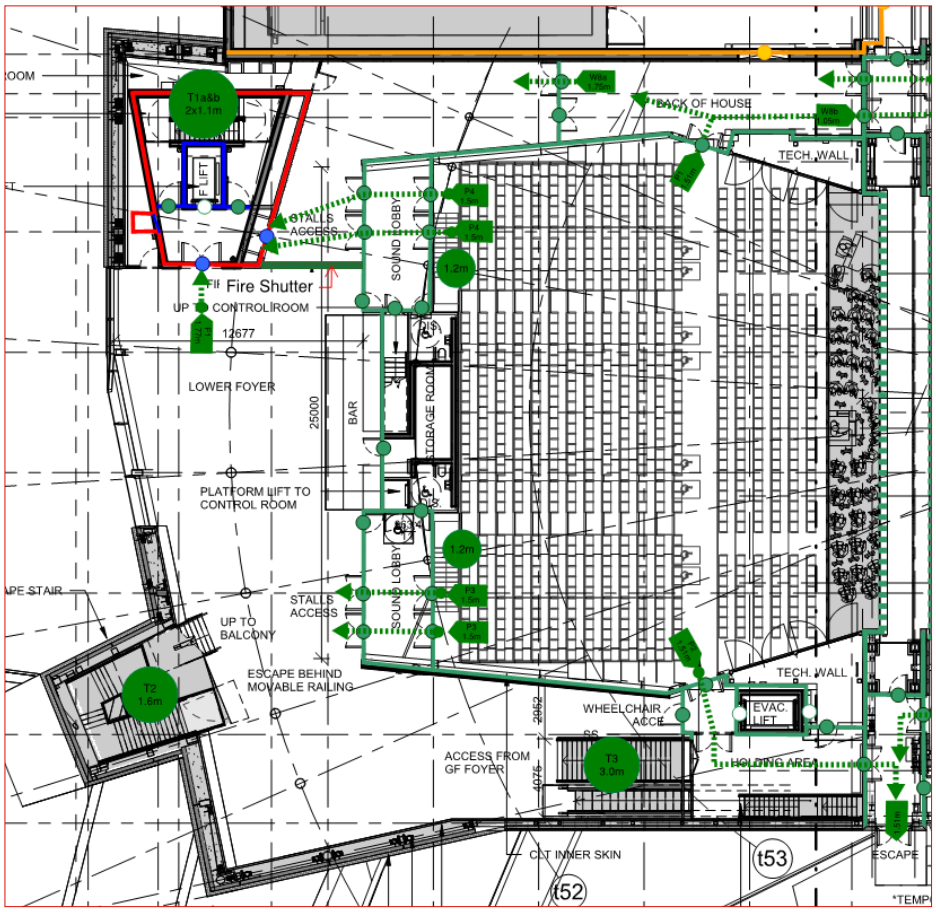
Table 6-30: Theatre – Level 2, means of escape description and capacity

Location	Exit No	Description	Width	
			Stair	Door
Foyer	F1	Exit leading into scissor stair T1 discharging to outside		1x1.77m
	T1a&b	Scissor stair leading to outside	2x1.1m	
	T2	Exit leading into accommodation stair T2 discharging to outside	1.8m	

Location	Exit No	Description	Width	
			Stair	Door
	T3	Exit leading into feature stair T3 discharging in Foyer	1x3.0m	
Lower tiers	P1	Exit into corridor leading into Warehouse		1x1.51m
	P2	Exit leading to outside		1x1.51m
	P3	Exit leading into Foyer	1.2m(1)	1x1.50m
	P4	Exit leading into Foyer	1.2m(1)	1x1.50m

(1) Stairs are only provided for events with the “sloping floor”.

Figure 6-17: Theatre – Level 2, means of escape numbering system



6.12.2 EXIT CAPACITY

BS 9999 provides minimum width per person in order to size means of escape. Moreover, the guidance allows for reduced width per person when additional fire protection measures are provided as discussed in Section 5.10.

- **Ceiling Height**: the significant ceiling height and the size of this area create a large smoke reservoir above head height. It, therefore, provides a greater capacity to hold the smoke compared to a traditional floor to ceiling of 3m. As such a 30% reduction can be introduced as per Table 15 of BS 9999. This is considered as being conservative as
  - BS 9999 only considers floor to ceiling heights of up to 10m while the roof of the Theatre is c. 20m above floor level and ~6m above the top tier level; and
  - A mechanical smoke extraction system is provided as such tenable conditions will be maintained for a longer period.
- **Early warning**: Automatic fire detection may not be provided for events requiring the use of smoke; however given that this space is completely open a fire should be detected at an early stage of its development and therefore the fire alarm should be triggered quickly through activation of manual call points. This will significantly reduce the detection time compared to a code-compliant design provided with partitions that may prevent people from noticing a fire at an early stage of its development. In addition, due to a high level of management being provided the occupants should be alerted and guided towards the nearest exit at an early stage which will limit the confusion that can happen in this type of building where occupants are unfamiliar with the surrounding premises and the fire alarm sounders.

Based on the above it can be clearly seen that for most events the maximum reduction percentage provided in BS 9999 can be applied in the auditorium. This should be confirmed by a fire risk assessment prior to any events to ensure that the event does not affect the parameters benefiting the safety of the occupants in the event of a fire (early warning and ceiling height).

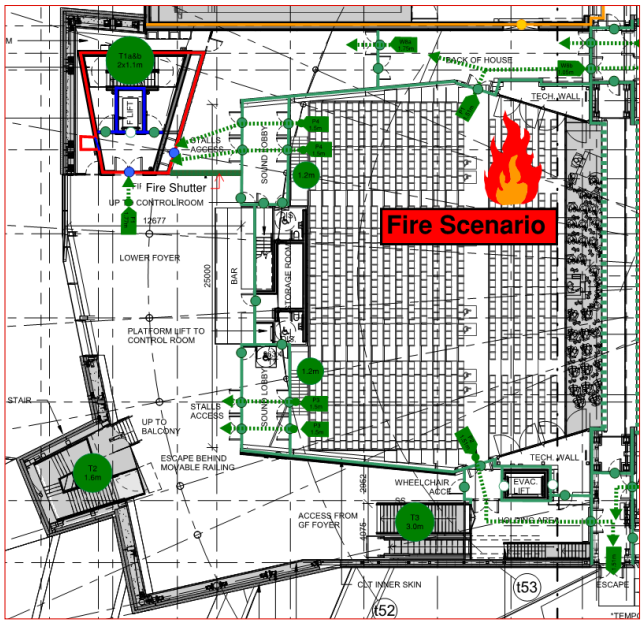
6.12.3 DISCOUNTING OF EXITS

As described in Section 5.8.1, the largest exit will be discounted when assessing the capacity of the premises. One scenario has been considered as described below and presented in the figure below.

- **Fire in the auditorium:** A fire in the auditorium is likely to start on stage as the combustible materials will be limited in the rest of the auditorium; therefore it should not affect the means of escape provided as they are all located away from this area. However, for conservatism, it has been assumed that the largest capacity exit is not available - one of the 1.51m wide exits (P1 or P2). Note: whilst exits P3 and P4 are wider at 2x1.5m, they are each accessed by two 1.2m wide stairs which restricts the capacity to a lower value than the 1.51m wide exits of P1 or P2.

It is noted that in previous revisions of this document, two fire scenarios were considered. The second fire scenario was a fire in the Foyer which prevented the use of two exits, P3 and P4. However, this has since been resolved by the proposals for a fire curtain which creates a protected escape route linking exit P4 to stair T1a&b in the event of a fire in the Foyer. The worst-case fire scenario is therefore considered to be a fire in the auditorium.

Figure 6-18: Theatre - Exit discount scenario



6.12.4 THEATRE MODE NO1: SLOPING FLOOR - SEATING

For this mode, two risk profiles have been considered:

- **B1** which corresponds to an event with a slow fire growth. This would occur in the event where the main fire risk – the stage - is in the Warehouse. The fire would therefore not affect the occupants during the evacuation process (refer to Appendix B). A fire starting anywhere else will have a slow fire growth given the amount of combustible materials provided in this type of event is very limited (refer to Section 9.2 regarding restrictions on furniture to limit fire risk).
- **B2** which corresponds to an event with a medium fire growth. This would occur in the event where the main fire risk – the stage - is in the Theatre.

The capacity has been calculated in the following table: taking into account the additional fire protection measures described in Section 5.10. These are sufficient for the maximum occupancy that can be accommodated for these type of events.

Table 6-31: Level 2 – Sloping floor, Means of Escape Capacity

Exit		B1				B2			
Number	Clear Width	mm/p	Capacity	Total	Occupancy	mm/p	Capacity	Total	Occupancy
~~P1~~	~~1.51m~~	~~2.4~~	~~629~~	1,389	860/960	~~3.3~~	~~457~~	1,123	860/960
P2	1.51m	2.4	629			3.3	457		
P3(1)	2x1.5m	3.15	380			3.6	333		
P4(1)	2x1.5m	3.15	380			3.6	333		

(1) These exits are served by separate 1.2m wide staircases which will be limiting the flow.

6.12.5 THEATRE MODE NO2: FLAT FLOOR – STANDING

For this mode, two risk profiles have been considered:

- **B1** which corresponds to an event with a slow fire growth. This would occur in the event where the main fire risk, the stage, is in the Warehouse. The fire would therefore not affect the occupants during the evacuation process (refer to Appendix B). A fire starting anywhere else will be limited given the amount of combustible materials provided in this type of event. The number of occupants for this event will be 1,840 people.
- **B2** which corresponds to an event with a medium fire growth. This would occur in the event where the main fire risk – the stage - is in the Theatre. The number of occupants for this event will be 1,420 people.

The capacity has been calculated and shown in the table below taking into account the additional fire protection measures described in Section 5.10.

Table 6-32: Theatre - Flat floor, Means of Escape Capacity

Exit		B1				B2			
Number	Clear Width	mm/p	Capacity	Total	Occupancy	mm/p	Capacity	Total	Occupancy
P1	1.51m	2.4	629	2508	1,840	3.3	457	1823	1,420
P2	1.51m	2.4	629			3.3	457		
P3	2x1.50m	2.4	1250			3.3	909		
~~P4~~	~~2x1.50m~~	~~2.4~~	~~1250~~			~~3.3~~	~~485~~		

6.13 THEATRE UPPER TIER

6.13.1 DESCRIPTION

The upper-tier starts at Level 3 and continues up to Level 5 and can accommodate up to 640 people. The upper tiers will be provided with the means of escape, for more information see appendix G and relevant figures showing available exits.

Table 6-33: Theatre – Upper Tier – Means of escape description

level	Exit No	Description	Width	
			Stair	Door
3	U1	Exit leading into scissor stair T1		1.8m(1)
	U2	Exit leading into foyer served by open stair T2		1.8m
	T2	Open stair discharging to outside	1.8m	
5	U3	Exit leading into scissor stair T1		1.7m(1)
3 & 5	T1	Scissor stair serving all floors and discharging to outside	2x1.1m	

(1) The doors opening into the scissor stair should be 1.05m wide as a minimum.

Figure 6-19: Theatre - Upper Tiers, level 3 means of escape

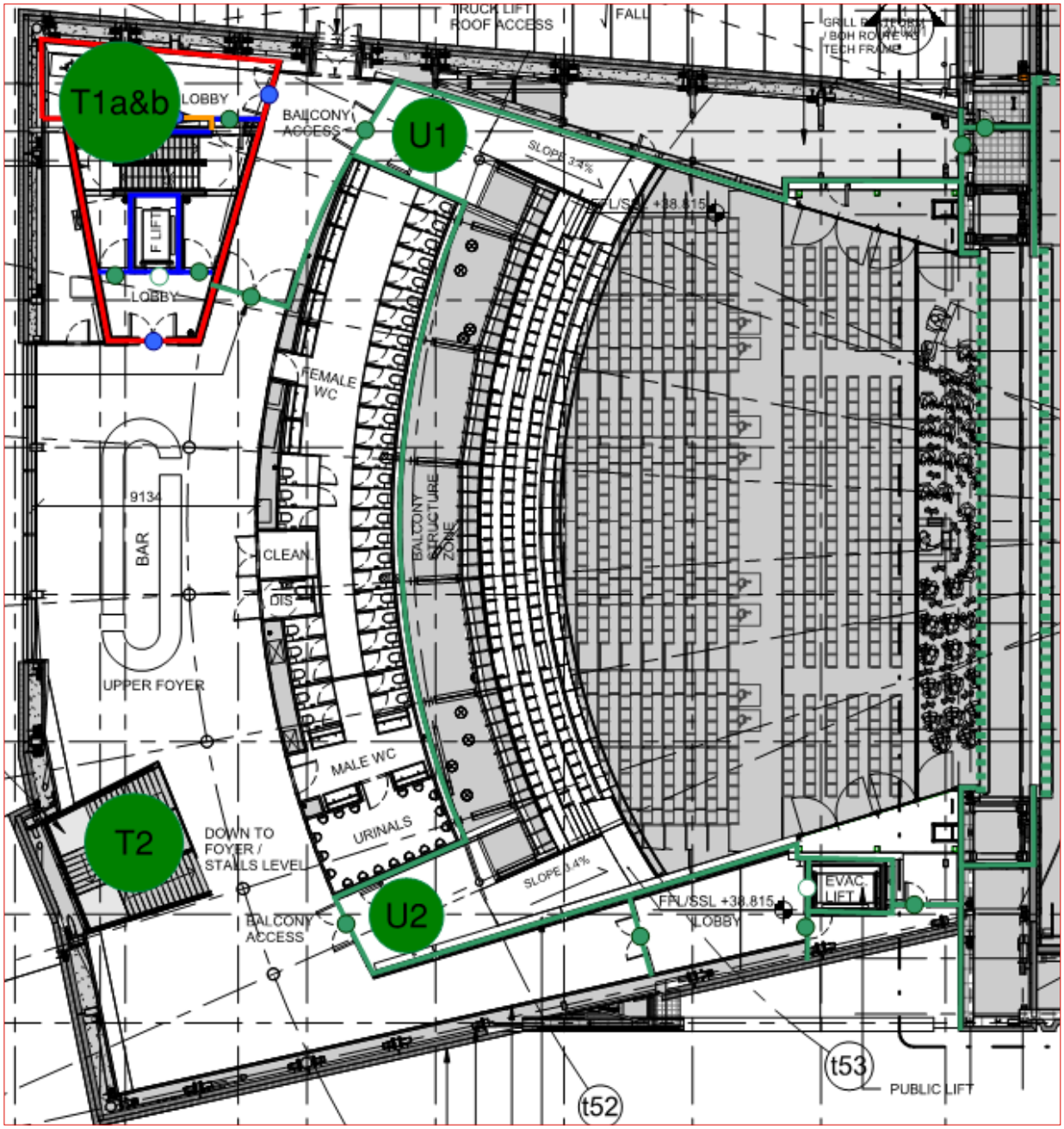
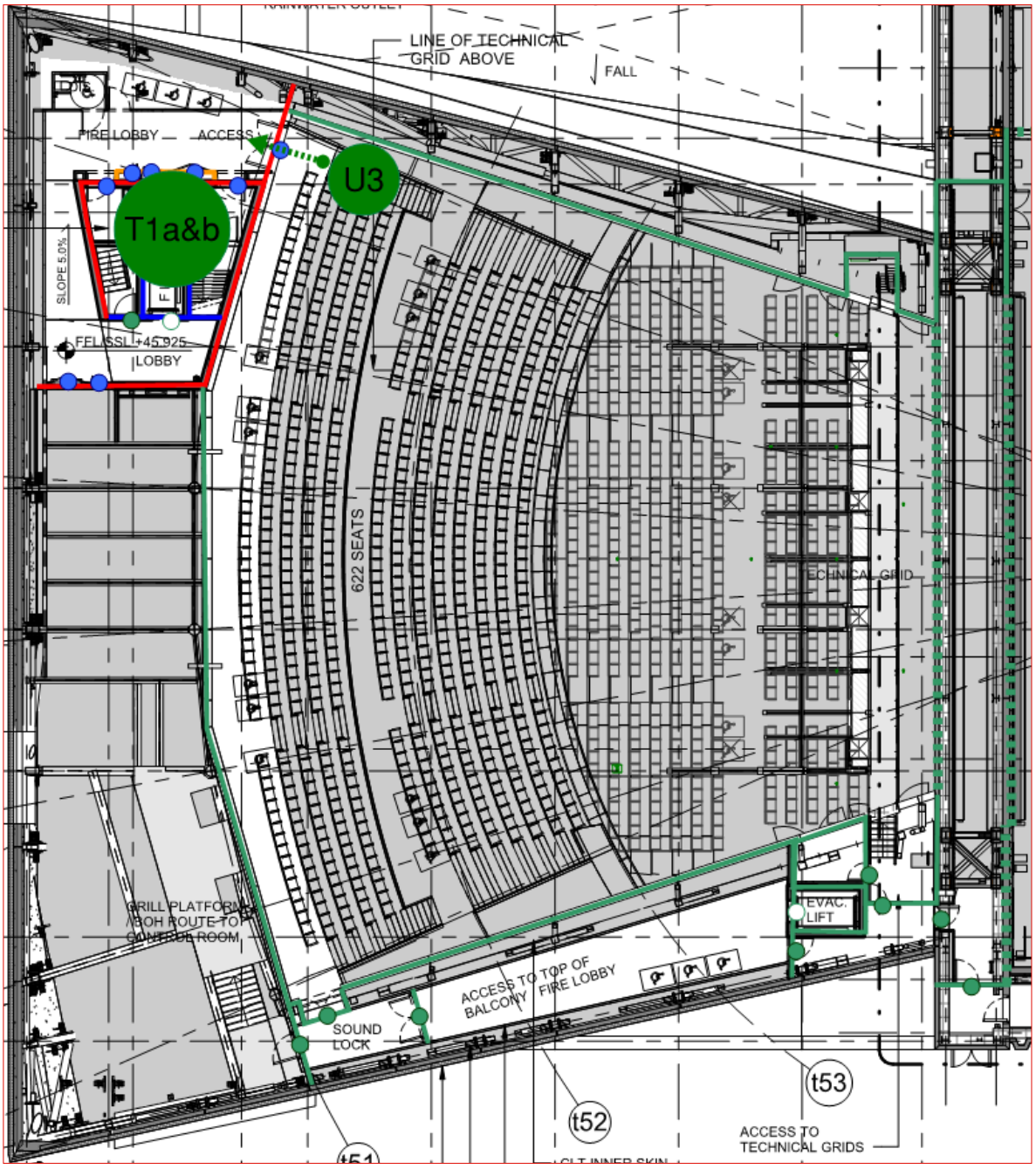


Figure 6-20: Theatre - Upper Tiers, level 5 means of escape



6.13.2 ADDITIONAL FIRE PROTECTION MEASURES

BS 9999 provides minimum width per person in order to size means of escape. Moreover, the guidance allows for reduced width per person when additional fire protection measures are provided as discussed in Section 5.10.

The Theatre will be provided with an automatic fire detection and alarm system. This system could be disabled during events where smoke is used in order to prevent false alarm actuation. However automatic fire detection is of limited use to detect fires starting in the Theatre during events as this

space is all open and a fire will be noticed at an early stage by the public. In addition, a high level of management will be provided during events; staff will therefore trigger the alarm at an early stage of the fire development. On that basis, it is considered acceptable to apply a 15% reduction on the minimum width per person as allowed under BS 9999 where means of reducing the fire detection time are provided.

6.13.3 HORIZONTAL CAPACITY

A width per person of 3.49mm/person (B2 risk profile with 15% reduction) will therefore be applied. The widest exit has been discounted as described in Section 5.8.

Table 6-34: Upper Tiers – Horizontal capacity

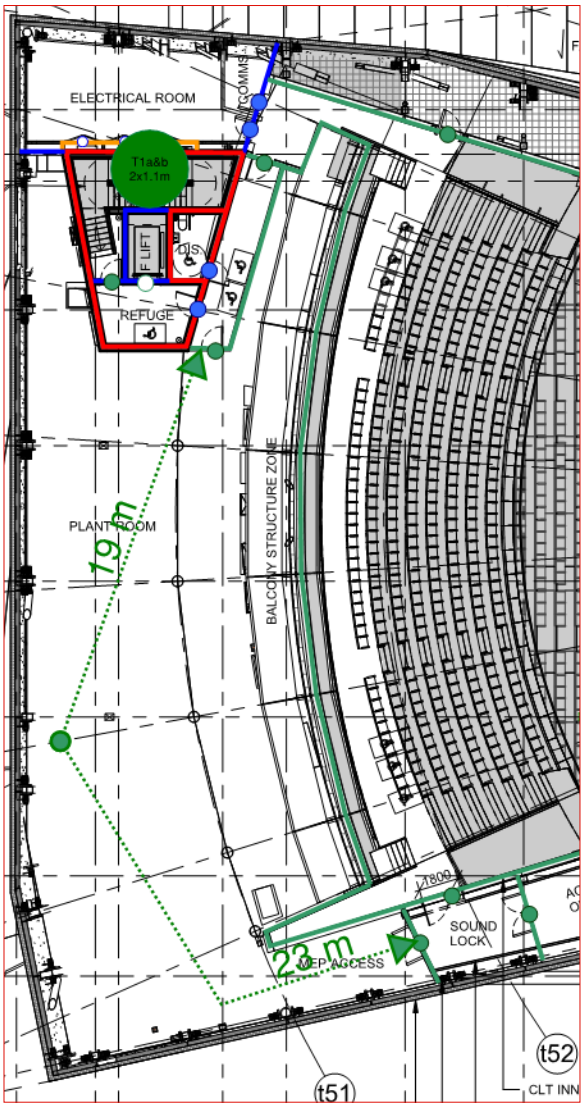
Exit		Capacity		
Number	Clear Width	mm/p	Per exit	Total
U1(1)	1.8m	3.49	515 p	1,002
~~U2~~	~~1.8m~~	~~3.49~~	~~515 p~~	
U3(1)	1.7m	3.49	487 p	

(1) The doors opening into the scissor stair should be 1.05m wide as a minimum.

6.14 MEANS OF ESCAPE FROM LEVEL 4

A plant room is provided at Level 4. It will be ensured that an alternative escape route is provided where the travel distance in one direction to a place of safety exceeds 16m (B3 risk profile). Secondary means of escape is provided within the plant room as shown in the figure below which ensures that the travel distance is less than 40m where two means of escape are provided.

Figure 6-21: Alternate Escape Routes within the Level 4 Plant Room

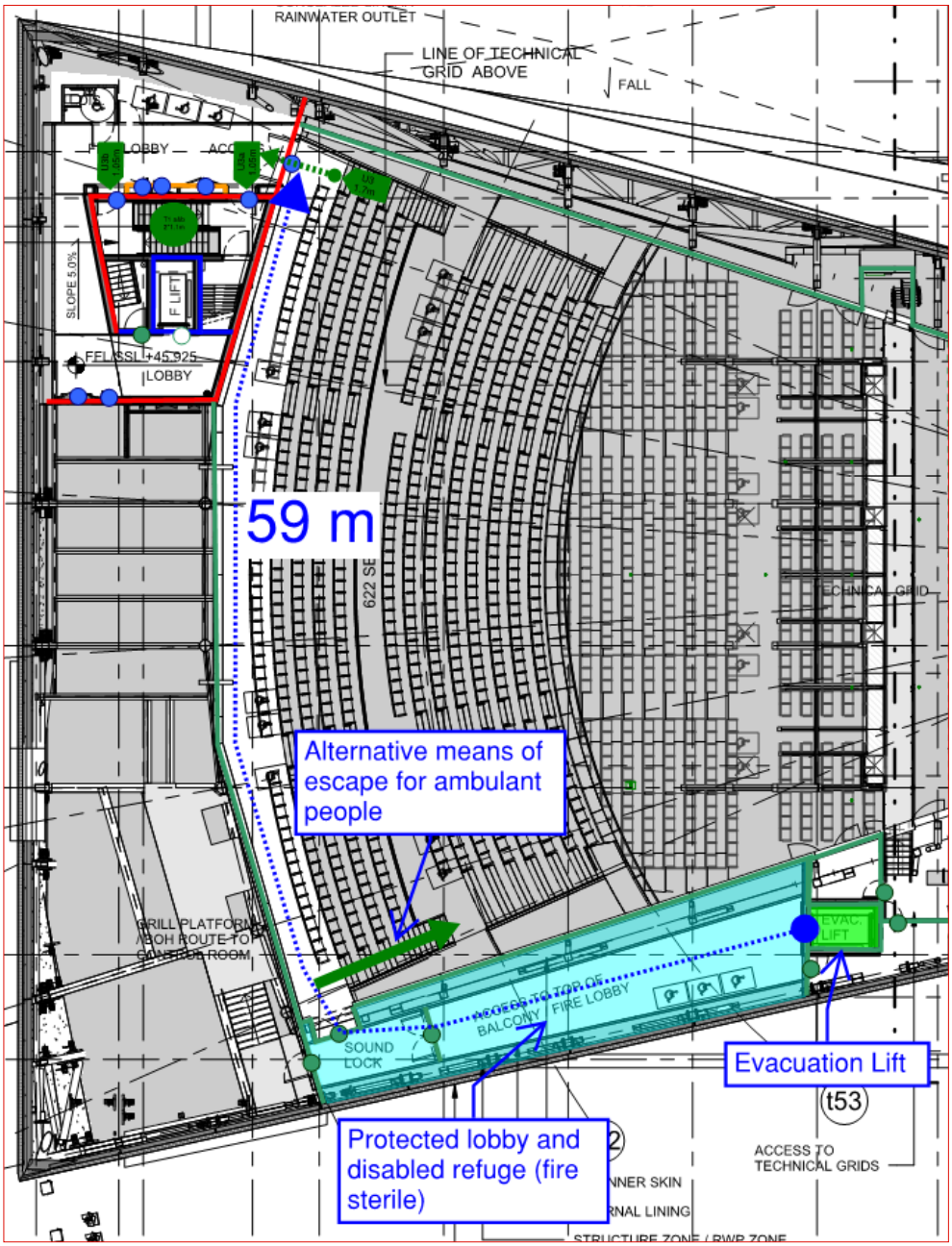


6.15 THEATRE DISABLED LIFT

The lift located in the South part of the Theatre will be used for disabled access. Travel distance from this lift to a stair is extended as shown in the figure below (up to 60m for disabled occupants – note that ambulant people can evacuate down to Level 3 once in the auditorium). The proposed arrangement is considered as acceptable for the following reasons:

- This corridor will only be temporary occupied by a limited number of people to access the upper tiers;
- The corridor will be kept fire sterile and is separated from adjacent areas by fire resisting walls; occupants in this area will therefore be located in a place of relative safety;
- In the event of a fire in the auditorium that prevents access to the stair, the occupants will be able to use the lift that will be designed as an evacuation lift. This lift will be provided with an emergency power supply and a fire-rated lobby on every floor.

Figure 6-22: Theatre – Level 5, access / egress to lift



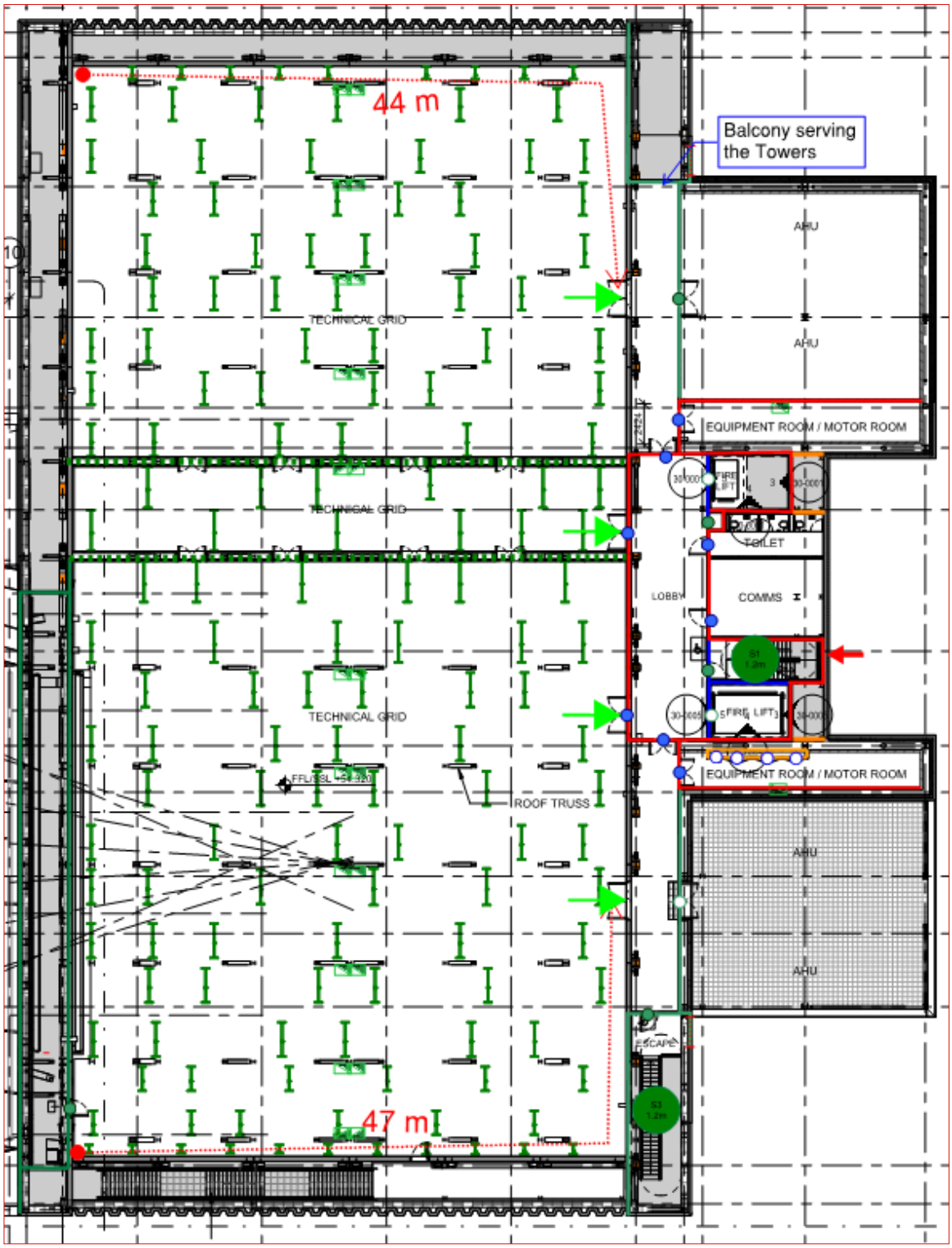
6.16 TECHNICAL GRID

A technical grid (room no. 702) will be provided at Level 7 on top of the Warehouse. This space will be accessed by staff only.

This space is provided with a large number of exits leading into the balcony serving the Towers. The travel distance will be well within the maximum travel distances of BS 9999 for a A2 risk profile:

- Single means of escape: 22m
- More than one direction of escape: 55m.

Figure 6-23: Means of escape from the technical grid



6.17 GANTRIES

Gantries are provided in The Factory to provide access to maintenance equipment. This section sets out the principles to be followed in the design of any escape from the gantries. The risk profile of these spaces is taken to be A2 – occupants will be awake and familiar with a medium fire growth rate. Based on this and the enhanced automatic detection, discussed in Section 5.10, the travel distances in this area will be limited to:

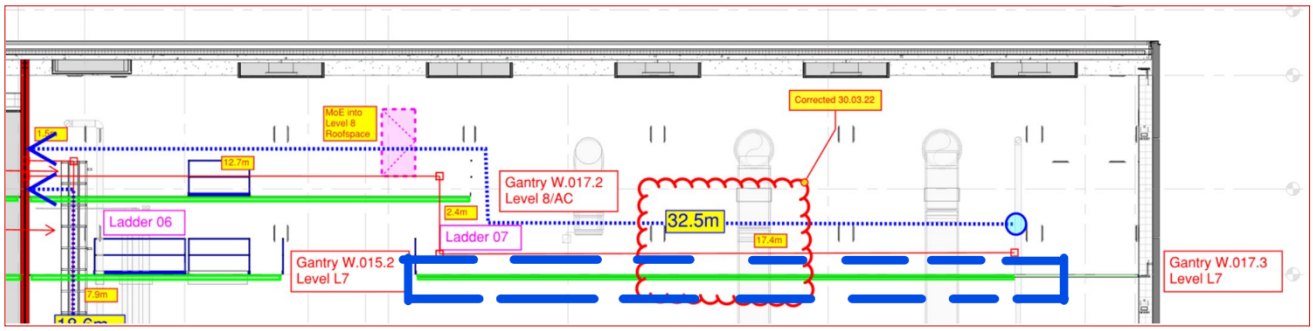
- 25m in a single direction; and
- 63m where there is more than one direction of escape to choose from.

In areas that are infrequently accessed where dead-end travel distance exceeds the permitted travel distance 32.5m, a locked gate will be provided to ensure only trained specialist individual will access the area.

Furthermore, it has been agreed in principle with the Building Control that the gantries will rely on ladders for vertical escape, this is acceptable due to there being no public occupants in these areas and only trained maintenance personnel who will only require periodic access with work permit will be present in the spaces.

Manual call points will be provided at each change of level in the gantry spaces, to ensure that no occupant can escape without passing a manual call point and raising the alarm.

Figure 6-24: Gantry Means of Escape



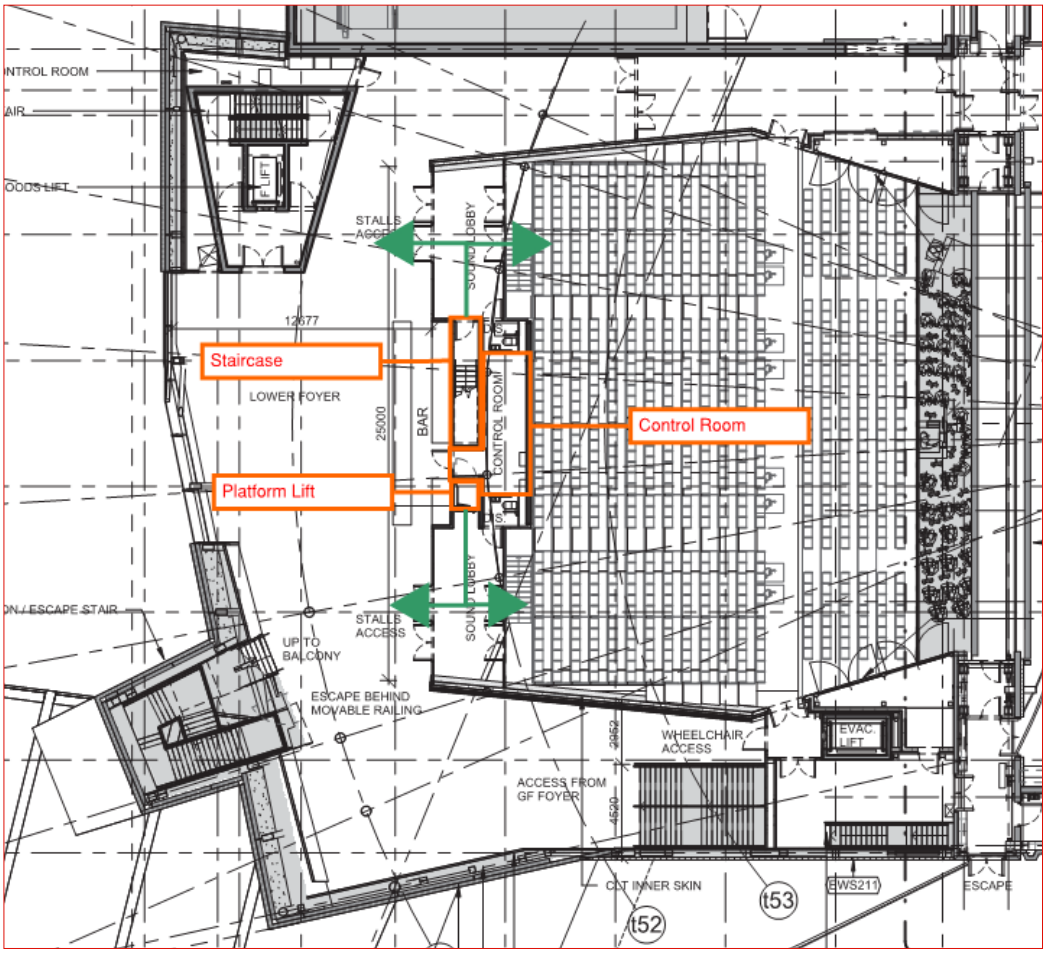
6.18 MEANS OF ESCAPE – CONTROL ROOM

One control room is provided in the Theatre and opens at Level 2 in the sound lobbies provided between the Theatre foyer and the auditorium. As these rooms are slightly above the foyer, once in the control room, the occupants will have to climb several steps or use the platform lift to access the room.

The two sound lobbies will be fire rated so that in the event of a fire in the Foyer, the occupants can escape safely via the auditorium and vice versa.

In addition, the platform lift will be designed as an evacuation lift that can be operated by a person of reduced mobility located in the control room in the event of a fire and provided with an alternative power supply to ensure that it can be operated in the event of power failure. This will shorten the evacuation time and ensure that the person can evacuate without assistance; however, the evacuation will still require some management to ensure that the lift is available when required and that anyone with a mobility impairment is not left alone.

Figure 6-25: Means of Escape from control room



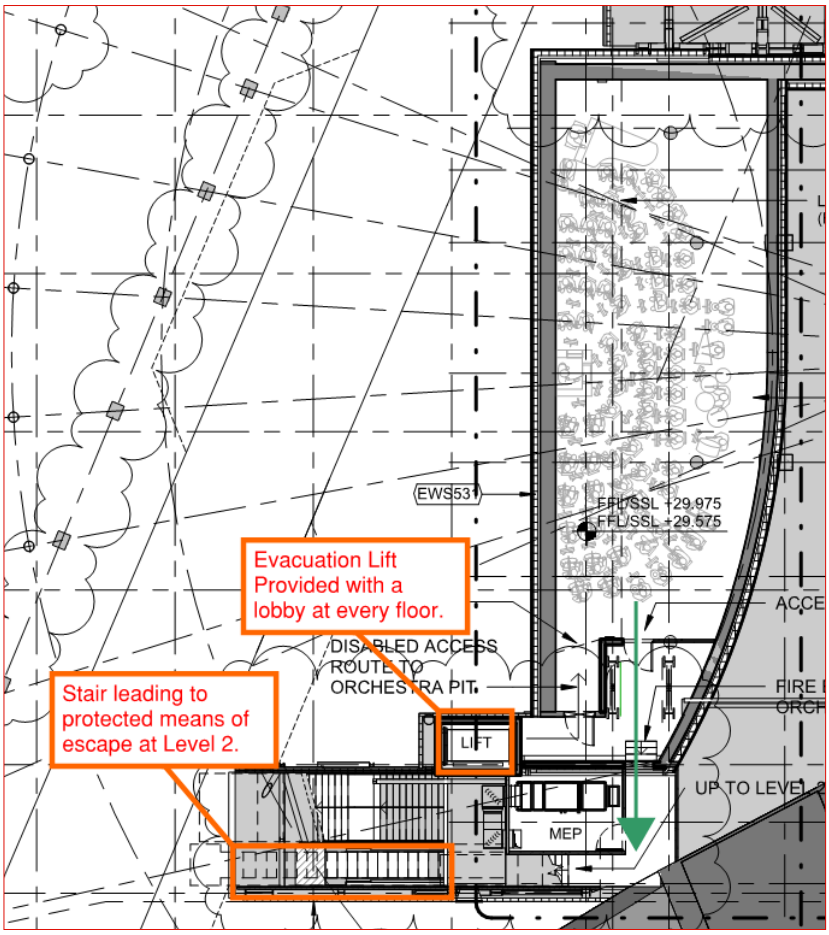
6.19 MEANS OF ESCAPE – ORCHESTRA PIT

The orchestra pit (room no. 102) is shown as being provided with one means of escape (stair leading to protected means of escape at Level 2) as shown in Figure 6-26: . The orchestra pit will have an occupancy greater than 60 persons and should therefore be provided with more than one means of escape. However, it is deemed acceptable for only one means of escape to be provided to the orchestra pit as analysis has been conducted in Appendix B showing that tenable conditions are maintained for the escape of occupants within the theatre auditorium. As the orchestra pit will be below the plane of fire origin, it can be said that persons within the orchestra pit will also have adequate time to escape in the event of a fire within the theatre.

The lift serving the orchestra pit will be designed as an evacuation lift that can be operated by a disabled person located in the orchestra pit in the event of a fire and provided with an alternative power supply to ensure that it can be operated in the event of power failure. This will shorten the evacuation time and ensure that the person can evacuate without using the stair. Adequate management procedure will have to be implemented by the end-user (MIF).

The lift will therefore be provided with a protected lobby on every floor.

Figure 6-26: Means of escape from the orchestra pit



6.20 SAFETY CURTAINS

Due to having several theatre stage formats, it is not possible to have a safety curtain between the stage area and the seating area as it would not offer any benefit for life safety.

To compensate for this omission, it is intended to mechanically ventilate the theatre space and controls placed on the open theatre.

Computational Fluid Dynamics (CFD) has been used to determine the required amount of extract ventilation required. The detailed CFD analysis can be found in Appendix B.

6.21 SEATING ARRANGEMENT

Where seating is provided it should comply with the recommendations presented in Section 5.11.

7 MEANS OF ESCAPE – GROUND FLOOR FOYER AND UNDERCROFT AREAS

7.1 DESCRIPTION

The Foyer consists of the main entrance area provided at the ground floor level of the building, underneath the Warehouse.

The foyer area will serve as a bar area and the internal fit-out is subject to a specialist fit-out contractor. The end-user must ensure the internal fit-out is in line with the overall building fire strategy. It must be ensured that the stage, bar or any other elements do not reduce or prevent access to the required means of escape during 5,055 people events. Where the maximum expected occupancy is lower, the required means of escape should be reassessed if a number of exits cannot be accessed.

The contents in the foyer/bar area should be subject to a risk assessment and classed to be low-risk contents identical to a typical medium fire growth rate as defined in Table 3 of BS 9999 below.

If the fire load in the bar exceed a typical medium fire growth, then the bar should be separated from the escape routes by means of fire shutters or curtain not less than 60-minutes fire resistance.

Figure 7-1: Level 00 Bar Area Fire Load.

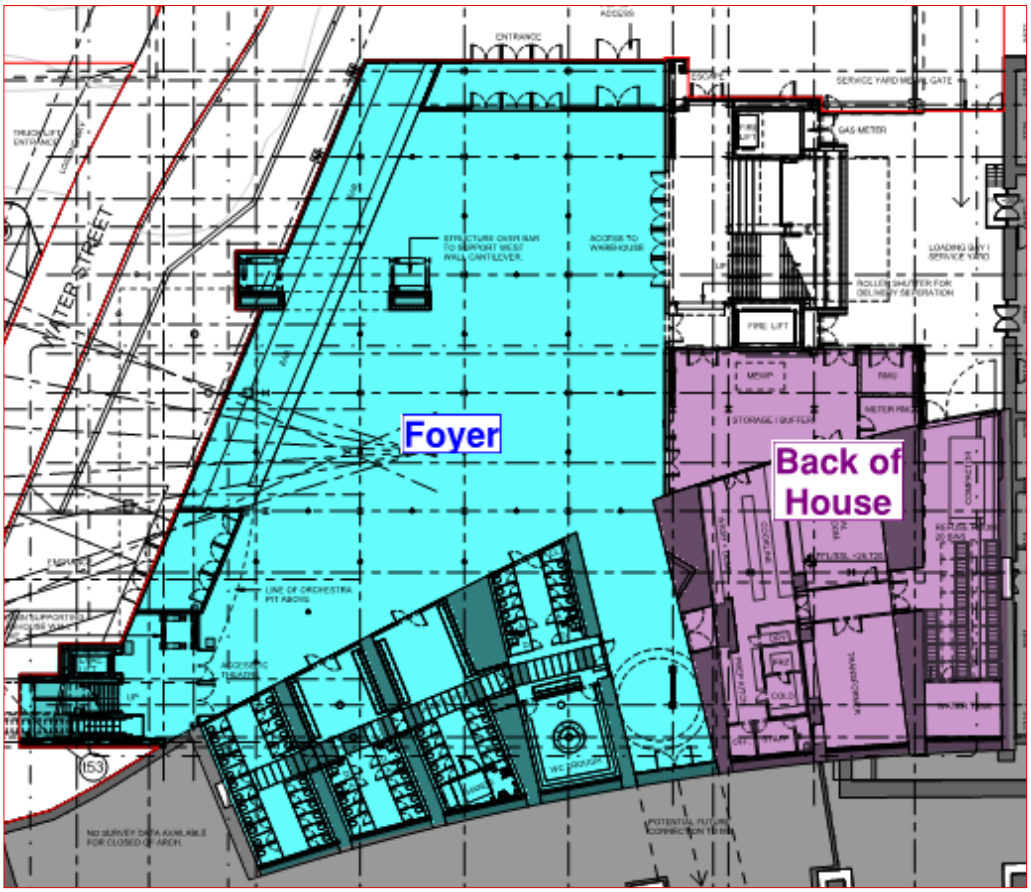
BRITISH STANDARD BS 9999:2017

Table 3 Fire growth rates

Category	Fire growth rate [A]	Fire growth parameter [B] kJ/s³	Description	Typical examples [C]
1	Slow	0.003	Evenly distributed low level fire load, small discrete packets of fuel or material of limited combustibility [D]	Reception areas, concourses (without concession outlets) and halls with limited fire load such as sports stadia and foyers
2	Medium	0.012	Evenly distributed low to mid-level fire load comprising a mix of combustible materials	Offices, lounges, classrooms, auditoria, seating areas, galleries and car parks [E]

A back of house area incorporating plant rooms and bin store will also be provided on the east of the Foyer.

Figure 7-2: The Foyer Level 00 Bar Area.



7.2 RISK PROFILE

In accordance with BS 9999, the risk profile is established to determine appropriate means of escape and other fire safety provisions are provided. The risk profile is a function of the occupancy of the building and the fire growth rate.

- **Occupancy characteristics**: It is assumed that the majority of the people using the Foyer will be members of the public awake and unfamiliar with their surroundings and as such will be classified as occupancy characteristic B under BS 9999. The plant room area will only be accessed by staff and as such will be classified as occupancy characteristic A.
- **Fire Growth Rate**: The fire growth rate depends of the event organised and the amount and type of combustible that could be used within the Foyer. As such, the fire load will need to be assessed prior each event to select the appropriate risk profile and hence determine adequate fire safety measures. When the Foyer is fully occupied, it is assumed that the fire load will be limited at this time given the limited space available and as such a medium fire growth rate 2 is considered as acceptable. The plant room area will be classified as fast growth rate (3).

As a result, the risk profile of the Foyer will be B2. The capacity for a B3 (fast fire growth rate) has also been specified in the following section will the event organised require the use of significant fire load. The plant room area is classified as A3.

7.3 OCCUPANCY

As specified by the Design Team and the end-user, the Foyer has been designed to accommodate a maximum of 600 people. The means of escape have therefore been sized on that basis.

Note: it is anticipated that during event mode, occupants present in the foyer will not be present in the event spaces on level 2 vice versa.

7.4 MEANS OF ESCAPE CAPACITY

The capacity has been calculated in Table 7-1: . The following minimum width per person has been used:

- For a risk profile B2, 3.49mm per person (including 15% reduction due to the provision of automatic fire detection and alarm system).
- For a risk profile B3, 5.4mm per person (including 10% reduction due to the 5m ceiling heights in the main foyer).

The means of escape are shown in Figure 7-3:

Table 7-1: Foyer - Means of escape capacity

Area	Exit		Capacity B2		Capacity B3	
	Number	Free Width	Per exit	Total	Per exit	Total
Foyer	~~F1~~	~~3x1.8m~~	~~1,547 p~~	2,062 p	~~1,000 p~~	1333 p
	F2	1x1.8m	515 p		333 p	
	F3	3x1.8m	1,547 p		1,000 p	

As discussed in Section 4.2, the foyer and Warehouse or theatre may be in use at the same time, in this scenario (where there is a fire in the Warehouse) the exit capacity is shown to be sufficient for escape in Table 7-2: for both the Warehouse and foyer to operate at maximum capacity.

Table 7-2: Capacity from foyer when S1 evacuates into foyer.

Scenario	Occupancy	Exit width required	Total exit width required (m)	Exit width provided (m)
Occupancy from Warehouse (S1 with B1 Risk profile)	1,429	4.99	12	12.6
Occupancy from Foyer (B2 Risk Profile)	600	2.1		

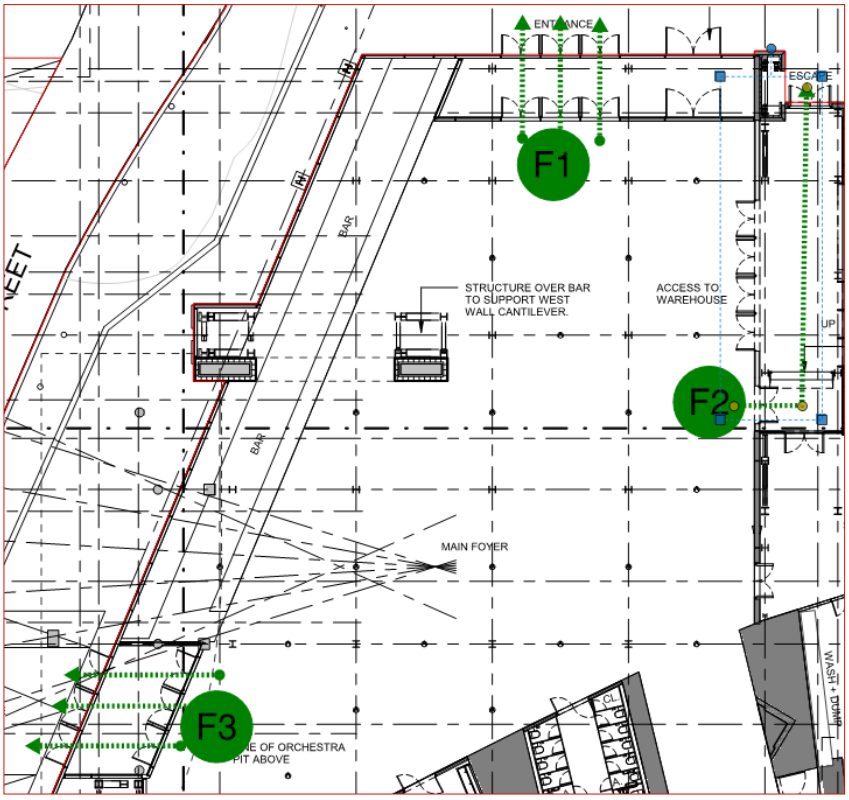
7.5 TRAVEL DISTANCES

The travel distances in the Foyer currently comply with the recommendations of BS 9999 given in Table 7-3: .

Table 7-3: Foyer - Travel Distance Recommendations

Risk Profile	Travel Distance in…	
	More than one direction	One direction
B2	50m	20m
B3	40m	16m
A3	45m	18m

Figure 7-3: Means of escape from the Foyer (ground floor level)



7.6 LEVEL 00 UNDERCROFT

It is proposed that street retail stalls similar to an island will be provided on a non-permanent basis in the undercroft green area below. The stalls will sell merchandise and similar products during some event modes.

Island definition - Island units are those typically with a floor area greater than 25m² and located within the general concourse areas and therefore surrounded by circulation. They have no access to back of house Landlord areas. Island units can be with a canopy or without a canopy.

In order to protect the occupants in the warehouse above, the following fire safety measure will be adopted;

- The undercroft will be provided with heat detectors, therefore, building occupants can be alerted in the event of a fire in a stall. (the heat detector can be adjusted accordingly for sensitivity purposes to mitigate the risk of false alarms)
- The stalls are to be located a minimum of 5m away from the building final exits.
- The stalls will not impede egress by ensuring they are located away from the permanent tactile egress pavings.
- The stalls must not impede fire and rescue service access to the building.
- The floor above the undercroft will be designed and constructed with 90 minutes fire resistance with appropriate fire-stopping where stalls are proposed beneath to prevent smoke ingress to the upper levels. Note: it has been agreed that fire stopping will be omitted in the north tower undercroft area, therefore, it is not permissible to have retail units in the north tower area.
- The cladding for the undercroft will be of limited combustible material, Class B-s3,d2 or better (European class).

7.6.1 UNIT CONSTRUCTION (FIT-OUT)

The following requirements apply to the tenant in terms of unit construction:

- Any proposed stall canopy should be non-combustible or limited combustible material.
- All walls, floors and ceilings/slabs should be non-combustible or limited combustible materials.
- Lining materials on walls or ceilings are required to be fire tested to EN 13501 and achieve a Class B, s1, d0 classification.
- All framing, shelving, displays, cabinetry, counter tops are required to be of non-combustible or limited combustible construction. E.g. metal, glass, gypsum, ceramic, stone.
- Fire retardant treated timber or MDF is permitted up to 25% of total cabinetry/shelving/lining in the unit and not more than 20m² of surface area. If used, it should be pressure treated and not painted.
- Floors should be non-combustible or limited combustible. Carpets are not permitted except under sofas or chairs. Carpets are not permitted under racks or displays. Fire retardant treated timber flooring in addition to the 20m² of cabinetry is permitted.
- Plastic and foam plastic trim are not permitted.
- Foam plastics and expanded vinyl are not permitted.

7.6.2 UNIT CONTENTS (FIT-OUT)

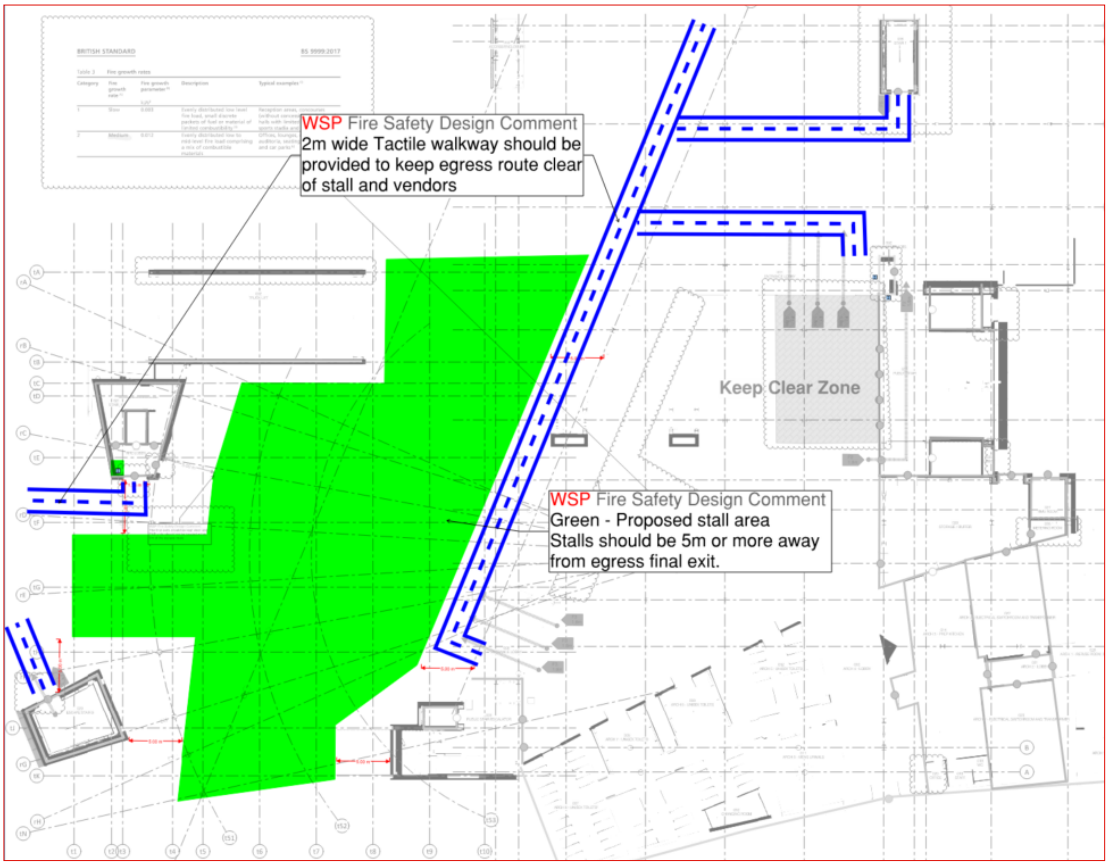
Unit contents are restricted as these units do not have smoke control to prevent lateral smoke flow from impeding the final escape from the upper level of the building. The following requirements apply to the tenant stalls in terms of unit contents:

- Stalls or displays should have an upper limit area of 5m² with adequate separation between displays/stalls.
- Clothing racks should meet the following:
    1. The maximum dimensions and area taken up by a rack and associated garments should not exceed 2m length x 1m width x 2m height.
    2. Single racks only are permitted i.e. not doubled sided or back to back.
    3. Racks should not be stacked one on top of each other over the height of a wall.
    4. Racks and hangars should be metal or non-combustible.

5. To prevent sustained burning or development of larger fire spread, racks should be separated from each other by a minimum of 2m.
6. Up to 3 racks are permitted in a single stall/display.

- The total permitted mass of garments should not exceed 20kg. This equates to about 20 men's suits at about 0.5-1kg per suit and assumes normal high-quality clothing fabric is used (i.e. cotton, wool, silk with limited manmade fibres such as nylon, polyester). If the display comprises blouses, shirts, scarves etc. then the number of garments can increase but the mass of 20 kg is fixed.
- Traditional heavy timber furniture is permitted but limited to 2 pieces or a total of 20m² surface area. Other materials with limited combustible properties would also be considered on a case by case basis.
- Soft furnishings are permitted but should be resistant to ignition. Upholstered furniture is to be tested to BS 7176 + A1 to achieve a Medium hazard rating for ignition resistance. Predictive assessment of the fire performance of the furniture based on tests of individual components will generally not be accepted. Labels to be provided on all furniture as required by BS 7176.
- Drapes or curtains are to be tested to BS 5867: Part 2 to achieve a Type B rating. Labels to be provided on all drapes as required by BS 5867.
- Foam plastics and expanded vinyl are not permitted.

Figure 7-4: Means of escape from the Foyer



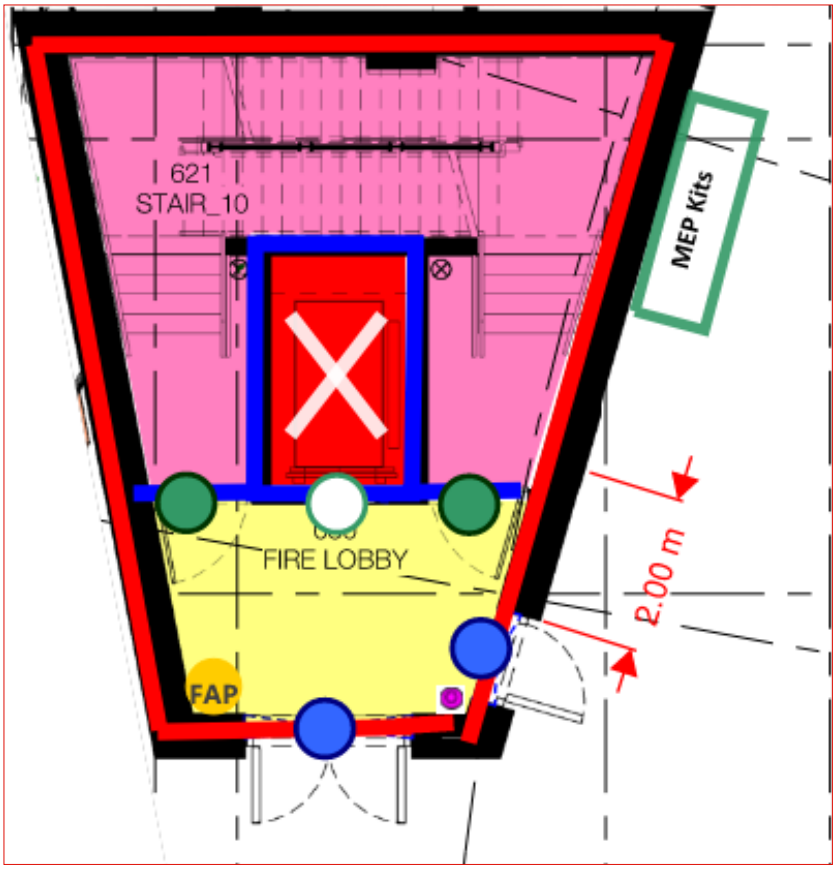
Note: it has been agreed that fire stopping will be omitted in the north tower undercroft area, therefore, it is not permissible to have retail units in the north tower area.

7.7 LEVEL 00 – THEATRE EXITS MEP KITS

The proposed MEP kits located in the vicinity of the theatre stairs final exits will be meets the following;

- Combustible material should be avoided in the space.
- Enclosed in a minimum of 30 minutes fire resisting enclosure.
- Located at a minimum of 2m from the stair exit door.

Figure 7-5: Theatre exit MEP kits



8 MEANS OF ESCAPE – TOWERS

8.1 DESCRIPTION

The Towers consist of the premises located to the east of the Warehouse (Figure 8-1). They consist of two 6-storey blocks starting at Level 2 (Warehouse Level) and linked by a central core.

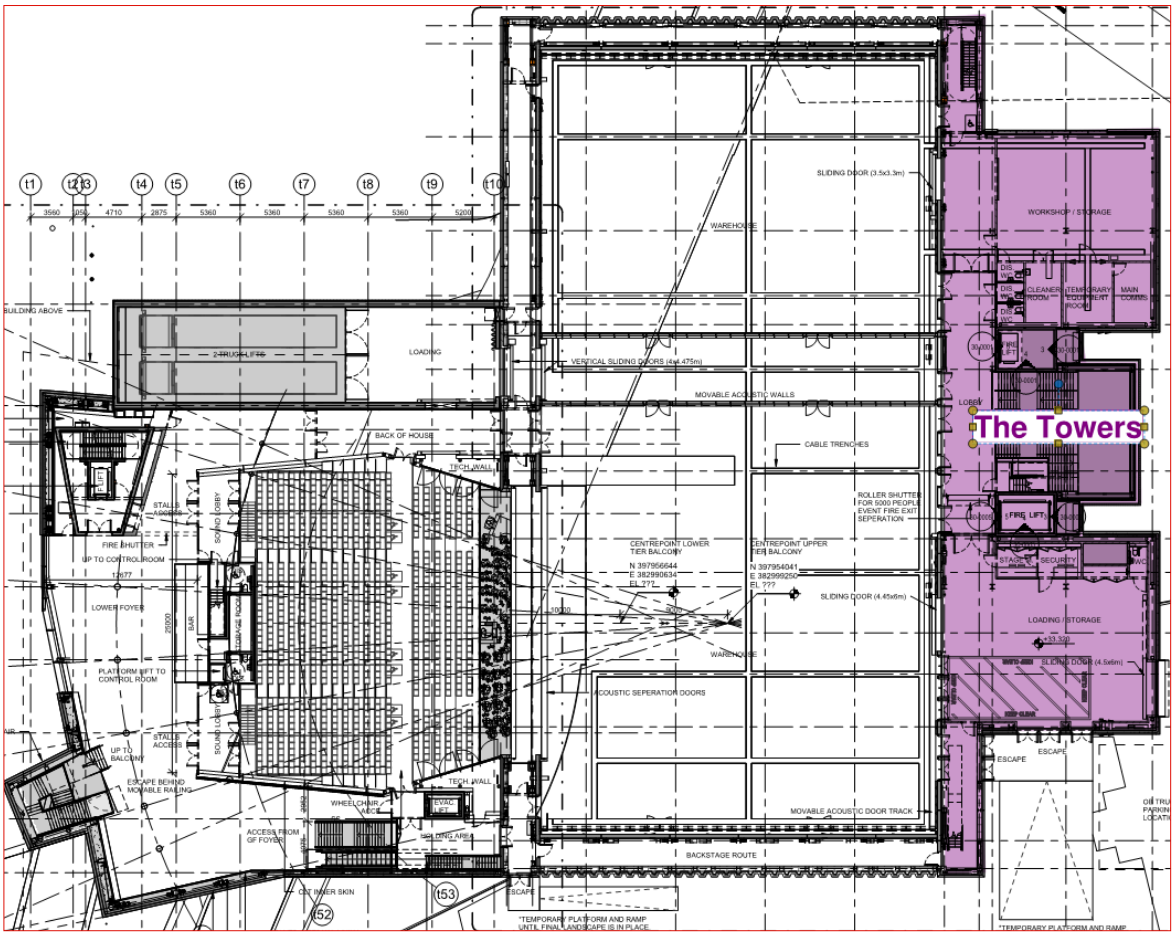
These premises will accommodate the back of house areas of the development that are described in Table 8-1.

Table 8-1: Towers Description

Level	Description		Occupancy
	Tower A	Tower B	
Level 2	Workshop/Storage (room no.204), cleaning room (room no. 207), Temperature equipment (room no. 206) and IT coms room (room no. 205)	Loading-bay (double-height space) (room no. 210)	10 Persons
Level 3	Green room (room no. 302)	-	20 Persons
Level 4	Dressing / changing rooms (room no's. 403-409)	Dressing / changing rooms(room no's. 416-425)	20 Persons
Level 5	Offices (room no. 502)	Offices (room no. 502)	80 Persons
Level 6	Corporate/Education space (room no. 602), Meeting room (room no. 604) and Kitchen (room no. 614)	Plant rooms (room no. 611)	20 Persons
Level 7	Plant rooms / Equipment room (room no. 715)	Plant rooms / Equipment room (room no. 711B)	5 Persons

At level 7 in the Towers, there are Equipment rooms, which will be used as the stage storage and will house the smoke vent control system. This will require 60-minutes fire-rated construction to form a compartment to segregate the store and smoke control panel. This will likely be achieved through some form of fire-rated box being used for the smoke control system. There will also be repeaters to the smoke control system at the entrance of each firefighting shaft.

Figure 8-1: The Towers



8.2 RISK PROFILE

In accordance with BS 9999, the risk profile is established to determine appropriate means of escape and other fire safety provisions are provided. The risk profile is a function of the occupancy of the building and the fire growth rate.

- **Occupancy characteristics**: this area, while accessed mainly by staff, can also be accessed by members of the public. As such an occupancy characteristic B will be used except for plant and storage rooms that will only be accessed by staff and as such will be classified as occupancy characteristic B.
- **Fire Growth Rate**: A medium fire growth rate (2) has been applied. Any space that can contain a large amount of combustibles and electrical equipment will be enclosed with fire-rated partitions.

Based on the above a risk profile B2 has been applied when designing the means of escape.

8.3 HORIZONTAL MEANS OF ESCAPE

8.3.1 TRAVEL DISTANCES

The travel distances in the Towers currently comply with the recommendations of BS 9999 given in Table 8-2.

Table 8-2: Tower - Travel Distance Recommendations

Risk Profile	Travel Distance in…	
	More than one direction	One direction
B2	57m	23m

8.3.2 CAPACITY

The capacity per level has been calculated in Table 8-3. A width per person of 3.49mm per person has been used (risk profile B2 including 15% reduction due to the provision of an automatic fire detection and alarm system).

Table 8-3: Towers - Means of escape capacity

Area	Exit	Capacity	
		Per exit	Per level
Levels 4 & 5	1*1.05m	300 p	600 p
	1*1.05m	300 p	
	~~1*1.05m~~	~~300 p~~	
Levels 3, 6 & 7	1*1.05m	300 p	300 p
	~~1*1.05m~~	~~300 p~~	

8.4 VERTICAL MEANS OF ESCAPE

8.4.1 DESCRIPTION

As shown in Figure 8-2, three 1.2m wide staircases serve the Towers:

- The central stair S1 that discharges at Level 2 into the large feature stair serving the Warehouse;
- The north stair S2 that discharges at ground floor level directly to outside;
- The south stair S3 that discharges at Level 2 directly to outside.

8.4.2 CAPACITY

The vertical capacity of the Towers is calculated in Table 8-4. The stair having the greatest capacity has been discounted. The width per person used is the one provided in Table 13 of BS 9999 for B2 risk profile and includes a 15% reduction given that an automatic fire detection and alarm system will be provided.

8.4.3 CAPACITY VS OCCUPANCY

As specified in Table 8-1, the total occupancy of the Towers is 155 people; hence an extra capacity of 819 people is available based on Table 8-4.

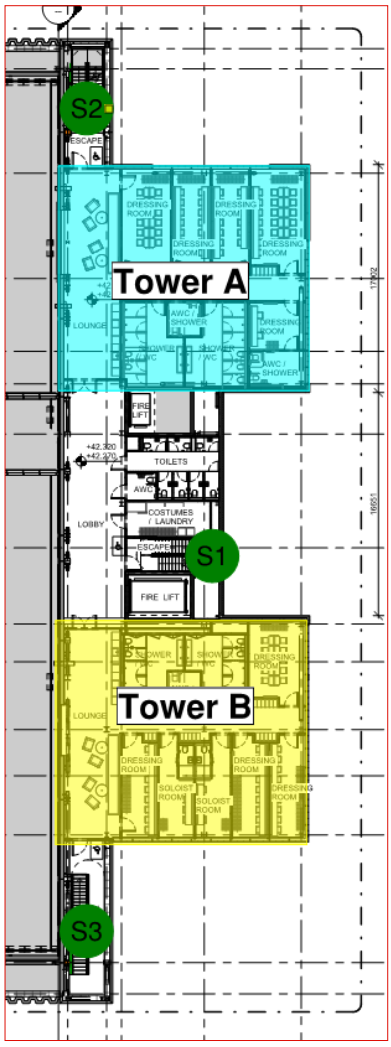
Table 8-4: Towers – Vertical capacity

Stair	Width	Storey Served	Width per person	Capacity	
				Per stair	Total
~~S1~~	~~1.2m~~	~~5~~	~~2.21~~	~~542 p~~	974 p
S2	1.2m	4	2.46	487 p	
S3	1.2m	4	2.46	487 p	

8.4.4 DISABLED REFUGES

Disabled refuges will be provided in each staircase or lobby adjacent to the staircase in order to provide a place of relative safety for people that cannot evacuate the building without assistance. These will comply with the provisions described in Section 5.9.2.

Figure 8-2: Means of escape from the Towers



9 INTERNAL FIRE SPREAD - LININGS

9.1 CLASSIFICATION OF INTERNAL WALL AND CEILING LININGS

Restrictions are placed on the wall and ceiling lining materials within certain areas of buildings, in order to limit the spread of fire and production of smoke in particular areas. All wall and ceiling linings of the building will meet the recommendations of Section 34 of the BS 9999 summarized in Table 9-1.

Table 9-1: Classification of linings

Location	National Class	European Class
Small room of area not exceeding 30 m²	3	D-s3, d2
Other rooms	1	C-s3, d2
Circulation spaces	0	B-s3, d2
Temporary thrust stage	0	B-s3, d2

9.2 SEATS, FURNISHINGS, FABRICS AND DECORATIVE FEATURES

Seats provided for a closely seated audience should meet the pass criteria for smouldering ignition source 0, flaming ignition source 1 and crib ignition source 5 when tested in accordance with BS 5852:2006.

Furnishings, fabrics and decorative features (which include drapes and artificial foliage) should conform to the following specific recommendations.

- Furnishings, fabrics and decorative features will be non-combustible or will conform to the requirements for classification as type B in accordance with BS 5867-2:2008 after being subjected to the appropriate wetting or cleansing procedure described in BS 5651.
- Furnishings, fabrics and decorative features will not be provided within enclosed escape routes (other than foyers) unless made from non-combustible materials.
- Drapes will not be provided in front of exit doors or across escape routes.
- Textile floor coverings, together with any underlay, will when tested in accordance with BS 4790, using the test procedure reflecting the method used for securing the floor covering to the floor, either:
    - Not ignite; or
    - Have effects of ignition on both the use-surfaces and under-surfaces not extending beyond a circle of radius 35 mm centred on the central point of application of the nut.

As an open stage arrangement exists in this scheme (i.e. no provision for a safety curtain), any curtains provided between the stage and the seating should be heavy weight and made of non-combustible material or inherently or durably-treated flame retardant fabric throughout including any trimmings. On an open stage and elsewhere in the premises any permanently installed scenery should be made from non-combustible materials or similar.

10 STRUCTURAL FIRE RESISTANCE AND COMPARTMENTATION

The purpose of providing the structure with suitable fire resistance is:

- To minimise the risk to the occupants while evacuation proceeds.
- To reduce the risk to firefighters who may enter the building to engage in search and rescue operations.
- To reduce the danger to people in the vicinity of the building who might be hurt by falling debris or as a result of the collapsing structure

10.1 STRUCTURAL FIRE RESISTANCE

A structural fire engineering analysis has been completed[1] using a performance-based approach and reference should be made to the latest version of the report for the structural fire engineering requirements.

The building is classed as Ordinary Hazard and greater than 18m in height but less than 30m high when measured from the ground floor access level up to the surface of the top most occupied floor.

All loadbearing elements of the structure will be provided with not less than 90 minutes fire resistance, in terms of loadbearing capacity. Elements that only support the roof do not require any fire resistance, with the exception of areas containing plant and equipment, including any access routes and means of escape, which will be provided with not less than 30* minutes fire resistance.

Where floor is supporting generator or life safety equipment, it will not be less than 90 minutes fire resistance based on the following:

- The building is 90 minutes fire resistant to the elements of structure, therefore, it is assumed that at 90 minutes some elements such as floors may fail.
- The generator is located in the open air at roof level, with a low-risk MEP room located below.
- The fire and rescue service personnel can use the stair located within a 2 hours enclosure.
- The stair is provided with an AOV which should be in the open position and therefore, the stair should be well ventilated to allow the personnel to safely leave the building.
- The 90 minutes is sufficient based on the structural fire protection analysis carried out by WSP with report number - The Factory_SFA_final_Report_70014540-02

This approach has been previously discussed and approved by the statutory authority, however, it will be revisited for approval due to the introduction of additional secondary steels.

All secondary steel supporting elements of structure will be provided with a minimum of 90 minutes fire resistances appropriately. Where steel work penetrates, the steel fire protection will include loadbearing, integrity and insulation.

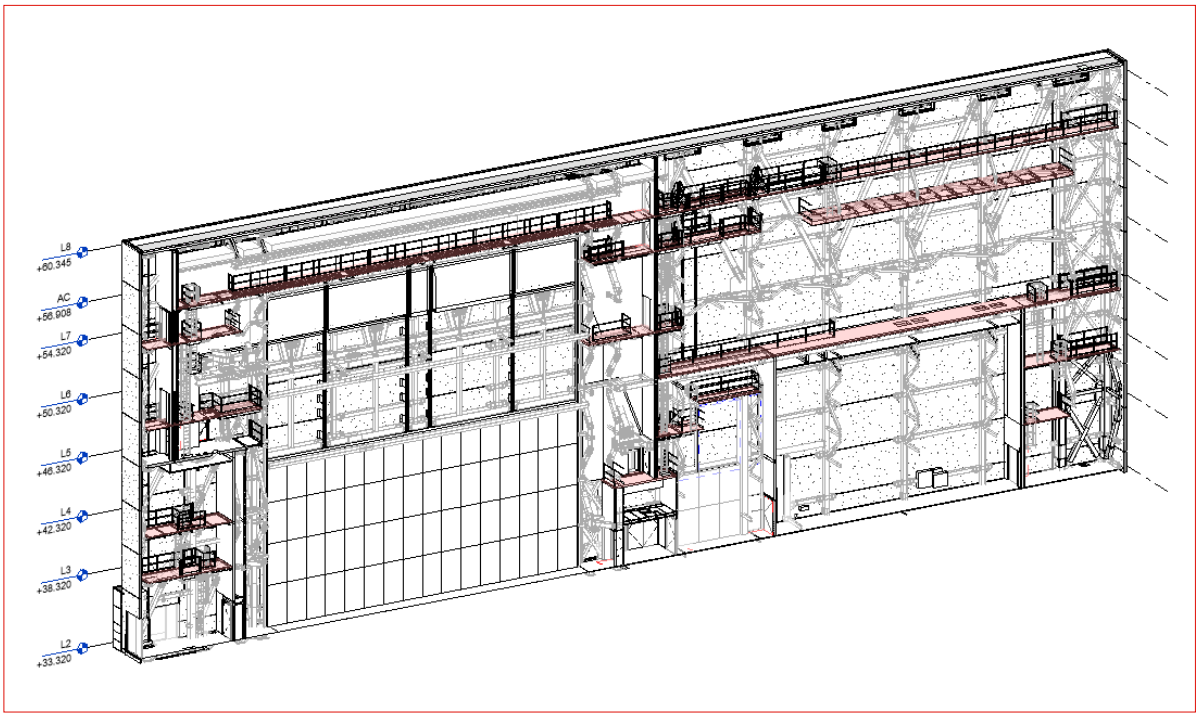
Where steelworks support plant rooms or are located in areas where failure may result in impeding the one-way travel direction, then a minimum of 30 minutes fire resistance will be provided to the steel.

[1] The Factory, Manchester, WSP Structural Fire Engineering Analysis, First Issue, January 2018.

Furthermore, steels supporting the external cladding located in areas adjacent to or above the escape route will be provided with not less than 30 minutes fire resistance.

The megawalls located around the warehouse are to house some MEP equipment, the area is identical to a small mezzanine floor, the MEP equipment will be enclosed in fire-resisting boxes and the travel distance in the area is within the recommendations of this report, therefore the risk considered low. Based on these, the megawalls floors will not be provided with fire resistance.

Figure 10-1: Illustration of the Gantry/Mesh Walkways in West Megawall



10.2 COMPARTMENTATION

As per Table 28 of BS 9999, the compartment size for a B2 risk profile building should not exceed 4000m^2 as the building has a top floor above 18m.

With the exception of Level 02, each floor will be within these limits; For Level 02 fire modelling the CFD results have identified that there is no requirement for fire compartmentation given the low smoke temperatures. Nonetheless, the floors in the building will be constructed as compartment floors. furthermore, smoke resisting construction is in place to support the evacuation strategy in high ceiling space.

Where services are to be passed through the floors, these will be fire stopped to match the structural fire rating of the floor (90 minutes, EI90).

The voids identified in Figure 4.5 – 4.7 of this report do not need to be subdivided where the voids are inaccessible.

Table 10-1 – Fire Resistance Summary

Element	Rating (minutes) When Tested to the Relevant Part of BS 476	Method of Exposure

	Load Bearing Capacity (R*)	Integrity (E*)	Insulation (I*)	
Structure frame, beam or column	90	N/A	N/A	Exposed face
Load-bearing wall	90	N/A	N/A	Each side separately
Floor – any floor including compartment floors	90	90	90	From underside
Any part of a roof forming an escape route	30	30	30	From underside
External Wall				
Any part more than 1000mm from the relevant boundary (1)	90	90	15	From inside the building
Any part adjacent to an external escape route	30	30	No provision	From inside the building
Enclosures				
Theatre compartment construction	30	30	30	Each side separately
Compartment walls	90	90	90	Each side separately
Firefighting shaft Construction separating firefighting shaft from the rest of the building Construction separating firefighting stair, firefighting lift shaft and firefighting lobby	120 60 60	120 60 60	120 60 60	From side remote from shaft From shaft side Each side separately
Stairs, Lifts, Protected corridor / lobby	30	30	30	Each side separately
Service risers	90	90	90	Each side separately
Place of special fire hazard/ancillary accommodation	See Section 10.4 of this report for more details			Each side separately
Cavity Barriers	N/A	30	15	Each side separately

Note 1: *See Section 11 of this report for more details on the allowable unprotected areas.*

- *R* - Loadbearing capacity; the ability of the element to continue to support an imposed load when subject to a fire;*
- *E* – Integrity; the ability of the element to withstand the formation of holes, cracks etc. through which hot gases and flames can pass; and*
- *I* – Insulation; the ability of the element to resist the transfer of heat from the exposed face across the thickness of the element to the unexposed face.*

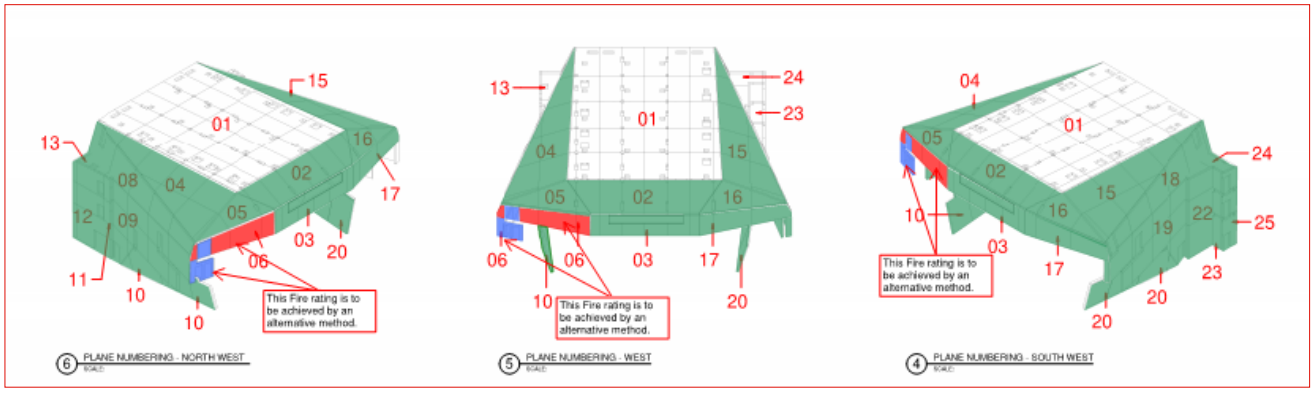
10.3 THEATRE FIRE COMPARTMENTATION

Earlier versions of the fire strategy report have identified that there would be fire compartmentation separating the Theatre performance space from the foyer and plant rooms to the west. This fire compartmentation was to continue from the Level 02 floor up to roof level. However, following a review of the buildability of the fire compartmentation structure in these areas, it has been identified that there are no routes clear of significant and complex steel work where the fire compartmentation could be assured.

Following this, a change of approach has been to utilise the fire-rated CLT (cross-laminated timber) theatre structure as the fire compartmentation boundary from the adjacent spaces. The challenge this creates is in the roof structure of the theatre, as there are a number of ventilation grilles and smoke dampers that assist with the smoke extract system for the theatre space. If this roof structure was to be designated as a fire compartmentation boundary the dampers and grilles would need to be installed as per a fire tested detail and it has been communicated that there are no such details for the horizontal installation of fire dampers/ grilles in CLT.

This section, therefore, assesses the risk of continuing with the smoke sealed details (also required for acoustics) for the roof line and therefore leaving the horizontal portion of the theatre CLT roof structure with no fire rating designation. The proposals are shown in the figure below.

Figure 10-2: Theatre CLT Fire Rating



The focus of this risk assessment is on the CLT roof line and the justification for providing the fire rating only at the vertical and angled orientations of the CLT. Other construction materials are used to provide the fire rating between the theatre auditorium and the lower levels of the theatre foyer, so the risk from these is not assessed further. The remaining fire risk is present in the Level 04 / Level 05 Plant Room, a double-height space that links to the void space above the theatre CLT roof.

A review of the MEP layouts for this Plant Room has been carried out and the space is predominately filled with air handling units and smoke control fans for the theatre spaces.

Air handling units are recognised as presenting a low fire risk within BS 9999 and have a specific exclusion (Clause 31.4.7) from the need to provide fire compartmentation. The additional equipment within the Plant Room space is localised between the low-risk air handling units and therefore if they were to be the initiator of a fire in the Plant Room, the fire would be expected to be small, due to it being slow-growing and localised.

With the identified fire risks assessed to be small and localised, the double-height space presents an area where the smoke will cool down such that, whilst its buoyancy may take it to roof level, the temperature will not be as high as would be experienced in a flashover fire that the fire tests are designed to replicate. It is also noted that with the small and localised fire, there would not be an expectation of a flashover fire in this space and certainly not in the short time it would take to evacuate the building following the detection of a fire.

To alleviate the localised fire risks within the Plant Room, it is proposed to provide the designated fire rating construction at these localised areas. This is in the form of the 30 minute fire-rated construction to the vertical and angled CLT panels (as shown in Figure 10-2:). It is noted that the theatre will be smoke sealed from the Plant Room and any dampers passing to the Theatre Auditorium from the Plant Room will be smoke rated and linked to the fire detection system. This will provide the primary protection to prevent smoke from entering the theatre whilst occupants are evacuating the area.

On this basis, the approach to the fire compartmentation of the theatre is considered to be reasonable and achieves its objectives by delaying the spread of fire and allowing sufficient time for occupants to escape the building. It is recognised that the construction design is not being changed by these proposals, more that the removal of the fire rating designation from the theatre CLT roof removes the onerous requirement to commission a series of fire tests on horizontally installed dampers and grilles.

10.4 ANCILLARY ACCOMMODATION

Areas of ancillary accommodation will be enclosed as described in Table 10-2 below.

Table 10-2: Ancillary Accommodation

Ancillary Accommodation	Minimum Fire Resistance
Storage areas not greater than 450 m²	Robust construction having a minimum standard of fire resistance of 30 minutes (REI30)
Workshops where flammable or highly flammable liquids are not used or stored	
Kitchens	
Transformer, switchgear, and battery rooms for low-voltage or extra-low-voltage equipment	
Dressing rooms or changing rooms	

Ancillary Accommodation	Minimum Fire Resistance
Engineering services installation rooms	
Storage areas greater than 450 m²	Robust solid non-combustible construction having a minimum standard of fire resistance of 60 minutes (REI60)
Workshops where flammable or highly flammable liquids are used or stored	
Covered loading bays	Robust solid non-combustible construction having a minimum standard of fire resistance equivalent to that required for the elements of the construction of the building and in no case less than 90 minutes (REI90).
Refuse storage areas	
Boiler rooms	
Transformer and switchgear rooms for equipment above the low voltage	
Scene docks	

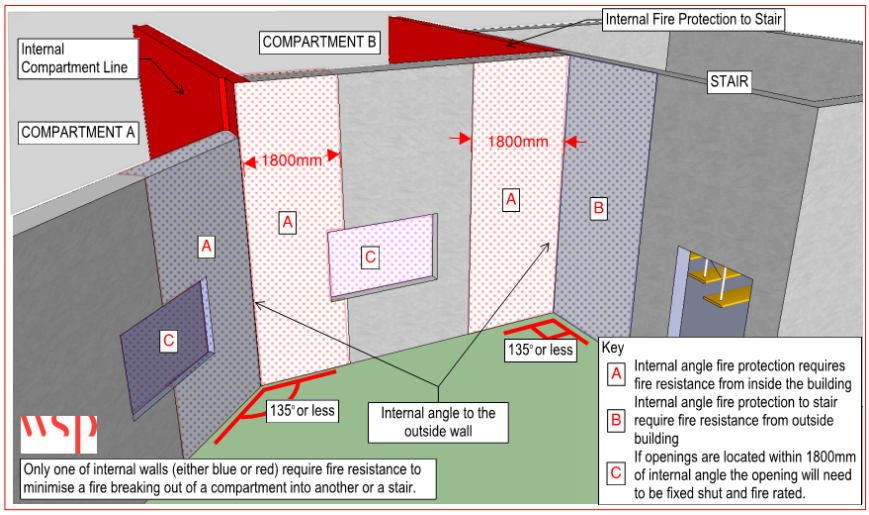
Note: *Rooms housing life safety pieces of equipment such as Transformer room etc, should be enclosed in 120 minutes robust fire-resisting construction. However, a dispensation has been agreed to provide 90 minutes fire resistance to the floor supporting the open generator room at level 8, this includes all steels supporting the floor as well.*

10.5 FIRE PROTECTION TO INTERNAL ANGLES ON EXTERNAL WALLS

There is a risk of fire and heat from the building affecting the stair externally. On this basis, the distance between any unprotected area in the external enclosures to the building and any unprotected area in the enclosure should be at least 1800mm. The wall within 1800mm will achieve 90 minutes fire resistance. See the figure below for the method of exposure which differs on the location of the fire resistance.

Refer to the fire safety drawings for areas where additional protection to the stair is required externally.

Figure 10-3: Re-Entrant Corners

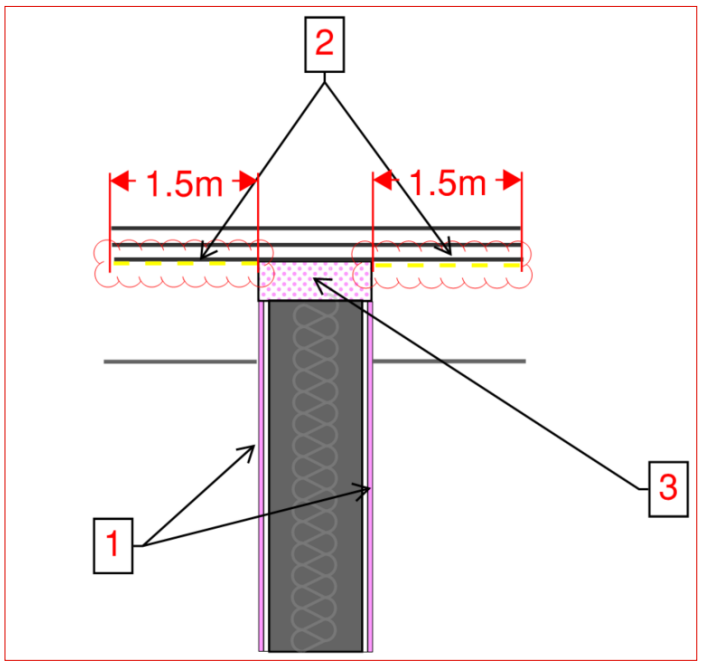


Note: *The protection of compartment to compartment fire re-entry is a recommendation and not a requirement of the guidance document.*

10.5.1 JUNCTIONS

A compartment wall will be taken up to meet the underside of the roof covering or compartment floor soffit, with appropriate fire-stopping where necessary at the wall/roof junction to maintain continuity. To reduce the risk of a fire affecting both compartments a zone of roof 1.5m wide on either side of the wall will have a covering of AA, AB or AC (National class) or $B_{ROOF}(t4)$ (European class) on a substrate or deck of limited combustibility. The junctions of the compartment wall with the roof will meet the provisions from Clause 31.4.5 from BS 9999.

Figure 10-4: Junction of Compartment Wall



Where:

1. Compartment wall (fire resistance on both sides of the wall)
2. Roof covering AA, AB or AC or B_{ROOF}(t4) on deck of the material of limited combustibility. See Clause 31.4.5 of BS 9999 for more information on other roof types.
3. Resilient fire stopping (EI) (same fire resistance as the compartment wall) to be carried to the underside of the roof covering.

10.6 FIRE DOORS

The fire doors will meet the fire rating given in Table 30 of BS 9999.

Any fire doors, except to a cupboard or service duct (both of which are normally kept locked shut), and lift landing doors, will be fitted with a self-closing device designed according to the relevant British Standard. If this device could represent a hindrance to the occupants of the building the use of hold-open devices can be considered.

The fire doors will meet the appropriate fire-resistance rating as shown in the table below.

Table 10-3 – Fire Doors

Position of Door	Requirement Tested to BS 476-22	When Classified in Accordance with BS EN 13501-2
Enclosing ancillary accommodation (accessed from protected corridor/ lobby)	As for the wall in which door is fitted and with suffix S	As for the wall in which door is fitted and with suffix S_a
Enclosing ancillary accommodation (not accessed from protected corridor/ lobby)	As for the wall in which the door is fitted	As for the wall in which the door is fitted
Risers (accessed from protected corridor/ lobby)	Half the period of fire resistance of the wall in which it is fitted and with suffix S	Half the period of fire resistance of the wall in which it is fitted and with suffix S
Risers (not accessed from protected corridor/ lobby)	Half the period of fire resistance of the wall in which it is fitted	Half the period of fire resistance of the wall in which it is fitted
Stair	FD 30S	E 30 S_a
Lift	FD 30	E 30
Protected Lobby or Corridor	FD 30S	E 30 S_a
Cavity Barriers	FD 30	E 30
Compartments walls	As for the wall in which the door is fitted with S	As for the wall in which the door is fitted with S_a
Cross Corridor Door	FD 30S	E 30 S_a

Fire doors annotated S / S_a will either:

- Have a leakage rate not exceeding 3m^3/h per metre, when tested in accordance with BS 476-31.1 with the threshold taped and subjected to a pressure of 25 Pa; or

- Meet the classification requirement of S_a in accordance with BS EN 1634-3.

Where hold-open devices are used they will be installed in accordance with BS EN 1155 and BS 9999 Clause 32.1.6.2. Hold-open devices can be either fusible link (unless protecting a means of escape), an automatic release mechanism which is linked to the fire alarm or be a delayed closing device with a delay not exceeding 25 seconds.

The gaps between the fire door and frame will be in accordance with manufacturer tests and BS 8214. Generally, the gaps at the head and sides will not exceed 3mm unless accompanied by test information from the manufacturer. The under-door (threshold) gap will be in accordance with the manufacturer's installation instructions for the particular door set.

All fire doors except those leading to cupboards or service ducts (which will be locked shut) and with the exception of lift doors will be fitted with self-closing devices. For more information on the type and requirements see Clause 32.1.6.1 of BS 9999.

10.7 DEAD-END CORRIDOR

As per BS 9999 dead-end corridors, longer than 2m will be enclosed with 30 minutes fire resisting partitions.

However, as specified in Section 4.1 of this report an automatic fire detection and alarm system is provided while a manual fire detection and alarm system would be sufficient under BS 9999.

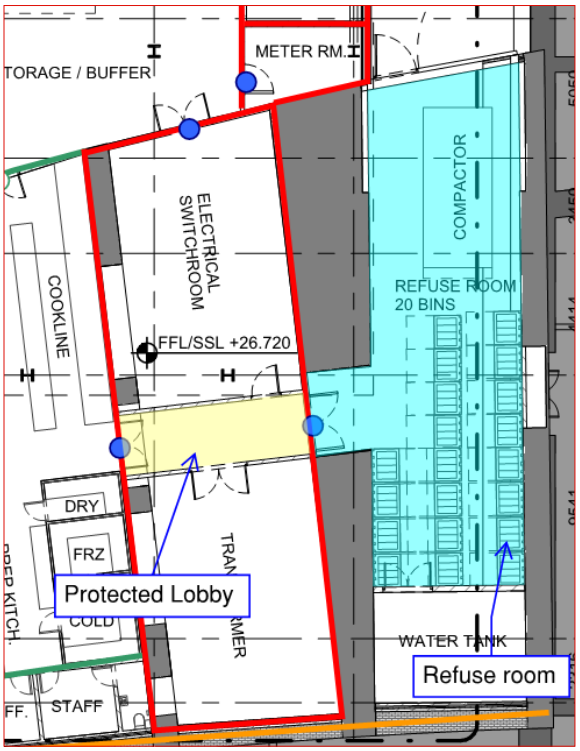
Dead-end corridors will be fire rated in buildings provided with a manual fire detection system only as a fire could have grown significantly before being noticed by the occupants and could have therefore compromised the only means of escape available. However, in this development, a fire will be detected at an early stage given that automatic fire detection will be provided throughout the building. Moreover, the partitions enclosing corridors will be full height (slab to slab); therefore smoke is unlikely to spread from a room to a corridor during the initial stages of the fire development. Therefore, with this early warning and these full-height partitions, the corridor is unlikely to be compromised by a fire during the evacuation process.

10.8 REFUSE STORE

In line with the provisions of BS 5906 refuse storage (room no. 025) areas shall be separated from the remainder of the building with construction achieving the level of fire resistance indicated in Table 10-2.

The refuse store is accessed from outside and by a protected lobby, it is not required to ventilate this lobby as the openings to outside will achieve the required ventilation for the refuse store.

Figure 10-5: Refuse room



10.9 TECHNICAL GRID

The technical grids located above the Warehouse and the Theatre will be made of non-combustible materials but do not need to achieve any fire resistance with the exception of the escape routes which need to be provided with 30 minutes fire resistance.

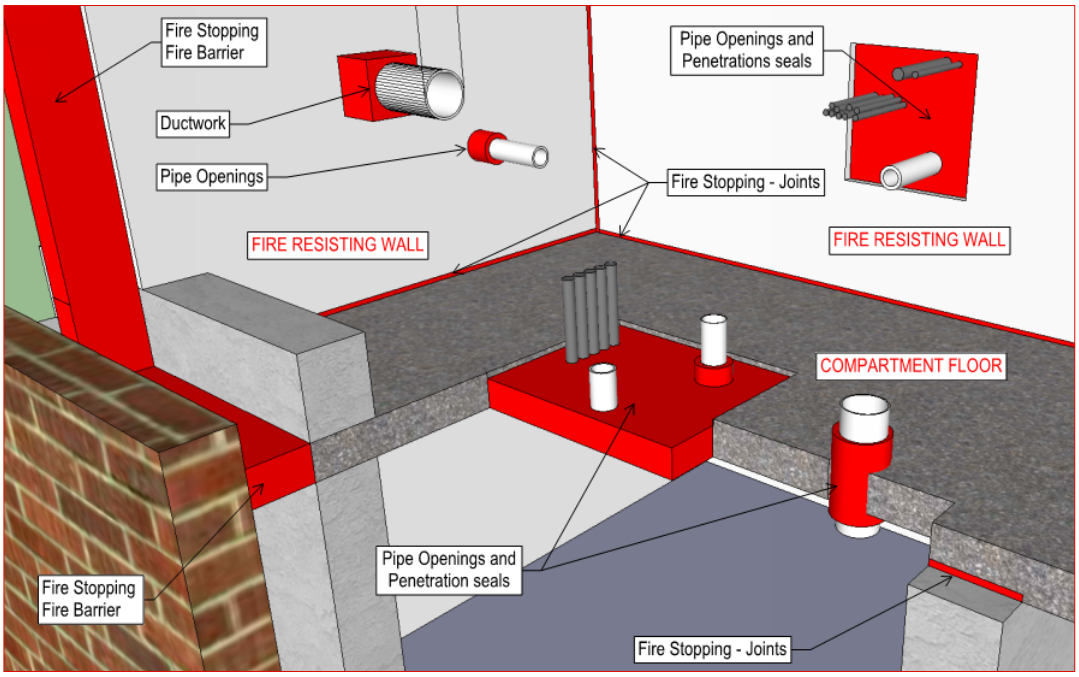
10.10 FIRE STOPPING

Fire stopping is used for sealing apertures, imperfections or design tolerances between fire-resisting walls, floor and ceiling to restrict the passage of both fire and smoke. Fire stopping will achieve the same fire resistance (integrity and insulation (EI)) as the element into which they penetrate.

To maintain the physical integrity of fire stopping, it will be reinforced with (or supported by) non-combustible materials or materials of limited combustibility, in the following circumstances:

- In all cases where the gap between the elements that need to be fire stopped is greater than 100mm; and
- In any other case where non-rigid or flexible materials are used.

Figure 10-6: Fire Stopping



10.10.1 JOINTS

All joints between fire-separating elements and all openings for pipes, ducts, conduits or cables to pass through any part of a fire separating element will be fire-stopped for the full thickness of the fire separating element and;

- Kept as few in number as possible;
- Kept as small as practicable; and
- Fire stopped (which in the case of a flue or duct, should allow thermal movement) so that the level of fire resistance of the joint is not less than that of the fire separating element.

10.10.2 FIRE BARRIERS

Fire barriers are installed within cavities to continue the compartment floor/ wall or fire resisting floor/ wall to the outer leaf to the external wall or roof. Fire barriers will maintain the standard of fire resistance provided by the wall or floor.

10.10.3 PENETRATIONS

Where services pass through fire separating elements and/ or compartment walls or floors. They will be suitably fire stopped which includes penetration seals that will maintain the same fire resistance (integrity and insulation (EI)) as the element into which they penetrate.

10.10.3.1 Pipe Openings

Pipework that breaches fire separating elements and/ or compartment walls or floors has the potential to compromise the integrity of the separating element/ compartmentation if the pipework is not provided with fire protection. In accordance with Clause 32.5.14 of BS 9999, the following methods are recommended for protecting the pipework:

- For pipes of any diameter, provided with a proprietary seal that has been tested in accordance with BS 476-20, BS 476-21 and BS 476-22 or BS EN 366-6 and shown by test to maintain the fire resistance of the wall, floor or cavity barrier it is sited in; or
- For pipes with a restricted diameter, provided with fire stopping around the pipe, keeping the opening as small as possible. The nominal interior diameter of the pipe will be not more than the relevant dimensions shown below.

Where more than two small (<40mm) service penetrations occur within 40mm of each other, they will either be treated as a single penetration and a suitable proprietary seal will be used to protect the combined opening area as described in options above, or each is to be protected with a suitable proprietary seal.

Table 10-4 - Maximum Diameter of Pipes

Situation	Pipe Material and Maximum Internal Diameter		
	Non-Combustible Material (1)	Lead, Aluminium Alloy, uPVC, Fibre Cement (2)	Any other material
Structure enclosing a protected shaft which is not a stairway or lift shaft	160mm	110mm	40mm
Any other situation	160mm	40mm	40mm

(1) Non-combustible material (for example cast iron or steel) which, if exposed to a temperature of 800°C should not soften or fracture to the extent that flame or hot gas will pass through the wall or pipe.

(2) uPVC pipes should conform to BS 4514 and BS 5255.

Note: Whilst minimum requirements suggest maximum sizes of pipes without the requirement of supplementary fire stopping, it is recommended fire-stopping and proprietary seals are installed.

Note: An engineering judgement was sought for (flue) by crown house technology (CHT), this was done by submitting a report, discussed and approved by statutory authority.

10.10.3.2 Ductwork

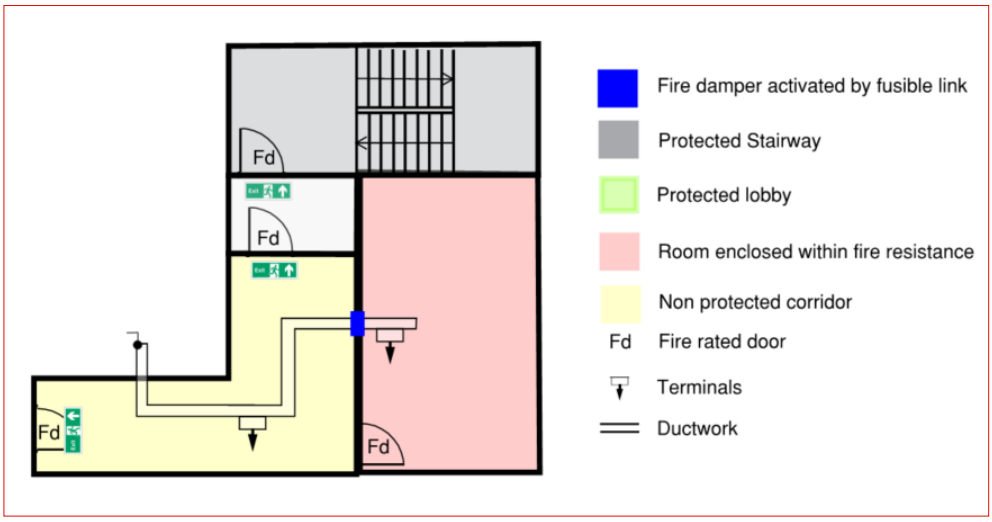
Where ductwork passes through fire-rated construction (for example compartment walls or enclosures to protect escape routes) the integrity will be maintained. In accordance with Clause 32.5.2.1 of BS 9999 there are four recommended options (it should be noted that the ASFP blue book contains further information on fire-resisting ductwork).

Note: see section 4.5 on the use of non-fire-rated ductwork for the smoke ventilation system.

Method 1 – Thermally actuated fire dampers

- This method will not be used where ductwork passes through or serves as an escape route.
- This method is not suitable for kitchen extract systems.
- Fire dampers will conform to BS EN 15650 and have an E Classification equal to or greater than 60 minutes.

Figure 10-7: Method 1



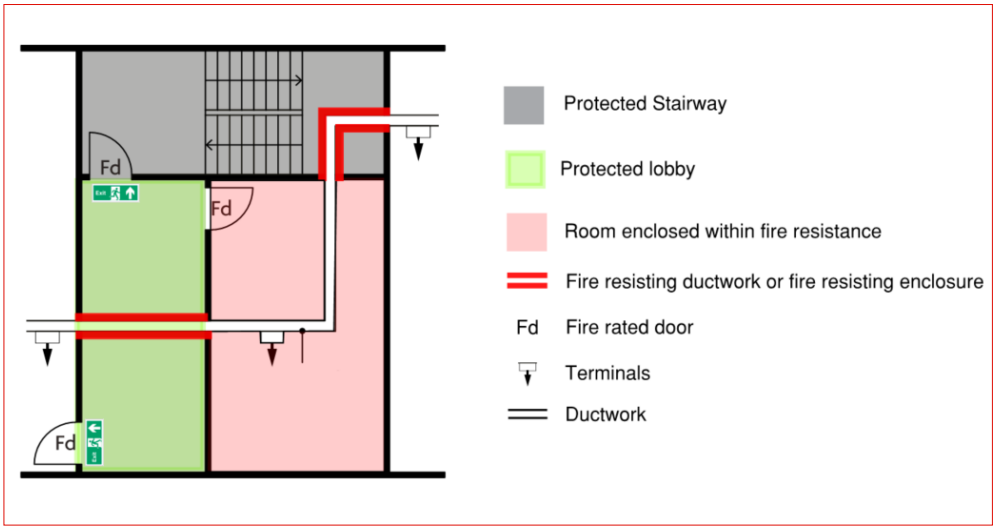
Method 2 – Fire resisting enclosures

- This method can be used in protected escape routes providing the ductwork does not serve the escape route it passes through.
- The fire-resisting enclosure will be classified EIX in accordance with BS EN 13501-2 (fire exposure from the duct side) (where X is the fire-resisting rating (in minutes) of the walls of the protected route).

Method 3 – Protected using fire resisting ductwork

- This method can be used in protected escape routes providing the ductwork does not serve the escape route it passes through.
- The fire-resisting ductwork will be classified EISX in accordance with BS EN 13501 (where X is the fire-resisting rating (in minutes) of the walls of the protected route).

Figure 10-8: Method 2 or 3

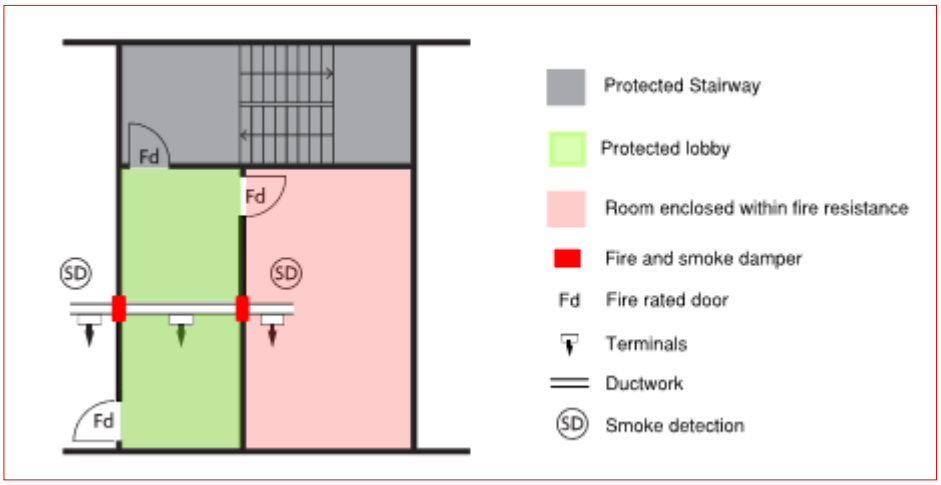


Method 4 – Automatically actuated fire and smoke dampers triggered by smoke detectors

- This method may be used for extract ductwork passing through protected escape routes where the ductwork does and does not serve the protected escape route.
- This method is not suitable for kitchen extract systems.

Fire and smoke dampers will conform to BS EN 15650, they will have an ES classification equal to or greater than 60 minutes.

Figure 10-9: Method 4



10.10.3.3 Fire Dampers

The fire dampers will be sited within the thickness of the fire separating element. This will ensure the damper will not be displaced by movement or collapse of the duct. The dampers will be securely fixed in place and provided with breakaway joints in accordance with the manufacturer's instructions.

Adequate means of access will be provided to allow inspection, testing, and maintenance of both the fire damper and its actuating mechanism.

Where ductwork runs through any compartment lines, fire/smoke dampers must be provided.

10.10.3.4 Air Transfer Grilles

Air transfer grilles will be in accordance with Clause 32.5.6 of BS 9999. Generally, air transfer grilles will not be installed in:

- Elements of construction enclosing compartments;
- Enclosures to protected stairways;
- protected corridors,

Air transfer grilles fitted in any construction or door that needs to be fire-resisting should be of the intumescent type or fitted with fire dampers. Where these grilles are within the enclosure of protected escape routes, they should incorporate fire and smoke shutters operated by adjacent automatic smoke detectors. Fire and smoke shutters will be in accordance with Method 4 above.

10.10.4 ELECTRICAL SERVICES

Electrical risers are to be enclosed with 90 minutes fire resistance unless fire-stopped at slab level.

10.11 CONCEALED SPACES

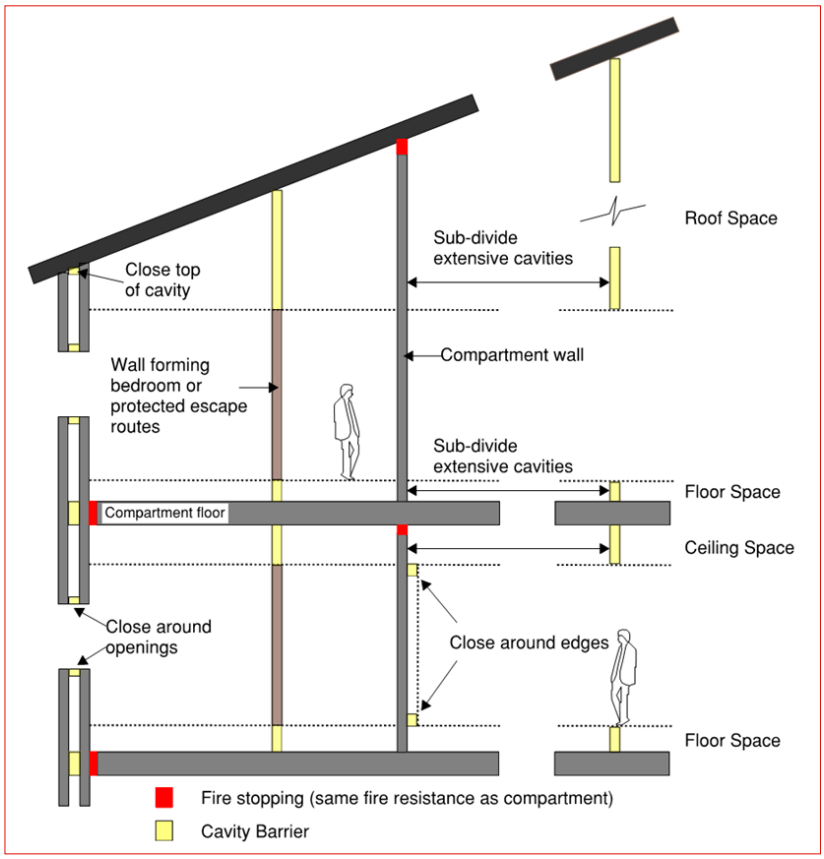
Cavity barriers will be provided as per the recommendations of Section 33 of BS 9999 in order to restrict the unseen fire and smoke spread through concealed spaces and shall meet the fire resistance specified in Table 10-1.

- Cavity barriers should typically be provided:
- To close the edges of cavities, including around openings; and
- At the junction between an external cavity wall and every compartment floor and compartment wall; and
- At the junction between an internal cavity wall and every compartment floor, compartment wall or other wall or door assembly which forms a fire-resisting barrier; and
- If a cavity surface is class 0 or class 1 type material, or there is this type of material within the cavity (excluding the surface of any pipe, cable or conduit, or any insulation to the pipe) then the void will require a cavity barrier every 20m. If other class materials are used then the void will require cavity barriers every 10m (excluding cavities between the roof and ceiling).

Compartment walls will be carried up full storey height to the underside of a compartment floor or to the roof as appropriate. Cavity barriers will not be used to complete the line of compartmentation.

The figure below shows the difference between cavity barriers and fire stopping.

Figure 10-10: Cavity barrier and fire stopping locations



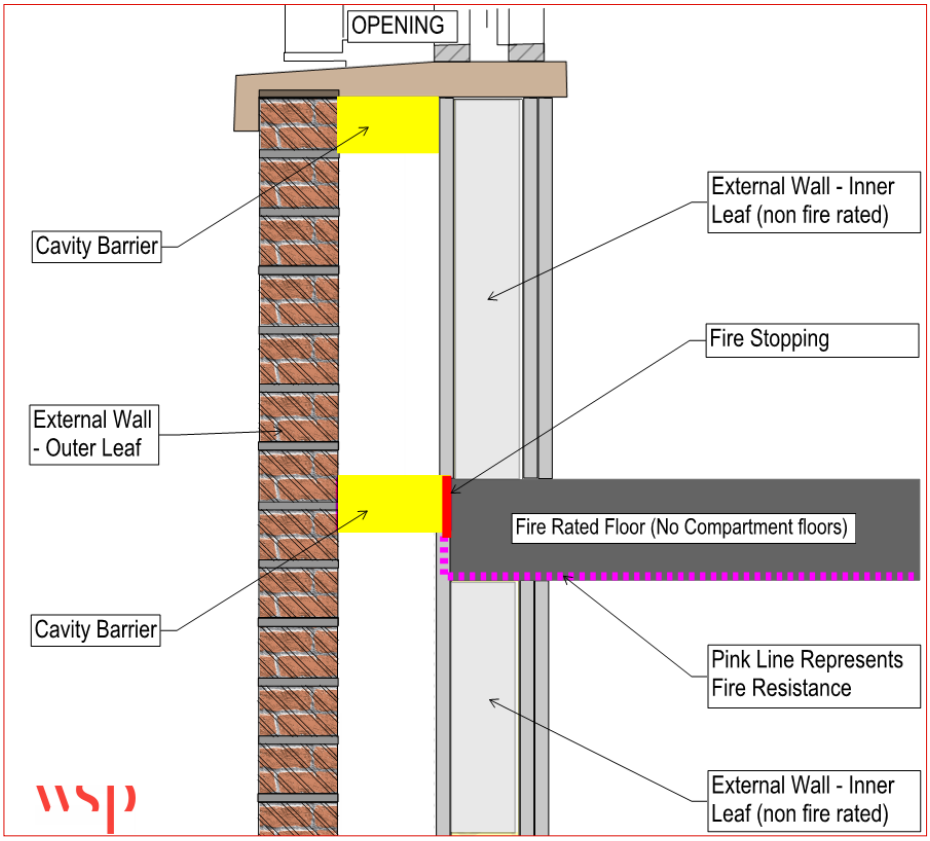
10.11.1 JUNCTION AND COMPARTMENT WALLS

Cavity barriers will sub-divide any cavity, including the roof space to restrict the spread of smoke and flame through the building. Cavity barriers will also be provided:

- At the junction between an external cavity wall (except where the cavity wall is two leaves of masonry or concrete at least 75mm thick) and every compartment floor and compartment wall.

At the junction between an internal cavity wall (except where the cavity wall is two leaves of masonry or concrete at least 75mm thick) and every compartment floor, compartment wall, or other wall or door assembly which forms a fire-resisting barrier.

Figure 10-11: Cavity Barrier and Fire Stopping Principles for Illustration Purpose Only



Cavity barriers will be used to sub-divide any cavity, including roof space so that the distance between cavity barriers does not exceed 20m.

Any openings in a cavity barrier will be limited to those for:

- Doors that have at least 30 minutes fire resistance;
- The passage of pipes that meet the provisions of BS 9999;
- The passage of cables or conduits containing one or more cables;
- Openings fitted with a suitably mounted automatic fire and smoke damper; and
- Ducts which, unless they are fire-resisting, are fitted with a suitably mounted automatic fire and smoke damper where they pass through the cavity barrier.

All cavity barriers will be tightly fitted to rigid construction and, where possible, mechanically fixed into position. Where ductwork penetrates a cavity barrier, it will be provided with an automatic smoke/fire damper as required.

Adequate means of access will be provided to allow inspection, testing, and maintaining of both the fire damper and its actuation mechanism.

Cavity barriers will also be used to subdivide any cavity within the external wall or inside the building. The maximum distance between cavity barriers will not exceed the dimensions given in Table 10-5.

Table 10-5 - Maximum Dimensions of Cavities

Location of Cavity	Walls of Surface / Product Exposed in Cavity [1]		Maximum Dimensions in any Direction (m)
	National Class	European Class	
Between a roof and ceiling	Any	Any	20
Any other cavity	Class 0 or Class 1	Class A1	20
		Class A2-s3, d2	
		Class B-s3, d2	
		Class C-s3, d2	
	Not Class 0 or Class 1	Not any of the classes above	10

Note 1: This excludes the surface of any pipe, cable or conduit, or any insulation to any pipe

Every cavity barrier will be constructed to at least 30 minutes (E30 EI15) fire resistance as indicated in Section Table 10-5 of this report. It may be formed by any construction provided for another purpose if it meets the provisions for cavity barriers. Cavity barriers in a stud wall, or provided around openings may be formed of the following;

a) Steel at least 0.5mm thick;
b) Timber at least 38mm thick;
c) Polythene-sleeved mineral wool, or mineral wool slab, in either case under compression when installed in the cavity;
d) Calcium silicate, cement-based or gypsum-based boards at least 12mm thick.

The cavity barriers wherever possible will be tightly fitted to a rigid construction and mechanically fixed in position. Where this is not possible the junction will be fire stopped. It is possible for door and window frames to be formed as cavity barriers is the frames are constructed of timber or steel of the minimum thickness in (a) or (b), as appropriate.

Where a single room exceeds the dimensions provided within Table 10-5, there is guidance within Clause 33.2 of BS 9999 that allows the cavity to be larger if additional measures are provided within the cavity.

11 EXTERNAL FIRE SPREAD

11.1 GENERAL

This section aims to address how the building satisfies the following Functional Requirements B4 of the Building Regulations:

- *"The external walls of the building shall adequately resist the spread of fire over the walls and from one building to another, having regard to the height, use and position of the building.*
- *The roof of the building shall adequately resist the spread of fire over the roof and from one building to another, having regard to the use and position of the building." Part B of Schedule 1 to the Building Regulations 2010.*

For the purpose of this section,

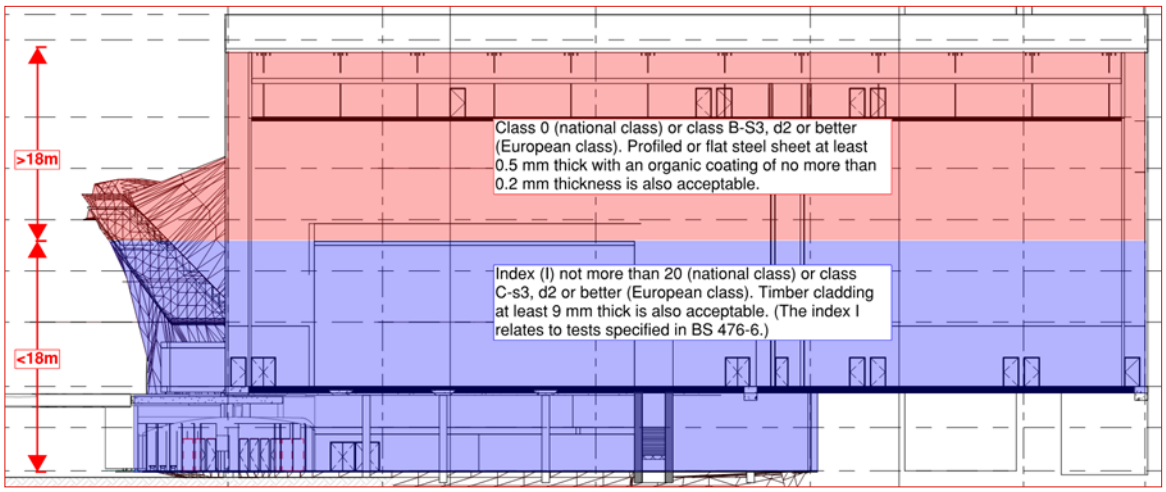
- A wall corresponds to any part of the structure forming an angle greater than 70° to the horizontal; and
- A roof corresponds to any part of the structure forming an angle less than 70° to the horizontal.

11.2 EXTERNAL FIRE SPREAD OVER THE EXTERNAL FACES

The following dispositions should be taken to restrict fire spread over the external faces of the buildings as described in Section 35.5 of BS 9999:

- External surfaces of walls will meet the provisions of Figure 47 of BS 9999 summarised in Figure 11-1 below;
- Any insulation product, filler material (not including gaskets, sealants and similar), etc., used in the external wall construction will be of limited combustibility;
- Cavity barriers should be provided in accordance with Section 10.11.

Figure 11-1: Provisions for external surfaces of walls



The Theatre will be clad in a Class B membrane system (tested in accordance with the guidance of BS EN 13501-1: 2007) with Class A2 insulation for the entirety of the facade from the ground floor upwards. This meets the requirements of BS 9999 and therefore achieves compliance with the Building Regulations.

11.1 BOUNDARY DISTANCES

There is a general requirement to ensure that a fire in one building will not spread to adjacent buildings, by means of emitted radiation from the openings in the facades.

There are two types of relevant boundaries which can be considered, these are;

- Site boundary – where the site boundary is adjacent to public roads, pathways, train tracks or waterways the boundary can be extended to the mid-point of that feature.
- Notional boundary – this is an imaginary line drawn between two buildings on the same site.

11.2 SPACE SEPARATION BETWEEN NEIGHBOURING BUILDINGS

The heights of enclosing rectangles are taken to be 6m which represents a fire over approximately 2 floors and the width of the exposed facade is detailed below.

Due to the large volume of the warehouse area, the assumed 6m is considered to be reasonable by WSP and not the entire elevation which would be required by BR 187, therefore, the assumption is subject to discussion and building control approval.

The staircases do not need to be included in the enclosing rectangle and therefore have been omitted. In addition, the figures in bracket (Assembly use) from Table B detailed in the annexe of BRE 187 have been used in all areas, with the exception of the truck lift where risk is considered to be higher.

Figure 11-2: The Factory Boundary Distances (1)

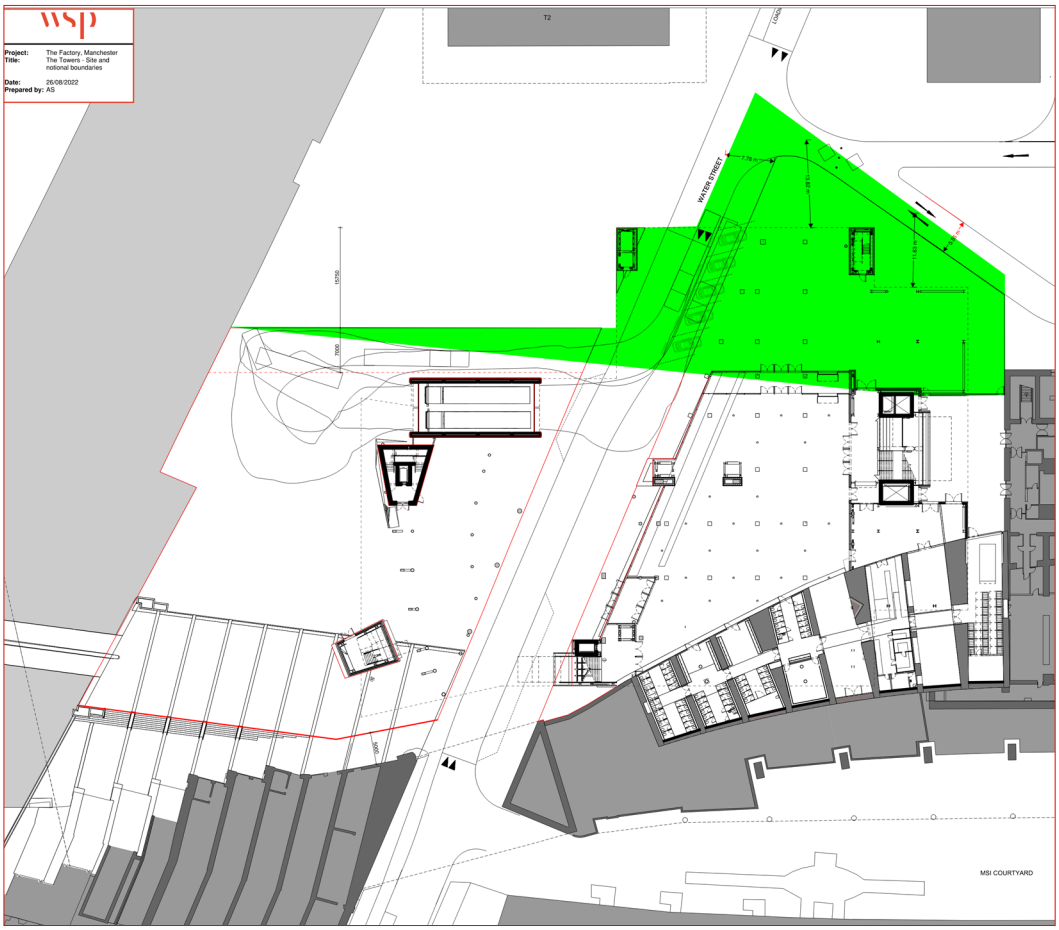


Figure 11-3: The Factory Boundary Distances (2)

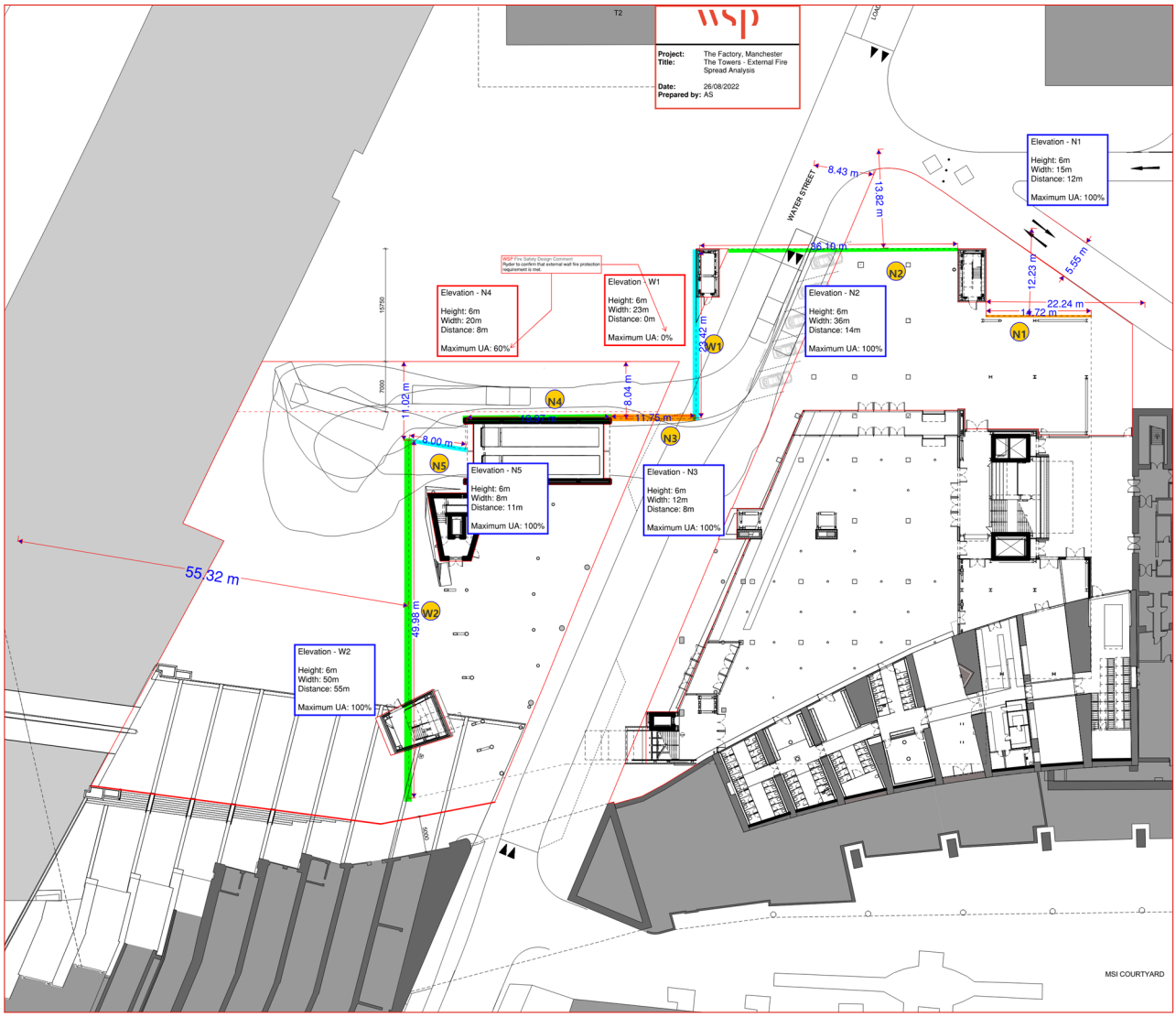


Table 11-1 – Space Separation Calculations

Elevation Considered	BR187 Enclosing Rectangle (hxw) (m^2)	Actual Boundary Distance (m)	Allowable Unprotected Area (%) (m^2)
N1	6 x 15	12	100%
N2	6 x 36	14	100%
N3	6 x 12	8	100%
N4	6 x 20 = 120m^2	8	60% (72m^2)

N5	6 x 8	11	100%
W1	6 x 23 = 138m^2	0	0% (138m^2)
W2	6 x 50	55	100%

For all elevations, the assessment demonstrates that the maximum permitted unprotected area for the facade can be 100% in accordance with BRE 187, except in the following areas:

- Elevation N4 - The truck's lift shaft is permitted to have a maximum of 60% unprotected area, the rest should be provided with 90 minutes fire resistance in terms of load bearing and integrity with 15 minutes of insulation from the inside.
- Elevation W1 - The western elevation is right up against the site boundaries, therefore, it is permitted to have a maximum of 0% unprotected area and only small but limited openings are permissible, the rest should be provided with 90 minutes fire resistance in terms of load bearing, integrity and insulation from the inside.

The remaining elevations less than 1m bordering neighbouring sites will maintain the party wall not less than 90 minutes fire resistance without any openings.

The as-built openings or unprotected areas of the external walls for Elevations N4 and W1 meet the above recommendations therefore, meeting the functional requirement of the building regulations with the build-up of the elevations detailed below.

11.3 ELEVATIONS N4 AND W1 WALL BUILD-UP

Figure 11-4: Areas to be Protected

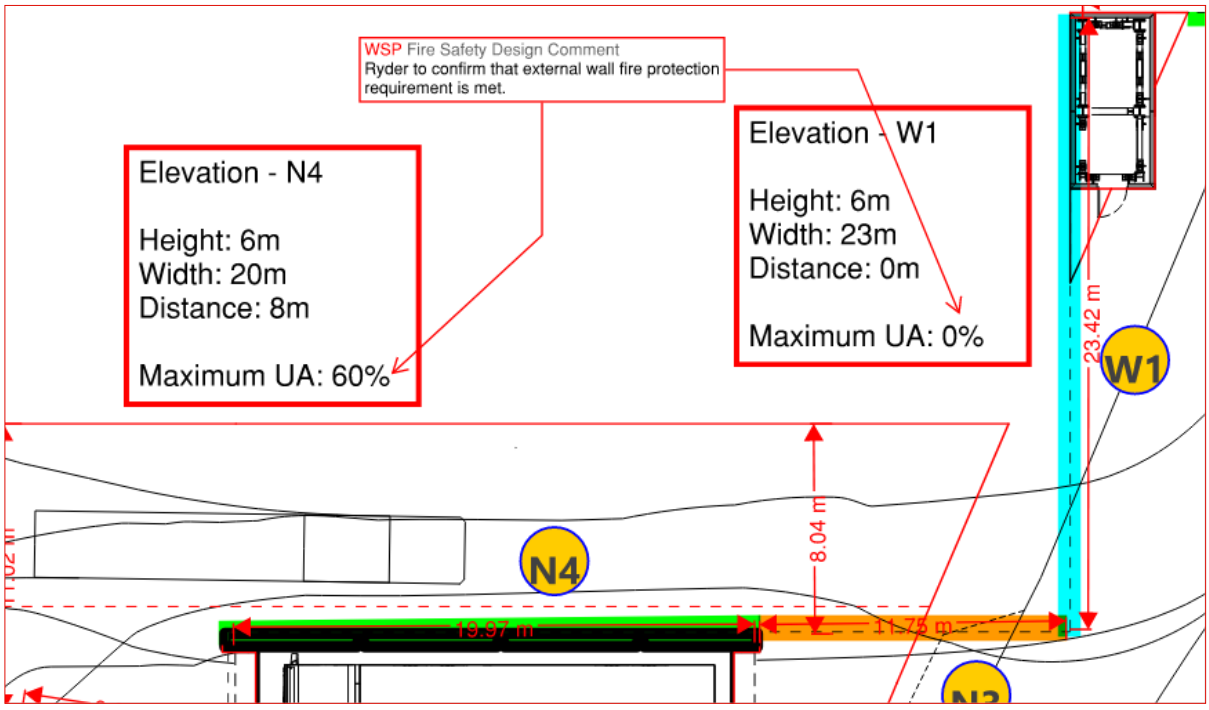
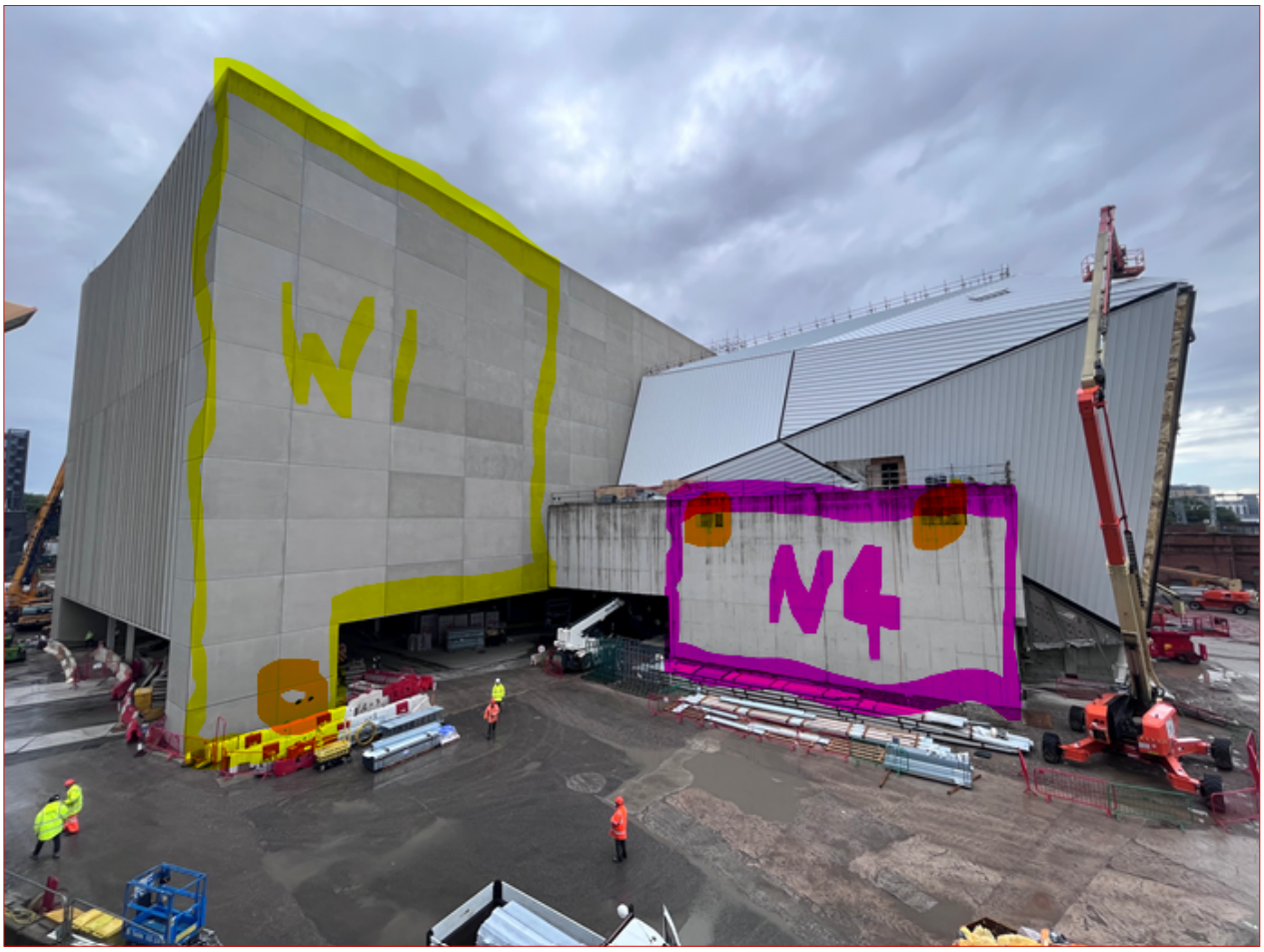


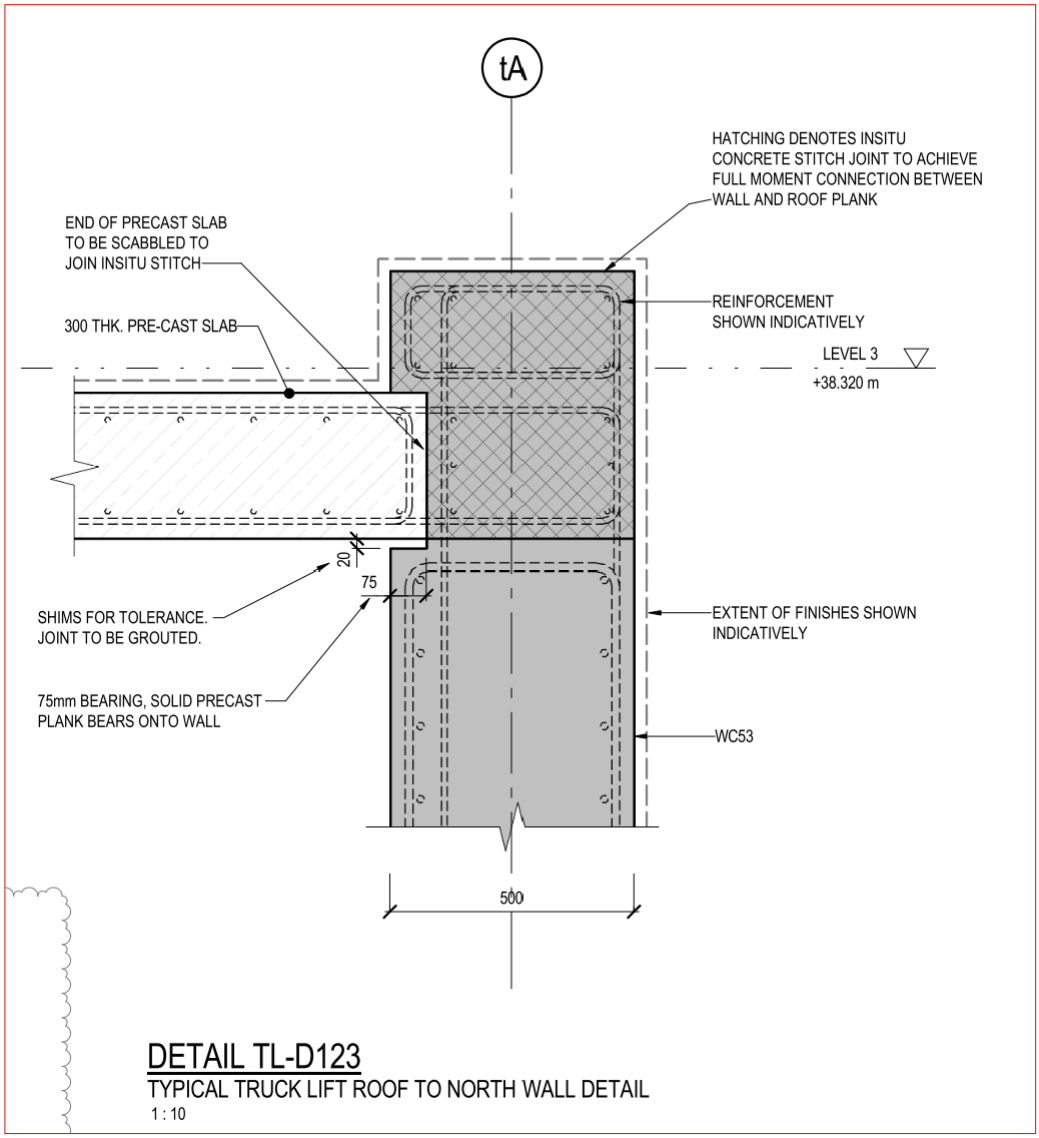
Figure 11-5: Elevations As-built



Elevation Wall N4 - Truck Lift North Wall

The as-built wall is a 500mm thick reinforced In-situ concrete as shown in figure 4 above with louvres indicated in orange, the combined louvres area is less than the allowed 40% therefore, it is considered acceptable.

Figure 11-6: Elevation N4 Wall Build-up



Elevation Wall W1 - Warehouse West Wall

The as-built wall is a 500mm thick reinforced In-situ concrete as shown in the figure above, in addition, elevation W1 is made up of two layers of in-situ concrete for acoustic purposes. Although, some of the joints between panels are acoustic only and not fire rated, given that the joints are less than 1cm and the loss of one acoustic joint/sealant should not result in the loss of the concrete panel system. In addition, the build-up including acoustic fixings are made up of limited combustible materials. The current proposal is considered to meet the intent of Section 11 of the design fire strategy and therefore, satisfy the functional requirement of Part B of the Building Regulations.

Figure 11-7: Elevation W1 GA

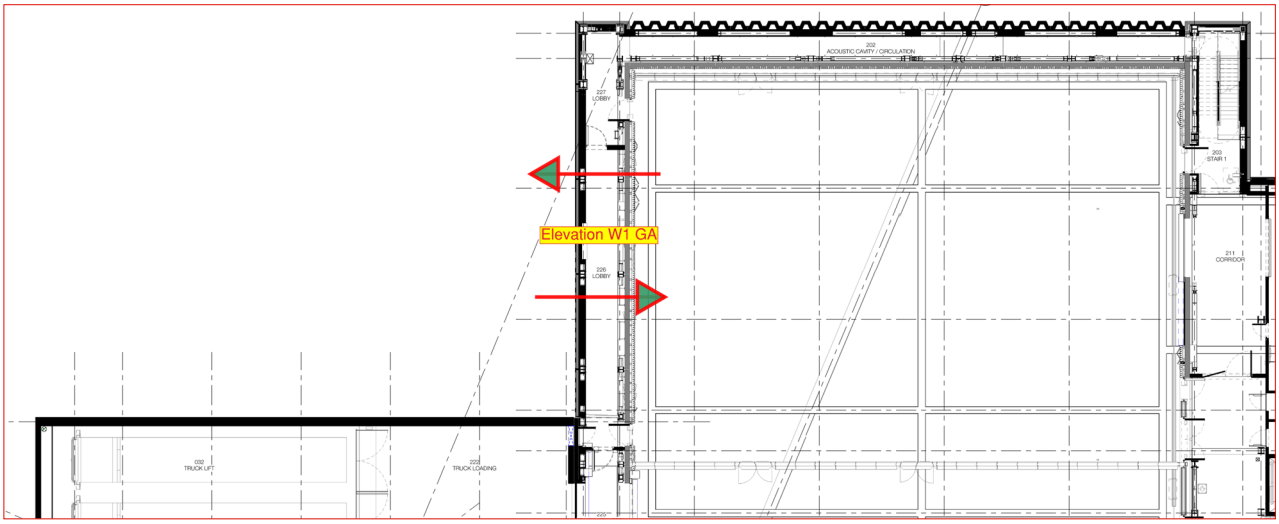
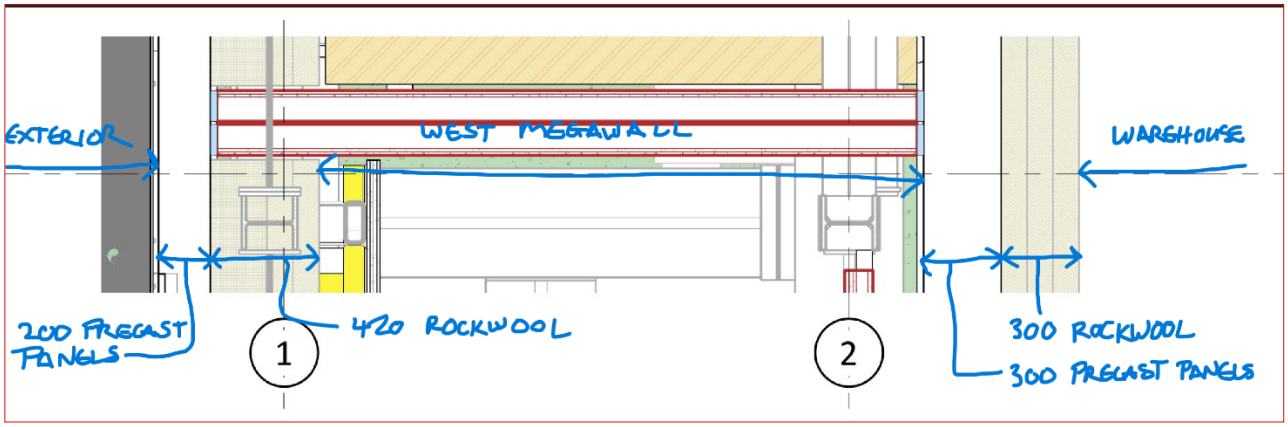


Figure 11-8: Elevation W1 Wall Build-up



11.4 ROOF COVERING

Roof coverings refer to the external material layers, not the roof structure itself. The table below describes the relationship between separation distances and roof covering classification from BS9999. The purpose of the roof covering fire test is to assess representative systems of the roof construction in their response to fire from outside the building (not internal). The tests cover two primary elements, penetration of flame and the surface spread of flame. The roof covering will comply with the following table.

Table 11-2 - Roof Covering Requirements

Designation of covering of roof or part of a roof		Minimum distance from any point to the relevant boundary			
National Class	European Class	Less than 6m	At least 6m	At least 12m	At least 20m
AA, AB or AC	$B_{ROOF}(t4)$	Acceptable	Acceptable	Acceptable	Acceptable
BA, BB or BC	$C_{ROOF}(t4)$	Not acceptable	Acceptable	Acceptable	Acceptable

CA, CB or CC	D_{ROOF}(t4)	Not acceptable	Acceptable*^	Acceptable^	Acceptable
AD, BD or CD	E_{ROOF}(t4)	Not acceptable	Acceptable*	Acceptable	Acceptable
DA, DB, DC or DD	F_{ROOF}(t4)	Not acceptable	Not acceptable	Not acceptable	Acceptable*

Note*: Acceptable on buildings if part of the roof is no more than 3m^2 in area and is at least 1500mm apart from any other similar section of roof, with roof between the parts covered with a material of limited combustibility*

Note^*: Not acceptable on any of the buildings with a volume of more than 1500m^2*

For more information on the roof coverings, see Clause 35.4 of BS 9999.

12 ACCESS AND FACILITIES FOR THE FIRE SERVICE

12.1 FUNCTIONAL REQUIREMENT B5

This section aims to address how the building satisfies the following Functional Requirements B5 of the Building Regulations.

- *"The building shall be designed and constructed so as to provide reasonable facilities to assist firefighters in the protection of life.*
- *Reasonable provision shall be made within the site of the building to enable fire appliances to gain access to the building."*

Part B of Schedule 1 to the Building Regulations 2010.

12.2 INTERNAL FIRE BRIGADE ACCESS AND FACILITIES

12.2.1 GENERAL

As noted in Section 4.1.2, smoke control and fire alarm repeater panels are to be located at the firefighter entry points. An emergency microphone linked to the PA/VA system will also be located in these positions.

12.2.2 FIRE-FIGHTING SHAFTS

A fire-fighting shaft provided with fire lift is to serve the Towers and the upper tier of the Theatre given that:

- The height of the towers measured between the fire service access level (Ground Floor) and the top habitable floor (Level 6) is circa 24m. Note that Level 7 is not taken into account as it only consists of plant rooms; and
- The height of the upper tier of the Theatre measured between the fire service access level (Ground Floor) and the top habitable floor (Level 6) is circa 24m.

The fire-fighting shaft will be arranged as shown in the Figure below and will include the elements described in table 10-1 of this report. However, a number of deviations have been identified. These have been analysed hereinafter.

Figure 12-1: Fire Fighting Shaft

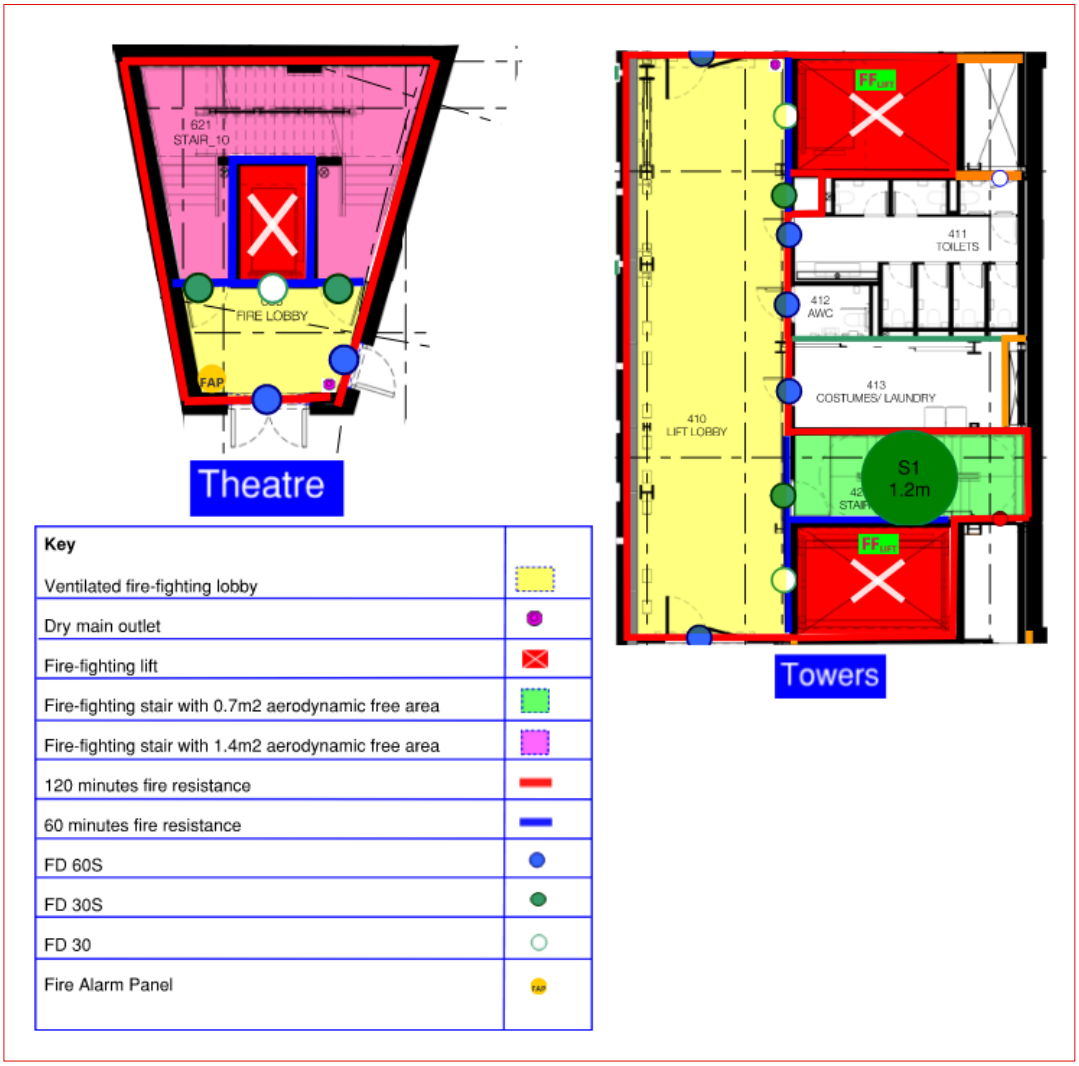


Table 12-1: Fire-fighting Shaft design

No.	BS 9999 provision		Compliant	
			The Towers	The Theatre
1	Direct access to outside	At ground floor level or through a protected corridor	×	✓
2	A fire-fighting stair	Having a clear width of 1.1m	✓	✓
3		Provided with a 0.7m² (aerodynamic free area) remotely openable vent at its head	✓	✓
4		Scissor Stair	✓	×

No.	BS 9999 provision		Compliant	
			The Towers	The Theatre
5	A fire-fighting lobby	Provided with a smoke ventilation system	✓	✓
6		Having a floor area between 5m² and 20m²	×	✓
7		No services passing through lobby	×	✓
8	A fire-fighting lift	Designed in accordance with BS EN 81-72, and to BS EN 81-1 or BS EN 81-2	✓	✓
9		Not used as a goods lift	×	✓
10		Provided with primary and secondary power supply	✓	✓
11		Protected against water in accordance with BS EN 81-72	✓	✓
12		Dual Entry Lift	✓	✓
13	A dry main	Provided with an outlet at every level	✓	✓
14		Designed as per BS 9990	✓	✓
15	Construction	Shaft to be enclosed with 120 minutes fire resisting construction and FD 60S doors Internal separation to achieve 60 minutes fire resistance and FD 30S doors.	×	✓
16		The flights and landings of every escape stair should be constructed of materials of limited combustibility.	✓	✓

Note: *Stair 2 and 3 will be provided with a 0.7m² (aerodynamic free area) automatic openable vent at the head of the stairs.*

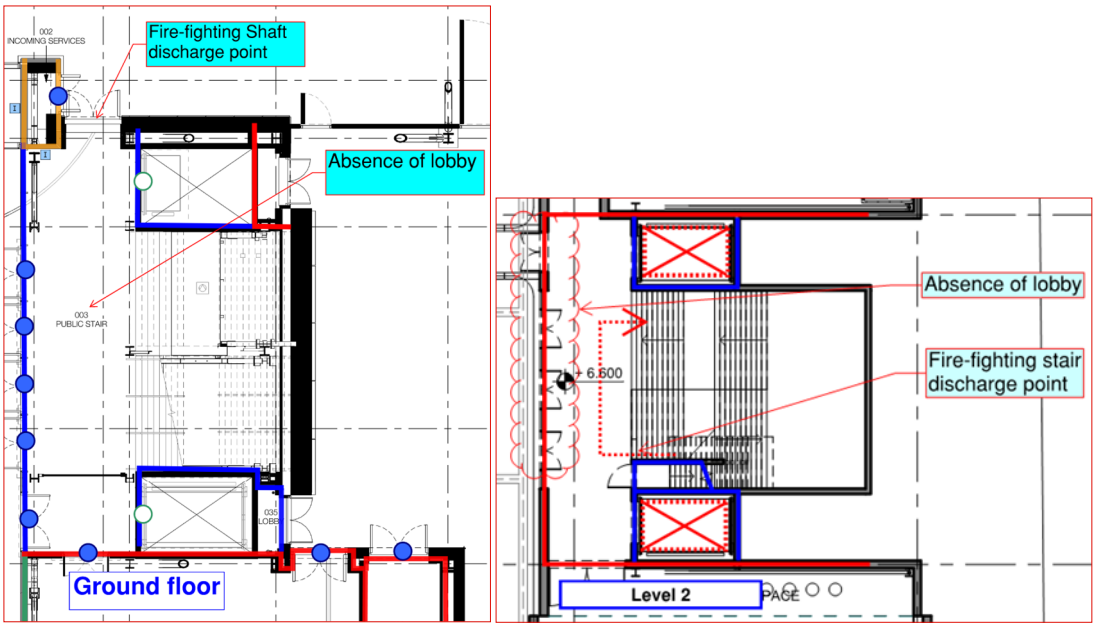
12.2.3 DEVIATIONS

NO1: ACCESS TO OUTSIDE

The fire-fighting shaft should discharge directly to outside or through a protected corridor. A lobby should be provided between this corridor and adjacent spaces. Moreover, the distance through the protected corridor should not exceed 18m.

The fire-fighting stair serving the towers discharges into the large stair serving the Warehouse at Level 2. This stair is enclosed in 2 hours fire rated construction (with any doors being FD60S fire doors) and therefore provides an equivalent level of protection as a protected corridor leading to outside. However, no lobbies are provided at ground floor level and Level 02 between this protected corridor and adjacent spaces (Foyer at ground floor level and Warehouse at Level 2). The 18m limit from the fire-fighting stair discharge point (level 2) to outside is also significantly exceeded.

Figure 12-2: Deviations from BS 9999 recommendations

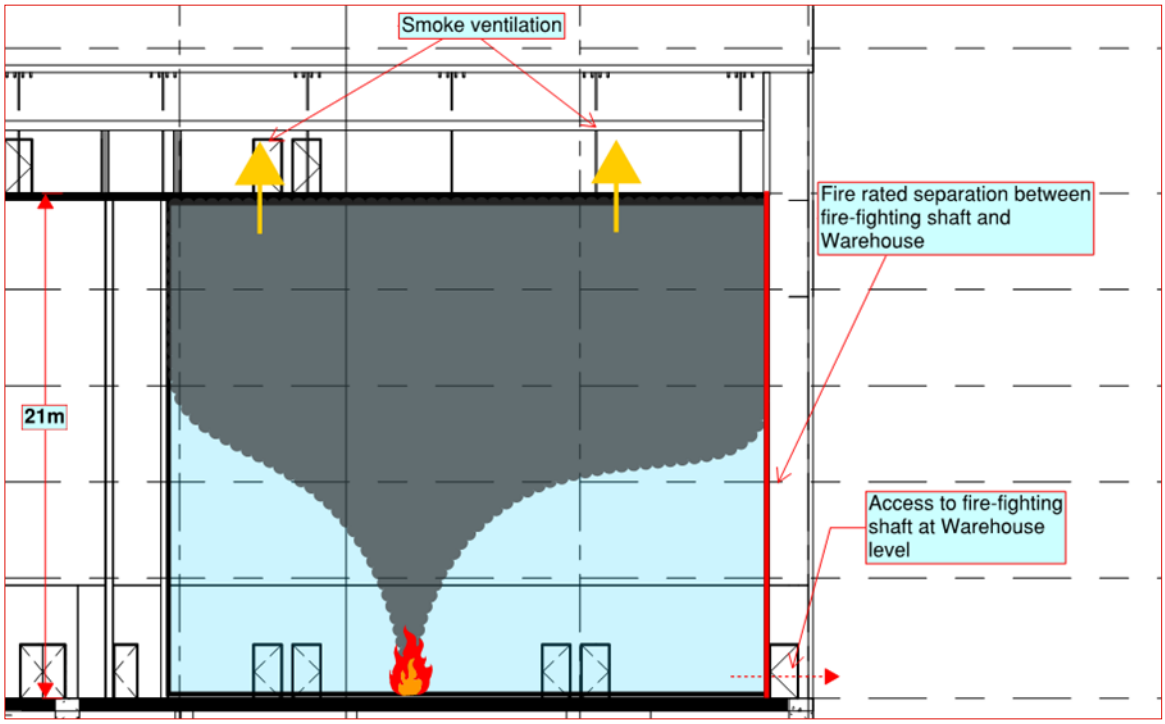


The impact on the safety of the Fire-Service has been assessed as follows:

- A fire starting in the Foyer (room no. 004) is unlikely to affect the upper floors as these two spaces are separated with fire rated floors and compartment walls. Therefore, the Fire-Service will not need to use the fire-fighting shaft for their intervention. The provision of a lobby to protect the Fire Service when accessing the shaft is therefore irrelevant in this fire scenario. Moreover, the Foyer is a large double height space. Therefore a circa 3m deep smoke reservoir is provided above the door giving access to the large feature stair that will delay the time before the smoke layer reaches the door.
- Smoke produced by a fire starting in the Warehouse is unlikely to affect the fire-fighting shaft due to the significant floor to ceiling height of this space (circa 21m) and the provision of a mechanical ventilation system as shown in Figure 12-3: . Any smoke will therefore spread at high level and is unlikely to spread through the doors. As the doors between the Warehouse and the feature stair are used as the main entry point to the Warehouse, it is highly unlikely that combustible materials will be stored in close vicinity to this point.

- The distance between the fire-fighting stair discharge point (at Level 02) and outside is irrelevant as the Fire Service will be able to use the fire-fighting lifts to access the towers.

Figure 12-3: Access between fire-fighting shaft and Warehouse



NO2: FIRE-FIGHTING LIFT

The fire-fighting lifts will also be used as goods lifts. Such an arrangement is not recommended under BS 9999 as good lifts are more likely to get out of use and could be used as a storage space (likewise the lobby serving them). A management strategy will have to be implemented to limit the risk of storage. CCTV coverage to the lift lobby is recommended to aid management in reducing the risk of the space being used for storage. As these lifts are also used as a means of access between the North and South Towers and can be used by the public they are considered more likely to be kept free of storage.

In order to provide additional redundancy both goods lifts will be designed as fire-lifts so that if one lift is out of use for a period of time the Fire-Service have an alternative means of access.

NO3: FIRE-FIGHTING LOBBY

The fire-fighting lobby is larger than the recommended 20m^2 (measures as 64m^2). This figure aims at limiting the risk of storage. As described in the previous item, a management strategy will have to be implemented to limit this risk.

NO4: FIRE-RESISTING CONSTRUCTION

In lieu of 120 minutes fire separation, it is proposed to provide 60 minutes separation between the Feature Stair and the Foyer and between the Feature Stair and the Warehouse. This is considered acceptable due to the following conditions:

FOYER:

The reduction in fire rating between the Feature Stair and the Foyer can be justified through the following mitigations:

- In order to determine their fire resistance, elements of construction are tested in a furnace with the fire located directly adjacent to them. The separation between the Feature Stair and the Foyer is unlikely to be exposed to these conditions as it is the main circulation route for the Warehouse and will have thousands of people using it. As such, a fire is unlikely to develop in close proximity to the partition as combustible materials will be limited within the Foyer. This is taken into account by BS 9999 which mentions that fire resistance of doors protecting a fire-fighting shaft can be half the fire resistance of the wall in which they are located (it should be noted that this particular partition will consist mainly of doors);
- The temperatures within the Foyer in the event of a fire are unlikely to reach similar temperatures as in a furnace test used to determine the fire resistance of elements of construction (over 1000^{o}C). These temperatures would be reached post-flashover. Given the dimensions of the Foyer (over 1000m^{2} and 6m in height) a significant volume of combustible materials would be required to lead to a flashover fire;
- If temperatures increase drastically in the Foyer the non-fire rated glazing to outside provided along the perimeter of the Foyer will fail well before the fire rated glazing protecting the stair. This will decrease the temperatures in the compartment of fire origin;
- In the unlikely event where the temperatures are such that the fire rated separation fails smoke will compromise the feature stair. This will have the following impact on the fire strategy:

  Means of escape: The occupants located within the Warehouse and the Towers will not be able to use this stair as a means of escape. Means of escape calculations (refer to fire strategy report) showed that the remaining means of escape provides sufficient capacity for the maximum occupancy expected within the building and therefore such a scenario will have limited impact on the means of escape strategy.
  - **Compartmentation:** Any smoke spreading into the feature stair will be contained in its enclosure given that it is separated from adjacent areas by fire resisting elements achieving a minimum of 60 minutes fire resistance.
  - **Fire Service Access and facilities:** The Fire Service should not have to use the stair in the event of a fire at ground floor level. If access to the upper floors is required as part of their rescue operations and the feature stair is compromised, two additional stairs with direct access from outside are available.

WAREHOUSE:

The fire rating between the Feature Stair and the Warehouse can be considered as acceptable at only 60 minutes for the following reasons:

- In order to determine their fire resistance, elements of construction are tested in a furnace with the fire located directly adjacent to them. The separation between the Feature Stair and the Warehouse is unlikely to be exposed to these conditions as it is the main circulation route for the Warehouse and will have thousands of people using it. As such, a fire is unlikely to develop in close proximity to the partition as combustible materials will be limited within this particular part of the Warehouse. This is taken into account by BS 9999 which mentions that fire resistance of

doors protecting a fire-fighting shaft can be half the fire resistance of the wall in which they are located (it should be noted that this particular partition will consist mainly of doors);

- The temperatures within the Warehouse in the event of a fire are unlikely to reach similar temperatures as in a furnace test used to determine the fire resistance of elements of construction (over 1000°C). These temperatures would be reached post-flashover. Given the dimensions of the Warehouse (over 2300m^2 and 21m in height) a significant volume of combustible materials would be required to lead to a flashover fire. A smoke ventilation system is also provided within the Warehouse, this will dilute the smoke layer and decrease its temperature. It should be noted that he CFD study for the Warehouse (Appendix B- carried out for the means of escape strategy) confirms this assumption.

FIRE SERVICE ACCESS TO WAREHOUSE AND THEATRE (LEVEL 02)

Since the Warehouse and the lower tiers of the Theatre are located less than 7.5m above the fire and rescue service access level they do not require the provision of fire-fighting shaft. However, the fire-fighting shafts serving the high-rise areas of the building will also provide access to these spaces should the Fire Service want to use them.

The Foyer can be accessed directly from outside.

NO5: SCISSOR STAIR

The fire fighting stairs for the Theatre are arranged as a scissor stair which is not recommended in BS 9999. However, in this building it has been judged to be acceptable given the single lobby arrangement at each level which removes the risk of confusion that can be caused by a typical scissor stair arrangement.

NO6: SERVICES PASSING THROUGH FIREFIGHTING LOBBY

In line with BS9999, no services should pass through a firefighting lobby except to serve the lobby itself (e.g. lighting, fire alarm).

Within the Towers' firefighting lobby, there are a number of services passing through the lobby from the service risers on the east to the occupied spaces on the west. In order to minimise the risk of a fire within the fire fighting lobby, the electrical services will be protected by fire rated construction to remove the risk from the area. Any ventilation ductwork will be provided with fire and smoke rated dampers and will not have any openings into the lobby (i.e. will be fully sealed) or will be encased in fire rated construction.

12.3 EXTERNAL ACCESS TO THE SITE AND FACILITIES

12.3.1 VEHICLE ACCESS

The building will be provided with a dry main in each of the fire-fighting shafts. Access for a pumping appliance will be provided to within 18 m of each fire main inlet connection point, typically on the face of the building, and the inlet should be visible from the appliance parking position.

Access roads should be designed as per the recommendations of Section 21 of BS 9999. These dimensions will have to be confirmed by the local Fire Brigade as fire appliances are not standardised.

12.3.2 FIRE HYDRANTS

A number of existing hydrants are provided around the site less than 100m from the building, therefore no additional hydrants are required. The fire hydrant is located as illustrated in Figure 12-4: overleaf.

Figure 12-4: Hydrant locations

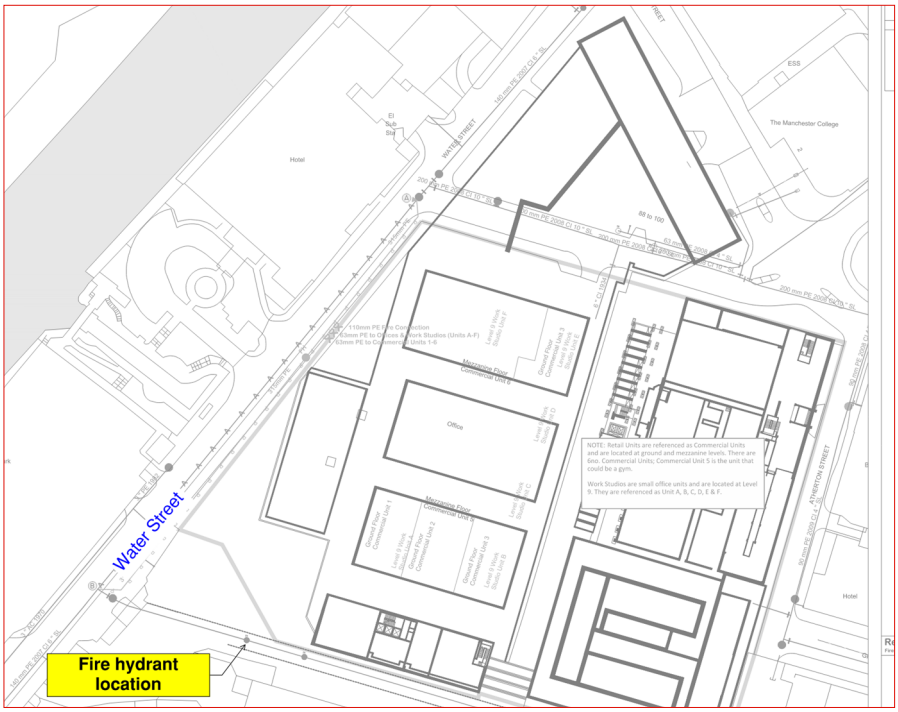
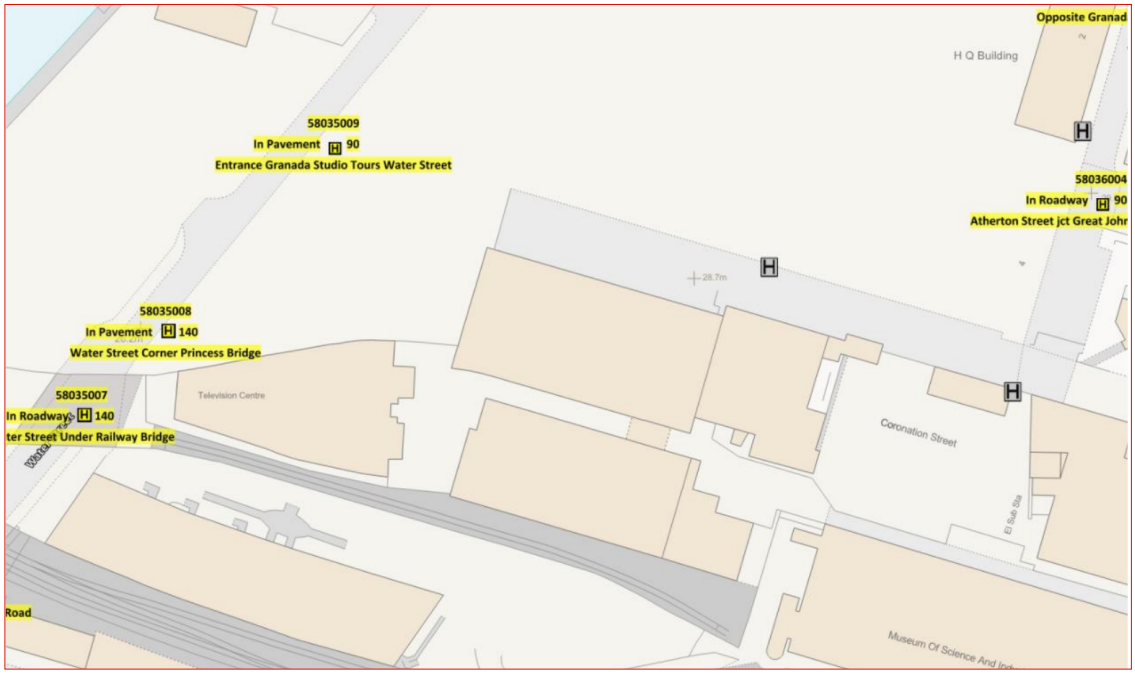


Figure 12-5: Hydrant locations Site Wide



13 MANAGEMENT OF THE FIRE SAFETY STRATEGY

13.1 MANAGEMENT LEVELS

The standard or quality of management referred to in BS 9999 as management levels depends on the risk profile of the building. As the overall risk profile of the building is B2 (refer to Section 3.2), Table 5 of BS 9999 recommends a management Level 2.

However, given the flexibility required by the end user and the reliance on management on this type of premises, Level 1 is recommended.

13.2 ASSESSING THE MANAGEMENT LEVELS

Table 13-1 below highlights the main points that should be considered when developing the fire management plan of the building.

Table 13-1: Management Factors description

Management factor	Description
Planning for changes in risk profile	The system anticipates and proactively identifies the impact of any proposed changes, including changes to the occupancy, periods of abnormal occupancy, and fire growth characteristics. The system identifies any alternative protection and management measures that will be required as a result, and ensures that they are implemented.
Resources and authority	The manager(s) with responsibility for fire safety are empowered to ensure that legislative requirements are met; initiate testing, initiate maintenance or repair, and, where necessary, have direct control of staff responsible for these tasks. Such powers are supported by the necessary, sufficient and appropriate resources, including funds.
Staffing level (staff–occupant ratio)	The staffing level provided is specifically appropriate to the building concerned, including the use of the building, the nature of the occupants, the management systems in place, and the active and passive systems provided. It also includes sufficient trained personnel to ensure that all occupants are assisted, or supported, to make their way out of the building effectively in an emergency – where necessary, e.g. in the case of elderly or disabled persons, or children, this might include making appropriate additional arrangements to ensure their safe evacuation. The system may include arrangements for security such as regular patrols, perimeter controls, entry control systems, and staff able to respond to an intrusion. A level 1 system will also provide for contingencies such as training, sickness, and other unexpected absences etc.
Fire training	The training ensures that there are sufficient numbers of staff trained in all aspects of fire prevention, fire protection and evacuation procedures, and able to use the appropriate extinguishing equipment (and media), so as to provide full coverage of the building, with provision for contingencies, sickness or holiday absences.

Management factor	Description
Work control (e.g. repairs to structure)	The work control system is developed proactively with clear lines of responsibility; a permit system; logging and audit processes and routine checking and supervision.
Communications procedures	The communications system is able to ensure that all of those involved, or potentially involved, in an incident are informed rapidly and effectively, of relevant information. In addition the systems make use of alternative formats as necessary, with contingency plans for when systems fail.
Maintenance and testing of fire safety systems	The maintenance system is one where there is dynamic monitoring of the fire safety systems, and the equipment is kept fully functional at all the times the building is in use. There will also be alternative procedures, etc., identified for those times when systems, equipment and other arrangements are not available or not functioning correctly.
Liaison with fire and rescue service	The liaison is proactive in nature and includes effective arrangements for notifying the fire and rescue service of changes to the occupancy, periods of abnormal occupancy, fire growth characteristics, and other relevant factors. The arrangements will also allow for routine meetings with the fire and rescue service, and additional meetings where a change in the building or its occupancy is proposed.
Contingency planning	The planning system is proactive, and takes into account a wide range of possible emergencies and incidents. These are likely to include planning for logistical issues such as the provision of shelter, communications, transport, the weather, time of day, time of week, time of year (holidays, etc.) and traffic-related issues, as well as scenarios such as power failures or floods.
Additional information	For more information – see document *220506 – Factory fire strategy MIF's Specific Management Requirement Rev 02*

13.3 REGULATION 38

Regulation 38 requires that, where work involves the erection or extension of a relevant building, or relevant changes of use of a building, fire safety information shall be given to the responsible person at the completion of the project or when the building or extension is first occupied. The information will facilitate the production of the risk assessment, a requirement under the Regulatory Reform (Fire Safety) Order 2005.

This fire strategy should be maintained throughout the building works and accurately reflect the complete design. Table 13-2 is a summary of the active and passive systems provided within the site.

Table 13-2: Active & Passive Systems

Passive System	Provision	Reference in Report
Internal Linings	In line with BS 9999	Table 9-1
Structural Elements	90 minutes fire resistance	Section 10-1
Compartmentation	Refer to fire strategy drawings	-

Signage	System designed in accordance with BS ISO 3864 Part 1: 2011 and BS 5499 Part 4: 2013	Section 4.9
Undercroft usage	Note: it has been agreed that fire stopping will be omitted in the north tower undercroft area, therefore, it is not permissible to have retail units in the north tower area.	Section 7.6
Active System	**Provision**	**Reference in Report**
Fire Alarm and Detection	L2 system in accordance with BS 5839-1.	Section 4.1
Emergency Lighting	System designed in accordance with BS 5266-1	Section 4.8
Smoke ventilation	Smoke ventilation provided in: ▪ Fire-fighting shaft; ▪ Theatre; ▪ Warehouse	Section 4
Fire-Fighting	**Provision**	**Reference in Report**
Facilities provided	Dry main provided in staircase with inlet connection located within 18m from fire appliance parking position Fire-fighting lift serving all floors Existing fire hydrant provided within 100m of site	Section 12

14 CONCLUSIONS

The primary objective of this Fire Strategy Report was to set out the key fire safety challenges for the scheme and identify how the building design achieves an acceptable level of fire safety, commensurate with the requirements of the Building Regulations 2010. The guidance document BS 9999 has been used as the basis of the design to ensure that the Functional Requirements of the Building Regulations 2010 are met.

There are areas in the report that propose alternative solutions using fire engineering approach and have concluded the whilst BS9999 recommendations are not fully met in all cases, the functional requirements of the Building Regulations 2010 are achieved by the design. These deviations have been discussed and agreed with the relevant Fire Authorities and Building Control.

Appendix A

CFD ANALYSIS - WAREHOUSE SMOKE MODELLING

Confidential

INTRODUCTION

An ASET / RSET analysis has been undertaken to demonstrate that 5000 occupants will have sufficient time to exit the warehouse floor before the onset of untenable conditions in the warehouse. This compares Available Safe Egress Time (ASET) with the Required Safe Egress Time (RSET). The ASET is the time available from ignition before untenable conditions occur at Level 02 of the warehouse which could prevent occupants from exiting the building. The RSET is the time which is required for occupants of the building to be alerted to a fire and to safely evacuate

ACCEPTANCE CRITERIA

It is proposed to utilise Computational Fluid Dynamics (CFD) modelling to determine the amount of extract ventilation required during the evacuation period of the warehouse.

The following tenability criteria will be used to determine the ASET time.

- Temperatures not more than 60°C and;
- Visibility distances not below 10m measured at a height of 3m above the floor level of the warehouse.

This is based on the guidance within BS 7974 Part 6 - The application of fire safety engineering principles to the fire safety design of buildings – Human factors: Life safety strategies- Occupancy behaviour, evacuation and condition (sub-system 6), 2004. Local location indicates places near the exits where queues are likely for evacuees. The ASET value has been taken when these tenability criteria are reached within the space.

Evacuation calculations will be used to determine the RSET time. This analysis is also based upon the recommendations within BS 7974 – 6, 2004.

CFD MODELLING METHODOLOGY

SOFTWARE

The modelling software used in this assessment is the Fire Dynamics Simulator (FDS) version 6.0.1. This is used in conjunction with Smokeview version 6.0 visualisation software. Both pieces of software are available and validated and supported by the National Institute of Science and Technology (NIST) (http://fire.nist.gov/fds/). FDS is widely regarded as the industry benchmark for fire modelling, and is used by many local and international organisations and research bodies.

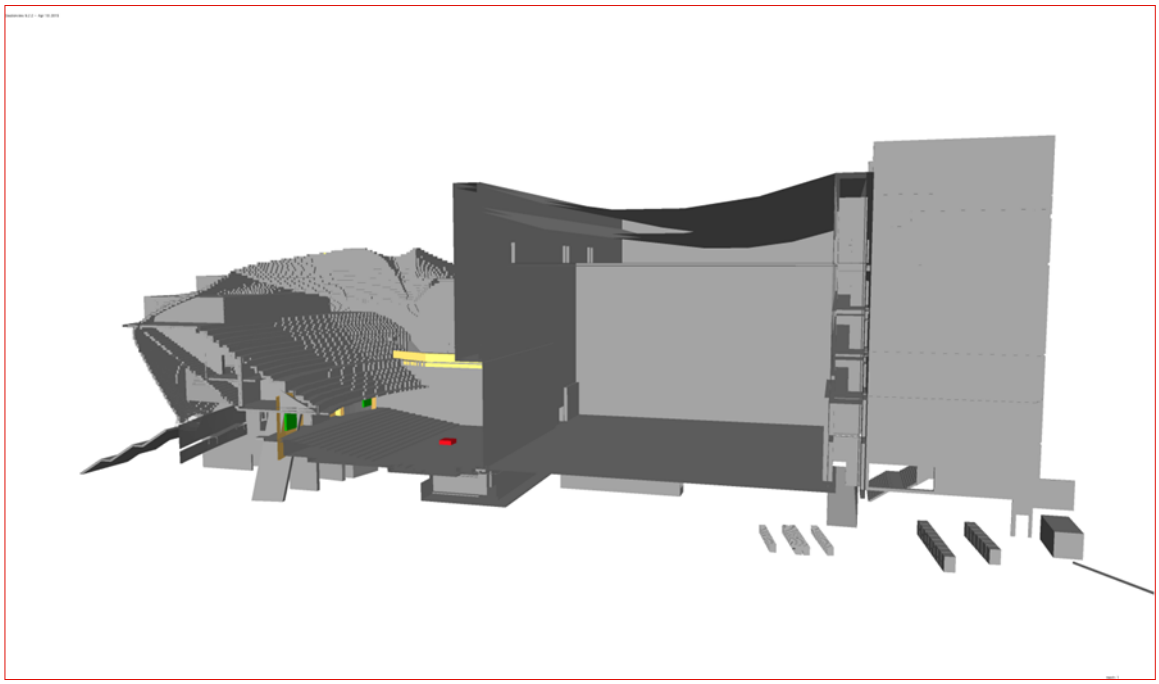
The FDS software solves numerically a form of the Navier-Stokes equations appropriate for low-speed, thermally driven flow, with an emphasis on smoke and heat transport, which is appropriate to fire simulations.

The Large Eddy Simulation (LES) model employed in FDS allows transient features of fires to be caught with great accuracy.

MODEL GEOMETRY AND ASSUMPTIONS

A 3D model suitable for CFD analysis has been built based on the Revit model: MF-OMA-XX-XX-M3-A-00_001.rvt July 2016.

Figure 6 Factory Revit Model



A 0.25m mesh has been used throughout to accurately capture the building geometry and fire region.

All surfaces have been modelled as inert.

Due to the fact that the theatre will be ventilated mechanically for occupant comfort there will not be a ramp up time on the inlet air and due to the comfort ventilation system extracting at high level

FIRE SCENARIOS

A building which is a single large volume such as the warehouse does not typically require smoke ventilation. However, in a pop concert mode, the high occupant load of 5000 persons requires further analysis to be carried out as the width of available escape routes is less than what is required based upon applying standard guidance recommendations. It is therefore necessary to demonstrate that occupants will have sufficient time to escape in the event of a fire.

For the pop concert scenario, the largest fire load will be on the stage, and a 5MW fire on a stage has been modelled in the Warehouse.

A 10% polyurethane soot yield soot yield has been used to conservatively represent the smoke production from the fire.

Two scenarios have been considered; one with the smoke ventilation system operating and one where the system does not operate (for conservatism).

VENTILATION DESIGN

It is proposed to utilise the general ventilation system provided in the warehouse for smoke exhaust in the event of a fire in the warehouse. The warehouse has the potential to be divided into two

sections by the acoustic walls, with the sections referred to as Warehouse North and Warehouse South

- Warehouse North – 16m³/s mechanical exhaust with make-up air provided at low level (a minimum of 7.5m²)
- Warehouse South – 30m³/s mechanical exhaust with make-up air provided at low level (a minimum of 7.5m²)

The above volumetric rates are understood to be sized based upon the 5055 occupancy music concert mode which is the largest occupancy mode for the warehouse. Therefore, in the event of a fire during this mode, the ventilation system will be already running at the time of the fire. Smoke detection is provided at high level within the warehouse which will activate the ventilation system if it isn't already running. In addition, emergency controls shall be provided at ground floor in the fire-fighting lobbies for use by the fire service.

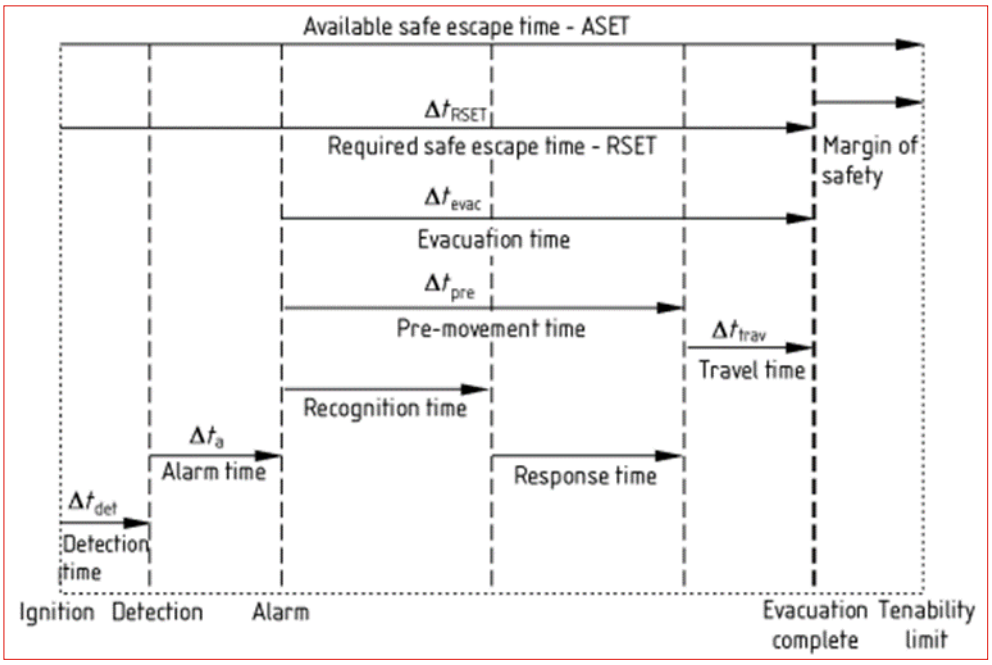
ASET VS RSET ANALYSIS

Introduction

An ASET/ RSET analysis has been carried out to confirm that occupants within the theatre have sufficient time to escape to a place of relative safety in the event of a fire in the theatre.

The evacuation analysis is based upon the recommendations in BS 7974 – The application of fire safety engineering principles to the fire safety design of buildings – Part 6 – Human factors: Life safety strategies- Occupancy behaviour, evacuation and condition (sub-system 6), 2004.

Figure 7 The Principles of ASET vs RSET Analysis



REQUIRED SAFE EGRESS TIME (RSET)

RSET is the measure of how much time is required by occupants of the building to safely evacuate. The RSET consists of several components, these are;

- Time for detection of fire and raising of the alarm,
- Pre movement time (time taken for occupants to decide to evacuate),
- Escape time (time required for occupant to exit to a place of relative safety).

Detection and Alarm Time

The building is fitted with an automatic detection system at high level within the warehouse technical grid area. The activation time of the smoke detectors has been derived from the CFD analysis at 3 minutes.

Pre-movement Time

A pre-movement time of 1-minute is used, as discussed in Section 6.11.3 .

Escape Time

The escape time for each scenario is calculated in Section6 of this report.

Required Safe Escape Time

The RSET is calculated in Section 6.11.3, as 9.02 minutes for Scenario 1.

AVAILABLE SAFE EGRESS TIME (ASET)

Simulation 1 – No Smoke Ventilation

Tenable conditions have been maintained 3m above the warehouse floor level for 720s.The provision of mechanical ventilation and a large smoke reservoir above the stage area contains the spread of smoke for a sufficient period to allow occupants to escape.

Figure 8: Smoke Layer Visibility 3m above floor level (plan)

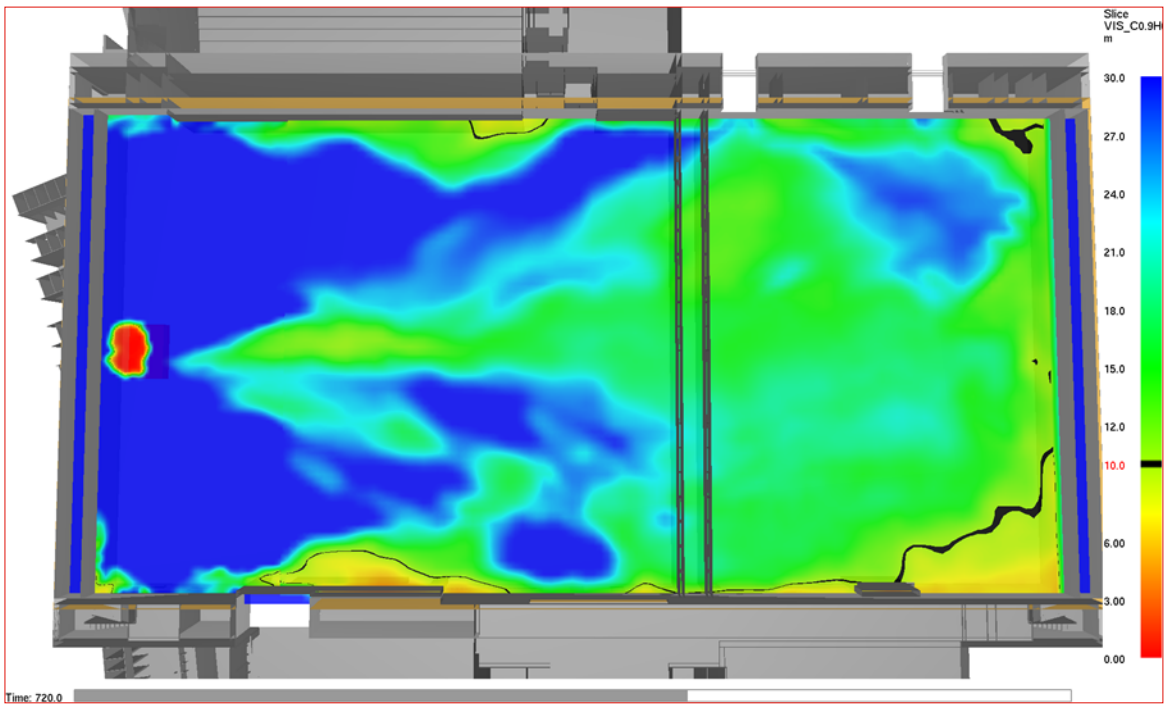
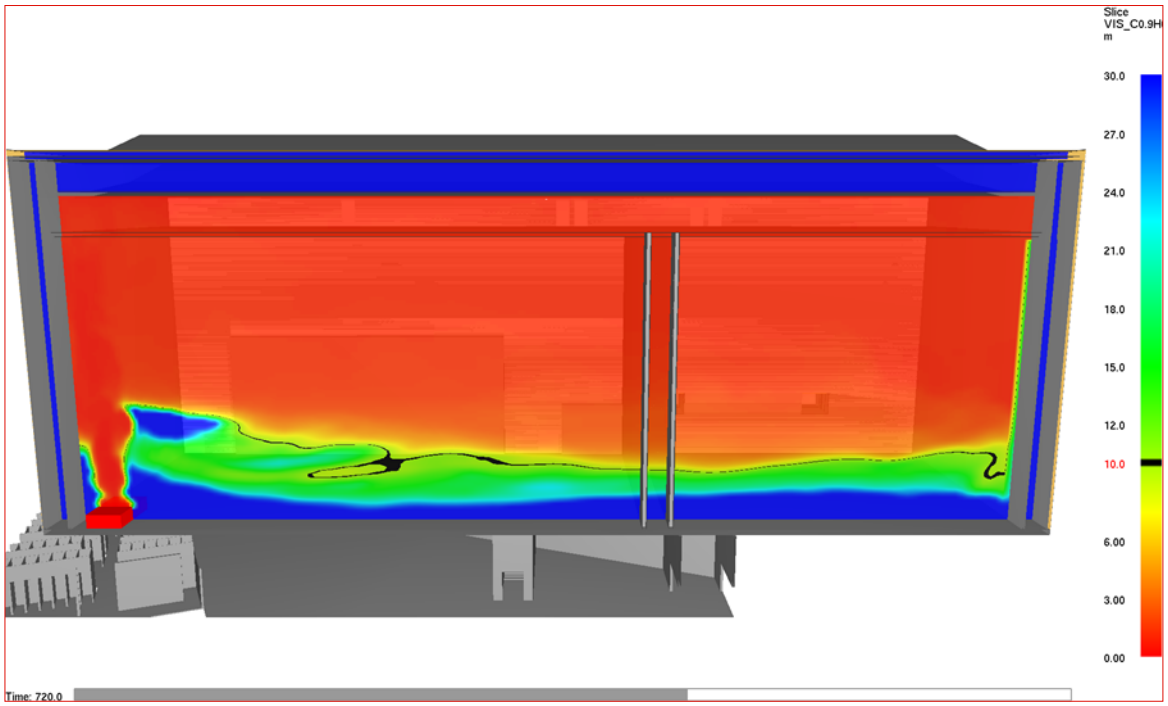
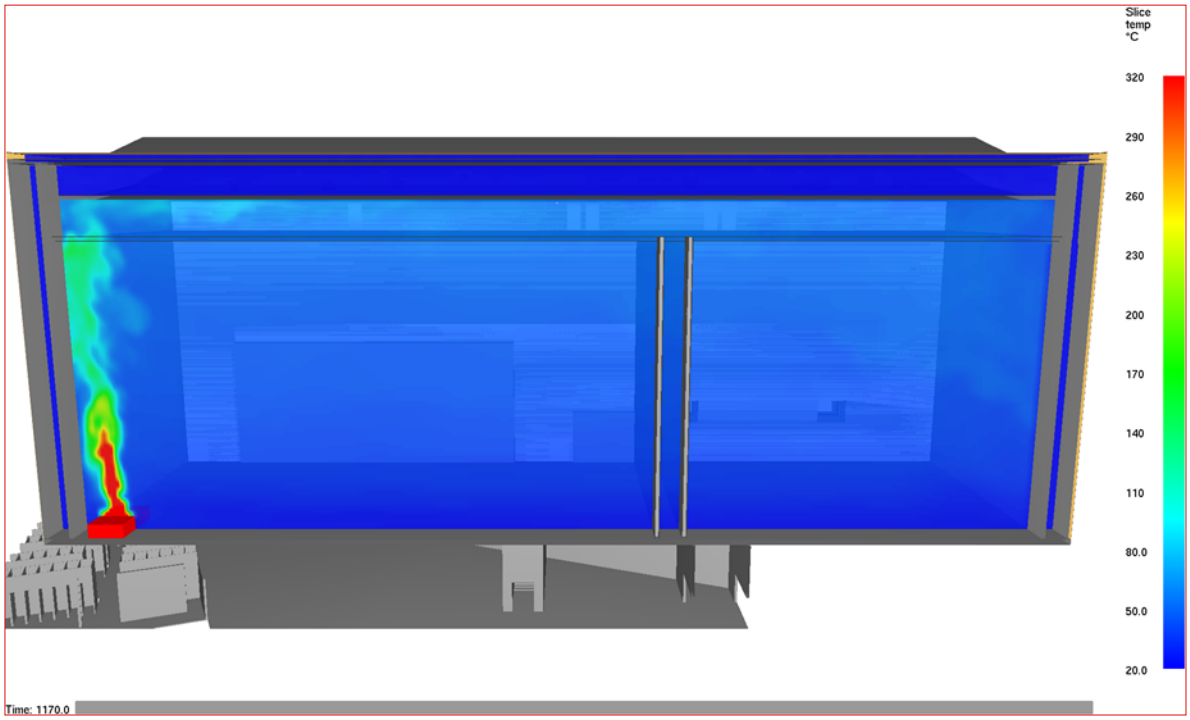


Figure: 9 Smoke Layer Visibility (section)



The smoke layer temperatures reach a maximum of c. 200^{0}C above the source of the fire but is less than 100^{0}C generally as shown in Figure 10

Figure 10: Smoke Layer Temperature



Simulation 2 – Smoke Ventilation

Tenable conditions have been maintained 3m above the warehouse floor level for more than 1200s (the duration of the CFD model run time). The provision of mechanical ventilation and a large smoke reservoir above the stage area contains the spread of smoke for a sufficient period to allow occupants to escape.

Figure 11 Smoke Layer Visibility 3m above floor level (plan)

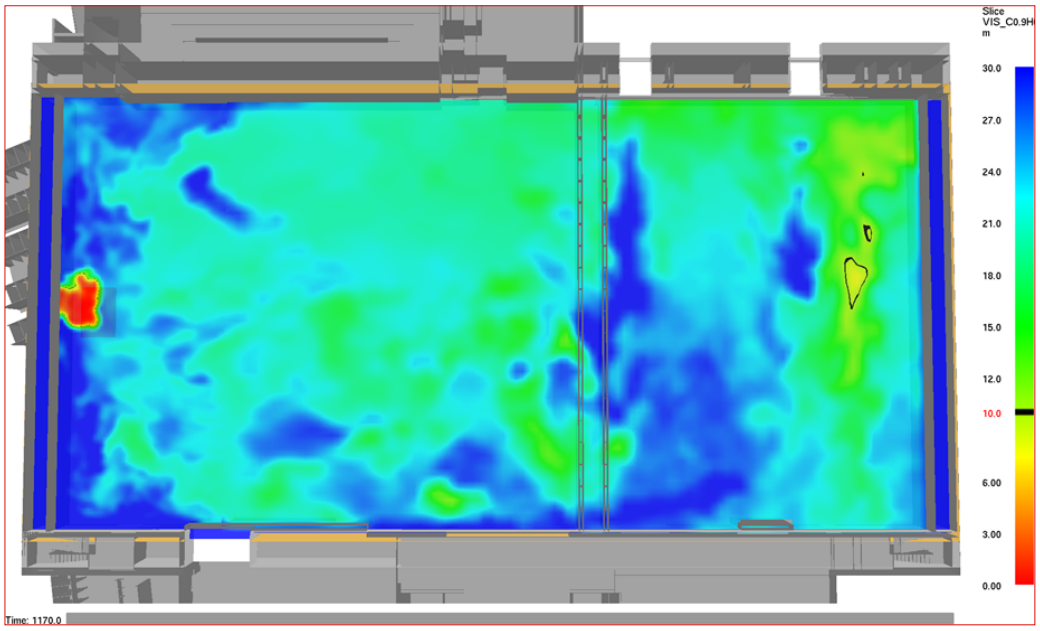
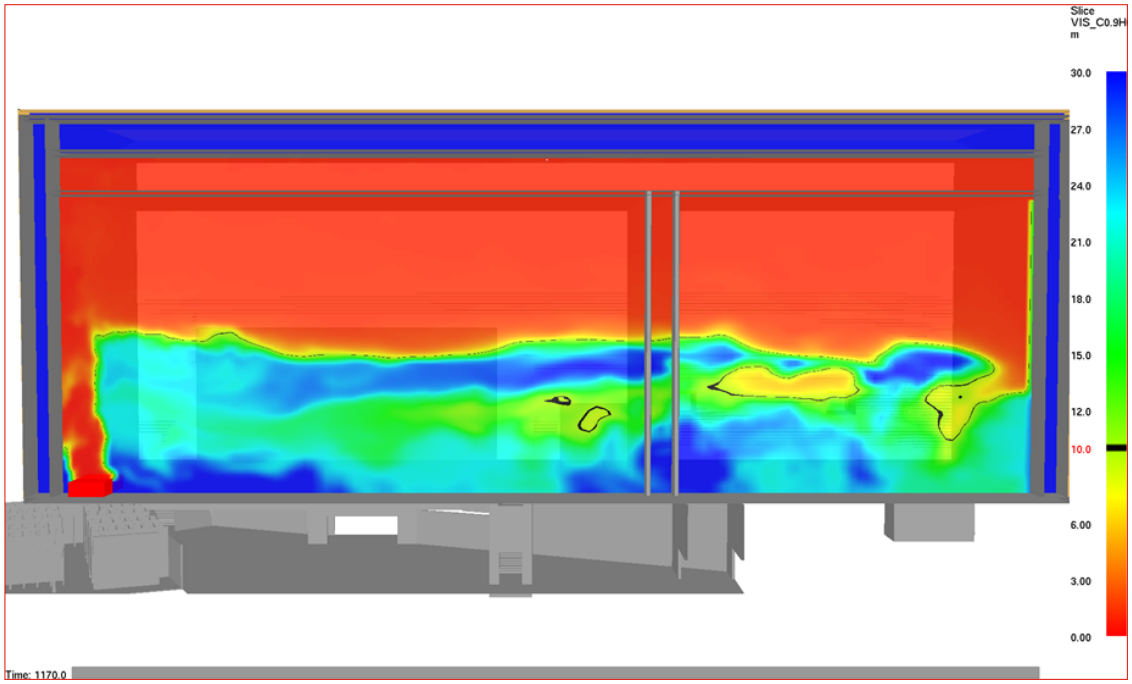
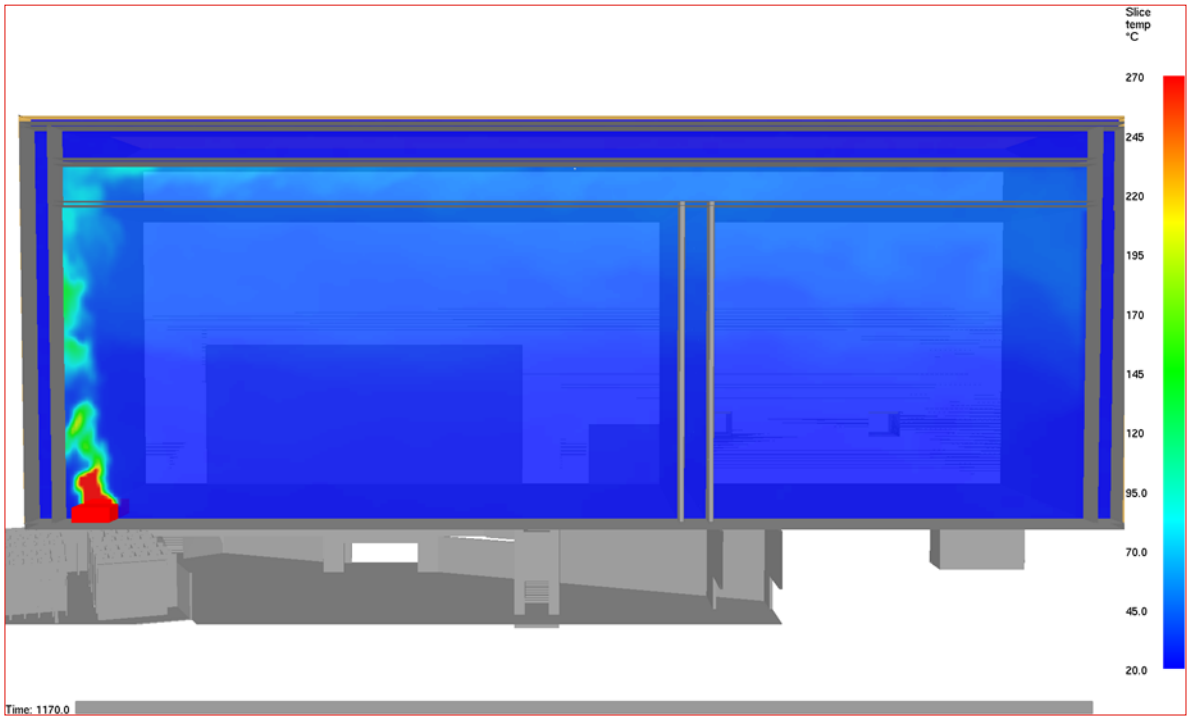


Figure 12 Smoke Layer Visibility (section)



The smoke layer temperatures reach a maximum of c. 150^{0}C above the source of the fire but is less than 100^{0}C generally as shown in Figure 13.

Figure 13 Smoke Layer Temperature



ASET VS RSET ASSESSMENT

COMPARISON OF RESULTS

The comparison of ASET and RSET is shown in Table 6-29: .

CONCLUSION

The prescriptive methodology in BS 9999 suggests that the Warehouse has insufficient exit capacity for the proposed worst case occupant load of 5055 people during a music concert type event. A fire engineered analysis, based upon the ASET vs RSET methodology in BS 7974, demonstrates that for the worst case fire scenarios considered, occupants will have sufficient time to escape before subject to untenable conditions on escape routes.

Appendix B

CFD ANALYSIS – THEATRE SMOKE MODELLING

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INTRODUCTION

The two stage formats, used in the Theatre consist of:

- An end stage arrangement with the stage in the Warehouse; and
- A thrust stage format where the stage is located within the theatre auditorium.

Due to having two stage formats it is not proposed to have a safety curtain between the stage area and the seating area as it would not offer any benefit for life safety.

Therefore BS 9999:2017 and the Technical Standards for Places of Assembly recommend the following provision for smoke ventilation for theatres with open stage arrangements.

"Exhaust ventilation, preferably mechanical, should be provided over any open stage. The extract system over an open stage should be sized to keep the auditorium relatively clear of smoke during the period of evacuation in the event of a fire on stage. The size and minimum fire resistance of the system should be determined according to the size of the stage. Unless determined otherwise, exhaust ventilators over an o pen stage should have a combined total aerodynamic free area at least 10% of the area of the stage."

The theatre in the Factory will be mechanically ventilated.

It is therefore proposed to carry out an ASET / RSET (Available Safe Escape Time Vs Required Safe Escape Time) to demonstrate that the proposed smoke ventilation system provides an adequate level of safety.

ACCEPTANCE CRITERIA

It is proposed to utilise Computational Fluid Dynamics (CFD) modelling to determine the amount of extract ventilation required during the evacuation period of the theatre.

This provides a building specific ventilation system rather than a system based on a generic requirement such as utilising the recommendation of 10% of stage area(s) as stated in the applicable literature.

The following tenability criteria will be used to determine the ASET time.

- Temperatures not more than 60°C and;
- Visibility distances not below 5m at local locations and not below 10m generally.

This is based on the guidance within BS 7974 Part 6 - The application of fire safety engineering principles to the fire safety design of buildings – Human factors: Life safety strategies- Occupancy behaviour, evacuation and condition (sub-system 6), 2004. Local location indicates places near the exits where queues are likely for evacuees. The ASET value has been taken when these tenability criteria are reached within the space.

Evacuation calculations will be used to determine the RSET time. This analysis is also based upon the recommendations within BS 7974 – 6, 2004.

CFD MODELLING METHODOLOGY

SOFTWARE

CFD is used to explore complex scenarios and provide a greater level of detail and accuracy achievable with simple hand calculations. The principle of CFD modelling is to split a physical domain into thousands or millions of individual cells in which transport equations are solved for

important physical conditions such as conservation of mass, momentum and energy, and the transport of defined species such as ‘soot’.

The Fire Dynamics Simulator (FDS) is a CFD model for fire-driven fluid flow from the National Institute of Standards and Technology (NIST). The model solves numerically a form of the Navier-Stokes equations appropriate for low-speed (low Mach-number), thermally driven flow with emphasis on smoke and heat transport from fires. The partial derivatives of the conservation equations of mass, momentum, and energy are approximated as finite differences, and the solution is updated in time on a three-dimensional, rectilinear grid.

The core algorithm is an explicit predictor-corrector scheme that is second-order accurate in space and time. Turbulence is treated using a Very Large-Eddy Simulation (VLES) technique; with a variation of the Deardoff model used to calculate turbulent viscosity.

FDS version 6.7.1 is made available through NIST and commonly regarded as an international standard for fire and smoke modelling. Verification and validation documentation is available on the NIST website, https://pages.nist.gov/fds-smv/manuals.html.

MODEL GEOMETRY AND ASSUMPTIONS

A 3D model suitable for CFD analysis has been built based on the latest Revit model: MF-OMA-XX-XX-M3-A-00-0001_Ver43.rvt July 2019.

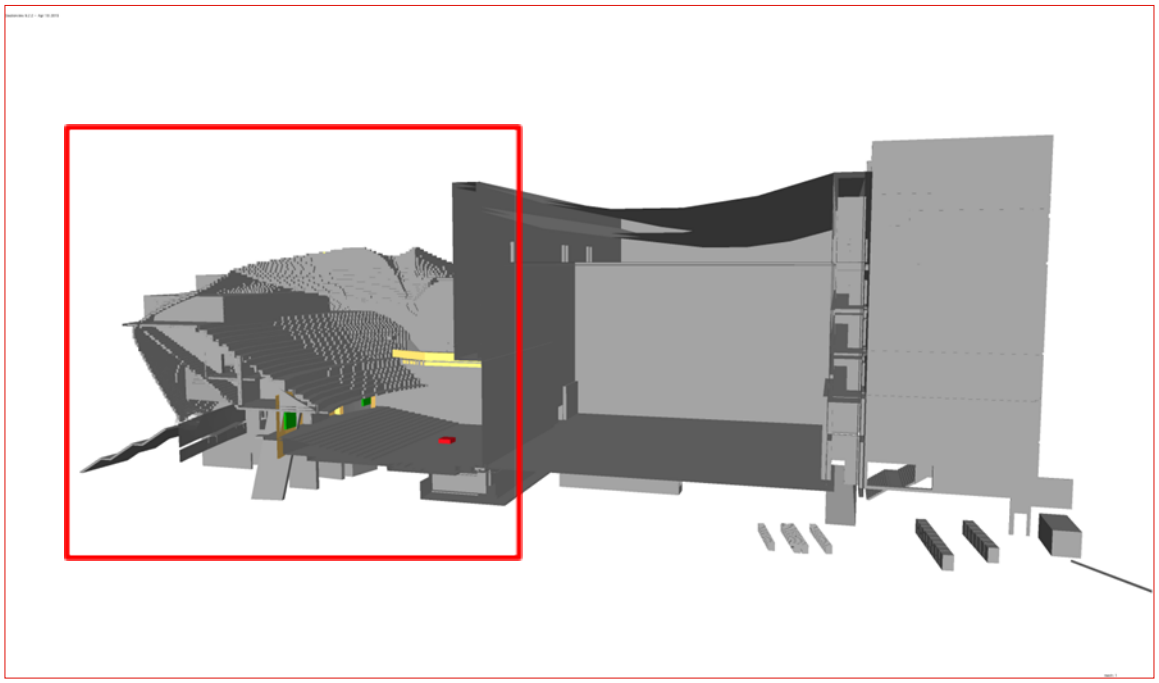


Figure 14 Revit Model of The Factory

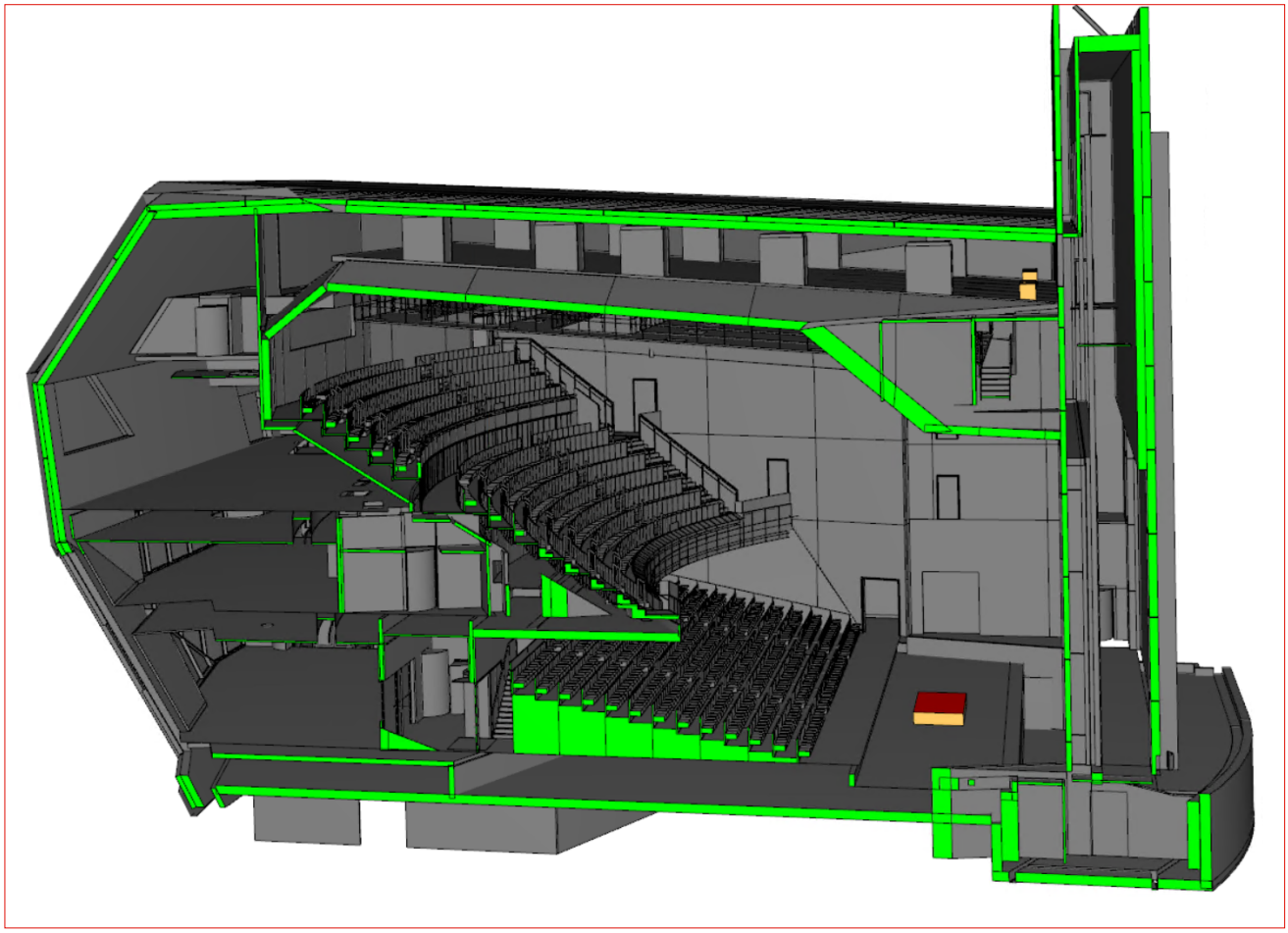


Figure 15 Revit Model of The Factory

Computational domain is modelled with a 0.1 m x 0.1 m x 0.1 m cell size around the fire and smoke extracts, and a 0.2 m x 0.2 m x 0.2 m everywhere else, yielding approximately 3,700,000 cells.

All surfaces have been modelled as inert and ambient air temperature set at 20°C.

Due to the fact that the theatre will be ventilated mechanically for occupant comfort there will not be a ramp up time on the inlet air and due to the comfort ventilation system extracting at high level.

FIRE SCENARIOS

Two fire scenarios have been investigated for the theatre, one for the end stage and the other for the thrust stage. For the End Stage format, the fire will actually be located within the Warehouse and hence the Warehouse ventilation system will operate in this case. A 5MW fire on a stage has been modelled in the Warehouse and this analysis is presented in Appendix A. For the Thrust stage a 2MW medium growing fire with an area of 8m^2 has been used. Due to the way the thrust stage is used the amount of combustibles in this area will be limited hence the reduced fire area.

It should be noted that the size of the fire (i.e. 2MW) is not significantly important for both analyses. This peak fire size has been defined as a requirement of the CFD software. The important factor is the growth rate during the early stages of the fire i.e. during the evacuation phase. As once the peak fire size has been achieved, the occupants within the theatre space would have evacuated.

A 10% polyurethane soot yield soot yield has been used to conservatively represent the smoke production from the fire.

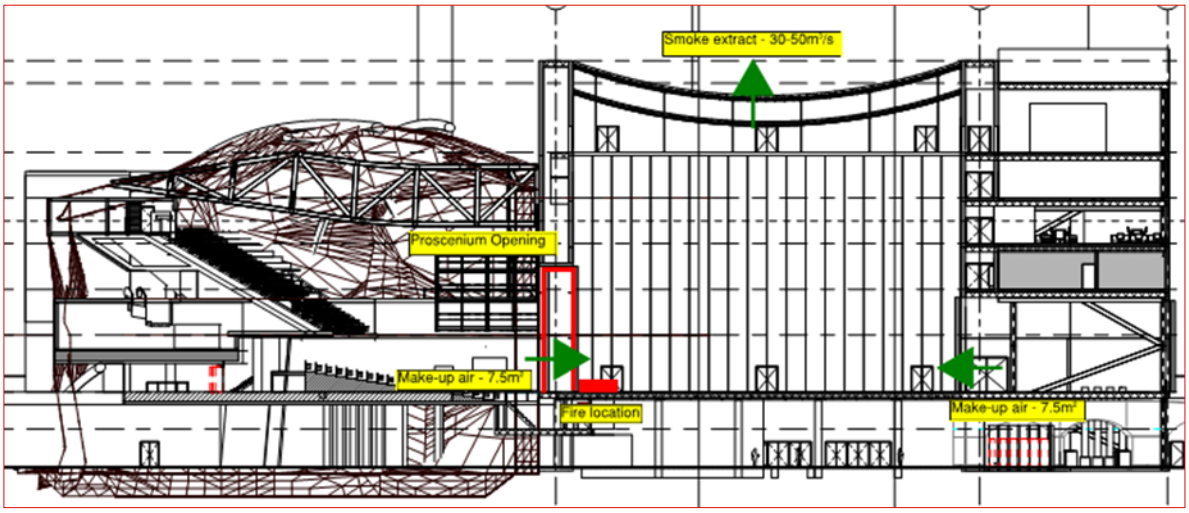
VENTILATION DESIGN

END STAGE FORMAT

The Figure below shows the proposed ventilation design for the End Stage configuration. This system utilises the following ventilation features:

- A minimum of 30m³/s mechanical exhaust (Warehouse South Zone) with make-up air provided at low level (7.5m² or mechanical equivalent). This applies if the acoustic wall is in place.
- If the warehouse is undivided, an additional 16m³/s mechanical exhaust will be provided in Warehouse North Zone with additional make-up air provided at low level (7.5m² or mechanical equivalent).

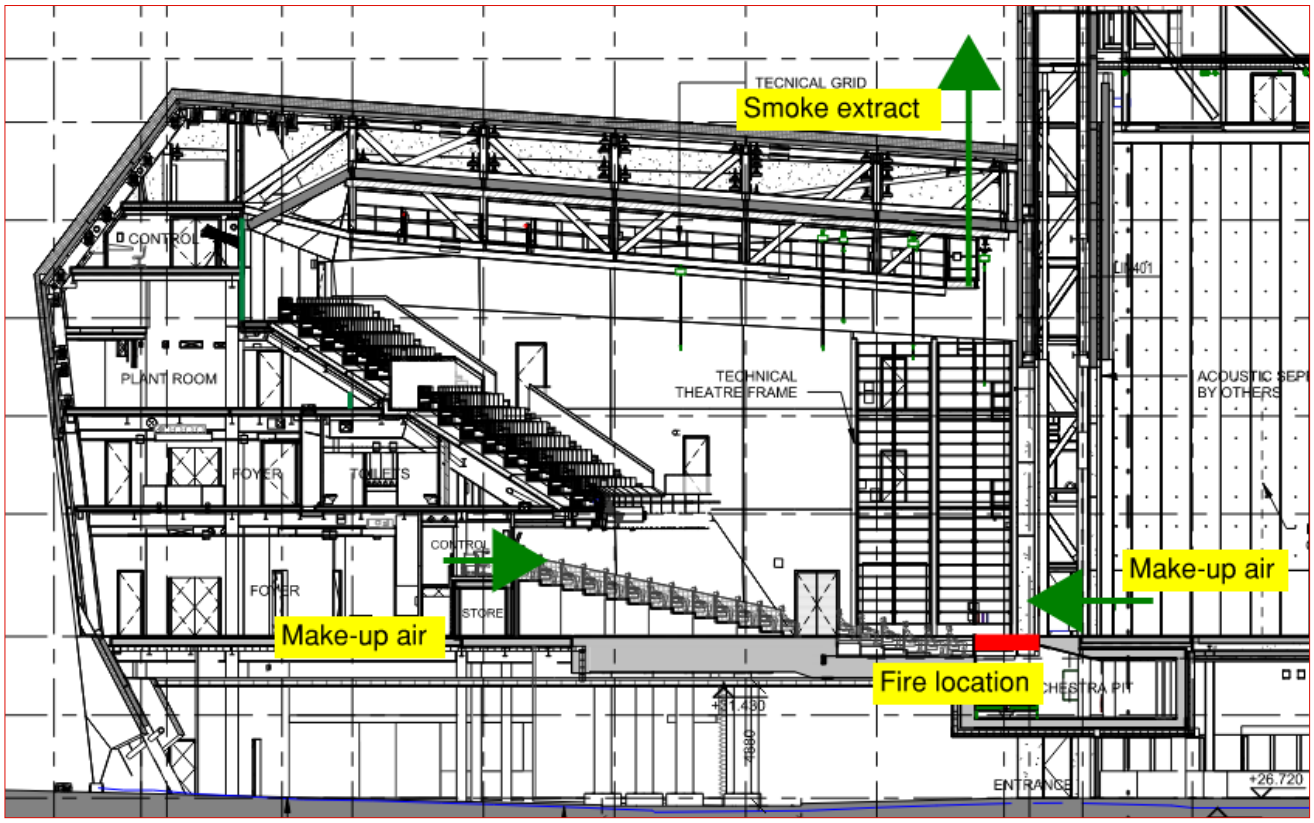
Figure 16 End Stage Format



THRUST STAGE FORMAT

The Figure below shows the proposed ventilation design for the Thrust Stage configuration. This system utilises 13 m3/s mechanical exhaust at high level.

Figure 17: Thrust Stage Format



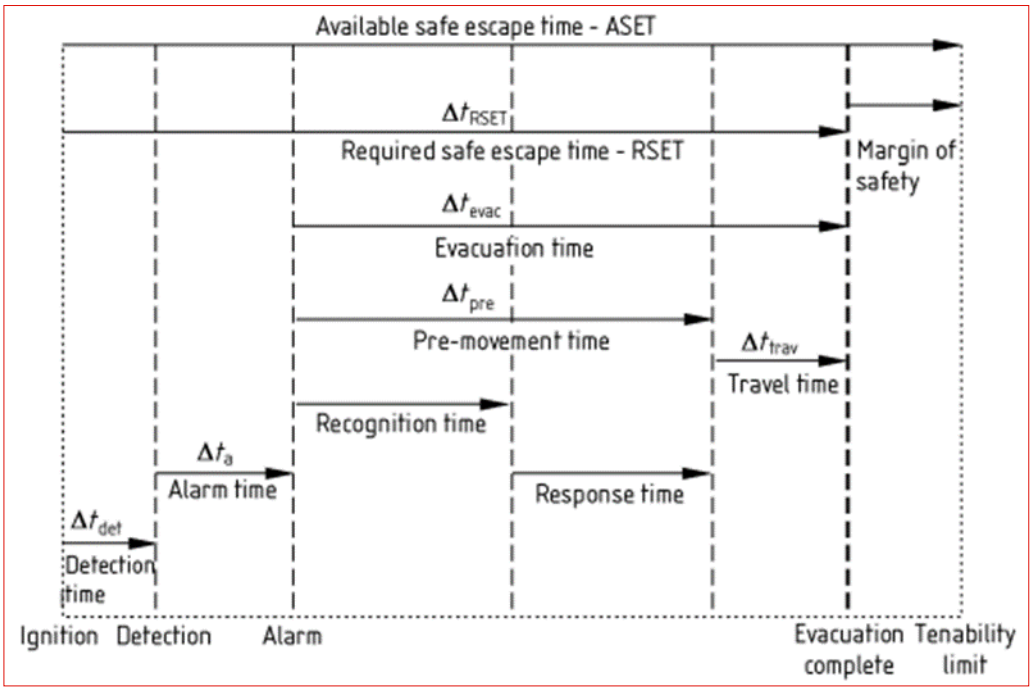
ASET VS RSET ANALYSIS

INTRODUCTION

An ASET/ RSET analysis has been carried out to confirm that occupants within the theatre have sufficient time to escape to a place of relative safety in the event of a fire in the theatre.

The evacuation analysis is based upon the recommendations in BS 7974 – The application of fire safety engineering principles to the fire safety design of buildings – Part 6 – Human factors: Life safety strategies- Occupancy behaviour, evacuation and condition (sub-system 6), 2004.

Figure 18 The Principles of ASET vs RSET Analysis



REQUIRED SAFE ESCAPE TIME (RSET)

The RSET analysis is the measure of how much time is required by occupants of the building to safely evacuate. The following sections will define each of the items shown in the above figure and the times that will apply for the theatre:

Time to Detection

Detection time – is the time from ignition to detection by an automatic system or the first occupant to activate a manual system.

The building is fitted with an automatic fire detection and alarm system which includes smoke detection throughout the theatre. However, a fire on either stage will be detected immediately as the stage is the main focal point for the occupants throughout the theatre, therefore will be aware of a fire immediately before the detection system is activated. Therefore, no detection time (0 seconds) shall be considered for this analysis.

Pre-Movement Time

Pre-movement time – is the time taken from the sounding of the alarm before the first occupants begin to move. The pre-movement time is influenced by the complexity of the building, occupant's familiarity with the building, building management (to assist with the evacuation) and the type of alarm signal.

In theatres, occupants are attending to the stage or screen, and this provides the primary focal point, which can be used by management to control an evacuation. A pre-movement time of 60 seconds is assumed for the theatre given that the occupants will be viewing the stage area at the time of a potential fire.

Travel Time

Travel time - is a function of both the walking time and the time required for occupants to flow through an exit. The walking time is generally considered the average time required to walk to an exit and is influenced by the travel distance to the exit, the distribution of occupants and their unimpeded walking speed.

The worst case travel distance from the upper tier seating level within the theatre (worst case scenario) is 25m to exit the compartment. Therefore, utilising a walking speed of 1.2m/s (BS 7974-6 Annex D), it will take 21 seconds to travel to a place of safety.

However, the total escape time will be based upon the flow of occupants through the exits. No exits are assumed to be compromised as the fire has been indicated on the stage. The escape time is based upon a flow rate of 1.33 persons/m/second (Table D3. BS 7974-6) through each of the 1800mm exits as indicated below:

Theatre Upper Tier Seating

- 2 x 1800mm exits
- 960 occupants
- Maximum flow capacity – 1.33 persons/s/m (Table D.3 of BS 7974 Part 6)
- Flow time = 640 / (1.8 x 1.33) – 134 seconds

RSET

Therefore, the total required safe escape time is approximately 194 seconds (3.2 minutes), which includes a pre-movement time / detection time of 60 seconds.

AVAILABLE SAFE ESCAPE TIME (ASET)

To determine the available safe escape time for occupants of the theatre, a fire within the theatre during end stage configuration and thrust stage configuration has been modelled using a Computational Fluid Dynamics (CFD) simulation to study the conditions within the space.

The aim of this simulation is to demonstrate that tenable conditions on the escape routes from the upper tier seating level within the theatre (worst case scenario) are maintained for the duration of the evacuation.

Simulation 1 – End Stage Configuration

In the end stage format, a fire on the stage will be within the Warehouse and as such it will be the Warehouse ventilation which will actuate. Occupants in the theatre will not be at risk of fire and smoke until the smoke layer descends below the proscenium opening. This occurs after 600s as shown in Figure 100.

Figure: 19 Time at which smoke layer descends below proscenium opening

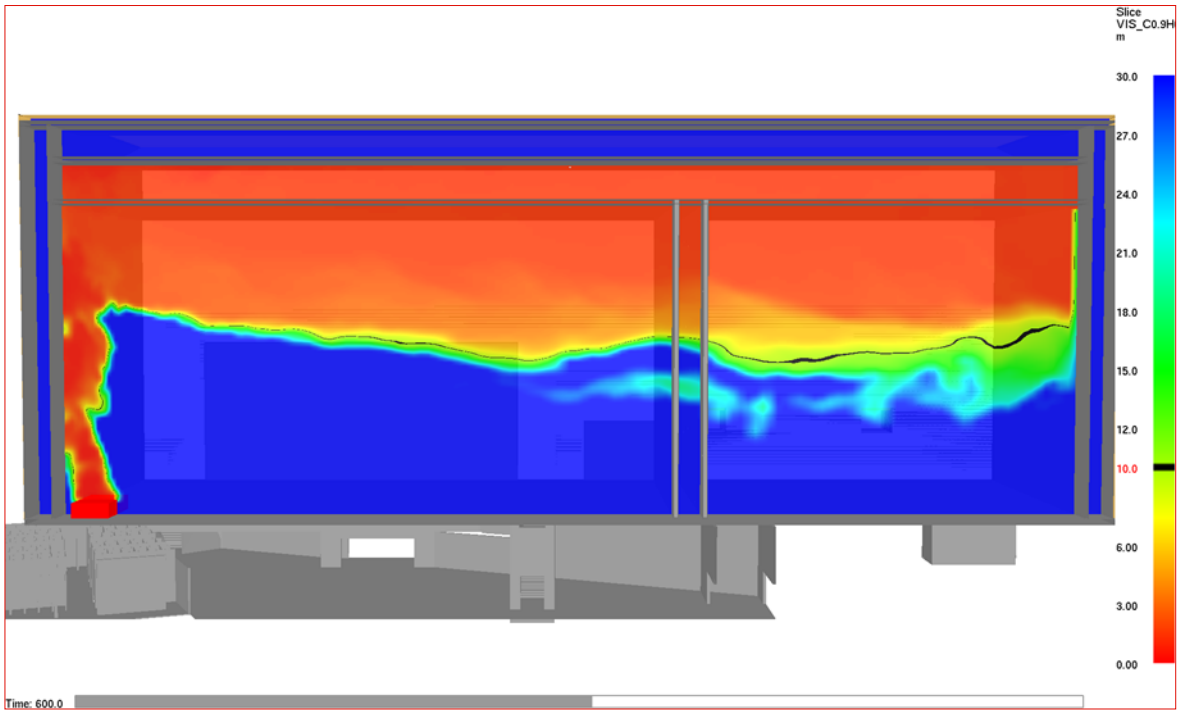
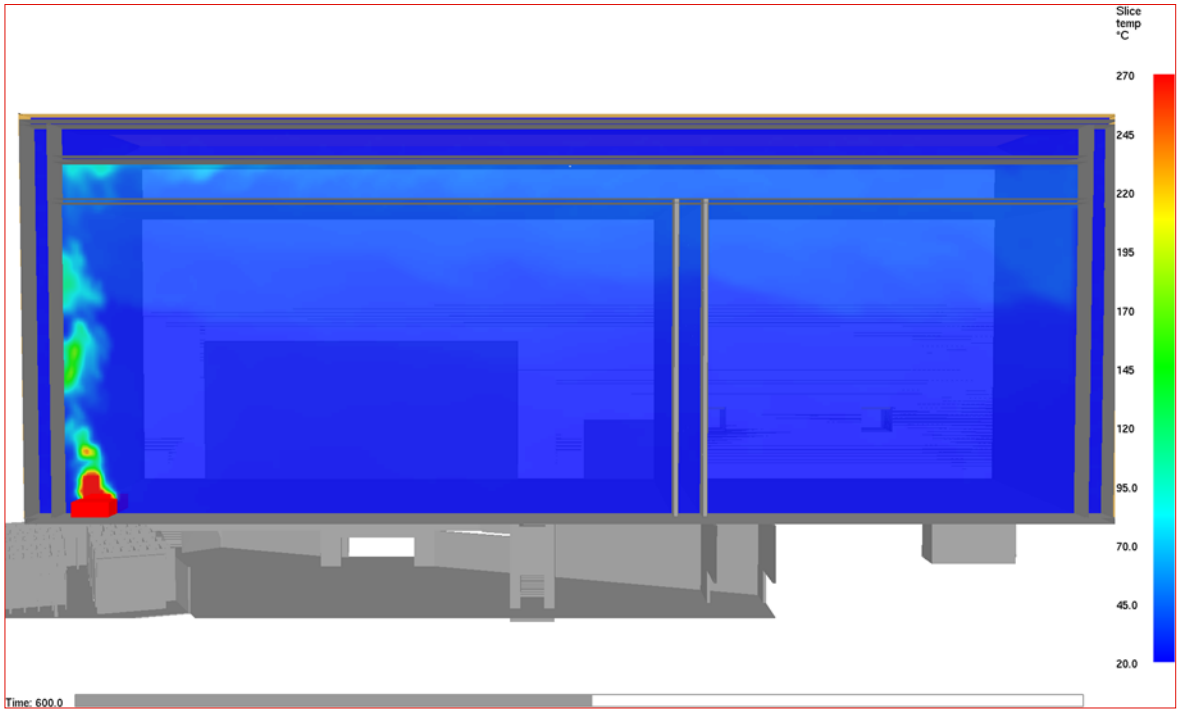


Figure 20: Smoke layer temperature



Simulation 2 – Thrust Stage Configuration

Table 14-1 – Event Mode I – Evacuation Modelling Result

Areas	ASET (sec)	ASET (mins)
Theatre top row of seating	240 seconds	4 minutes
Theatre top tier clearance	290 seconds	4.8 minutes
Theatre main exit level for the upper-tier	390 seconds	6.5 minutes
Theatre lower-level full evacuation	600 seconds	10 minutes

Tenable conditions have been maintained at the top row of seating up to 240s, 290 for clearing the top layer and for 390s at the main exit level for the upper tier at Level 4. The tenable condition is maintained at main exits at level for the rest of the simulation 600s. The provision of mechanical ventilation and a large smoke reservoir above the stage area contains the spread of smoke for a sufficient period to allow occupants to escape. Temperatures, Toxicity (CO concentration) remain tenable throughout the simulation.

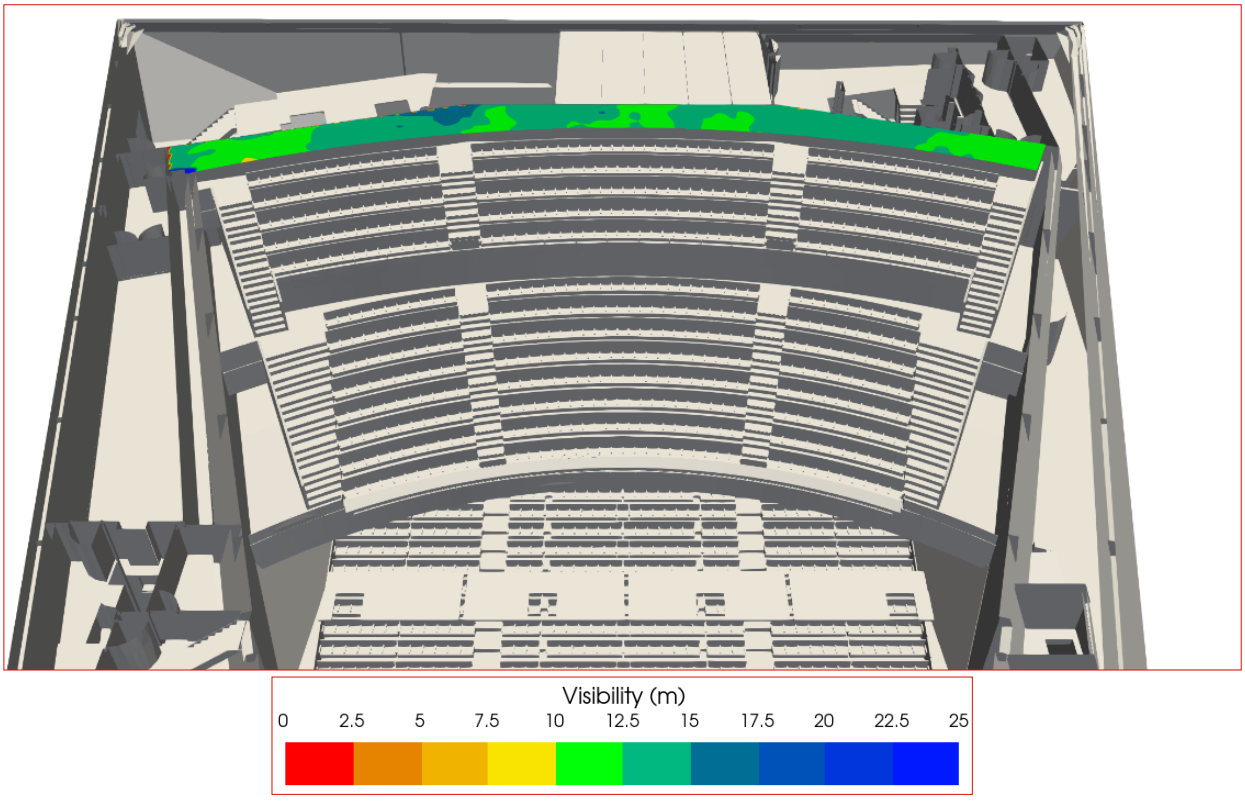


Figure 21: Time to untenable visibility conditions at +2m FFL for the top row of seating on Level 5 (240 seconds)

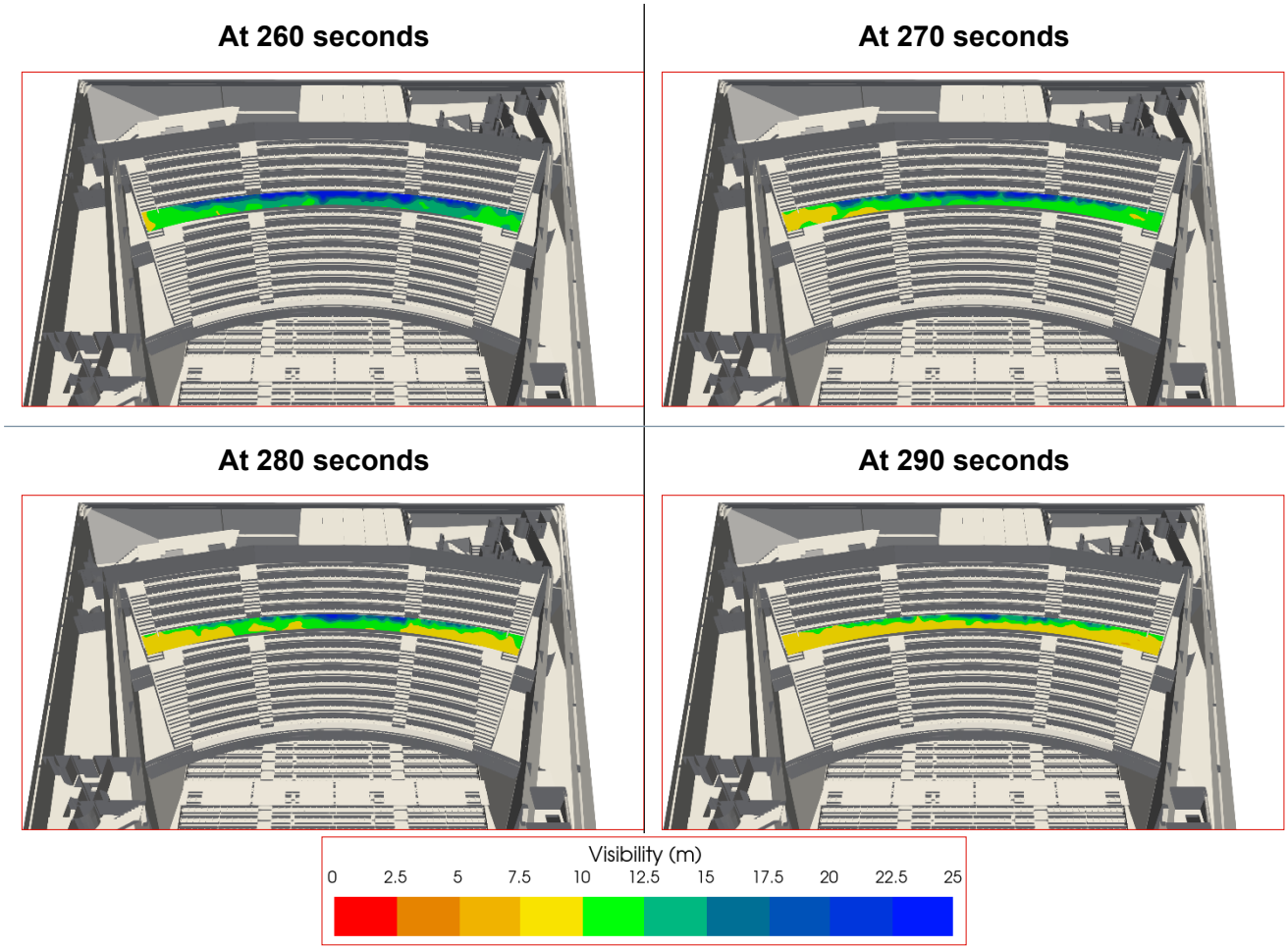


Figure 22: Time to untenable visibility conditions at +2m FFL for the upper tier escape route on Level 4.

Note: the figure above shows visibility reduced to less than 10m at 280 seconds at the theatre top tier clearance, nonetheless, the condition continues to be tenable up to 290 seconds as the travel distance to leave the area is less than 10m, approximately 5m so visibility is acceptable for escapees, the toxicity (CO concentration level <800PPM) continues to be acceptable. Furthermore, the temperature is maintained at tenable level during these times.

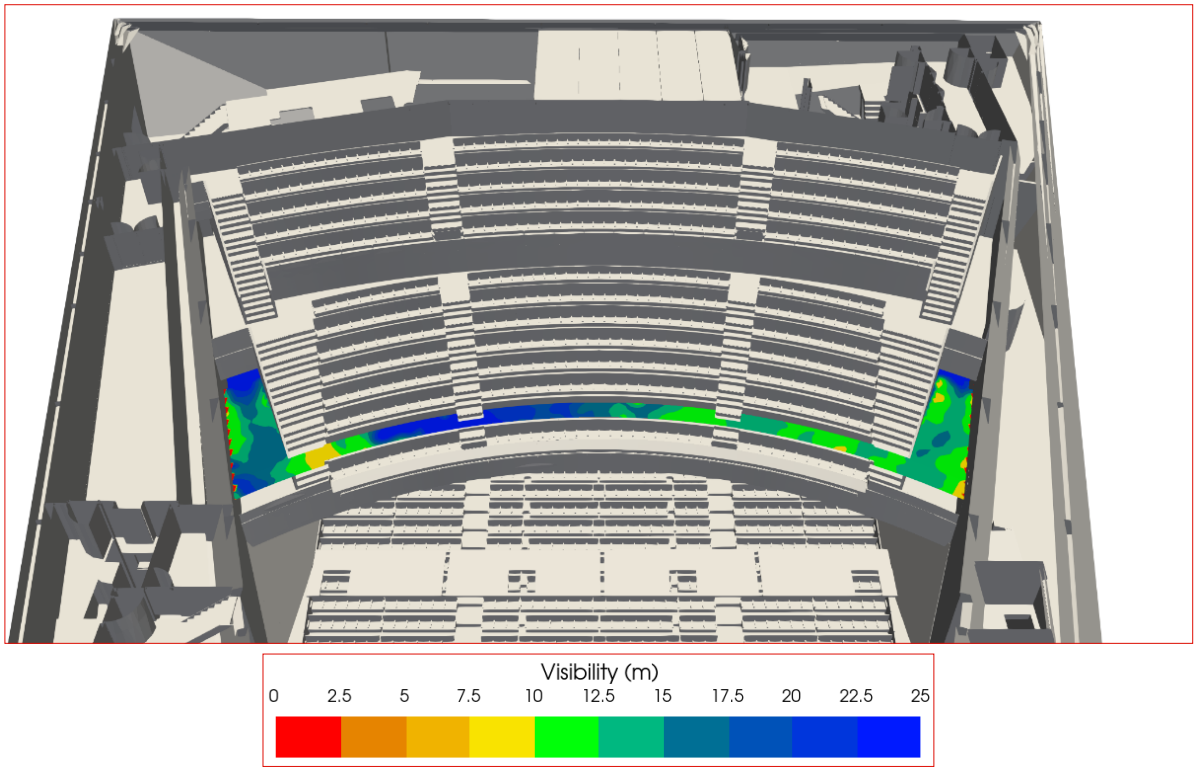


Figure 23: Time to untenable visibility conditions at +2m FFL for main exit level for the upper-tier on Level 3 (390 seconds).

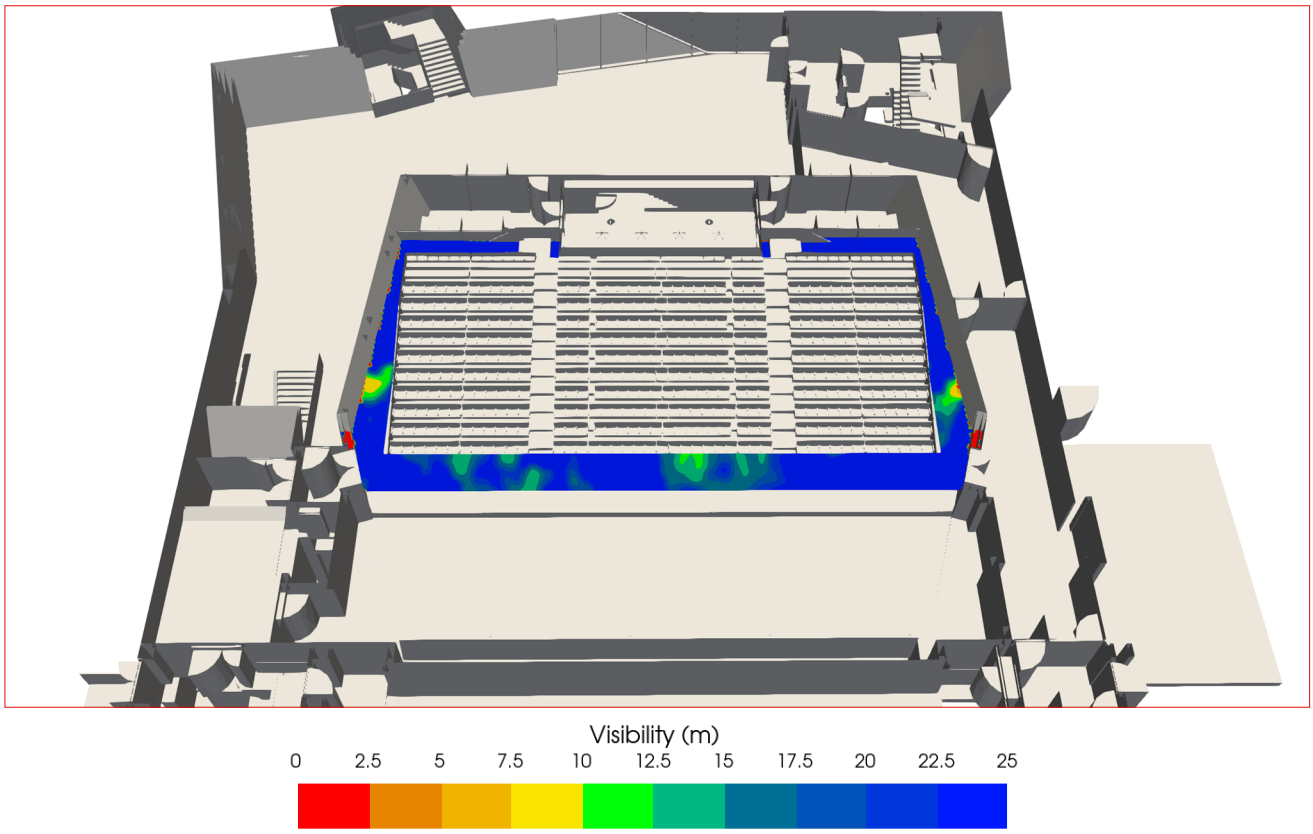


Figure 24: Time to untenable visibility conditions at +2m FFL for the lower level on Level 2 (600 seconds).

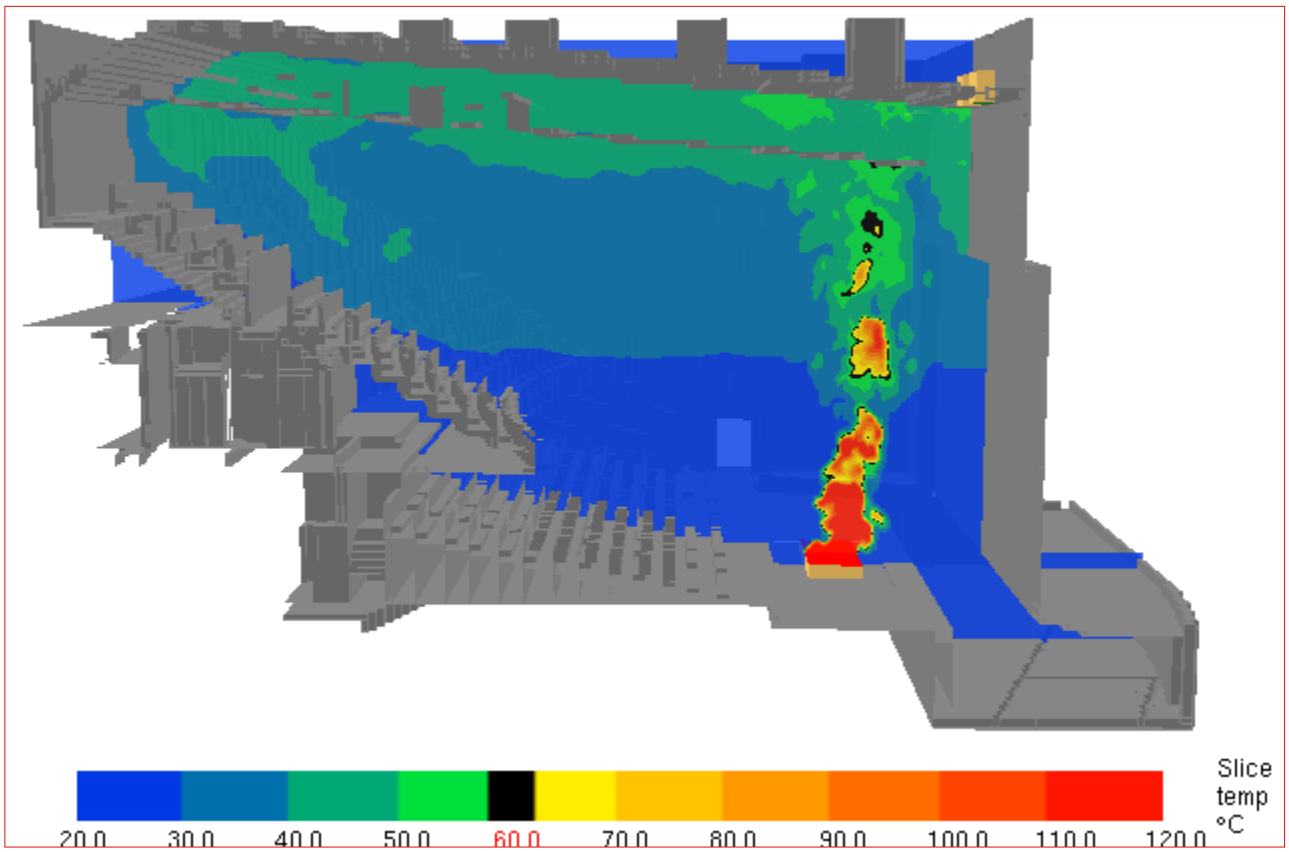


Figure 25: Smoke layer temperature through the theatre after 600 seconds.

CONCLUSION

The primary objectives of this study were to determine the required amount of extract from the theatre and to demonstrate that tenable conditions within the theatre are maintained for the duration of the evacuation.

An ASET/ RSET analysis has been carried out to confirm that occupants of the theatre have sufficient time to escape to a place of relative safety in the event of a fire on the stage areas. The Thrust Stage configuration was determined to be the worst case scenario.

Table 2 ASET vs RSET Comparison

Scenario	ASET (mins)	RSET (mins)	Safety Margin
End Stage Format	10(1)	2.73	>100%
Thrust Stage Format	4.5	2.73	65%

(1) This is the time taken by the smoke to spread underneath the proscenium opening not the time to untenable conditions in the seating area.

Appendix C

CFD MODELLING OF FIREFIGHTING SHAFT VENTILATION

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Appendix D

FIRE-FIGHTING SHAFT DESIGN NOTE

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Appendix E

INDICATIVE FIRE ALARM CAUSE AND EFFECTS FLOW CHART

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5 EVACUATION PHILOSOPHY

The means of escape has been designed based on the following assumptions:

- Any fire in the building is assumed to be unintentional and therefore it is unlikely to start in two different locations at one time;
- The building will be evacuated by staged simultaneous evacuation in the event of a fire, the area affected will evacuate first followed by the rest of the areas.
- Each event mode will be provided with a sufficient number of trained staff/safety stewards.

In order to limit the impact of false alarms, a two-stage evacuation will be in place where there is an investigation period before the fire alarm sounders are activated. Also, the evacuation will be staged to allow for the performance areas (Theatre and Warehouse) to be evacuated separately to the Towers, as discussed in Section 4.2. The exact detailing of the alarm arrangements will depend on the events taking place and will be controlled in line with a Fire Safety Management Plan.

A typical sequence of events for two-staged evacuation is as follows:

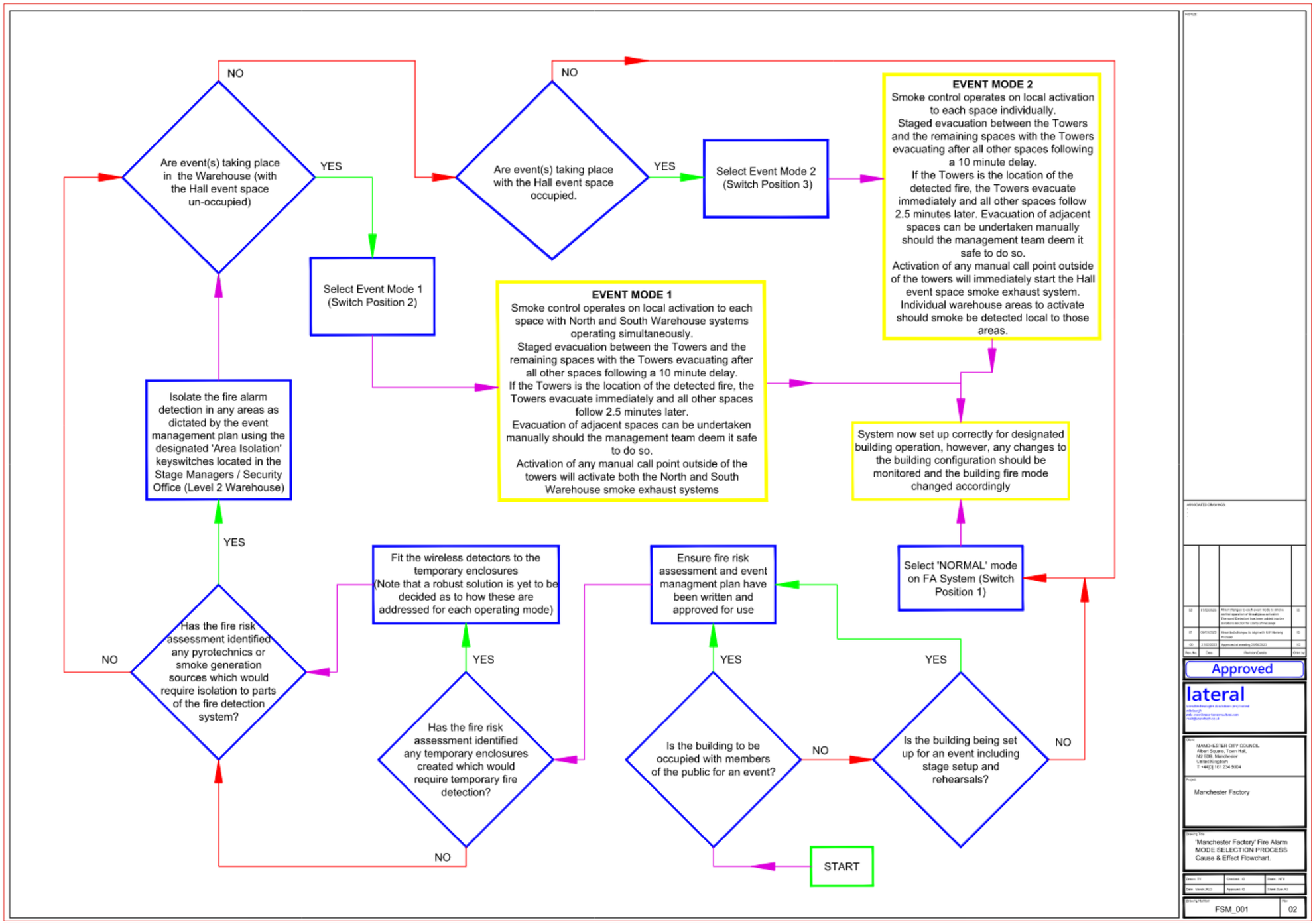
- Initially, a coded staff alert is given.
- There is then an investigation period (Not exceeding 6 minutes) *.
- The evacuation signal is broadcast:

*Note: It is anticipated that in events mode, a fire on stage in the theatre or warehouse will be detected early by the occupant and therefore evacuation of the space will commence immediately. Furthermore, means will be provided to the theatre control room (Big red button) to stop stage shows and manually put the lights etc back on.

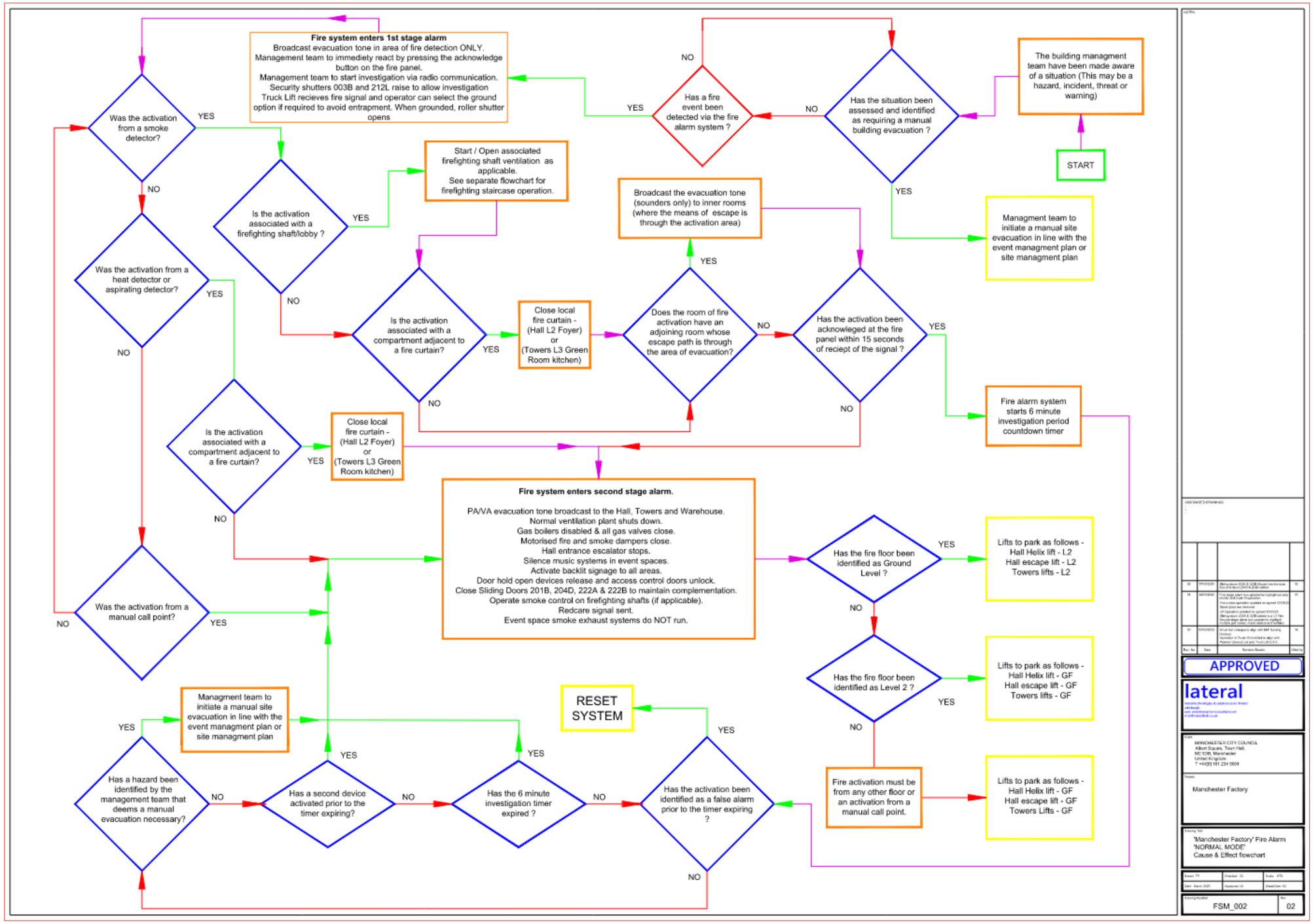
The fire detection and alarm system shall have interfaces and links as necessary to operate equipment/devices within the building, key examples are indicated below. The list is not exhaustive and for further information see BS 5839-1

- Electromagnetic hold-open devices on fire doors – released to closed position;
- Security systems on exit doors - released as required;
- Non evacuation and fire lifts – travel to appropriate floor, open doors and go out of service;
- Evacuation and fire lift - travel to appropriate floor, ready to be operated by appropriate staff
- Heating, ventilation and air conditioning systems – shut down to restrict spread of smoke and hot gases;
- Fire and smoke dampers – activate;
- Smoke control system

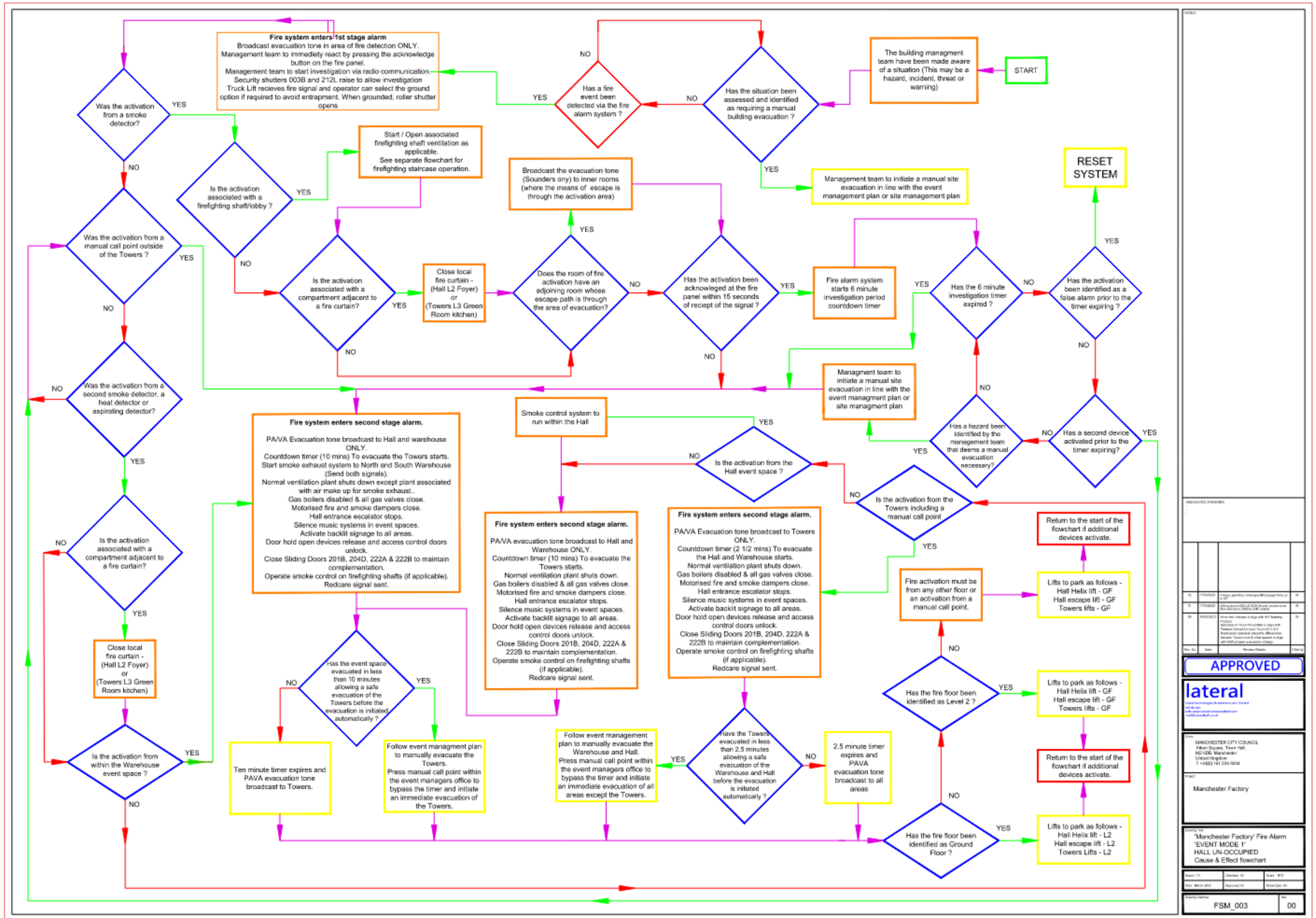
5.1 MODE SELECTION PROCESS



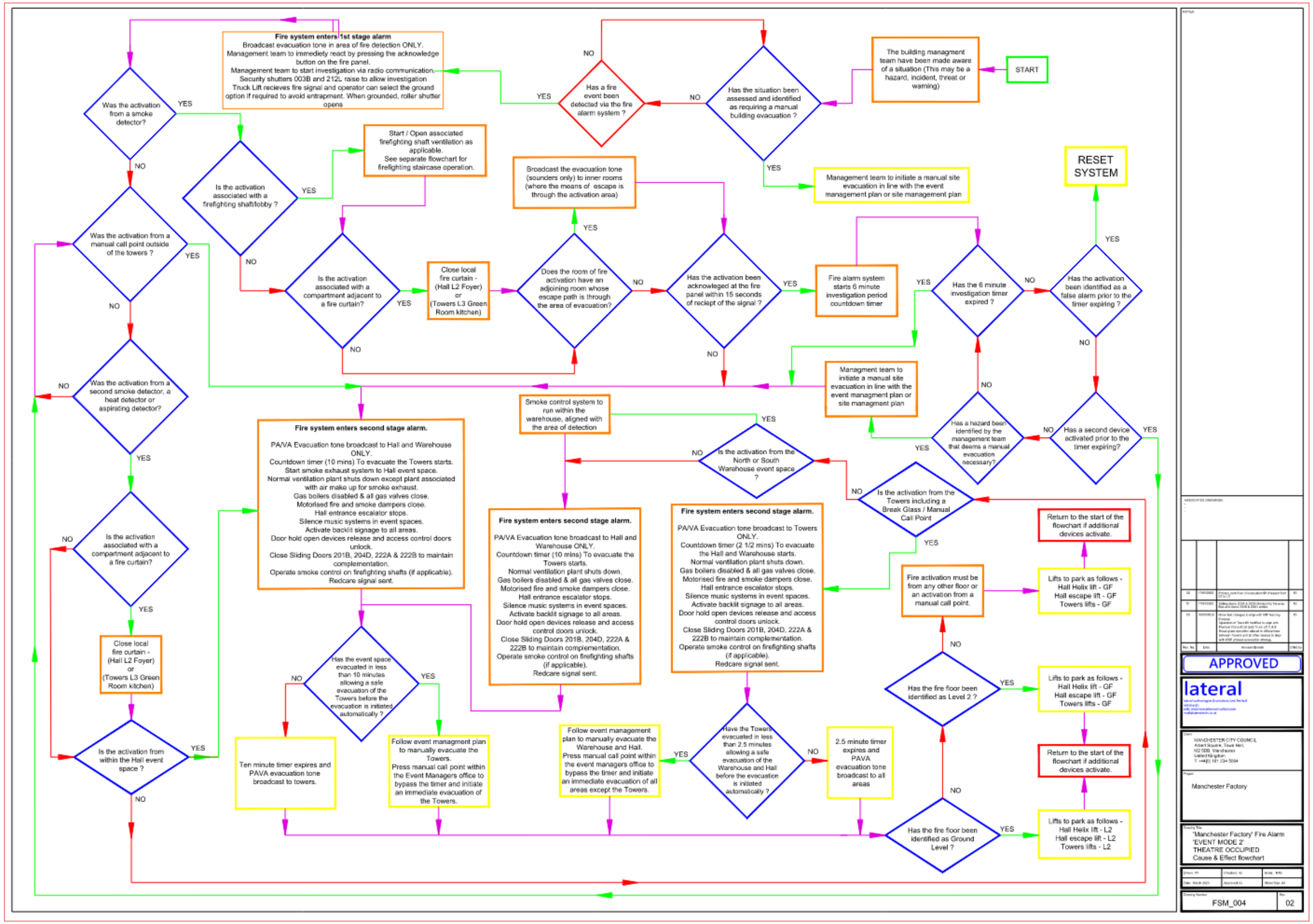
5.2 NORMAL MODE - CAUSE & EFFECT FLOWCHART



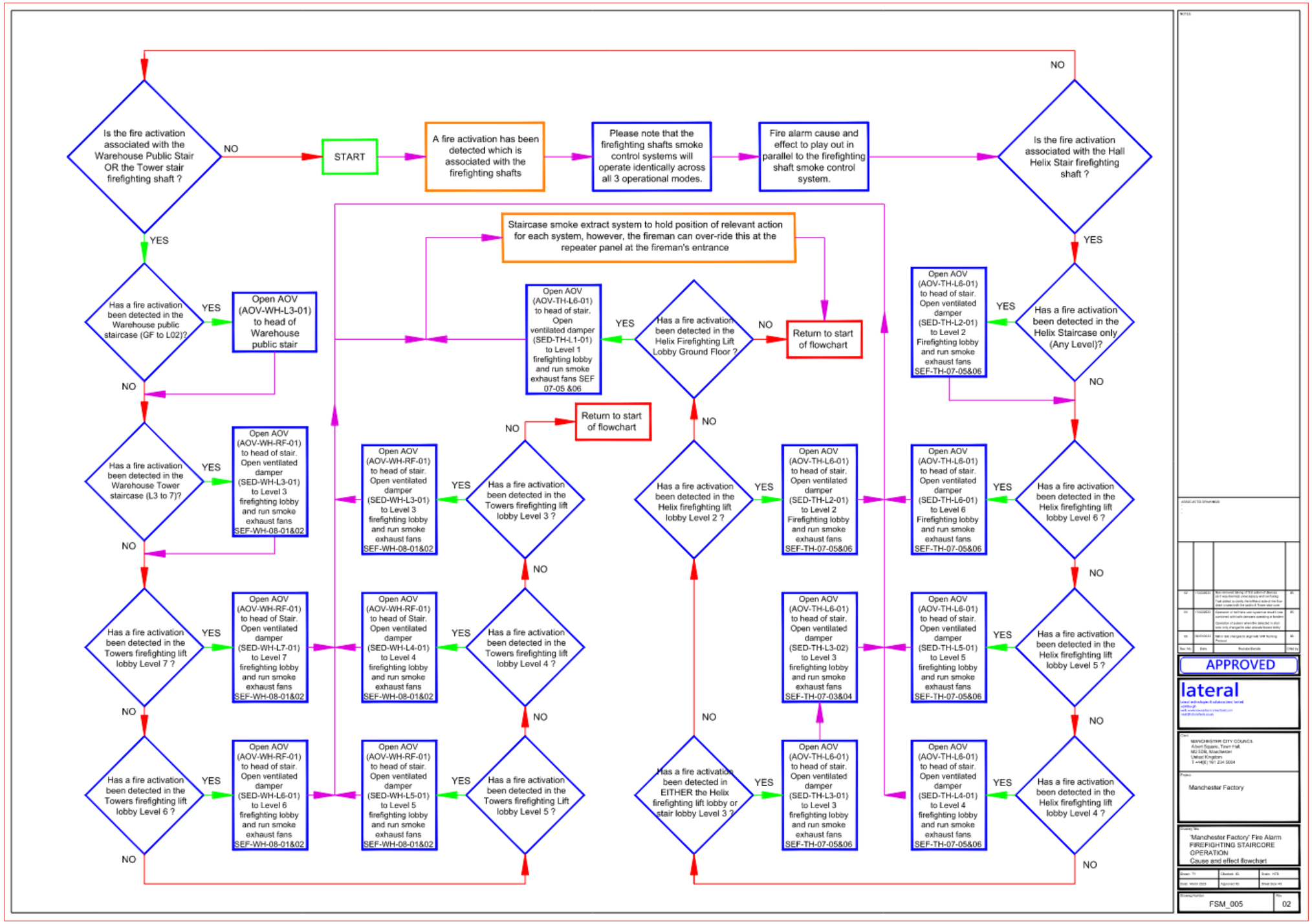
5.3 EVENT MODE 1 – THEARTRE UN-OCCUPIED



5.4 EVENT MODE 2 - THEATRE OCCUPIED



5.5 FIREFIGHTING STAIRCORE - OPERATION



Appendix F

BDP RELEVANT DOCUMENTATION

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No revision/ date is specified in this table and the latest version of the drawings should be referred to on the online project document management system.

Document Reference	Description
MF-BDP-XX-XX-RP-MX-45-0004	BDP Fire Strategy Clarifications
ELECTRICAL LAYOUT DRAWINGS	
MF-BDP-WH-GF-DR-E-70-0001	Warehouse Ground Floor Electricity Distribution and Transmission Systems
MF-BDP-WH-L5-DR-E-70-0051	Warehouse Fifth Floor Electricity Distribution and Transmission Systems
MF-BDP-WH-L6-DR-E-70-0061	Warehouse Sixth Floor Electricity Distribution and Transmission Systems
MF-BDP-WH-L7-DR-E-70-0071	Warehouse Seventh Floor Electricity Distribution and Transmission Systems
MF-BDP-WH-RF-DR-E-70-0081	Warehouse Roof Level Electricity Distribution and Transmission Systems
MF-BDP-TH-L6-DR-E-70-0061	Theatre Sixth Floor Electricity Distribution and Transmission Systems
ELECTRICAL SCHEMATICS	
MF-BDP-XX-XX-DR-E-70-0101	Theatre & Warehouse Schematic Low-voltage Distribution Systems
ELECTRICAL SCHEDULES	
MF-BDP-XX-XX-SH-E-70-058	Cable Schedule MLVA
MF-BDP-XX-XX-SH-E-70-059	Cable Schedule Generator
MF-BDP-XX-XX-SH-E-70-060	Cable Schedule MLVB
MF-BDP-XX-XX-SH-E-70-001-40 and 47-57	LV Switchboard, Section Board and Distribution Board Schedules
MF-BDP-XX-XX-SH-YX-70-8003	Lighting criteria table
MF-BDP-XX-XX-SH-YX-70-8006	Emergency lighting & management lighting criteria
ELECTRICAL SPECIFICATION	

Document Reference	Description
MF-BDP-XX-XX-SP-E-70-0001	Electrical Services Specification
MECHANICAL LAYOUT DRAWINGS	
MF-BDP-TH-GF-DR-M-65-0001	Theatre Ground Floor Ventilation and Air Conditioning Systems
MF-BDP-TH-L1-DR-M-65-0011	Theatre First Floor Ventilation and Air Conditioning Systems
MF-BDP-TH-L2-DR-M-65-0021	Theatre Second Floor Ventilation and Air Conditioning Systems
MF-BDP-TH-L3-DR-M-65-0031	Theatre Third Floor Ventilation and Air Conditioning Systems
MF-BDP-TH-L4-DR-M-65-0041	Theatre Fourth Floor Ventilation and Air Conditioning Systems
MF-BDP-TH-L5-DR-M-65-0051	Theatre Fifth Floor Ventilation and Air Conditioning Systems
MF-BDP-TH-L6-DR-M-65-0061	Theatre Sixth Floor Ventilation and Air Conditioning Systems
MF-BDP-WH-GF-DR-M-65-0001	Warehouse Ground Floor Ventilation and Air Conditioning Systems
MF-BDP-WH-L2-DR-M-65-0021	Warehouse Second Floor Ventilation and Air Conditioning Systems
MF-BDP-WH-L3-DR-M-65-0031	Warehouse Third Floor Ventilation and Air Conditioning Systems
MF-BDP-WH-L4-DR-M-65-0041	Warehouse Fourth Floor Ventilation and Air Conditioning Systems
MF-BDP-WH-L5-DR-M-65-0051	Warehouse Fifth Floor Ventilation and Air Conditioning Systems
MF-BDP-WH-L6-DR-M-65-0061	Warehouse Sixth Floor Ventilation and Air Conditioning Systems
MF-BDP-WH-L7-DR-M-65-0071	Warehouse Seventh Floor Ventilation and Air Conditioning Systems
MF-BDP-WH-RF-DR-M-65-0081	Warehouse Roof Level Ventilation and Air Conditioning Systems
MECHANICAL SCHEMATICS	

Document Reference	Description
MF-BDP-TH-XX-DR-M-65-0101	Theatre Schematic Venitlation and Air Conditioning Systems Sheet 1 of 2
MF-BDP-TH-XX-DR-M-65-0102	Theatre Schematic Venitlation and Air Conditioning Systems Sheet 2 of 2
MF-BDP-WH-XX-DR-M-65-0101	Warehouse Schematic Venitlation and Air Conditioning Systems
MF-BDP-WH-XX-DR-M-65-0102	Warehouse Schematic Ventilation and Air Conditioning Systems
MF-BDP-WH-XX-DR-M-65-0103	Warehouse Schematic Ventilation and Air Conditioning Systems
MF-BDP-ZZ-XX-DR-M-65-0101	Theatre & Warehouse Smoke Extract Schematic sheet 1 of 2
MF-BDP-ZZ-XX-DR-M-65-0102	Theatre & Warehouse Smoke Extract Schematic sheet 2 of 2
MECHANICAL SCHEDULES	
MF-BDP-ZZ-ZZ-SH-M-68-0028	Attenuator Schedule
MF-BDP-ZZ-ZZ-SH-M-68-0030	Grilles and Diffuser Schedule
MF-BDP-ZZ-ZZ-SH-M-68-0033	Smoke Extract Fan Schedule
MF-BDP-ZZ-ZZ-SH-M-68-0034	Fire-Smoke Damper Schedule
MF-BDP-ZZ-ZZ-SH-M-68-0035	Automatic Opening Vents Schedule
MF-BDP-ZZ-ZZ-SH-M-68-0037	Smoke vent control panel Schedule
MF-BDP-ZZ-ZZ-SH-M-68-0041	Fire-Smoke Damper Control matrix
MECHANICAL SPECIFICATION	
MF-BDP-XX-XX-SP-M-68-0001	Mechanical Services Specification

Appendix G

EVACUATION MODELLING SUMMARY

16 EGRESS MODELLING BRIEF

The evacuation modelling was carried out to validate the egress calculation for The Factory event modes.

The egress modelling has been undertaken using Pathfinder developed by Thunderhead Engineering. Version 2021, Revision 2021.2.0525 has been used for this analysis.

Pathfinder is a partial behaviour model that takes into account the dynamic environment an occupant is in and models some of the behaviours that the occupant may have when interacting within the environment. The model uses triangular mesh representation to navigate the space where the agents (occupants) are in to find an exit. It also provides visualisations of evacuation movements in real time along with other features. It incorporates counter-flows, delay times, fire input and has an individual perspective of occupant. The occupants have a local view of the model and will choose the shortest route to the exit of the space currently located in, unless specified otherwise.

There are two 'modes' available, SFPE Mode and Steering Mode. SFPE Mode implements the concepts in the SFPE Handbook of Fire Protection Engineering. This is a flow model, where walking speeds are determined by occupant density within each room and flow through doors is controlled by door width. It allows occupants to occupy the same space and physical obstruction avoidance is limited.

The Steering Mode is based on the idea of inverse steering behaviours. This mode allows more complex behaviours to naturally emerge as a by-product of the movement algorithms – eliminating the need for explicit door queues and density calculations.

In summary, the walking speed in Pathfinder depends on the density, maximum speed of the occupants and the evacuation speed constant. The walking speed distributions available are constant, uniform, standard normal and constant.

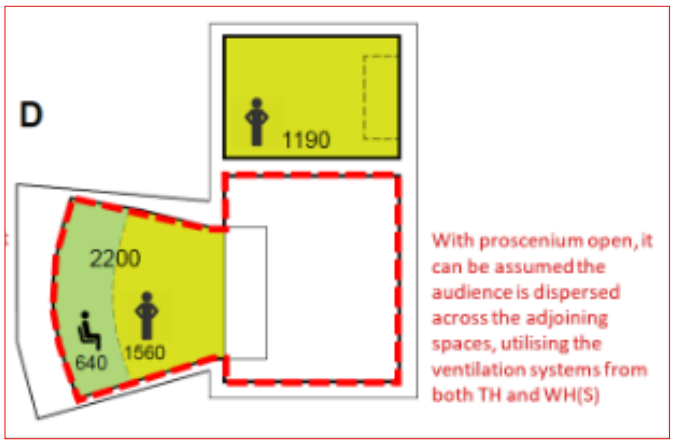
The walking speed used in this assessment is constant and set to a conservative 1.2 m/s speed while Steering Mode has been used to achieve a more natural evacuation.

16.1 RESULT SUMMARY

The following is a summary of the evacuation modelling result with screenshot.

16.1.1 EVENT MODE D

Figure 16-1: Event Mode D



The figure below is an illustration showing the anticipated location of a fire, it should be noted that only a single fire is expected for both events, for example, a fire may occur in the theatre stage area or in the north-warehouse. But not in two locations at the same time.

Figure 16-2: Event Mode D - Direction of Escape.

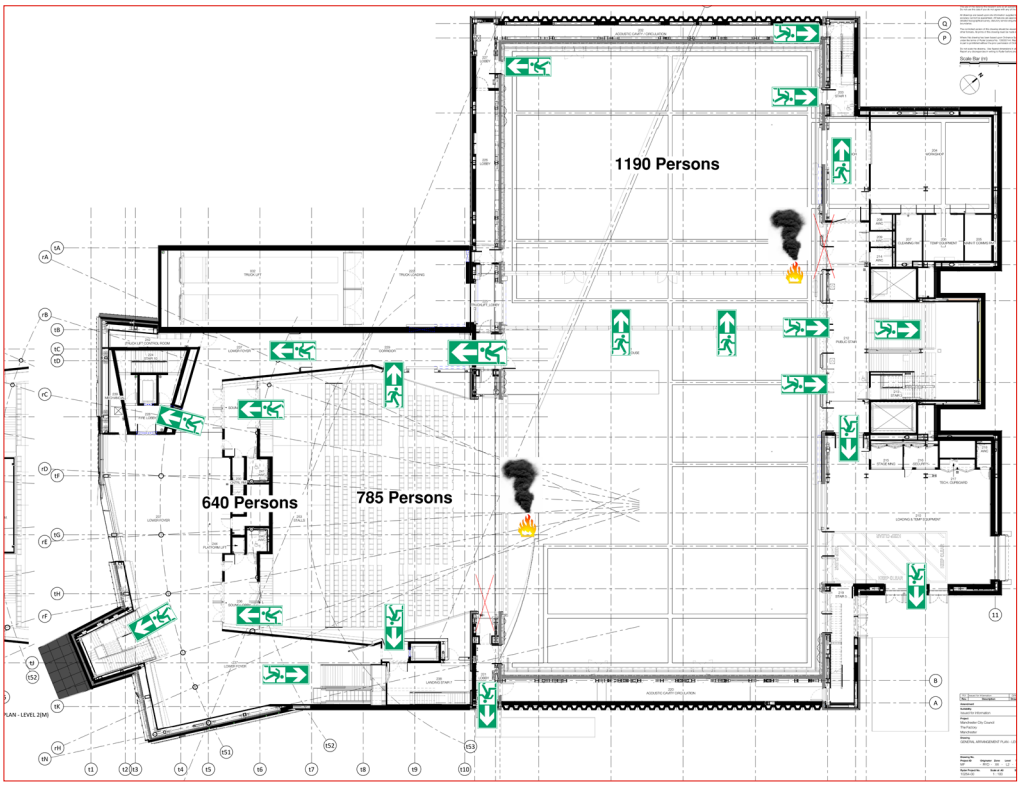


Figure 16-3: Event Mode D - T = 0 sec

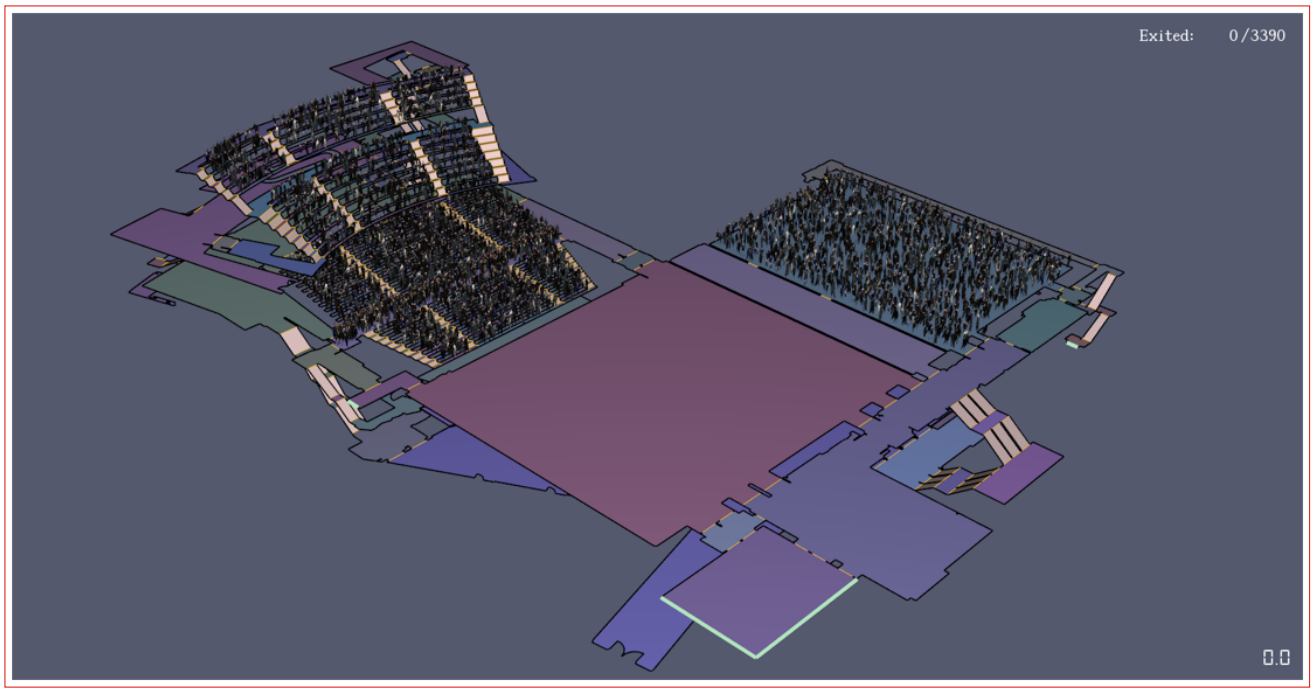


Figure 16-4: Event Mode D - T = 100 sec

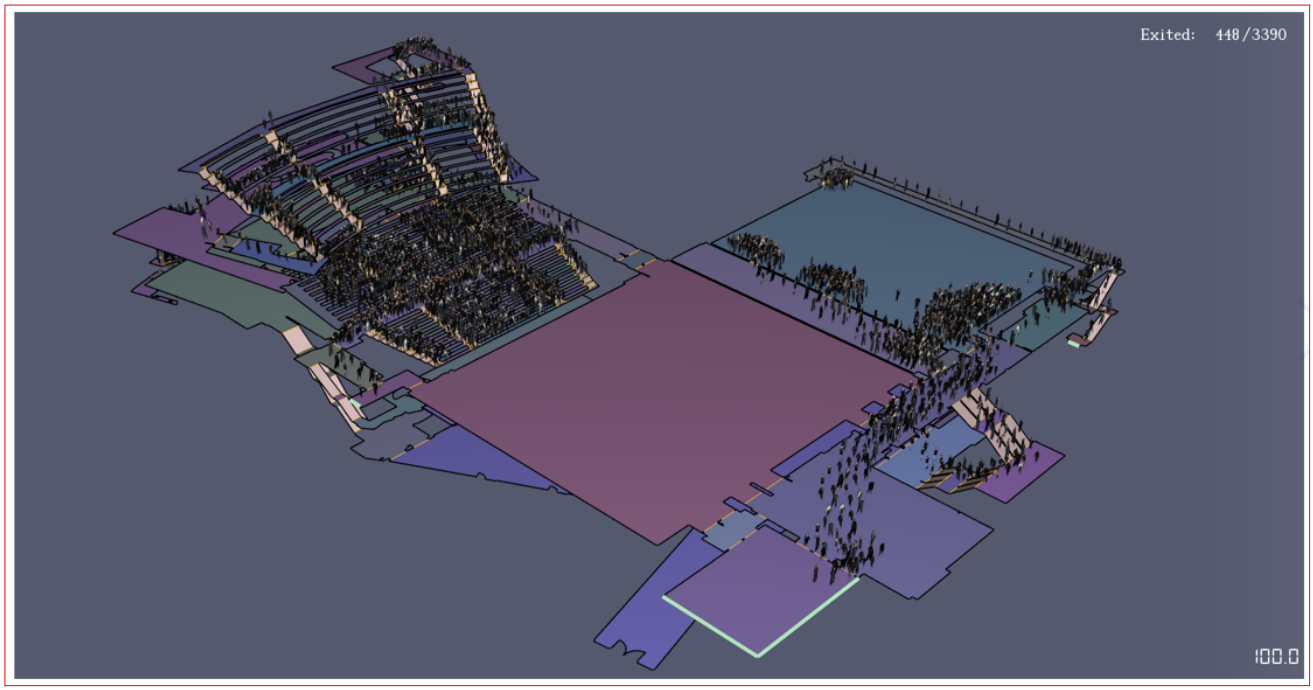


Figure 16-5: Event Mode D - T = 139 sec

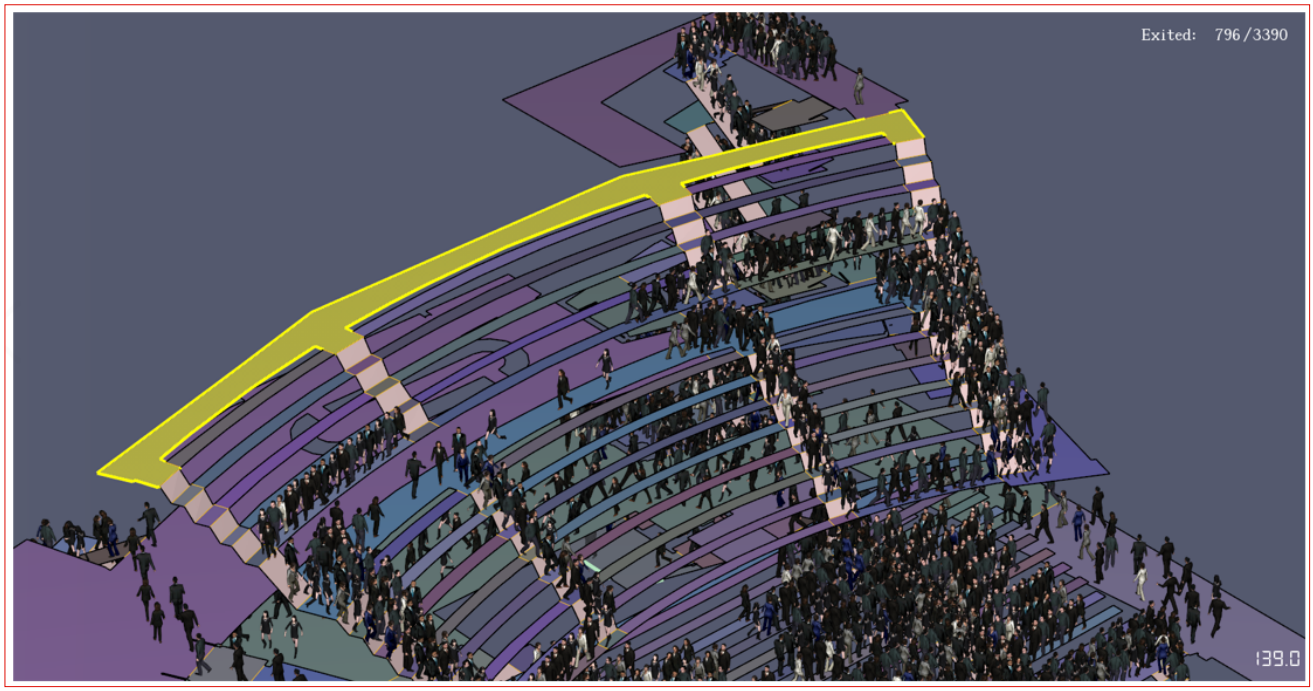


Figure 16-6: Event Mode D - T = 238 sec

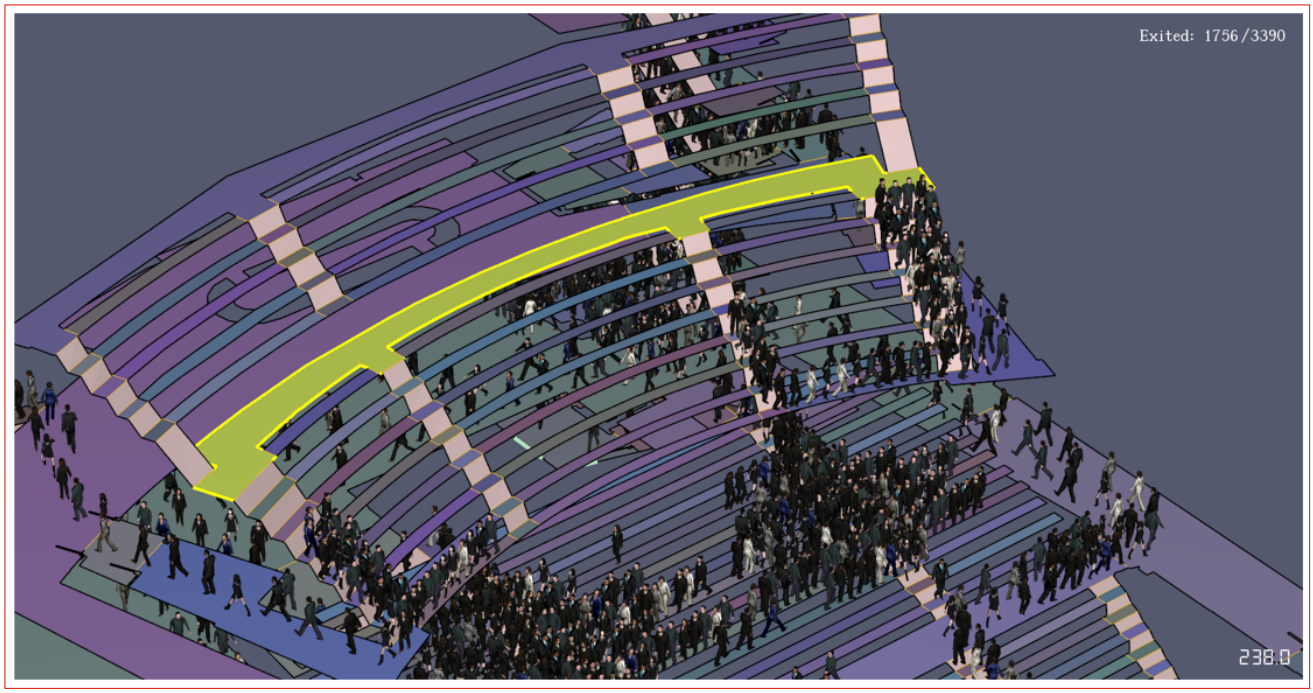


Figure 16-7: Event Mode D - T = 313 sec

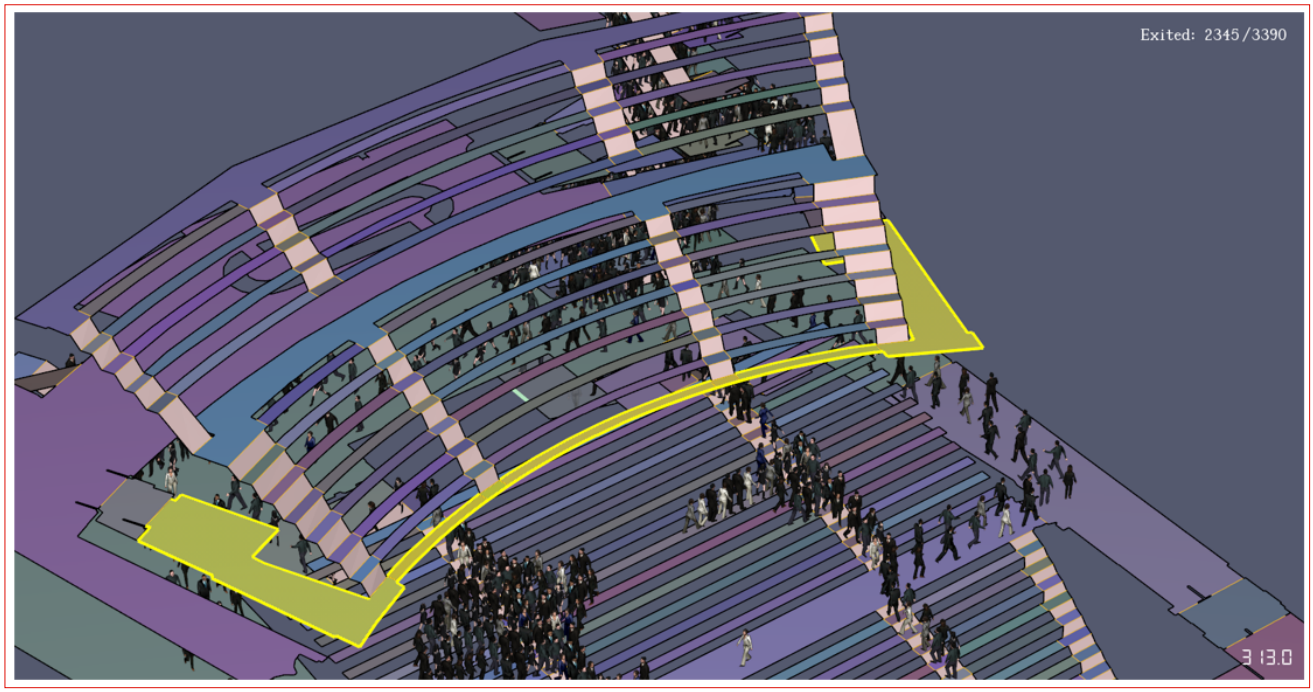


Figure 16-8: Event Mode D - T = 437 sec

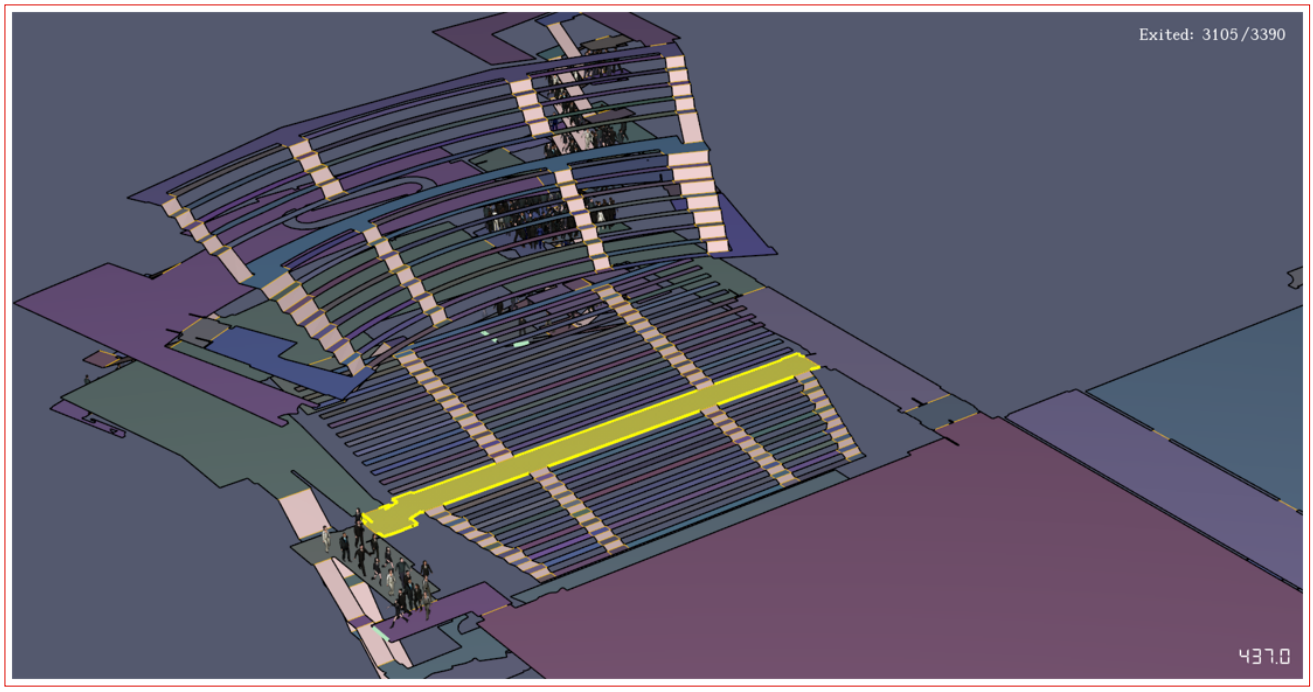


Figure 16-9: Event Mode D - T = 303 sec

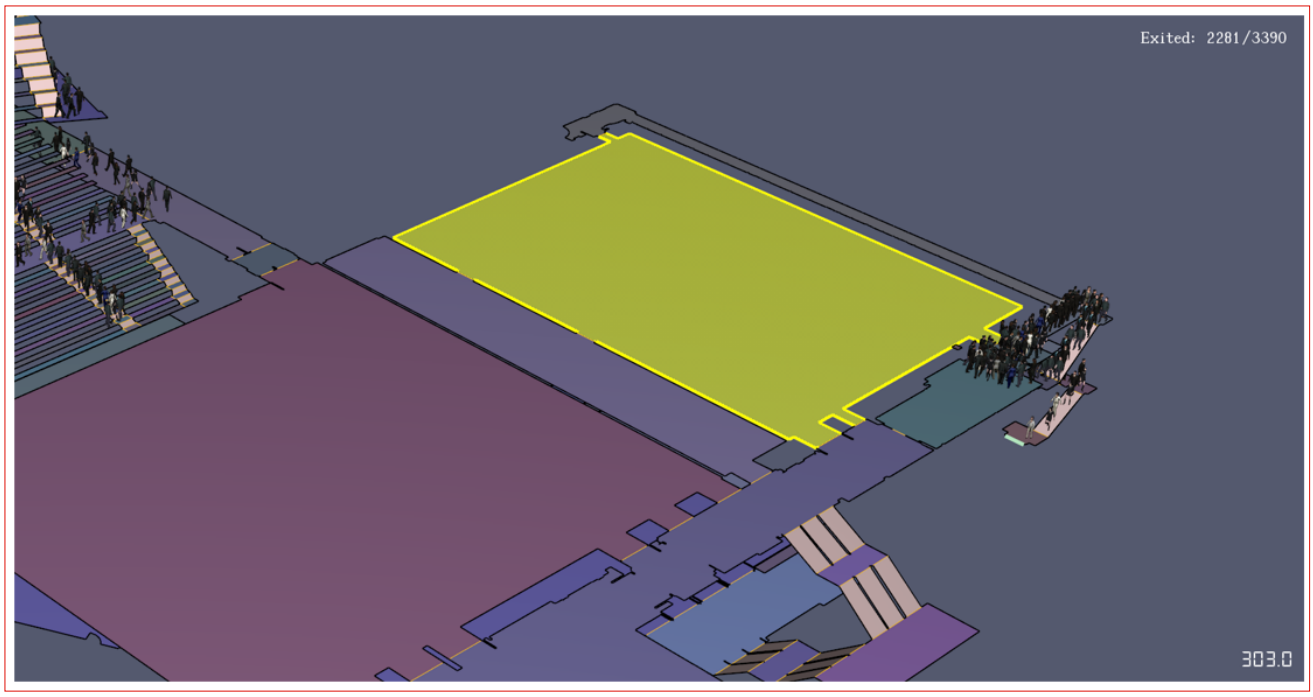


Figure 16-10: Event Mode D - T = 634 sec

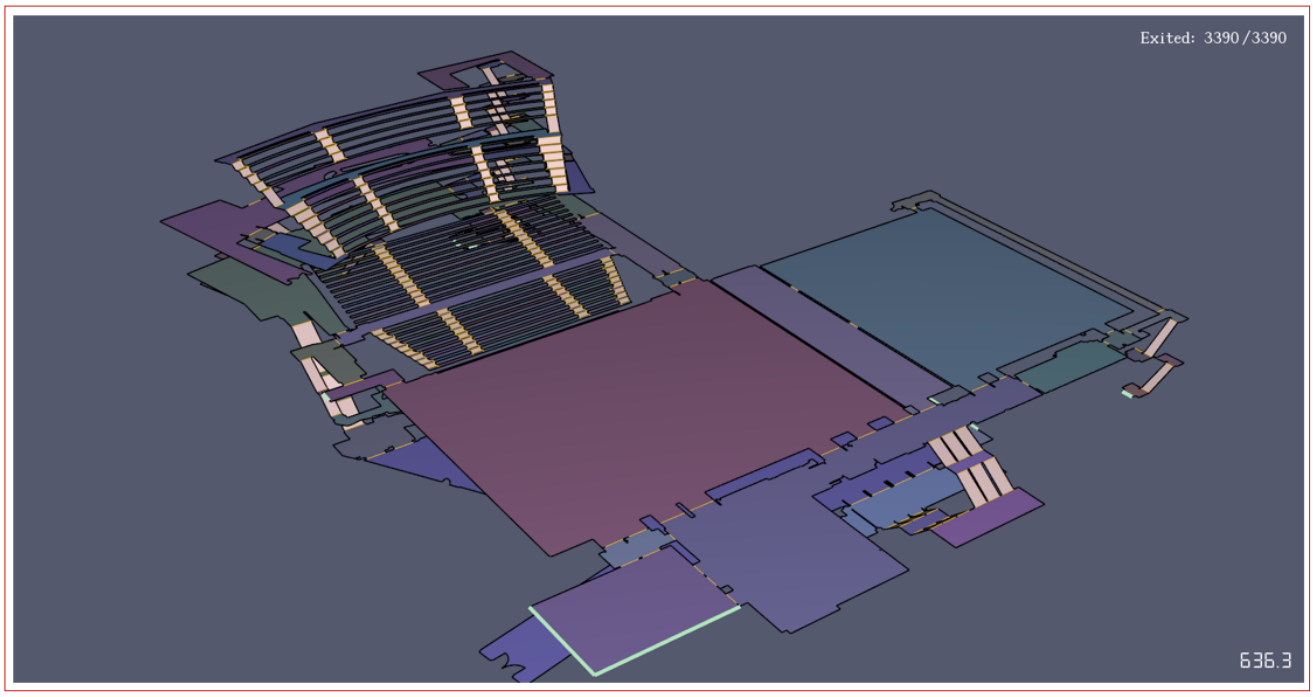


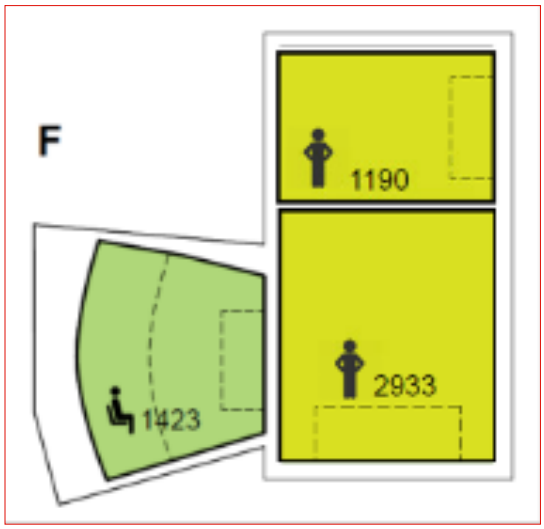
Table 16-1 – Event Mode D – Evacuation Modelling Result

Areas	ASET (sec)	ASET (mins)	RSET (sec)	RSET (mins)
Warehouse North	1200 seconds	20 minutes	363 seconds	**6.05 minutes**
Theatre top row of seating	240 seconds	4 minutes	199 seconds	**3.3 minutes**
Theatre top tier clearance	290 seconds	4.8 minutes	2187 seconds	**4.7 minutes**
Theatre main exit level for the upper-tier	8390 seconds	6.5 minutes	373 seconds	**6.2 minutes**
Theatre lower-level full evacuation	600	10 minutes	497 seconds	**8.3 minutes**
The whole building	N/A	N/A	697 Seconds	**11.6 minutes**

Based on the above table, Event mode D tenable condition can be maintained. An additional 60 seconds premovement time (detection and start of evacuation) has been added to the result timing and the RSET is still less than ASET. Henceforth the event mode is considered acceptable.

16.1.2 SCENARIO F

Figure 16-11: Event Mode F



An evacuation modelling has been carried out for event mode F which is more onerous than mode E and H, the evacuation time are as follows;

Figure 16-12: Event Mode F - Direction of Escape.

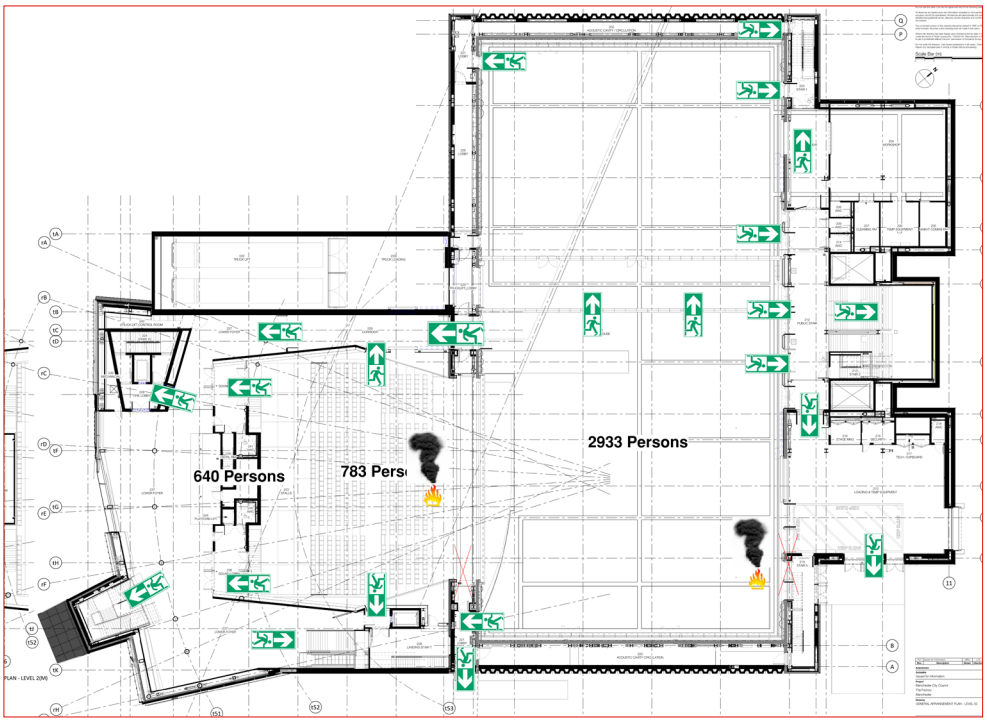


Figure 16-13: Event Mode F - T = 0 sec

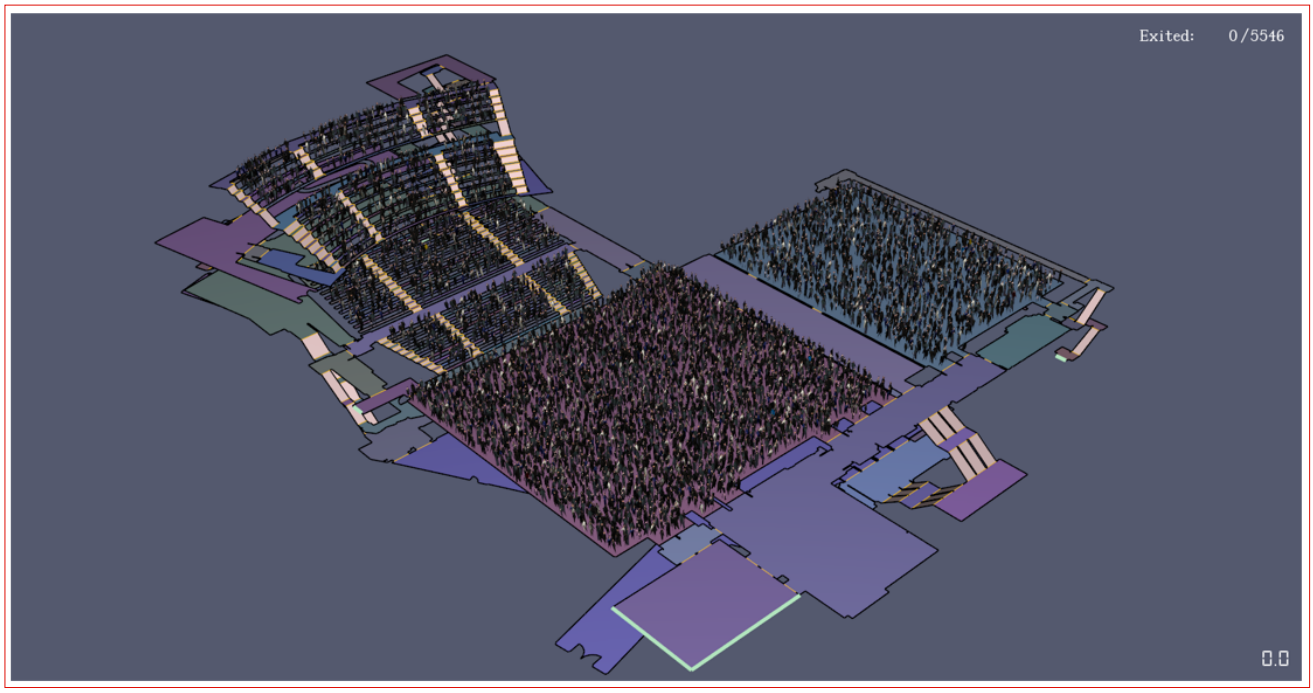


Figure 16-14: Event Mode F - T = 100 sec

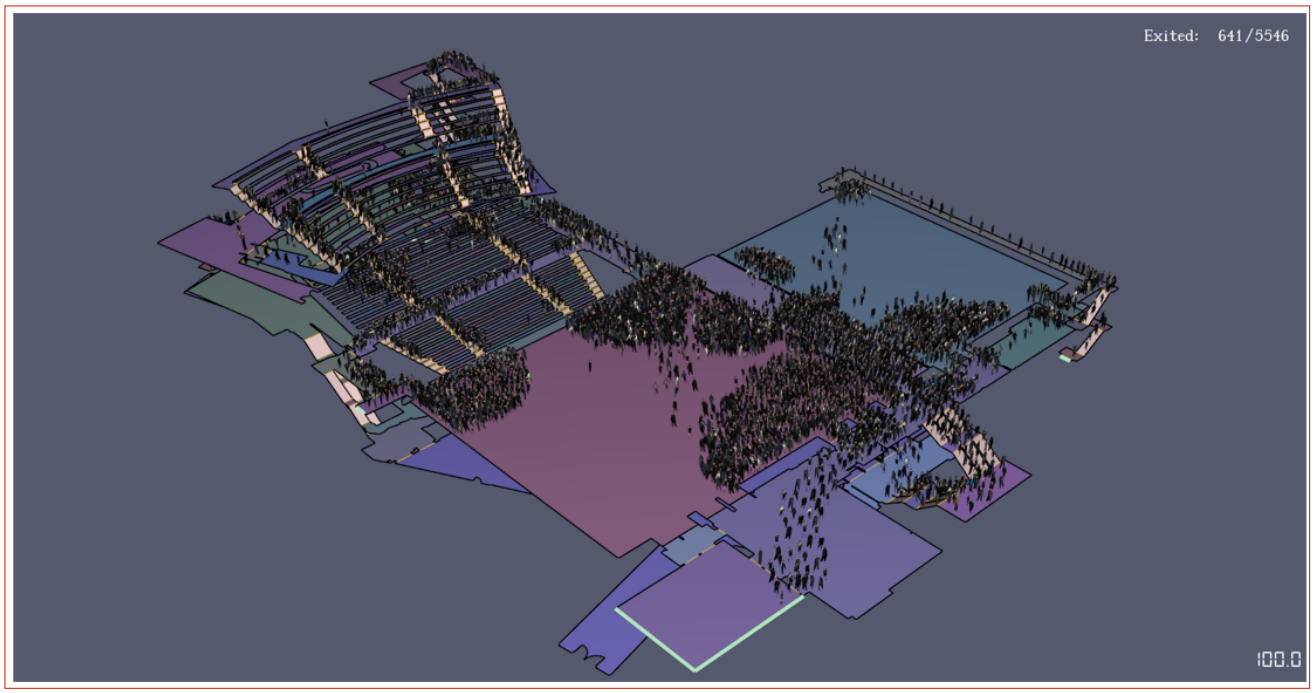


Figure 16-15: Event Mode F - T = 143 sec

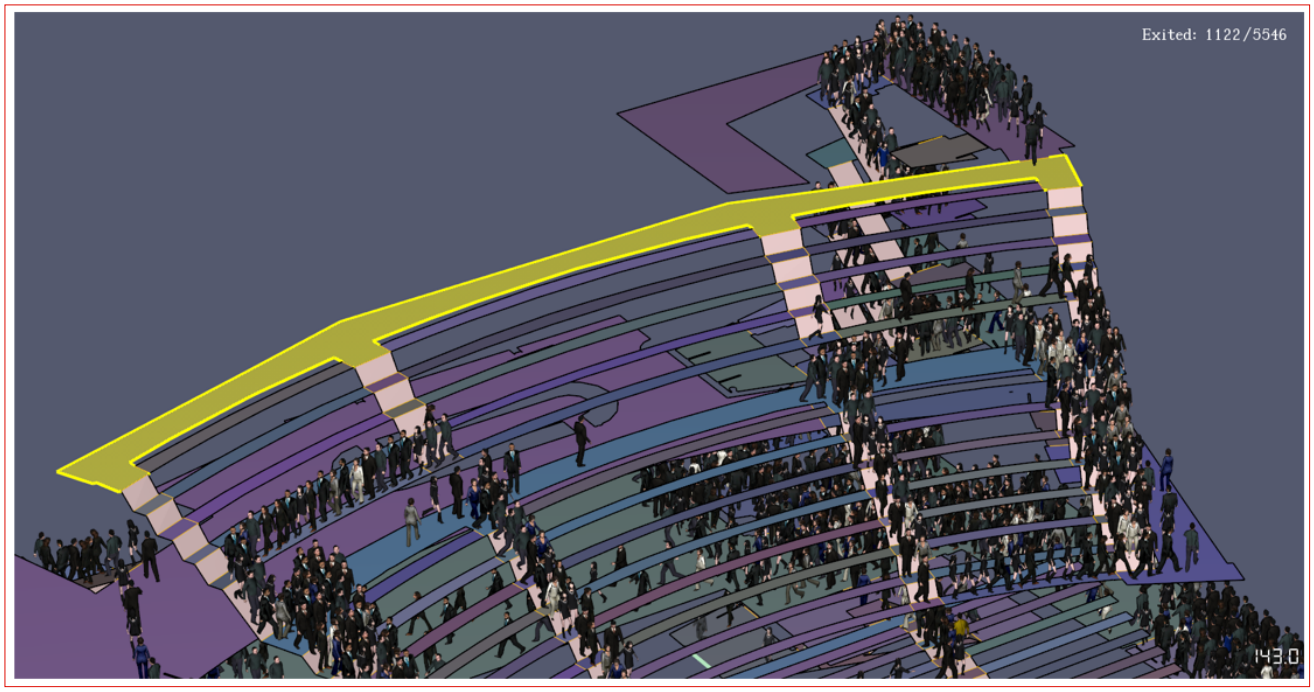


Figure 16-16: Event Mode F - T = 219 sec

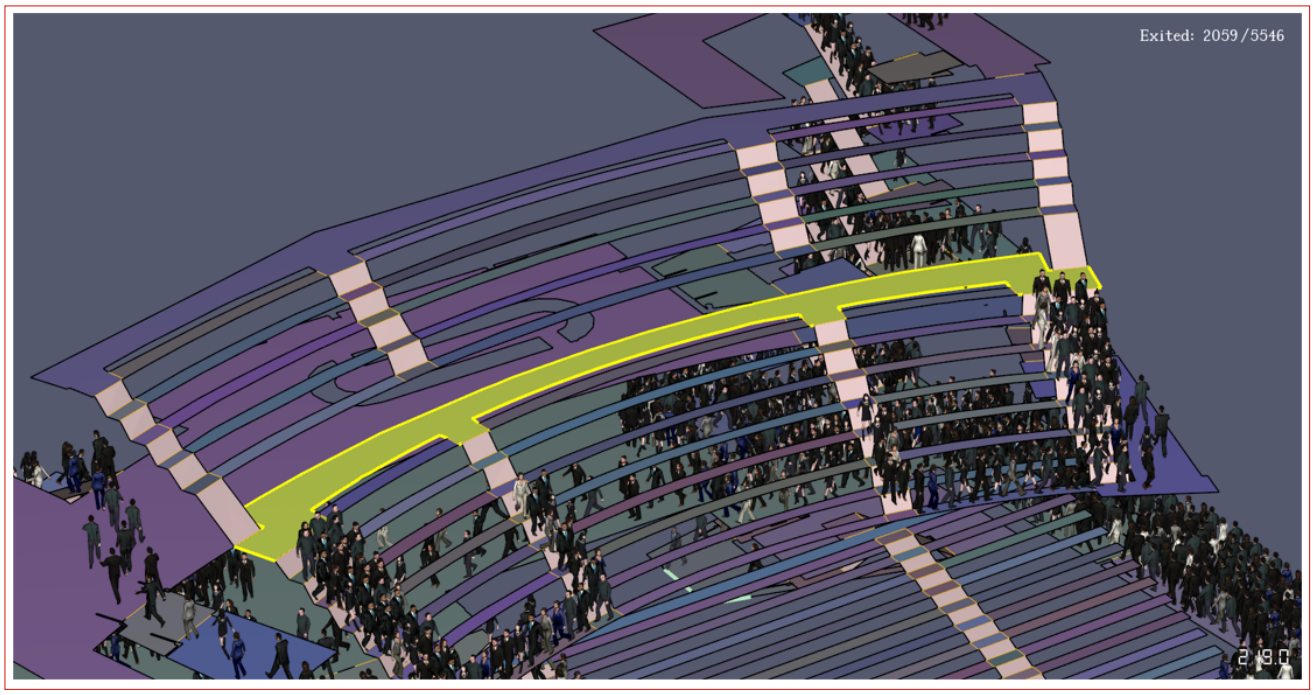


Figure 16-17: Event Mode F - T = 296 sec

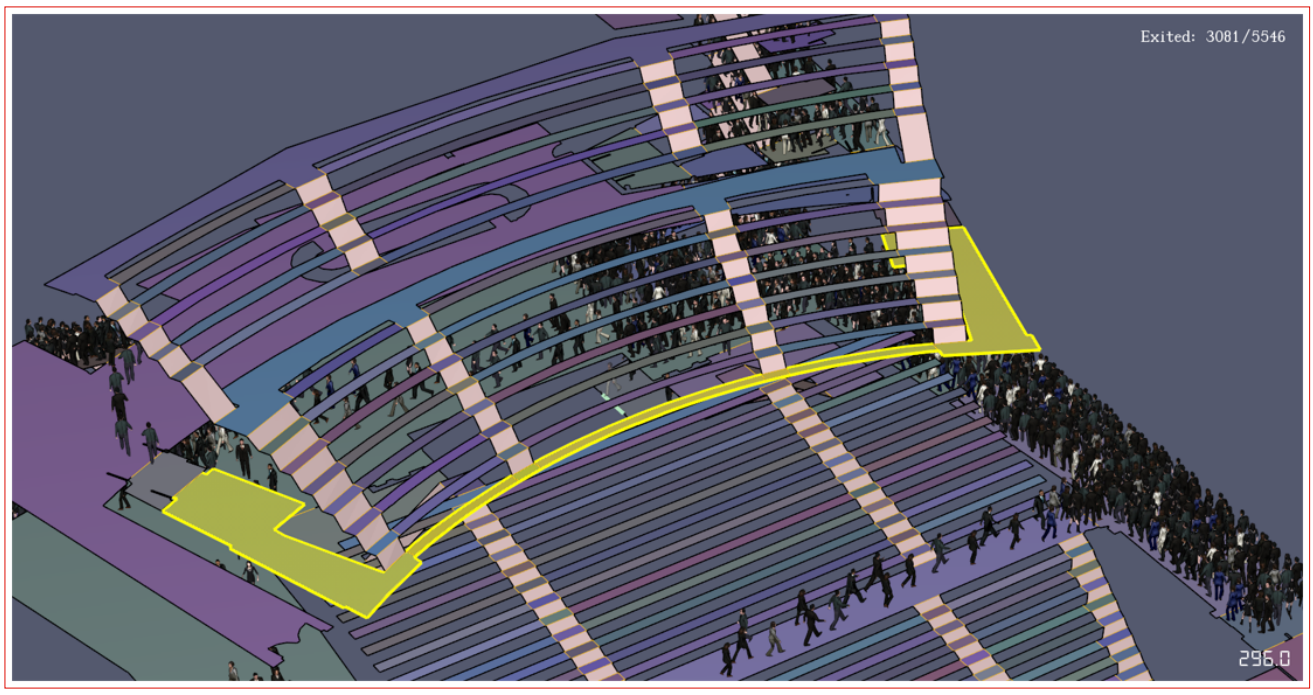


Figure 16-18: Event Mode F - T = 365 sec

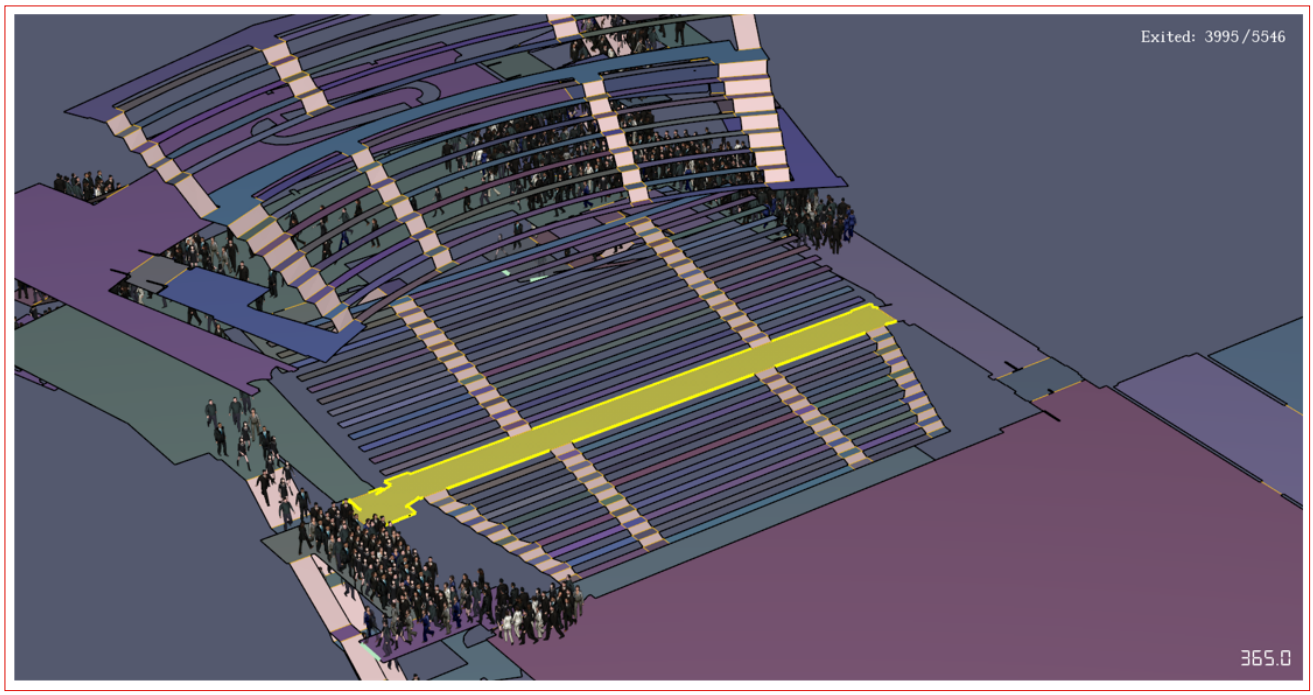


Figure 16-19: Event Mode F - T = 468 sec

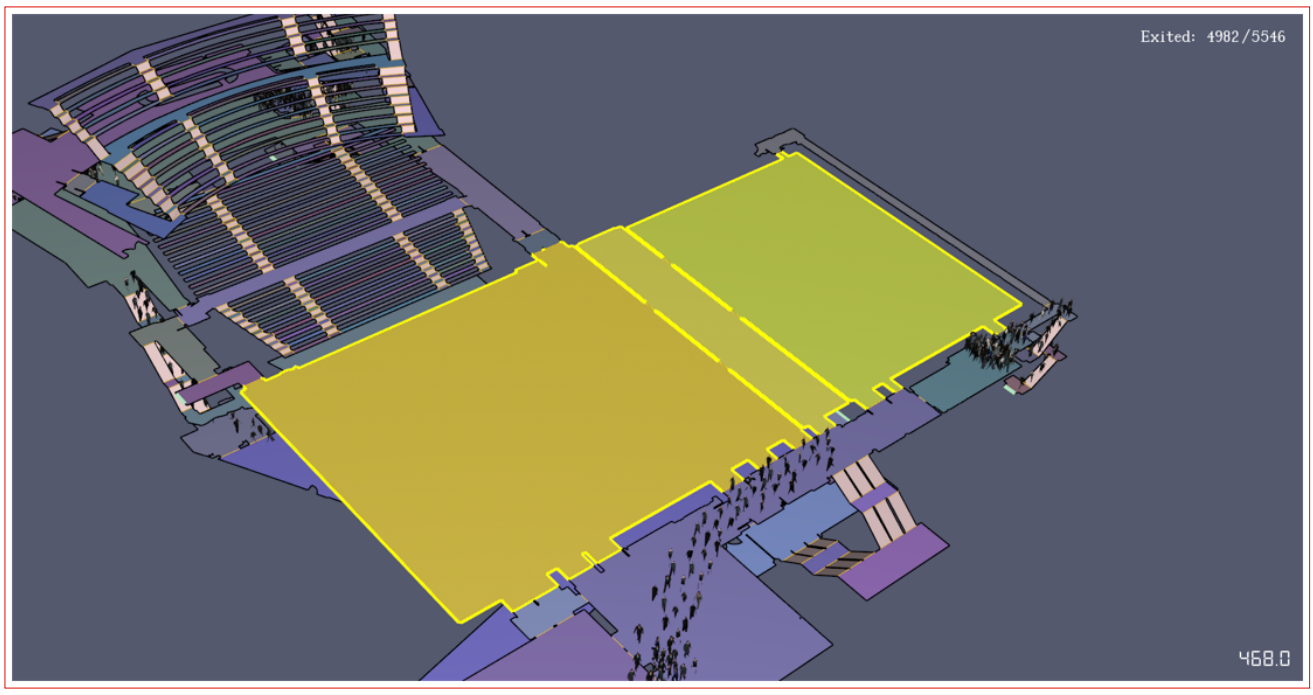


Figure 16-20: Event Mode F - T = 671 sec

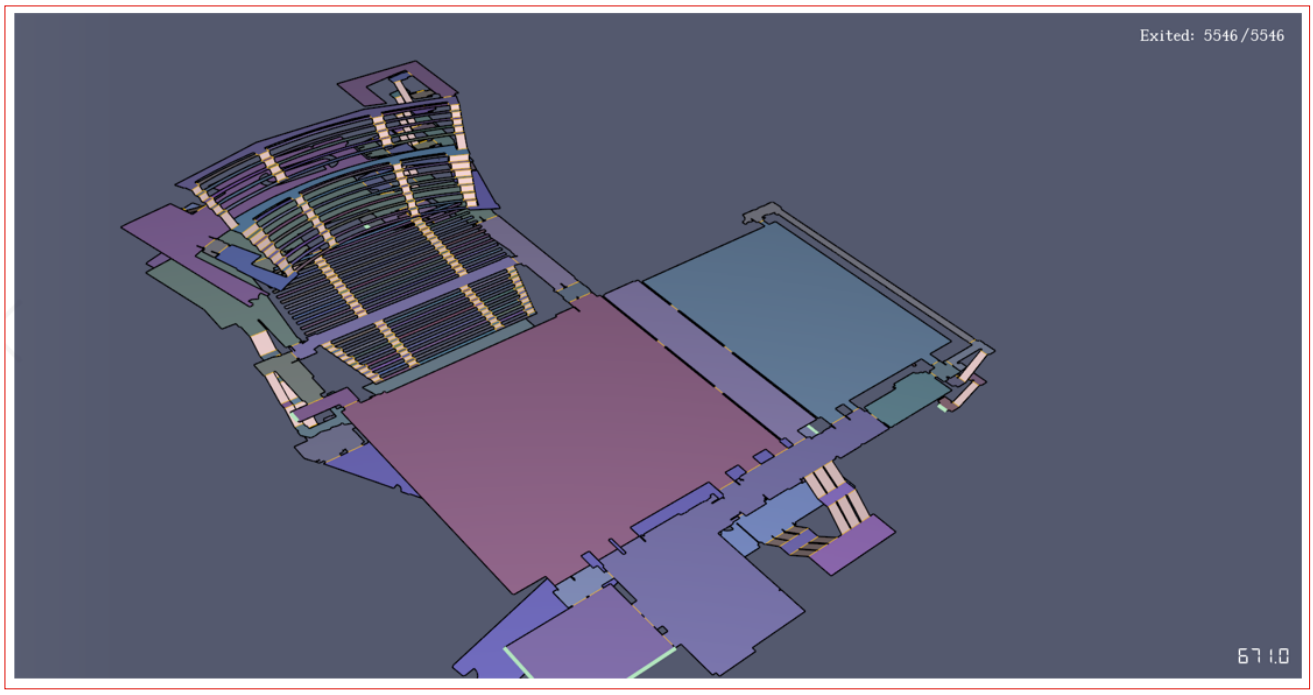


Table 16-2 – Event Mode F – Evacuation Modelling Result

Areas	ASET (sec)	ASET (mins)	RSET (sec)	RSET (mins)
Warehouse Area	1200 seconds	20 minutes	528 seconds	**8.8 minutes**
Theatre top row of seating	240 seconds	4 minutes	203 seconds	**3.3 minutes**
Theatre top tier clearance	290 seconds	4.5 minutes	279 seconds	**4.6 minutes**
Theatre main exit level for the upper-tier	390 seconds	6.5 minutes	356 seconds	**5.9 minutes**
Theatre lower-level full evacuation	600 seconds	10 minutes	425 seconds	**7 minutes**
The whole building	N/A	N/A	731 Seconds	**12.1 minutes**

Based on the above table, Event mode F tenable conditions can be maintained. An additional 60 seconds premovement time (detection and start of evacuation) has been added to the result timing and the RSET is still less than ASET. Henceforth the event mode is considered acceptable.

16.1.3 SCENARIO G

Figure 16-21: Event Mode G



The figure below shows the direction of escape available to the occupants, the combined 7.8m wide exit have been discounted due to a fire in the vicinity of the exits within the warehouse space. The set of doors represent the largest combine exit from the warehouse.

Figure 16-22: Event Mode G - Direction of Escape.

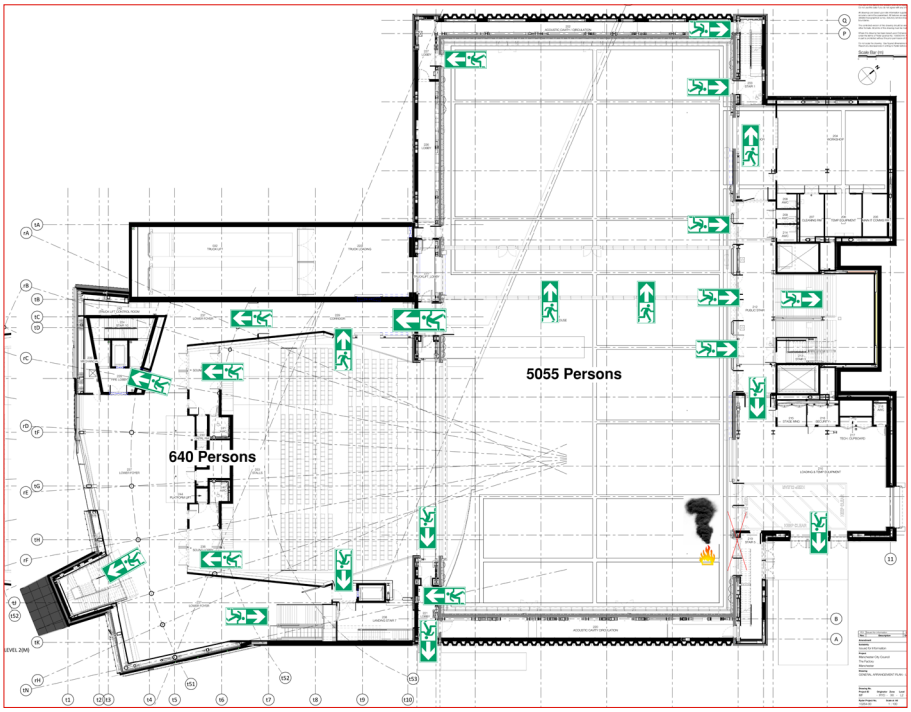


Figure 16-23: Event Mode G - T = 0 sec

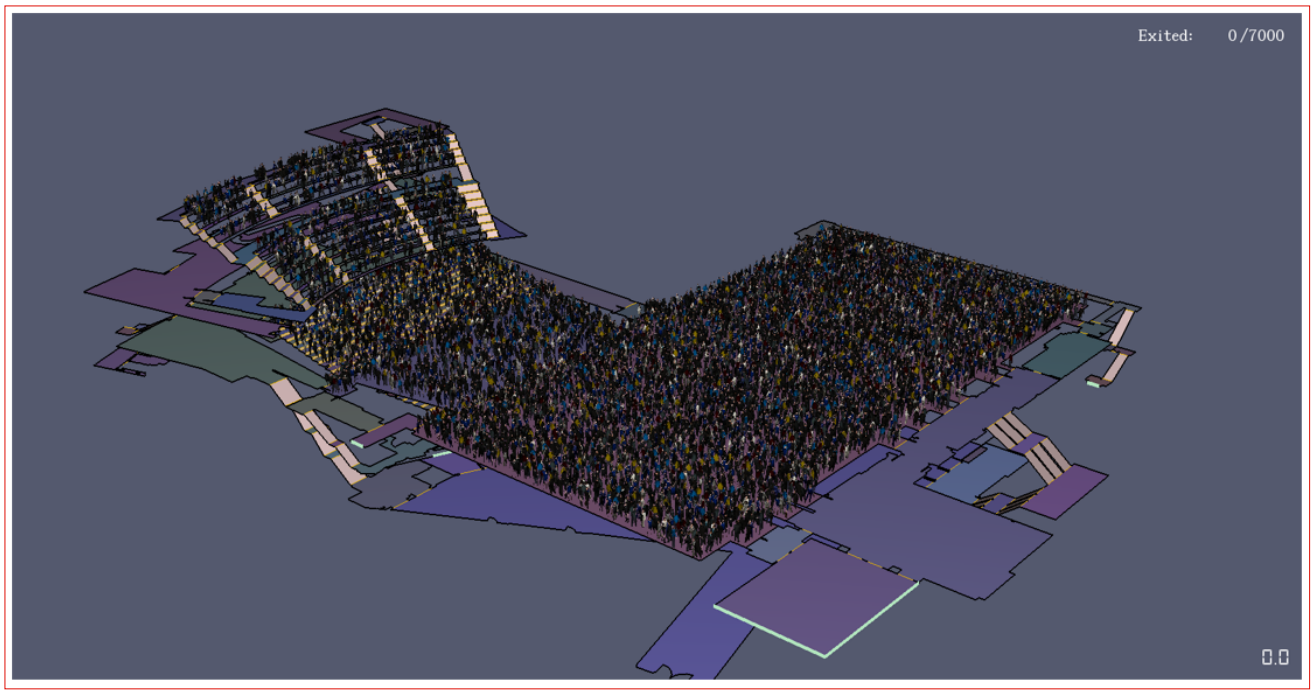


Figure 16-24: Event Mode G - T = 100 sec

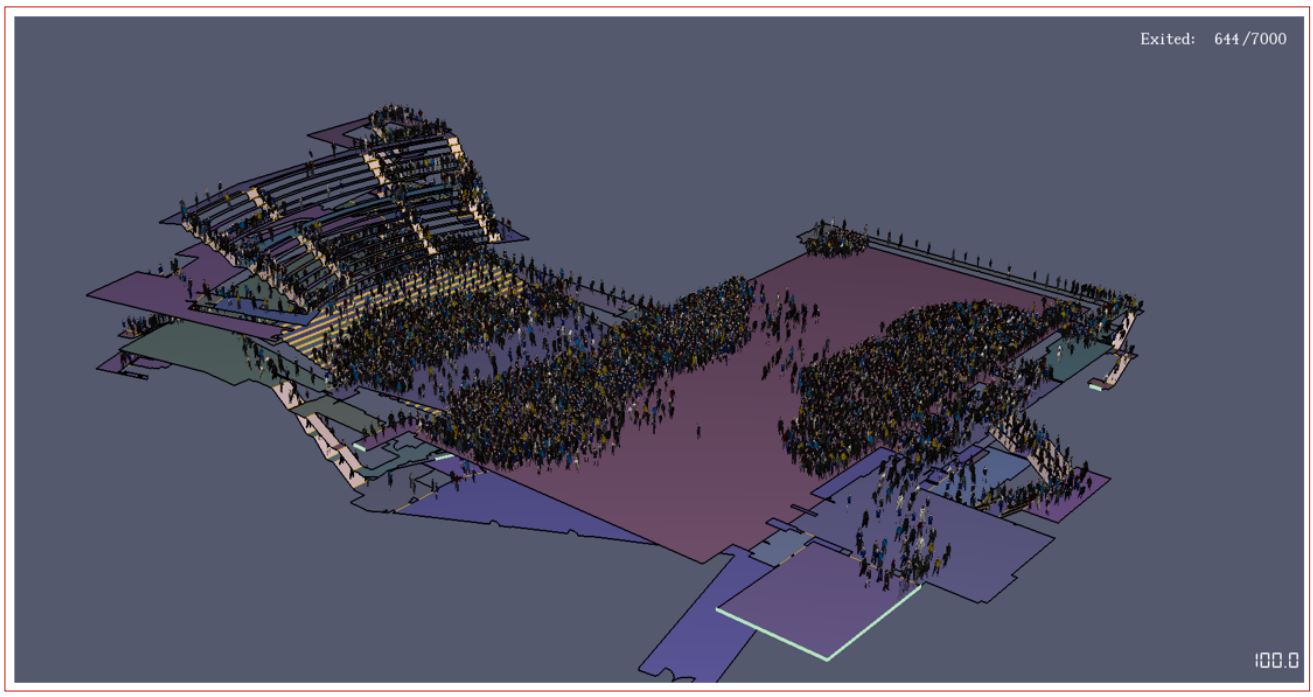


Figure 16-25: Event Mode G - T = 144 sec

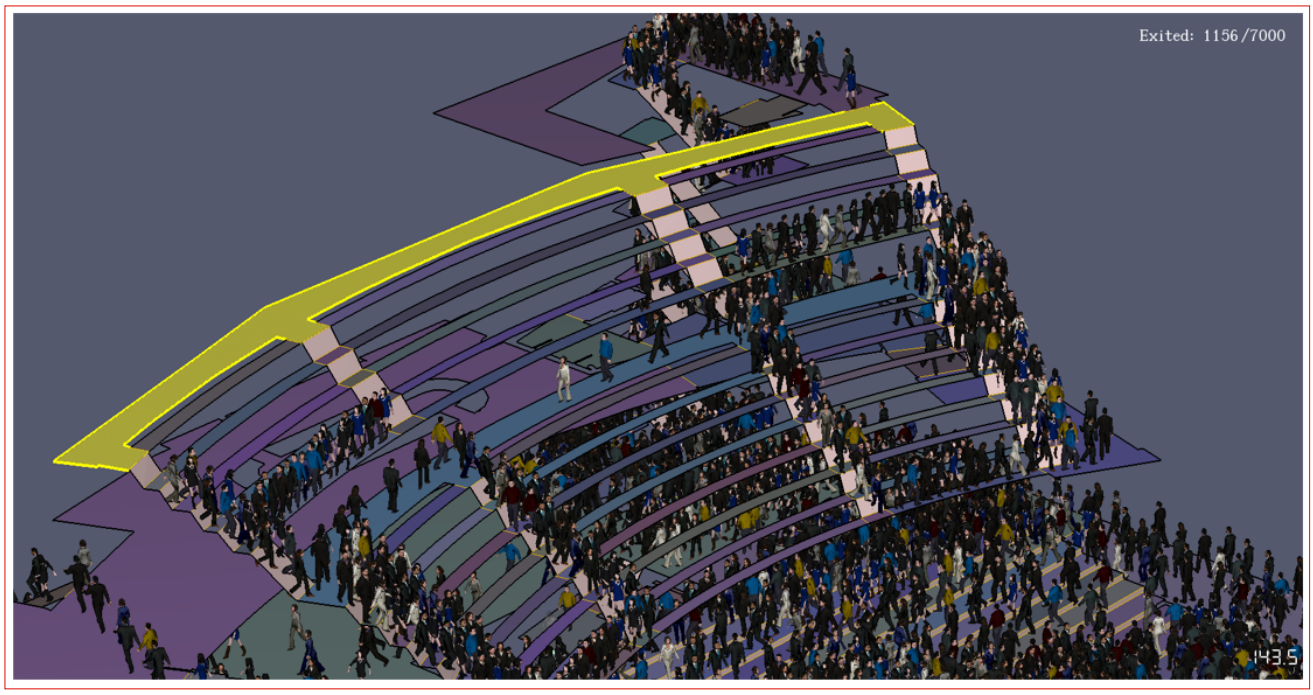


Figure 16-26: Event Mode G - T = 214 sec

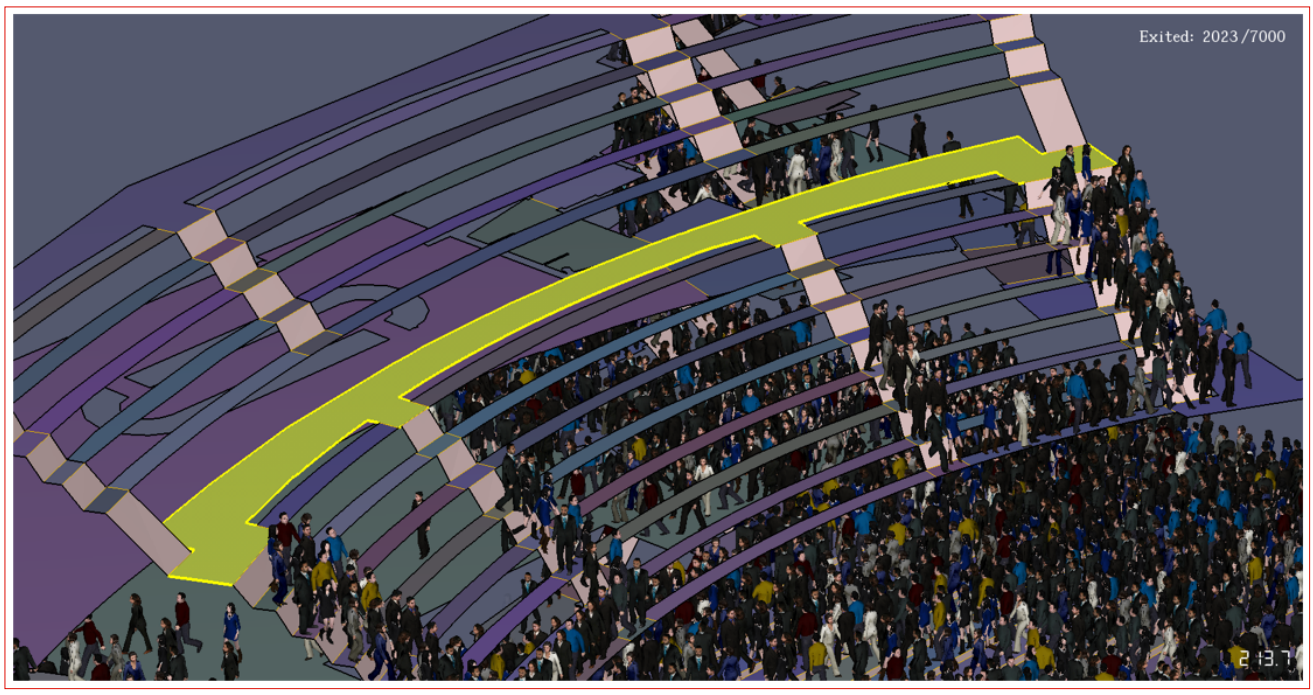


Figure 16-27: Event Mode G - T = 289 sec

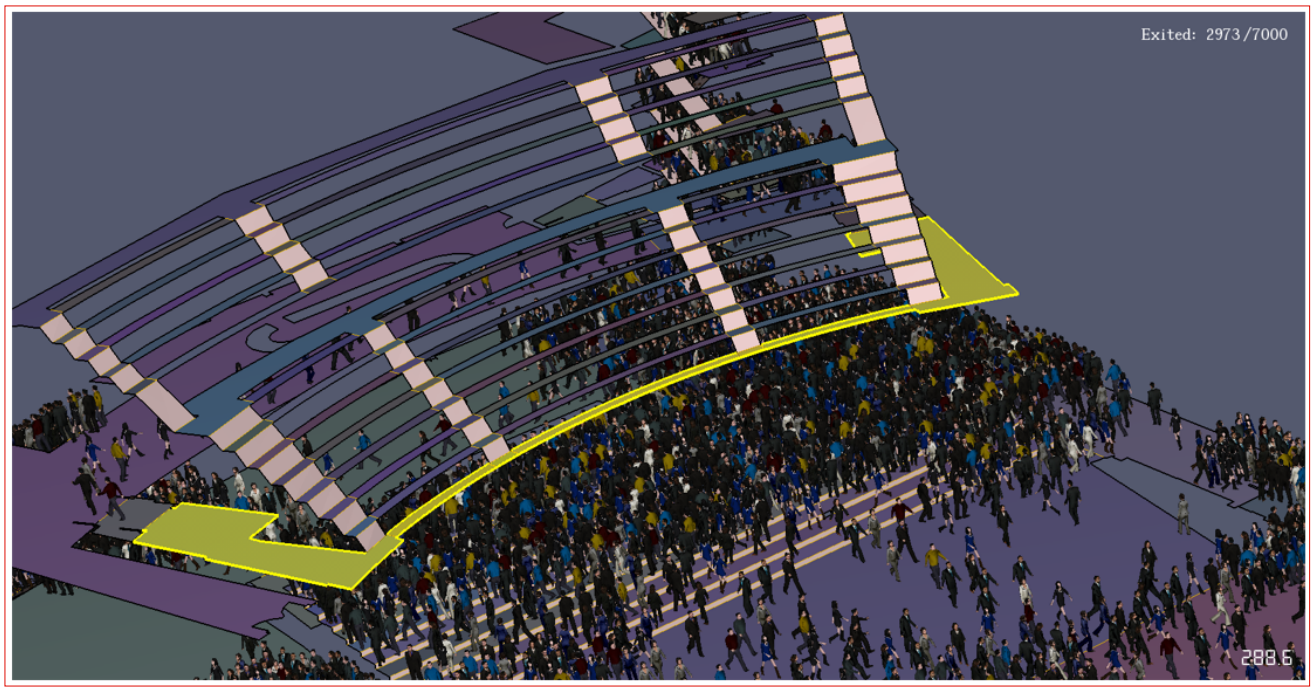


Figure 16-28: Event Mode G - T = 574 sec

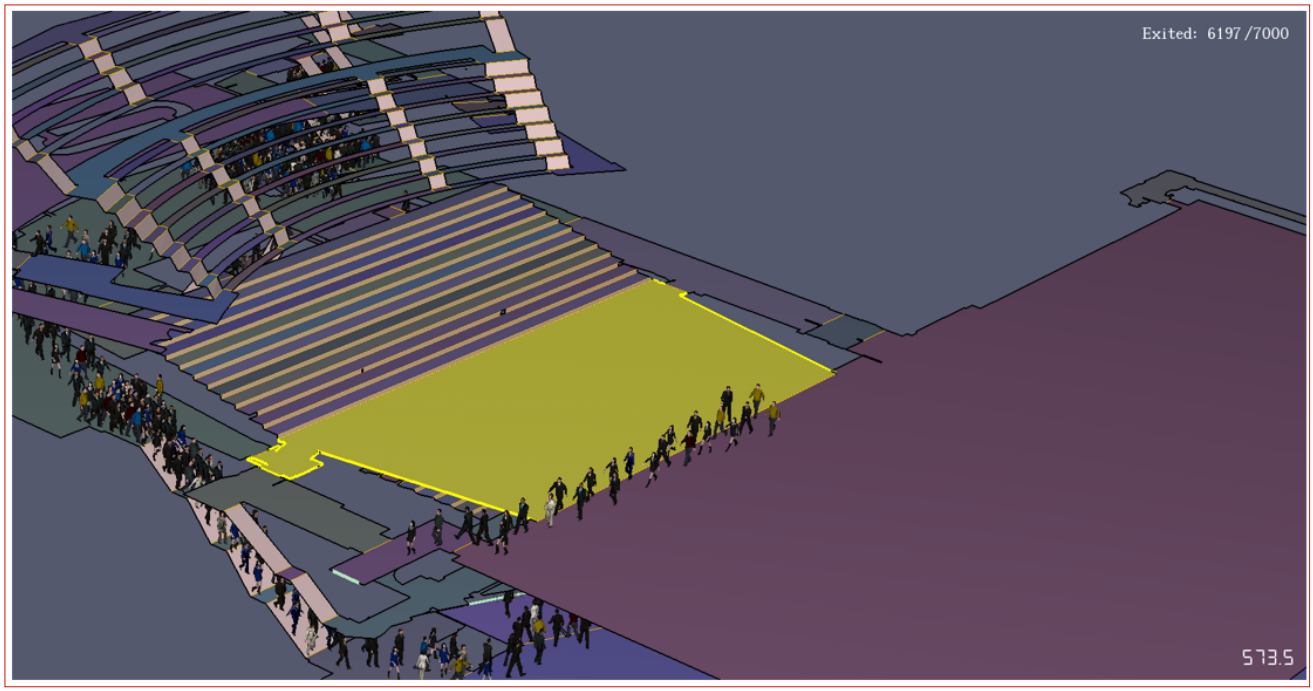


Figure 16-29: Event Mode G - T = 649 sec

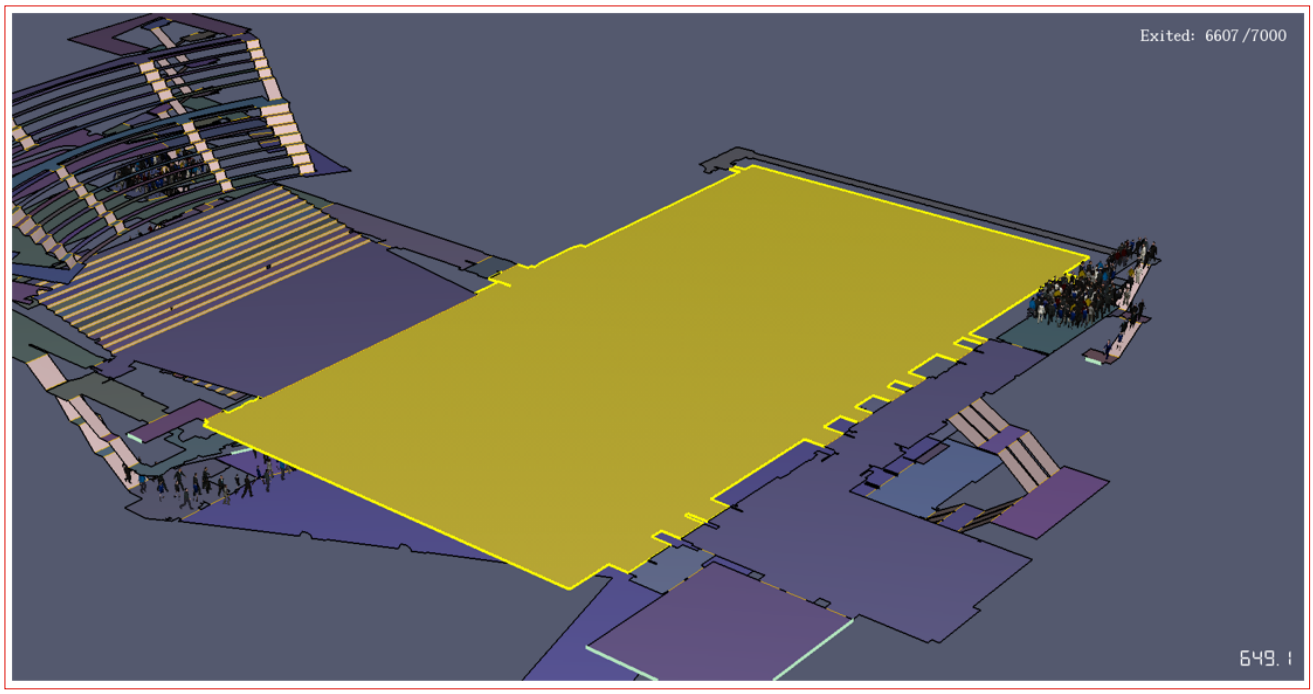


Figure 16-30: Event Mode G - T = 868 sec

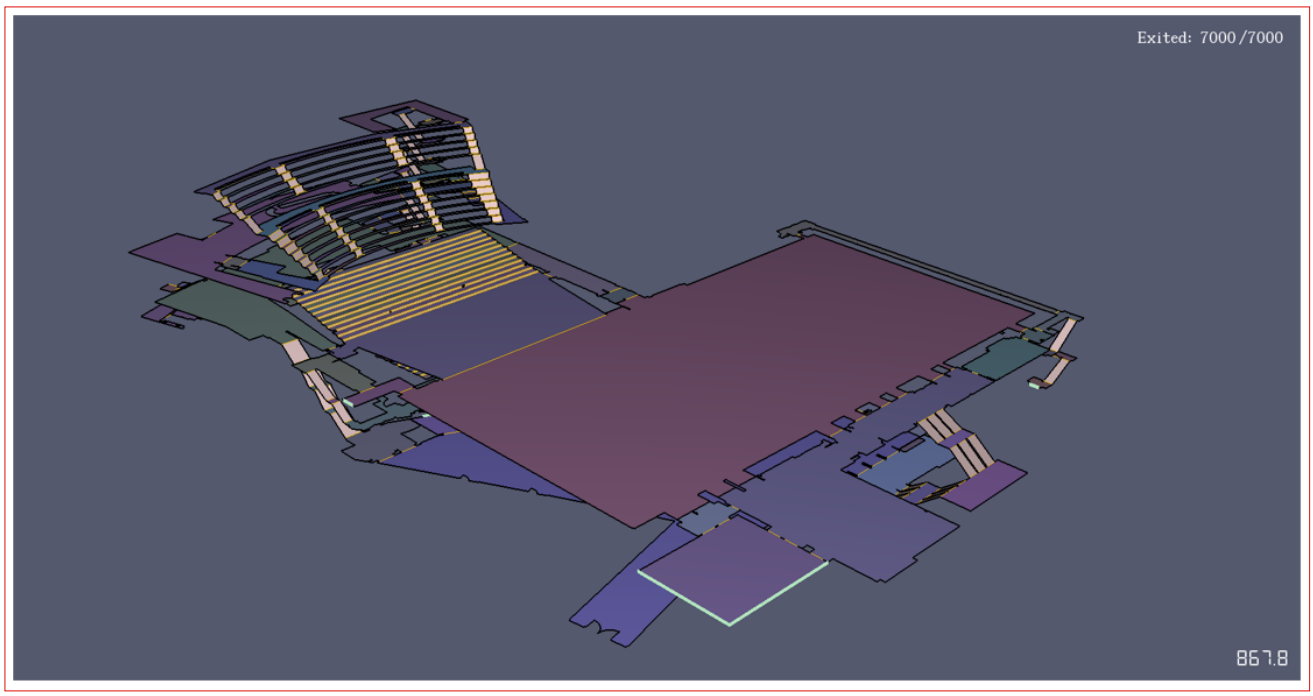


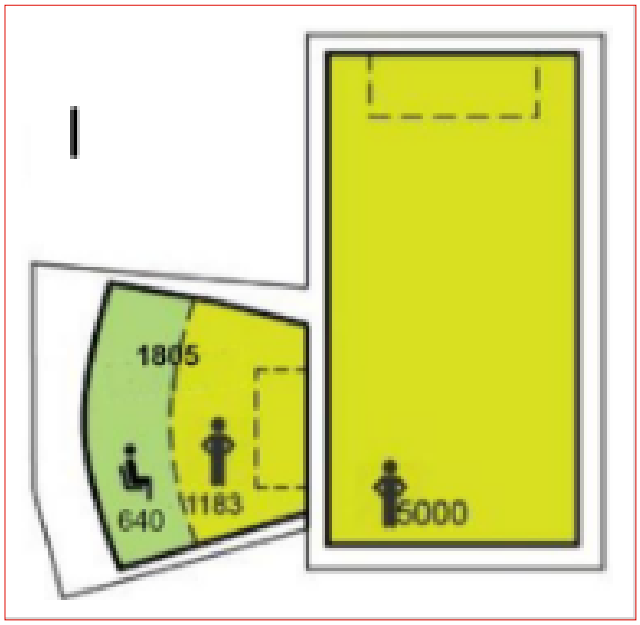
Table 16-3 – Event Mode G – Evacuation Modelling Result

Areas	ASET (sec)	ASET (mins)	RSET (sec)	RSET (mins)
Theatre top row of seating	240 seconds	4 minutes	204 seconds	**3.4 minutes**
Theatre top tier clearance	290 seconds	4.8 minutes	274 seconds	**4.5 minutes**
Theatre main exit level for the upper-tier	390 seconds	6.5 minutes	349 seconds	**5.8 minutes**
Warehouse and Theatre Stall Areas	1200 seconds	20 minutes	710 seconds	**11.8 minutes**
The whole building	N/A	N/A	928 Seconds	**15.4 minutes**

Based on the above table, Event mode G tenable condition can be maintained. An additional 60 seconds premovement time (detection and start of evacuation) has been added to the result timing and the RSET is still less than ASET. Henceforth the event mode is considered acceptable.

16.1.4 SCENARIO I

Figure 16-31: Event Mode I



The figure below shows the direction of escape available to the occupants. It should be noted that only a single fire is expected for both events, for example, a fire may occur in the theatre stage area or in the warehouse. But not in two locations at the same time.

Figure 16-32: Event Mode I - Direction of Escape.

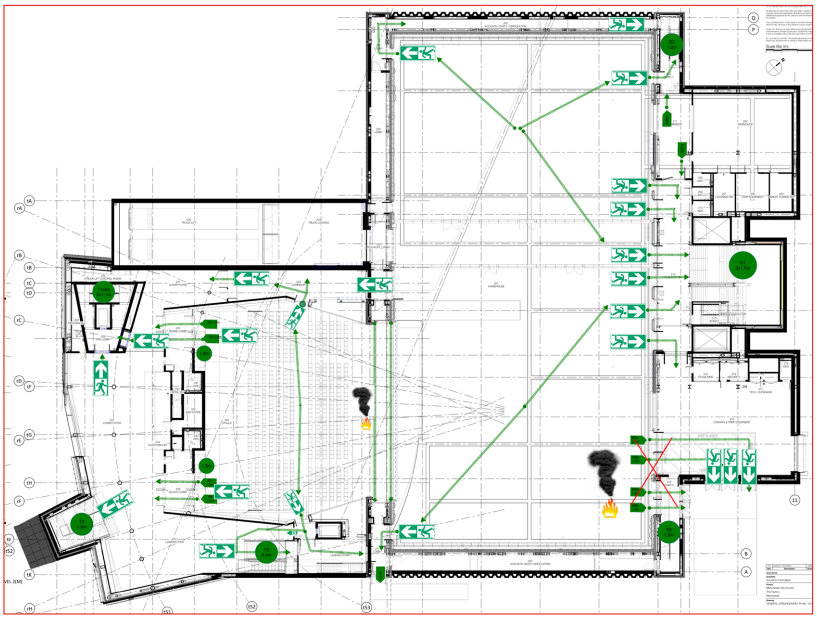


Figure 16-33: Event Mode I - T = 0 sec

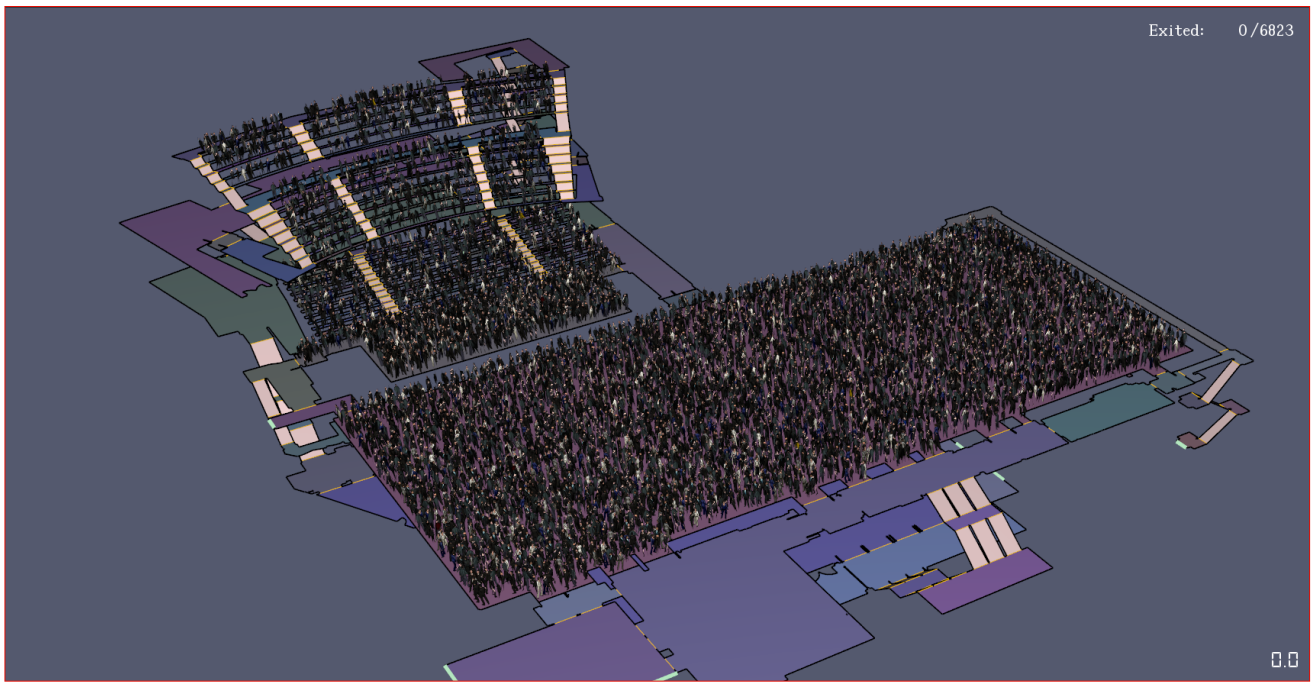


Figure 16-34: Event Mode I - T = 100 sec

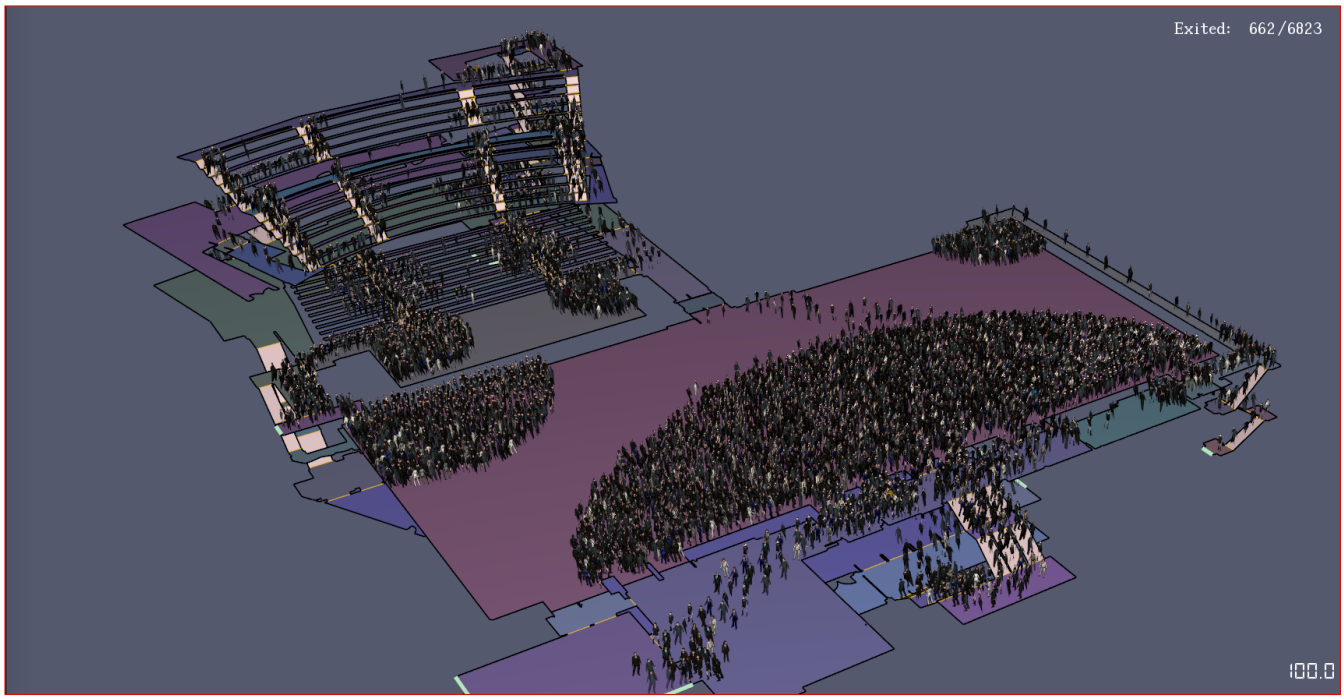


Figure 16-35: Event Mode I - T = 138 sec

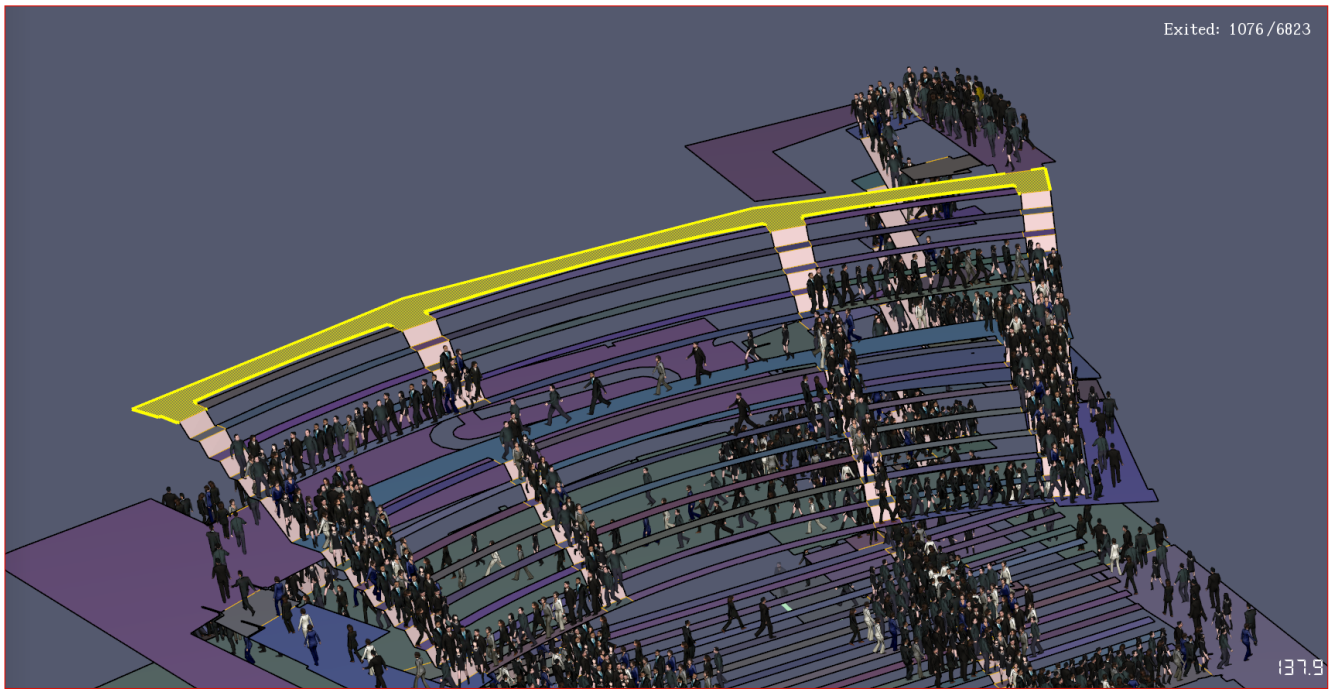


Figure 16-36: Event Mode I - T = 226 sec

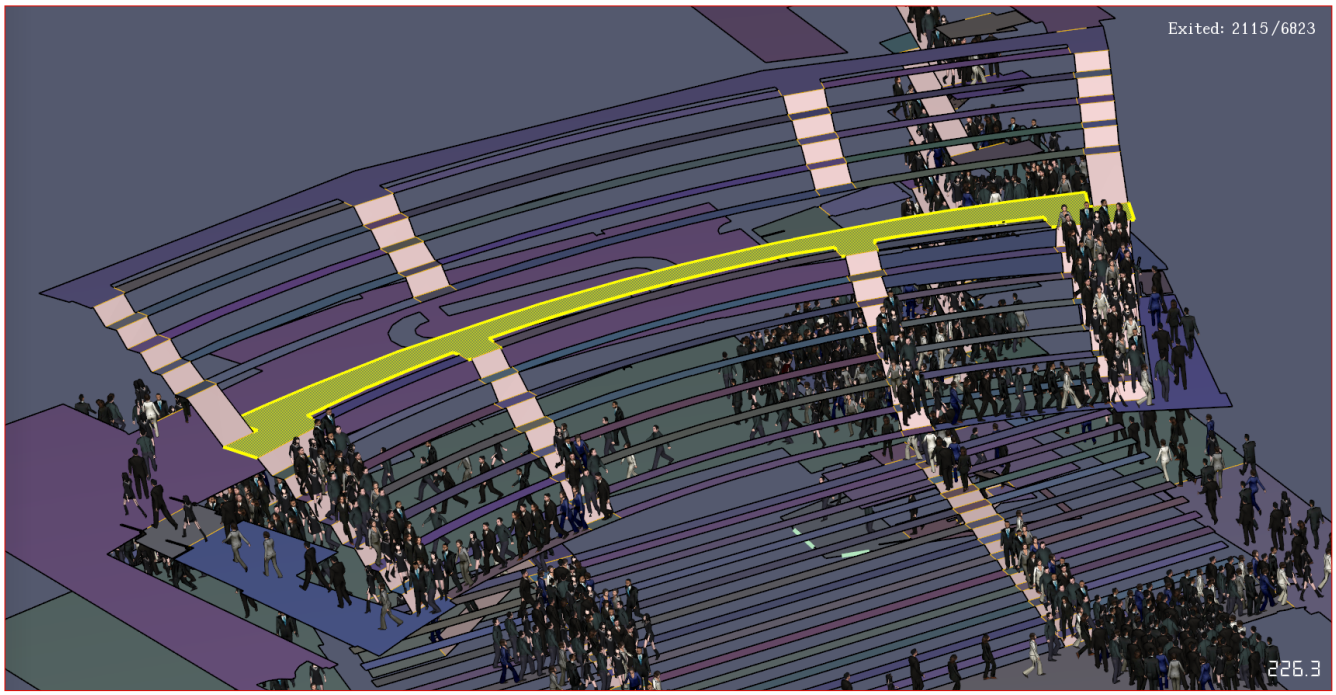


Figure 16-37: Event Mode I - T = 305 sec

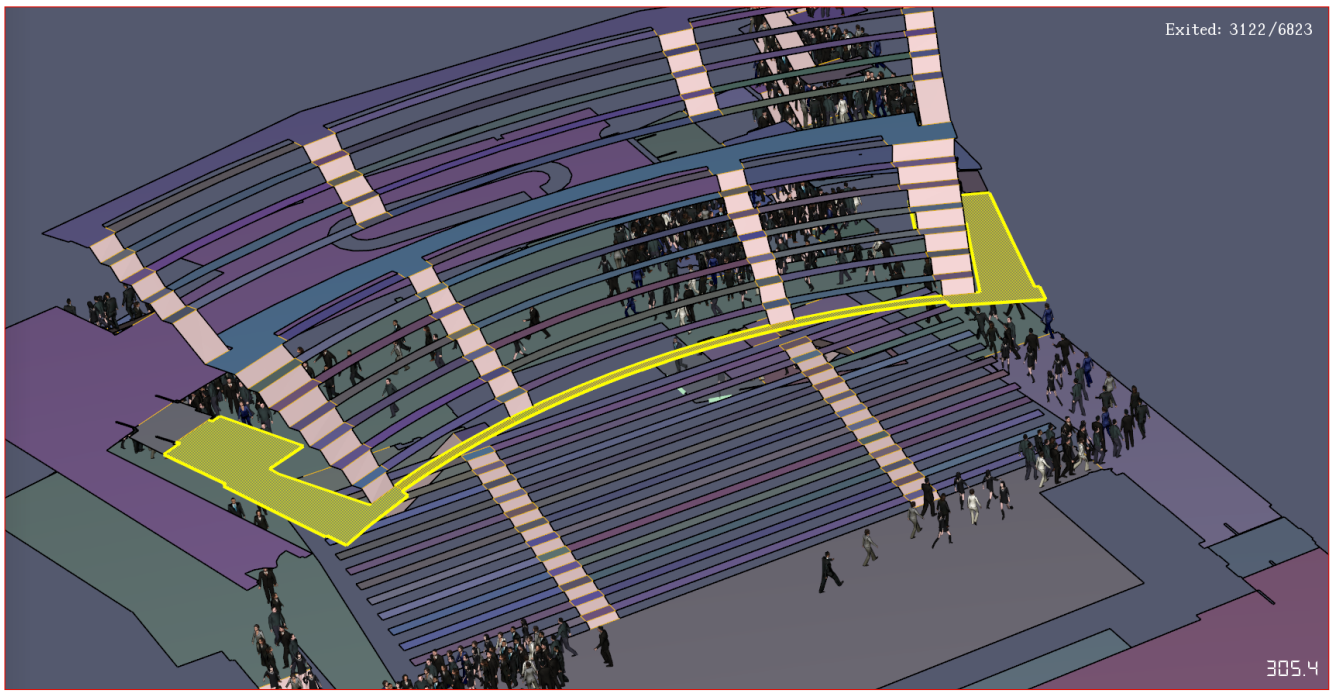


Figure 16-38: Event Mode I - T = 378 sec

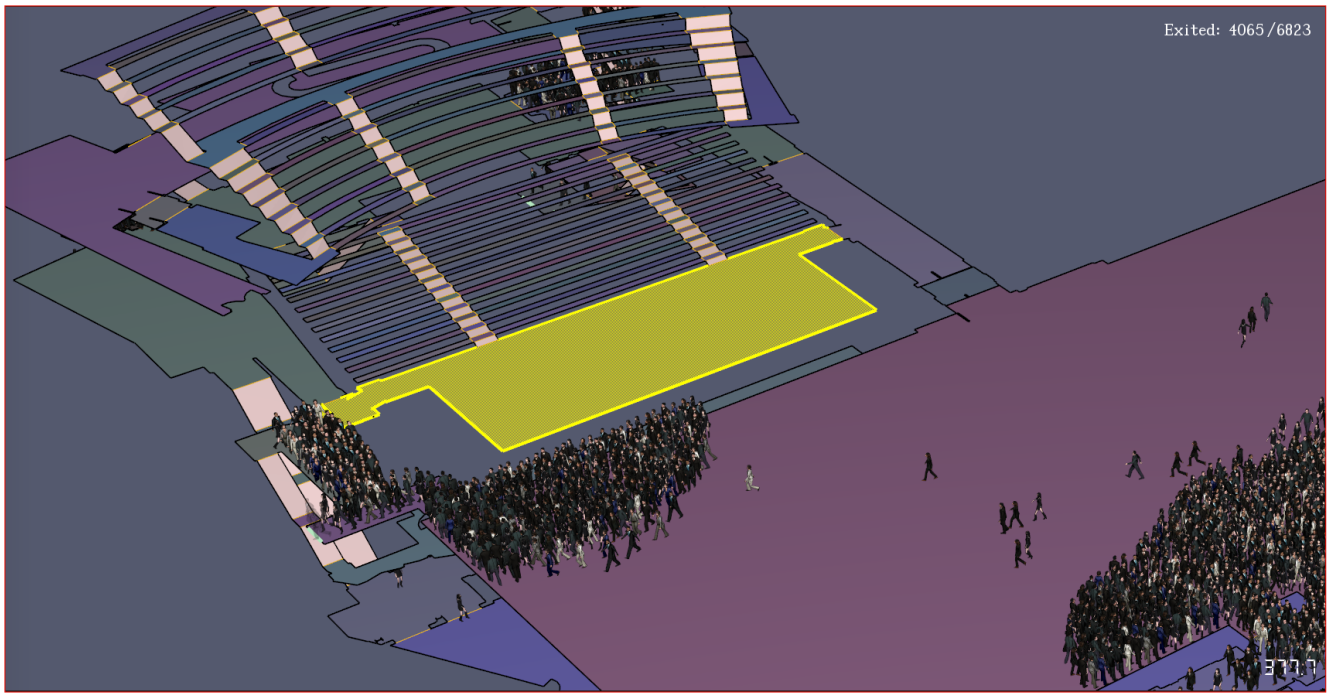


Figure 16-39: Event Mode I - T = 792 sec

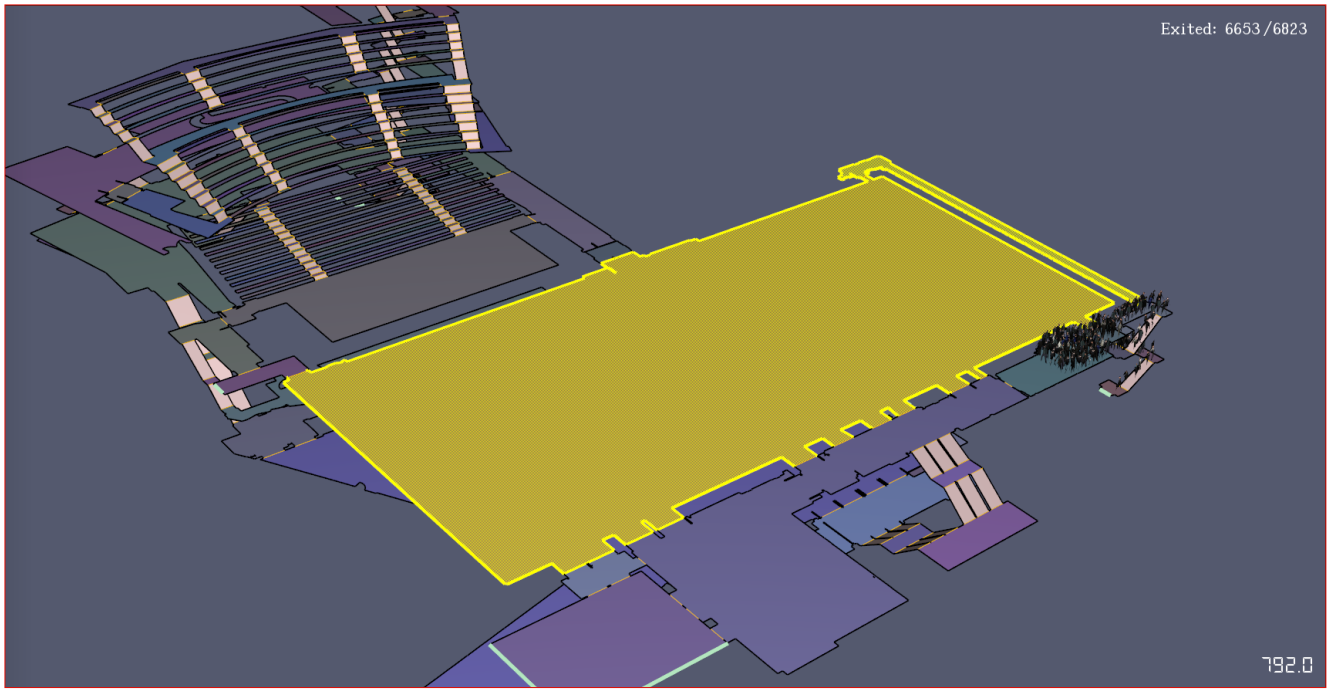


Figure 16-40: Event Mode I - T = 1023 sec

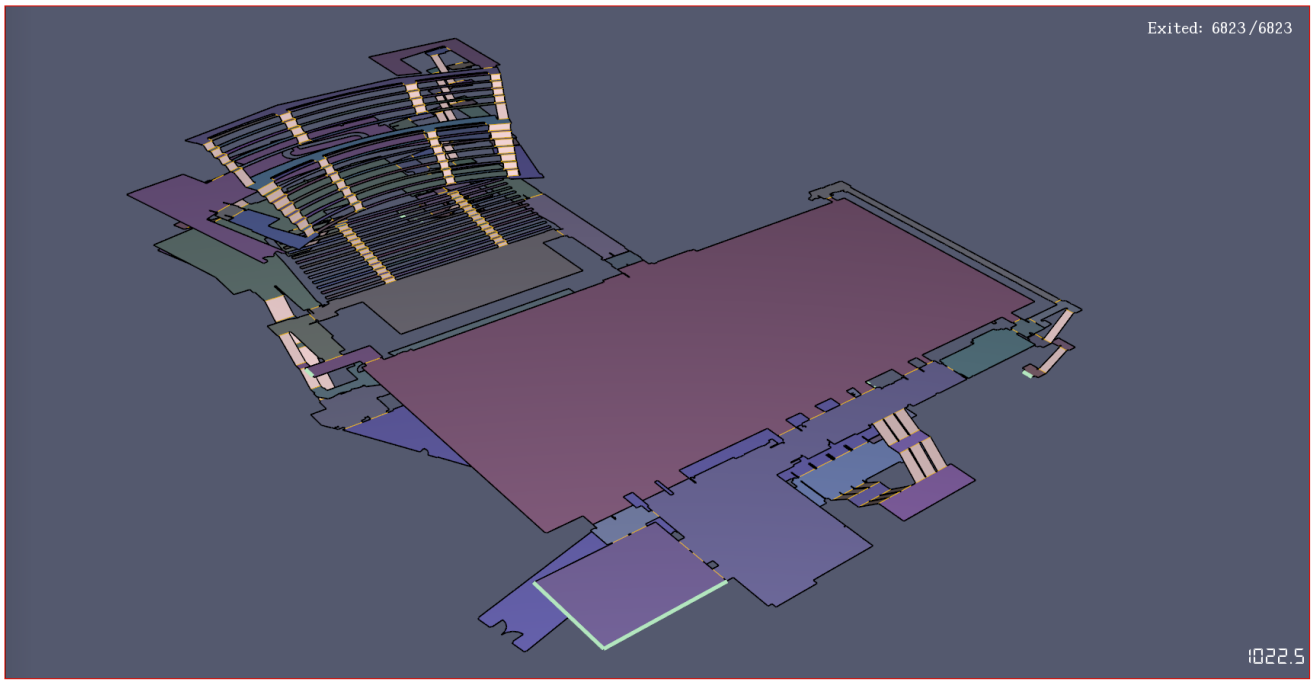
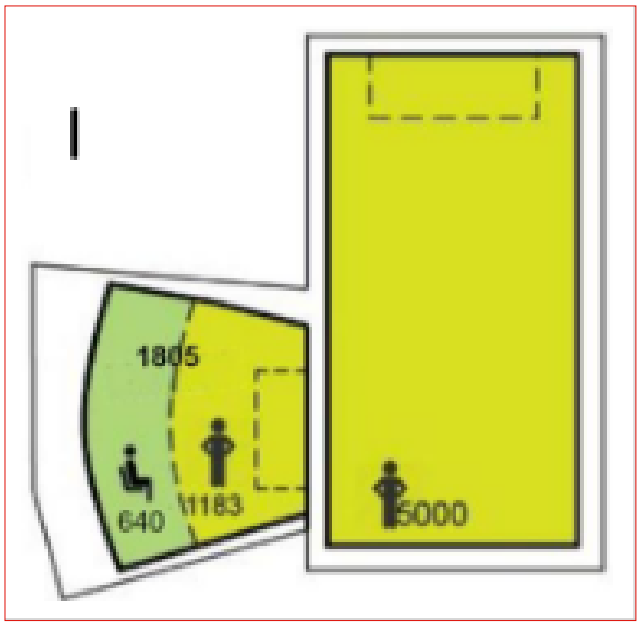


Table 16-4 – Event Mode I – Evacuation Modelling Result

Areas	ASET (sec)	ASET (mins)	RSET (sec)	RSET (mins)
Warehouse Area	1200 seconds	20 minutes	852 seconds	**14.2 minutes**
Theatre top row of seating	240 seconds	4 minutes	198 seconds	**3.3 minutes**
Theatre top tier clearance	290 seconds	4.8 minutes	286 seconds	**4.7 minutes**
Theatre main exit level for the upper-tier	390 seconds	6.5 minutes	365 seconds	**6 minutes**
Theatre lower-level full evacuation	600 seconds	10 minutes	437 seconds	**7.2 minutes**
The whole building	N/A	N/A	1,083 Seconds	**18 minutes**

Based on the above table, Event mode I tenable conditions can be maintained. An additional 60 seconds premovement time (detection and start of evacuation) has been added to the result timing and the RSET is still less than ASET. Henceforth the event mode is considered acceptable.

Figure 16-41: Event Mode I Revised 230213 - Revised Door Width Egress Modelling



The figure below shows the direction of escape available to the occupants. The storey exits widths have been restricted to the width of the stairs and the width of the final exit they are leading to.

This scenario has been carried out to provide a stress test for the client, therefore allowing the end user the flexibility to close off some exit doors to allow direct flow to the staircase.

Figure 16-42: Event Mode I Revised 230213 – Fire in non-events area

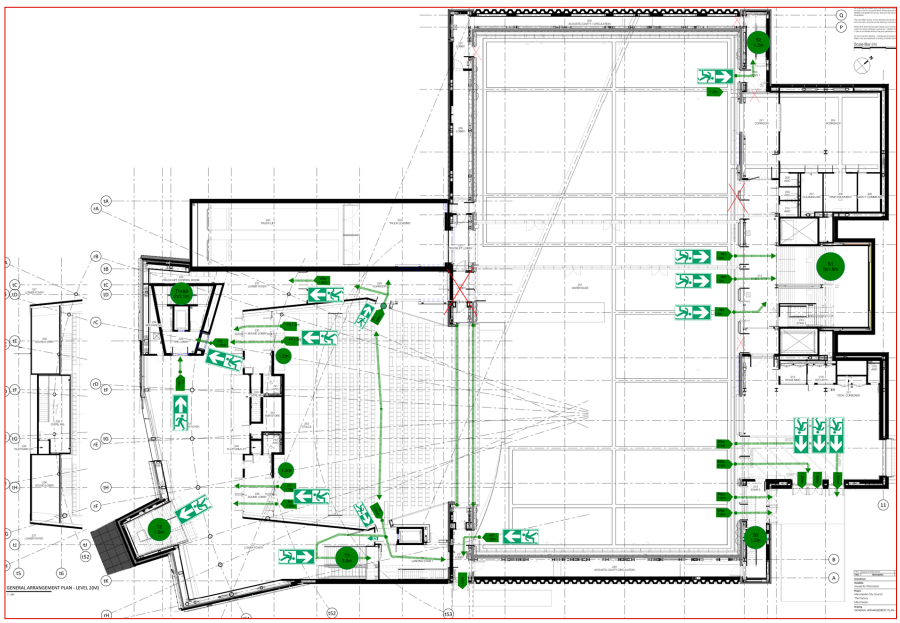


Figure 16-43: Event Mode I Revised 230213 - T = 0 sec

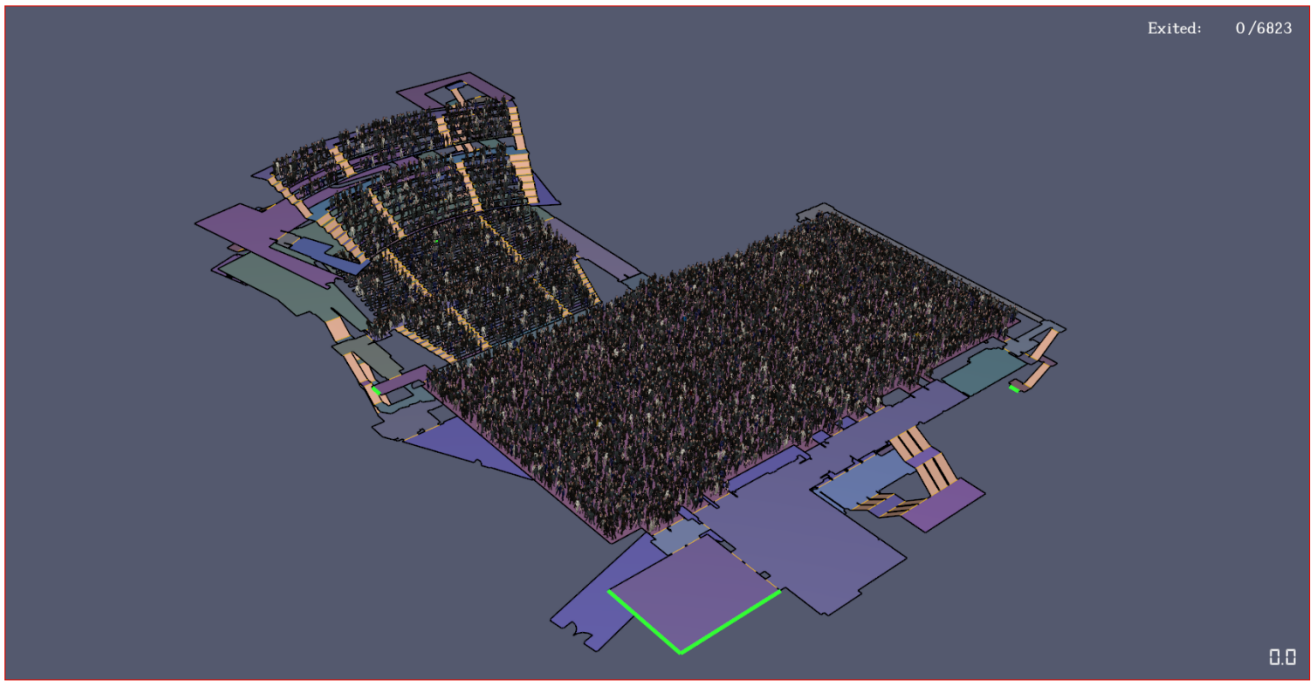


Figure 16-44: Event Mode I Revised 230213 - T = 100 sec

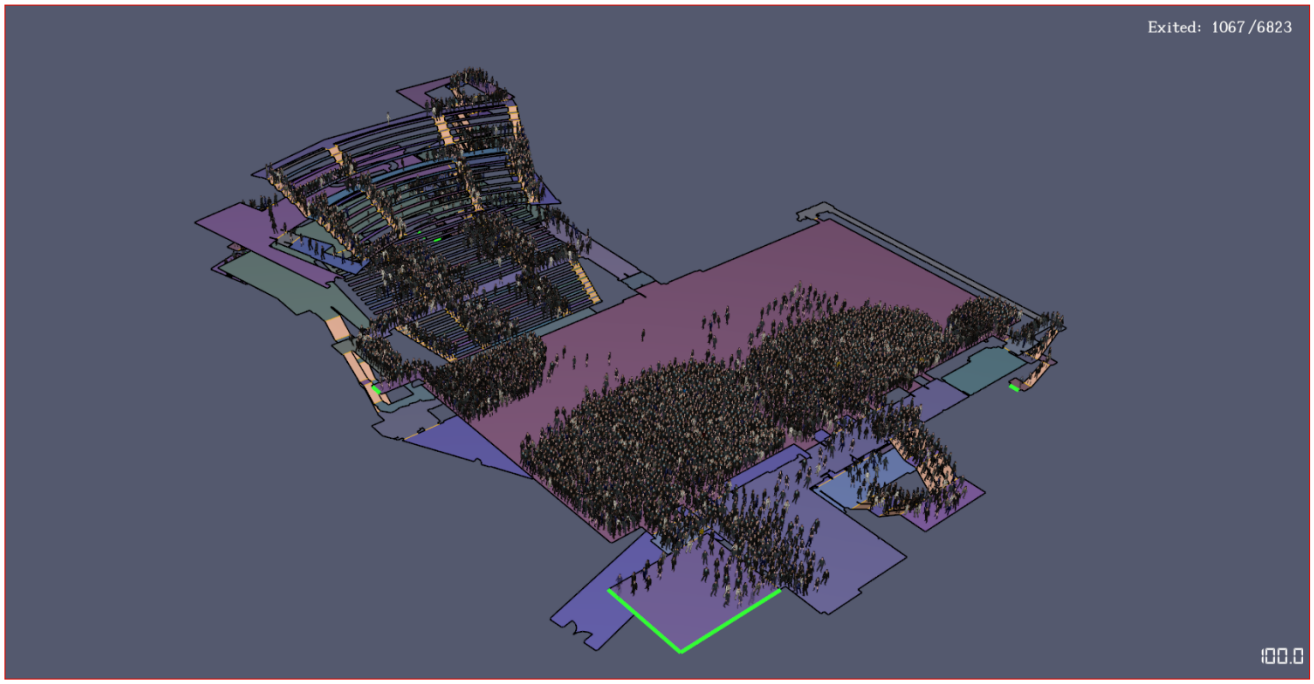


Figure 16-45: Event Mode I Revised 230213 - T = 139 sec

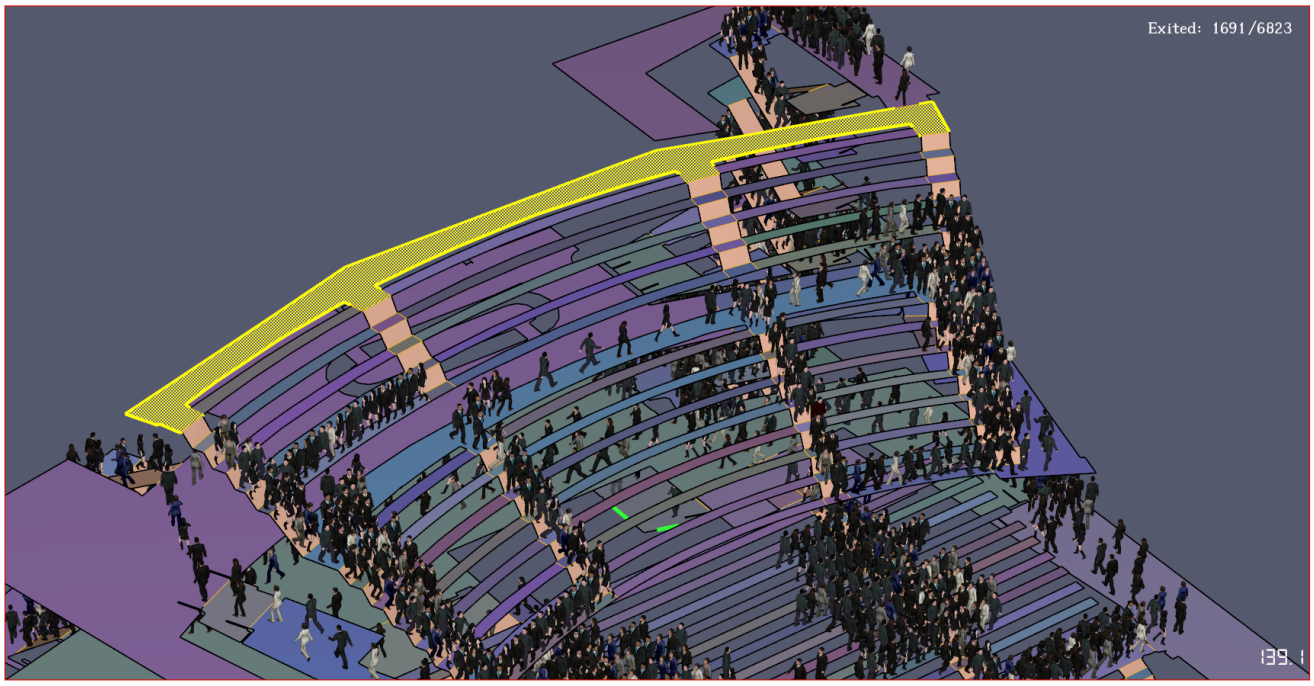


Figure 16-46: Event Mode I Revised 230213 - T = 223 sec

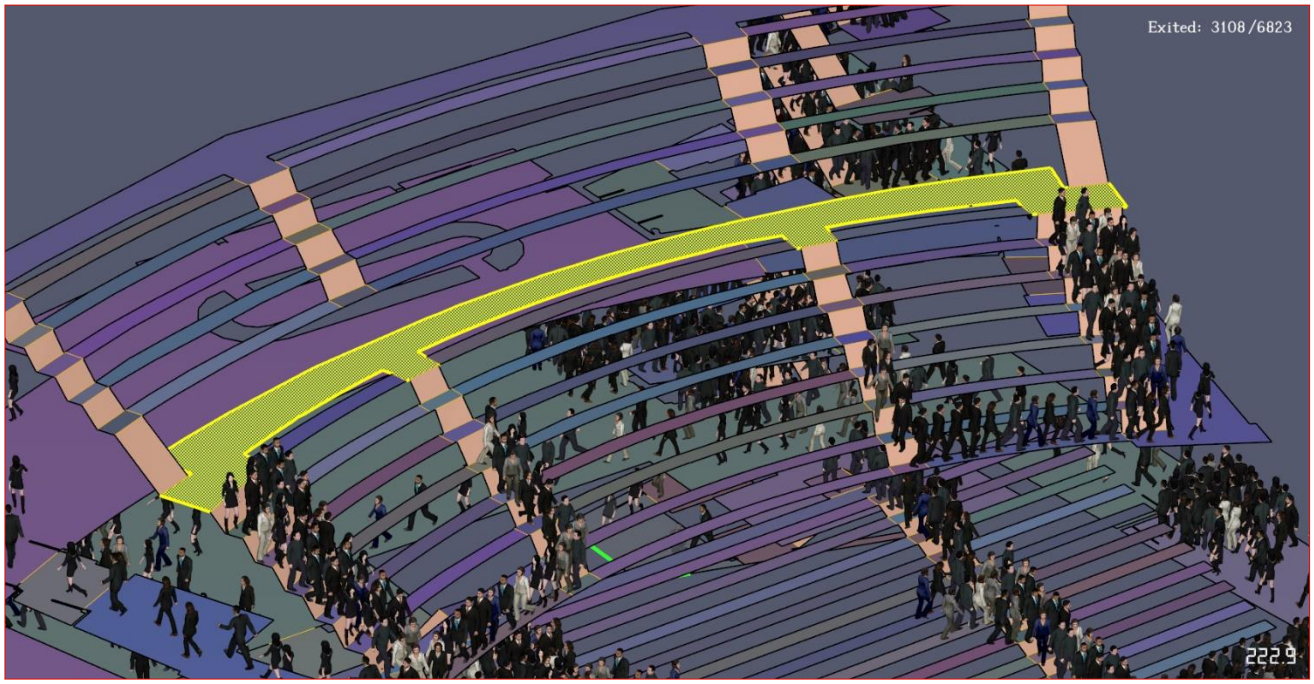


Figure 16-47: Event Mode I Revised 230213 - T = 307 sec

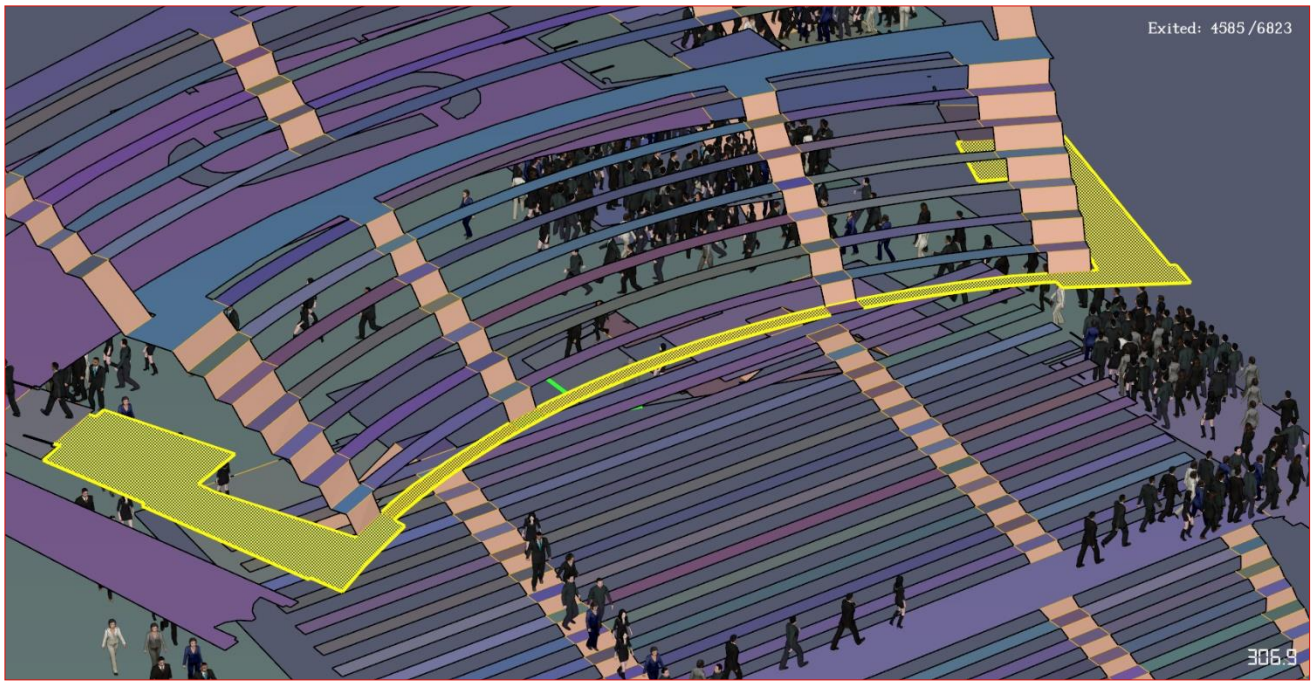


Figure 16-48: Event Mode I Revised 230213 - T = 370 sec

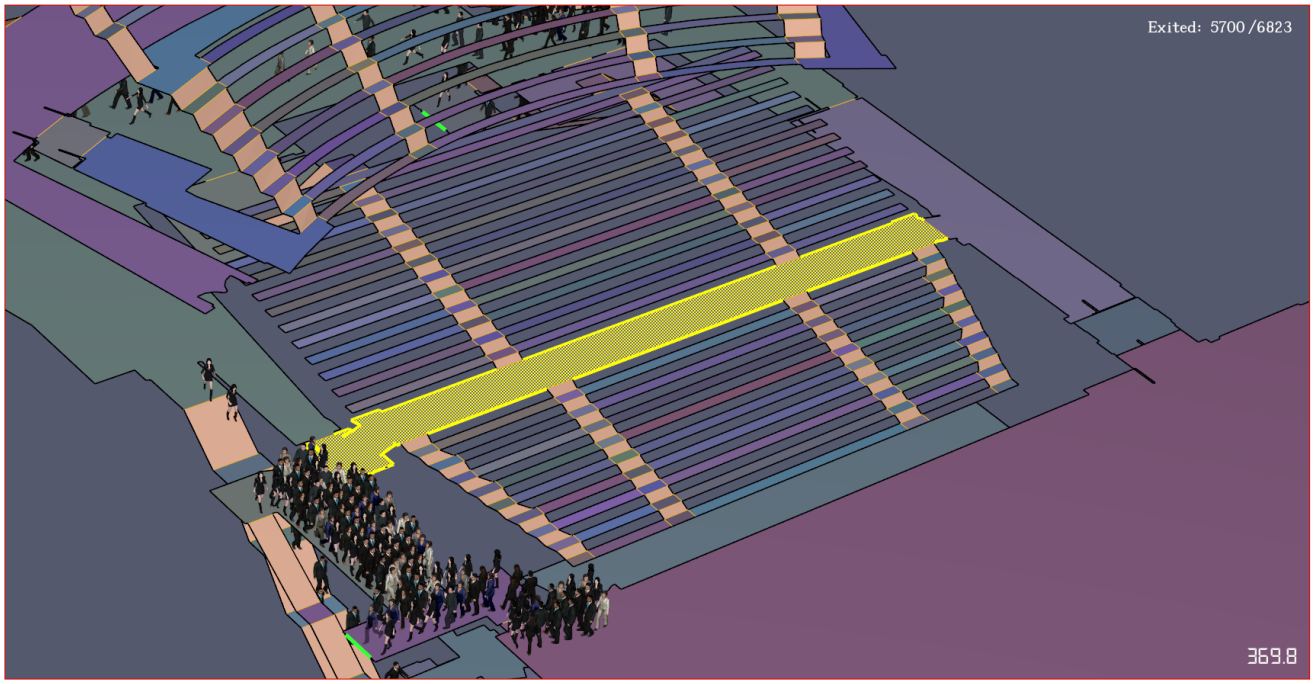


Figure 16-49: Event Mode I Revised 230213 - T = 384 sec

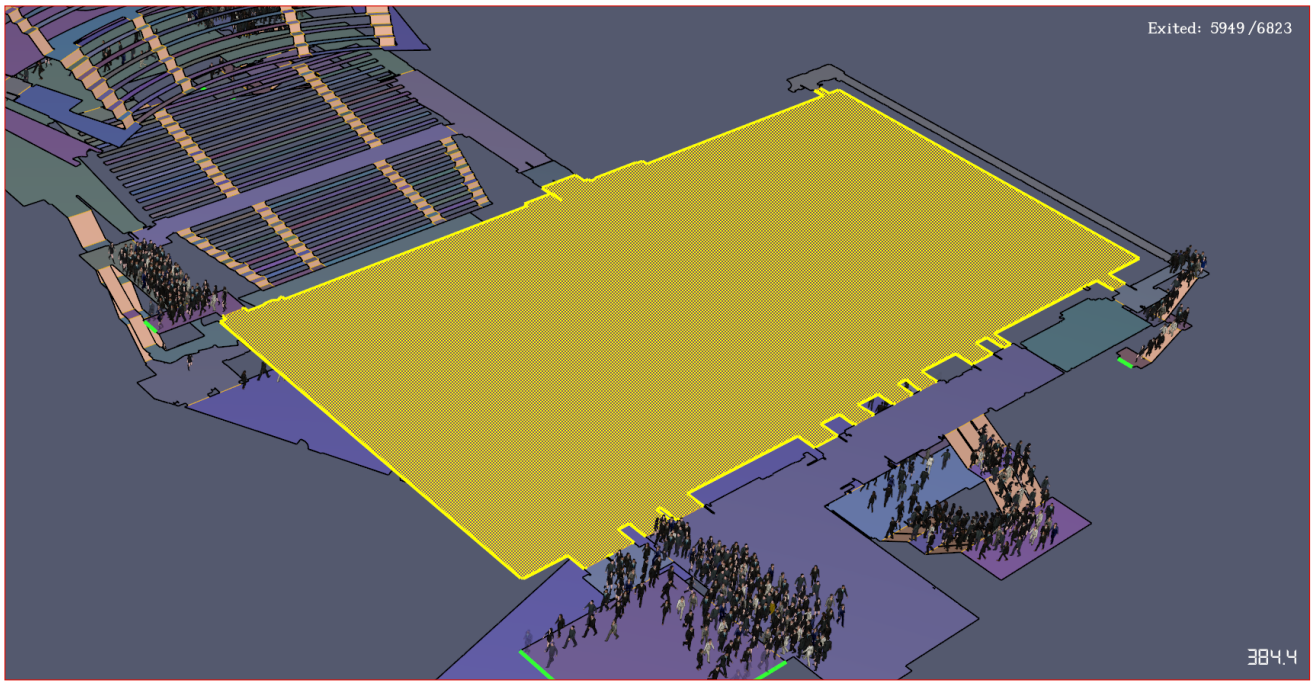


Figure 16-50: Event Mode I Revised 230213 - T = 594 sec

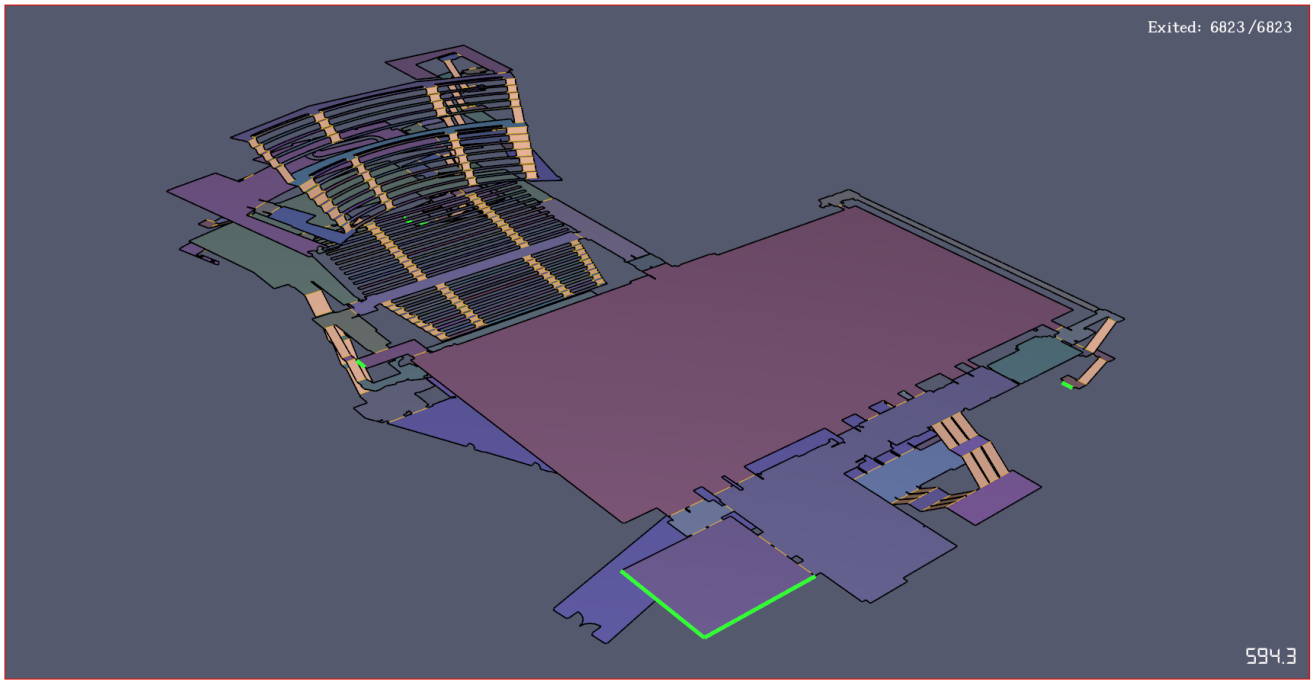


Table 16-5 – Event Mode I Revised 230213 – Evacuation Modelling Result

Areas	ASET (sec)	ASET (mins)	RSET (sec)	RSET (mins)
Warehouse Area	1200 seconds	20 minutes	444 seconds	**7.4 minutes**
Theatre top row of seating	240 seconds	4 minutes	199 seconds	**3.3 minutes**
Theatre top tier clearance	290 seconds	4.8 minutes	283 seconds	**4.7 minutes**
Theatre main exit level for the upper-tier	390 seconds	6.5 minutes	367 seconds	**6.1 minutes**
Theatre lower-level full evacuation	600 seconds	10 minutes	430 seconds	**7.1 minutes**
The whole building	N/A	N/A	654 Seconds	**10.9 minutes**

Based on the above table, Event mode I (Revised 230213) tenable condition can be maintained. An additional 60 seconds premovement time (detection and start of evacuation) has been added to the result timing and the RSET is less than ASET. Based on the result, the occupants should be able to escape to a place of relative safety prior to the condition been untenable. Henceforth the event mode is considered acceptable.

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