Revised Performance Based Design Brief

scientific fire services

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creating intelligent fire safety solutions

Western Sydney University – Indigenous Centre of Excellence NSW

Project Address:	**171 Victoria Road, Parramatta NSW**
Date:	**5 August 2025**
Document ref:	**24000072**
Issue No:	**3.0**

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Document verification history

Issue No	Date	Document control - Purpose of issue	Prepared by	Checked by	Approved by
1-0	14/02/2025	Draft Performance Based Design Brief (PBDB) for stakeholder review and comment	Kapilan Sarma	Russell Kilmartin	Russell Kilmartin
2-0	01/04/2025	Revised Performance Based Design Brief (PBDB) for stakeholder review and comment	Kapilan Sarma	Russell Kilmartin	Russell Kilmartin
3-0	05/08/2025	Revised Performance Based Design Brief (PBDB) for stakeholder review and comment	Kapilan Sarma	Russell Kilmartin	Russell Kilmartin

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Contents

0. Executive Summary

0.1 General

This executive summary has been prepared to provide a concise statement of the Performance Solution issues identified and addressed in the assessment. The details of the Building Solution so assessed are described in full.

The purpose is to provide a readily accessible source to the intent and engineering methodologies of the assessment with respect to the Building Solution presented.

The PBDB is intended to represent a transparent account of the assessment process consistent with the documented PBDB process and reflects the discussions and agreements between SFS Australia Pty Ltd T/A Scientific Fire Services (SFS), the design team and the relevant authorities based on the information provided to date.

The Client is to ensure that the relevant stakeholders and services consultants that have been involved in the project are in agreement with the proposals made in this document. Furthermore it is the responsibility of the other designers and consultants (not SFS) to complete the detailed design of the various active and passive fire safety systems in accordance with the relevant design and installation Australian Standards and in accordance with the requirements listed in this report.

The relevant project stakeholders should note the sections of this document that outline the scope of works, the assumptions and limitations and the fire safety objectives documented in this report. The building owner should be made aware of these sections of the PBDB.

The executive summary must always be read in the context of the report as a whole.

0.2 Brief Building Description

The subject site is located within WSU South Parramatta Campus, whereby it is proposed to construct a new tertiary education building to serve the growing WSU campus at 171 Victoria Road, Parramatta NSW. The site is bounded by Victoria Road to the north, Railway Street to the east, Fifth Street to the south, which serves as the principal site entry, and Bridge Street to the west. The development shall also be accessible via the newly constructed Yallamundi Light Rail station, which is currently awaiting operation. The site is noted to currently comprise a hardstand area for carparking and the existing Central Energy Plant, the latter of which is to remain unaffected by the proposed works. With respect to the car parking areas serving this building, it is proposed to maintain the 13 spaces on the existing P1 car park site, introduce 107 spaces to the new western car park on the western side of Bridge Street and introduce 181 spaces to the new eastern car park on the southern side of Fifth Street.

Figure 0.1: Site locality within the WSU South Parramatta Campus (Image courtesy of Near map/Ethos Urban)

Figure 0.2: Artist impressions of the Indigenous Centre of Excellence (indicative only)

The proposed works entail the construction of a four (4) storey building, named the Indigenous Centre of Excellence, which is noted to incorporate extensive timber construction. The new development shall mainly consist of Class 9b facilities, most notably an outdoor amphitheatre, a gallery and a triple height theatre on Ground Floor. Further Class 9b facilities housed in the building include a cinema/lecture hall, various study/learning spaces and a rooftop recreational area comprising a garden and a sports court. Additionally, the building shall contain Class 5 office spaces, mainly concentrated on Ground Floor and Level 2. Table 0.1 provides a detailed summary of the key building characteristics.

Table 0.1: Overview of building characteristics

Occupancy Levels	Key Characteristics	
Ground Floor	• Welcome Foyer • Theatre (triple height) • Cinema/Lecture Hall (double height) • Gallery (double height) • Outdoor Amphitheatre	• Art Studios & Exhibition spaces • General Learning/Study spaces • Consulting offices • Loading bay & plant rooms

Occupancy Levels	Key Characteristics
Level 1	• Library facilities • General Learning/Study spaces • Outdoor Terraces • Plant rooms
Level 2	• Offices & Workspaces • General Learning/Study spaces • Outdoor Terraces • Plant rooms
Level 3 (Rooftop)	• Outdoor astronomy garden • Outdoor BBQ facilities • Outdoor multi-purpose sports court

0.3 Building Design Issues and Performance Requirements

There are design issues that have been identified by BM+G that represent deviations from the traditional prescriptive design requirements of the BCA. Rather than seeking compliance with the more traditional 'Deemed-to-Satisfy' (DtS) provisions of the BCA a 'Performance Solution' has been formulated such that the identified design issues achieve compliance with the minimum level of compliance with the BCA namely the Performance Requirements of the BCA. The following table lists the identified design issues, the corresponding Performance Requirements, the methods of meeting the Performance Requirements and the Performance Solutions. It should be noted that the DtS provisions and Performance Requirements listed in the following table were identified by the Certifying Authority and agreed by relevant stakeholders.

Table 0.2: BCA design issues pertinent to the proposed Performance Solution

No.	Design Issue to be Addressed	BCA DtS Provision	Performance Requirement	Performance Solution
1.	It is proposed to review the method of fire separation between the CLT slab edge and the external façade system. The design incorporates a non-combustible element/barrier in order to mitigate vertical fire and smoke between levels however is not deemed to be strictly in accordance with the BCA DtS provisions. More specifically, the prescriptive provisions of the BCA are silent on the method of sealing the slab edge gap and AS1530.4 does not have criteria to test a fire sealing system between fire-rated (slab) / non-fire rated (external wall) elements.	Clause C2D2 inter alia Specification 5 and Clause C4D16	C1P2 and C1P8	A2G2(2)(b)(ii)
2.	It is proposed to permit the use of mass timber construction to the building as per the following: • It is proposed to permit the use of exposed (no fire-protective covering) CLT flooring system (limited areas), Glulam columns and Glulam beams	Clause C2D15	C1P1 and C1P2	A2G2(2)(b)(ii)
3.	It is proposed to permit the proposed building to be located within 6m of the existing Central Energy Plant (CEP) building which is on the same allotment.	Clause C4D3 inter alia Specification 5	C1P2 and C1P8	A2G2(2)(b)(ii)
4.	It is proposed to permit the stairway known as "Badanami Stair" serving all levels to be not fully contained within a fire-rated shaft.	Clause D2D4	D1P4 and D1P5	A2G2(2)(b)(ii)
5.	It is proposed to permit the exit travel distances to a point of choice and to an exit to exceed the maximum DtS provisions as per the following: • Level 1 – 28m to a point of choice in lieu of 20m • Level 1 Plant room – 27m to a point of choice in lieu of 20m – 50m to an exit in lieu of 40m • Level 2	Clause D2D5	D1P4 and E2P2	A2G2(2)(b)(ii) A2G2(2)(d)

No.	Design Issue to be Addressed	BCA DtS Provision	Performance Requirement	Performance Solution
	– 28m to a point of choice in lieu of 20m • Level 2 Plant Room/Catwalks – 22m to a point of choice in lieu of 20m – 47m to an exit in lieu of 40m • Level 3 – 28m to a point of choice in lieu of 20m			
6.	It is proposed to permit the fire stair serving all levels of the building to discharge internally on Ground Level in lieu of a road or open space.	Clause D2D12	D1P4 and D1P5	A2G2(2)(b)(ii)
7.	The non-fire-isolated stair serving Level 3 and ladder serving the Level 2 plant room does not have a continuous path of travel from the storey served to the level of discharge.	Clause D2D14 inter alia Clause D2D21	D1P4 and D1P5	
8.	It is proposed to permit the occupants within the theatre catwalk, which is not a plant room and is greater than 200m^2 to utilise the plant room ladder for egress on Level 2 only.	Clause D2D21	D1P4 and D1P5	A2G2(2)(b)(ii)
9.	A fire hydrant system shall be provided which is designed and installed in accordance with Clause E1D2 of the BCA and AS2419.1:2021 with the inclusion of the following: • Permit the fire hydrant booster assembly serving the building to be located in a position that is not within sight of the main entry of this new building. **Draft note: Fire services consultant to confirm any further non-compliances*	Clause E1D2	E1P3	A2G2(2)(b)(ii)
10.	The proposed sprinkler booster assembly serving the site is located in a position that is not within sight of the main entry of this new building.	Clause E1D2 and E1D4	E1P3 and E1P4	A2G2(2)(b)(ii)
11.	The gallery located on Level 00 is within a building/fire compartment containing a floor area greater than 3,500m^2, as such a smoke exhaust system is required. In this instance, it is proposed to permit the omission of the required smoke exhaust system to the gallery/exhibition areas of the building on Level 00.	Clause E2D3 inter alia NSW Clause E2D18	E2P2	A2G2(2)(b)(ii)

0.4 Methodologies

The following PBDB has been undertaken generally in accordance with the Australian Fire Engineering Guidelines (AFEG) (ABCB, 2021). The assessment has considered the alternative solution to show compliance with the identified Performance Requirements of the BCA. The evaluation methodologies have been applied to demonstrate the Performance Requirements of the BCA as allowed under Clause A2G1 are complied with. The analysis has been undertaken by qualitative and quantitative analysis and system assessments as allowed under Clause A2G2 of the BCA. Specific methodologies adopted in relation to the identified design issues are further detailed in the body of this report.

0.5 Fire Safety Philosophy

0.5.1 Basis of Fire Safety Strategy

Scientific Fire Services provides the following high-level summary of the fire and life safety strategy proposed for the building:

- The building is predominantly constructed from mass timber in the form of Cross Laminated Timber (CLT) floor and Glulam structural columns and beams with areas adopting concrete construction.
- It is proposed to expose substantial portions of the structural timber columns, beams and CLT soffit (where nominated).
- The proposed mass timber structure shall be designed to resist the impact of fire for a minimum duration of 120 minutes and as such the inherent fire resistance performance shall achieve no less than 120-minute resistance to fire;
- The building will be sprinkler protected throughout and automatic sprinkler systems are very effective at reducing the severity of fires in assembly building properties;

- The building is proposed to be protected throughout by an enhanced fire detection and alarm systems offering early occupant warning and fire brigade notification;
- The building is provided with multiple internal open stairways and a single fire stair. The fire stair core and elevator cores shall be constructed of traditional reinforced concrete construction methods;
- The ground level is provided with multiple egress pathways and exits and clear lines of sight to assist in occupant wayfinding. As such aggregate egress widths are compliant to the DtS provisions of the BCA and therefore prolonged queuing at exits is unlikely to occur.
- Fire services personnel shall be provided with the infrastructure to undertake their intervention activities. These include:
  - Fully Sprinkler protected building
  - Fire hydrant and sprinkler booster assembly

The overall fire safety philosophy is considered to be robust and includes fire resistant construction required to achieve adequate fire safety and structural integrity margins for evacuating occupants and attending fire services personnel to undertake evacuation and brigade intervention activities. Furthermore, the strategy includes early warning and detection and fire control suppression systems.

0.5.2 Structural Fire Design Philosophy

This PBDB has detailed the structural design philosophy and methodology to assess the timber structure (i.e. CLT and Glulam) with respect to fire resistance. The salient items are listed below:

- The building shall utilise methods and material of construction which will include a combination of CLT flooring system, structural Glulam beams and columns and concrete/masonry construction.
- The fire resistance period for the CLT floors and Glulam beams and columns shall be 120 minutes.
- CLT floor slabs shall be permitted to be predominantly exposed and encapsulated with fire rated plasterboard where nominated. Glulam columns and beams are permitted to be exposed.
- The fire resistance performance for the proposed CLT floor slabs shall be supported by an approved manufacturer with Australian testing certification in accordance with AS1530.4:2014 and/or a “Letter of Assessment” from a registered testing authority to achieve an FRL of 120 minutes
- From a design perspective either Eurocode 5: Design of Timber Structures – Part 1-2: General – Structural Fire Design (EN 1995-1-2:2004) and/or Timber structures – Fire resistance of timber elements (AS/NZS 1720.4 (2019)) shall be adopted for the structural design of the Glulam beams and columns. The methodology used to calculate the fire resistance period of the exposed Glulam elements shall be reduced cross section method to 120 minute duration for charring.
- Fire protection to steel connectors shall achieve 120 minutes which is consistent with the timber elements. Where steel plates/connectors are not fully within the Glulam element with a thickness at least equal to the charring depth, allowance should be made for additional fire protection to the steel via intumescent paint or spray fire protection.
- The structural design of the timber structure shall fulfil the requirements for structural robustness and progressive collapse.

0.6 Fire Safety Measures (Trial Design)

The Performance Solution for the subject building consists in part of some features which are included within the prescriptive provisions of the BCA and additional features which are specific to this building alone. The combination of these ‘DtS’ and additional fire safety system features comprises the ‘Performance Solution’ which form the basis of the trial design.

Unless otherwise stated the required fire safety systems for the subject building are to be designed and installed in accordance with the DtS provisions of the BCA and relevant referenced Australian Standards. Note the following list is considered to be a summary of the project specific fire safety features that form part of the proposed ‘Performance Solution’. It should be noted however that given the status of the PBDB in the fire engineering process, the following list is not exhaustive and may be subject to amendment pending resolution of the final fire safety engineering assessment process.

The proposed ‘Trial Design’ applicable to the subject building, which is to be the subject matter of this assessment, may be summarised as follows:

0.6.1 Fire Resistance and Type of Construction

Unless otherwise stated, the required passive fire resistance and fire separation measures for the subject building are to be designed and installed in accordance with the DtS provisions of the BCA and relevant referenced Australian Standards. The proposed fire resistance and compartmentations strategy is further detailed in the following sub-sections.

0.6.1.1 General

1. The building shall be constructed in accordance with Type A fire resisting construction however will utilise methods and material of construction which will include a combination of Cross Laminated Timber (CLT) floors, structural Glulam beams and columns and concrete/masonry construction; and
2. The main fire stair serving all building levels and lift shafts shall be constructed from traditional concrete construction and fire separated as per the DtS provisions of the BCA (minimum 120 minute FRL); and
3. The stairways that connects from The Ground Floor to Level 02 shall be constructed as a steel structure with timber inlays/coverings; and
4. It is proposed to assess the fire resistance performance of the mass timber loadbearing structural building elements such as CLT floor slab and Glulam columns and beams to achieve a minimum resistance to fire of 120 minutes; and
5. From a design perspective either Eurocode 5: Design of Timber Structures – Part 1-2: General – Structural Fire Design (EN 1995-1-2:2004) and/or Timber structures – Fire resistance of timber elements (AS/NZS 1720.4 (2019)) shall be adopted for the structural design of the Glulam beams and columns. The methodology used to calculate the fire resistance period of the exposed Glulam elements shall be reduced cross section method to 120-minute duration for charring; and

   Note: As previously advised the timber supplier is yet to be determined which will influence the structural fire design methodology.
6. Structural bracing elements are to achieve the same minimum FRL as the structural member being supported (minimum FRL 120 Minutes); and
7. It is proposed to expose (non-encapsulation) the Glulam beams and internal/external columns throughout the building; and
8. The fire resistance performance for the proposed CLT floor slabs shall be supported by an approved manufacturer with Australian testing certification in accordance with AS1530.4:2014 and/or a "Letter of Assessment" from a registered testing authority to achieve an FRL of 120 minutes. In the scenario where the CLT floor slabs are to be designed in accordance with a design standard all charring and fire resistance calculations must be carried out in accordance with the relevant standard/technical assessment guide; and

   Note: As previously advised the timber supplier is yet to be determined which will influence the structural fire design methodology.
9. The thickness of CLT floors shall be established by the CLT supplier based on the fire rating requirement stated herein. A minimum outer lamella thickness of 40mm shall be adopted for the CLT floor slabs; and
10. It is proposed to expose the underside of the CLT floor soffits throughout various parts of the building; and
    a. The following areas as shown in Appendix J are not permitted to be provided with an exposed CLT soffit or timber lining products attached to the CLT soffit such as timber panels/battens; and
    b. The nominated areas where CLT soffit is not permitted to be exposed or timber lining products attached to the CLT soffit such as timber panels/battens are not permitted, the CLT soffit shall be encapsulated with a single layer of 16mm fire rated plasterboard as described in Item 11. Any linings covering the fire rated plasterboard shall be of non-combustible construction; and
    c. All CLT soffits behind the suspended ceilings within the building shall be encapsulated with a single layer of 16mm fire rated plasterboard as described in Item 11; and

    **Draft note: With respect to the exposed CLT soffit within the Level 1 and 2 external terrace areas further information is required with respect to its function and use plus any bushfire assessments to understand any potential risks.*

    **Draft note: Architect to provide an updated set of architectural drawings illustrating the final location of exposed CLT soffits subject to the advice provided above.*
11. Where the CLT soffit is required to be encapsulated (TBC) the following shall be adhered to:
    a. The CLT floor slab (where required to be encapsulated) shall be encapsulated with a single layer of 16mm fire rated plasterboard to the underside of the slab soffit only. The minimum resistance to fire of 120 minutes to the floor slab shall be achieved by the CLT and fire rated plasterboard via a tested system; and
    b. The thickness of CLT floors shall be established by the CLT supplier based on the minimum fire rating requirement stated herein. A minimum outer lamella thickness of 40mm shall be adopted for the CLT floor slabs; and
    c. The method of encapsulation via the adoption of the fire rated plasterboard (i.e. 16mm) to cover the CLT floor slab is to ensure that the temperature at the interface between the protection system and the timber does not exceed 300°C for 30 minutes as determined under Specification S10C3 of Volume One of the BCA 2022. Direct fixed 16mm fire rated plasterboard to the underside of the CLT floor slab shall be fixed in accordance with the spacing requirements stated by the plasterboard manufacturer's specifications; and

12. Connections between timber elements (i.e. Glulam beams and internal/external columns) are either fully embedded in the timber at a depth established beyond the 120-minute charring calculation or encapsulated with fire rated plasterboard to achieve the required structural adequacy of 120 minutes where required; and
13. Generally, any fixings supporting building services shall ensure that the screw depths are long enough to penetrate into the second lamella of the Cross Laminated Timber member with a minimum depth of 60mm; and
14. As required, building materials, components and structures shall be suitably tested and approved to achieve the test criteria consistent with AS1530.1:1994 in order to satisfy the DtS provisions from Volume One of the BCA; and
15. As required, building elements and passive systems (requiring an FRL) shall be suitably tested to meet the test criteria consistent with the minimum requirements prescribed by the DtS provisions of the BCA and/or AS1530.4:2014. All building elements which require an FRL shall be designed, prefabricated and installed in accordance with the tested and approved prototype; and
16. All parts of the building must be constructed in an appropriate manner using materials that a fit for purpose as well as being provided with evidence of suitability with respect to fire resistance and fire hazard properties to the satisfaction of the building certifier; and
17. Where required, all components forming part of the external wall system serving the building shall be non-combustible in accordance with Clause C2D10 (1)(a) from Volume One of the BCA 2022 unless otherwise stated herein; and
18. Unless otherwise allowed (exposed mass timber), the fire hazard properties of the floor, wall and ceiling materials shall achieve compliance with the BCA Clause C2D11; and
19. All service penetration fire stopping methods through mass timber floor systems shall be in accordance with the following:
    a. All openings required for building services installations passing through a fire rated building element(s) (i.e. floors and walls) with respect to integrity or insulation or a resistance to the incipient spread of fire shall be appropriately sealed with a protection method at the penetration commensurate to the minimum requirements prescribed by the DtS provisions of the BCA and/or AS1530.4:2014; and
20. Should any openings and/or penetrations be proposed, the FRL of the penetrating wall/floor shall be reinstated commensurate with the FRL required for the building element. Appropriately tested fire stopping protection methods shall be proposed to the openings/penetrations.
21. As required, building elements and passive systems (120 minutes requiring under Performance Solution) shall be suitably tested to meet the test criteria consistent with the minimum requirements prescribed by the DtS provisions of the BCA and/or AS1530.4:2014. All building elements which require an FRL shall be designed, pre-fabricated and installed in accordance with the tested and approved prototype; and
22. Services cupboard doorways within the egress paths shall be non-combustible and fitted with medium temperature smoke seals.
23. The double volume gallery space on Ground Floor level (i.e. Level 00) shall be smoke separated from the remainder of the floor plate; and
24. The multi-purpose shall shall be constructed from traditional concrete and steel construction and fire separated as per the DtS provisions of the BCA; and
25. The multi-purpose hall shall comply with BCA Part I4 entertainment venue fire separation requirements; and
26. The lobby space at the Ground Floor level directly outside the fire stair shall be provided with smoke proof construction (refer to Figure 0.3) and as per the following:
    a. Smoke proof wall construction commensurate with the provisions prescribed in Specification 11 and shall extend to the underside of the intervening floor above; and
    b. Provide smoke doors to be self-closing and fitted with magnetic hold open devices designed to auto-release upon GFA and operation initiated by smoke detectors located 1.5m horizontal distance on each side of the doorways as per Specification 12 of the BCA. Smoke doors shall swing in the direction of egress or in both directions and door leaves shall be provided with medium temperature smoke seals; and

Figure 0.3: Smoke proof construction on ground floor

27. The stairway known as “Badanami Stair” connects four (4) consecutive levels (i.e. Level 00 to 03) without the requirement of fire separation throughout. The stairway shall be provided with the following:
    a. The stairway shall be constructed of steel construction (non-combustible); and
    b. This stairway is required to be fire separated between Level 02 and Level 03 via fire rated construction achieving a minimum FRL of 120 minutes achieved from both sides; and
    c. The remainder of the stairway from Level 00 to Level 02 is permitted to be open and provided with a smoke baffle bounding the stair at Level 02. The smoke baffle shall be fixed to the underside of the floor slab, extend a minimum of 500mm below the suspended ceiling line and be of non-combustible construction (i.e. glazed); and
28. The doorway separating the plant room and theatre corridor on Level 02 shall be self-closing and fitted with medium temperature smoke seals. The doorway shall be provided with signage on the corridor side only to note restricted access only (refer to Figure 0.4).

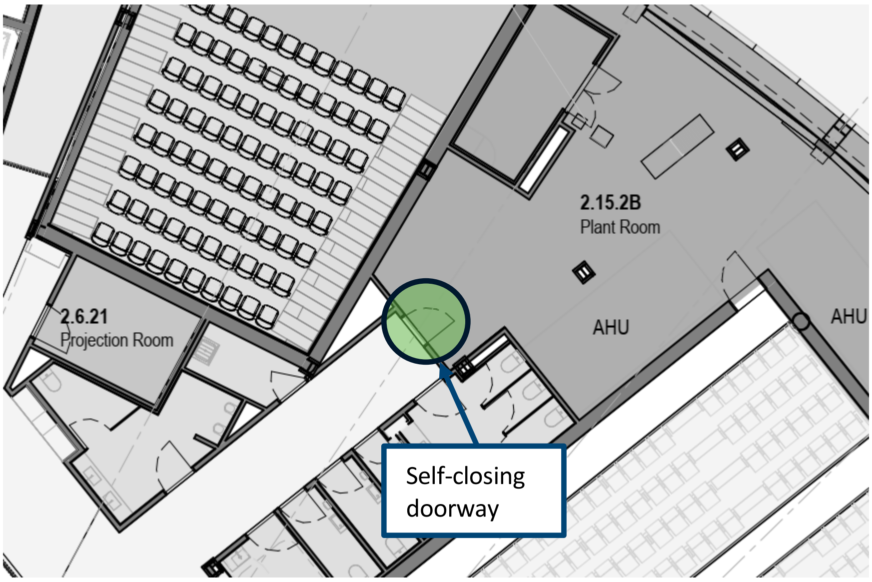


Figure 0.4: Self-closing doorway on Level 02 between corridor and plant room

0.6.1.2 Façade Construction

1. The external walls of the subject building is to be constructed in accordance with either Type A fire resisting construction unless otherwise stated herein; and
2. To prevent fire/smoke spread at the junction of the non-encapsulation CLT slab edge and the building façade the following requirements:
    a. The external cladding system (i.e. external façade) shall be a non-combustible material; and
    b. Insulation material proposed within the external shall be a non-combustible material (i.e. rockwool); and

    c. The CLT slab edge/façade gap shall be infilled with non-combustible mineral wool (e.g., Rockwool or similar equivalent). The mineral wool shall be mechanically fixed to the slab edge and/or supported via bracket that is mechanically supported; and
    d. A continuous galvanised steel panels/angle shall be installed on the upper and lower side of the CLT slab edge structure providing and barrier/seal to close the gap between the fire rated floor slab and external wall system junction in order to mitigate fire/smoke spread between levels via the façade interface. The galvanised steel plate shall be suitably sealed by an applied fire rated sealant application (sealant to achieve a fire resistance of 120 minutes); and
    e. The sarking material associated with the external wall system shall be in accordance with the requirements detailed in Specification 7 of Volume One of the BCA 2022. The sarking material is deemed to be non-combustible material by BCA 2022 such that it does not exceed 1mm in thickness and have a Flammability Index not greater than 5 (as per AS1530.2:1993); and
3. Where internal Glulam columns are being fixed into the external walls, the fixings/screws into the internal Glulam columns are required to be beyond the char depth for the particular exposed timber element. Since the Glulam internal column is required to achieve an inherent fire resistance of 120 minutes, the fixings should be located beyond the char depth for 120 minutes; and
4. Where required for this building (i.e. wall and floor junctions) under DtS provisions, cavity barriers shall be installed in accordance with Specification 9 of Volume One of the BCA 2022; and
5. It is proposed to permit the building to be located within 6m of the existing Central Energy Plant building on the same allotment.

   **Draft Note: Architect to confirm if the CEP plant has to be a certain distance from other buildings on the same allotment due to authority requirements.*

0.6.2 Occupant Egress Provisions

1. The proposed building shall be provided with three (3) stairways. In general, the emergency fire egress design appears to be adequate for the university building; and
2. Any storage rooms or enclosures located below the stairways serving the building shall comply with Clause D3D9 of the BCA; and
3. It is proposed to permit the exit travel distances to a point of choice or an exit to be as per the following:
    a. Level 1
        i. 28m to a point of choice in lieu of 20m; and
    b. Level 1 Plant room
        i. 27m to a point of choice in lieu of 20m; and
        ii. 50m to an exit in lieu of 40m; and
    c. Level 2
        i. 28m to a point of choice in lieu of 20m; and
    d. Level 2 Plant Room/Catwalks
        i. 22m to a point of choice in lieu of 20m; and
        ii. 47m to an exit in lieu of 40m; and
    e. Level 3
        i. 28m to a point of choice in lieu of 20m; and
4. The non-fire-isolated stair serving Level 3 and ladder serving the Level 2 plant room is permitted to not have a continuous path of travel from the storey served to the level of discharge; and
5. It is proposed to permit the occupants within the theatre catwalk which is not a plant room and is greater than 200m^2 to utilise the plant room ladder for egress on Level 2 only; and
6. It is proposed to permit the fire stair serving all levels of the building to discharge internally on Ground Level in lieu of a road or open space; and
7. Provide an additional doorway which connects the Level 02 catwalk spaces directly to the Level 02 plantroom; and
8. The double volume gallery space on ground level (i.e. Level 00) shall be served with a total aggregate egress width which is double the requirement for the proposed occupant loading (i.e. for 100 occupants is 1m as such provide 2m in total aggregate egress width from the gallery space); and
9. The doorway serving the double volume gallery space on ground level (i.e. Level 00) shall swing in the direction of egress; and

0.6.3 Fire Services and Equipment

0.6.3.1 General Requirements

Unless otherwise stated the required fire safety systems for the subject building are to be designed and installed in accordance with the DtS provisions of the BCA and relevant referenced Australian Standards. The fire safety system features which are specific to the Performance Solution proposed for this building are:

1. The main Fire Indicator Panel (FIP) shall be located within the main entry to the welcome foyer on the south side of the building; and
2. A fire hydrant system shall be provided which is designed and installed in accordance with Clause E1D2 of the BCA and AS2419.1:2021 with the inclusion of the following:
   a. Permit the fire hydrant booster assembly serving the building to be located in a position that is not within sight of the main entry of this new building.

   **Draft note: Fire services consultant to confirm any deviations to the fire hydrant system*
3. Couplings in the fire hydrant system (including fire hydrant booster assembly) shall be compatible with those of the fire appliances and equipment used by Fire and Rescue NSW. Fire hydrant booster assembly connections and all fire hydrant valves shall be fitted with Storz aluminium alloy delivery couplings manufactured and installed in accordance with Clause 9.3.1 and Clause 9.4 and AS2419.1-2021; and
4. Block plans are to be provided at the main Fire Indicator Panel (FIP), sprinkler booster assembly and fire hydrant booster assembly serving the building in accordance with AS2419.1:2021 and the FRNSW Tactical Fire Fight Plans Guideline (Policy number 6, Version 02); and
   a. The block plan should be orientated to reflect the aspect of the installation as it is presented to the reader; and
   b. The block plan at the fire hydrant and sprinkler booster assembly serving the building shall show the path of travel fire crews will need to take to reach the building; and
5. The following locations shall be denoted by a red strobe light that is set to activate upon General Fire Alarm (GFA):
   a. Proposed sprinkler booster assembly serving the building; and
   b. Proposed fire hydrant booster assembly serving the building; and
   c. Main/principal building entrance containing the main FIP; and
6. Fire hose reel system shall be designed and installed in accordance with Clause E1D3 from Volume One of the BCA and AS2441:2005; and
7. Portable fire extinguishers in accordance with BCA Clause E1D14 and AS2444:2001 within the building; and
8. Emergency lighting throughout shall be designed and installed in accordance with AS2293.1:2018; and
9. Exit signs and directional exit signs are to be installed throughout the buildings in accordance with BCA Clauses E4D4, E4D5 and E4D8 of Volume One of the BCA and AS2293.1:2018 unless otherwise stated herein.

0.6.3.2 Automatic Suppression Systems

The entire development shall be protected by automatic suppression systems. The following design parameters are proposed/noted:

1. Automatic sprinkler protection throughout suitably designed and installed appropriate to the building classification and occupancy hazard in accordance with AS2118.1:2017; and
   a. The building shall adopt Ordinary Hazard 3 sprinkler hazard classification as required in accordance with AS2118.1:2017; and
2. Automatic sprinkler protection throughout the building suitably designed and installed appropriate to the building classification and occupancy hazard in accordance with AS2118.1:2017 incorporating fast response sprinkler heads within internal spaces with an activation temperature rating of 68°C and an RTI of no more than $50m^{0.5}s^{0.5}$; and
3. Automatic sprinklers shall be installed to the external under-croft area with activation temperature ratings and RTI's suitable prescribed appropriate to the external environment. The services consultant should make allowance for sprinkler head protection in consideration of the possible damage to sprinkler heads; and

0.6.3.3 Fire Detection and Alarm System Requirements

The automatic smoke detection and alarm systems shall be installed throughout in order to provide occupants with early warning/detection of fire to allow occupants to initiate emergency evacuation plans. The following design parameters are proposed/noted:

1. Smoke detection and alarm systems are to be installed in accordance with Specification 20 and AS 1670.1:2018 throughout with smoke detectors located at a spacing of 10mx10m in accordance with Section 5; and
2. The fire detection and alarm system shall be an addressable system such that the precise smoke detector activated, and subsequent location of the fire can be identified at the Fire Indicator Panel (FIP); and

3. An Emergency Warning and Intercom System (EWIS) shall be provided throughout the development in accordance with Clause E4D9 of the BCA and AS1670.4:2018; and
4. Installations activating the EWIS shall also be connected to a fire alarm monitoring system connected to a fire station or fire station dispatch centre in accordance with AS1670.3:2018; and
5. All installations initiating a General Fire Alarm shall be monitored through an approved monitoring agency as required by the DtS provisions of the BCA; and
6. Provide an alarm horn sounder & strobe light which is readily visible from the most remote travel distance location. The sounder/strobe shall be interconnected into the EWIS and set activate upon General Fire Alarm (GFA). The alarm horn sounder & strobe light shall be provided within the following locations (refer to Figure 0.5 to Figure 0.7):
    a. Level 1 Plant Room; and
    b. Level 2 Plant Room/Catwalks; and
    c. Level 3 Communal area; and

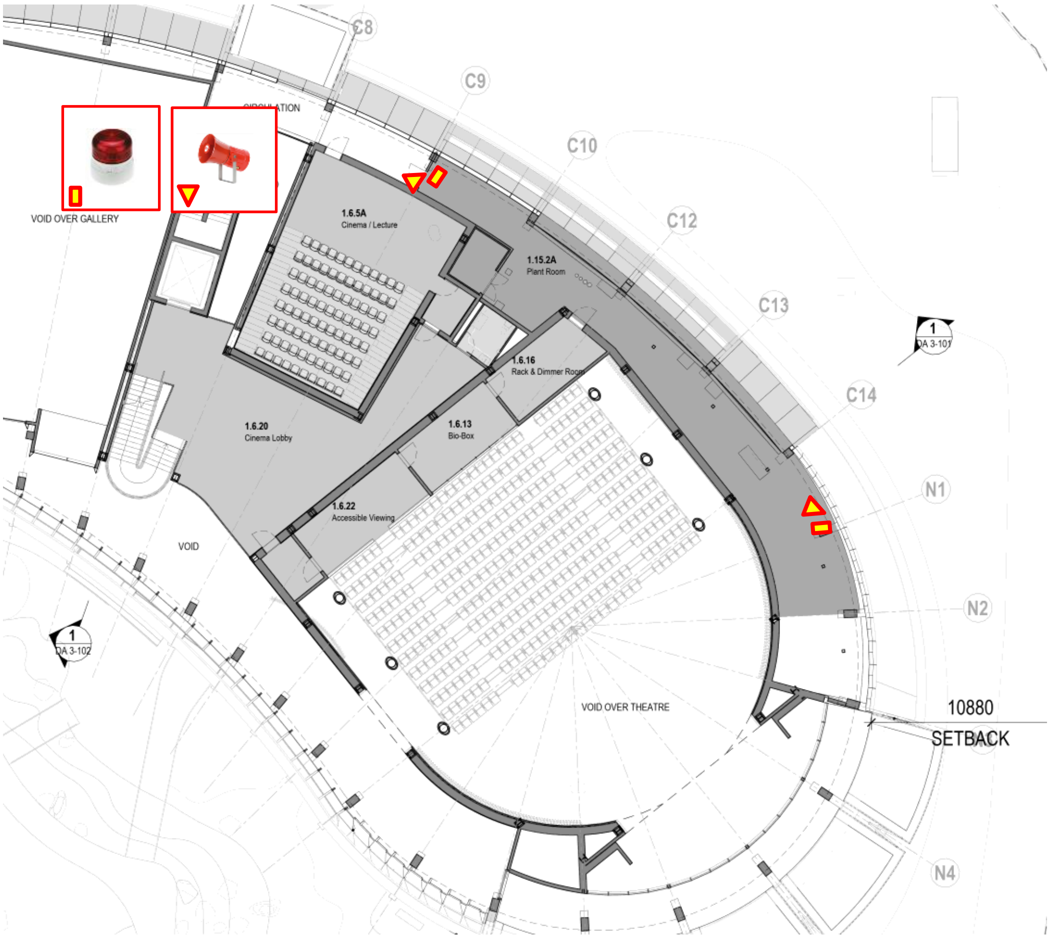


Figure 0.5: Enhanced notification within Level 1 Plant Room

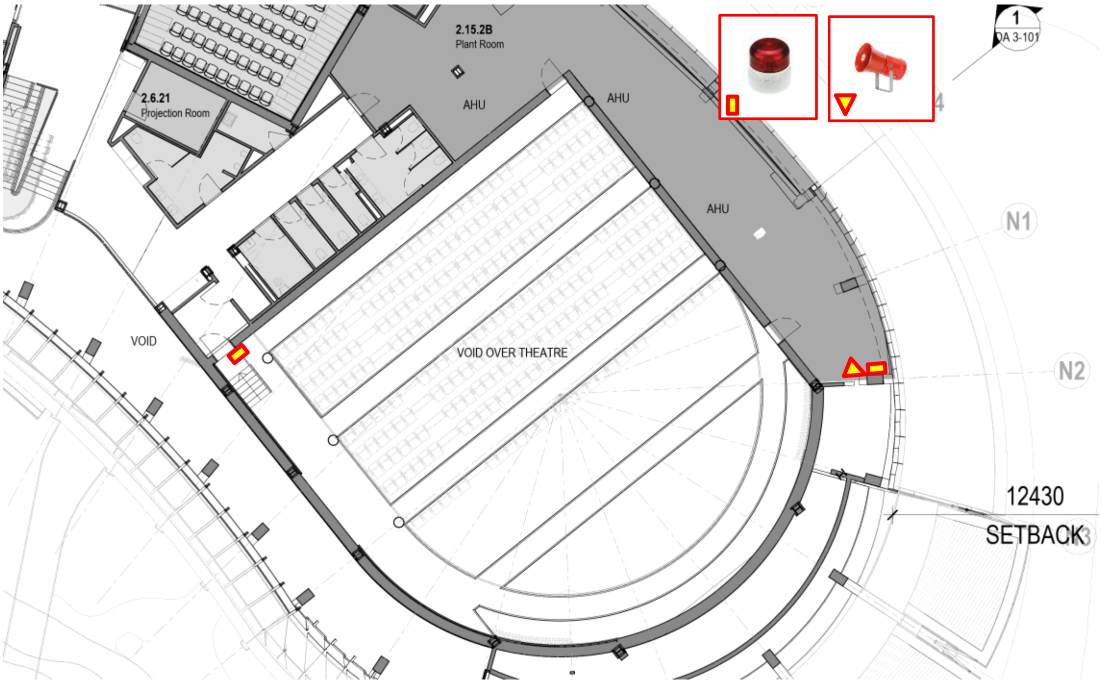


Figure 0.6: Enhanced notification within Level 2 Plant Room/Catwalks

Figure 0.7: Enhanced notification within Level 3

7. A fire alarm/evacuation matrix has been developed for the subject building(s) in order to ensure effective evacuation is achieved. Active Dynamic Signage System (ADSS) shall be installed outside the stairways providing egress on Level 3 of the building to enhance occupant wayfinding and direct occupants to a safe egress path. The system shall comprise intelligent exit signage which shall be programmed based on GFA (i.e. sprinkler or detector activation) signal location and further detailed below (refer to Figure 0.8, Figure 0.9 and Table 0.3):
   a. Should a fire initiate within Level 00-02, the ADSS exit signage shall direct occupants evacuating Level 03 to the primary fire stair (i.e. FS1) only; and
   b. Should a fire initiate within Level 03, the ADSS exit signage shall direct occupants evacuating Level 03 to both stairways (i.e. FS1 and FS02); and

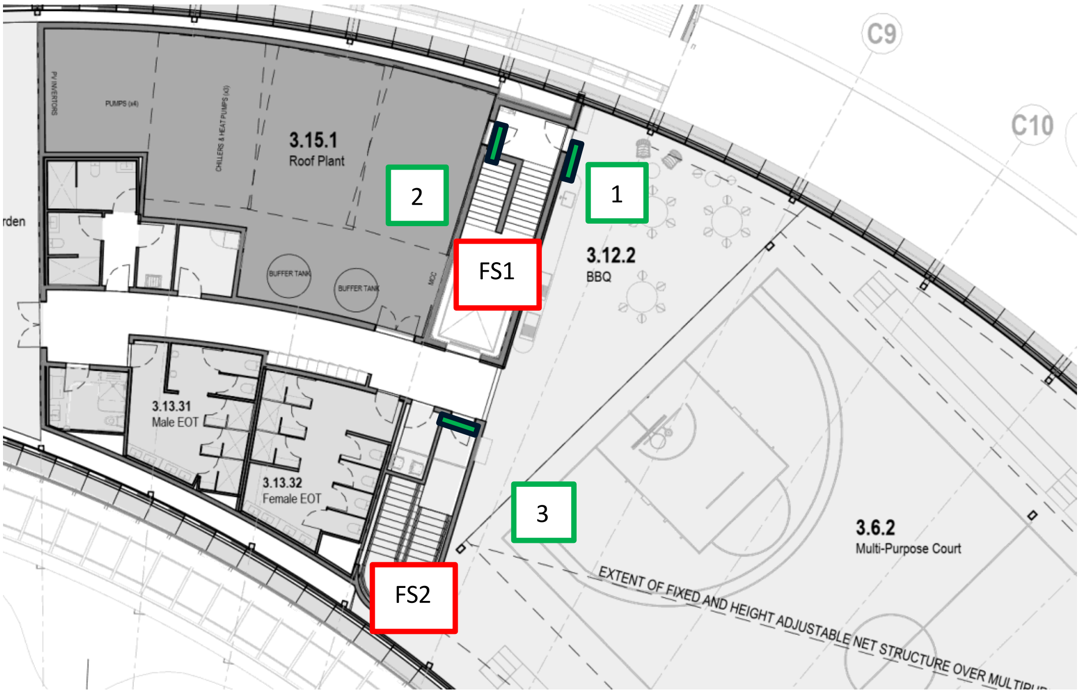


Figure 0.8: ADSS Signage Location on Level 3

c. Dynamic **GREEN** exit sign. In fire mode, the exit sign shall flash **GREEN**.
   i. The **GREEN** flashing lights are intended to alert occupants and assist occupant decision making with respect to safe egress direction to an exit (refer to Figure 0.9); and

d. Dynamic **RED X** exit sign. In fire mode, the exit sign shall flash **GREEN** or **RED X**, depending on fire location.
   i. The **GREEN** flashing lights are intended alert occupants and assist occupant decision making with respect to safe egress direction to an exit (refer to Figure 0.9); and
   ii. The **RED X** flashing lights are intended alert occupants and assist occupant decision making with respect to seeking alternative exits and preventing occupants from travelling in the direction of the fire (refer to
   iii. Figure 0.9).

Figure 0.9: Example of Dynamic GREEN exit sign (Courtesy of CleverEVAC.com.au)

Table 0.3: ADSS Activation Matrix

Fire Alarm Zone	Sign 1	Sign 2	Sign 3
Level 00-Level 02	Green	Green	Red X
Level 03	Green	Green	Green

0.6.3.4 Smoke Hazard Management Requirements

1. The theatre located on Level 00 shall be provided with an automatic mechanical smoke hazard management system in accordance within NSW E2D16 and Specification 21 (including Figure S21C2); and
2. The gallery located on Level 00 is within a building/fire compartment containing a floor area greater than 3,500m^2, as such a smoke exhaust system is required. In this instance, it is proposed to permit the omission of the required smoke exhaust system to the gallery/exhibition areas on Level 00; and
3. Automatic shutdown of mechanical systems in accordance with the requirements of AS/NZS 1668.1:2015; and

4. In accordance with BCA Clause E2.2, air-handling system which does not form part of a smoke hazard management system in accordance with Table E2.2a or Table E2.2b and which recycles air from one fire compartment to another fire compartment or operates in a manner that may unduly contribute to the spread of smoke must:
    a. Incorporate smoke dampers where the air-handling ducts penetrate any elements separating the fire compartments served; and
    b. Be arranged such that the air-handing system is shut down and smoke dampers are activated to close automatically by smoke detectors complying with Clause 7.5 of AS 1670.1:2018; and

0.6.4 Management in Use Requirements

1. Maintain paths of travel to an egress, stair entrances, vehicular access ramp, thoroughfares and lobby areas free of static storage and combustible materials at all times; and
2. Smoking shall not be permitted within the public areas of the building; and
3. All fire safety measures and Management in Use requirements shall be incorporated into an Essential Safety Measures list. All fire safety measures shall be maintained in accordance with the requirements of AS1851 (or equivalent maintenance standard) as identified by Scientific Fire Services. Management in Use requirements shall be inspected and logged on an annual basis; and
4. A Fire Safety manual and emergency evacuation procedure should generally be in accordance with the principles set out in the AS3745; and
5. Evacuation plans illustrating the exit routes and locations shall be installed within all levels within the building.
    a. Emergency evacuation plans shall highlight the location of the ladders which serve the catwalk and plant room areas on Level 02 which are to be used for evacuation.

0.7 Brief Statement on Acceptability of Proposed Performance Solution

The basis of the following assessment, conditions, methodologies and acceptance criteria, the general and specific objectives, relevant hazards, preventative measures, the proposed trial design etc. are however, considered to be detailed within this report. The above requirements are not limiting. Schedules and records must be in accordance with AS1851-2012. There shall be evidence of all inspection whether maintenance was required or not. It is drawn to the client’s attention that if this maintenance is not undertaken as per these instructions, they may be fully liable to legal responsibilities and without the cover of insurance.

1. Introduction

1.1 General

This Performance Based Design Brief (PBDB) has been prepared by SFS Australia Pty Ltd T/A Scientific Fire Services (SFS) on behalf of Jackson Clements Burrows. The PBDB is a Performance-based Design Brief that deals specifically with matters relating to fire safety in buildings. The PBDB details the fire safety engineering assessment process and methodologies to be undertaken on the proposed Building Solution of Western Sydney University – Indigenous Centre of Excellence NSW.

The Building Solution, and in particular the Performance Solution components, described in this PBDB do not necessarily reflect the final design of the building nor its fire safety systems This document has been prepared at the stage of the design process where it is considered appropriate to undertake a fire safety engineering analysis. The purpose of the PBDB, prepared by the Fire Safety Engineers with appropriated input from the design team and relevant authorities, is to provide the stakeholders in the project with the proposed assessment methodologies to be used and justification for the assessment approach to be adopted. Subject to their acceptance of the PBDB, or its modified form, the fire safety engineering assessment will be conducted in the manner described.

The client is to ensure that all the necessary stakeholders have been identified and included in the PBDB development process as appropriate.

All stakeholders should be aware of the qualifying statements, which are included in the PBDB, which are applicable to any subsequent fire safety engineering assessment and report.

The Building Solution and the fire safety measures for the building described in this PBDB are subject to change and therefore not to be relied upon. No responsibility will be accepted for any losses or damages arising from construction or related activity based upon the contents of this PBDB.

The project is located at 171 Victoria Road, Parramatta NSW and can be described as being comprised of the following BCA classifications.

Occupancy Use	BCA Building Classification
Public Hall, Auditorium & Art Gallery	Class 9b (Public Assembly)

The Building Solution proposed for this project, which is required to comply with the Performance Requirements of the National Construction Code 2022, Vol. 1, Building Code of Australia (BCA) (ABCB 2022), is a combination of Performance Solution and Deemed-to-Satisfy Solution elements in accordance with Clause A2G2(4) of the BCA.

The fire safety engineering assessment process, methodologies employed and reporting are to generally conform to the Australian Fire Engineering Guidelines (AFEG)(ABCB 2021).

1.2 Supporting Documentation

The assessment to be carried out as described in this PBDB has been based on the referenced drawings prepared by Jackson Clements Burrows. The drawings to which the assessment applies are listed in Appendix A - A.1.

The project issues, the proposed Building Solution and the intended assessment methodologies will be submitted to and discussed with the relevant Fire Authority where warranted. Their comments and responses arising from these consultations will be contained in the subsequent Fire Safety Engineering Report (FSER).

Documentation from the Building Certifier/Building Code Consultant identifying issues in regard to the proposed project design relevant to the fire safety engineering assessment are included in Appendix C.

1.3 Scope

1.3.1 Regulatory Framework

The National Construction Code is a uniform set of technical provisions for the design and construction of buildings and other structures and plumbing and drainage systems throughout Australia. It allows for variations in climate and geological or geographic conditions.

The BCA is given legal effect by building regulatory legislation in each State and Territory. This legislation consists of an Act of Parliament and subordinate legislation that empowers the regulation of certain aspects of buildings and structures and contains the administrative provisions necessary to give effect to the legislation.

Each State and Territory's legislation adopts the BCA subject to the variation or non-requirement of some of its provisions, or the addition of extra provisions. These provisions are contained in Appendices to the BCA.

Any provision of the BCA may be overridden by, or subject to, State or Territory legislation. The BCA must therefore be read in conjunction with that legislation.

In accordance with BCA Clause A2G2, a Performance Solution must comply with the BCA.

(1) A *Performance Solution* is achieved by demonstrating—
  (a) compliance with all relevant *Performance Requirements*; or
  (b) the solution is at least *equivalent* to the *Deemed-to-Satisfy Provisions*.

(2) A *Performance Solution* must be shown to comply with the relevant *Performance Requirements* through one or a combination of the *Assessment Methods:*
  (a) Evidence to suitability in accordance with Part A5 that shows that the use of a material, a product, *plumbing* and *drainage product*, form of construction or design meets the relevant *Performance Requirements*.
  (b) A *Verification Methods* including the following—
    i. The *Verification Methods* provide in the NCC.
    ii. Other *Verification Methods* accepted by the *appropriate authority* that show compliance with the relevant *Performance Requirements*.
  (c) *Expert Judgement*.
  (d) Comparison with the *Deemed-to-Satisfy Provisions*.

(3) Where a *Performance Requirements* is satisfied entirely by a *Performance Solution*, in order to comply with (1) the following method must be used to determine the *Performance Requirement* or *Performance Requirements* relevant to the Performance Solution:
  (a) Identify the relevant *Performance Requirements* from the Section or Part to which the *Performance Solution* applies.
  (b) Identify *Performance Requirements* from other Sections or Parts that are relevant to any aspects of the *Performance Solution* proposed or that are affected by the application of the *Performance Solution*.

(4) Where a *Performance Requirements* is proposed to be satisfied by a *Performance Solution*, the following steps must be undertaken:
  (a) Prepare a *performance-based design brief* in consultation with relevant stakeholders.
  (b) Carry out analysis, as proposed by the *performance-based design brief*.
  (c) Evaluate results from (4)(b) against the acceptance criteria in the *performance-based design brief*.
  (d) Prepare a final report that includes—
    i. all *Performance Requirements* and/or *Deemed-to- Satisfy Provisions* identified through A2G2(3) or A2G4(3) as applicable: and
    ii. identification *Assessment Methods* used; and
    iii. details of steps (4)(a) and (4)(c); and
    iv. confirmation that the *Performance Requirements* has been met; and
    v. details of conditions or limitations, if any exist, regarding the *Performance Solution*.

1.3.2 Australian Fire Engineering Guidelines

The AFEG document has been created for the purpose of providing guidance to experienced fire safety practitioners in the process and methodologies needed to demonstrate that a Performance Solution complies with the Performance Requirements.

AFEG is widely recognised as the appropriate document to be used as the basis of fire safety engineering assessments in Australia and other jurisdictions.

Since AFEG is a guideline document, the processes and methodologies adopted in an assessment may vary from those described in AFEG. However, any PBDB and FSER documents prepared for a project should incorporate the essential information alluded to in AFEG.

1.3.3 General Objectives

The building regulatory objectives, though not explicitly stated in the BCA, are concerned with the issues of occupant life safety, fire services ability to perform their necessary tasks and protect adjoining properties. It is accepted that these objectives are satisfied by a Building Solution meeting the relevant Performance Requirements of the code.

The Fire Authority objectives are enshrined in State or Territory legislation. However, where appropriate, the Performance Requirements in BCA require consideration of fire brigade intervention in the assessment process. In undertaking the appropriate assessment of fire brigade intervention and showing compliance with the Performance Requirements, it can be taken that the objectives of the Fire Authority will be met.

SFS have not been advised of any additional regulatory objectives that are required to be considered during the assessment process for this project.

1.3.4 Client Objectives

The client has not identified any additional objectives for this project over and above those arising from the provisions of the BCA.

1.4 Stakeholders

The parties included in Table 1.1 have been identified as relevant stakeholders in this project.

The preparation of the PBDB involves a consultative process. Input and collaboration has been sought from appropriate stakeholders as required.

Table 1.1: Stakeholders

Role	Company/Organisation	Representative
Client	Western Sydney University	TBC
Architect	Jackson Clements Burrows	Will Christian
Building Certifier	TBC	TBC
BCA Consultant	BM+G	Rick Beardwood Hayden Green
Fire Authority	Fire & Rescue New South Wales (FRNSW)	TBC
Fire Safety Engineers	SFS Australia Pty Ltd	Russell Kilmartin Kapilan Sarma
Fire Services Engineer	WSCE Pty Ltd	TBC
Structural Engineer	TTW	TBC

1.5 Role of Scientific Fire Services

AFEG recognises that the fire engineering process may be considered to be used for two purposes, namely in the design of fire safety systems and components or, in the evaluation of a given fire safety system or systems. In the former case, experienced fire safety engineers may contribute to the project design process by assisting in the development and selection of effective and efficient fire safety systems. Once the design process has progressed to the point where a possible Building Solution has been developed, the fire safety engineer may then undertake the assessment of the proposed design in the manner prescribed by AFEG.

The above process is considered to be consistent with the 'application of the process' defined in the AFEG document.

In this project, Scientific Fire Services have not been involved in any aspect of the detailed design in the preparation of the Building Solution to be offered for assessment.

1.6 Qualifying Statements

1. This PBDB relates to the design detailed in the referenced drawings identified in Appendix A - A.1. These drawings have been relied upon to be an accurate representation of the project buildings.
2. Scientific Fire Services has relied on the Building Certifier/BCA consultant to identify all the issues of non-compliance with the Deemed-to-Satisfy provisions of the BCA. Apart from these design issues, listed in this PBDB, it is taken that the proposed design meets all other Deemed-to-Satisfy provisions. It is also considered that all other regulatory requirements have been met unless these have been specifically identified for assessment.

3. Where a building has previously included a Performance Solution it is presumed, unless specifically identified otherwise, that the prior Performance Solution has been appropriately approved.
4. Unless otherwise stated, the assessment will not address any issues that are outside the requirements of the BCA.
5. The outcomes of any assessment of the Building Solution subsequently reported in the FSER will not apply to any other parts of the building not included in the assessment, nor to any other building projects unless so identified by Scientific Fire Services.
6. The fire safety engineering assessment methodologies will be based on the assumption of a single ignition and fire source, which is the expectation of a natural fire start. The assessment will not consider multiple fire start scenarios arising from arson or other such events such as bushfire.
7. Analysis of emergency incidents such as bomb threats or other such occurrences, requiring partial or total evacuation of the building will not form part of this assessment.
8. The provisions for fire safety in this building, as incorporated into the Building Solution, will be assessed purely from the perspective of fire safety and their usage under any other circumstances is beyond the scope of this assessment.
9. Unless it has been specifically identified as an issue to be considered, the assessment will not include any consideration of losses arising directly or indirectly from a fire in respect of buildings, contents, business interruption, environmental damages or other consequential losses
10. The assessment to be undertaken for this project will be concerned only with the final completed and functional building. The assessment will not address any issues arising during construction, partial usage, renovation or demolition unless these aspects have been specifically identified for assessment.
11. The fire safety assessment to be undertaken will be based entirely on the usage of the building/tenancy as described in the PBDB. Any subsequent deviation from the usage as described will render any assessment invalid until a review by a qualified Fire Safety Engineer has been carried out.
12. Issues associated with workplace Occupational Health and Safety will not be considered as part of this fire safety assessment.
13. No liability is accepted for the accuracy of the documents and drawings supplied upon which this PBDB and subsequent FSER is based.
14. Fires involving explosive components will not form part of the subsequent assessment.
15. The storage, usage, handling and transport of any listed Dangerous Goods in this facility will not be considered in the subsequent fire safety assessment undertaken. It is presumed that all such matters relating to Dangerous Goods will be dealt with in accordance with all relevant regulations and by appropriate consultants.
16. SFS has no role or responsibility in the use and management of the facility.

2. Building Description and Occupant Profiles

2.1 Building Description

The subject site is located within WSU South Parramatta Campus, whereby it is proposed to construct a new tertiary education building to serve the growing WSU campus at 171 Victoria Road, Parramatta NSW. The site is bounded by Victoria Road to the north, Railway Street to the east, Fifth Street to the south, which serves as the principal site entry, and Bridge Street to the west (Refer to Figure 2.2). The development shall also be accessible via the newly constructed Yallamundi Light Rail station, which is currently awaiting operation. The site is noted to currently comprise a hardstand area for carparking and the existing Central Energy Plant, the latter of which is to remain unaffected by the proposed works. With respect to the car parking areas serving this building, it is proposed to maintain the 13 spaces on the existing P1 car park site, introduce 107 spaces to the new western car park on the western side of Bridge Street and introduce 181 spaces to the new eastern car park on the southern side of Fifth Street.

Figure 2.1: Site locality within the WSU South Parramatta Campus (Image courtesy of Near map/Ethos Urban)

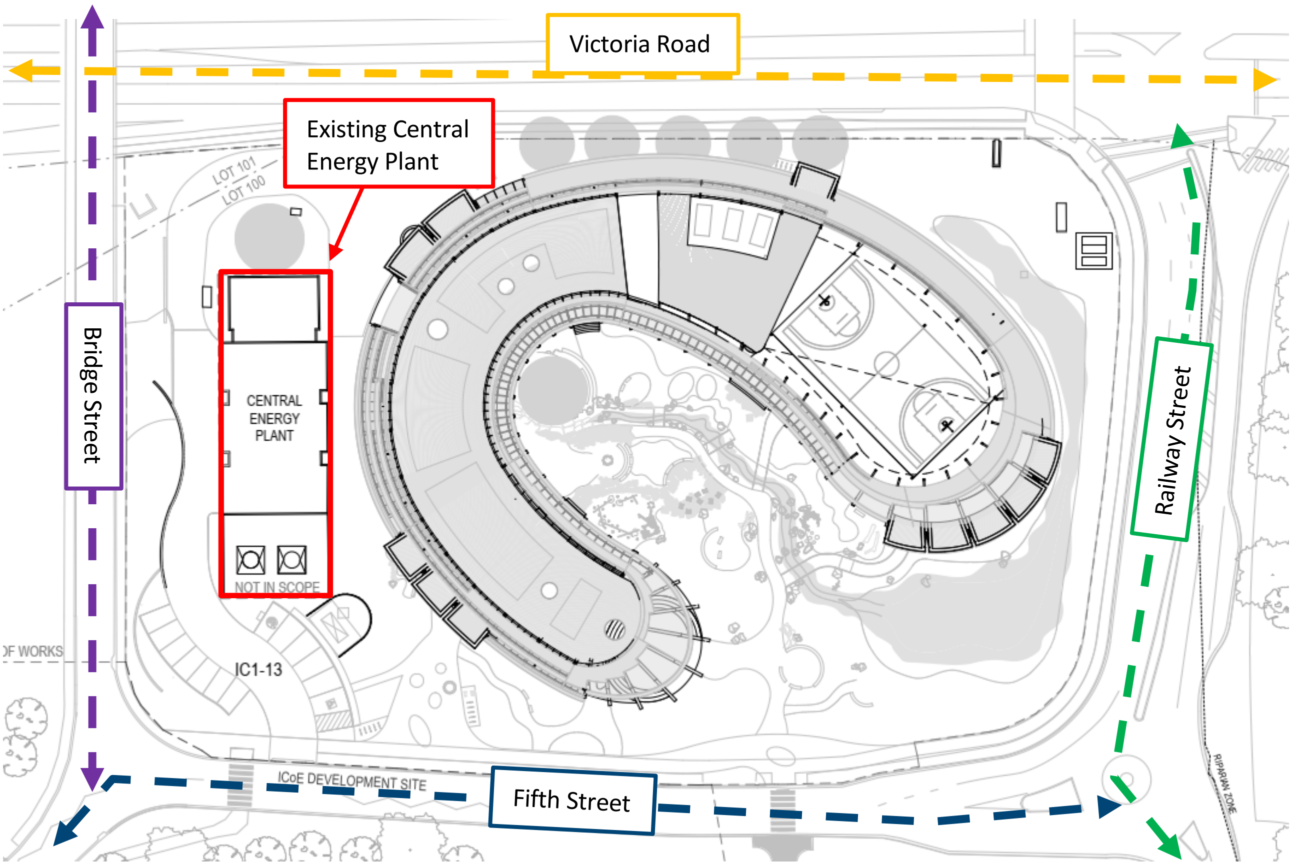
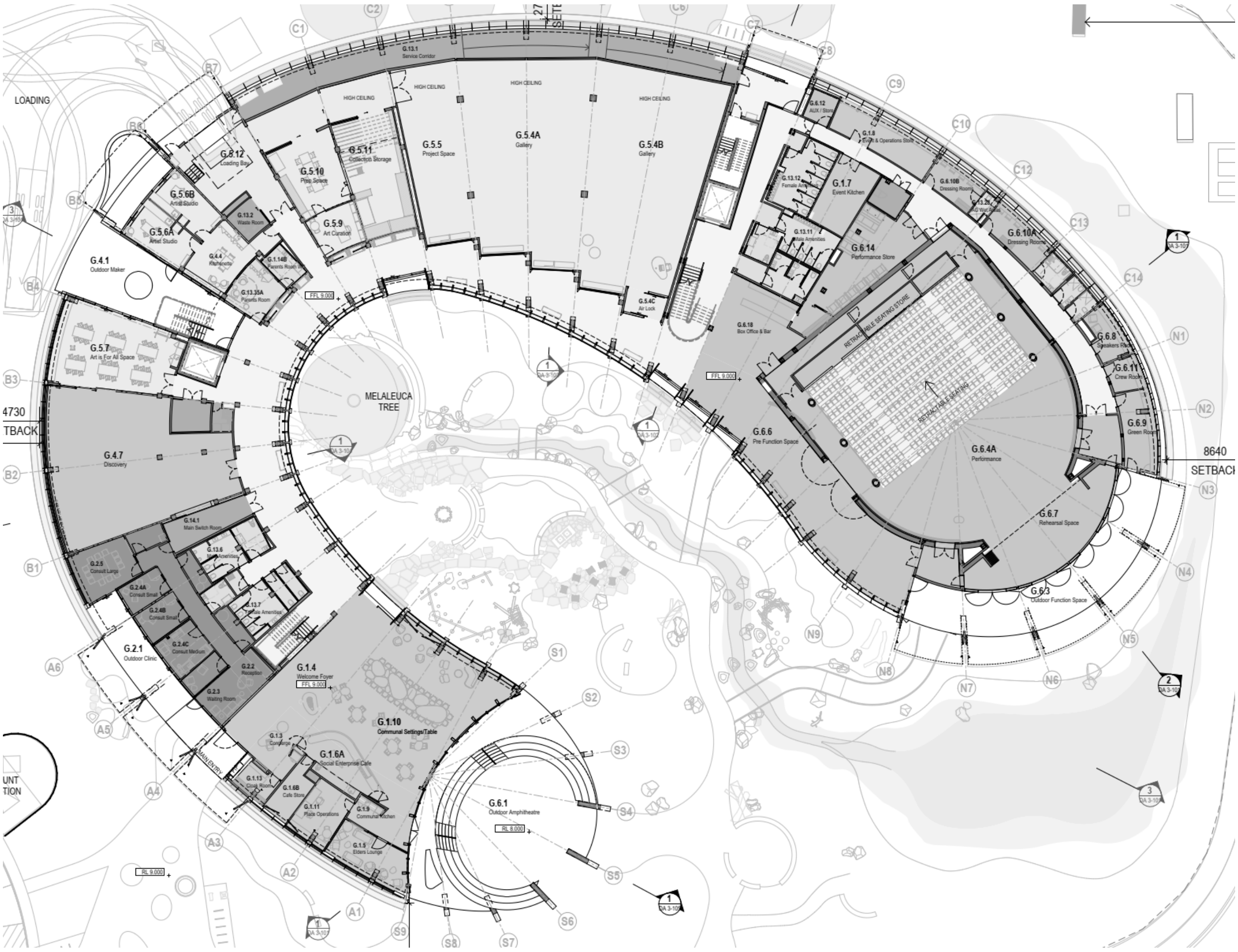


Figure 2.2: Site Plan

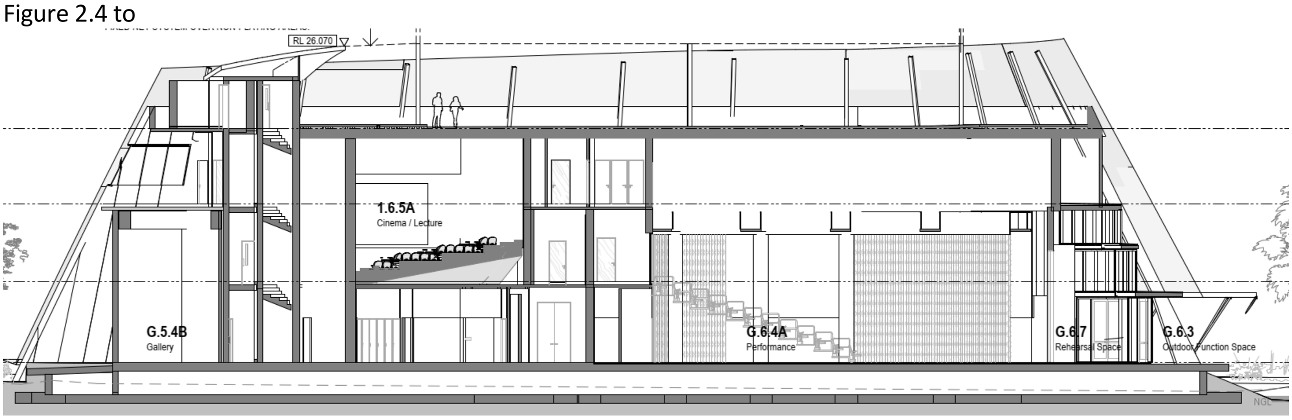
Figure 2.3: Artist impressions of the Indigenous Centre of Excellence (indicative only)

The proposed works entail the construction of a four (4) storey building, named the Indigenous Centre of Excellence, which is noted to incorporate extensive timber construction. The new development shall mainly consist of Class 9b facilities, most notably an outdoor amphitheatre, a gallery and a triple height theatre on Ground Floor. Further Class 9b facilities housed in the building include a cinema/lecture hall, various study/learning spaces and a rooftop recreational area comprising a garden and a sports court. Additionally, the building shall contain Class 5 office spaces, mainly concentrated on Ground Floor and Level 2.



Stairways Outdoor Spaces Amenities Art Studios & Workshop Spaces Art Gallery Office Spaces Public Spaces Theatre & Cinema Spaces

Figure 2.4 to



Stairways Outdoor Spaces General Learning & Study Spaces Amenities Art Gallery Theatre & Cinema Spaces

Figure 2.8 illustrate the planned building layout.

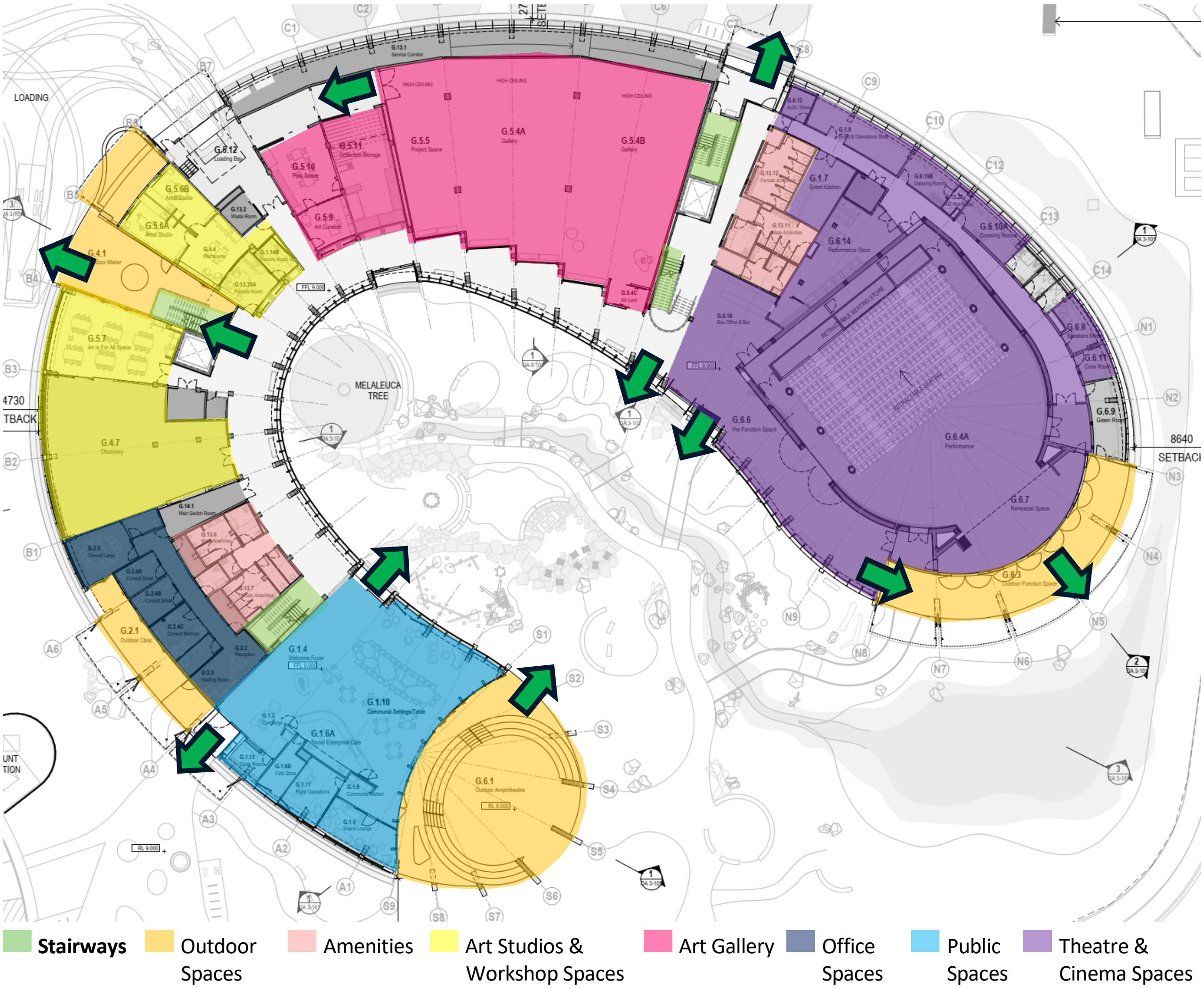
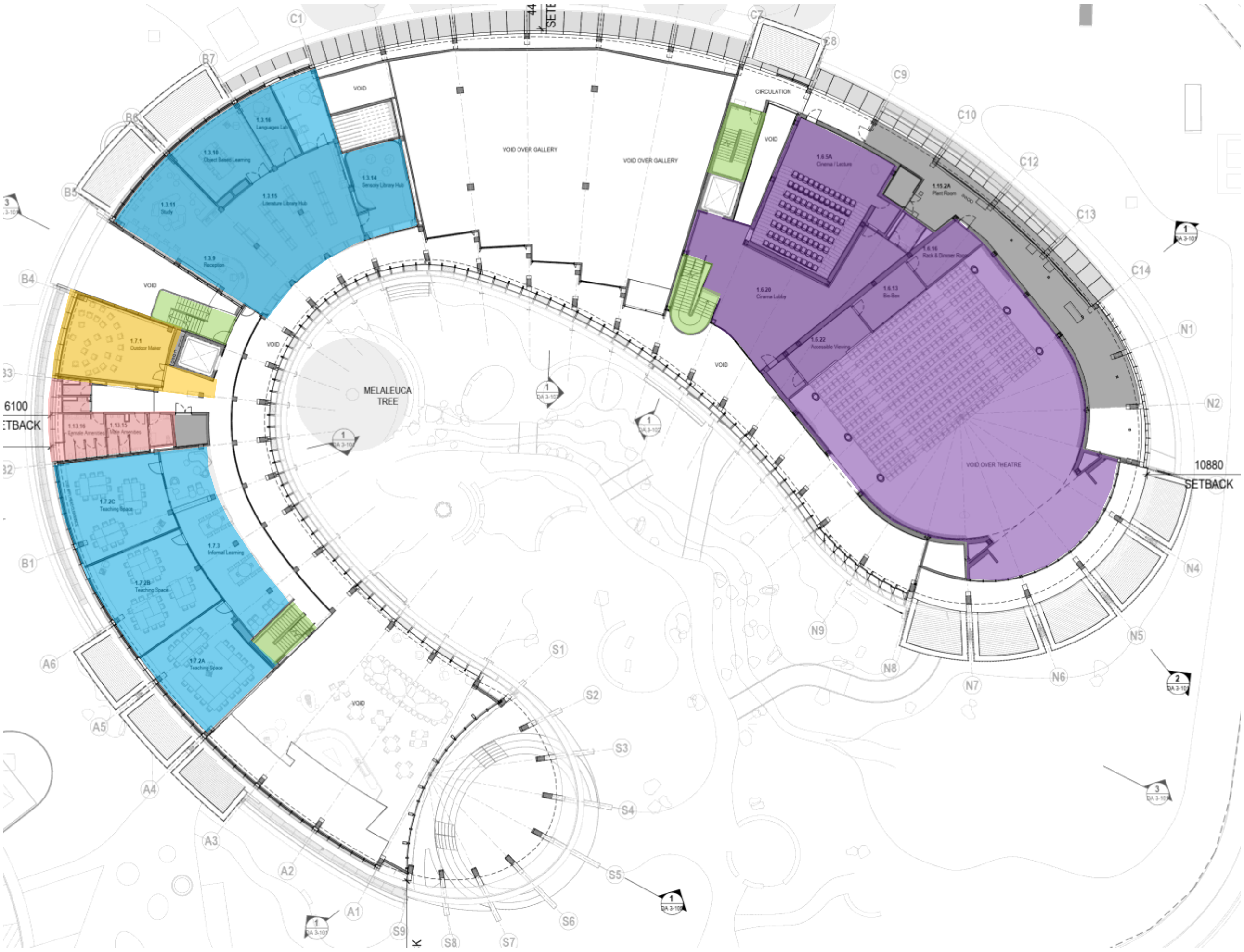


Figure 2.4: Floor Plan – Ground Floor



Stairways | Outdoor Spaces | Amenities | General Learning & Study Spaces | Theatre & Cinema Spaces

Figure 2.5: Floor Plan – Level 1

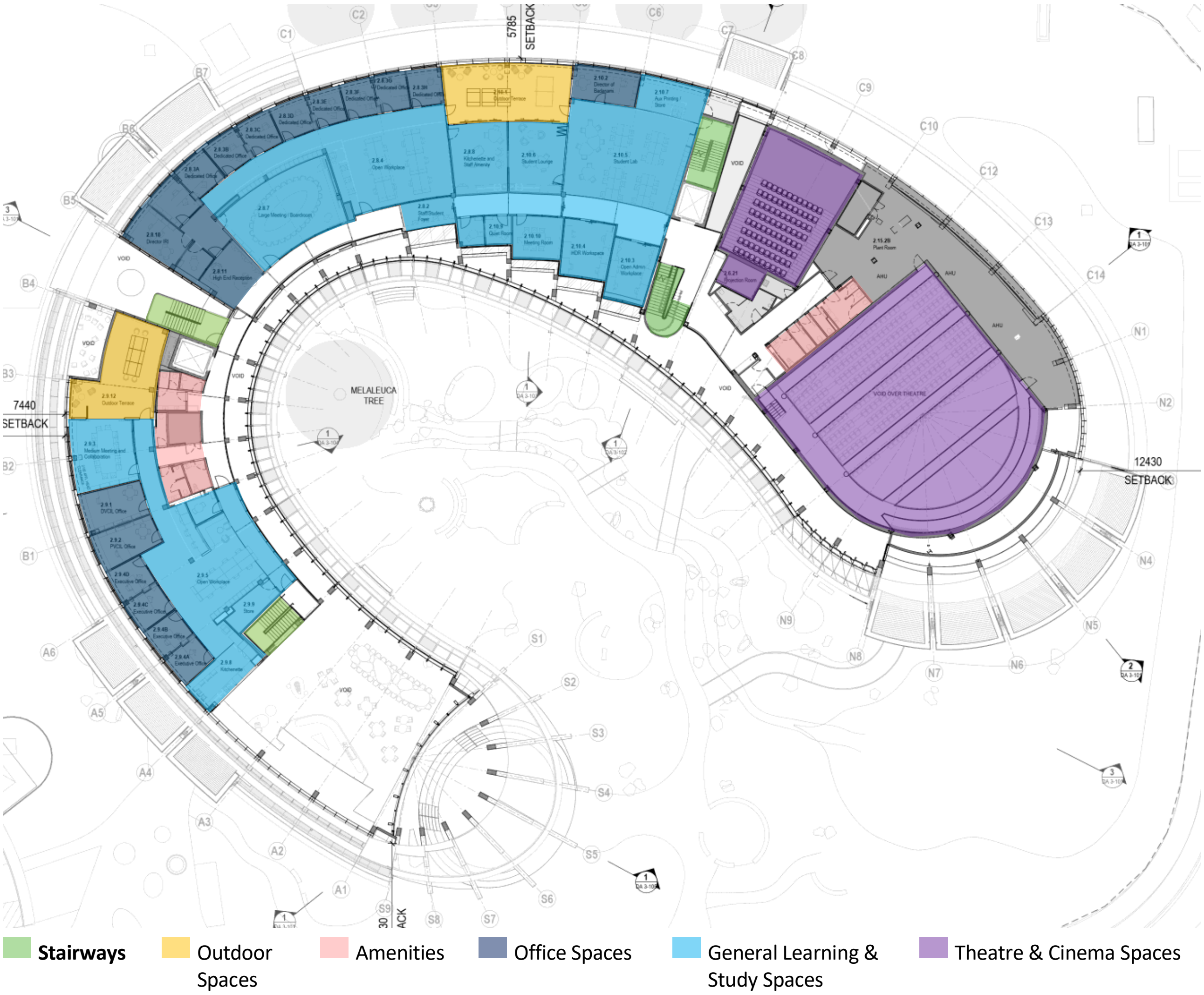
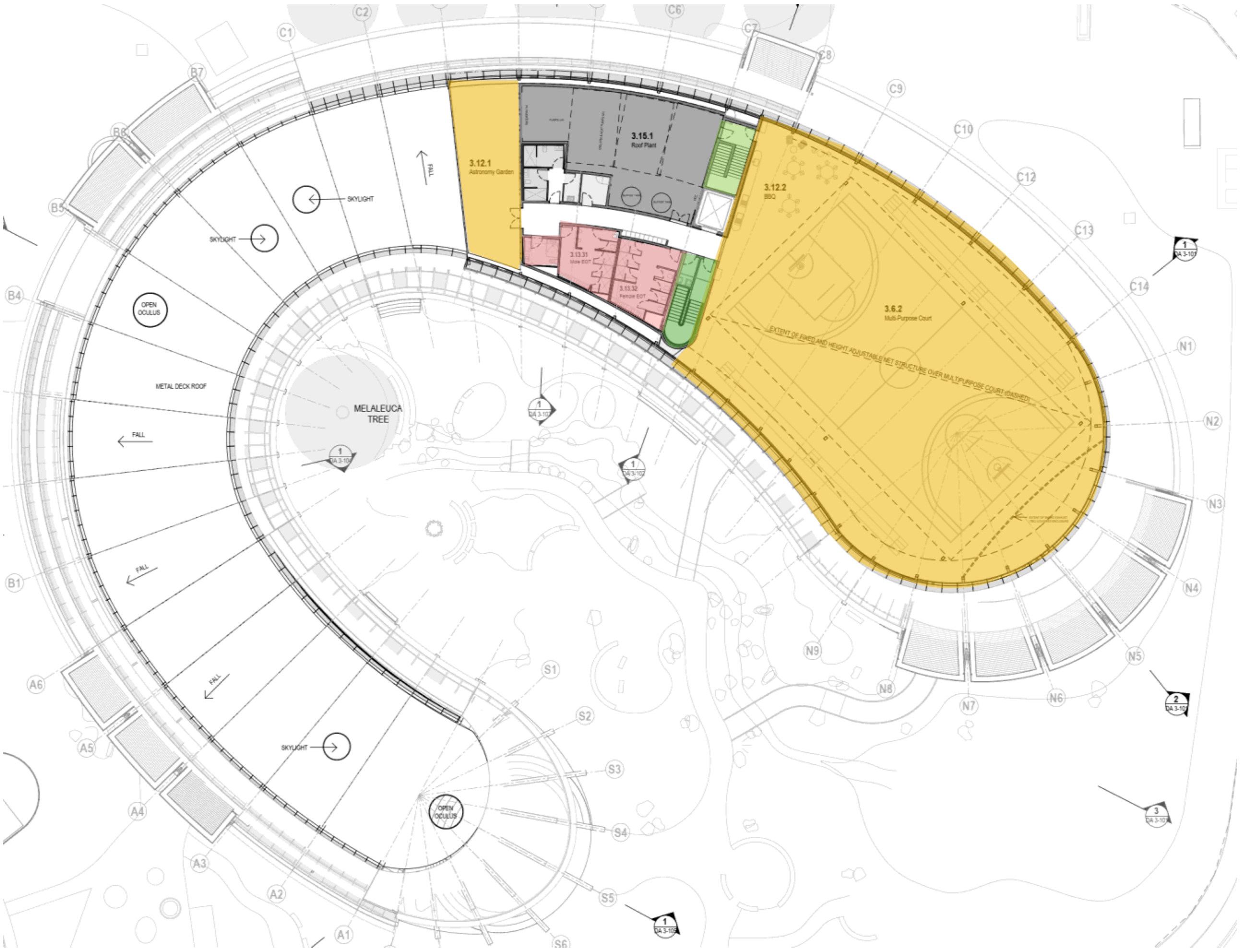
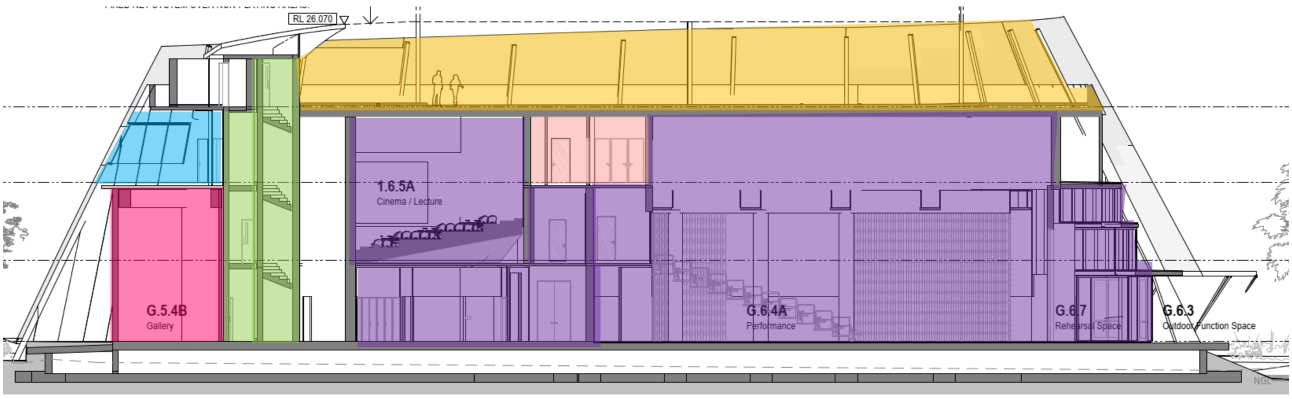


Figure 2.6: Floor Plan – Level 2



Stairways Outdoor Area Amenities

Figure 2.7: Floor Plan – Level 3



Stairways Outdoor Spaces General Learning & Study Spaces Amenities Art Gallery Theatre & Cinema Spaces

Figure 2.8: Section drawing

Table 2.1 provides a detailed summary of the key building characteristics.

Table 2.1: Overview of building characteristics

Occupancy Levels	Key Characteristics	
Ground Floor	• Welcome Foyer • Theatre (triple height) • Cinema/Lecture Hall (double height) • Gallery (double height) • Outdoor Amphitheatre	• Art Studios & Exhibition spaces • General Learning/Study spaces • Consulting offices • Loading bay & plant rooms
Level 1	• Library facilities • General Learning/Study spaces • Outdoor Terraces • Plant rooms	
Level 2	• Offices & Workspaces • General Learning/Study spaces • Outdoor Terraces • Plant rooms	
Level 3 (Rooftop)	• Outdoor astronomy garden • Outdoor BBQ facilities • Outdoor multi-purpose sports court	

The building description based on the BCA classification system is provided in Table 2.2.

Table 2.2: BCA Description of building

Summary of Building/Tenancy	
Building Classification(s):	Class 9b (Public Assembly)
Number of Storeys Contained :	Four (4)
Rise in Storeys:	Four (4) Note: Level 3 has been considered a storey due to the extent of the roof over.
Effective Height:	12.62m
Required Type of Construction:	Type A Construction (Mass Timber Construction)

2.2 Occupant Profiles

2.2.1 Occupant Characteristics

Understanding the likely behaviour of the building's occupants is an important element of the analyses of life safety in a building fire. Where there are a number of occupants involved, there are many characteristics relating to these occupants and their probable behaviour in a fire emergency that can be identified. Hence, making complete characterisation of individual occupants is a complex and difficult task.

However, for the purposes of analysis only a limited number of 'dominant occupant groups' may be considered, as these have been shown to have the greatest impact on the outcome of evacuation modelling. Characteristics therefore need only be developed for these dominant occupant groups

Guidance provided by IFEG (2005), the Engineering Guide: Human Behaviour in Fire (SFPE 2003) and Proulx (2003) has been considered in the determination of dominant occupant characteristics for this fire safety engineering evaluation.

2.2.1.1 Class 9b (Public Assembly)

As described in the previous sections the activities taking place within this building include the following which need to be undertaken in to account when determining the occupant characteristics:

- Theatre
- Cinema/Lecture Hall
- Gallery
- Outdoor Amphitheatre
- Art Studios & Exhibition spaces
- General Learning/Study spaces

- Consulting offices
- Library facilities
- General Learning/Study spaces
- Offices & Workspaces
- Outdoor multi-purpose sports court

The multi-purpose sports court, art studios, exhibitions spaces, gallery and theatre could consist occupants who are expected to be of the general public who are there to attend a performance, functions and events. Therefore, we can essentially classify the occupants in two major groups, transient (i.e. the public, performers) and permanent (i.e. staff). Therefore, the occupants would comprise persons from all gender and of age groups. It is considered that the general occupant's characteristics are consistent with the general population.

The transient occupants sub group would have a varying degree of familiarity of the public access areas. However, it is expected only a minority will be unfamiliar given the simple floor plan and open nature of the building as the exits are visible. Given the nature of public access areas, it is expected from time to time that there may be large crowds and also people focused on tasks. So, it would be expected that the permanent staff members are likely to be knowledgeable of the specific evacuation process and aid other occupants so effective evacuation from the building can be undertaken

With respect to the library, lecture hall and general learning/study spaces this would consist of a combination of university students and staff. The full-time staff and to a lesser degree the university students in an educational building would be considered as permanent occupants of the building. The university students will be in the majority and have various degrees of familiarity. Teachers, while few in number relative to the university students will be familiar having the natural tendency to take charge in an event such as a fire emergency directing students to safely evacuate. As the subject areas are utilised for educational purposes, university students may be present at particular times when the permanent staff occupants are not present within the building.

The visitors would be considered to be awake and alert, predominantly able bodied but not necessarily familiar with the building layout or the emergency procedures. However, as a result of the relatively small and simple geometries, issues such as way finding and familiarisation of the buildings are considered not to pose any significant life safety concerns for visitors given that staff would be expected to have an understanding of the emergency evacuation procedures and would also be in a position to assist visitors to evacuate the building.

The evaluation has considered the occupant characteristics identified and the usage of the building as noted. Any changes in the building usage and consequent potential change to the occupant characteristics will require a re-evaluation of the fire safety systems.

There is no proposed usage of the building that would indicate that the proportion of persons with disabilities would be significantly different from the general national population norms. However it should be noted, that in the event of an emergency evacuation able-bodied occupants are likely to be altruistic and assist the small proportion of disabled occupants, if any (Proulx 2002).

The characteristics (response capability, coping capability, and evacuation/avoidance capability) of the occupants are taken as those which are considered to be typical for this occupancy, where the occupant is familiar with their surrounds and understands the cues of a fire alarm.

2.2.2 Occupant Numbers

The occupant numbers have been acquired for the sole purpose of the fire safety assessment detailed in this report. These numbers must not be used for any other purpose without appropriate approvals. The design team has confirmed the maximum occupant numbers for the site is as follows in Table 2.3 and Appendix A.

Table 2.3: Occupant Loading

Level	Public Space	Bookable Space	Student Area	Staff Area	Total
Level 00	412	594	30	76	1112
Level 01	63	116	-	2	181
Level 02	-	30	41	64	135
Level 03	-	155	-	-	155

2.3 Conditional Statement

It is not anticipated that the occupant characteristics or the usage of the building will change significantly. Any such change would require a re-assessment of the fire safety levels. The evaluation has considered the occupant characteristics identified and the usage of the building as noted. Any changes in the building usage and consequent potential change to the occupant characteristics will require a re-evaluation of the fire safety systems.

3. Performance Solution Design Issues

The Building Certifier/BCA Consultant has identified the following design aspects of this project that do not comply with the Deemed-to-Satisfy provisions of the BCA. For each of these issues an alternate Performance Solution has been presented and is to be the subject of the assessment described herein to demonstrate compliance with the relevant Performance Requirements.

Table 3.1 lists the Performance Solution design issues to be addressed in the assessment, the applicable BCA DtS provision to which the Performance Solution applies, the Performance Requirement(s) to be satisfied, and the Assessment Method to be adopted in accordance with Clause A2G2 of the BCA.

Table 3.1: BCA design issues pertinent to the proposed Performance Solution

No.	Design Issue to be Addressed	BCA DtS Provision	Performance Requirement	Performance Solution
1.	It is proposed to review the method of fire separation between the CLT slab edge and the external façade system. The design incorporates a non-combustible element/barrier in order to mitigate vertical fire and smoke between levels however is not deemed to be strictly in accordance with the BCA DtS provisions. More specifically, the prescriptive provisions of the BCA are silent on the method of sealing the slab edge gap and AS1530.4 does not have criteria to test a fire sealing system between fire-rated (slab) / non-fire rated (external wall) elements.	Clause C2D2 inter alia Specification 5 and Clause C4D16	C1P2 and C1P8	A2G2(2)(b)(ii)
2.	It is proposed to permit the use of mass timber construction to the building as per the following: • It is proposed to permit the use of exposed (no fire-protective covering) CLT flooring system (limited areas), Glulam columns and Glulam beams	Clause C2D15	C1P1 and C1P2	A2G2(2)(b)(ii)
3.	It is proposed to permit the proposed building to be located within 6m of the existing Central Energy Plant (CEP) building which is on the same allotment.	Clause C4D3 inter alia Specification 5	C1P2 and C1P8	A2G2(2)(b)(ii)
4.	It is proposed to permit the stairway known as "Badanami Stair" serving all levels to be not fully contained within a fire-rated shaft.	Clause D2D4	D1P4 and D1P5	A2G2(2)(b)(ii)
5.	It is proposed to permit the exit travel distances to a point of choice and to an exit to exceed the maximum DtS provisions as per the following: • Level 1 – 28m to a point of choice in lieu of 20m • Level 1 Plant room – 27m to a point of choice in lieu of 20m – 50m to an exit in lieu of 40m • Level 2 – 28m to a point of choice in lieu of 20m • Level 2 Plant Room/Catwalks – 22m to a point of choice in lieu of 20m – 47m to an exit in lieu of 40m • Level 3 – 28m to a point of choice in lieu of 20m	Clause D2D5	D1P4 and E2P2	A2G2(2)(b)(ii) A2G2(2)(d)
6.	It is proposed to permit the fire stair serving all levels of the building to discharge internally on Ground Level in lieu of a road or open space.	Clause D2D12	D1P4 and D1P5	A2G2(2)(b)(ii)
7.	The non-fire-isolated stair serving Level 3 and ladder serving the Level 2 plant room does not have a continuous path of travel from the storey served to the level of discharge.	Clause D2D14 inter alia Clause D2D21	D1P4 and D1P5	

No.	Design Issue to be Addressed	BCA DtS Provision	Performance Requirement	Performance Solution
8.	It is proposed to permit the occupants within the theatre catwalk, which is not a plant room and is greater than 200m^2 to utilise the plant room ladder for egress on Level 2 only.	Clause D2D21	D1P4 and D1P5	A2G2(2)(b)(ii)
9.	A fire hydrant system shall be provided which is designed and installed in accordance with Clause E1D2 of the BCA and AS2419.1:2021 with the inclusion of the following: • Permit the fire hydrant booster assembly serving the building to be located in a position that is not within sight of the main entry of this new building. **Draft note: Fire services consultant to confirm any further non-compliances*	Clause E1D2	E1P3	A2G2(2)(b)(ii)
10.	The proposed sprinkler booster assembly serving the site is located in a position that is not within sight of the main entry of this new building.	Clause E1D2 and E1D4	E1P3 and E1P4	A2G2(2)(b)(ii)
11.	The gallery located on Level 00 is within a building/fire compartment containing a floor area greater than 3,500m^2, as such a smoke exhaust system is required. In this instance, it is proposed to permit the omission of the required smoke exhaust system to the gallery/exhibition areas of the building on Level 00.	Clause E2D3 inter alia NSW Clause E2D18	E2P2	A2G2(2)(b)(ii)

4. Hazard Analysis

4.1 Introduction

The IFEG (2005) & AFEG (2021) state that a systematic review should be conducted to establish potential fire hazards (both normal and special) of the facility under evaluation. A hazard is the outcome of a particular set of circumstances that has the potential to give rise to unwanted consequences. In regard to a building fire, a fire hazard means the danger in terms of potential harm and degree of exposure arising from the start and spread of fire and the smoke and gases that are thereby generated.

The fire related hazards in a facility can arise from the layout of the building including its location with respect to adjoining properties, the construction materials, the activities undertaken in the facility, the possible ignition sources and the fuel sources.

One of the first stages in reviewing potential fire hazards for a project is to examine available fire incident data for facilities having the same or very similar form and usage. This data may be international in origin and therefore must be used with care in order to establish possible hazards and a realistic measure of the possible unwanted consequences of fire.

Every hazard has a risk associated with it. The risk arising from a hazard is the frequency of an event involving that hazard, times, the expected consequences. A hazard may be eliminated, but there will always be an event frequency of occurrence and therefore always a positive value of risk associated with the hazard.

Fire safety engineering is essentially a risk management process wherein the outcome is to minimize the overall fire risk associated with a facility by mitigating or eliminating serious hazards, or by reducing the frequency of hazardous events.

The risk assessment process, of which hazard analysis forms part, is the means by which those hazardous events with the most serious consequences are identified. This then enables the most appropriate fire scenarios related to these events to be defined. This process then allows the analyses to be carried out to ensure that the fire safety systems and strategies employed are sufficient to satisfy the Performance Requirements.

Whilst the frequency of hazardous events (probability) is considered during the hazard analysis, the consequent analyses for the evaluation of the resultant fire scenarios are deterministic.

The following sections provide data specific to the occupancies involved in this assessment.

4.2 Summary of Project Specific Hazards

A thorough and comprehensive analysis of the fire hazards associated with the subject building has been provided in Appendix B of this PBDB. A summary of the fire hazard analysis is provided in the following sub-sections presented below.

4.2.1 Hazards Specific to Public Assembly Classification (Class 9b)

In relation to the Public Assembly classification, the hazard analysis undertaken illustrates the following:

- The proposed building will undergo a wide variety of functions and use due to the presence of an auditorium, lecture hall, general learning spaces and gallery spaces in the form of orchestral performances, plays, productions and various functions type events. Thus, the venue is likely to present a wide range of hazards and possible fire scenarios.
- The fire load of the theatre and gallery spaces is expected to primarily consist of performance props/decorations, and audio/visual equipment. The fire load of the general learning spaces, lecture hall, office space is expected to primarily consist of seating, tables and combustible furniture in the form of plastic.
- The ignition sources that are primarily related to the proposed building include:
  - electrical switch assemblies,
  - lighting,
  - electronic audio/video stage equipment,
  - Occasional special effects equipment for staged performances.
- The statistics identify "Public Assembly" and "Eating Drinking" as specific occupancy types which would include all components of the subject building. Table 4.1 shows 1996 statistics from US for non-residential occupancies.

Table 4.1: US Fire Statistics

Design Issue	Number of non-residential:	Public Assembly % / no	Eating Drinking % / no	Total % / no
Fires	73,325	4.2/3080	7.5/5500	11.7/8580

Design Issue	Number of non-residential:	Public Assembly % / no	Eating Drinking % / no	Total % / no
Deaths	111	0.9/1	2.7/3	3.6/4
Injuries	1636	4.5/74	7.6/125	12.1/199

4.3 Mass Timber Hazards

The use of mass timber as a building material introduces additional hazards to those already existing in a conventional non-combustible building. In a building with structural timber columns, beams, walls or/and floor slabs is proposed to be exposed, a fire in a compartment may result in the ignition of mass timber elements that would contribute to the fire load.

Therefore, the main hazard to address is the **Contribution of Mass Timber to the Fuel Load**. The consequence associated with the contribution of mass timber are as follows and illustrated in Figure 4.1:

- Increased fire size and prolonged fire profile
- Growth rate;
- Burning duration;
- Onset of delamination;
- Decay
- Prolonged exposure and structural integrity
- Fire resistance of structural elements;
- Fire performance of structural connections;
- Structural robustness

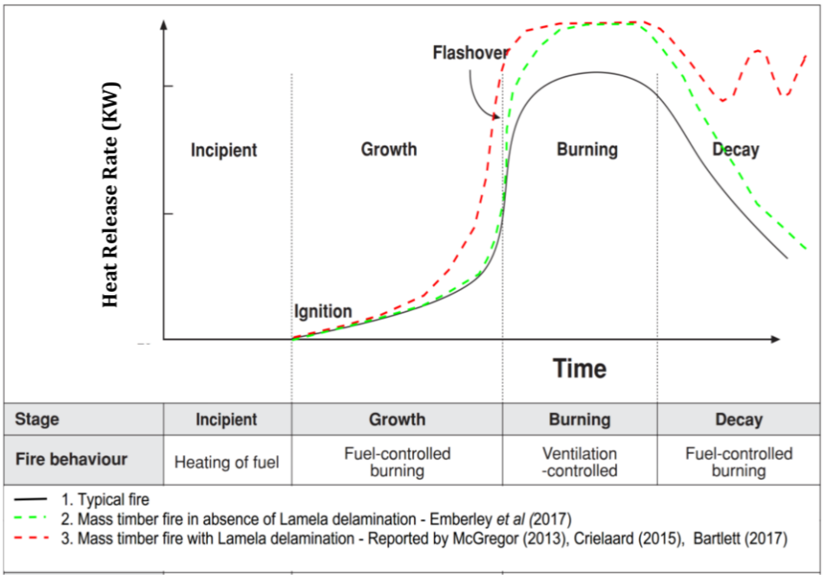


Figure 4.1: Fire Profile

The fire engineering assessment shall determine the contribution of mass timber to the fuel load and analyse its impact on:

- Fire Spread
  - Internal fire spread
  - External fire spread
  - Fire spread to adjacent properties
- Occupant Life Safety
- Fire Brigade Intervention

In summary, the building shall adopt exposed mass timber. Taking into account of the hazard introduced by mass timber, the objective of this PBDB is to describe the principles of the fire safety strategy and assessment methodologies that will be adopted to ensure occupant life safety and fire brigade intervention according to current regulatory requirements has been satisfied (i.e. Performance Requirements C1P1 and C1P2).

5. Fire Brigade Intervention

5.1 General

Fire Brigade Intervention shall be analysed from Fire Brigade notification through to search, rescue, fire control and extinguishment and overhaul activities. Fire brigade intervention is required to be considered to determine the potential impact on the activities of the fire brigade. This relates primarily to the potential for fire spread and structural failure with respect to the time required for fire brigade personnel to arrive and ready to undertake fire-fighting operations.

In this instance, there are no issues relating to fire brigade intervention activities and the performance of the building to accommodate Fire Brigade Intervention, therefore fire-fighting operations have been assessed qualitatively.

5.2 Fire Services Infrastructure & Equipment

Fire safety services are generally based on the level of risk. The height and use of the building are the key criteria when considering the level of risk associate within a building. Based on the minimum provisions required according to the DtS provisions from Volume One of the BCA, the subject building is required to afford a suite of fire services. The fire services incorporated in the building design are listed below and illustrated in Figure 5.1:

- Automatic fire sprinkler system in accordance with AS2118.1:2017; and
- Automatic smoke detection system in accordance with AS1670.1:2018; and
- An Emergency Warning and Intercom System (EWIS) throughout the building; and
- Fire Brigade monitoring of the EWIS for automatic notification and dispatch of Fire Brigade resources; and
- The buildings are served by a combination of external and internal fire hydrants; and
- The main Fire Indicator Panel (FIP) shall be located within the main entry to the welcome foyer on the south side of the building; and
- The site is provided with a fire hydrant and sprinkler booster assembly.
- Fire Brigade Turnout into the site is Fifth Street to the south, which serves as the principal site entry and is bounded by Victoria Road to the north, Railway Street to the east and Bridge Street to the west; and

The site and building are afforded with a fire hydrant system generally in accordance with Volume One of the BCA and the relevant Australian Standard unless otherwise approved by the Commissioner of the Fire Authority.

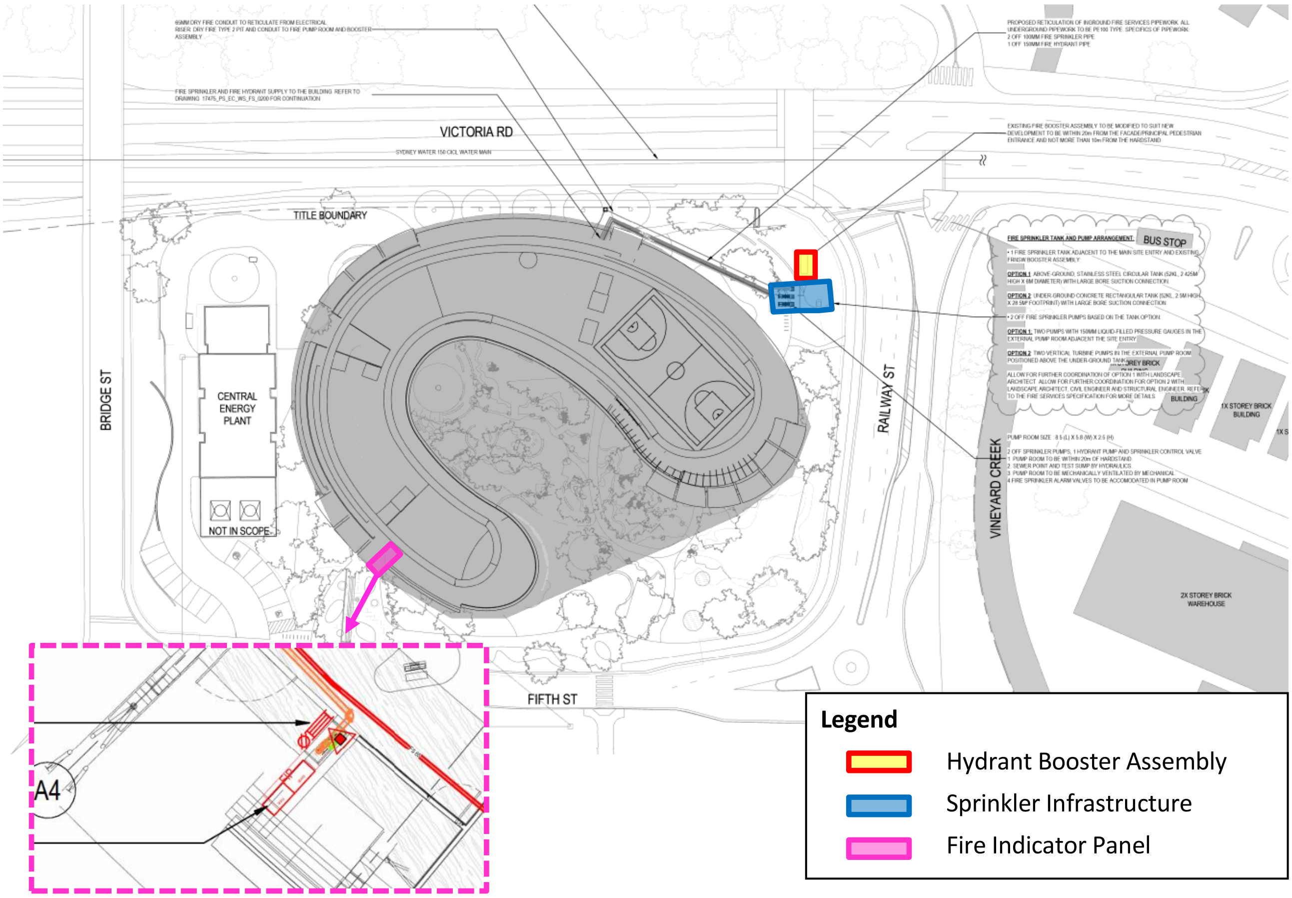


Figure 5.1: Location of fire services infrastructure

5.3 Fire Brigade – Primary Response

The subject site falls within FRNSW response area. The nearest responding fire stations to the subject site via road travel have been illustrated in Figure 5.2. The relevant fire stations are as follows:

Table 5.1: Responding Fire Stations

Fire Station	Address	Distance
Rydalmere Fire Station	75 Park Rd, Rydalmere NSW 2116	2.3 km
Parramatta Fire Station	110 Wigram St, Harris Park NSW 2150	3.6 km

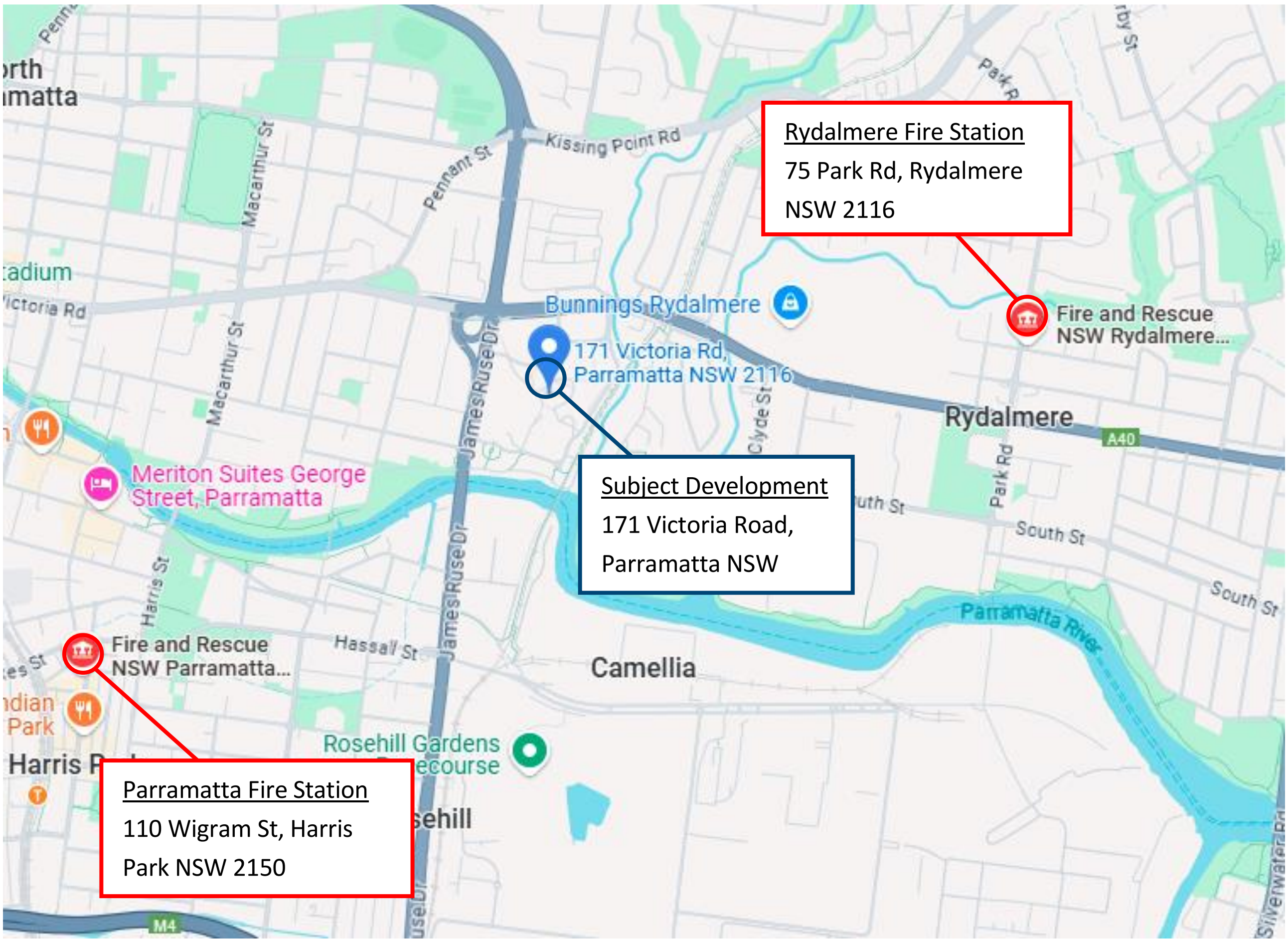


Figure 5.2: Responding Fire Stations (Rydalmere and Parramatta) to 171 Victoria Road, Parramatta NSW

5.4 Fire Brigade Response Time

Fire Brigade Response times are measured by the length of time between an appliance being dispatched to an emergency incident and arrival on scene (i.e. kerbside). Fire brigade personnel are expected to readily undertake operations either internally or externally. Given they have the ability to setup the appliance at the front of the subject building early fire spread or exposure intervention may be directed to the neighbouring building(s) if required. Therefore, upon arrival or whilst undertaking activities fire brigade personnel are able to assess the situation and determine the most suitable option to attack the fire.

Based on the proximity of the nearest fire stations to the subject site it is anticipated that a response to the site will occur within 90th percentile response times recorded. Referring to the FRNSW annual report 2022/23, the response time to fires within the Fire District has been recorded to be within 12 minutes and 14 seconds for 90% of incidents (refer to Figure 5.3).

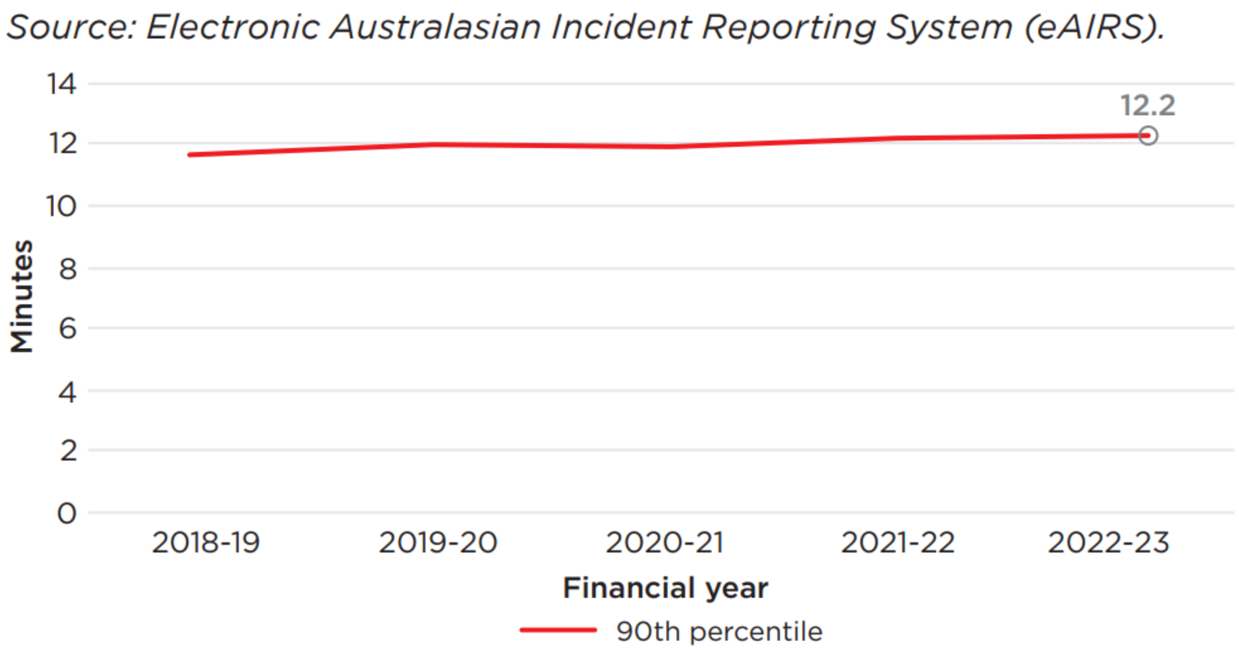


Figure 5.3: FRNSW Fire Brigade Response Times (FRNSW, 2022/2023)

The time above is noted to be the time for fire brigades to arrive on site. Additional time to setup and commence extinguishment activities is expected to be required. To account for these activities and any uncertainties an additional 10 minutes shall be added to the service delivery time.

Therefore, based on the response time and additional time needed to undertake firefighting procedures a conservative value of approximately **23 minutes** (i.e. Response time standard + 10 minutes) is expected for fire crews to commence fire control and extinguishment activities.

Note: *the above is intended as an estimation for FRNSW to attend site and is intended as supplementary information for the report. The above time does not include time taken for brigade to notified of the fire and this will be documented in the subsequent Fire Safety Engineering Report.*

6. Mass Timber Assessment Framework

The main hazard to address is the **Contribution of Mass Timber to the Fuel Load** and how the timber structure will perform during the fire development and after the fire fuel load within the enclosure of fire origin has been consumed. In order to undertake this assessment key events, need to be assessed and quantified based on a fire timeline (refer to Figure 6.1). The key events to be quantified in the fire engineering assessment are as follows:

- **Fire Initiation:** This shall be based on the proposed fire scenarios adopted to quantify the contribution of mass timber to the fuel load; and
- **Fire Sprinkler Performance:** A qualitative assessment shall investigate the impact of the proposed sprinkler system in relation to the contribution of mass timber to the fuel load. In a sprinklered building, once the sprinklers activate the hot layer temperatures will remain below 100-150°C (Hall, 2010) which is significantly below the minimum of 300°C (Wade, 2019) temperature required to ignite the mass timber. Furthermore, the fire is likely to be contained to the zone of fire origin which shall assist in effective occupant egress and fire brigade intervention activities which shall be assessed; and
- **Char Fall Off:** Based on the contribution of mass timber to the fuel load a qualitative assessment shall be undertaken to determine if char fall off would occur; and
- **Contribution of Mass Timber:** A quantitative assessment shall be undertaken to demonstrate that the timber contribution duration via Eurocode Parametric Fire Duration is within the proposed fire resistance period of 120 minutes; and
- **Fire Spread:** Based on the contribution of mass timber to the fuel load a qualitative assessment shall investigate the impact on the potential for internal and external fire spread within the building and to adjacent properties; and
- **Occupant Evacuation:** A quantitative assessment shall investigate the impact on occupant life safety based on the quantified contribution of mass timber to the fuel load; and
- **Fire Brigade Intervention:** A quantitative assessment shall investigate the impact on fire brigade intervention based on the quantified contribution of mass timber to the fuel load; and
- **Structural Integrity:** A quantitative assessment shall be undertaken to demonstrate that the structural stability of timber structure is maintained for the proposed fire resistance of 120 based on the contribution of mass timber to the fuel load.

Therefore, the primary objective is to demonstrate that the proposed fire safety strategy accounts for the contribution of timber to the fire load during the development of the fire. As such an adequate level of fire resistance performance (i.e. structural integrity) is to be achieved relevant to occupant life safety, fire brigade intervention activities and mitigation of fire spread.

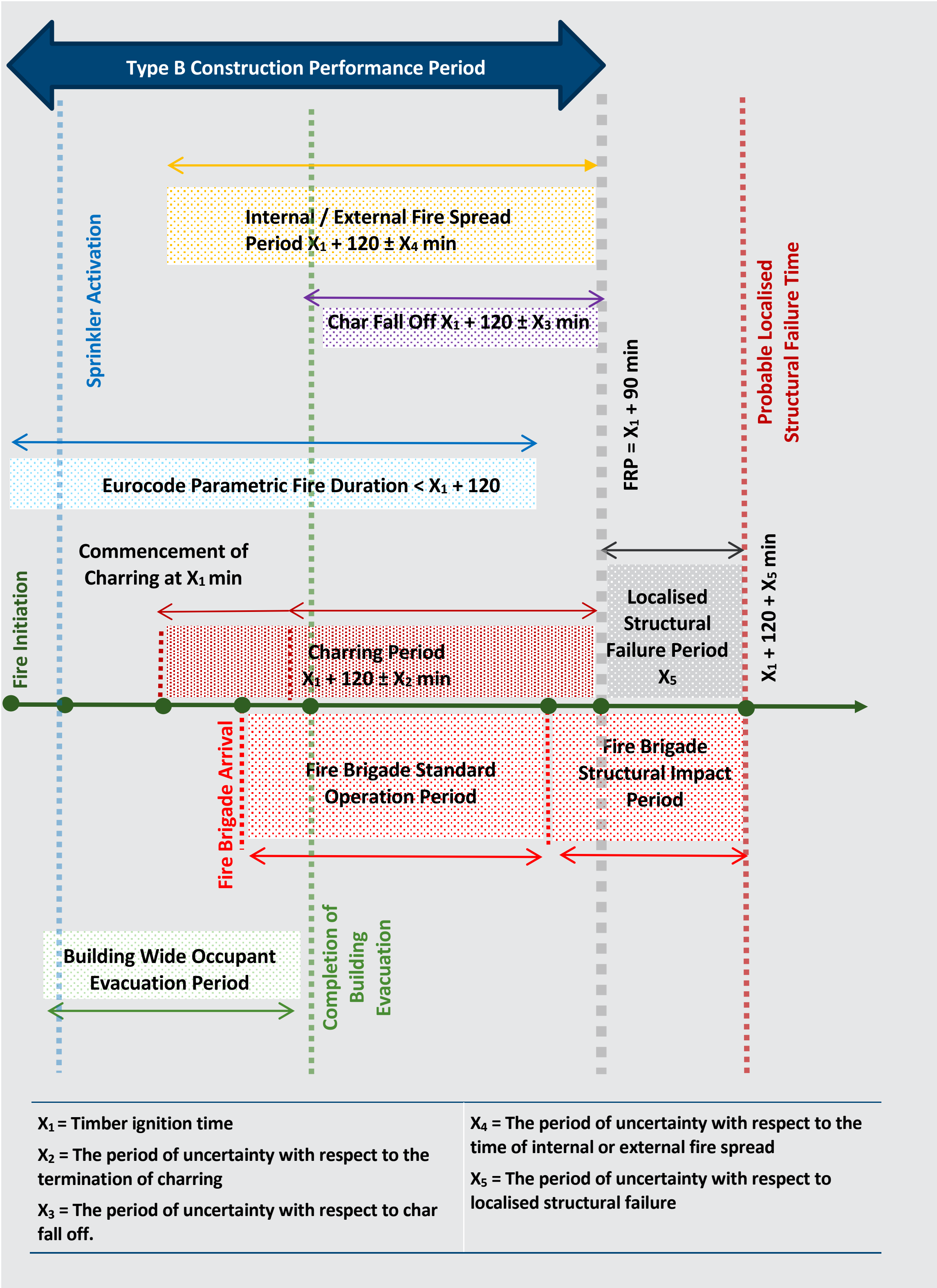


Figure 6.1: Fire timeline with mass timber contribution

7. Structural Fire Design Strategy

7.1 General

TTW have been appointed to undertake the structural design of the mass timber associated with the development. The assessment of the structure in the event of a fire shall consider (refer to Appendix I):

- the fire resistance of the mass timber structure (i.e. charring period); and
- the design of the connections under fire conditions; and
- the design basis for structural adequacy and robustness checks (i.e. localised structural failure).

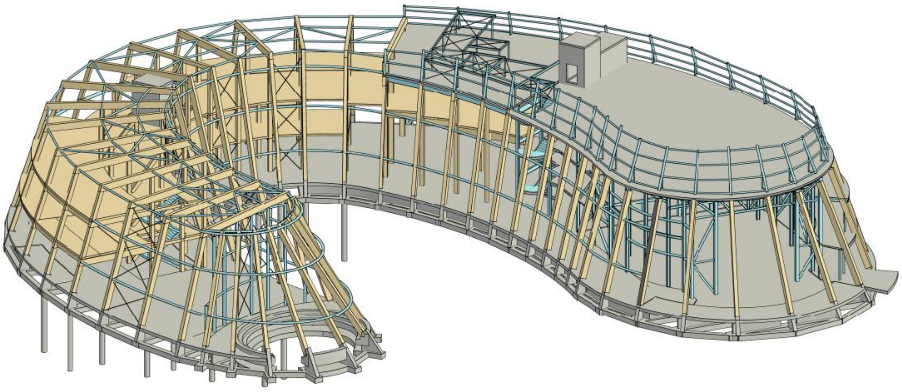


Figure 7.1: 3D image of structural design

7.2 Fire Resistance

The mass timber structure of CLT floors and Glulam columns and beams is permitted to be exposed. The fire resistance period for the CLT floors and Glulam beams and columns shall be based on a minimum charring period of 120 minutes.

At this stage the structural engineer has indicated that *Eurocode 5: Design of Timber Structures – Part 1-2: General – Structural Fire Design (EN 1995-1-2:2004) and/or Timber structures – Fire resistance of timber elements (AS/NZS 1720.4 (2019))* shall be adopted for the structural design of the Glulam beams and columns. Once the timber species, beam/column dimensions, relevant densities are known for the Glulam members, the nominal charring rate shall be determined. To determine the adequacy of Glulam members in a fire scenario the analysis is divided into two (2) parts. Firstly, the reduced structural loading for a fire scenario is calculated and secondly, the reduced design resistance of the timber member is determined using the residual cross section method. Thereafter, the reduced cross section method shall be adopted to demonstrate the inherent fire resistance of 120 minutes shall be satisfied.

Fire protection to steel connectors shall achieve 120 minutes which is consistent with the timber elements. Where steel plates/connectors are not fully within the Glulam element with a thickness at least equal to the charring depth, allowance should be made for additional fire protection to the steel via intumescent paint or spray fire protection.

The fire resistance performance for the proposed CLT floor slabs shall be supported by an approved manufacturer with Australian testing certification in accordance with AS1530.4:2014 and/or a "Letter of Assessment" from a registered testing authority to achieve an FRL of 120 minutes. In the scenario where the CLT floor slabs are to be designed in accordance with a design standard all charring and fire resistance calculations must be carried out in accordance with the relevant standard/technical assessment guide.

Note: As previously advised the timber supplier is yet to be determined which will influence the structural fire design methodology.

7.3 Structural Robustness

As part of the structural design the BCA 2022 requires specific consideration of robustness of structures beyond the relatively limited requirements of AS 1170.0. The structure shall be designed to comply with both the BCA and Australian Standard Requirements. Structural robustness can be achieved via AS1170.0 (Section 6) which is a Deemed-to Satisfy Solution or the Verification Method BV2 within the BCA which is a Performance Solution. As such the structure shall be designed for structural robustness with a combination of the following methods:

- Section 6 of AS1170.0:2002 as a DtS approach
- Clause BV2 of the BCA as the Performance Solution
- The Institute of Structural Engineers: Practical guide to structural robustness and disproportionate collapse in buildings

- Wood Solutions Design Guide 39: Robustness in Structures

Disproportionate collapse can be a by-product of events such as a fire. It is important that a structure is designed and constructed in such a way that an event like fire does not cause it to disproportionate from its original cause. According to Section 6 of AS1170.0:2002, used for structural design actions, structures shall be detailed that all parts of the structure which are in horizontal and vertical planes must be fixed together so that the structure can endure circumstances/event without damaging it to an magnitude disproportionate to that event. As such the following design mechanisms will be applied to ensure against disproportionate collapse:

**Draft note: Structural engineer to confirm design mechanisms will be applied to ensure against disproportionate collapse*

The objective is to ensure that the building can withstand an exceptional design scenario without being damaged to result in disproportionate collapse. As such the impact and likelihood of localised structure failure with respect to occupant life safety and fire brigade intervention shall be evaluated.

8. Fire Separation between Floor Slabs and Facade

8.1 Background to the Issue

The BCA Consultant has identified that the fire/smoke separation detail at the internal interface of the structural CLT slab edge and the external facade wall system does not strictly comply with the BCA prescriptive provisions. According to the BCA Consultant, the strict interpretation of the BCA is that the fire rated floor slab structure is required to be continuous and extend to the external face of the external façade wall system or external wall that is fire rated to avoid internal vertical fire spread between levels. It should be noted that the BCA prescriptive provisions do not offer a specific method of fire/smoke sealing of the slab edge gap and façade connection detail. Furthermore, it is noted that AS1530.4:2014 does not have criteria or test methodology to test a fire separation system between a fire-rated element (slab) and non-fire rated element (External wall facade). In this instance, it is proposed to provide the following:

- A steel angle and smoke-proof barrier at the gap between the CLT slab edge projections and external wall/façade system as shown in Figure 8.1.

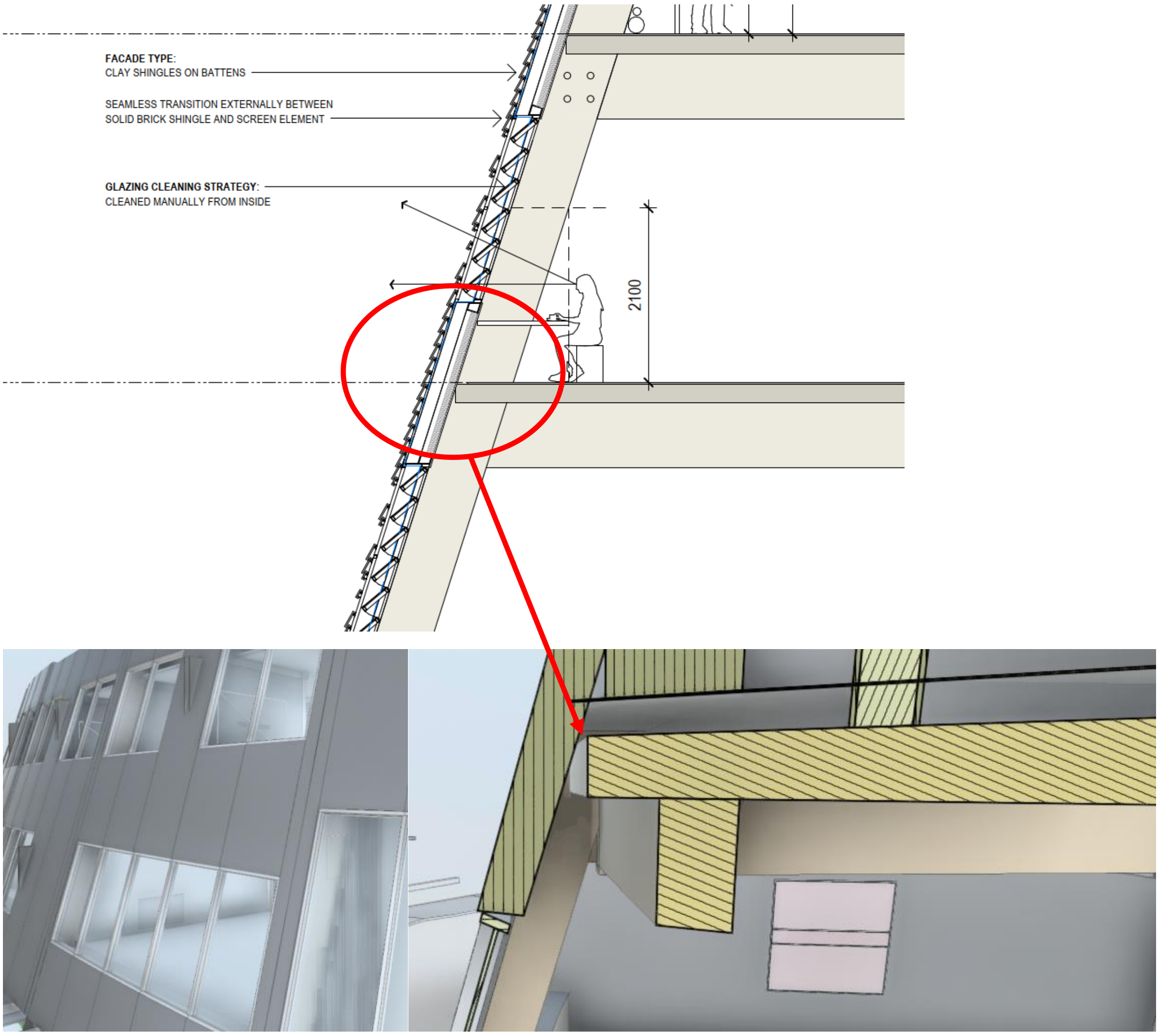


Figure 8.1: External Wall Façade Details

The proposed design forms a deviation from Clause C2D2 of the BCA which prescribes horizontal fire separation (between storeys) to achieve a minimum FRL of 90/90/90. The design also deviates from BCA Clause C2D2, C4D16 and Specification 5 whereby the proposed shall not be strictly tested in accordance with AS1530.4:2014.

8.2 Performance Solution

In accordance with the BCA Clause A2G2 *Performance Solution* the following assessment method shall be adopted to demonstrate that the *Performance Solution* complies with the *Performance Requirements C1P2 & C1P8.*

Table 8.1: Method of Analysis

Identified Design Issue	Performance Solution	IFEG Method of Analysis
It is proposed to review the method of fire separation between the slab edge and the external façade system. The design incorporates a non-combustible element/barrier in order to mitigate vertical fire and smoke between levels however is not deemed to be strictly in accordance with the BCA DtS provisions. More specifically, the prescriptive provisions of the BCA are silent on the method of sealing the slab edge gap and AS1530.4 does not have criteria to test a fire sealing system between fire-rated (slab) / non-fire rated (external wall) elements.	A2G2(2)(b)(ii) such other *Verification Methods* as the *appropriate authority* accepts for determining compliance with the *Performance Requirements.*	A qualitative 'risk' approach to demonstrate that the performance solution satisfies the relevant Performance Requirements of the BCA.

8.3 Hazard Specific Fire Separation between Slab Edge & Façade System

The 'Guide to the BCA' (ABCB, 2022) states that the intent associated with prescribing a required FRL is *"To establish the minimum fire-resisting construction to maintain an adequate level of structural stability and minimise fire spread"*. It is therefore considered that the main hazard associated with the identified design issue relates to:

- The potential for fire & smoke spread between fire compartments on different levels through the gap at the slab edge & façade junction; and
- The potential for occupant & fire-fighter life safety to become negatively impacted upon as a result of potential fire/smoke spread through the slab edge & façade junction.

8.4 Hazard Mitigation

The 'Guide to the BCA' (ABCB, 2022) identifies the potential for fire/smoke spread to occur through the façade junction where the slab edge/façade gap occurs. In this regard, the following hazard mitigation systems, requirements and features of the design are noted:

- Automatic sprinkler protection shall be provided throughout the buildings which shall activate to control or suppress a potential fire event; and
- The subject building is to be constructed generally in accordance with Type A fire resisting construction. As such all external wall systems (i.e. external façade) shall be constructed using non-combustible materials unless otherwise stated herein; and
- To prevent fire/smoke spread at the junction of the non-encapsulation CLT slab edge and the building façade the following requirements:
  - The facade shall incorporate a pre-fabricated system; and
  - The external cladding system (i.e. external façade) shall be a non-combustible material; and
  - Insulation material proposed within the external shall be a non-combustible material (i.e. rockwool); and
  - The CLT slab edge/façade gap shall be infilled with non-combustible mineral wool (e.g., Rockwool or similar equivalent). The mineral wool shall be mechanically fixed to the slab edge and/or supported via bracket that is mechanically supported; and
  - A continuous galvanised steel panels/angle shall be installed on the upper and lower side of the CLT slab edge structure providing and barrier/seal to close the gap between the fire rated floor slab and external wall system junction in order to mitigate fire/smoke spread between levels via the façade interface. The galvanised steel plate shall be suitably sealed by an applied fire rated sealant application (sealant to achieve a fire resistance of 120 minutes); and
  - The sarking material associated with the external wall system shall be in accordance with the requirements detailed in Specification 7 of Volume One of the BCA 2022. The sarking material is deemed to be non-combustible material by BCA 2022 such that it does not exceed 1mm in thickness and have a Flammability Index not greater than 5 (as per AS1530.2:1993); and

8.5 Methodology

The methodology to be adopted to address the design issue relative to the separation at the slab edge/façade gap shall be based upon a combined qualitative 'risk' & quantitative 'comparative' approach evaluation. The evaluation shall consider the proposed fire separation configuration and its effectiveness to serve as a fire barrier and the provision of active fire safety measures that will assist in limiting fire spread.

The evaluation shall consider the slab edge gap proposed infill system (steel angle & smoke-proof insulation) and potential paths for vertical fire spread. In order to determine the most likely path of fire/smoke spread, the evaluation shall consider the following:

- Fire performance of the façade glazing system; and
- Fire performance of the smoke seal junction gap failure.

The evaluation shall also consider the following key design aspects:

- **Overview of proposed fire separation** at façade junction which shall include:
  - Smoke seal at the slab edge/junction gap to mitigate vertical fire spread between floor levels.
- **Potential paths for fire spread** (incl. horizontally & vertically) due to:
  - Failure of the façade system
  - Failure of the infill system at the façade junction gap
- **Impact of automatic sprinkler protection** which shall provide a level of redundancy should the passive separation become compromised.
- **Impact on life safety** including:
  - Impact on occupant egress performance
  - Impact on fire brigade intervention activities.

8.6 Acceptance Criteria

The basic objective and intent of the analysis shall pertain to mitigating fire spread between floor levels and occupant/fire-fighter life safety. Thus, the primary acceptance criterion shall be met by demonstrating that the proposed barrier will provide a suitable level of fire/smoke separation between floor levels based on the failure criteria of the façade system occurring prior to the smoke seal provided at the fire rated slab gap. This is based on the following material properties (i.e. these values are the upper limit or failure criteria limits of the nominated materials):

- Façade System
  - Aluminium mullions and framing: 660^0C (et al UK Aluminium Industry Fact Sheet); and
  - Glazing System: 600^0C (Lei Peng, Zhao Peng Ni and Xin Huang, 2013)
- Fire Rated Slab Gap/Smoke Seal:
  - Galvanized Steel: Melting temperature at around 1500°C (et al engineeringtoolbox.com)

The secondary acceptance criterion shall be met by demonstrating that occupant & fire-fighter life safety is not negatively impacted upon.

8.7 Trial Design for Assessment

The trial design outlines in Section 0.5 are preliminary recommendations which need to be verified by a detailed fire engineering assessment. All other items not specifically addressed are to be in accordance with DtS provisions of the BCA or as accepted by the relevant authorities.

9. Type of Construction (Load Bearing Building Elements)

9.1 Background to the Issue

The building shall utilise methods and material of construction which will include a combination of CLT flooring system, structural Glulam beams and columns and concrete/masonry construction. Refer to Figure 9.1 for an illustration of the internal renders of the mass timber construction within the building.

Figure 9.1: Internal Renders of Mass Timber Construction

The main aspects where the proposed load-bearing elements deviate from the prescriptive provisions of the BCA are as per the following:

- It is proposed to permit the use of exposed (no fire-protective covering) CLT flooring system (limited areas), Glulam columns and Glulam beams. This is a deviation where the mass timber elements under the fire protected timber provisions is required to be encapsulated with a fire protective covering.

The design issue highlighted above is a deviation from the BCA as per the following:

- Clause C2D13 inter alia Specification 9 and 10 with respect to exposed mass timber elements.

9.2 Performance Solution

In accordance with the BCA Clause A2G2 *Performance Solution* the following assessment method has been adopted to determine that the *Performance Solution* complies with the *Performance Requirements of C1P1, C1P2, C1P4 & C1P8*.

Table 9.1: Methods of Analysis

Identified Design Issue	Performance Solution	AFEG Method of Analysis
It is proposed to permit the use of mass timber construction to the building as per the following: • It is proposed to permit the use of exposed (no fire-protective covering) CLT flooring system (limited areas), Glulam columns and Glulam beams	A2G2(2)(a) Evidence to support the use of mass timber construction meets the performance requirements. and A2G2(2) (b)(ii) such other Verification Methods as the appropriate authority accepts for determining compliance with the Performance Requirements. Holistic/first principles approach to the use of mass timber construction methods for the structure.	A combined qualitative & quantitative assessment has demonstrated that the proposed design satisfies the Performance Requirements of the BCA.

9.3 Hazard Specific to the Type of Construction (Load Bearing Elements)

The Guide to the BCA (ABCB, 2022) states that the intent associated with prescribing an effective height to the use of mass timber is to establish the minimum fire-resisting construction is to maintain an adequate level of structural stability and minimise fire spread when permitting mass combustible timber to be used where an element is required to be non-combustible. The 'Guide to the BCA' (ABCB, 2022) further states that the intent associated with prescribing a required

FRL is "To establish the minimum fire-resisting construction to maintain an adequate level of structural stability and minimise fire spread". It is therefore considered that the main hazard associated with the identified design issue relates to:

- Introducing combustible materials that may continue to burn/re-ignite and therefore not survive burnout.
- The potential for structural collapse of the load bearing mass timber elements and fire spread between levels located throughout the subject building.
- The potential for structural adequacy to negatively impact on occupant evacuation and fire brigade operations.
- Potential for disproportionate structural failure to impact on adjacent properties.

9.4 Hazard Mitigation

The Guide to the BCA (ABCB 2022) identifies the potential for occupants and fire-fighting personnel to encounter unsafe conditions during evacuation due to the presence of mass timber construction methods and reduced FRL to loadbearing elements. In this regard the following hazard mitigation systems, requirements and features of the design are noted:

- The statistics worldwide indicate that a low/mid-rise assembly building rates relatively low with respect to the risk of fire and life safety when compared to buildings of other occupancies; and
- The building shall be protected by an automatic sprinkler system in accordance with AS2118.1:2017 unless otherwise stated herein. Automatic sprinkler systems are very effective at reducing the severity of fires in assembly building properties.
- The building shall utilise methods and material of construction which will include a combination of CLT flooring system, structural Glulam beams and columns and concrete/masonry construction; and
- The fire resistance performance of the mass timber loadbearing structural building elements such as CLT floor slab and Glulam columns and beams shall be designed to achieve a minimum resistance to fire of 120 minutes; and
- Structural bracing elements are to achieve the same minimum FRL as the structural member being supported (minimum FRL 120 Minutes); and
- The thickness of CLT floors shall be established by the CLT supplier based on the fire rating requirement stated herein. A minimum outer lamella thickness of 40mm shall be adopted for the CLT floor slabs; and
- Connections between timber elements (i.e. Glulam beams and internal/external columns) are either fully embedded in the timber at a depth established beyond the 120-minute charring calculation or encapsulated with fire rated plasterboard to achieve the required structural adequacy of 120 minutes where required; and
- Emergency Lighting and Exit Signs shall be designed and installed in accordance with to AS 2293.1:2018 and BCA part E4.

9.5 Method of Analysis

In order to the permit exposed mass timber elements achieving a fire resistance period of 120 minutes the assessment shall be focused on the fire performance of the mass timber structure located within the building. The assessment framework as shown in Section 6 has been applied for this assessment.

To determine the contribution of mass timber duration to the fuel load a quantitative assessment shall be undertaken to demonstrate that the duration is within the proposed fire resistance period of 120 minutes for a sprinkler failure case. The Eurocode parametric fire duration approach described in Section 9.5.1 shall be used to estimate the time-temperature relationship for the expected fuel loads and establish the expected burning duration under fully developed fire conditions. The analysis considers the expected fuel load relevant to the classification and building use. It also considers the contribution of timber structure to the fuel load, available ventilation conditions along with sensitivities (i.e. limited ventilation conditions with respect to the breakage of glass facade).

Based on the outcomes of the Eurocode parametric fire duration approach, the impact on occupant life safety, fire brigade intervention and structural integrity of the building shall be assessed. The summary of the structural design brief and proposed methodology which shall be relied upon as part of the assessment to demonstrate an FRL of 120 minutes shall be provided in the subsequent FSER. The aim is to demonstrate that the mass timber construction does not have a detrimental impact on occupant life safety and the ability for fire personnel to undertake intervention activities.

To support the quantitative assessment detailed above a qualitative literature review shall investigate the intensity profile of typical fires in relation to mass timber construction and fire performance. The objective of the literature review is to provide some validation to the input and output of the quantitative analysis. Furthermore, the use of mass timber construction shall require provision of evidence in support via fire testing from a NATA registered facility or evidence of design compliance or academic research. In some instances, the assessment shall rely on the fire testing as evidence in support of the quantitative assessments to be conducted for the proposed mass timber construction.

The proposed minimum uniform FRL of exposed mass timber elements achieving 120 minutes shall be compared to the time taken for expected contribution of timber to the fuel load duration (i.e., Eurocode parametric fire duration) for the compartment. An occupant egress analysis shall be conducted to determine the localised time associated with occupant evacuation from the building whilst a Fire Brigade Intervention Model (FBIM) shall be conducted to estimate the time taken for fire brigade notification, arrival and extinguishment activities.

9.5.1 Eurocode Parametric Fire Duration

Eurocode 5 Annexe A (EN 1995-1-2:2004) provides the method to account for the charring rates and strength reduction factors for timber structures for 'parametric fires'. The method for the determination of parametric time-temperature curves is given in EN 1991-1-2:2002 Annex A. A time-temperature curve can be produced for any combination of fuel load, ventilation openings and wall lining materials. Refer to Appendix G for the methodology to determine the parametric time-temperature curves.

In order to determine the contribution of timber to the fuel load, the charring rate and resultant depth of the timber member shall be calculated under a parametric fire. The Eurocode 5 Annexe A method assumes that the charring proceeds at the initial rate β_{par} for a time t_0 (initial char time) then reduces linearly to zero over subsequent time periods of $2t_0$ so that the total depth of char at the end of the exposure (time $3t_0$) is as shown in Figure 9.2.

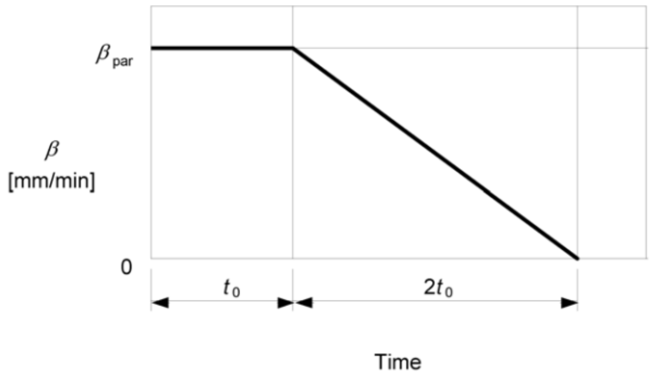


Figure A1 — Relationship between charring rate and time

Figure 9.2: Relationship between charring rate and time

The final part of the analysis is utilised to calculate the contribution of timber to the fuel load. During the fire as the timber structure chars the additional fuel load shall be considered in the development of the fire. Guidance in calculating the contribution of timber to the fuel load is provided in Fire Safety Challenges of Tall Wood Buildings – Phase 2: Task 4 – Engineering Methods (Brandon .D, 2018). The contribution of exposed timber to the fuel load of the fire can be estimated from charring rates and using the ratio between heat release and char depth of 5.39 MJ/m^2mm.

The ratio provides depth unit which assists in establishing the volume of timber involved in fire per unit area based on the char depth. In order to calculate the additional fuel load contributed by the timber (MJ/m^2) the following analysis shall be undertaken. It should be noted that this is an iterative process to ensure the resultant char depth equals the added timber fuel:

- Based on the parametric fire equation calculate $3t_0$ and the initial char depth based on the internal fuel load only (no timber); and
- Based on the initial char depth calculated from Item 1 multiply the ratio to calculate the additional fuel load added by the timber.
- Undertake the parametric fire equation again to calculate $3t_0$ based on the fuel load including the additional timber from Item 2. Please note there shall be a difference between the initial char depth calculated in Item 1 and the resultant char depth calculated in Item 3.
- Undertake this iterative process multiple times by increasing the initial char depth until it equals the resultant char depth. The burnout duration when this intersects is the final $3t_0$

Refer to Appendix G for the methodology to determine parametric temperature-time curve contributed by CLT soffit and final char depth based on the burnout duration.

9.5.2 Input Parameters

In order to determine the contribution of timber to the fuel load duration a fire scenario on ground level shall be adopted. In this instance, the fire scenario shall be located within the study/library/General Learning Space areas on Level 01 and the analysis shall consider increased fuel loads and reduced ventilation parameters as sensitivity studies which have been summarised Table 9.2. Table 9.4 provides the input parameters and location for the fire scenarios.

Table 9.2: Fire Scenarios

Floor Area of Exposed Timber (m^2)	Fire Scenarios	Description
270 m^2 for CLT floor system	Core Fire Scenario (Fuel-controlled)	Fire scenario involving exposed CLT floor system occupying an enclosure. The mean fuel load density of 285 MJ/m^2 was utilised.
270 m^2 for CLT floor system	Sensitivity Fire Scenario (Fuel-controlled)	Fire scenario involving exposed CLT floor system occupying an enclosure. The fuel load density of 450 MJ/m^2 (95th percentile) was utilised.
270 m^2 for CLT floor system	Sensitivity Fire Scenario (Ventilation-controlled)	Ventilation controlled fire scenario involving exposed CLT floor system occupying part of the floor plate. The fuel load density of 285 MJ/m^2 was utilised.

In this instance, the subject building is an assembly building with galleries, office spaces and the like. However, the building incorporates a number of General Learning Space/ Learning Commons areas for university students on Level 01 and 02 and as such these areas have been selected for the purposes of the analysis. The fuel loads located within such areas are akin to school fuel loads and as such the school fuel loads provided in Table 3.4.1b of IFEG (2005) shall be adopted for this analysis as shown in Table 9.3.

Table 9.3: Table 3.4.1b of IFEG (2005)

Densities in Mega-Joules per Square Metre				
		Percentile fractile*		
Occupancy	***Mean (MJ/m^2)***	***80***	***90***	***95***
Schools	285	360	410	450
Offices	420	570	670	760
Hotel Bedroom	310	400	460	510

The fuel load density (FLD) shall adopt a value of **285 MJ/m^2** for mean and **450 MJ/m^2** is based on the 95% fractile provided in Table 3.4.1b of IFEG (2005).

The charring rate of the CLT soffit which form part of the flooring system has been based on the product specific testing data.

Table 9.4: Input Parameters

Fire Scenario	Location	Area of Exposed Timber	Fire Cell Height	Fuel Load Density	Ventilation Openings
Core Scenario	CLT floor system	270m^2	4.0m	285 MJ/m^2 + Additional Char	80% of total area of openings (0.8 x 68m^2 = 54.0m^2)
Sensitivity Scenario (Increased fuel load)	CLT floor system	270m^2	4.0m	450 MJ/m^2 + Additional Char	80% of total area of openings (0.8 x 68m^2 = 54.0m^2)
Sensitivity Scenario (Ventilation controlled)	CLT floor system	270m^2	4.0m	285 MJ/m^2 + Additional Char	50% of total area of openings (0.5 x 68m^2 = 34m^2)

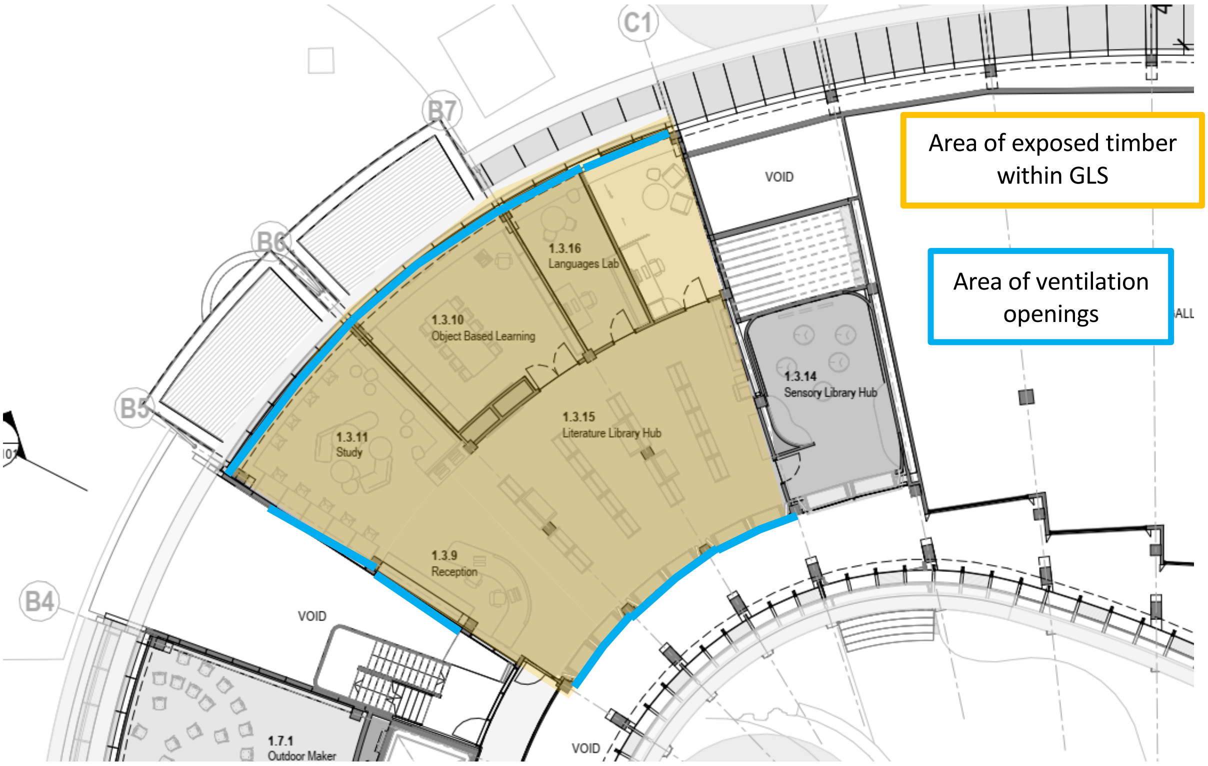


Figure 9.3: Floor area and ventilation openings for analysis

9.6 Acceptance Criteria

The basic objective and intent of the analysis pertains to the life safety of occupants and fire brigade personnel and structural collapse of load bearing elements. Thus, the primary acceptance criterion shall be met by demonstrating that the exposed nature of the mass timber construction does not have an adverse effect on occupant life safety during the evacuation and Fire Brigade intervention periods.

The function of fire rating in a building is to ensure that the building structure resist the most credible fires for a pre-determined duration. In the context of occupant life safety, the duration must correspond to a period where all occupants can evacuate the building comfortably and safely. In the context of fire brigade intervention, the failure should not occur prior to the commencement of fire extinguishment activities of the fire brigade.

The adopted safety factors for mass timber construction including exposed mass timber are defined as the following:

Mass Timber Elements

$$FRP_{(120\ minutes)} \geq 1.5xRSET$$

$$FRP_{(120\ minutes)} \geq 1.5xFBIM$$

$$FRP_{(120\ minutes\ )} \geq 1\ x\ \text{Eurocode Parametric Fire Duration}\ _{(Core\ Scenario\ -\ 80\%\ opening)}$$

$$FRP_{(120\ minutes\ )} \geq 1\ x\ \text{Eurocode Parametric Fire Duration}\ _{(Sensitivity\ Scenario\ -\ 50\%\ opening)}$$

9.7 Trial Design for Assessment

The trial design outlines in Section 0.5 are preliminary recommendations which need to be verified by a detailed fire engineering assessment. All other items not specifically addressed are to be in accordance with DtS provisions of the BCA or as accepted by the relevant authorities.

10. Protection of Openings within the External Walls

10.1 Background to the Issue

It has been identified that there are openings within the external walls located of the subject building that is located within 6m from another building on the same allotment. The existing building is known as the Central Energy Plant (CEP) and is located 4.4m from the external façade wall of subject building.

As prescribed by Clause C4D3 from Volume One of the BCA, any openings within 6.0m from another building on the same allotment are required to be protected in accordance with Clause C4D5 of the BCA. Refer to Figure 10.1 and Figure 10.2 for the location of the openings.

Clause C4D5 provides direction into acceptable means of protecting openings that may be impacted on by a fire within the same building or a building on an adjacent allotment. If a fire is assumed to take place within the subject building, there is a potential path for fire spread to and from the adjacent building via the identified external window openings. Therefore, by calculating the incident radiation at a given distance away from the opening and comparing this with the acceptance criteria, the acceptability of the proposed design has been established.

The fire engineering assessment documented in the following sections has demonstrated the following:

- Prevention of spread of fire between buildings on the same allotment satiated within 6m of each other; and
- Mitigation of radiant heat flux emitted/received between fire source features.

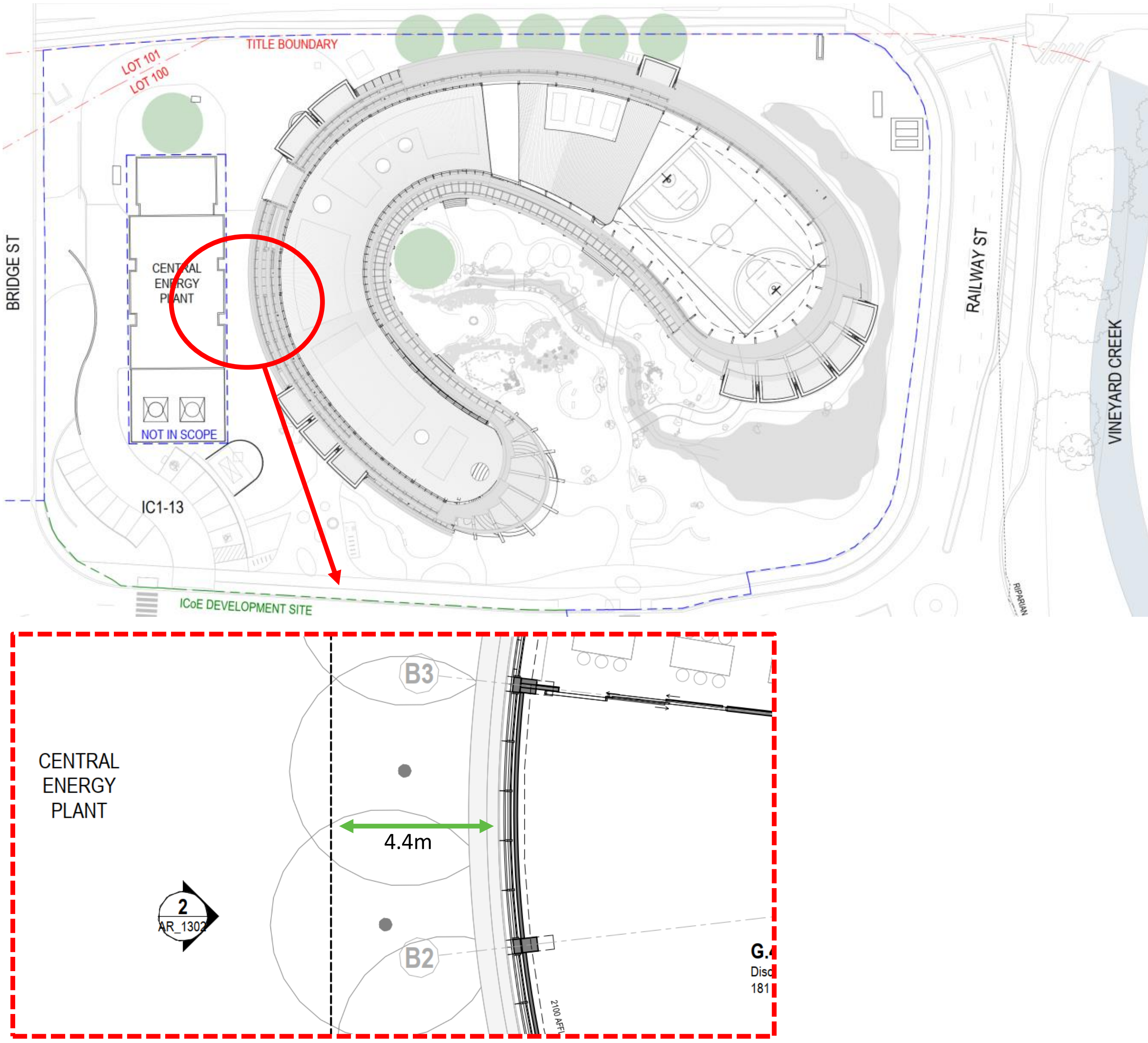


Figure 10.1: Site Plan

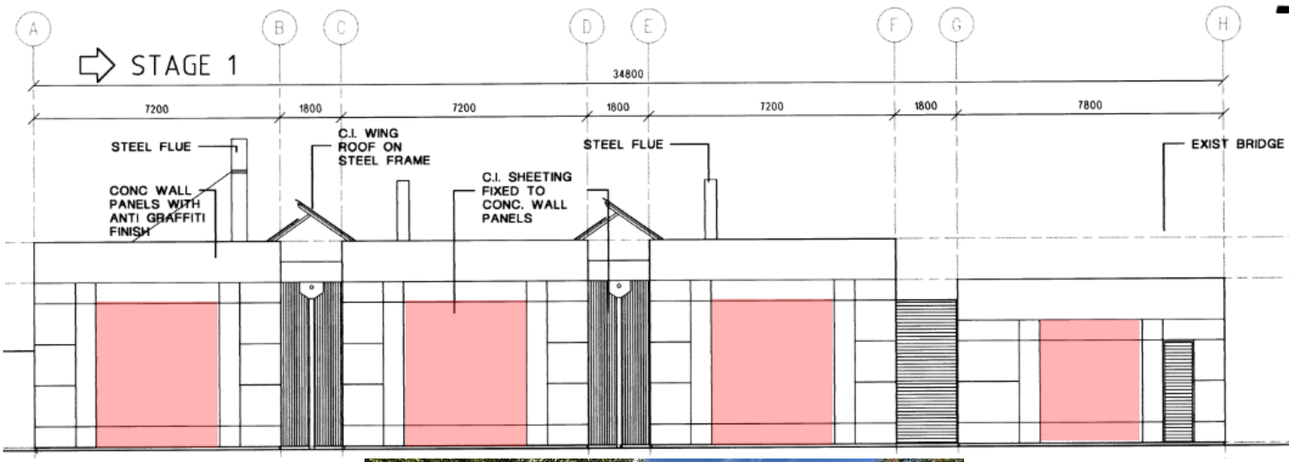


Figure 10.2: CEP Building (Eastern Elevation)

10.2 Performance Solution

In accordance with the BCA Clause A2G2 *Performance Solution* the following assessment method shall be adopted which demonstrated that the *Building Solution* shall meet the relevant *Performance Requirement CP2 and CP8*.

Table 10.1: Method of Analysis

Identified Design Issue	Performance Solution	AFEG Method of Analysis
It is proposed to permit the proposed building to be located within 6m of the existing Central Energy Plant (CEP) building which is on the same allotment.	A2G2(2)(b)(ii) Other Verification methods such as other Verification Methods as the appropriate authority accepts for determining compliance with the Performance Requirements	A qualitative analysis shall be undertaken whereby the performance of the external wall system in relation to ignitability. A quantitative 'deterministic' approach shall demonstrate the performance solution satisfies the relevant Performance Requirement of the BCA.

10.3 Hazards Specific to the Design Issue

The Guide to the BCA (ABCB, 2022) states that the intent associated with the prescribing a minimum distance where openings are to be located as being '*To require any opening in external walls to be protected, only where the wall is required to have an FRL, to prevent the spread of fire from the boundary of an adjoining allotment, or one building to another building on the same allotment'.* With respect to the proposed development the hazard analysis illustrates a number of consistent observations. These include the following:

- The potential for fire spread to and from the subject building to the adjacent building.

10.4 Hazard Mitigation

The Guide to the BCA (ABCB, 2022) identifies the potential for occupants and fire fighter to encounter unsafe conditions as fire may spread between buildings. In this regard, the following hazard mitigation systems, requirements and features of the design are noted:

- The statistics worldwide indicate that a low/mid-rise assembly building rates relatively low with respect to the risk of fire and life safety when compared to buildings of other occupancies; and
- The CEP building is predominantly constructed of non-combustible construction in the form of concrete/masonry and corrugated iron sheets and does not have any ventilation openings within the external façade of the building.
- The building façade shall incorporate a pre-fabricated system and the external cladding system (i.e. external façade) shall be a non-combustible material; and
- The mass timber columns are fixed to the internal side of the building façade behind the glazed facade construction; and
- Fire brigade personnel are afforded setup locations around the site of the building; and

10.5 Method of Analysis

10.5.1 Qualitative Analysis

A qualitative analysis shall be adopted to assess the external wall for the proposed building and the Central Energy Plant (CEP) building. The analysis shall consider the composition of the external wall materials in relation to ignition, fire development and spread as well as the likelihood of the external wall contributing to fire spread. In summary the following key items shall be considered:

- The location of the Glulam building elements around the perimeter of the building and its fixing method into the external wall.
- The CEP building is predominantly constructed of non-combustible construction in the form of concrete/masonry and corrugated iron sheets and does not have any ventilation openings within the external façade of the building.

10.5.2 Quantitative Analysis

The quantitative assessment shall adopt radiant heat calculations from the closest fire source feature being the CEP building which is located within 6m to the subject building on the same allotment to determine if the external wall would be compromised from an external credible fire source feature. The radiant heat flux, Q (W/m^2) from a single opening of a burning building to a point some distance away was determined by the black body emission equation as shown in the following equation. (ABCB, FSEG, 2001).

$$Q = \varepsilon \sigma F T^4$$

where,

ε = emissivity = 0.9

σ = Stephan-Boltzmann constant = 5.67x10^{-8} W/m^{2}K^4

T = temperature of emitting surface = 1173 K (900°C) - angle of 90° and 0° for non-sprinkler protected building

F = configuration (view) factor

According to Klote and Milke (2003) the majority of radiant heat as it is transferred away by convection. Despite this and in order to adopt a level of conservatism, a temperature of **900°C** shall be adopted throughout the analysis when determining radiant heat flux levels received from an external credible fire source feature to the subject building and the convection losses shall be ignored. For the purpose of the assessment, it was proposed to adopt the worst credible case emissivity scenario whereby the emissivity (ε) for sheet steel with rough oxide layer shall be adopted (i.e. 0.9).

Refer to Appendix H for further information regarding the calculation for radiant heat flux.

10.5.2.1 Input Parameters

To assess the likelihood of the fire spread between the subject building and CEP building shall be considered as part of the quantitative assessment. A single notional panel shall be selected based on the closest building (CEP building) which acts as of the fire source feature to the external wall of the subject building (refer to Figure 10.3). There is a portion of the proposed building at the western side that is within approximately 4.4 metres of the existing building. The opening identified for the quantitative analysis is presented in Table 10.2.

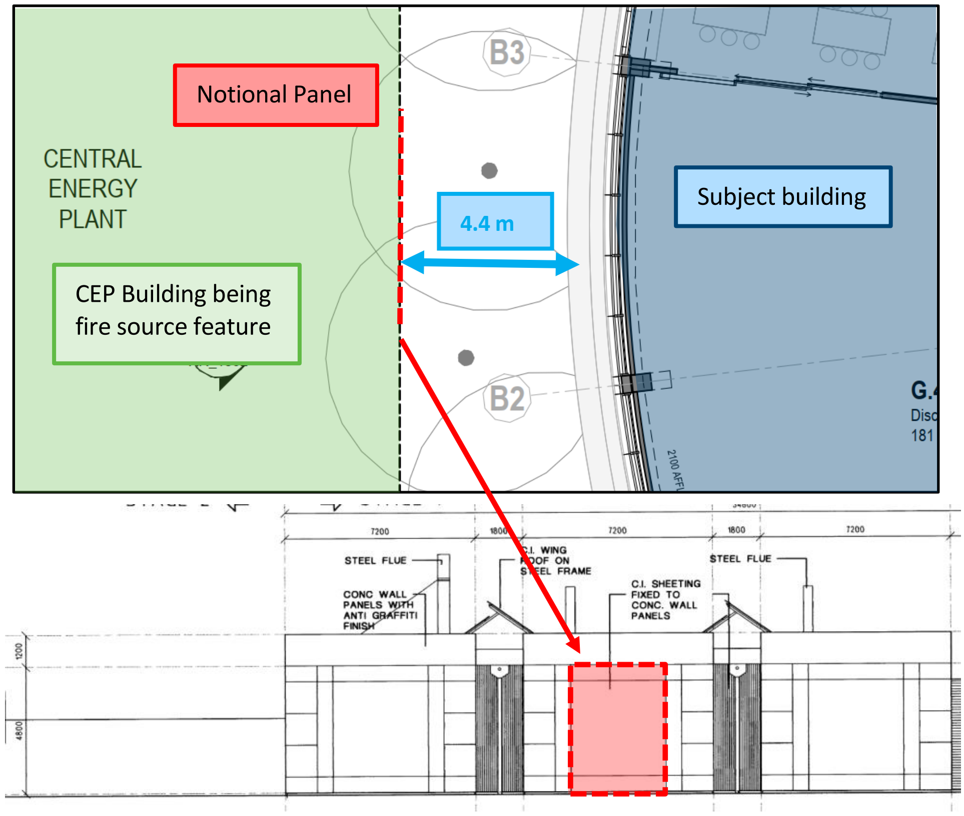


Figure 10.3: Distance to Adjacent Building and Location of Notional Panel

Figure 10.4 provides a section view of the façade and the thermal properties of each material which has been considered as part of the quantitative assessment. As shown the only combustible element is the Glulam column and as such the ignition radiant heat for that element has been adopted as part of the acceptance criteria.

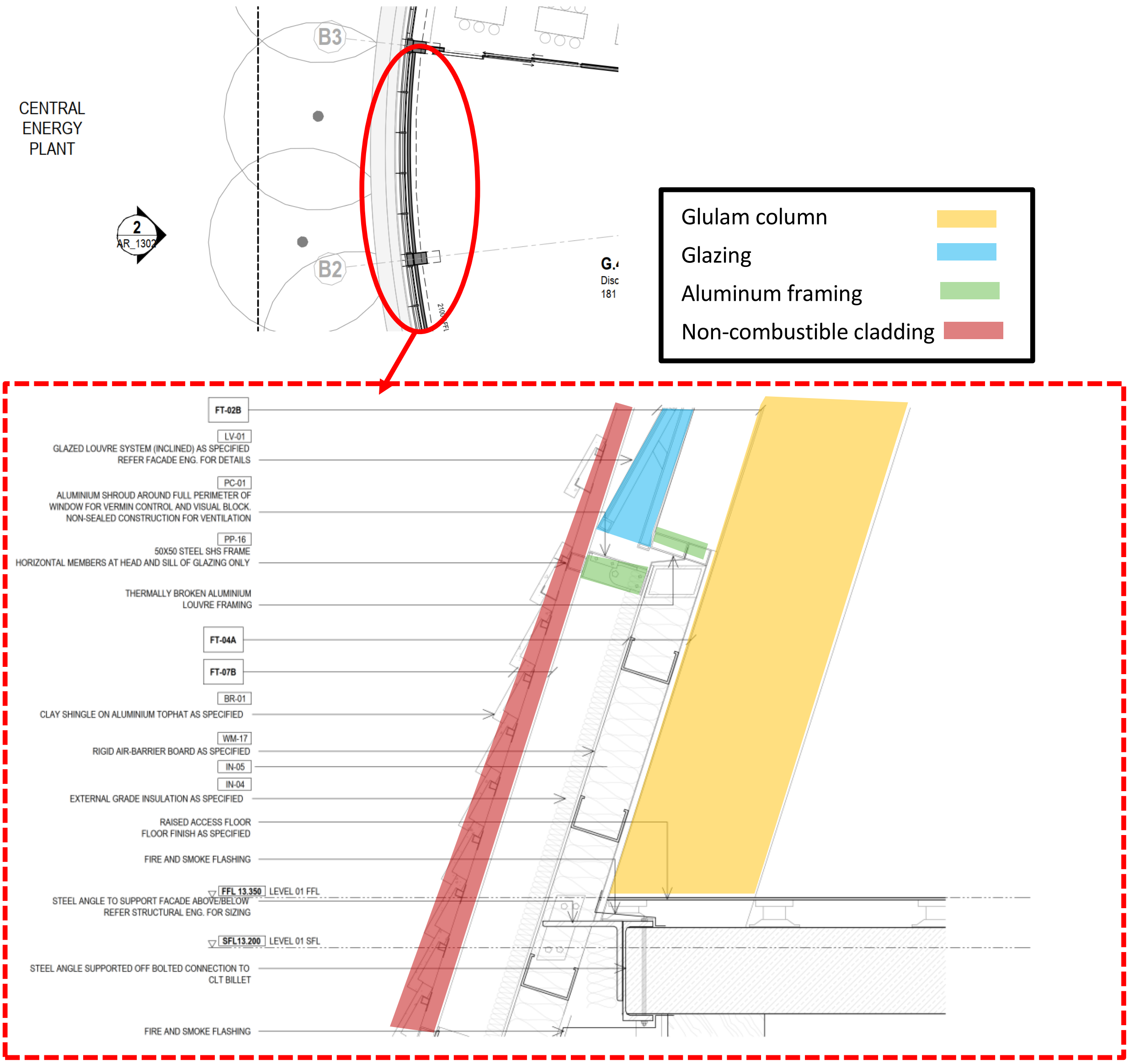


Figure 10.4: Section of the external wall and the material properties

Table 10.2: Input Parameters

Opening ID	Location	Dimensions	Configuration	Setback
W1	External wall of the CEP building facing the subject building	5.0m (w) x 4.8m (h)	Parallel	4.4m

The preliminary assessment suggest that fire spread between the buildings shall be mitigated. Radiant heat calculations indicate that fire spread will not occur due to the presence of the CEP building being located within 6m of the subject building. The preliminary calculations indicate that the radiant heat flux levels are below the acceptance criteria nominated in Section 10.6.

10.6 Acceptance Criteria

The basic objective and intent of the analysis pertains to fire spread between building both on the same allotment. The acceptance criterion shall be met by demonstrating that the construction method of the external wall of the subject building will not unduly contribute to the risk of fire spread to the existing CEP building and vice versa.

With respect to the quantitative assessment the radiant heat calculations shall demonstrate that a fire source feature from the existing CEP building shall not impose a radiant heat flux greater than **35 kW/m²** (ignition of timber in the absence of a spark, Guide to the BCA 2022 under Section C1V1 Verification Methods).

10.7 Trial Design for Assessment

The trial design outlines in Section 0.5 are preliminary recommendations which need to be verified by a detailed fire engineering assessment. All other items not specifically addressed are to be in accordance with DtS provisions of the BCA or as accepted by the relevant authorities.

11. Non-Fire Isolated Stairway

11.1 Background to the Issue

It has been identified that the subject building shall be provided with the stairway known as “Badanami Stair” serving all levels connecting to four (4) storeys. In accordance with Clause D2D4(2) of Volume One of the BCA, states that a Class 9 occupancy such as in this instance may be non-fire isolated if it connects, passes through or passes by not more than 2 consecutive storeys and one extra storey may be included if the building has a sprinkler system installed throughout. Therefore, the stair design forms a deviation from the building code since it connects greater than three (3) consecutive levels. Therefore, it is proposed to permit the stairway known as “Badanami Stair” serving all levels to be not fully contained within a fire-rated shaft. Refer to Figure 11.1 and Figure 11.2 for the open stair design.

Figure 11.1: Plan view of Open Stairway on each level

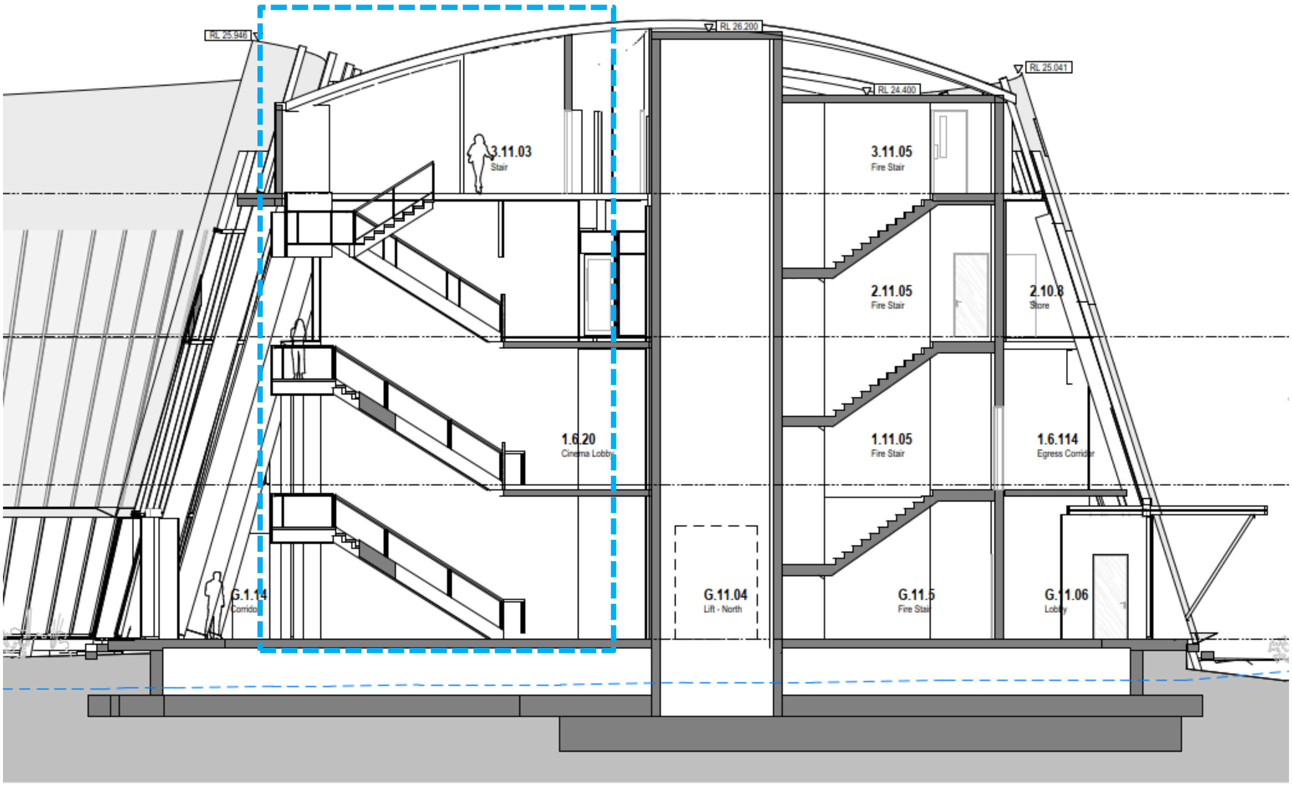


Figure 11.2: Section view of Open Stairway

11.2 Performance Solution

In accordance with the BCA Clause A2G2 *Performance Solution* the following assessment method shall be adopted to demonstrate that the *Building Solution* complies with the *Performance Requirements D1P4 and D1P5*.

Table 11.1: Method of Analysis

Identified design issue	Performance Solution	AFEG Method of Analysis
It is proposed to permit the stairway known as "Badanami Stair" serving all levels to be not fully contained within a fire-rated shaft.	A2G2(2)(b)(ii) Other Verification Methods as the appropriate authority accepts for determining compliance with the Performance Requirements and comparison to the DtS provisions of the BCA.	A qualitative risk-based analysis shall be undertaken to demonstrate that the non-fire isolated stair shall not negatively impact occupant life safety within the subject building.

11.3 Hazards Specific to the Non-fire Isolated Stairway

The 'Guide to the BCA' (ABCB, 2022) states that the intent associated with the prescriptive provisions requiring fire-isolated exits in buildings "*is to enable people to evacuate past a storey on fire allowing occupants to safely enter a fire-isolated exit which discharges to a safe location*". The DtS building solution also enables the fire brigade to carry out search and rescue and fire-fighting activities. It is therefore considered that the main hazard associated with the identified design issue relates to:

- Increasing the risk of fire spread throughout the building; and
- Egress via a non-fire isolated stairway may expose occupants to potential hot smoke and gases due to a potential fire at any level within the building; and
- Egress via a non-fire isolated stairway may expose occupants to potential high radiant heat flux levels as a result of a fire adjacent to the open emergency fire exit stairs; and
- Occupants located remote from fire origin may be delayed or unable to evacuate due to untenable conditions; and
- Extending the total building evacuation time.

11.4 Hazard Mitigation

The Guide to the BCA (ABCB 2022) identifies the potential for occupants to be hindered whilst they evacuate from the required open stairway. In this regard the following hazard mitigation systems, requirements and features of the design are noted:

- The building shall be protected by an automatic sprinkler system in accordance with AS2118.1:2017 unless otherwise stated herein. Automatic sprinkler systems are very effective at reducing the severity of fires in assembly building properties.
- The stairway known as “Badanami Stair” connects four (4) consecutive levels (i.e. Level 00 to 03) is of steel construction (non-combustible) and will not contribute to fire spread between levels; and
- The stairway known as “Badanami Stair” connects four (4) consecutive levels (i.e. Level 00 to 03) without the requirement of fire separation throughout. The stairway shall be provided with the following:
  - This stairway is required to be fire separated between Level 02 and Level 03 via fire rated construction achieving a minimum FRL of 120 minutes achieved from both sides.
  - The remainder of the stairway from Level 00 to Level 02 is permitted to be open and provided with smoke proof construction in the form of a smoke baffle (i.e. minimum depth of 500mm) bounding the stair at Level 02; and
- A fire alarm/evacuation matrix has been developed for the subject building(s) in order to ensure effective evacuation is achieved. Active Dynamic Signage System (ADSS) shall be installed outside the stairways providing egress on Level 3 of the building to enhance occupant wayfinding and direct occupants to a safe egress path. The system shall comprise intelligent exit signage which shall be programmed based on GFA (i.e. sprinkler or detector activation) signal location and detailed in Figure 0.8, Figure 0.9 and Table 0.3).
- The main occupants are considered to be awake, coherent and aware of their surroundings.
- Smoke detection and alarm systems are to be installed in accordance with Specification 20 and AS 1670.1:2018 throughout; and
- Installations activating the EWIS shall also be connected to a fire alarm monitoring system connected to a fire station or fire station dispatch centre in accordance with AS1670.3:2018; and
- The sterile nature in front of the open stairway within the public corridors and circulation spaces on each floor; and
- Housekeeping and management-in-use process shall be implemented to maintain clear and sterile public corridors and paths of travel to exits.

11.5 Method of Analysis

The methodology adopted to address the design issue relative to the non-fire isolated stairway shall be based upon a qualitative ‘risk’ based evaluation. The evaluation shall consider the following:

- Function and use of the open stairway.
- The construction material of the “Badanami Stair” being steel.
- Potential fire hazards and its impact the open stairway.
- The proposed passive fire separation between Level 02 and 03 and the smoke proof construction in the form of a smoke baffle at Level 02 to mitigate smoke and fire spread to the topmost level.
- The presence of multiple egress pathways on Level 00-02 which allows occupants to access another exit if the open stairway is deemed compromised.
- The presence of active fire safety measures such as sprinkler system and fire detection and alarm system to assist in identifying the fire in its early stages and containing the fire to the zone of fire origin.
- The adoption of a fire alarm/evacuation matrix in order to ensure effective evacuation is achieved. More specifically, Active Dynamic Signage System (ADSS) shall be installed outside the stairways providing egress on Level 3 of the building to enhance occupant wayfinding and direct occupants to a safe egress pathway to a road or open space.
- The impact on fire brigade personnel undertaking firefighting activities within the building.

11.6 Acceptance Criteria

The basic objective and intent of this analysis pertains to life safety of occupants and fire-fighters. Therefore, the acceptance criterion shall be met by demonstrating that the proposed stairway configuration, fire separation strategy, multiple egress pathways and evacuation matrix shall not negatively impact on evacuating occupants during a fire emergency. The acceptance criterion shall also be met by demonstrating that the proposed stair configuration does not have a negative impact on attending fire crews due to the location and construction of the stairway, enabling them to set up and carry out their activities in a safe environment.

11.7 Trial Design for Assessment

The trial design outlines in Section 0.5 are preliminary recommendations which need to be verified by a detailed fire engineering assessment. All other items not specifically addressed are to be in accordance with DtS provisions of the BCA or as accepted by the relevant authorities.

12. Exit Travel Distances

12.1 Background to the Issue

It is proposed to review exit travel distances within Level 1 and 2 Communal Areas which are to exceed the maximum distances as prescribed by the DtS provisions of the BCA. In this instance, it is proposed to permit travel distances as per the following:

- Level 1
  - 28m to a point of choice in lieu of 20m
- Level 1 Plant room
  - 27m to a point of choice in lieu of 20m
  - 50m to an exit in lieu of 40m
- Level 2
  - 28m to a point of choice in lieu of 20m
- Level 2 Plant Room/Catwalks
  - 22m to a point of choice in lieu of 20m
  - 47m to an exit in lieu of 40m
- Level 3
  - 28m to a point of choice in lieu of 20m

The proposed design forms a deviation from Clause D2D5 of the BCA. Figure 12.1, Figure 12.2, Figure 12.3, Figure 12.4 and Figure 12.5 provide illustrations of where the travel distances occur.

**Draft Note: BCA consultant to confirm the above distances are consistent with the BCA report.*

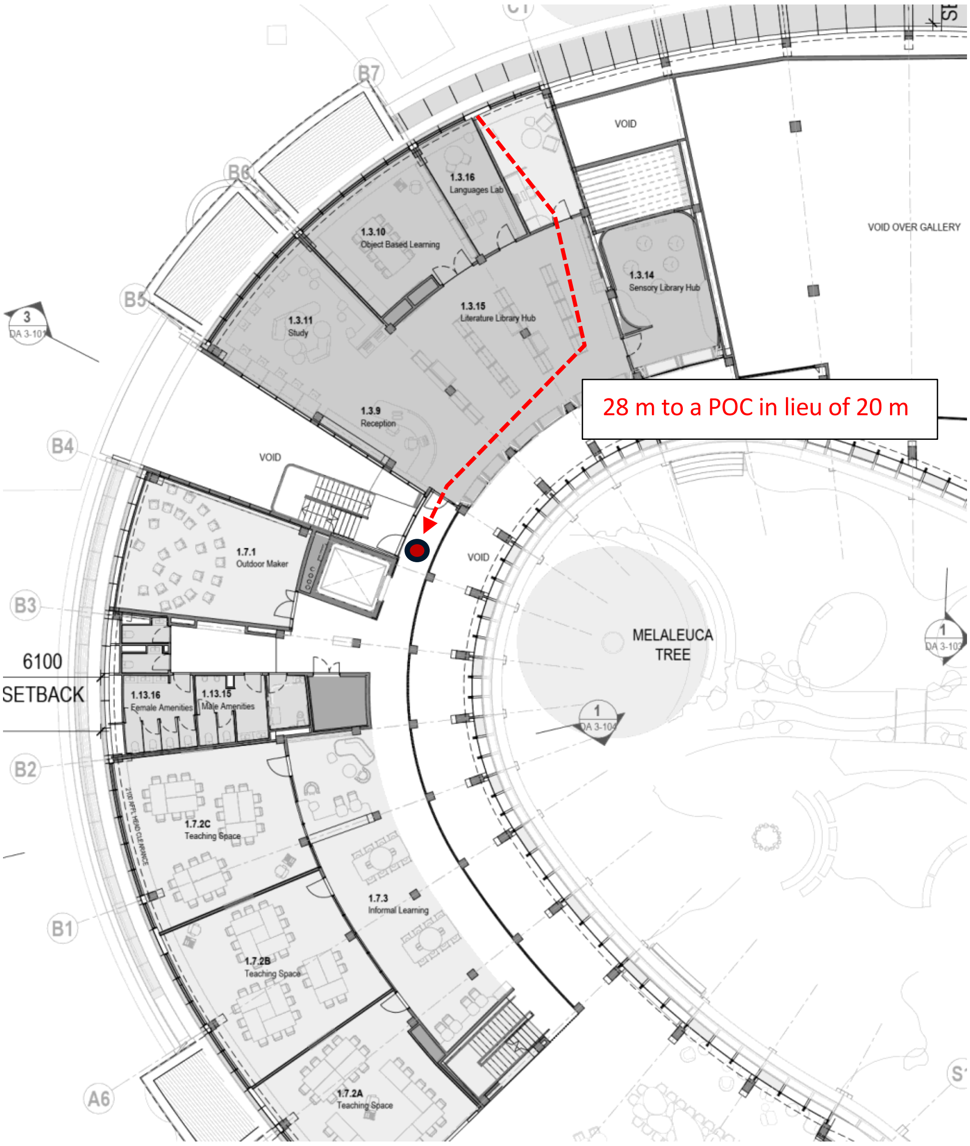


Figure 12.1: Level 1

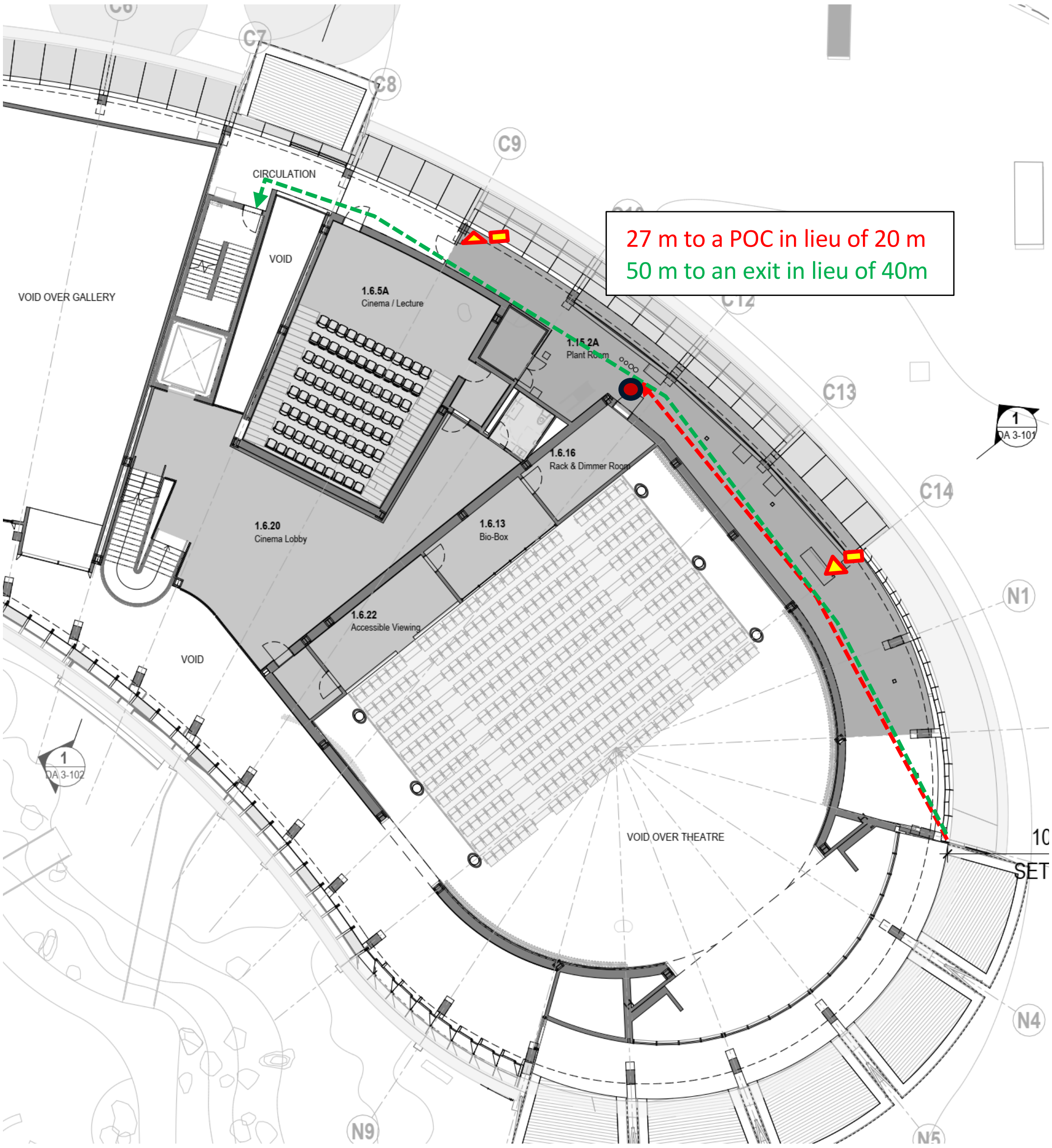


Figure 12.2: Level 1 Plant room

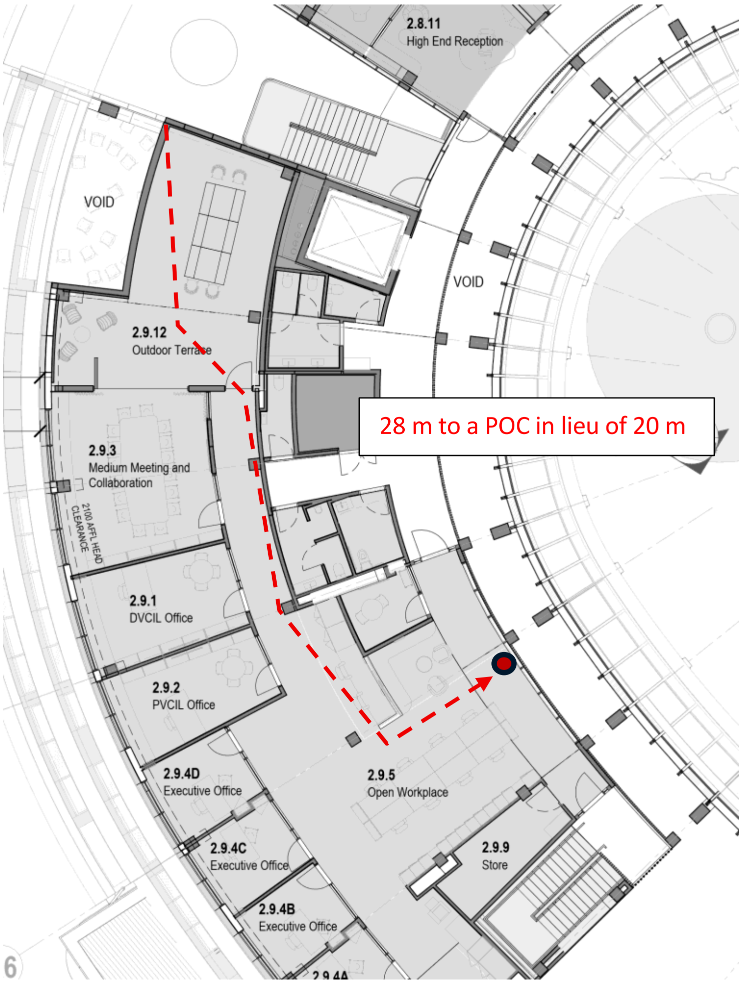


Figure 12.3: Level 2

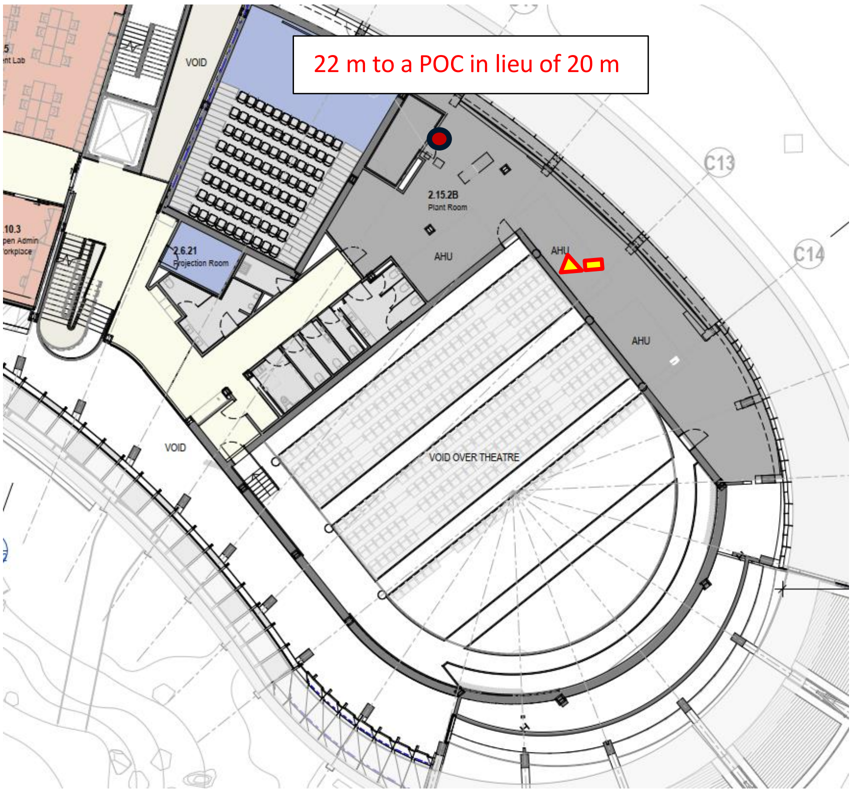


Figure 12.4: Level 2 Plant Room

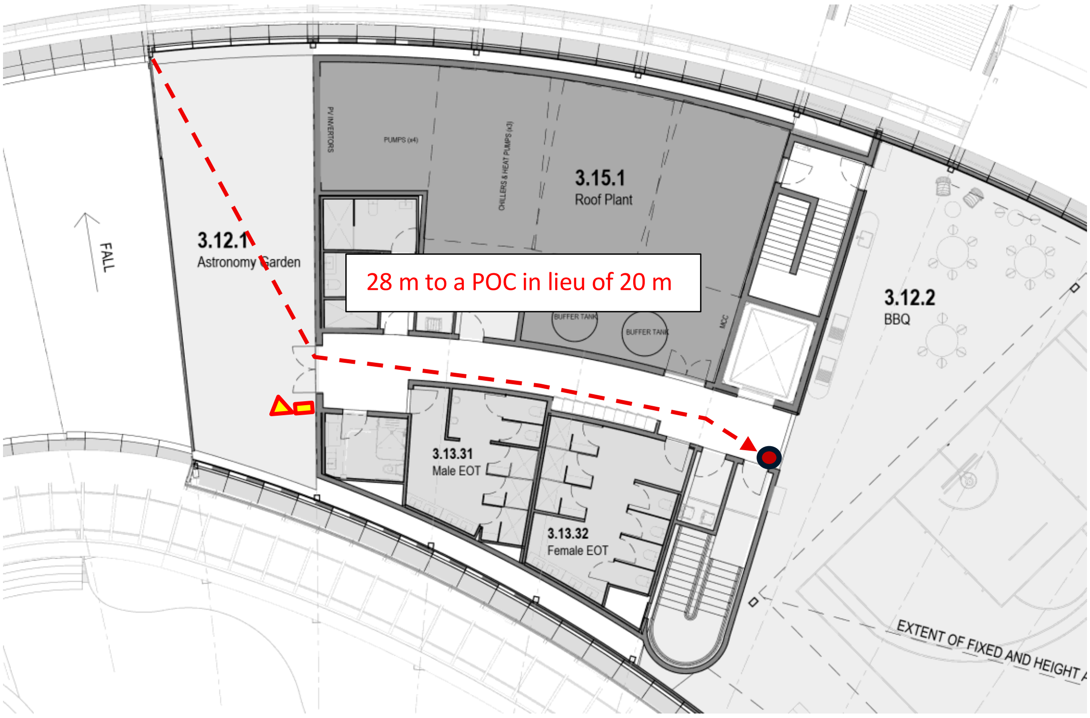


Figure 12.5: Level 3

12.2 Performance Solution

In accordance with the BCA Clause A2G2 *Performance Solution* the following assessment method shall be adopted to demonstrate that the *Building Solution* meets the relevant *Performance Requirements of D1P4 & E1P2.*

Table 12.1: Method of Analysis

Identified Design Issue	Performance Solution	AFEG Method of Analysis
It is proposed to permit the exit travel distances to a point of choice and to an exit to exceed the maximum DtS provisions as per the following: • Level 1 – 28m to a point of choice in lieu of 20m • Level 1 Plant room – 27m to a point of choice in lieu of 20m – 50m to an exit in lieu of 40m • Level 2 – 28m to a point of choice in lieu of 20m • Level 2 Plant Room/Catwalks – 22m to a point of choice in lieu of 20m – 47m to an exit in lieu of 40m • Level 3 – 28m to a point of choice in lieu of 20m	A2G2(2)(b)(ii) Other Verification Methods, accepted by the appropriate authority that show compliance with the relevant Performance Requirements. A2G2(2)(d) Comparison with the *Deemed-to-Satisfy Provisions.*	A qualitative & quantitative ‘comparative’ approach to demonstrate that the proposed design is at least equivalent to a DtS building solution.

12.3 Hazards Specific to Exit Travel Distances

The ‘Guide to the BCA’ (ABCB, 2022) states that the intent associated with prescribing a maximum distance of travel to a point of choice and to an exit as being *‘To maximise the safety of occupants by enabling them to be close enough to an exit to safely evacuate”.* It is therefore, considered that the main hazards specific to the issue to be considered in the assessment are:

- Increase in travel time associated with the additional distance of travel; that is time to evacuate will be increased from that of the BCA prescriptive design; and
- Increase in potential obstructions within the path of travel; and

- Potential for fire by-products (smoke and toxic gasses) to restrict the path of travel where distance of travel is extended (i.e. potential for tenability limits to be exceeded within the path of travel).

12.4 Hazard Mitigation

The 'Guide to the BCA' (ABCB, 2016) identifies the potential for occupants to encounter unsafe conditions whilst they evacuate from the building and hence prescribes *"what is a reasonable distance for occupants to travel to an exit"*. In this regard the following hazard mitigation systems, requirements and features of the design are noted

- Aggregate egress width are compliant to the DtS provisions of the BCA and therefore prolonged queuing at exits is unlikely to occur.
- The building shall be protected by an automatic sprinkler system in accordance with AS2118.1:2017 unless otherwise stated herein. Automatic sprinkler systems are very effective at reducing the severity of fires in assembly building properties.
- The main occupants within the building are considered to be awake, familiar, coherent and aware of their surroundings; and
- Enhanced notification shall be provided within Level 1 and Level 2 plant room, L2 catwalks and the L3 landscape area within the presence of strobe lights and sounders; and
- The identified areas shall be provided with automatic fire detection & alarm system adopting a reduced spacing of 10m x 10m as per AS1670.1:2018; and
- An Emergency Warning and Intercom System (EWIS) shall be provided throughout the development in accordance with Clause E4D9 of the BCA and AS1670.4:2018; and
- System monitoring to a fire station and/or fire station dispatch centre shall be provided in accordance with AS1670.3-2004; and
- Emergency lighting and exit signage in accordance with AS2293.1:2005 with potential size and location enhancements.

12.5 Methodology

12.5.1 Level 1 and 2 Common Areas (general populated areas)

The methodology to address the design issue relative to the extended travel distances shall be based upon a combination of both a qualitative 'risk' and quantitative 'comparative' evaluation. The qualitative aspect of the evaluation shall consider the assembly building common areas on Level 1 and 2 function & use, risk of fire ignition and the proposed fire safety measures (i.e. provision of reduced smoke detection spacing being an enhancement). Further consideration of the impact imposed onto attending fire-fighter personnel shall also be undertaken.

The analysis shall consider the three (3) main components: detection, pre-movement and movement (i.e. $t_d + t_{pm} + t_m$ = RSET) to demonstrate that the increased time associated with the identified travel distances shall be suitably compensated through enhanced occupant warnings and detection (i.e. smoke detection system). The overall occupant evacuation time shall be enhanced such that the egress strategy suitably compensates the additional travel distance and is at least equivalent to a DtS building solution.

The Available Safe Egress Time (ASET) for evacuation (prior to the onset of untenable conditions occurring within the egress path) will be considered to be equivalent in both instances as there are no significant fire hazard features of the design that will affect the nature of a potential fire (e.g. fire load, intensity & growth rate) as a consequence of the presence of an extended travel distance.

The following input parameters shall be adopted as part of the quantitative analysis:

- **Detection Time (T_{det})**: The time for occupants to detect a fire shall be based on a reduced smoke detection spacing from 15m x 15m to 10m x 10m. The time for smoke detection shall be calculated using Alpert's Correlation. The input parameters for detector activation times are provided in Table 12.2.

Table 12.2: Input parameters for Detector activation calculations

Item	Proposed Performance Solution	Equivalent DtS Building Solution
Detector Activation Temperature	13°C above ambient conditions (Heskestad, 1995 – Temperature Equivalence method)	13°C above ambient conditions (Heskestad, 1995 – Temperature Equivalence method)
Response Time Index (RTI)	$10m^{0.5}s^{0.5}$ (Bukowski & Averill, 1998)	$10m^{0.5}s^{0.5}$ (Bukowski & Averill, 1998)
Location of Detector	4.0m Ceiling level for both Level 1 and 2	4.0m Ceiling level for both Level 1 and 2

Item	Proposed Performance Solution	Equivalent DtS Building Solution
Detector Spacing	10m x 10m grid spacing based on AS1670.1:2018 (Radial Distance 7.1m)	15m x 15m grid spacing based on Section 7 of AS1670.1:2018 (Radial Distance 10.6m)
Fire Growth Rate	Medium t^2 Steffanson (2010)	Medium t^2 Steffanson (2010)

A medium t^2 fire growth rate will be adopted based on Steffanson (2010) as shown in Figure 12.6. The medium t^2 growth rate represents the common spaces on Level 1 and 2 being akin to offices and school environments.

Table 10.2. Examples of fire growth rates based only on estimated use and occupancy, found in various literatures.

Occupancy	Growth rate
Dwellings	Fast [13] Medium [17] Medium [22]
Schools, offices	Medium [13] Medium [17] Fast [22]
Hotels, nursing homes etcetera	Fast [13] Fast [22]
Shopping centres, entertainment centres	Fast [13] Fast [17] Ultra-fast [22]

Figure 12.6: Typical fire growth rates

- **Pre-Movement Time (T_{pm})**: Based on British Standard PD 7974-6:2019 which suggests pre-movement time of up to 180 seconds where an alarm system activates a general fire alarm to all affected parts of an assembly building. More specifically, with reference to the SFPE Handbook of Fire Protection (SFPE, 3rd Edition) it stipulates based the occupancy types and occupant characteristics the response times are illustrated in Figure 12.7.

Occupancy Type	W1 (min)	W2 (min)	W3 (min)
Offices, commercial and Industrial buildings, schools, colleges and universities (Occupants awake and familiar with the building, the alarm system, and evacuation procedure.)	< 1	3	> 4
Shops, museums, leisure-sport centers, and other assembly buildings (Occupants awake but may be unfamiliar with building, alarm system, and evacuation procedure.)	< 2	3	> 6
Dormitories, residential mid-rise and high-rise (Occupants may be asleep but are predominantly familiar with the building, alarm system, and evacuation procedure.)	< 2	4	> 5
Hotels and boarding houses (Occupants may be asleep and unfamiliar with the building, alarm system, and evacuation procedure.)	< 2	4	> 6
Hospitals, nursing homes, and other institutional establishment (A significant number of occupants may require assistance.)	< 3	5	> 8

W1: live directives using a voice communication system from a control room with closed-circuit television facility, or live directives in conjunction with well-trained, uniformed staff that can be seen and heard by all occupants in the space
W2: nondirective voice messages (prerecorded) and/or informative warning visual display with trained staff
W3: warning system using fire alarm signal and staff with no relevant training

Source: Adapted from *Fire Safety Engineering in Buildings, Part 1: Guide to the Application of Fire Safety Engineering Principles,* Table 21, British Standard Institue, DD240, London, 1997.

Figure 12.7: Pre movement times as per the SFPE Handbook

- **Movement Time (T_m):** Based upon a movement speed of 0.9m/s(SFPE 5th Ed. 2017, Ramachandran & Charters 2011, Lord et al, 2005 & Fahy et al 2001 and refer to Appendix F).
  - The distance of travel to a point of choice where two (2) exits are available is 28m (i.e. 28m/0.9m/s = 31 seconds) that exceeds 20m (i.e. 40m/0.9m/s = 22 seconds).

12.5.2 Level 1 and 2 Plant Room Areas (limited populated areas)

The methodology to be adopted to address the design issue relative to single exit and travel distances in the rooftop and plant areas shall be based upon a qualitative risk based approach which shall consider the following:

- The plant room function/use, fire hazard and proposed fire safety measures which shall improve warning/notification; and

- The limited number of occupants within this space being predominantly maintenance staff and catwalk operators. Occupants are expected to be familiar with the layout and awake, and as such expected to promptly commence evacuation in case of a fire; and
- Assessment shall consider the requirement for the ongoing maintenance of sterile lobbies/corridors, inclusive of the egress path via the plant room to ensure that the egress paths are clear of obstructions at all times; and
- Evaluation of the provision of active suppression (i.e., sprinklers) and detection measures that shall mitigate potential fire development and spread, resulting in favourable conditions and prevent excessive fire compartment temperatures and subsequently provide improved egress provisions; and
- The assessment shall review the building design, more specifically emphasising on the plant rooms have a simple layout and relatively small floor area whereby occupants can easily locate the exit locations; and
- Effectiveness of the proposed sounder(s) and red strobe light(s) within the plant rooms shall be considered whereby they are expected to provide the occupants with early warning and assist in initiating the evacuation procedures in a timely manner; and
- Consideration shall also be given to the impact on attending fire brigade personnel with consideration to the active fire safety measures (i.e., sprinklers), the proposed fire-fighting equipment (i.e., hydrant system) and building characteristics with limited fuel loads and ignition, which are not expected to pose a considerable risk towards attending FRNSW personnel.

12.5.3 Level 3 Communal Areas (general populated areas)

The methodology to be adopted to address the design issue relative to exit travel distances in the Level 3 communal areas shall be based upon a qualitative risk based approach which shall consider the following:

- The Level 3 communal area function/use, fire hazard and proposed fire safety measures which shall improve warning/notification; and
- The assessment shall review the building design, more specifically emphasising on the fact that Level 3 communal area has a simple layout and relatively small floor area whereby occupants can easily locate the exit locations; and
- Assessment shall consider the requirement for the ongoing maintenance of sterile lobbies/corridors, inclusive of the egress path via the Level 3 communal area to ensure that the egress paths are clear of obstructions at all times; and
- Evaluation of building characteristics where the egress path provided on the Level 3 communal area is mostly open to sky whereby the byproducts of any potential fire within the Level 3 communal area is expected freely vent into the atmosphere and resulting in infinite tenable conditions ; and
- Furthermore, the analysis shall consider that limited number of occupants are expected within the Level 3 communal area at any given time. Occupants are expected to be familiar with the layout and awake, and as such expected to promptly commence evacuation in case of a fire; and
- Effectiveness of the proposed sounder(s) and red strobe light(s) within the Level 3 communal area shall be considered whereby they are expected to provide the occupants with early warning and assist in initiating the evacuation procedures in a timely manner; and
- Consideration shall also be given to the impact on attending fire brigade personnel with consideration to the active fire safety measures (i.e., sprinklers), the proposed fire-fighting equipment (i.e., hydrant system) and building characteristics with limited fuel loads and ignition, which are not expected to pose a considerable risk towards attending FRNSW personnel.

12.6 Acceptance Criteria

12.6.1 Level 1 and 2 Common Areas (general populated areas)

The basic objective and intent of this analysis shall pertain to the life safety of evacuating occupants. Thus, the primary acceptance criterion shall be met by demonstrating that the Required Safe Egress Time (RSET) associated with the proposed Performance Solution is at least equivalent to the RSET associated with a DtS building solution as per the following:

$$RSET_{\text{Performance Solution}} \leq RSET_{\text{DtS Building Solution}}$$

12.6.2 Level 1 and 2 Plant Room Areas (limited populated areas)

The basic objective and intent of the analysis pertains to the life safety of evacuating occupants and attending fire-fighter personnel. Thus, the primary acceptance criterion shall be met by demonstrating that the egress provisions relative to the plant room areas on Level 1 and 2 is provided to enable safe egress for evacuating occupants and safe fire brigade intervention.

12.6.3 Level 3 Communal Areas (general populated areas)

The basic objective and intent of the analysis pertains to the life safety of evacuating occupants and attending fire-fighter personnel. Thus, the primary acceptance criterion shall be met by demonstrating that the egress provisions relative to the Level 3 communal space is provided to enable safe egress for evacuating occupants and safe fire brigade intervention.

12.7 Trial Design for Assessment

The trial design outlines in Section 0.5 are preliminary recommendations which need to be verified by a detailed fire engineering assessment. All other items not specifically addressed are to be in accordance with DtS provisions of the BCA or as accepted by the relevant authorities.

13. Internally Discharging Fire Stair

13.1 Background to the Issue

It has been identified that a fire isolated stairway serving all levels of the building discharges internally to a lobby at ground level then proceed to egress via the main doors to the lobby in lieu of directly discharging to a road or open space. The proposed design results in a non-compliance BCA Clause D2D12(2) which states that each fire-isolated stairway or fire-isolated ramp must provide independent egress from each storey served and discharge directly, or by way of its own fire-isolated passageway to a road or open space. Refer to Figure 13.1 for the location of the fire stair discharge location on ground level.

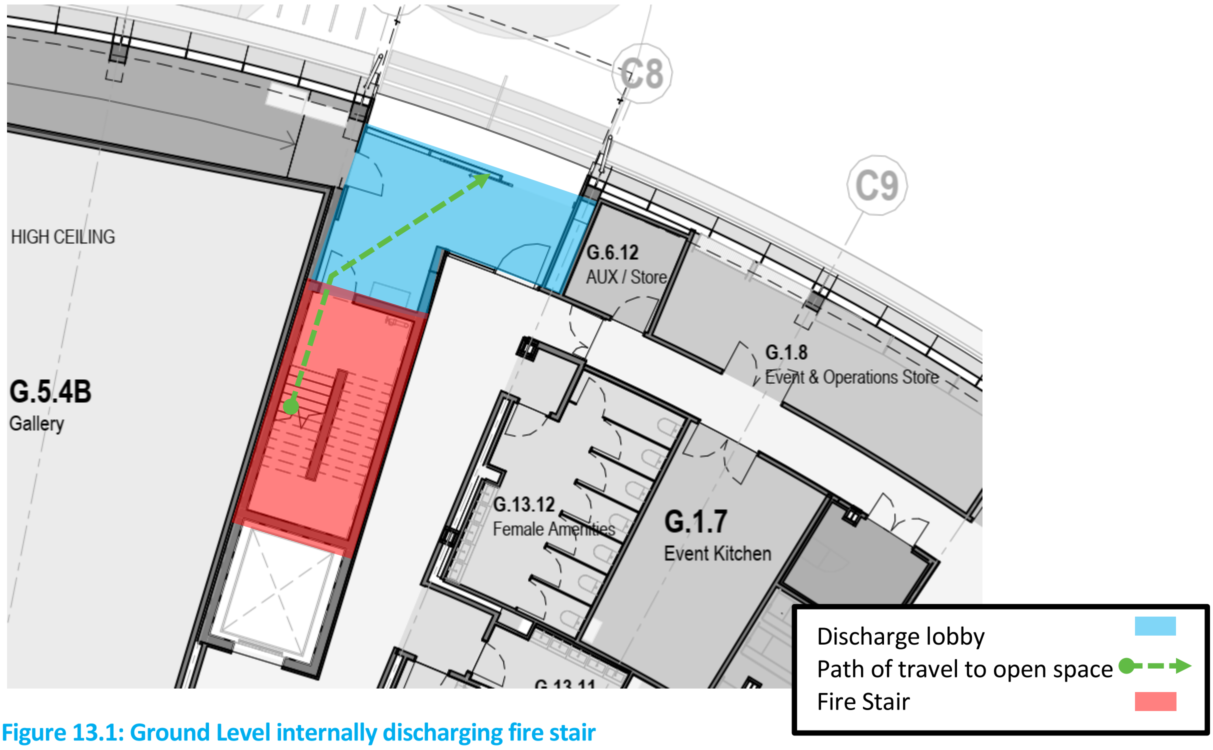


Figure 13.1: Ground Level internally discharging fire stair

13.2 BCA Assessment Method

In accordance with the BCA Clause A2G2 *Assessment Methods* the following assessment method shall be adopted to demonstrate that the *Building Solution* shall comply with the *Performance Requirements D1P4, D1P5.*

Table 13.1: Methods of Analysis

Identified Design Issue	BCA Assessment Method	IFEG Method of Analysis
It is proposed to permit the fire stair serving all levels of the building to discharge internally on Ground Level in lieu of a road or open space.	A2G2(2)(b)(ii) Other *Verification Methods*, accepted by the *appropriate authority* that show compliance with the relevant *Performance Requirements.*	A qualitative 'risk' approach to demonstrate that the Performance solution satisfies the relevant *Performance Requirements* of the BCA.

13.3 Hazard Specific to Fire Stair Discharge Location

The Guide to the BCA (ABCB, 2022) states that the intent associated with prescribing the location of the final discharge point of a fire isolated stair as being *"To enable occupants to discharge from a fire isolated exit into a safe location".* It is therefore, considered that the main hazards specific to the issue to be considered in the assessment are:

- The potential for the discharge area to be impacted by a fire and become smoke logged due to a fire within the adjacent areas.

13.4 Hazard Mitigation

The Guide to the BCA (ABCB, 2022) identifies the potential for occupants to encounter unsafe conditions at the point of discharge that has the potential to block the evacuating occupants. In this regard the following hazard mitigation systems, requirements and features of the design are noted.

- The main occupants are considered to be awake, coherent and aware of their surroundings.
- The discharge area shall be kept clear of all fuel and ignition sources at all times. The fire stair opening into the lobby is a transient space which are not expected to comprise fuel loads and ignition sources; and
- The lobby space at ground level directly outside the fire stair shall be provided with smoke proof construction (refer to Figure 0.3) and as per the following:
  - Smoke proof wall construction commensurate with the provisions prescribed in Specification 11 and shall extend to the underside of the intervening floor above; and
  - Provide smoke doors to be self-closing and fitted with magnetic hold open devices designed to auto-release upon GFA and operation initiated by smoke detectors located 1.5m horizontal distance on each side of the doorways as per Specification 12 of the BCA. Smoke doors shall swing in the direction of egress or in both directions and door leaves shall be provided with medium temperature smoke seals; and
- The building shall be protected by an automatic sprinkler system in accordance with AS2118.1:2017 unless otherwise stated herein. Automatic sprinkler systems are very effective at reducing the severity of fires in assembly building properties.
- Smoke detection and alarm systems are to be installed in accordance with Specification 20 and AS 1670.1:2018 throughout; and
- Installations activating the EWIS shall also be connected to a fire alarm monitoring system connected to a fire station or fire station dispatch centre in accordance with AS1670.3:2018; and
- Housekeeping and management-in-use process shall be implemented to maintain clear and sterile public corridors and paths of travel to exits.

13.5 Methodology

A qualitative risk-based evaluation shall be employed to assess the discharge configuration of the subject fire stair serving the subject building. The assessment shall evaluate the function and use of the discharge area that will generally be maintained as a sterile space at ground level. Consideration shall also be given to the smoke separation afforded to isolate the adjacent areas from the discharge lobby.

13.6 Acceptance Criteria

The basic objective and intent of the analysis pertains to the life safety of occupants. Thus, the primary acceptance criterion shall be met by demonstrating that the proposed fire safety measures shall assist in maintaining favourable tenable condition in the discharge location and facilitate effective occupant evacuation.

13.7 Trial Design for Assessment

The trial design outlines in Section 0.5 are preliminary recommendations which need to be verified by a detailed fire engineering assessment. All other items not specifically addressed are to be in accordance with DtS provisions of the BCA or as accepted by the relevant authorities.

14. Egress via a Discontinuous Stair

14.1 Background to the Issue

14.1.1 Level 2 Plant Room Egress

It is proposed to provide an alternative path of travel from the Level 2 plant room occupants via a ladder which descends to Level 1. The occupants then traverse to a fire stair which eventually discharges to a lobby at GF. Eventually occupants egress via the main exit from the lobby. The proposed design forms a deviation from Clause D2D14 of the BCA which prescribes a continuous means of egress by way of their own flights/landings directly to road or open space. Figure 14.1 illustrates the discontinuous egress path where Level 2 occupants enter the ladder, when they reach Level 1 and when they traverse across to the fire stair which takes them to the Ground Floor where they proceed to exit. The use of a ladder during egress has been assessed separately in Section 15 of this report.

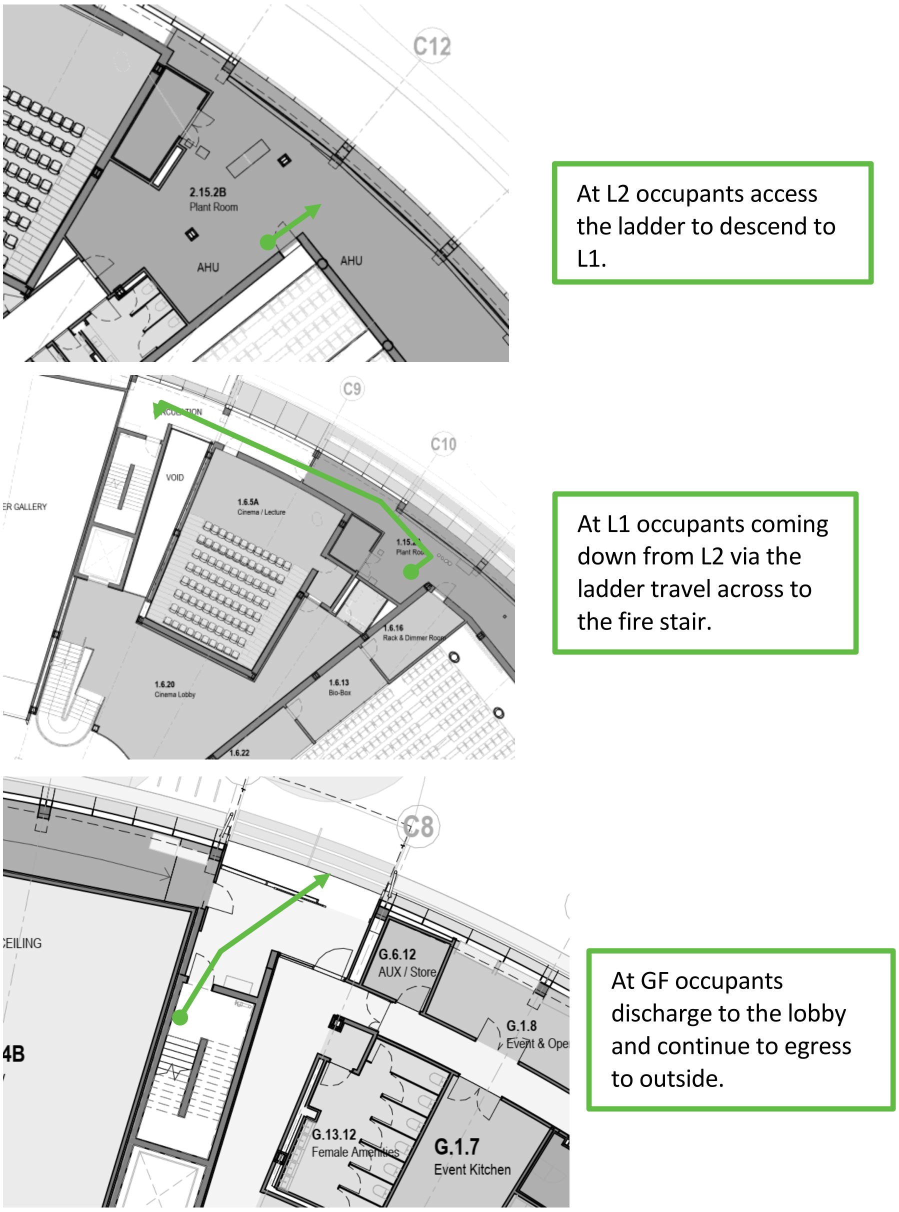


Figure 14.1: Discontinued egress path from L2 to outside at GF

14.1.2 Non-Fire Isolated Stair Serving Level 3

It has been identified that the subject building shall be provided with the stairway known as “Badanami Stair” serving all levels connecting to four (4) storeys (refer to Section 11). As the stair is not contained in a shaft the occupants descending from Level 3 are required to transverse across the floor to re-enter the next component of the stair and continue with their descent. In this instance, the proposed design forms a deviation from Clause D2D14 of the BCA which prescribes a continuous means of egress by way of their own flights/landings directly to road or open space. Figure 14.2 illustrate the details of the subject stair and its discontinuous nature.

Figure 14.2: Plan view of Open Stairway on each level

14.2 Performance Solution

In accordance with the BCA Clause A2G2 *Performance Solution* the following assessment method shall be adopted to demonstrate that the *Performance Solution* meets the relevant *Performance Requirements of D1P4 and D1P5.*

Table 14.1: Method of Analysis

Identified Design Issues	Performance Solution	AFEG Method of Analysis
The non-fire-isolated stair serving Level 3 and ladder serving the Level 2 plant room does not have a continuous path of travel from the storey served to the level of discharge.	A2G2(2)(b)(ii) Other *Verification Methods*, accepted by the *appropriate authority* that show compliance with the relevant *Performance Requirements.*	A qualitative ‘risk’ approach to demonstrate that the Performance solution satisfies the relevant *Performance Requirements* of the BCA.

14.3 Hazards Specific to Discontinuous Egress Paths

The ‘Guide to the BCA’ (ABCB, 2022) states that the intent associated with prescribing continuous means of egress via non-fire isolated stairs as being *“To require that a person using a non-fire-isolated stairway or ramp be provided with a* *safe evacuation path".* It is therefore, considered that the main hazards specific to the design issues requiring assessment are:

- The potential for fire by-products (smoke and toxic gasses) to restrict the path of occupant travel (i.e. potential for tenability limits to be exceeded within the path of travel); and
- Increase in potential obstructions within the path of travel; and
- The potential for smoke to obscure the view of the next stair occupants need to access providing egress during a potential fire situation.

14.4 Hazard Mitigation

The 'Guide to the BCA' (ABCB, 2022) identifies the potential for occupants to encounter unsafe conditions as they evacuate via discontinuous stair arrangements. In this regard the following hazard mitigation systems, requirements and features of the design are noted:

- The building shall be protected by an automatic sprinkler system in accordance with AS2118.1:2017 unless otherwise stated herein. Automatic sprinkler systems are very effective at reducing the severity of fires in assembly building properties.
- Occupants are considered to be awake, alert and ready to respond in the event of a fire emergency.
- The occupants within the catwalk will be familiar with their surroundings.
- There is an alternative path of egress via a conventional stair from the catwalk.
- Limited number of occupants within the catwalk.
- The stairway known as "Badanami Stair" is required to be fire separated between Level 02 and Level 03 via fire rated construction achieving a minimum FRL of 120 minutes achieved from both sides.
  - The remainder of the stairway from Level 00 to Level 02 is provided with smoke separating construction in the form of a smoke baffle (i.e. minimum depth of 500mm) bounding the stair at Level 02.
- A fire alarm/evacuation matrix has been developed for the subject building(s) in order to ensure effective evacuation is achieved from level 3 for occupants using stairway known as "Badanami Stair". Active Dynamic Signage System (ADSS) shall be installed outside the stairways providing egress on Level 3 of the building to enhance occupant wayfinding and direct occupants to a safe egress path. The system shall comprise intelligent exit signage which shall be programmed based on GFA (i.e. sprinkler or detector activation) signal location and detailed in Figure 0.8, Figure 0.9 and Table 0.3).
- Mounted exit signage shall be provided along the paths of travel and shall assist occupants in resolving wayfinding.
- Evacuation plans shall be provided to direct occupants to nearest alternative exit location(s).

14.5 Methodology

The methodology adopted to address the design issue relative to the discontinuous egress of the non-fire isolated stairway from Level 3 and ladder from Level 2 shall be based upon a qualitative 'risk' based evaluation. The evaluation shall consider the following:

- Function and use of the partially open stairway connecting L3-GF and ladder at Level 2.
- Potential fire hazards and its impact the partially open stairway connecting L3-GF and ladder at Level 2.
- The presence of multiple egress pathways which allows occupants to access another exit if either the partially open stairway or ladder is deemed compromised.
- The presence of active fire safety measures such as sprinkler system and fire detection and alarm system to assist in identifying the fire in its early stages and containing the fire to the zone of fire origin.
- The adoption of a fire alarm/evacuation matrix in order to ensure effective evacuation is achieved from occupants from Level 3 using the partially open stairway. More specifically, Active Dynamic Signage System (ADSS) shall be installed outside the stairways providing egress on Level 3 of the building to enhance occupant wayfinding and direct occupants to a safe egress pathway to a road or open space.
- The impact on fire brigade personnel undertaking firefighting activities within the building.

14.6 Acceptance Criteria

The basic objective and intent of the analysis shall pertain to occupant life safety. Thus, the primary acceptance criteria shall be met by demonstrating that occupants are able to safely evacuate via the discontinuous stair and ladder configurations without increasing ambiguity within the egress path. The secondary acceptance criterion shall be met by demonstrating that fire crews are able to traverse the open stairway and ladder configuration without being negatively impacted.

14.7 Trial Design for Assessment

The trial design outlines in Section 0.5 are preliminary recommendations which need to be verified by a detailed fire engineering assessment. All other items not specifically addressed are to be in accordance with DtS provisions of the BCA or as accepted by the relevant authorities.

15. Ladder for Egress

15.1 Background to the Issue

It is proposed to permit to utilise the plant room ladder on Level 2 for egress for occupants from the theatre catwalks which is not a plant room. The theatre catwalks are understood to not be considered as a plant room or a lift machine room. This forms a deviation from Clause D2D21 of Volume One of the BCA as it is stated that "*a ladder may be used in lieu of a stairway to provide egress from*":

- *A plant room with a floor area of not more than 100m²; or*
- *All but one point of egress from a plant room, a lift machine room or a Class 8 electricity network substation with a floor area of not more than 200m².*

The location of the proposed ladder within the plant room on Level 2 is provided in Figure 15.1 and Figure 15.2.

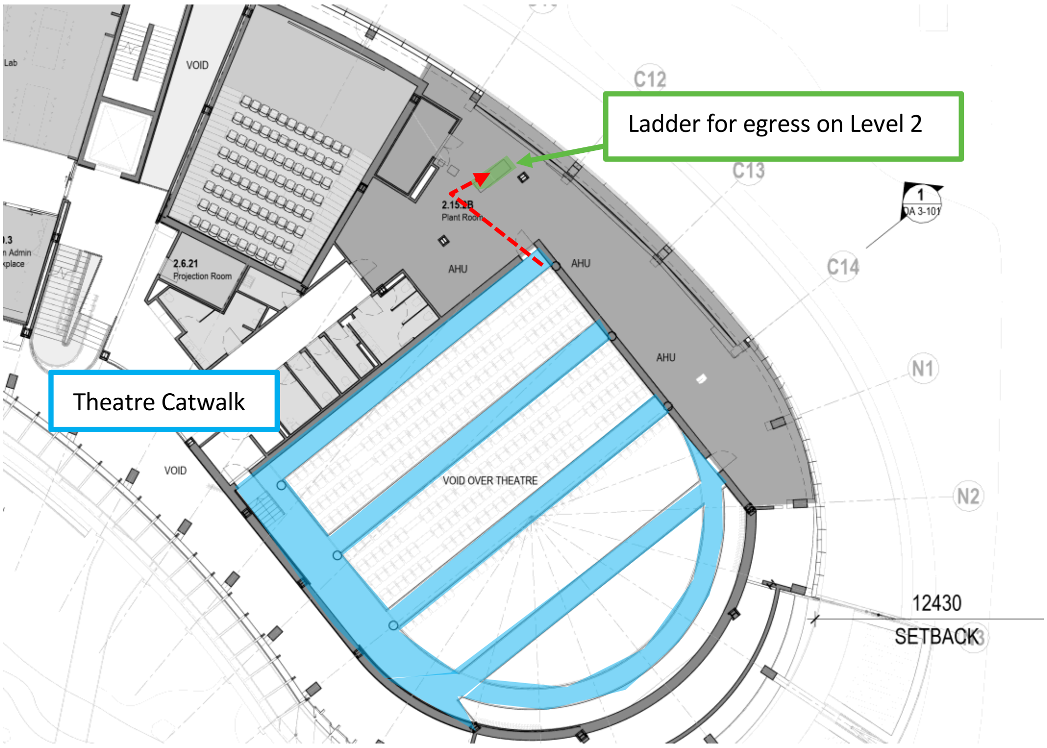


Figure 15.1: Path from Catwalks to the Egress Ladder on L2

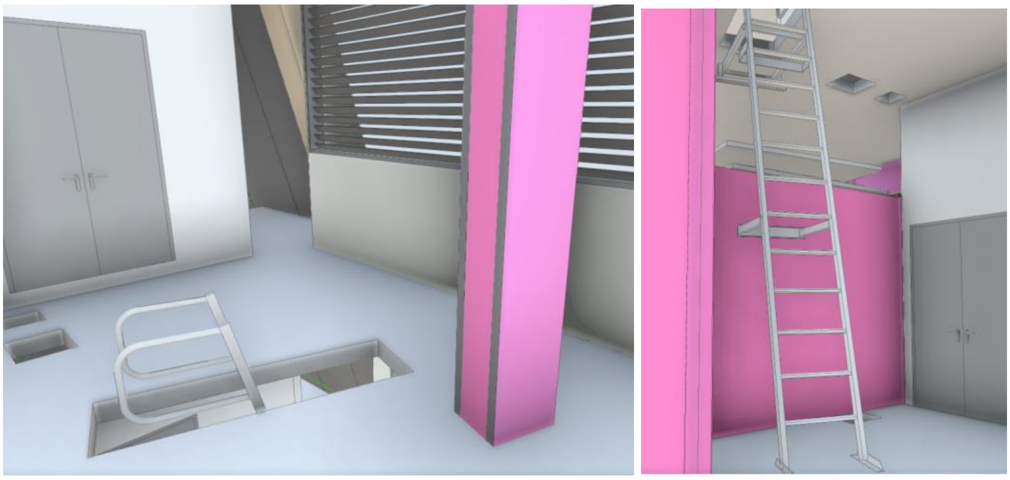


Figure 15.2: View of the subject ladder at L2 (left) and L1 (right)

15.2 Performance Solution

In accordance with BCA Clause A2G2 *Performance Solution* the following assessment method shall be adopted to demonstrate that the *Building Solution* shall meet the relevant *Performance Requirement D1P4 and D1P5.*

Table 15.1: Performance Solution

Identified Design Issue	Performance Solution	AFEG Method of Analysis
It is proposed to permit the occupants within the theatre catwalk (which is not a plant room and is greater than 200m^2) to utilise the plant room ladder for egress on Level 2 only.	A2G2(2)(b)(ii) Other Verification Methods as the appropriate authority accepts for determining compliance with the Performance Requirements.	A qualitative risk-based approach shall be undertaken to demonstrate that the performance solution meets the relevant the Performance Requirements.

15.3 Hazard Specific to Stair Configuration

The Guide to the BCA states that the intent associated with allowing the use of a ladder for egress is '*To provide concessions for small plant rooms, lift motor rooms and Class 8 electricity network substations*' It is therefore, considered that the main hazards specific to the issues to be considered in the assessment are:

- Occupants utilising the ladder for egress to be exposed to the risk of falling.

15.4 Hazard Mitigation

The 'Guide to the BCA' identifies the potential for occupants to become impeded and/or unduly delayed as a result of the difficulty in negotiating a ladder for egress. According to the Guide to BCA, concessions for the use of a ladder in lieu of a stairway are granted for small plant rooms, lift motor rooms and Class 8 electricity network substations for the following reasons:

- Occupants of a small plant room, lift motor room or Class 8 electricity network substation are trained maintenance personnel familiar with the room's hazards and layout and are capable of negotiating the service ladders in a safe manner; and
- Limited occupants will be present within the relatively small plant or lift motor rooms; and
- The small size of the rooms means that there is not a significant distance to travel to gain egress to the ladder; and
- In the larger rooms which qualify for this concession, and multiple exits are provided, only one egress needs to be a stair.

The theatre catwalk also satisfies these criteria.

Additionally, the following hazard mitigation systems, requirements and features of the design are noted:

- The building shall be protected by an automatic sprinkler system in accordance with AS2118.1:2017 unless otherwise stated herein. Automatic sprinkler systems are very effective at reducing the severity of fires in assembly building properties.
- The occupants within the catwalk will be familiar with their surroundings; and
- Limited number of occupants within the catwalk.
- There is an alternative path of egress via a conventional stair from the catwalk; and
- Exit Signage located and installed in accordance with Clauses E4D5 & E4D6 of the BCA and AS/NZS 2293.1:2018 and as identified herein; and

15.5 Methodology

The methodology adopted to address the design issue relative to the use of ladders in lieu of a stairway to provide egress shall be based upon a qualitative evaluation. The evaluation shall consider the function & use associated with the subject areas of the building, expected occupant characteristics and numbers. In addition, the assessment shall consider the fire safety systems present within the subject building to assist with occupant evacuation. The design of the stair will also be assessed from the perspective of safe clearances based on safety criteria published in literature (refer to Figure 15.3 for an example).

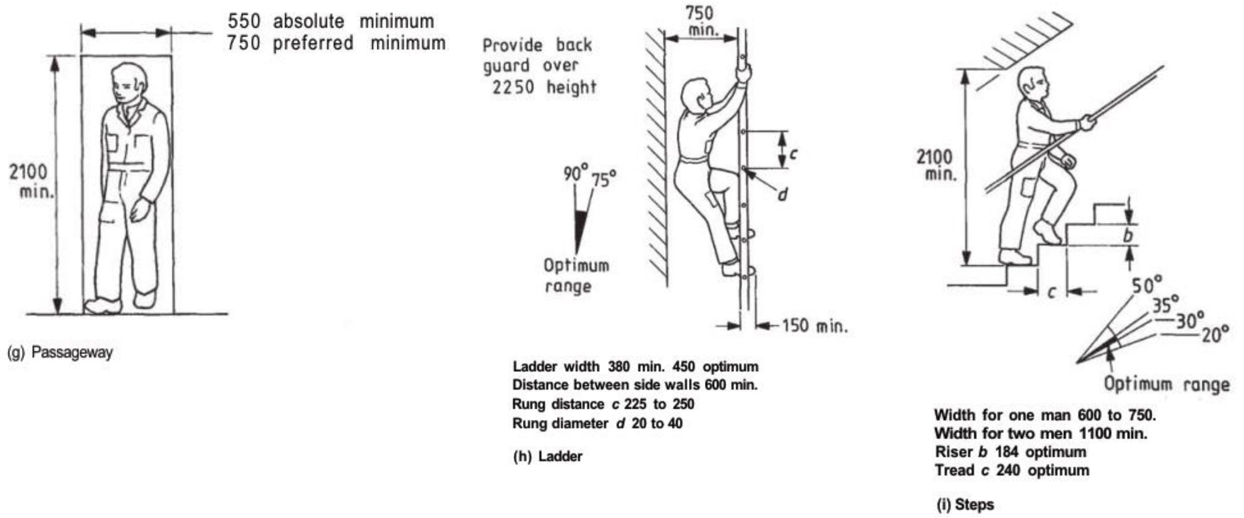


Figure 15.3: Safe clearances as nominated in Section 3.1 of "*Defence Works Functional Standard Design & Maintenance Guide 08*" (UK, 1996)

15.6 Acceptance Criteria

The basic objective and intent of this analysis pertains to the life safety of the evacuating occupants who utilise the ladders as a means of egress. Thus, the primary acceptance criterion shall be met by demonstrating that the occupants' ability to utilise the ladder to evacuate will not be adversely affected by the proposed design.

15.7 Trial Design for Assessment

The trial design outlines in Section 0.5 are preliminary recommendations which need to be verified by a detailed fire engineering assessment. All other items not specifically addressed are to be in accordance with DtS provisions of the BCA or as accepted by the relevant authorities.

16. Fire Hydrant System

16.1 Background to the Issue

A fire hydrant system shall be designed and installed in accordance with Clause E1D2 of the BCA and AS2419.1:2021, with the inclusion of the following:

- Permit the fire hydrant booster assembly serving the building to be located in a position that is not within sight of the main entry of this new building.

**Draft note: Fire services consultant to confirm any further compliances*

It has been identified that the fire hydrant booster assembly is located off Railway Street and not strictly within direct line of sight of the main entrance of the subject building. Fire Brigade Turnout into the site is on accessed via Fifth Street.

Therefore, the proposed design forms a deviation from Clause E1D2 and AS2419.1:2021 which requires the fire hydrant booster assembly to be located such that it is within direct line of site of the main entrance of the building. Refer to Figure 16.1 for the fire hydrant booster assembly.

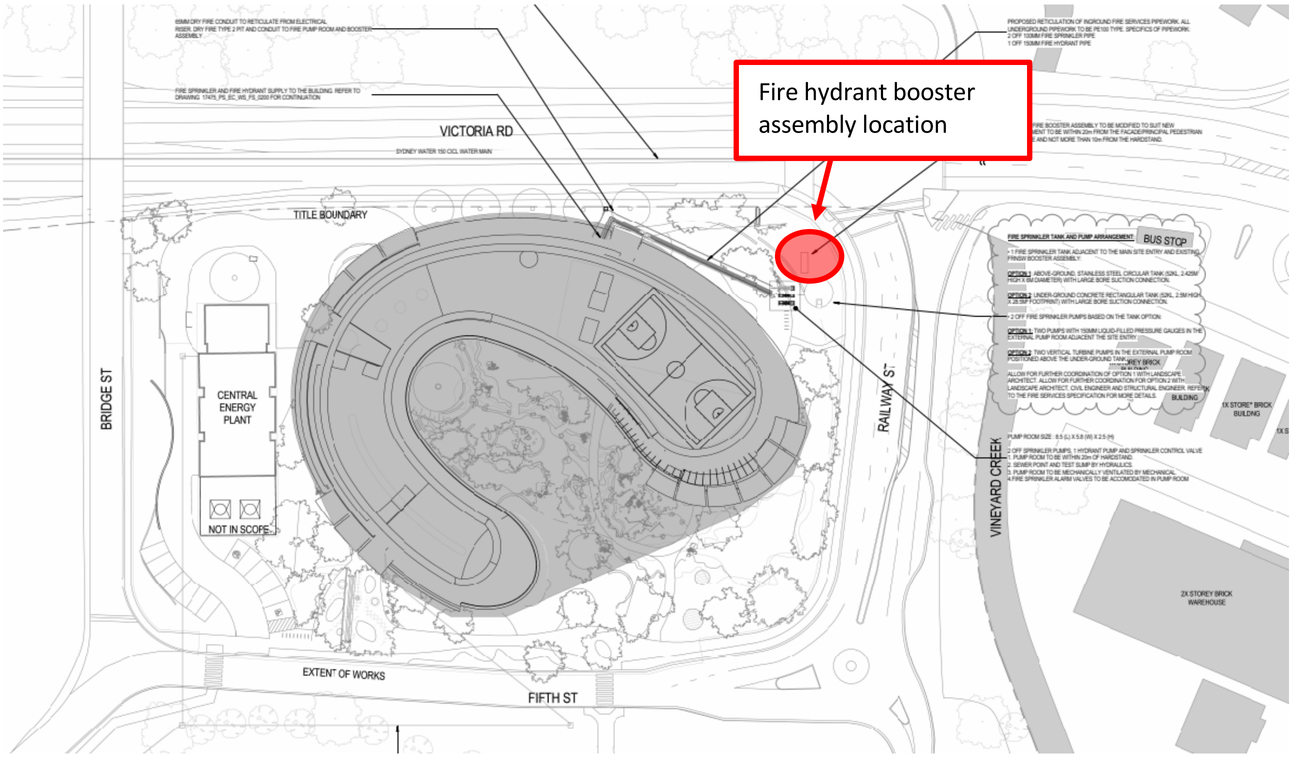


Figure 16.1: Location of fire hydrant booster assembly (indicative illustration)

16.2 Performance Solution

In accordance with the BCA Clause A2G2 *Performance Solution* the following assessment method shall be adopted to demonstrate that the *Building Solution* shall meet the relevant *Performance Requirements of E1P3*.

Table 16.1: Method of Analysis

Identified Design Issue	Performance Solution	AFEG Method of Analysis
A fire hydrant system shall be provided which is designed and installed in accordance with Clause E1D2 of the BCA and AS2419.1:2021 with the inclusion of the following: • Permit the fire hydrant booster assembly serving the building to be located in a position that is not within sight of the main entry of this new building. **Draft note: Fire services consultant to confirm any further compliances*	A2G2(2)(b)(ii) such other *Verification Methods* as the appropriate authority accepts for determining compliance with the *Performance Requirements.*	A qualitative approach shall be adopted to assess the acceptability of the fire hydrant booster assembly location.

16.3 Hazard Specific to the Fire Hydrant System

The 'Guide to the BCA' (ABCB, 2022) states that the intent associated with prescribing a fire hydrant booster assembly and associated fire hydrant system is "To require the installation of suitable fire hydrant systems to facilitate the fire brigade's firefighting operations". Booster assemblies are provided as a redundancy measure should the hydraulic pressure requirement for the installed fire systems (i.e., fire hydrants and/or automatic sprinkler system) require boosting by a fire brigade pumping appliance. In order for this to successfully be achieved, the fire hydrant booster assemblies must be located at a location that can be suitably accessed. It is therefore considered that the main hazards specific to the design issues requiring assessment are:

- Attending fire brigade personnel may face difficulty in locating the booster assembly and/or building entrances when arriving onsite; and
- Increase in the potential impact/risk of a fire on attending fire brigade personnel undertaking fire brigade operations due to delays in locating the booster assembly; and
- Fire crews may experience delays in accessing the fire services infrastructure which are not directly accessed from the main entrance location.

The Guide to the BCA (ABCB, 2022) identifies the potential for fire-fighting personnel to encounter unsafe conditions during Fire Brigade Intervention. In this regard the following hazard mitigation systems. Fire hydrant systems are required to:

- Enable fire crews to undertake search and rescue operations; and
- Enable fire crews to perform fire control activities which including minimising fire spread within a building and to/from adjacent properties/compartments; and
- Undertake fire extinguishment activities and salvage operations.

16.4 Hazard Mitigation

The 'Guide to the BCA' (ABCB, 2022) identifies the potential for fire-fighter personnel to become unduly hindered/ delayed as a result of the fire hydrant location. In this regard, the following hazard mitigation systems, requirements and features of the design are noted:

- The building shall be protected by an automatic sprinkler system in accordance with AS2118.1:2017 unless otherwise stated herein. Automatic sprinkler systems are very effective at reducing the severity of fires in assembly building properties.
- The main Fire Indicator Panel (FIP) to be located at the main entrance lobby; and
- A fire hydrant system shall be provided which is designed and installed in accordance with Clause E1D2 of the BCA and AS2419.1:2021, with the inclusion of the following:
  - Permit the existing fire hydrant booster assembly (i.e. Fire hydrant booster 1) serving the building to be located in a position that is not within sight of the main entry of this new building.
  - Permit the existing fire hydrant booster assembly (i.e. Fire hydrant booster 1) serving the building to comply with AS2419.1:2005 in lieu of AS2419.1:2021; and
- The following locations shall be denoted by a red strobe light that is set to activate upon General Fire Alarm (GFA):
  - Proposed sprinkler booster assembly serving the building; and
  - Proposed fire hydrant booster assembly serving the building; and
  - Main/principal building entrance containing the main FIP; and
- Block plans are to be provided at the main Fire Indicator Panel (FIP), sprinkler booster assembly and fire hydrant booster assembly serving the building in accordance with AS2419.1:2021 and the FRNSW Tactical Fire Fight Plans Guideline (Policy number 6, Version 02); and
  - The block plan should be orientated to reflect the aspect of the installation as it is presented to the reader; and
  - The block plan at the fire hydrant and sprinkler booster assembly serving the building shall show the path of travel fire crews will need to take to reach the building; and
- Fire & Rescue NSW (FRNSW) are afforded with vehicular access directly from street and the sprinkler booster assembly location shall be readily visible from the street.
- Couplings in the fire hydrant system (including fire hydrant booster assembly) shall be compatible with those of the fire appliances and equipment used by Fire and Rescue NSW. Fire hydrant booster assembly connections and all fire hydrant valves shall be fitted with Storz aluminium alloy delivery couplings manufactured and installed in accordance with Clause 9.3.1 and Clause 9.4 and AS2419.1-2021; and

16.5 Method of Analysis

The methodology to be adopted to address the design issue relative to the fire hydrant booster assembly shall be based upon a qualitative analysis which shall consider the followings:

- The evaluation shall consider the proposed location of the system with respect to the identified hazards and potential impact imposed towards attending fire-fighter personnel whilst undertaking their operations.; and
- Consideration shall be given to the fire hydrant booster assembly location located within the building site that is accessible from Princes Highway abutting the subject site despite not being visible from the subject building entrance; and
- The assessment shall consider the presence of block plans at the FIP, proposed sprinkler booster assembly at Princes Highway and existing fire hydrant booster assembly (i.e. Fire hydrant booster 1) serving the building which shall assist fire crews in locating and visualising the relative booster assembly location; and
- The evaluation shall also consider the provision of red strobe lights that shall assist fire-fighters to locate the existing fire hydrant booster assembly (i.e. Fire hydrant booster 1) serving the building & principal building entrance and also the building of fire origin upon arrival on site.

16.6 Acceptance Criteria

The basic objective and intent of the analysis pertains to the fire-fighting operational capabilities and life safety of attending fire-fighter personnel. Thus, the primary acceptance criteria shall be met by demonstrating that attending fire crews are able to safely locate, access and utilise the existing fire hydrant booster assembly (i.e. Fire hydrant booster 1) serving the building and main/principal building entrance whilst implementing their fire brigade intervention activities.

16.7 Trial Design for Assessment

The trial design outlines in Section 0.5 are preliminary recommendations which need to be verified by a detailed fire engineering assessment. All other items not specifically addressed are to be in accordance with DtS provisions of the BCA or as accepted by the relevant authorities.

17. Sprinkler Booster Assembly Location

17.1 Background to the Issue

It has been identified that the proposed sprinkler booster assembly serving the site is located in a position that is not within sight of the main entry of this new building. It has been identified that the proposed sprinkler booster assembly is located off Railway Street and not strictly within direct line of sight of the main entrance of the subject building. Fire Brigade Turnout into the site is on accessed via Fifth Street.

The proposed design forms a deviation from Clause E1D4 and AS2118.1:2017 which requires the proposed sprinkler booster assembly to be located such that it is within direct line of site of the main entrance of the building. Refer to Figure 17.1 for the proposed sprinkler booster assembly.

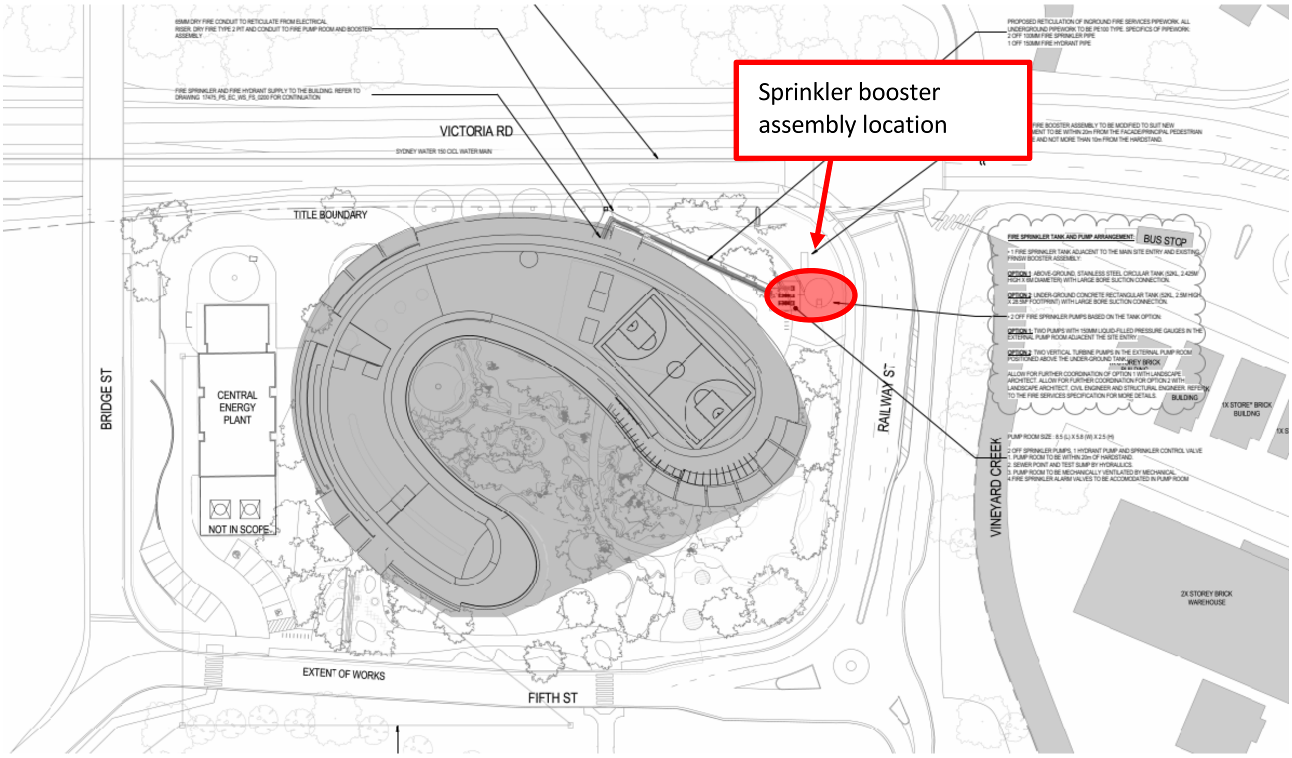


Figure 17.1: Location of proposed sprinkler booster assembly (indicative illustration)

17.2 Performance Solution

In accordance with the BCA Clause A2G2 *Performance Solution* the following assessment method shall be adopted to demonstrate that the *Building Solution* shall meet the relevant *Performance Requirements of E1P3*.

Table 17.1: Method of Analysis

Identified Design Issue	Performance Solution	AFEG Method of Analysis
The proposed sprinkler booster assembly serving the site is located in a position that is not within sight of the main entry of this new building.	A2G2(2)(b)(ii) such other *Verification Methods* as the appropriate authority accepts for determining compliance with the *Performance Requirements.*	A qualitative approach shall be adopted to assess the acceptability of the sprinkler booster assembly location.

17.3 Hazard Specific to the Booster Assembly Location

The Guide to the BCA (ABCB, 2022) clarifies that automatic fire suppression systems are intended to contain and extinguish fire, controlling or limiting fire development, and often extinguishing fires before they endanger occupants, or else allowing additional time for occupants to evacuate. It is therefore considered that the main hazard associated with the identified design issue relates to:

- Potential for delay in the time required to locate and access the sprinkler booster assembly.
- Attending fire brigade personnel may face difficulty in locating the booster assembly and/or building entrances when arriving onsite; and

- Increase in the potential impact/risk of a fire on attending fire brigade personnel undertaking fire brigade operations due to delays in locating the booster assembly; and
- Potential for fire appliances to obstruct the vehicular access roadways when connecting to the sprinkler booster assembly.

17.4 Hazard Mitigation

The 'Guide to the BCA' (ABCB, 2022) identifies the potential for fire-fighter personnel to become unduly hindered/ delayed as a result of the sprinkler booster location. In this regard, the following hazard mitigation systems, requirements and features of the design are noted:

- The building shall be protected by an automatic sprinkler system in accordance with AS2118.1:2017 unless otherwise stated herein. Automatic sprinkler systems are very effective at reducing the severity of fires in assembly building properties.
- The main Fire Indicator Panel (FIP) to be located at the main entrance lobby; and
- The following locations shall be denoted by a red strobe light that is set to activate upon General Fire Alarm (GFA):
  - Proposed sprinkler booster assembly serving the building; and
  - Proposed fire hydrant booster assembly serving the building; and
  - Main/principal building entrance containing the main FIP; and
- Block plans are to be provided at the main Fire Indicator Panel (FIP), sprinkler booster assembly and fire hydrant booster assembly serving the building in accordance with AS2419.1:2021 and the FRNSW Tactical Fire Fight Plans Guideline (Policy number 6, Version 02); and
  - The block plan should be orientated to reflect the aspect of the installation as it is presented to the reader; and
  - The block plan at the fire hydrant and sprinkler booster assembly serving the building shall show the path of travel fire crews will need to take to reach the building; and
- Fire & Rescue NSW (FRNSW) are afforded with vehicular access directly from street and the sprinkler booster assembly location shall be readily visible from the street.

17.5 Method of Analysis

The methodology to be adopted to address the design issue relative to the location of the proposed sprinkler booster assembly shall be based upon a qualitative analysis which shall consider the followings:

- The evaluation shall consider the proposed location of the system with respect to the identified hazards and potential impact imposed towards attending fire-fighter personnel whilst undertaking their operations.; and
- Consideration shall be given to the sprinkler booster assembly location that is accessible from a principal street abutting the subject site despite not being visible from the subject building entrance; and
- The assessment shall consider the presence of block plans at the FIP, proposed sprinkler booster assembly and fire hydrant booster assembly serving the building which shall assist fire crews in locating and visualising the relative booster assembly location; and
- The evaluation shall also consider the provision of red strobe lights that shall assist fire-fighters to locate the proposed sprinkler booster assembly serving the building & principal building entrance and also the building of fire origin upon arrival on site.

17.6 Acceptance Criteria

The basic objective and intent of the analysis pertains to the fire-fighting operational capabilities and life safety of attending fire-fighter personnel. Thus, the primary acceptance criteria shall be met by demonstrating that attending fire crews are able to safely locate, access and utilise the sprinkler booster assembly and main/principal building entrance whilst implementing their fire brigade intervention activities.

17.7 Trial Design for Assessment

The trial design outlines in Section 0.5 are preliminary recommendations which need to be verified by a detailed fire engineering assessment. All other items not specifically addressed are to be in accordance with DtS provisions of the BCA or as accepted by the relevant authorities.

18. Rationalisation of Smoke Hazard Management System

18.1 Background to the Issue

The gallery located on Level 00 is within a building/fire compartment containing a floor area greater than 3,500m^2, as such a smoke exhaust system is required. Clause E2D3 inter alia NSW Clause E2D18 states that a building or part of a building used as an exhibition hall, museum, art gallery or the like where the floor area is more than 3500m^2, a sprinkler system complying with Specification 17 and an automatic smoke exhaust system complying with Specification 21 or roof mounted automatic smoke-and-heat vents complying with Specification 22 must be provided in a single storey building or the top storey of a multi storey building.

It should be noted that the gallery space on Level 00 is a double volume space (extending to the underside of Level 02 floor slab) and is approximately 500m^2 only. Since it's not fire separated from the remainder of the floor plate the requirement for smoke exhaust has been triggered since the fire compartment is greater than 3,500m^2. Therefore, in this instance, it is proposed to permit the omission of the required smoke exhaust system to the gallery/exhibition areas of the building on Level 00. Refer to Figure 18.1 for the location of the Gallery Spaces on Level 00.

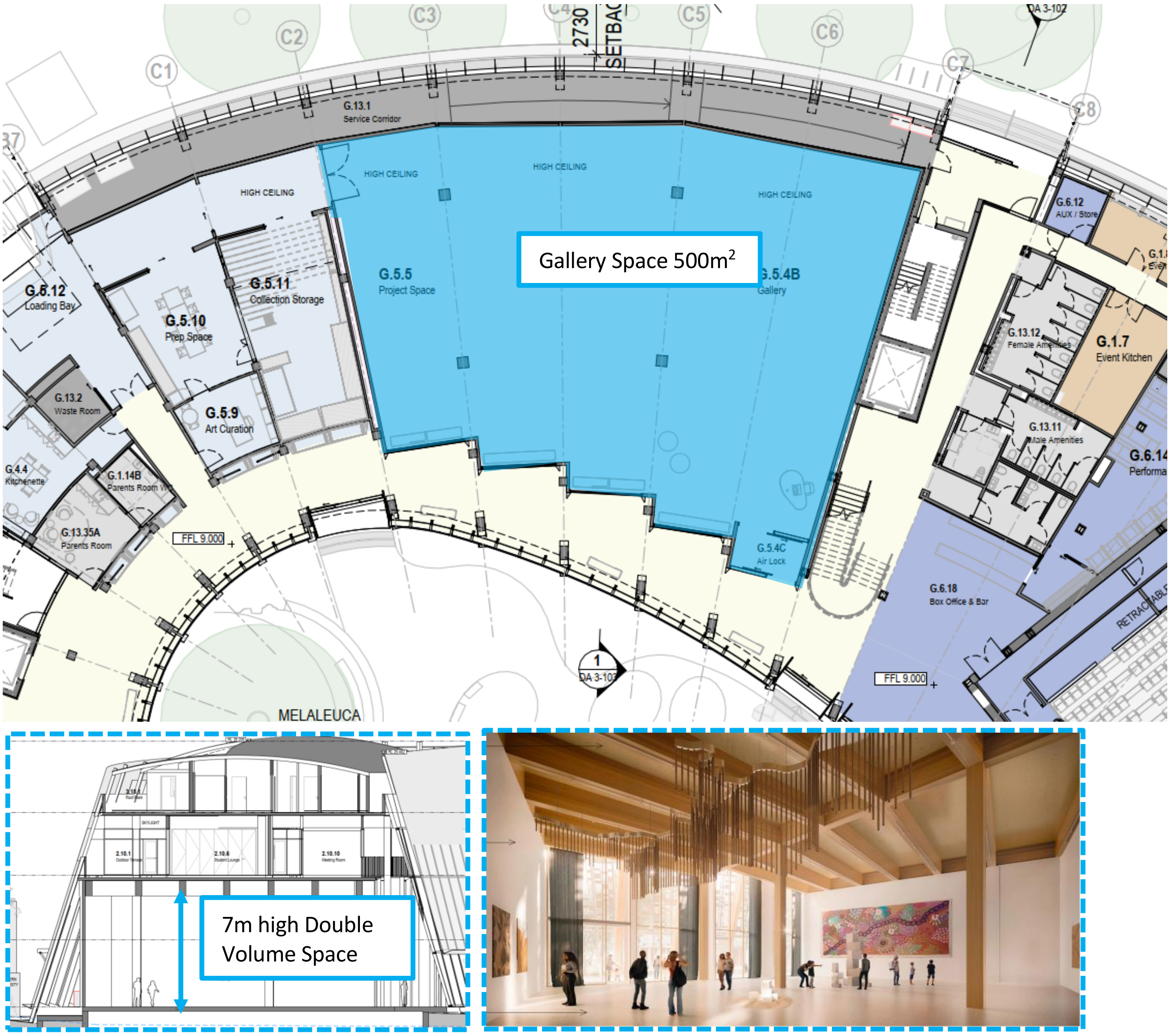


Figure 18.1: Omission of smoke exhaust system from Gallery Spaces on Level 00

18.2 Performance Solution

In accordance with the BCA Clause A2G2 *Performance Solution* the following assessment has been adopted to determine whether the *Performance Solution* meets the relevant *Performance Requirements of E2P2.*

Table 18.1: Method of Analysis

Identified Design Issue	Performance Solution	AFEG Method of Analysis
The gallery located on Level 00 is within a building/fire compartment containing a floor area greater than 3,500m2, as such a smoke exhaust system is required. In this instance, it is proposed to permit the omission of the required smoke exhaust system to the gallery/exhibition areas of the building on Level 00.	A2G2(2)(b)(ii) such other *Verification Methods* as the appropriate authority accepts for determining compliance with the *Performance Requirements.*	A qualitative assessment shall be undertaken for the omission of smoke exhaust system within the gallery portions of the building.

18.3 Hazards Specific to Rationalisation of Smoke Hazard Management

The 'Guide to the BCA (ABCB, 2022) states that the intent towards providing a smoke hazard management system within the building is "t*o minimise the risks associated with smoke to both the evacuating occupants and the attending fire fighters.* It is therefore, considered that the main hazards specific to the issue to be considered in the assessment are:

- The potential for fire by-products (smoke and toxic gasses) to restrict the path of occupant travel (i.e., potential for tenability limits to be exceeded within the path of travel).
- This issue is directly related to occupant evacuation and fire fighter operation as the smoke hazard management system needs to ensure that conditions are acceptable for both to occur.

18.4 Hazard Mitigation

The 'Guide to BCA (ABCB, 2022) identifies the hazards as being directly related to the facilitation of occupant evacuation and Fire Brigade intervention activities in the event of an emergency fire situation. In this regard the following hazard mitigation systems, requirements and features of the design are noted:

- The building shall be protected by an automatic sprinkler system in accordance with AS2118.1:2017 unless otherwise stated herein. Automatic sprinkler systems are very effective at reducing the severity of fires in assembly building properties.
- The double volume gallery space on ground level (i.e. Level 00) shall be smoke separated from the remainder of the floor plate.
- The double volume gallery space on ground level provides a natural smoke reservoir (>7.0m high) for the hot smoke and toxic gases to accumulate allowing additional time for safe occupant evacuation.
- The main occupants are considered to be awake, coherent and aware of their surroundings. The gallery space is provided with two (2) exits on opposite ends to assist in efficient occupant egress.
- Smoke detection and alarm systems are to be installed in accordance with Specification 20 and AS 1670.1:2018 throughout; and
- Installations activating the EWIS shall also be connected to a fire alarm monitoring system connected to a fire station or fire station dispatch centre in accordance with AS1670.3:2018; and
- Exit Signage located and installed in accordance with Clauses E4D5 & E4D6 of the BCA and AS/NZS 2293.1:2018 and as identified herein; and
- Emergency lighting serving the building shall be designed and installed in accordance with AS2293.1:2018.

18.5 Methodology

The methodology adopted to address the design issue relative to the non-fire isolated stairway shall be based upon a qualitative 'risk' based evaluation. The evaluation shall consider the following:

- Function and use and potential fire hazards within the gallery.
- The proposed passive smoke separation of the gallery space from the remainder of the floor plate and building to mitigate the spread of fire/smoke to the other areas of the building. It should be noted that the gallery space on Level 00 is a double volume space (extending to the underside of Level 02 floor slab) and is approximately 500m^2 only which is much less than 3,500m^2 which triggers the requirement for smoke exhaust system.
- The presence of active fire safety measures such as sprinkler system and fire detection and alarm system to assist in identifying the fire in its early stages and containing the fire to the zone of fire origin.
- The benefit of the double volume space providing a natural smoke reservoir for the hot smoke and toxic gases to accumulate and allowing additional time for safe occupant evacuation.

- The gallery space is provided with two (2) exits on opposite ends to assist in efficient occupant egress. Members of the public shall be assisted by permanent staff in an emergency evacuation procedure.
- The impact on fire brigade personnel undertaking firefighting activities within the gallery spaces. The proposed smoke separation shall allow fire brigade personnel to setup in multiple locations outside the gallery space and attack the fire accordingly.

18.6 Acceptance Criteria

The basic objective and intent of this analysis pertains to life safety of occupants and fire-fighters. Therefore, the acceptance criterion shall be met by demonstrating that the omission of smoke exhaust system from the gallery portions only on Level 00 does not increase the likelihood of smoke/fire spread throughout the building based on the proposed passive and active fire safety measures and proposed design layout is not expected to result in fire hazards and risks over and above a DtS compliant design solution.

18.7 Trial Design for Assessment

The trial design outlines in Section 0.5 are preliminary recommendations which need to be verified by a detailed fire engineering assessment. All other items not specifically addressed are to be in accordance with DtS provisions of the BCA or as accepted by the relevant authorities.

19. Conclusion

19.1 General

The Fire Safety Engineering assessment methodology detailed in this report will determine whether the proposed Performance Solution aspects of the Building Solution will be shown to meet the corresponding identified Performance Requirements of the BCA.

The assessment and verification methodologies employed have been documented in accordance with the requirements of the BCA and conform to the principles of AFEG.

The building incorporates a range of fire safety measures in accordance with the relevant BCA prescriptive clauses and Australian Standards. In summary, the BCA defines the fire safety measures and their applicable standards required to be installed within buildings. Unless otherwise stated, the applicable standard of fire safety system installation (active and passive) must be compliant with the BCA and the relevant Australian Standards.

The Client is to ensure that the relevant stakeholders and services consultants that have been involved in the project are in agreement with the proposals made in this document. Furthermore it is the responsibility of the other designers and consultants (not SFS) to complete the detailed design of the various active and passive fire safety systems in accordance with the relevant design and installation Australian Standards and in accordance with the requirements listed in the ensuing FSER report.

Prior to proceeding to the FSER stage, it is required that the proposed alternative solution is referred to relevant Fire Authority as part of the design team stakeholder for their opportunity to provide comment as to appropriateness of the proposed design. Once the relevant Fire Authority provides an "in-principle" agreement to the proposed alternative solution, Scientific Fire Services will conduct a FSER formally addressing the identified variations to the DtS provisions and documenting the proposed Performance Solution.

It is also a requirement that this PBDB be passed on to the property owner(s) for their opportunity to provide comment as to the appropriateness and or any specific objectives they may have.

19.2 Fire Safety Measures (Proposed Trial Design)

The performance solution for the subject building consists in part of some features which are included within the prescriptive provisions of the BCA and additional features which are specific to this building alone. The combination of these 'DtS' and additional fire safety system features comprises the 'Performance Solution' which form the basis of the trial design.

Unless otherwise stated the required fire safety systems for the subject building are to be designed and installed in accordance with the DtS provisions of the BCA and relevant referenced Australian Standards. Note the following list is considered to be a summary of the project specific fire safety features that form part of the proposed 'Performance Solution'. It should be noted however that given the status of the PBDB in the fire engineering process, the following list is not exhaustive and may be subject to amendment pending resolution of the final fire safety engineering assessment process.

The proposed 'Trial Design' applicable to the subject building, which is to be the subject matter of this assessment, is summarised in Section 0.5.

20. References

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Glulam Handbook Volume 1 Föreningen Sveriges Skogsindustrier, Stockholm, Sweden 2013 ISBN (Johan Fröbel will fix an ISBN-number) PUBLISHER Skogsindustrierna – The Swedish Forest Industries Federation

Appendix A. Project Information

A.1 Architectural & Services Drawings

Table A.1: Architectural drawings relied upon

Drawing No.	Drawing Name	Date	Revision
DA 0-000	COVER PAGE	July 2025	5
DA 0-101	SITE PLAN - EXISTING	June 2025	3
DA 0-102	SITE PLAN - PROPOSED	July 2025	4
DA 0-103	EXISTING CONDITIONS AND DEMOLITION PLAN	July 2025	4
DA 0-201	SITE ANALYSIS	June 2025	3
DA 1-102	PROPOSED FLOOR PLAN_LEVEL G	June 2025	3
DA 1-103	PROPOSED FLOOR PLAN_LEVEL 01	June 2025	3
DA 1-104	PROPOSED FLOOR PLAN_LEVEL 02	June 2025	3
DA 1-105	PROPOSED FLOOR PLAN_LEVEL 03	June 2025	3
DA 1-106	PROPOSED ROOF PLAN	June 2025	4
DA 2-101	NORTH AND EAST ELEVATION	July 2025	4
DA 2-102	SOUTH AND WEST ELEVATION	July 2025	4
DA 3-101	SECTIONS	April 2025	3
DA 3-102	SECTIONS	February 2025	2
DA 3-103	SECTIONS	February 2025	2
DA 3-104	SECTIONS	February 2025	2
DA 3-105	SECTIONS	February 2025	2
DA 3-106	TYPICAL FACADE SECTION 01	February 2025	2

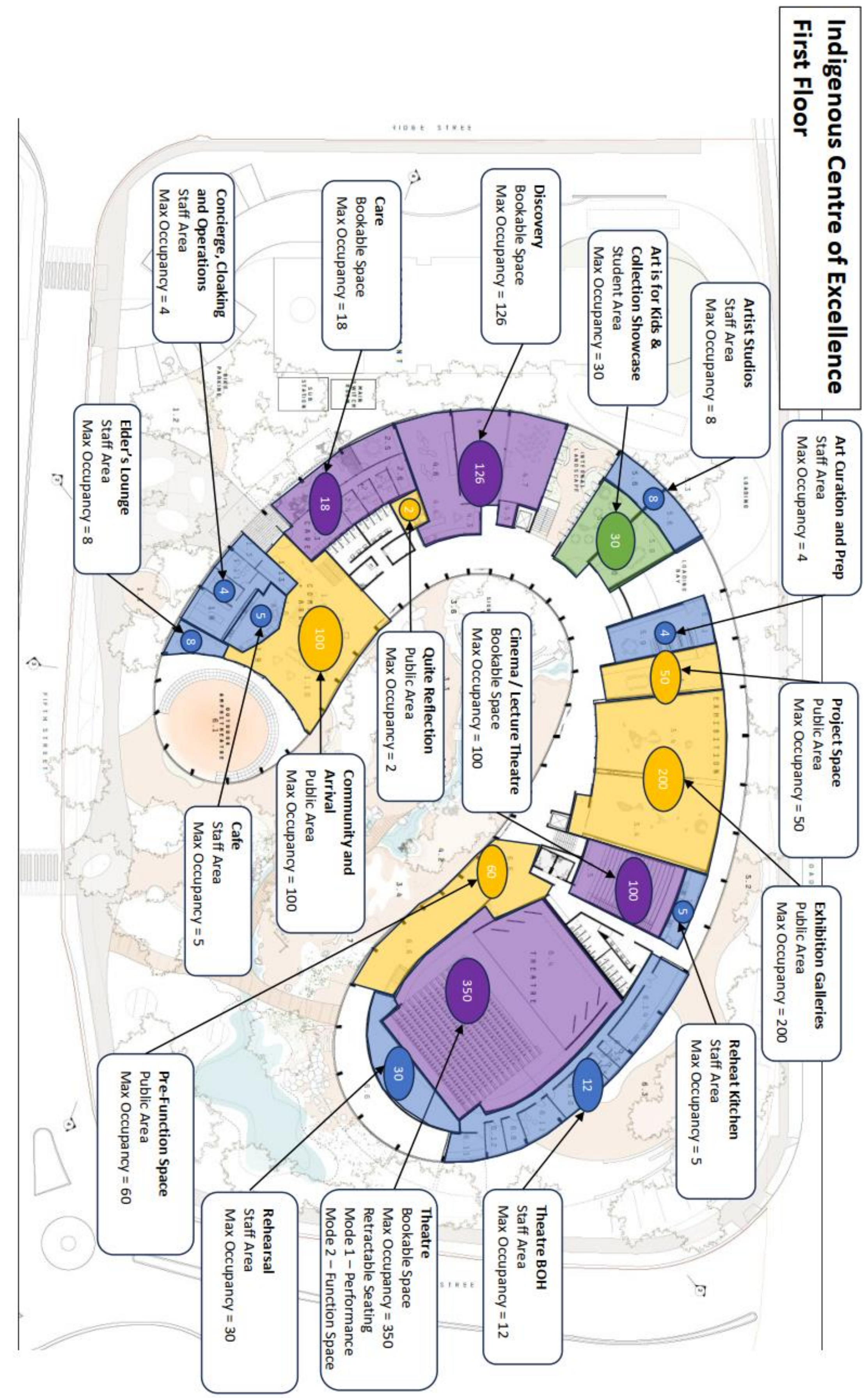
Table A.2: Services drawings relied upon

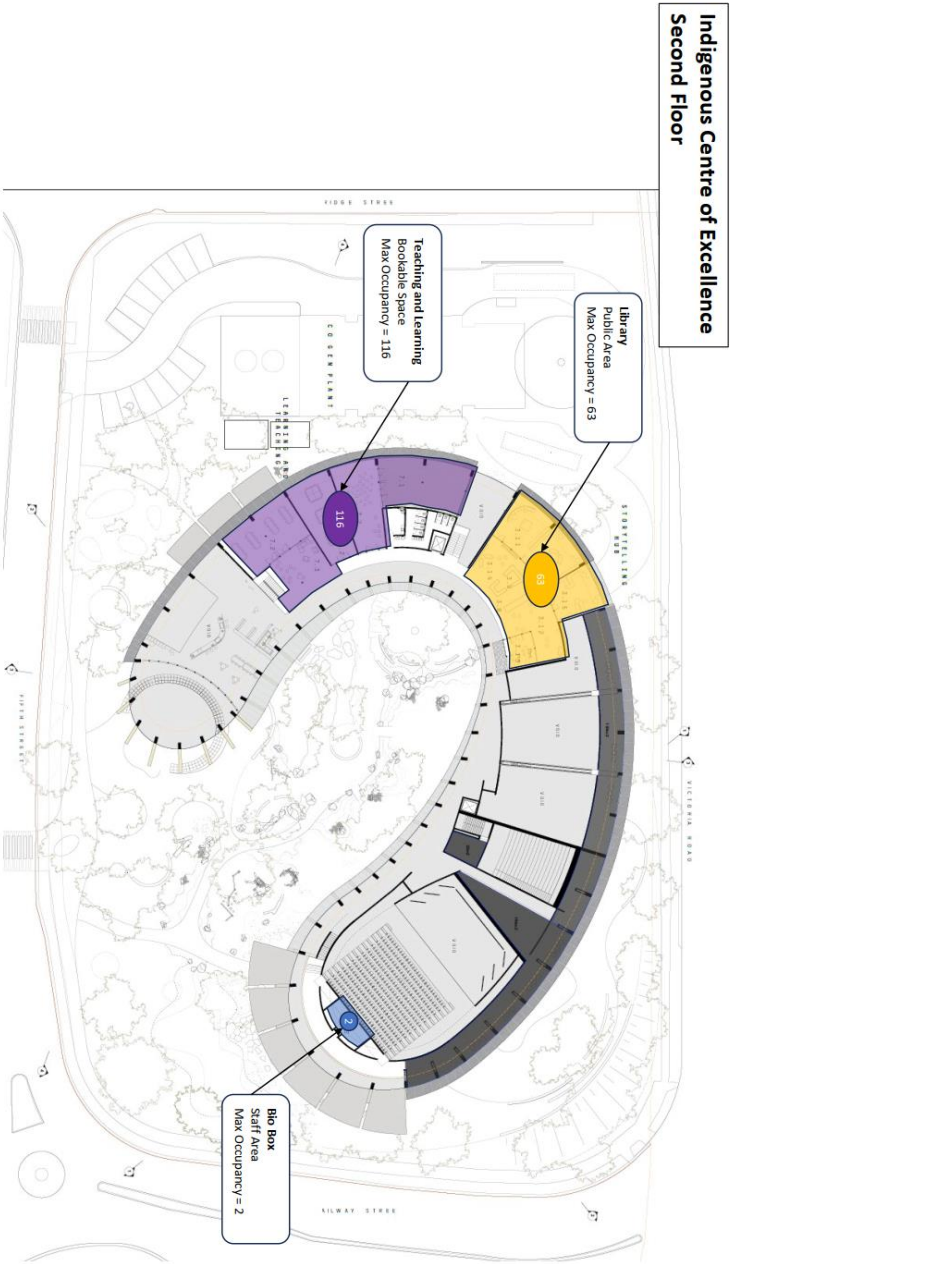
Drawing No.	Drawing Name	Date	Revision
17475_PS_EC_WS_FS_00_000_00	COVER SHEET, LEGEND & DRAWING LIST	24/10/24	01
17475_PS_EC_WS_FS_00_000_01	SITE PLAN	24/10/24	01
17475_PS_EC_WS_FS_02_00_01	LEVEL 00 - FIRE SERVICES - ZONE 01	24/10/24	01
17475_PS_EC_WS_FS_02_00_02	LEVEL 00 - FIRE SERVICES - ZONE 02	24/10/24	01
17475_PS_EC_WS_FS_02_01_01	LEVEL 01 - FIRE SERVICES - ZONE 01	24/10/24	01
17475_PS_EC_WS_FS_02_01_02	LEVEL 01 - FIRE SERVICES - ZONE 02	24/10/24	01
17475_PS_EC_WS_FS_02_02_01	LEVEL 02 - FIRE SERVICES - ZONE 01	24/10/24	01
17475_PS_EC_WS_FS_02_02_02	LEVEL 02 - FIRE SERVICES - ZONE 02	24/10/24	01
17475_PS_EC_WS_FS_02_03_02	LEVEL 03 - FIRE SERVICES - ZONE 02	24/10/24	01
17475_PS_EC_WS_FS_05_000_00	FIRE SERVICES - WET SYSTEMS SCHEMATIC	24/10/24	01
17475_PS_EC_WS_FS_05_000_01	FIRE SERVICES - DRY SYSTEMS SCHEMATIC	24/10/24	01

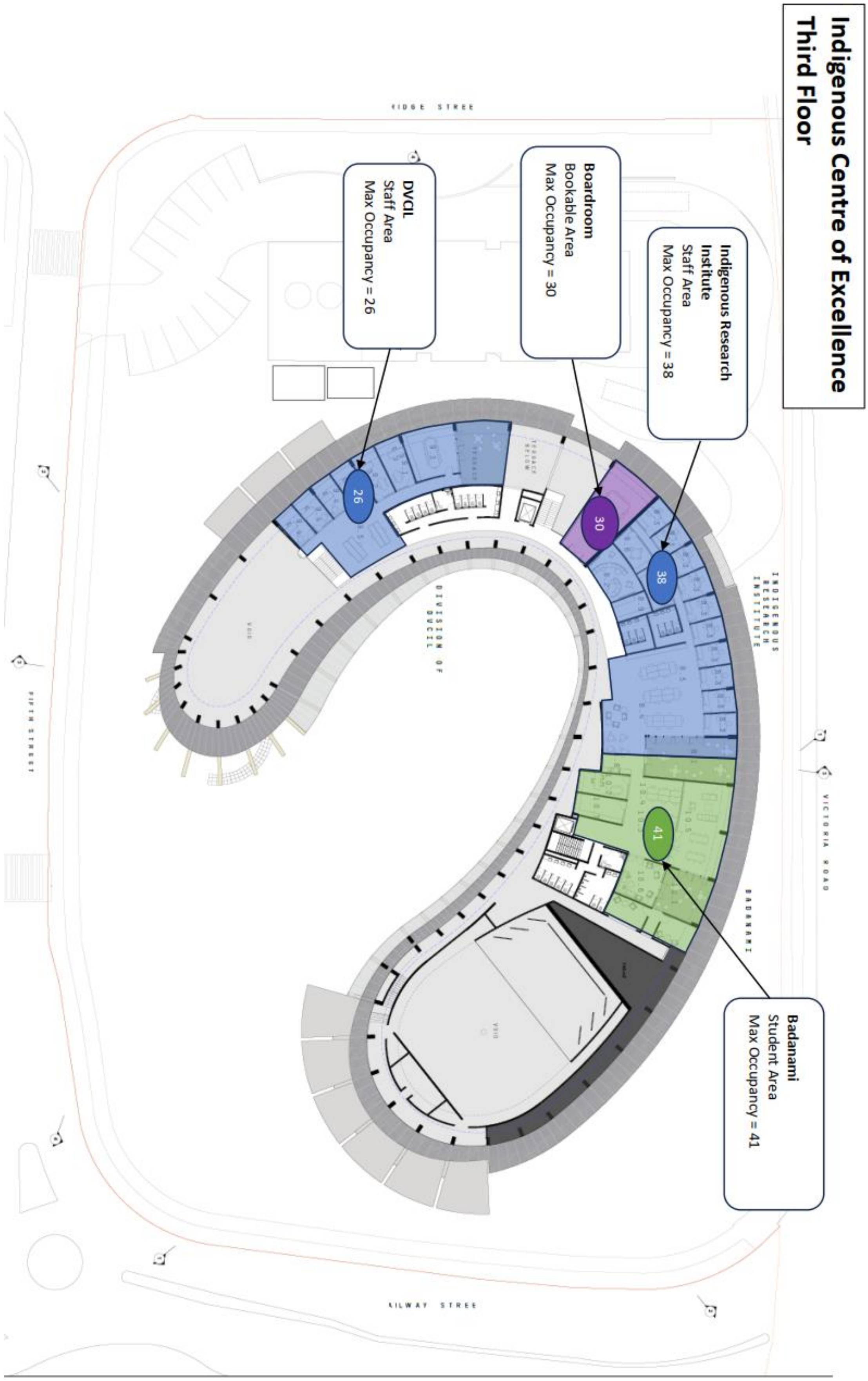
A.2 Occupant Loading

Indigenous Centre of Excellence
Building Occupancy Estimate
18 March 2024

Level	Public Space	Bookable Space	Student Area	Staff Area	Total
Level 1	412	594	30	76	1112
Level 2	63	116		2	181
Level 3	-	30	41	64	135
Level 4	-	155	-	-	155
Total Building Occupancy					**1583**


Indigenous Centre of Excellence
First Floor
Art Curation and Prep
Staff Area
Max Occupancy = 4
Artist Studios
Staff Area
Max Occupancy = 8
Art is for Kids & Collection Showcase
Student Area
Max Occupancy = 30
Discovery
Bookable Space
Max Occupancy = 126
Care
Bookable Space
Max Occupancy = 18
Concierge, Cloaking and Operations
Staff Area
Max Occupancy = 4
Elder's Lounge
Staff Area
Max Occupancy = 8
Project Space
Public Area
Max Occupancy = 50
Cinema / Lecture Theatre
Bookable Space
Max Occupancy = 100
Quite Reflection
Public Area
Max Occupancy = 2
Community and Arrival
Public Area
Max Occupancy = 100
Cafe
Staff Area
Max Occupancy = 5
Exhibition Galleries
Public Area
Max Occupancy = 200
Reheat Kitchen
Staff Area
Max Occupancy = 5
Pre-Function Space
Public Area
Max Occupancy = 60
Theatre BOH
Staff Area
Max Occupancy = 12
Theatre
Bookable Space
Max Occupancy = 350
Retractable Seating
Mode 1 – Performance
Mode 2 – Function Space
Rehearsal
Staff Area
Max Occupancy = 30


Indigenous Centre of Excellence
Second Floor
Library
Public Area
Max Occupancy = 63
Teaching and Learning
Bookable Space
Max Occupancy = 116
Bio Box
Staff Area
Max Occupancy = 2
116
63
2


Indigenous Centre of Excellence
Third Floor
DVCIL
Staff Area
Max Occupancy = 26
Boardroom
Bookable Area
Max Occupancy = 30
Indigenous Research
Institute
Staff Area
Max Occupancy = 38
Badanami
Student Area
Max Occupancy = 41
26
30
38
41


Indigenous Centre of Excellence
Fourth Floor
RIDGE STREET
CO GEN PLANT
FIFTH STREET
VICTORIA ROAD
Astronomy and Gathering Space
Bookable Area
Max Occupancy = 30
30
125
Multi-Purpose Court
Bookable Area
Max Occupancy = 125

Appendix B. Detailed Hazard Analysis

B.1 Class 9b – Public Hall, Auditorium and Gallery

The proposed building will undergo a wide variety of functions and use due to the presence of an auditorium, lecture hall, general learning spaces and gallery spaces in the form of orchestral performances, plays, productions and various functions type events. Thus, the venue is likely to present a wide range of hazards and possible fire scenarios.

B.1.1 Nature of Activities

The activities taking place would include:

- Welcome Foyer
- Theatre
- Cinema/Lecture Hall
- Gallery
- Outdoor Amphitheatre
- Art Studios & Exhibition spaces
- General Learning/Study spaces
- Consulting offices
- Library facilities
- General Learning/Study spaces
- Offices & Workspaces
- Outdoor multi-purpose sports court

As such the fire related hazards associated with the building arise from the usual mixture of ignition sources and fuel load content. The indoor non-smoking laws applying one of the major ignition sources have been removed. The other major potential source is the electrical wiring and equipment.

B.1.2 US Statistics (Fire Incidents):

US fire statistics indicate that the number of fatalities and/or injuries as a result of fires taking place in similar occupancies such as public assembly buildings and restaurants is very low. The statistics identify "Public Assembly" and "Eating Drinking" as specific occupancy types which would include all components of the subject building. Table B.1 shows 1996 statistics from US for non-residential occupancies.

Table B.1: US Fire Statistics

Design Issue	Number of non-residential:	Public Assembly % / no	Eating Drinking % / no	Total % / no
Fires	73,325	4.2/3080	7.5/5500	11.7/8580
Deaths	111	0.9/1	2.7/3	3.6/4
Injuries	1636	4.5/74	7.6/125	12.1/199

For public assemblies and eating-drinking places, the calculated rate of fire fatalities in US in 1996 was approximately 1.5 fatalities per 1000 fires. For the same period of time the calculated rate of fatalities in residential occupancies was 7.8 fatalities per 1000 fires. Thus, the risk to occupants is considered to be relatively low.

Based on the nature of activities that are often associated with multipurpose building and the data outlined in the US fire statistics, it can be stated that the risk of a significant fire within these types of buildings are relatively low compared to other types of classifications.

B.1.3 Ignition sources

In view of the likely use of the building it is anticipated that there will be some sources of ignition. The ignition sources that are primarily related to the proposed building include:

- electrical switch assemblies,
- lighting,
- electronic audio/video stage equipment,
- Occasional special effects equipment for staged performances.

B.1.4 Combustible content

In view of the variable nature of activities associated with the hall as an assembly building it is anticipated that the likely fuel loads will consist of the seating in the auditorium space, the office-type items within the reception and box-office area and the furnishings within the Bar area located in the Foyer portion. The stage area presents another potential fuel load of which the combustible content primarily related to the stage area of the proposed building include:

- Audio/Visual equipment
- Performance props and decorations
- Gallery and exhibition items
- Office equipment is in the form of paper or wood, but there are significant quantities of plastics and electronics present as well

Appendix C. BCA Checklist

bmg

Executive Summary

The following comprises a summary of the key compliance issues identified under the clause-by-clause assessment in Section 3.0 and 4.0 of this report that will be required to be addressed prior to the BCA Crown Certificate for the project.

A. Key matters requiring additional information at BCA Crown Certificate Stage:

+ BCA (DTS) Clause		+ Description
1.	C3D8 Part I4	Fire compartmentation plans are to be developed as the design progresses for the building. Specifically note that: + Entertainment Venues, including the cinema and multi-purpose hall (auditorium, stage, and backstage) are to be fire separated from the remainder of the building (60-minute construction). + Fire separation required between the storerooms and the remainder of the building (60-minute construction). + Level 3 is to be fire separated from the remainder of the building (120-minute construction). + Floors will require 120/120/120 FRL (regardless of if floors are shared within the same fire compartment). The current fire separation of the Entertainment Venues appears to be inadequate. Fire compartmentation plans to be provided for review.
2.	D2D8	Anticipated populations and egress widths have been revised on the basis of the JCB occupancy markup. Further information required regarding the maximum anticipated population within the Level 1 literature library hub. Where the population within this space exceeds 19 people (thus over 200 people accommodated on this storey), a performance solution will be required to rationalise egress widths from this level.
3.	D2D12	The current design is capable of compliance. Details to be provided for the following as the design progresses in relation to the fire-isolated stair serving Level 3: + External fire-rated walls within 6m of the discharge path from the exit. + Provision of airlock between service corridor/plant space and fire-isolated passageway/stair on Ground Level and Level 3. + Fire rating of passageway leading from the fire-isolated stair to open space on Ground Level (unless addressed via a fire engineered solution). Note: Where a Performance Solution is proposed for the open stair connecting into Level 3, the D2D12 requirements will not apply to the open stair.
4.	Part D4	Access-related items have not been considered as part of this assessment. A separate report from an access consultant will be required.
5.	Part E1	Refer to BMG markups on Warren Smith Consulting Engineers fire services drawings.
6.	Part E4	Refer to BMG markups on Steensen Varming electrical drawings.
7.	Part G3	Level 2 and Level 3 are to be fire separated so no more than 3 storeys are connected in a sprinkler-protected building to avoid atrium provisions. Further details are required of the fire separation between levels for our review, including the fire separation around the open stair.

bmg

B. Matters requiring fire safety engineered performance solutions:

+ BCA (DTS) Clause		+ Description
1.	C2D2, Spec 5, C4D16	Permit the gap between the floor slabs and the curtain wall (slab-edge) to be fire sealed on a performance basis in lieu of a DtS tested system. Note: Façade report nominates a curtain wall to the outdoor maker area. Architect to confirm selected façade system to confirm if this Performance Solution is applicable.
2.	C2D13, Spec 10	The building is proposed to be constructed from Mass Engineered Timber: + Selected elements to not be encapsulated with a fire protective covering. E.g., Columns, beams, floors. + Assessment of non-tested systems e.g., fire rated penetrations, 2-way floor/wall systems, lightweight terminating at CLT.
3.	C4D3, Spec 5	Fire-rated construction is not provided to both the ICoE building and the existing Central Energy Plant where they are within 6m of each other.
4.	D2D4	The open stair serving all levels is not fully contained within a fire-rated shaft.
5.	D2D5	Exit travel distances proposed to be extended as follows: Level 1 + 27m to a point of choice in lieu of 20m Level 1 Plant Room + 27m to a point of choice in lieu of 20m + 50m to an exit in lieu of 40m Level 2 + 28m to a point of choice in lieu of 20m Level 2 Plant Room/Catwalks + 38m to a point of choice in lieu of 20m (fire engineer to advise feasibility) + 47m to an exit in lieu of 40m Level 3 + 28m to a point of choice in lieu of 20m
6.	D2D6	Distances between alternative exits are proposed to be extended as follows: Level 2 Plant/Catwalks + Subject to location of additional egress door from the catwalks (if required)
7.	D2D12	Fire stair serving all storeys discharges internally on Ground Level.
8.	D2D14, D2D21	The non-fire-isolated stair serving Level 3 and ladder serving the Level 2 plant room do not have a continuous path of travel from the storey served to the level of discharge.
9.	D2D21	Permit the theatre catwalks, which is not a plant room <200m², to utilise the plant room ladder for egress.
10.	E1D2	Potential performance solution where additional internal fire hydrants are required remote from exits to achieve coverage.
11.	E1D2/E1D4	Subject to the new booster assembly location, a performance solution may be required to permit the assembly to be further than 20m from the building's principal pedestrian entrance.
12.	NSW E2D16, NSW E2D18, NSW E2D19	Rationalisation of the required smoke exhaust system (i.e. smoke exhaust rates, reservoir sizes etc) to: + Building generally due to gallery / exhibition / event / non-classroom uses (potential omission of smoke exhaust) + Theatre stage and auditorium Fire engineer to review and provide comment.

WSU ICoE NCC Report + 3 / 80

13.	NSW I4D2, NSW I4D44, NSW 14D47	Potential rationalisation of Part I4 entertainment venue fire separation requirements (e.g. to the [non-fire-rated] sliding door into the theatre).

C. Other matters requiring performance solutions:

+ BCA (DTS) Clause		+ Description
1.	**B1P2**	Structural performance solution for the calculation method to support CLT (in lieu of Australian Standards)
2.	**D1P1**	TBC Access Report by others
3.	**F3P1**	A performance solution report is required to be prepared to Performance Requirement F3P1 in relation to weatherproofing of external walls. This will be required from the Façade Engineer.
4.	**F4D4**	Performance solution is required where gender neutral facilities are proposed.
5.	**J1V3**	Performance solution (JV3 assessment) – TBC

Appendix D. Sprinkler System Reliability & Effectiveness

D.1 Reliability and Effectiveness

Automatic sprinklers are highly effective elements of total system designs for fire protection in buildings. They save lives and property, producing large reductions in the number of deaths per thousand fires, in average direct property damage per fire, and especially in the likelihood of a fire with large loss of life or large property loss.

For all occupancy classifications, where sprinklers were present in the fire area and fire was large enough to activate sprinklers ,the effectiveness of the sprinkler systems is significantly high (97% to 100%). Operational probabilities vary in US data but for majority of classifications remain above 90% (Aherns, 2017). The efficacy values show a similar trend. This excludes buildings under construction.

The US data showed that in the event of a fire the likelihood sprinklers operating and being effective is 88 % (i.e. fire being large enough to operate sprinklers and/or sprinklers being well maintained and effective).

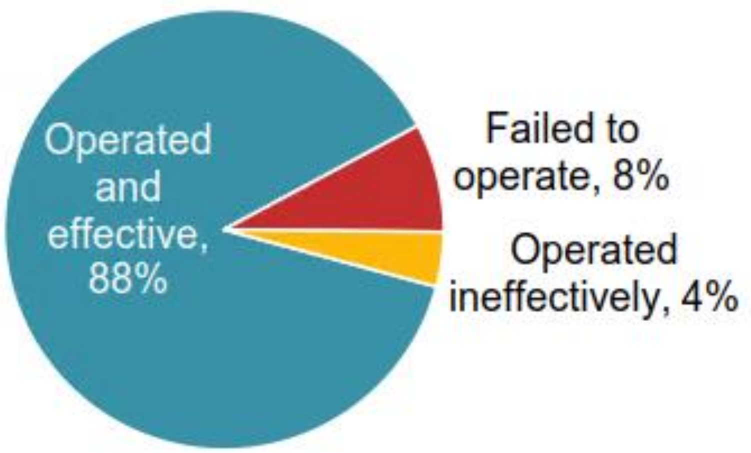


Figure D.1: Sprinkler operation and effectiveness (source: Ahrens, 2017)

Further research was performed specifically on U.S home fires, and it was identified that during 2010 to 2014 sprinklers operated in 94% of home fires; in which the fire was large enough to activate the sprinkler heads. It was further discovered that 96% of the fires were controlled effectively upon activation of sprinklers; and the sprinklers operated effectively in 91% of the fires (Ahrens,2017).

Whether with a performance design or with a prescriptive code, the reliability of fire protection systems and features must be considered. Reliability includes both operational reliability and performance reliability. The operational reliability is a measure of the probability that a system or component will operate as intended when needed. The performance reliability is a measure of the adequacy of the system once it has operated (Koffell, 2005). For a sprinkler system, operational reliability accounts for the "readiness" of the system components, while performance reliability addresses the "capability" of the system to perform satisfactorily under specific fire exposures.

Table D.1: Historical data on operational reliability (Koffell, 2005)

Reference	Reliability of Success	Comments
Marryat[1]	99.5	Inspection, testing, and maintenance exceeded normal expectations and higher pressures
Maybee[2]	99.4	Inspection, testing, and maintenance exceeded normal expectations.
Powers[3]	98.8	Office buildings only in New York City
Powers[4]	98.4	Other than office buildings in New York City
Finucane et al[5]	96.9 – 97.9	
Milne[6]	96.6/97.6/89.2	
NFPA[7]	88.2 – 98.2	Data provided for individual occupancies – total for all occupancies was 96.2%.
Linder[8]	96	
Richardson[9]	96	

Miller[10]	95.8	
Powers[11]	95.8	Low rise buildings in New York City
US Navy[12]	95.7	1964 – 1977
Smith[13]	95	UK data
Miller[14]	94.8	
Ahrens[15]	88	

17. Marryat, H. W., Fire: A Century of Automatic Sprinkler Protection in Australia and New Zealand 1886 –1986, Australia Fire Protection Association, Melbourne, Australia.
18. Maybee, W. W. "Summary of Fire Protection Programs in the U.S. Department of Energy—Calendar Year 1987," U.S. Department of Energy, Frederick, MD, August 1988.
19. Powers, R. W. "Sprinkler Experience in High-Rise Buildings (1969-1979)," SFPE Technology Report 79-1, Society of Fire Protection Engineers, Boston, MA, 1979.
20. Powers, R. W., ibid.
21. Finucane, M, and Pickney, D. "Reliability of Fire Protection and Detection Systems," United Kingdom Atomic Energy Authority, University of Edinburgh, Scotland.
22. Milne, W. D., "Automatic Sprinkler Protection Record, "Factors in Special Fire Risk Analysis, Chapter 9, pp. 73-89.
23. NFPA. "Automatic Sprinkler Performance Tables, 1970 Edition," Fire Journal, July 1970, pp. 35-39.
24. Linder, K. W. "Field Probability of Fire Detection Systems," Balanced Design Concepts Workshop,
25. NISTIR 5264, R.W. Bukowski (ed.), Building and Fire Research Laboratory, National Institute of Standards and Technology, September 1993.
26. Richardson, J. K. "The Reliability of Automatic Sprinkler Systems," Canadian Building Digest, Vol. 238, July 1985.
27. Miller, M. J. "Reliability of Fire Protection Systems," Loss Prevention ACEP Technical Manual 8, 1974.
28. Power, R. W., ibid.
29. Kelly, Kevin J. "Trade Ups", Sprinkler Quarterly, Summer 2003
30. Smith, Frank. "How Successful are Sprinklers," SFPE Bulletin, Vol. 83-2, April 1983, pp 23-25.
31. Miller, M. J., ibid.
32. Aherns,M. "US Experience with Sprinklers," NFPA, July 2017, pp. 21. It should be noted that Ahrens' data relates to operation and effectiveness and is not limited to reliability.

Most automatic sprinkler systems are designed to control a fire but not necessarily to completely extinguish the fire. The NFPA fire data supports the concept that sprinkler systems can control fires but do not necessarily result in complete extinguishment. Table D.2 indicates the percentage of fires where any type of sprinklers are present and that are reported as being extinguished by a sprinkler system.

Table D.2: Sprinkler reliability and efficacy – US data (Ahrens, 2017)

Property	Percent where sprinklers operated (A)	Percent effective of those operated (B)	Percent where equipment operated effectively (AxB)
Residential homes and apartments	94%	96%	91%
Office / commercial	91%	96%	87%
Educational	87%	96%	84%
Heath care including Nursing home, hospital, clinic, doctor's office, or development disability facility	85%	97%	82%
Large Retail / Department Store	90%	98%	88%
Warehouse and cold storage	86%	96%	82%
Hotel / Motel	90%	98%	89%
All public assembly	90%	94%	85%

The sprinkler effectiveness in reducing loss of life has been documented in the paper titled "US Experience with Sprinklers" (Ahrens, 2017). The following statistical data is summarised based on data collected during the period of 2010-2014.

Table D.3: Estimated reduction in 2010-2014 civilian deaths per thousand fires

Property Use	Civilian Deaths per Thousand Fires		
	Without Sprinklers	With Sprinklers	Percentage Reduction
Public Assembly	0.7	0.0	100%
Residential	7.5	1.1	84%
Manufacturing	1.6	1.0	21%
Warehouse excluding cold storage	2.7	0.6	74%
All structures	6.3	0.8	86%

With reference to Table D.3, in all structures, in average civilian fatalities have be reduced by up to 86% for all structure fires during the five year period due to the presence of sprinklers.

Table D.4: Number of sprinklers operating in 2010-2014 Structure Fires (Ahrens,2017)

Number of Sprinklers Operating	Percentage of structure fires where that many sprinklers operated
1	79%
1 or 2	91%
1 to 3	94%
1 to 4	96%
1 to 5	97%
1 to 10	99%

Table D.4 indicates the percentage of structure fires where that many sprinklers operated. The table shows that generally in structure fires, more than 90% of structure fires have resulted in an activation of more than 1 sprinkler head. Therefore, it can be said that in a sprinkler protected building, typically more than 1 sprinkler head activates in an event of a fire, which reassures the reliability of automatic sprinkler systems.

D.2 Sprinkler Performance in Other Occupancy Classifications

Carparks

All carparks accommodating more than 40 vehicles are required to be provided with sprinkler systems in Australia. Studies show that sprinklers are significantly effective in carparks

Based on UK fire data the sprinkler effectiveness in carparks assumed to be as high as 99%. Between 1994 and 2005 there were 3095 report fires in car parks in the UK. Of these, only 162 fires occurred where a fixed fire suppression system was present. Automatic fire sprinklers extinguished or contained 100 of these fires. In only 1% of cases, fire sprinklers operated but did not extinguish or contain the fire. It is assumed that the remainder were too small to actuate the sprinklers and either simply burned out or was extinguished quickly by persons using fire extinguishers etc. (UK Fire Statistics, 2010).

The most modern car designs, with increased flammability, are adequately protected by the latest sprinkler system designs because rapid rises in temperature cause earlier operation of the system which prevents faster fire spread, thus causing much less smoke and heat. Although sensitive to rapid heat increases caused by fire, inadvertent operation of a sprinkler system is virtually unknown due to "built in" integrity (Eurofeu Technical Report, 2009).

D.3 Failures that may be Attributed to the Sprinkler Systems

Several of the causes of failure are attributable to the human factor. This leads to a discussion about which causes of failure that really should be attributed to the sprinkler system. Based on the study conducted by Ahrens (2017), it was shown that there are several reasons that contributed to sprinkler failures.

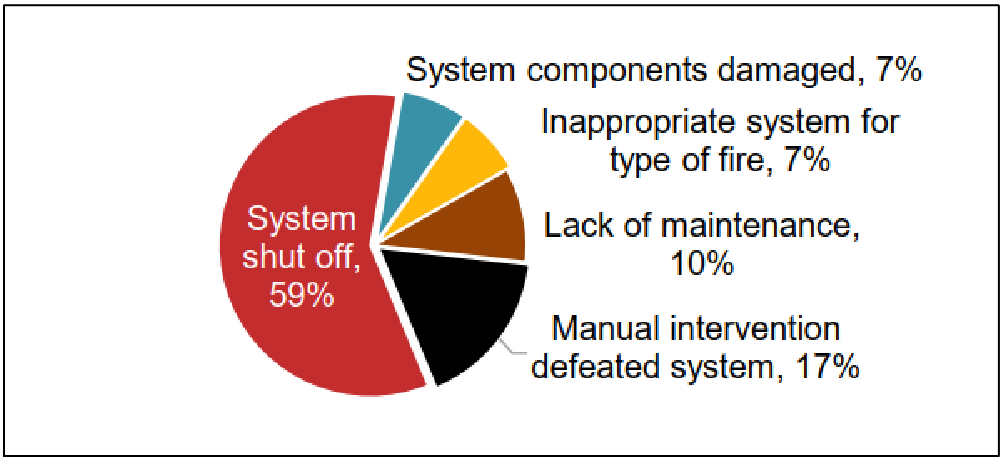


Figure D.2: Reasons for sprinkler failures: 2010-2014 (Ahrens, 2017)

As shown in Figure D.2, 59% of the time the systems were shut off leading to failure in sprinkler activation. Manual intervention was the secondary contribution to sprinkler systems failing to operate, followed by lack of maintenance, systems components damaged and inappropriate system for type of fire.

Further studies were also conducted to determine the reasons for sprinkler effectiveness. Based on the study by Ahrens (2017), over the 5 year period between 2010 and 2014, 51% (half) of the fires in which sprinklers were ineffective were due to the water not reaching the fire. It was also determined that 30% of the incidents were due to the limited amount of water discharged. In 7%, system components were damaged.

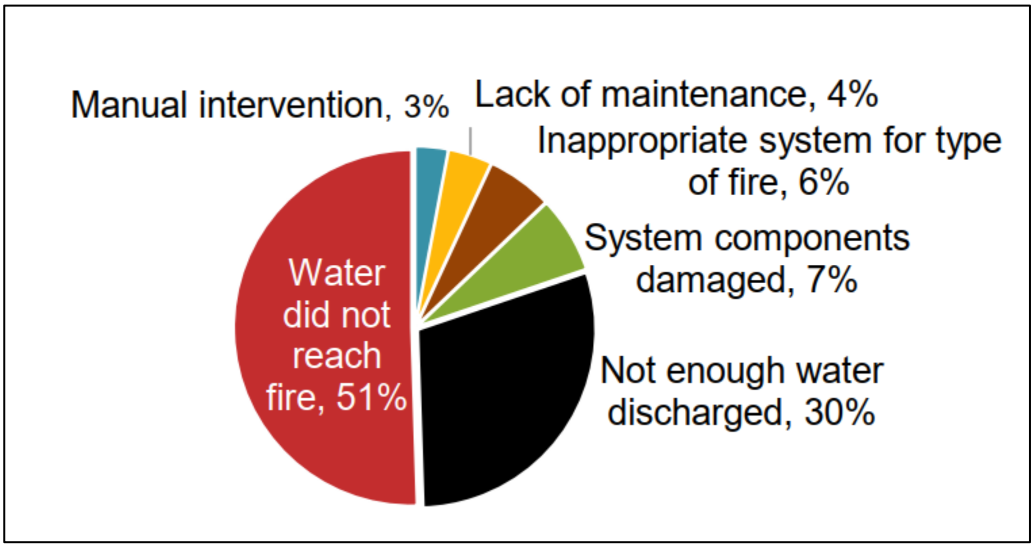


Figure D.3: Reasons for sprinkler ineffectiveness: 2010-2014 (Ahrens, 2017)

Furthermore, based on research data extracted from “Efficiency and Effectiveness of Sprinkler Systems in the United Kingdom: An Analysis from Fire Services Data” by the National Fire Sprinkler Network (NFSN) (May, 2017), it was determined that there were “additional” reasons for the sprinkler system to not operate.

Table 5: "Other" Reasons for System not Operating		
	Number	**%**
Insufficient fire or heat	115	79.3
Extinguished before activation	13	9.0
No fire, just smoke/not enough smoke	7	4.8
Fire contained to machine	5	3.4
Operating failure	3	2.1
Human error	1	0.7
Flash fire in cotton dust	1	0.7
Total	**145**	**100.0**
Source: Optimal Economics		

Figure D.4: "Other" Reasons for System not Operating

As extracted from Table 5 of the "Efficiency and Effectiveness of Sprinkler Systems in the United Kingdom: An Analysis from Fire Services Data" by the National Fire Sprinkler Network (NFSN) (May, 2017), Figure D.4 shows that's the majority of cases where sprinkler systems do not operate is due to insufficient fire or heat (i.e. 79.3% of the time). Human error and flash fire in cotton dust are also responsible for the sprinkler system not operating but was considered highly unlikely (i.e. 0.7% of the time).

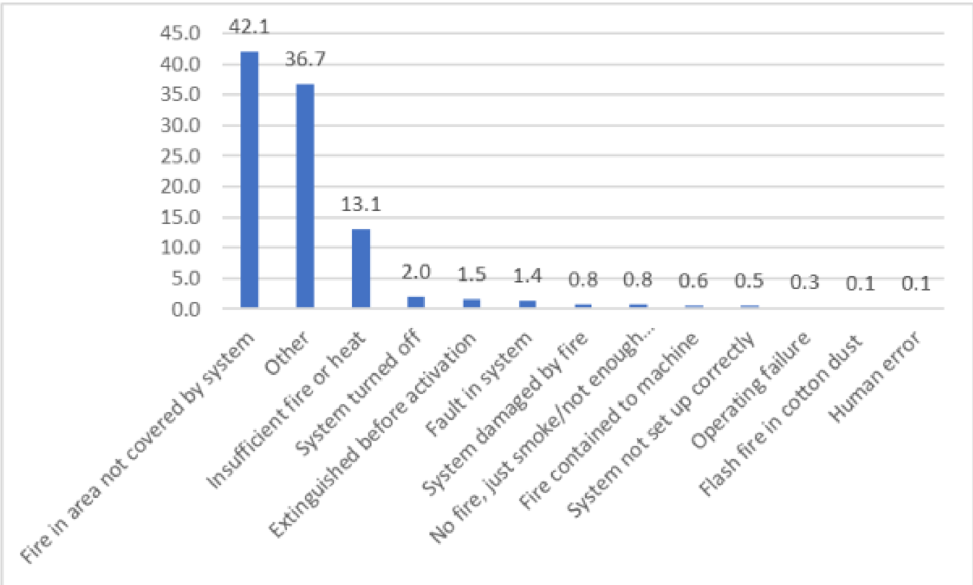


Figure D.5: Distribution of Reasons for Sprinkler not Operating. %

As shown in Figure D.5, the distribution of reasons for sprinkler not operating extracted from the research paper by the National Fire Sprinkler Network (NFSN) (May, 2017) shows that the main reason for sprinklers not operating is due to insufficient coverage by the sprinkler system within the area of fire origin (AFO).

In summary, it can be said that automatic sprinkler systems are highly reliable and the main reasons the systems do not operate are generally due the following:

- Lack of fire/heat within the area of fire origin; and
- Insufficient coverage by the system within the area of fire origin

D.4 Impact of Sprinkler Systems on Fire Temperatures and Heat Release Rates

With the presence of sprinklers, the likelihood of a fire growing to the extent where it will spread beyond the object of fire origin is considered unlikely. Sprinkler protection is expected to provide a reliable and effective means of maintaining tenable conditions for occupants and fire-fighters, structural adequacy, and limiting fire spread within the subject building as well as to adjacent building(s). Effective sprinkler activation and operation is also likely to reduce the generation of smoke and maintain low compartment temperatures thus mitigating smoke spread between adjacent compartments.

Experimental evidence and numerical studies have demonstrated that sprinklers are very effective in controlling and suppressing fires. Sprinkler systems are designed to contain a fire. Madrzykowski & Vettori (1992) have conducted single (small) room experiments to study the effect of sprinklers on the heat release rate (Nystedt,2011).

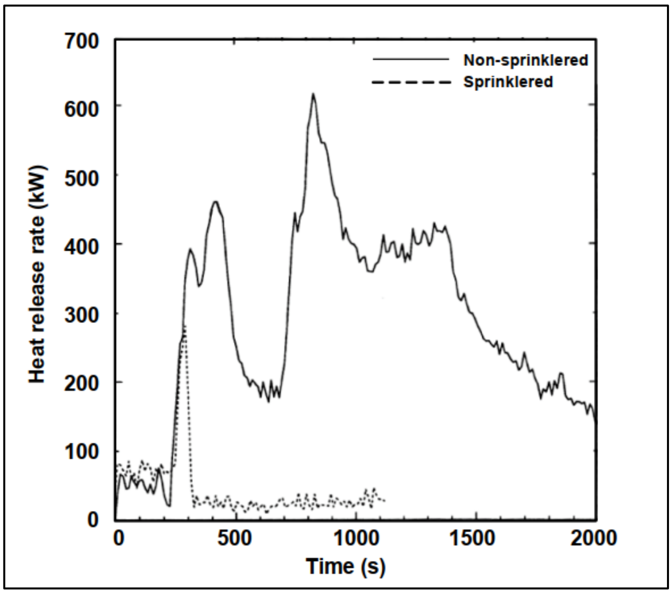


Figure D.6: Illustration of sprinkler effect on the fire development for a sofa fuel package (adopted from Madrzykowski & Vettori, 1992)

As shown in Figure D.6, the peak heat release rate in a sprinkler protected room is no more than 300 kW at the time of sprinkler activation, but the heat release rate peaks at approximately 600kW in a non-sprinkler protected room.

Further to the experiment conducted by Madrzykowski & Vettori, the Building Research Establishment in the UK (BRE,2002) has conducted a project that characterised fires for design purposes. The sprinkler tests were carried with a maximum of four sprinklers operating with a total rate of 270 litres per minute and with a pressure of 0.6 bar at the sprinkler heads. As defined by the British Standard BS5406 (BSI,2009) the sprinkler system was designed according to Ordinary Hazard Class III. Utilising the output from the BRE design fires, the Swedish Fire Sprinkler Association (Sprinklerframjandet) has financed a study to evaluate the difference between sprinklered and non-sprinklered fires (Lindsten, 2009).

Table D.5: The effect of sprinklers on the heat release rate (Lindsten, 2009)

Test	Immediate Effect	Secondary Effect
Open Plan Office	Reduced HRR	HRR reduced by 50% after 1 min
Luggage	Increased HRR by 25% - 50%	HRR reduced by 50% after 2-3 min
Reception	Reduced HRR	Extinguished after 2 min
Carpets	Reduced HRR	Extinguished after 1 min
Sports clothing	Increased HRR by 25%	Extinguished after 2 min
Pallets	HRR kept constant	None
Adventure Play Area	Reduced HRR	Extinguished after 2 min
Boxes	HRR kept constant	None
Soft Toys	Reduced HRR	Extinguished after 2 min

As shown in Table D.5, Lindsten (2009) concludes that the fire is extinguished by the sprinkler system in 50% of the fire tests. Three tests results showed a reduced in heat release rate and the remaining two tests showed that the heat release rate were maintained.

Multi/ large room experiments were also carried out to determine the effectiveness of sprinklers. The experiments were carried out by Schonberg (2000) in a room with a floor area of $14m^2$ and a ceiling height of 2.6m. Further experiments were conducted by Crocker et al. (2010) to study the impact of sprinklers sprays on the fire induced doorway flow. Based on the 34 experiments conducted, it was concluded that a spray sprinkler reduced the mass flow at the doorway while maintaining two stratified layers away from the sprinkler spray. In this instance, temperature measurements from both an unsprinklered and sprinklered cases are shown in Figure D.7.

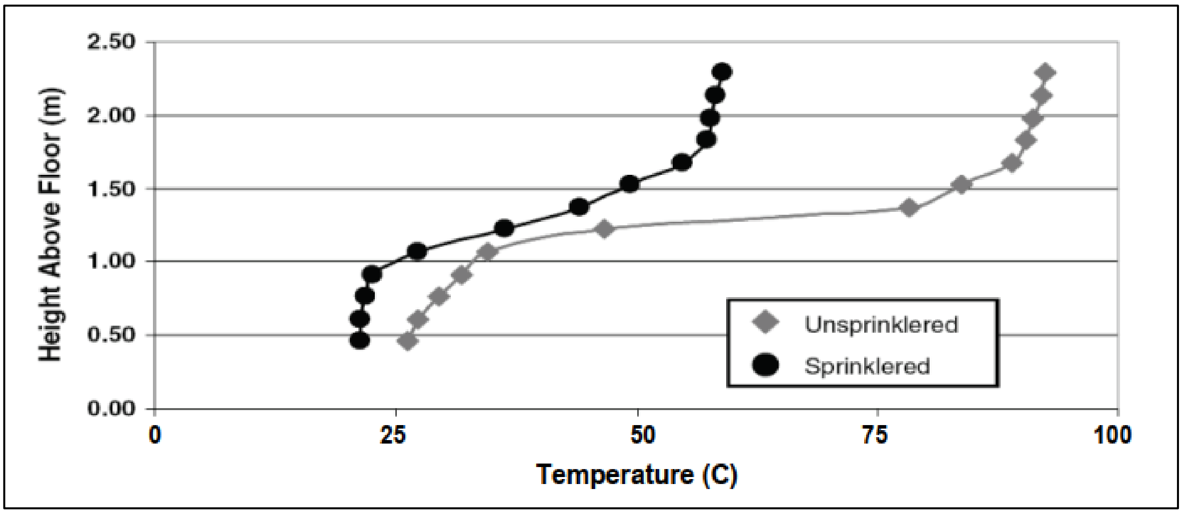


Figure D.7: Temperature measurements inside the compartment (Crocker et al. (2010))

Automatic sprinklers are capable of suppressing or controlling fires such that the temperature rise of fire product gases and radiant heat is significantly reduced. It is assumed that the hot layer gases remain at the same temperature, as they were when the sprinklers activate which is approximately 75-100°C. It is evident that the effect of sprinklers on a fire is to wet down potential fuel sources, control or suppress the burning process and to cool the resultant smoke layer. It has been cited that the resultant smoke temperatures in a sprinkler-controlled fire are reduced to 100°C -120°C (Milke, 2001; Madrzykowski, 2008) within 60 seconds of sprinkler activation.

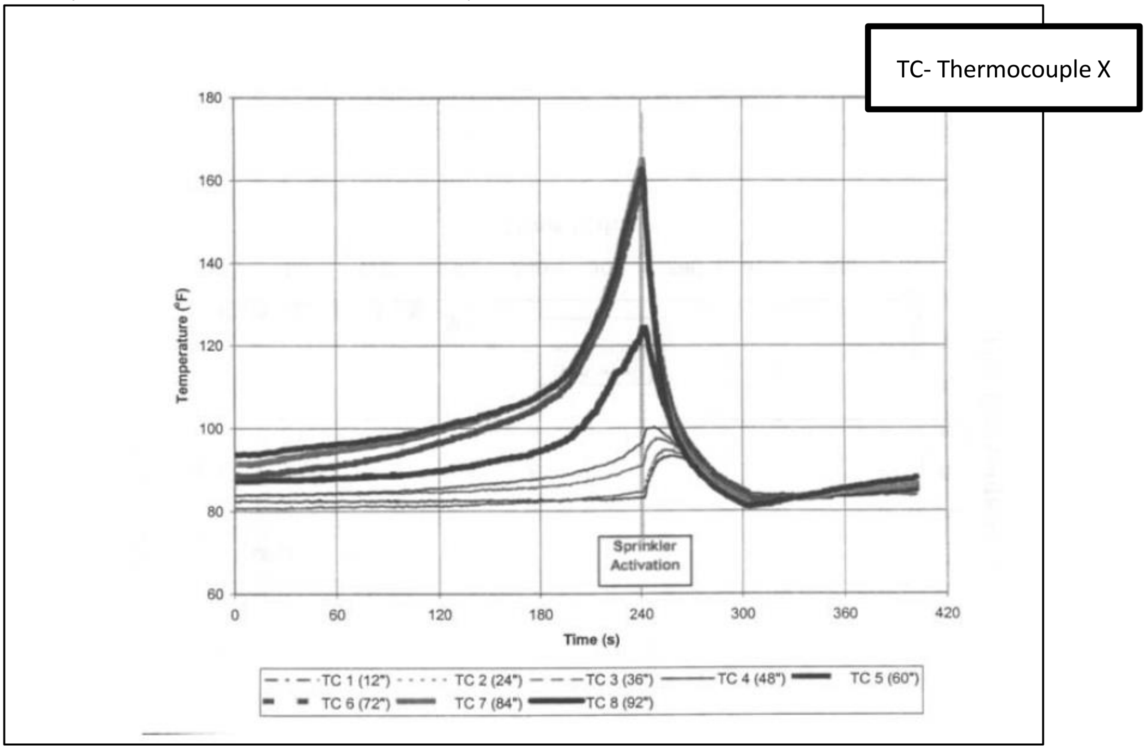


Figure D.8: Sprinkler controlled room temperatures (Milke, 2001)

With the presence of the sprinkler systems the risk of distress to building elements, barriers and the like is minimal. When a sprinkler system is activated within an enclosure a room fire the heat release rate of the burning fuel is reduced or controlled to a relatively small level. Similarly, the smoke and hot gas temperatures inside the room of fire origin are reduced or maintained due to the cooling effect of water spray.

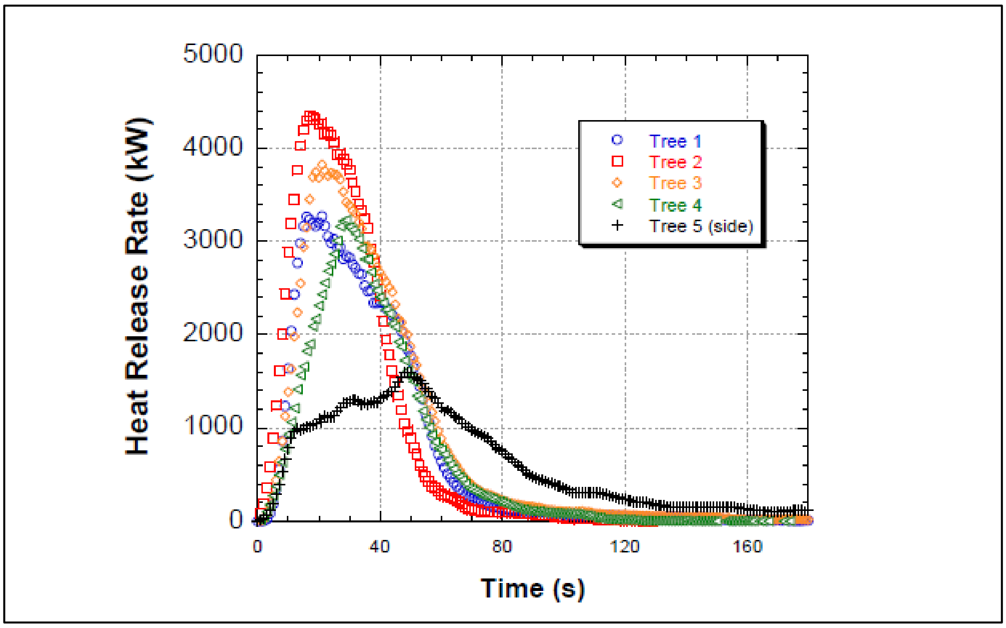
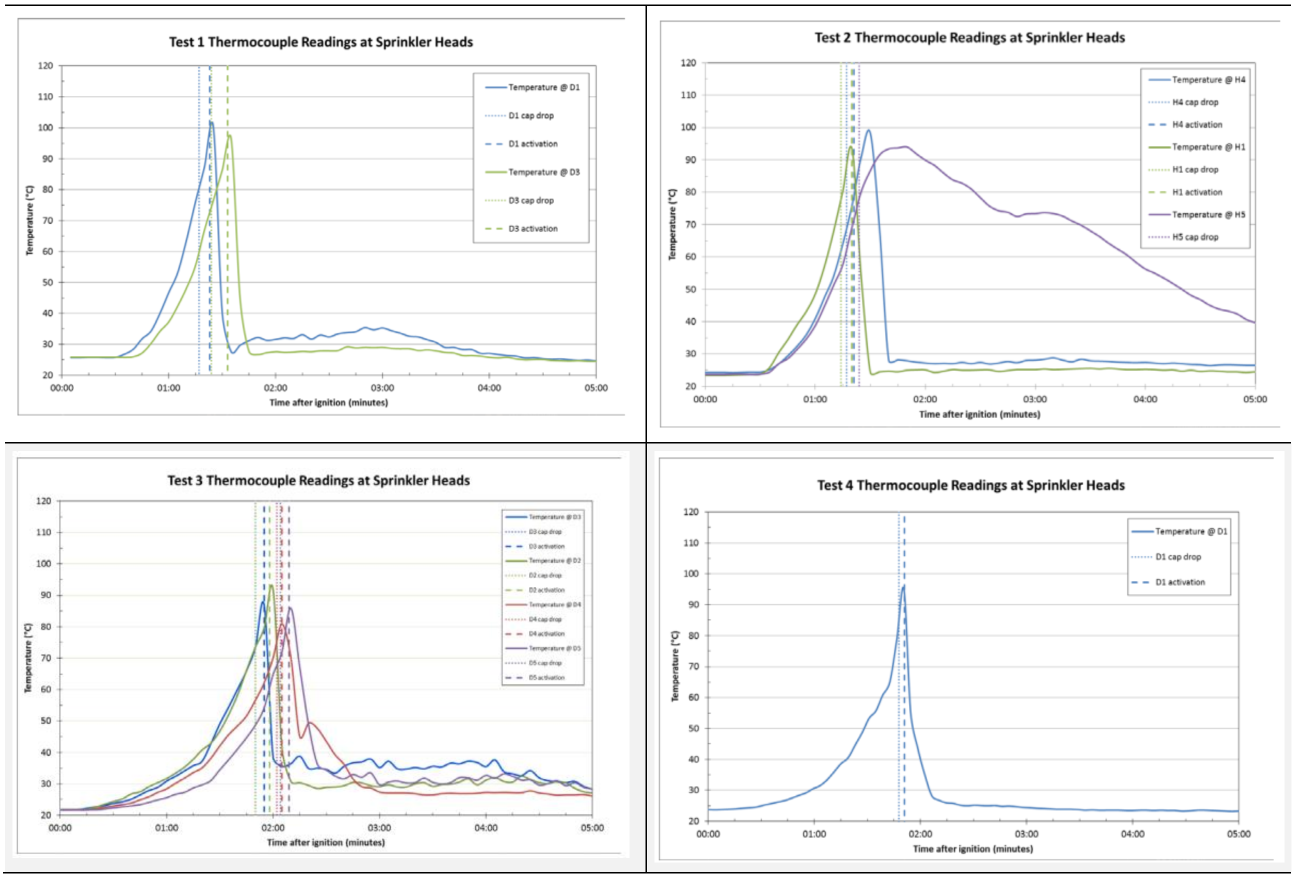
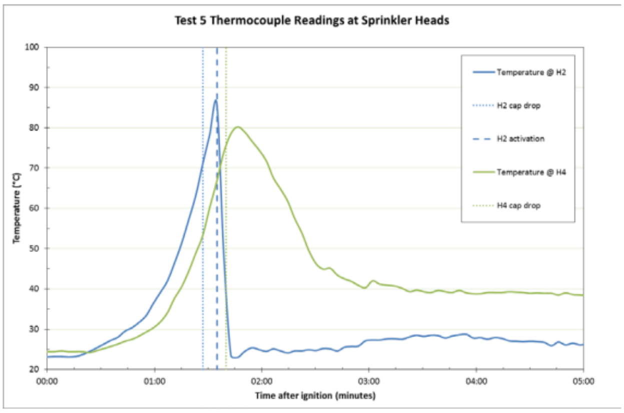
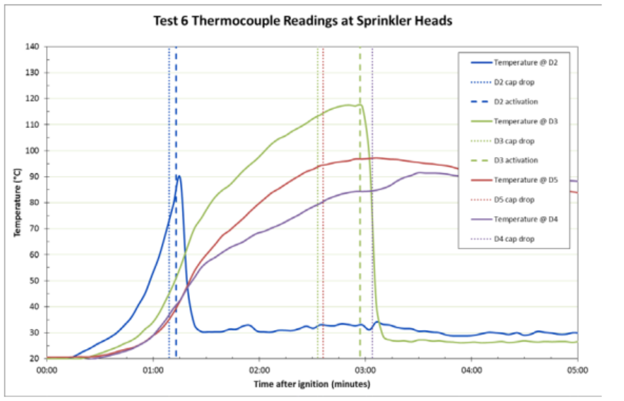


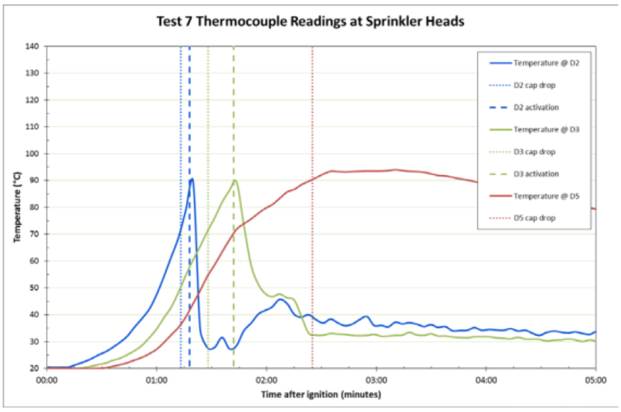
Figure D.9: Reduction in heat release rates with sprinkler activation (Madrzykowski, 2008)

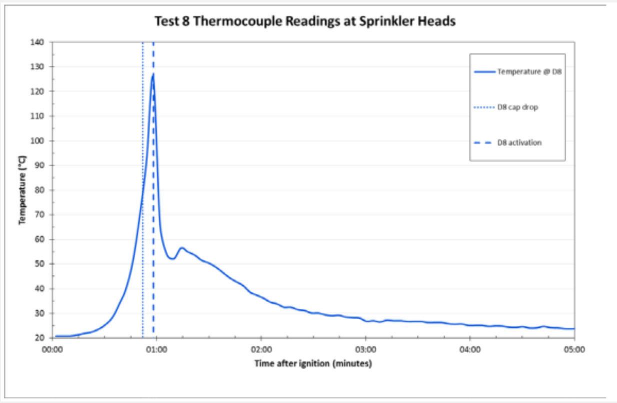
Based on the "Fire Research Report – Residential Sprinkler Research" (FRNSW, 2017), fourteen (14) tests were conducted to determine the reliability and effectiveness of automatic sprinkler systems within residential buildings of more than 25m in height. Out of the fourteen (14) tests, thirteen (13) tests were provided with sprinklers and the results have revealed a consistency in sprinkler activation times and temperature at the time of activation (Refer to Figure D.10). In relation to the effects of sprinklers on heat and atmospheric tenability, sprinklers had a significant effect on both aspects within the structure.

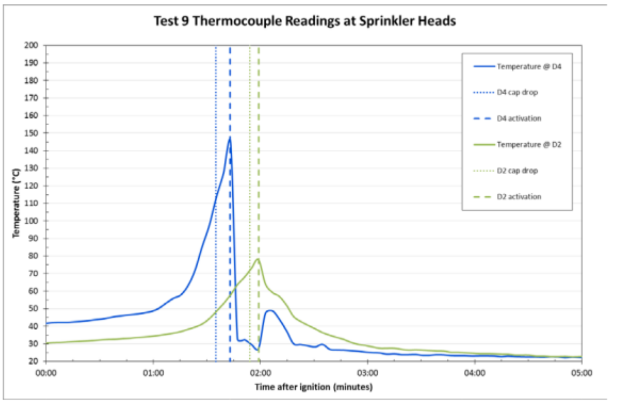


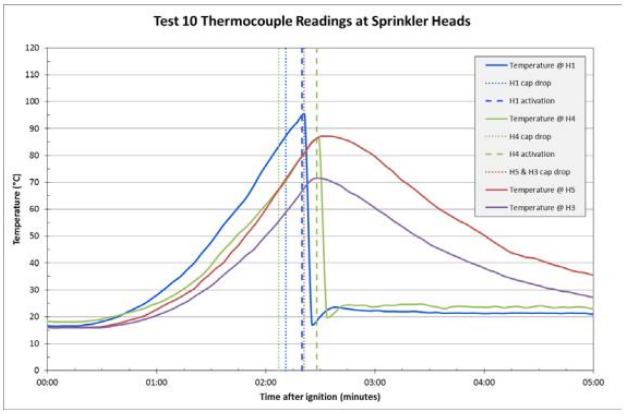

Test 5 Thermocouple Readings at Sprinkler Heads
Temperature (°C)
Time after ignition (minutes)
Temperature @ H2
H2 cap drop
H2 activation
Temperature @ H4
H4 cap drop

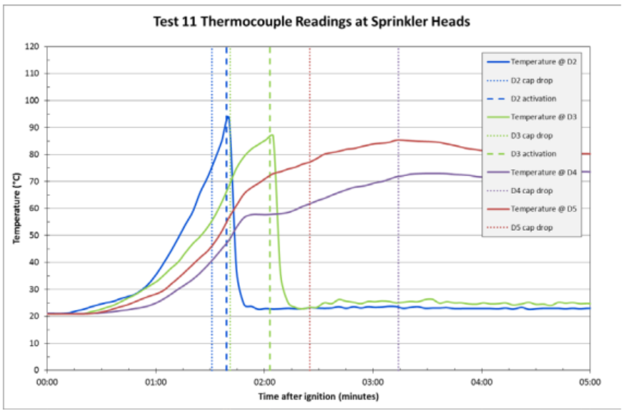

Test 6 Thermocouple Readings at Sprinkler Heads
Temperature (°C)
Time after ignition (minutes)
Temperature @ D2
D2 cap drop
D2 activation
Temperature @ D3
D3 cap drop
D3 activation
Temperature @ D5
D5 cap drop
Temperature @ D4
D4 cap drop

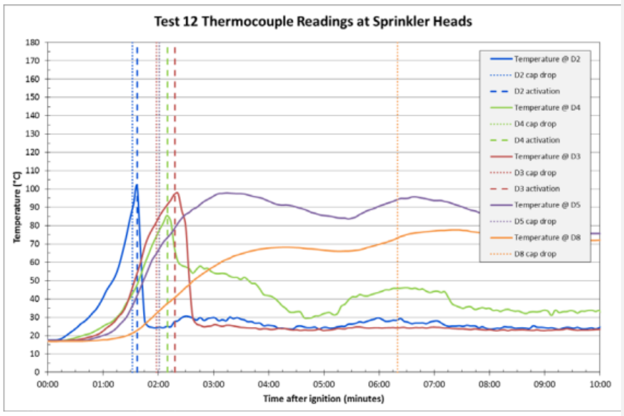

Test 7 Thermocouple Readings at Sprinkler Heads
Temperature (°C)
Time after ignition (minutes)
Temperature @ D2
D2 cap drop
D2 activation
Temperature @ D3
D3 cap drop
D3 activation
Temperature @ D5
D5 cap drop


Test 8 Thermocouple Readings at Sprinkler Heads
Temperature (°C)
Time after ignition (minutes)
Temperature @ D8
D8 cap drop
D8 activation


Test 9 Thermocouple Readings at Sprinkler Heads
Temperature (°C)
Time after ignition (minutes)
Temperature @ D4
D4 cap drop
D4 activation
Temperature @ D2
D2 cap drop
D2 activation


Test 10 Thermocouple Readings at Sprinkler Heads
Temperature (°C)
Time after ignition (minutes)
Temperature @ H1
H1 cap drop
H1 activation
Temperature @ H4
H4 cap drop
H4 activation
H5 & H3 cap drop
Temperature @ H5
Temperature @ H3


Test 11 Thermocouple Readings at Sprinkler Heads
Temperature (°C)
Time after ignition (minutes)
Temperature @ D2
D2 cap drop
D2 activation
Temperature @ D3
D3 cap drop
D3 activation
Temperature @ D4
D4 cap drop
Temperature @ D5
D5 cap drop


Test 12 Thermocouple Readings at Sprinkler Heads
Temperature (°C)
Time after ignition (minutes)
Temperature @ D2
D2 cap drop
D2 activation
Temperature @ D4
D4 cap drop
D4 activation
Temperature @ D3
D3 cap drop
D3 activation
Temperature @ D5
D5 cap drop
Temperature @ D8
D8 cap drop

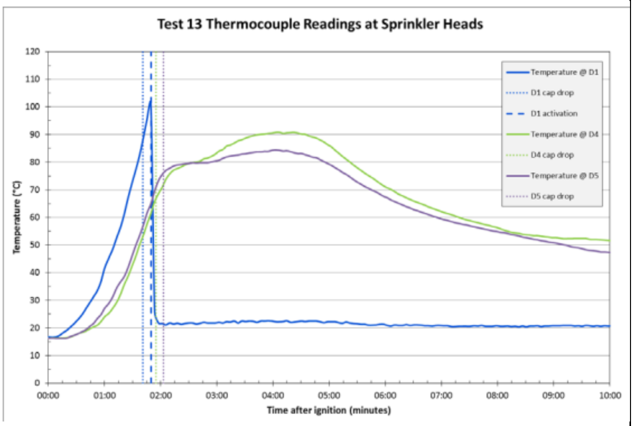


Figure D.10: Reduction in temperature with sprinkler activation (FRNSW, 2017)

It has come to a conclusion that sprinklers can maintain a lower compartment temperature as compared to a non-sprinkler protected compartment. Sprinkler activations had the effect of cooling conditions within the unit and preventing fire growth. Based on the abovementioned research data, it is clear that the activation of automatic fire sprinklers significantly improves the tenability of occupants in the event of a fire.

D.5 Conclusion

In conclusion, global data demonstrates that sprinkler systems are highly reliable especially in buildings where regular inspections and maintenance is conducted. Operational probabilities vary in US data but for majority of classifications remain above 90% (Aherns, 2017). The efficacy values show a similar trend.

Furthermore, once sprinklers activate the temperatures are expected to be reduced to approximately between 120°C and 100^{o}C within 60 seconds of the activation. The Heat Release Rate profiles also follow a similar downward trend upon activation of sprinklers.

Appendix E. Evacuation Modelling “Pathfinder”

E.1 General Overview

The movement (or the floor clearing times) is to be calculated using computer program Pathfinder. Pathfinder human movement simulation program is a validated and tested evacuation program. Pathfinder uses two primary options for occupant motion called SFPE mode and a steering mode. The SFPE mode implements the concepts in the SFPE Handbook of Fire Protection Engineering [Nelson and Mowrer, 2002]. 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. The pathfinder computer program adopts the methodologies and principles outlined and based on actual research that has been conducted (IMO-Evacuation Analyses for New and Existing Passenger Ships). Pathfinder uses an occupant profile system to manage distributions of parameters across groups of occupants. This system helps you control the occupant speed, size, and visual distributions.

The alternate method in Pathfinder is the steering mode which is based on the idea of inverse steering behaviours. Steering behaviours were first presented in Craig Reynolds' paper "Steering Behaviours For Autonomous Characters" [Reynolds, 1999] and later refined into inverse steering behaviours in a paper by Heni Ben Amor [Amor et. al., 2006]. Pathfinder's steering mode allows more complex behaviour to naturally emerge as a by-product of the movement algorithms - eliminating the need for explicit door queues and density calculations. It is noted that in this instance the SFPE mode was incorporated in the Pathfinder simulation.

Pathfinder is an agent-based egress simulator that uses steering behaviours to model occupant motion throughout evacuation. It consists of three modules:

- The graphical user interface: and
- The simulator; and
- The 3D results viewer.

In the Pathfinder evacuation modelling the occupants may be allocated profiles and behaviours. The profile defines characteristics of the occupants, such as speed, radius, avatar, and colour. The behaviour defines a sequence of actions the occupant will take throughout the simulation, such as moving to a refuge area, waiting or queuing at the exit, and then exiting.

Behaviours in Pathfinder represent a sequence of actions the occupant will take throughout the simulation. For each occupant behaviour in an evacuation model dedicated to agents there is an implicit action to move the occupant to an exit. This implicit action will always happen last. Additional intermediate actions may also be added in Pathfinder evacuation modelling can make the occupant wait or travel to a non-exit destination, such as a room or particular location on the floor plate. By default in the Pathfinder model the occupant behaviour is called “Go to Any Exit.” This behaviour type simply makes the occupant move from their starting position to any exit present in the model by the fastest route.

The SFPE mode uses the set of assumptions presented in the SFPE Handbook of Fire Protection Engineering and generally gives answers similar to hand calculations, depending on or if selected assumptions have been applied in the model. In SFPE simulations, the mechanism that controls simulation movement is the door queue, as queuing generally governs occupant evacuation. The Steering mode is more dependent on collision avoidance and occupant interaction for the final answer and often gives answers more similar to experimental data than the SFPE mode.

All occupants in Pathfinder use individual (or agent based) decision making algorithms. The model is a PC-based computer program capable of simulating the evacuation of large numbers of people through geometrically complex buildings.

Verification and Validation of the Pathfinder program have been documented by Thunderhead Engineering and Rolf Jensen & Associates Fire Protection Consultants (Document no: Pathfinder 2009.1.0417, Document Title: Verification and Validation). The aforementioned document has conducted the following:

- Verification tests: Synthetic test cases designed to ensure that the simulator is performing as specified by the Pathfinder Technical Reference. Usually these tests attempt to isolate specific simulated quantities or behaviours and may include only a small number of occupants. This type of test often has very specific pass/fail criteria. Verification tests ensure that the software is implements a particular model correctly –they are not designed to measure how accurately that model reflects reality.
  - The document has documented eleven (11) IMO (International Maritime Organization) Tests which have demonstrated satisfactory results. These tests are listed below:
    - Movement speed, and
    - Stairway speed (Up), and

- Stairway speed (Down), and
- Door flow rates, and
- Initial delay times, and
- Concave geometry (Boundaries), and
- Multiple movement speeds, and
- Counter flow, and
- Sensitivity to available doors, and
- Exit assignments, and
- Congestions.

- Validation tests – Designed to measure how well Pathfinder's implementation of simulation models captures real behaviour. Usually these tests will explore the interaction between multiple simulations elements and may have less specific pass/fail criteria. Validation tests are usually based on experimental data or experience.
- Comparisons – Pathfinder results alongside the results of other simulators. These tests are design to give the reader a sense of where Pathfinder "fits in" relative to other simulation software.

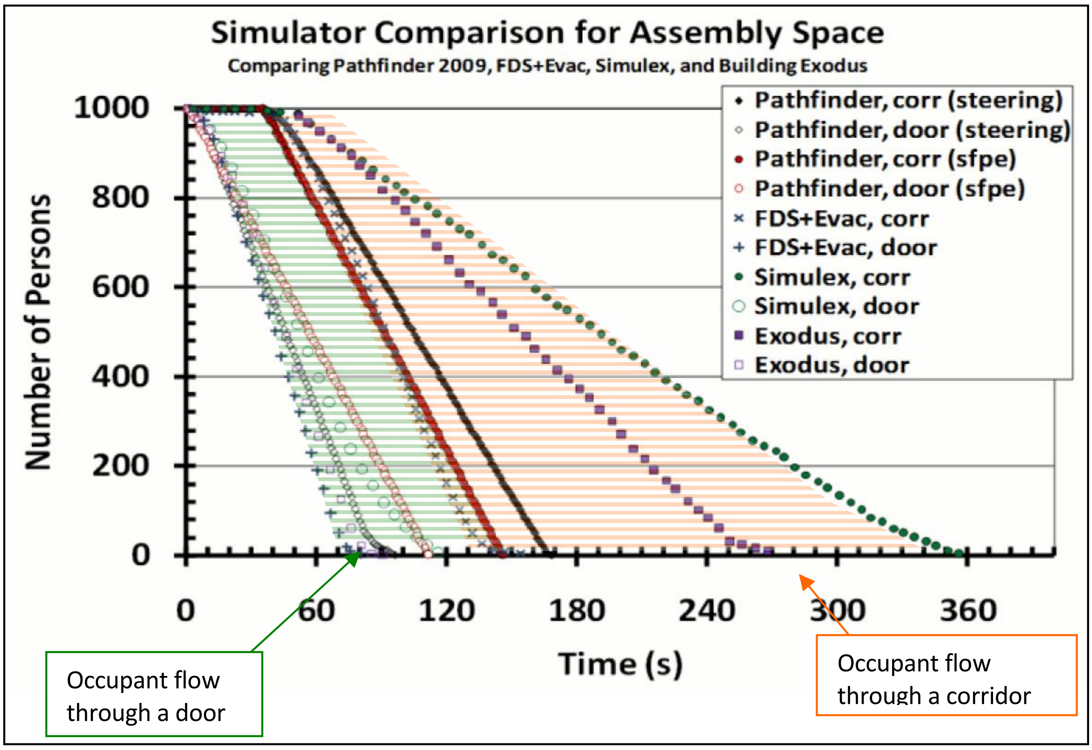


Figure E.1: Occupant movement simulator comparisons between different software.

E.2 Summary of Pathfinder Input Parameters

Project Details	
Model / Program Details	
Name	Pathfinder
Version	2016.1.0229 x64
Simulation Parameters	
Behaviour mode	Steering
Collision handling	Yes
Inertia	Yes
Geometry Parameters	
Floor layout	As per architectural drawings
Exit locations	As per architectural drawings
Number of storeys	4

Stairs	Yes
Occupant distribution	Evenly distributed throughout.
Number of occupants	In accordance with Section 2.2 of this report.
Occupant Parameters	
Occupant movement speed	0.9m/s
Occupant shoulder width	55 cm
Occupant height	1.8m
Alarm Delay time	Included in each evacuation scenario.
Pre-movement time	Included in each evacuation scenario.

E.3 Occupant Shoulder Width Justification

The studies conducted by Fruin et al (2007) have determined that an average male person's shoulder width is approximately 500-600 mm as indicated in Figure E.2. This is further supported by the NFPA 101B Annex A which presents selected anthropometric data for adults. The information provided in Annex A states that for an average person the static width is in the order of 508mm (20inch) which is similar to the results obtained by Fruin. Therefore, an occupant width of 500mm 600mm has been implemented into the Pathfinder software.

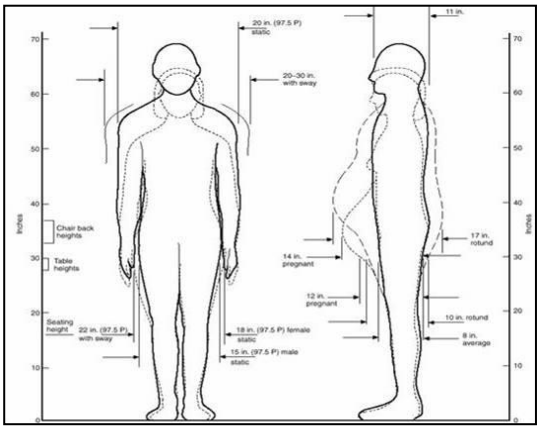


Figure E.2: Average shoulder widths of adults

E.4 Occupant Risk Contour Approach

The risk contour approach is the concept methodology (Horasan, Kilmartin 2009) which has been adopted in this instance for the evacuation modelling. This concept has also been adopted and reflected by the New Zealand Department of Building and Housing as part of the Building Codes in the document titled "C/VM2 Verification Method: Framework for Fire Safety Design For New Zealand Building Code Clauses C1-C6 Protection from Fire".

It is important to highlight that the evacuation modelling forming part of the overall Life Safety Analysis was performed utilising the 'Pathfinder' computer software program. The 'Pathfinder' computer software program was used to compute the cumulative time for both **pre-movement and movement times**. Verification and Validation of the Pathfinder program has been documented by Thunderhead Engineering and Rolf Jensen & Associates Fire Protection Consultants.

Appendix F. Movement Speeds for Evacuation Calculations

The travel time during an evacuation process is governed by the movement speed of occupants or queuing at potential bottlenecks such as at a fire-isolated stair. As a conservative approach travel distance is considered to govern the movement speed which would not necessarily be the case where maximum occupant loading is present within an enclosure.

Travel time of an occupant to a place of safety is generally the most predictable and typically is the smallest time involved. Travel speeds recommended by the SFPE Handbook of Fire Protection Engineering (5th Edition, 2017) for a corridor or an aisle is 1.19 m/s. For persons with limited mobility, i.e. a person on crutches, travel speeds as high as 0.94m/s are recommended (Ramachandran & Charters, Quantitative Risk Assessment in Fire Safety, 2011). This correlates well with studies conducted by various researchers detailed in 'Egress Design Solutions' (Lord et al, 2005 & Fahy et al 2001) and Kuligowski (2005) which have established occupant walking speeds for different occupant groups and/or disability and the corresponding travel speeds are provided in Table F.1.

Table F.1: Horizontal walking speeds for varying occupant groups (Egress Design Solutions, 2007 and Kuligowski, 2005).

Occupant Group	Walking Speed
Children (0-6 years old)	0.4 m/s
Children (7-12 years old)	0.8m/s
Male (13-69 years old)	1.2 m/s
Female (13-69 years old)	1.0 m/s
70+ years old	0.8 m/s
Mobility impaired	0.5 m/s

For a particular building it is difficult to determine the exact distribution /percentage of occupant groups. However, the following percentage distribution of occupant groups have been based on the Australian Census Data (2017) with respect to occupant age and gender.

- Children (0-6 years old) = 9%
  (a) Children (7-12 years old) = 8%
- Male (13-69 years old) = 36%
  (b) Female (13-69 years old) = 37%
- Adults (70+ years old) = 10%

Furthermore, the percentage of population having some level of mobility impairment, based on the data provided by the Australian Network on Disability, is estimated to be 20%. It should be noted that this is a conservative assumption as it includes all forms of disabilities including some which may not have any impact on movement capability of a person such as a hearing impairment. Based on the above percentages of occupant groups and occupant movement speeds detailed in Table F.1., the weighted average occupant horizontal travel speeds have been calculated and tabulated in Table F.2.

Table F.2: Weighted average of horizontal walking speeds for varying occupant groups

Occupant Group	% Base Population	% Mobility Impairment Adjusted Population (A)	Avg. Walking Speed (B)	Weighted Average Occupant Travel Speed (A x B)
Children (0-6 years old)	9 %	8 %	0.4 m/s	0.032
Children (7-12 years old)	8 %	7 %	0.8m/s	0.056
Male (13-69 years old)	36 %	30%	1.2 m/s	0.36
Female (13-69 years old)	37%	30 %	1.0 m/s	0.30
70+	10%	5 %	0.8 m/s	0.04
Mobility impaired	-	20 %	0.5 m/s	0.1
Average weighted horizontal movement speed for the whole spectrum of occupants based on age, gender and physical ability.				***0.9m/s***

Based on the likely characteristics of the occupants, the geometry of the building and the proposed egress provisions, the occupants would be expected to traverse at their normal walking speed to the subject exit locations. According to the above literature, the movement speed of 0.9m/s is considered conservative when considering the average movement speeds. Also, the breakdown may be reflective of a generic occupancy with the typical occupancy distribution with respect to age and disability, but, for occupancy classifications such as commercial or industrial, majority of the occupants are likely to be from the occupant groups with the fastest average walking speeds.

Travel speed is a function of occupant movement density. A speed of 0.9 m/s reflects a density of 1.5 persons per square meter (or 3 persons per 2 meter squares) which is a realistic assumption for residential, office and retail occupancies (refer to Figure F.1). For different occupancies such as sports venues higher densities and slower travel speeds may be adopted. On the other hand, for occupancies such as carparks lower densities and higher speeds may be adopted as per Figure F.1.

The software adopted for the purposes of modelling (i.e. Pathfinder, or Wayout) adjusts the travel speeds for stairway ascends and descents. Where manual input is required a an average constant ascend/descent speed of 0.6 may be adopted or the speed may be based on Figure F.1.

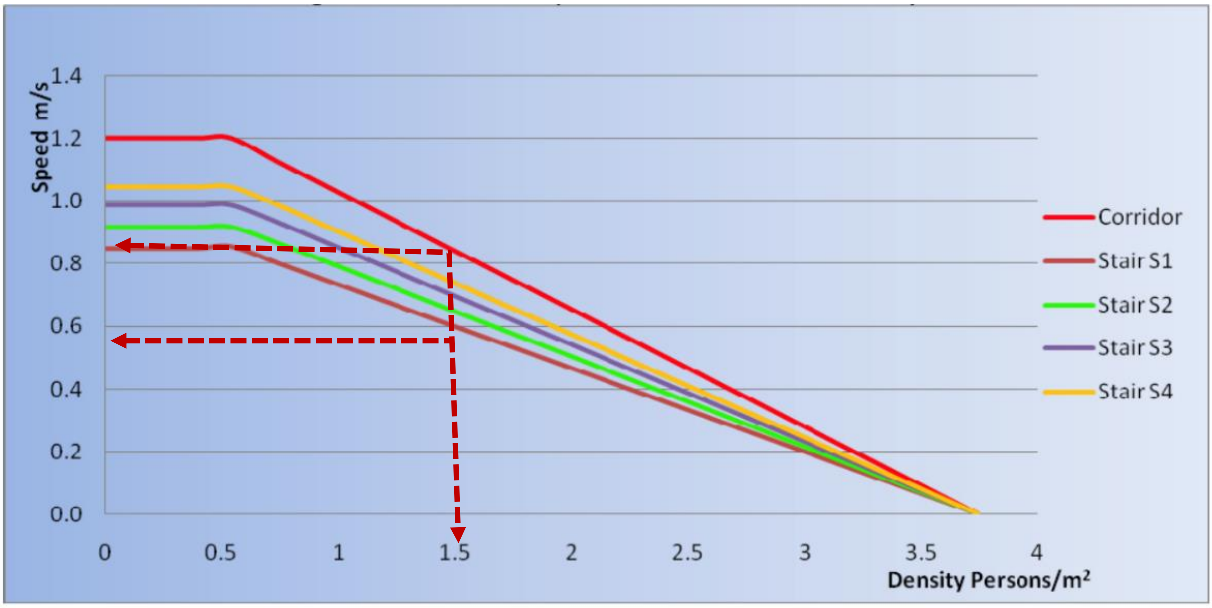


Figure F.1: Travel speeds based on occupant travel densities (Ref: "Fire safety engineering concerning evacuation from buildings"; CFPA-E Guideline No 19:2009 F; The Confederation of Fire Protection Associations in Europe)

Research studies have taken into consideration groups of grown-up people without any physical disabilities (not real situation). Specific estimations have been done considering disabled people. They have confirmed individual walking speed variability. Literature may give experimental examples on walking speed estimations. For occupants with mobility limitations SFPE Handbook recommends varying travel speeds as shown in Figure F.2 and Figure F.3. Based on the type of disability expected, travel speeds can be adopted from these sources.

Speed on horizontal surface				
Subject Group	Mean	Standard deviation	Range	Interquartile range
All disabled	1,00	0,42	0,10-1,77	0,71-1,28
With locomotion disabilities	0,80	0,32	0,24-1,68	0,57-1,02
No aid	0,95	0,32	0,24-0,1,68	0,70-1,02
Crutches	0,94	0,30	0,63-1,35	0,67-1,24
Walking sticks	0,81	0,38	0,26-1,60	0,49-1,08
Rollator	0,57	0,29	0,10-1,02	0,34-0,83
No locomotion disability	1,25	0,32	0,82-1,77	1.05-1,34
Electric wheelchair	0,89	-	0,85-1,77	-
Manual wheelchair	0,69	0,35	0,13-1,35	0,38-0,94
Manual wheelchair	0,36	0,14	0,11-0,70	0,20-0,47
Assisted manual wheelchair	1,30	0,94	0,84-1,98	1,02-1,59
Assisted ambulant	0,78	0,34	0,21-1,40	0,58-0,92

Source: Table 3-13.2 from Section 3, Chapter 13: "Movement Of People: The Evacuation Timing", The SFPE Handbook of Fire Protection Engineering, 3rd Edition, NFPA Inc., Quincy, Massachusetts, 2002

Figure F.2: Travel speeds for occupants with disabilities on horizontal surfaces.

Speed on stairs				
Subject Group	**Mean**	**Standard deviation**	**Range**	**Interquartile range**
Ascent				
With locomotion disabilities	0,38	0,14	0,13-0,62	0,26-0,52
No aid	0,43	0,13	0,14-0,62	0,35-0,55
Crutches	0,22	-	0,19-0,31	0,26-0,45
Walking stick	0,35	0,11	0,18-0,49	-
Rollator	0,14			
Without disabilities	0,70	0,24	0,55-0,82	0,55-0,78
Descendent				
With locomotion disabilities	0,33	0,16	0,11-0,70	0,22-0,45
No aid	0,36	0,14	0,11-0,70	0,20-0,47
Crutches	0,22	-	-	-
Walking stick	0,32	0,12	0,11-0,49	0,24-0,46
Rollator	0,16	-	-	-
Without disabilities	0,70	0,26	0,45-1,10	0,53-0,90

Source: Table 3-13.3 from Section 3, Chapter 13: "Movement Of People: The Evacuation Timing", The SFPE Handbook of Fire Protection Engineering, 3rd Edition, NFPA Inc., Quincy, Massachusetts, 2002

Figure F.3: Travel speeds for occupants with disabilities on stairs

References:

SFPE Handbook of Fire Protection Engineering (5th Edition, 2017)

Ramachandran & Charters, *Quantitative Risk Assessment in Fire Safety*, 2011

Egress Design Solutions' (Lord et al, 2005 & Fahy et al 2001)

Appendix G. Eurocode Parametric Fire

G.1 Methodology

G.1.1 Equation adopted for Quantitative Analysis

The quantitative assessment shall adopt the Eurocode Parametric Fire calculation in accordance with the empirical expression adopted by the Eurocode (EN 1991-1-2 (2002)) to determine temperature-time curves for fire compartments up to 500m^2 of the floor area, without openings in the roof and for a maximum compartment height of 4m. The fire load of the compartment is also assumed to be completely burnt out.

The temperature-time curves are divided into two (2) phases, which are the heating phase and the cooling phase.

The determination of the parametric temperature-time curve based on the equations and method above in accordance with the Eurocode (EN 1991-1-2 (2002)) shall be further assessed in the subsequent FSER.

G.1.1.1 Heating Phase

The temperature-time curve in the heating phase equation is as fo–lows:

$$\Theta_g = 20 + 1325\,(1 - 0.324e^{-0.2t^*} - 0.204e^{-1.7t^*} - 0.472e^{-19t^*}) \qquad \text{Eq (1)}$$

Where:

Θ_g	is the gas temperature in the fire compartment	[°C]
t*	t . Γ	[h]
with		
t	time	[h]
Γ	= $[O/b]^2 / (0.041/1160)^2$	[-]
b	= $\sqrt{(\rho c \lambda)}$	
	With the following limits: 100 <= b <= 2200	[$J/m^2s^{0.5}K$]
ρ	density of boundary of enclosure	[kg/m^3]
c	specific heat of boundary of enclosure	[J/kg.K]
λ	thermal conductivity of boundary of enclosure	[W/mK]
O	opening factor: $A_v\sqrt{h_{eq}}/A_f$	[$m^{0.5}$]
	With the following limits 0.02 <= O <= 0.20	
A_f	total area of vertical openings on all walls	[m^2]
h_{eq}	weighted average of window heights on all walls	[m]
A_t	total area of enclosure (walls, ceiling and floor, including openings)	[m^2]

For calculation of the b factor, the density ρ, the specific heat c and the thermal conductivity λ of the boundary may be taken at ambient temperature.

To account for an enclosure surface with different layers of material , b = $\sqrt{(\rho c \lambda)}$ should be introduced as:

If $b_1 < b_2$, $b = b_1$

If $b_1 > b_2$, a limit thickness s_{lim} is calculated for the exposed material according to:

$$S_{lim} = \sqrt{(3600\, t_{max}\, \lambda_1)/(c_1\, \rho_1)} \text{ with } t_{max}$$

If $S_1 > S_{lim}$ then $b = b_1$

If $S_1 < S_{lim}$ then $b = (S_1/S_{lim})b_1 + (1 - S_1/S_{lim})b_2$

Where:

S_1 il the thickness ol layer i

B_i √ ρici λi

ρ_i is the density of the layer i

C_i is the specific heat of the layer i

λ_i is the thermal conductivity of the layer i

To account for different b factors in walls, ceiling and floor, b = $\sqrt{(\rho c \lambda)}$ should be introduced as:

$$b = (\Sigma(b_j A_j))/(A_t - A_v)$$

where:

Aj is the area of enclosure surface j, openings not included

b_j is the thermal property of enclosure surface j

The maximum temperature Θ_{max} in the heating phase happens for $t^* = t^*_{max}$

$t^*_{max} = t_{max} . \Gamma$

with $t_{max} = \max [(0.2*10^{-3}*q_{t,d} / O); t_{lim}]$

Where:

$q_{t,d}$ is the design value of the fire load density related to the total surface area A_t of the enclosure whereby $q_{t,d} = q_{f,d} . A_f / A_t$ [MJ/m^2]. The following limits should be observed: $50 <= q_{t,d} <= 1000$ [MJ/m^2]

$q_{f,d}$ is the design value of the fire load density related to the surface area A_f of the floor [MJ/m^2]

Note: The time t_{max} corresponding to the maximum temperature is given by t_{lim} in case the fire is fuel controlled. If t_{lim} is given by $(0.2 * 10^{-3} * q_{t,d} / O)$, the fire is ventilation controlled.

When $t^* = t . \Gamma_{lim}$

With $\Gamma_{lim} = [O_{lim}/b]^2 / (0.04/1160)^2$

Where $O_{lim} = 0.1 * 10^{-3} * q_{t,d} / t_{lim}$

If (O>0.04 and $q_{t,d}$ < 75 and b < 1160), Γ_{lim} has to be multiplied by k given by:

$$k = 1 + \left(\frac{O-0.04}{0.04}\right)\left(\frac{qt,d-75}{75}\right)\left(\frac{1160-b}{1160}\right)$$

Note: In case of slow fire growth rate, t_{lim} = 25 min; in case of medium fire growth rate, t_{lim} = 20 min; in case of fast fire growth rate, t_{lim} = 15 min

G.1.1.2 Cooling Phase

The following equations are utilised to plot temperature-time curves in the cooling phase:

$\Theta_g = \Theta_{max} - 625\ (t^* - t^*_{max} . x)$ for $t^*_{max} <= 0.5$

$\Theta_g = \Theta_{max} - 250\ (3 - t^*_{max})(t^* - t^*_{max} . x)$ for $0.5 < t^*_{max} < 2$

$\Theta_g = \Theta_{max} - 250\ (t^* - t^*_{max} . x)$ for $t^*_{max} >= 2$

G.1.2 The Input Parameters

As detailed in Fire Safety Challenges of Tall Wood Buildings – Phase 2: Task 4 – Engineering Methods by (Brandon et.al 2018), the following parameters are considered when performing the parametric temperature-time curve:

- Compartment internal dimensions; and
- Ventilation opening; and
- Fire growth rate; and
- Fuel load density excluding CLT (i.e. fuel load within the compartment); and
- Exposed CLT surface; and
- Gypsum board protection

In order to determine the parametric temperature-time curve contributed by CLT, parameters corresponding to a compartment in which the CLT **does not** contribute must first be calculated. The contribution of CLT will be included using an iterative procedure. The calculation determined in table corresponds to the 1st iteration.

Step	Parameter	Equation and Notes
12.	Opening factor	$O = (A_v/A_t)\sqrt{h_v}$
13.	Heating rate factor	$\Gamma = [O/b]^2 / (0.041/1160)^2$ Where $b = \sqrt{(\rho c \lambda)}$
14.	Start time of decay (1st iteration)	$t_{max} = \max[(0.2*10^{-3}q_{t,d}/O);t_{lim}]$ Note that $q_{t,d}$ is the fuel load divided by the total surface area of the compartment boundaries, which is not equal to the fuel load density
15.	Initial charring rate	$B_{par} = 1.5B_0 \frac{0.2\sqrt{\Gamma}-0.04}{0.16\sqrt{\Gamma}+0.08}$
16.	Time at which char rate reduces	$t_0 = 0.009(q_{t,d}/O)$
17.	Final char depth (1st iteration)	$D_{char} = 2\beta_{par}t_0$

In order to determine the contribution of timber to the fuel load, the charring rate and resultant depth of the timber member shall be calculated under a parametric fire. The Eurocode 5 Annexe A method assumes that the charring proceeds at the initial rate β_{par} for a time t_0 (initial char time) then reduces linearly to zero over subsequent time periods of $2t_0$ so that the total depth of char at the end of the exposure (time $3t_0$) is as shown below.

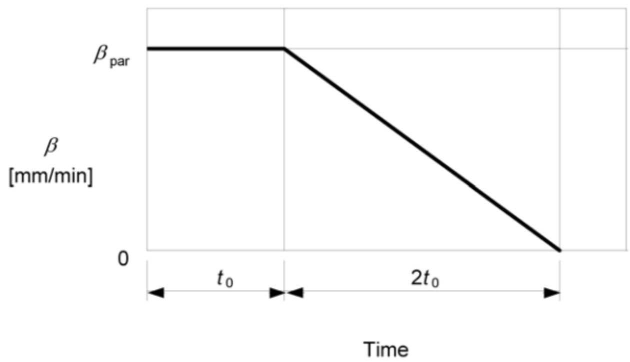


Figure A1 — Relationship between charring rate and time

At time $t=t_0$ the charring starts to reduce linearly until time $t=3t_0$. To calculate t_0 the following equation is adopted.

$$t_0 = 0{,}009\,\frac{q_{t,d}}{O}$$

Where

$q_{t,d}$ is the time period with a constant cing rate, in minutes;

- O is the design fire load density related to the total area of floors, walls and ceilings which enclose the fire compartment in MJ/m^2

From this the charring depth at any moment can be calculated using the equation highlighted below.

$$d_{char} = \begin{cases} \beta_{par}t & \text{for } t \le t_0 \\ \beta_{par}\left(1{,}5t_0 - \frac{t^2}{4t_0} - \frac{t_0}{4}\right) & \text{for } t_0 \le t \le 3t_0 \\ 2\beta_{par}t_0 & \text{for } 3t_0 \le t \le 5t_0 \end{cases}$$

To calculate the initial rate β_{par} for a time t_0 the following equation can be utilised

$$\beta_{par} = 1{,}5\,\beta_n\,\frac{0{,}2\sqrt{\Gamma}-0{,}04}{0{,}16\sqrt{\Gamma}+0{,}08}$$

β_{par} is the initial charring rate, in mm/min;

β_n is the notional design charring rate, in mm/min;

Γ is a factor accounting for the thermal properties of the boundaries of the compartment;

Once the 1st iteration is performed, the following iterations can be performed. Table D.2 shows the steps to perform the iterations involving the contribution of CLT. The calculation can be stopped once the resulting char depths of the iterations converge. According to the calculations, it is noted that the fire would be continuously developing if the resulting char depth does not converge.

Step	Parameter	Equation and Notes
18.	Total fuel load divided by the surface area of comp. boundaries	$q_{td}^{\,i+1} = q_{mfl} + ((A_{CLT} \,.\, \alpha_1 \,.\, (d^{i}_{char} - 0.7\ B_{par}t^{1}_{max})/A_c)$ Note: t^{1}_{max} does not change in different iterations
19.	Start time of decay (1st iteration)	$t_{max}^{\,i+1} = \max\,[(0.2{*}10^{-3}q^{i+1}_{t,d}/O);\ t_{lim}]$ Note that $q_{t,d}$ is the fuel load divided by the total surface area of the compartment boundaries, which is not equal to the fuel load density
20.	Time at which char rate reduces	$t_0^{i+1} = 0.009\ (q^{i+1}_{t,d}/O)$
21.	Final char depth (1st – ith iteration)	$d^{i+1}_{char} = 2\beta_{par}t_o^{i+1}$

Once the results converge through iterations, the temperatures in the fully developed phase can be calculated using the following equations:

$\Theta = \Theta_{max} - 625(t.\ \Gamma - t_{max}.\ \Gamma.x)$ if $t_{max}.\ \Gamma <= 0.5$

$\Theta = \Theta_{max} - 250(3 - t_{max}.\ \Gamma.x)(\ t.\ \Gamma - t_{max}.\ \Gamma.x)$ if $0.5 < t_{max}.\ \Gamma < 2$

$\Theta = \Theta_{max} - (\ t.\ \Gamma - t_{max}.\ \Gamma.x)$ if $t_{max}.\ \Gamma >= 2$

$x = 1.0$ if $t_{max} > t_{lim}$ **OR** $x = t_{lim}\ \Gamma/t_{max}\ \Gamma$ if $t_{max} = t_{lim}$

Appendix H. Radiant Heat Transfer Methodology

H.1 Radiant Heat Flux Equation

The radiant heat flux, Q (W/m^2) from a single opening of a burning building to a point some distance away is determined by the black body emission equation as shown in the following equation. (ABCB, FSEG, 2001).

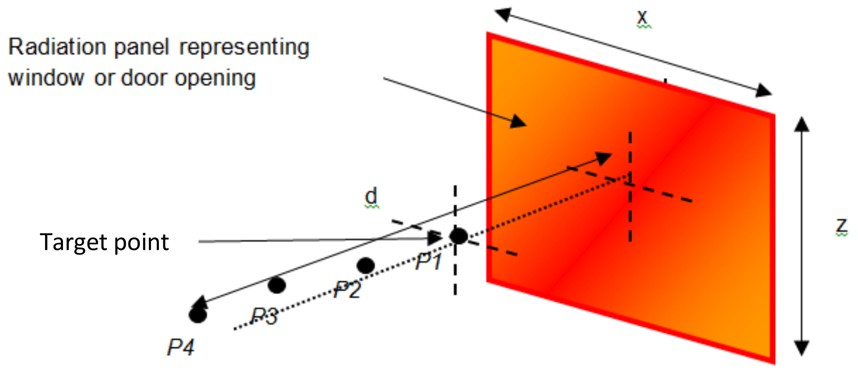


Figure H.1: Radiant heat transfer for calculating incident heat flux

$$Q = \varepsilon \sigma F T^4$$

where,

ε = emissivity = 0.9

σ = Stephan-Boltzmann constant = 5.67x10^{-8} W/m^{2}K^4

T = temperature of emitting surface = 1173 K (900°C) - angle of 90° and 0° for non-sprinkler protected building

F = configuration (view) factor

Each variable in the equation is explained in the following sections.

H.1.1 Estimation of Emissivity (ε)

Based on Drysdale (1999), the emissivity levels for different materials are tabulated. It is noted that for reflective surfaces such as polished steel, the emissivity levels are low due to radiant heat being reflected away. For the purpose of the assessment, it is proposed to adopt the worst-case scenario whereby the emissivity of sheet steel with rough oxide layer is **0.9** (i.e. absorbing 90% of the radiant heat).

Table H.1: Emissivity levels based on Drysdale (1999)

Surface	Emissivity
Steel (polished)	0.066
Mild Steel	0.2-0.3
Sheet steel with rough oxide layer	0.8-0.9
Fire brick	0.75
Concrete tiles	0.63

H.1.2 The Stefan–Boltzmann Constant (σ)

The Stefan–Boltzmann constant is the constant of proportionality in the Stefan–Boltzmann law: "the total intensity (physics) radiated over all wavelengths increases as the temperature increases". The Stefan-Boltzmann constant can be used to measure the amount of heat that is emitted by a blackbody, which absorbs all of the radiant energy that hits it, and will emit all the radiant energy. The value of the Stefan–Boltzmann constant is given in SI units by:

σ = 5.67x10^{-8} W/m^{2}K^4

H.1.3 Estimation of Flame Temperatures (T)

Alam and Beever (1996) states that an average surface temperature of 800°C is considered to exist as a result of flames from a fire emerging from open windows and/or doors.

However, as the windows are perpendicular to the building the glass must be broken and hence the flames must be external from the subject buildings. Therefore, the temperature of the radiating notional panel is significantly reduced as a result of the hot turbulent gases of the fire mixing with the cooler external air. As the flame projects from the window, 70% of the heat is convective and 30% is radiant (Klote and Milke 2003). The convection involves the rapid rise and turbulence of hot gases as they come into contact and mix with cool air. The turbulence cools the flame from some 900°C to 600°C as advised by Buchanan (2001). Similarly, studies and fire tests undertaken by Welch et al (2007) have demonstrated that external flame temperatures vary between 800°C to 400°C due to the direction and intensity of air movement passing though the external wall of the building.

A section through a flame showing that most of the flame has temperatures in the vicinity of 600°C is given. As a conservative approach a temperature of **900°C** has been adopted for the calculations for openings located within close proximity to the title boundary.

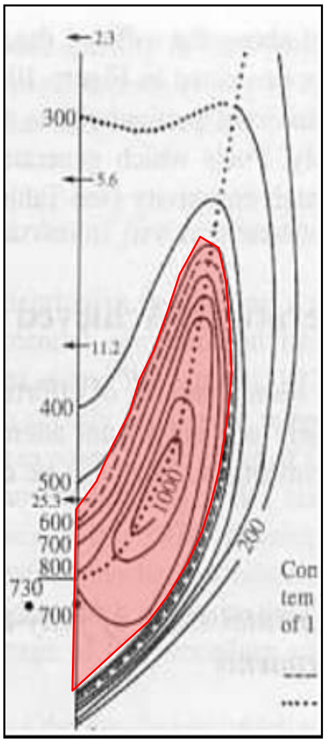


Figure H.2: Isotherms in flame projecting from a window (Drysdale, 1999)

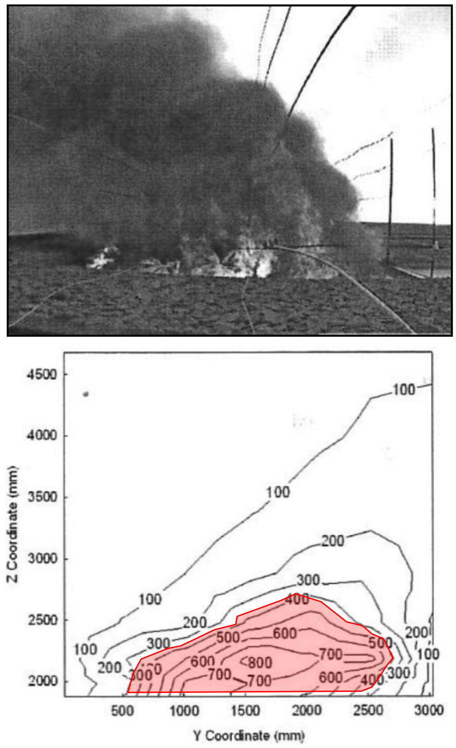


Figure H.3: External temperature contours (Welch et al., 2007)

H.1.4 Configuration / View Factor (F or Φ)

In radiative heat transfer, a view factor, F is the proportion of the radiation which leaves surface A that strikes surface B. View factors are also sometimes known as configuration factors, form factors or shape factors. To determine the intensity of radiation received by a surface remote from an emitter, a configuration factor is needed to take into account the geometrical relationship between the emitting surface and the receiver.

An approximate value of the configuration factor for radiation at a distance R from a rectangular radiator is given by the following equation:

$\Phi = A_v / \pi R^2$

Where $A_v = W_r H_r$ is the area of the radiating surface and R is the radiation distance between the emitting and receiving surfaces (m). The exact value of configuration factor is given by:

$$\Phi = \frac{1}{90}\left(\frac{x}{\sqrt{1+x^2}}\tan^{-1}\left(\frac{y}{\sqrt{1+x^2}}\right) + \frac{y}{\sqrt{1+y^2}}\tan^{-1}\left(\frac{x}{\sqrt{1+y^2}}\right)\right)$$

where $x = H_r/2R$

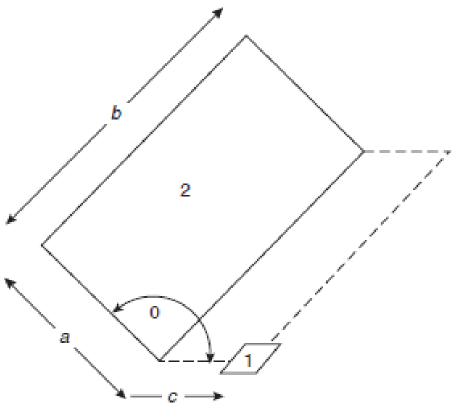
$y = W_r/2R$

H_r is the height of enclosing rectangle (m)

W_r is the width of enclosing rectangle (m)

$\tan^{-1}$ is the inverse tangent (in degrees).

For surfaces at an angle the following equation is adopted (Note $F_{12} = \Phi$):



$$F_{12} = \frac{1}{2\pi}\left\{\begin{array}{l}\tan^{-1}\left(\frac{1}{L}\right) + V(N\cos\phi - \phi L)\tan^{-1} V \\ + \frac{\cos\phi}{W}\left[\tan^{-1}\left(\frac{N - L\cos\phi}{W}\right) + \tan^{-1}\left(\frac{L\cos\phi}{W}\right)\right]\end{array}\right\}$$

$$V = \frac{1}{\sqrt{N^2 + L^2 - 2NL\cos\phi}}$$

$$W = \sqrt{1 + L^2\sin^2\phi}$$

$$N = \frac{a}{b}$$

$$L = \frac{c}{b}$$

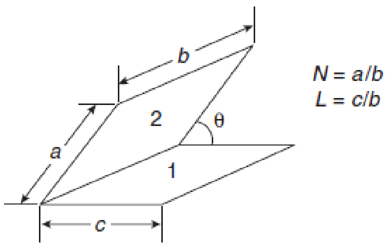


Figure H.4: Equation for determining surface at an angle

Appendix I. Structural Fire Design Advice

TTW Structural Civil Traffic Façade

TENDER

STRUCTURAL SPECIFICATIONS

WSU Indigenous Centre of Excellence

Victoria Road, Rydalmere NSW 2116

Western Sydney University / 25 October 2024

234338

TTW (NSW) PTY LTD (ACN 649 974 112) (ABN 74 649 974 112) I Consulting Engineers
Level 6, 73 Miller Street, North Sydney NSW 2060

TTW (ACT) PTY LTD (ACN 649 973 482) (ABN 12 649 973 482) I Consulting Engineers
Level 5, 224 Bunda St Canberra City ACT 2601

TTW (VIC) PTY LTD (ACN 649 973 848) (ABN 84 649 973 848) Consulting Engineers
Level 13, 379 Collins Street, Melbourne VIC 3000

TTW (QLD) PTY LTD (ACN 615 231 475) (ABN 59 615 231 475) I Consulting Engineers
Level 9/215 Adelaide Street, Brisbane City QLD 4000
[NB: Select Appropriate Office]

Your Partner in Engineering

Structural
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STRUCTURAL TIMBER SPECIFICATION

WSU Indigenous Centre of Excellence

Prepared for Western Sydney University / 25/10/2024

Issue: TENDER

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JOB NUMBER.

Connections

All connections are to be concealed in timber or fire protected (via intumescent paint or spray) in the final condition to satisfy FRL requirements.

Mark connections to distinguish those requiring high-strength bolts from others. Deliver bolts to each size and type in separate containers suitably identified.

Deliver screws and nails to each size and type in separate containers suitably identified.

1.11.6 COATINGS AND TREATMENT

General

Requirement: To *0185 Timber products, finishes and treatment*, including for termite treatments.

The final treatment and coatings are to be worked through with the architect, timber supplier, and the Principal Contractor.

Anti-fungal treatment should be avoided in enclosed areas. Final pest and insect report to determine if chemical treatment is required. Treatment manufacturers to determine available anti-fungal treatments for Service Class 1 or Service Class 2 or Service Class 3 and complying to Green Star requirements.

All timber to be protected from UV damage.

1.11.7 COMPLETION

Tightening

Initial: Retighten bolts, screws and other fixings so that joints and anchorages are secure at the date of practical completion.

Subsequent: If unseasoned timber is used, retighten all bolts, screws and other fixings again after 6 months.

Notice of Completion

Give at least 7 working days' notice of completion.

Temporary connections

Remove temporary connections on completion and restore the surface to match adjacent areas.

Project Records

Provide the workshop drawings and survey certificates with all field modifications to the Principal Contractor for "as built" drawings.

Provide all Quality Record sheets.

1.12 MAINTENANCE STRATEGY

Submit a Maintenance Strategy that includes;

- *Proposed materials*
- *Proposed inspection and Maintenance regime*
- *Proposed method statement for repair of replacement of components*

1.13 APPROVED SUBCONTRACTORS

Requirement: The proposed fabricator, shop detailer and other specialist subcontractors shall be specified by the Principal Contractor.

Structural timber connection shop drawings and fabricators shall be specified by the subcontractor and reviewed by the Principal Contractor during the tender submission.

Sub-Contractor to provide characteristic values for structural timber elements for review prior to fabrication. These characteristic values must be greater than or equal to the minimum characteristic values set out by the European Standard EN338, EN14080 and EN1194, and equivalent to the material characteristics indicated on the drawings.

1.14 FIRE PERFORMANCE

Fire-resistance of building elements

Requirement: Tested to AS 1530.4 (2014) or designed to AS/NZS 1720.4 (2019).

Fire-resistance level (FRL): 90 minutes to elements except where noted in the fire engineering report.

Unless noted on the structural drawings, the contractor is to allow for fire lining to all timber elements to satisfy FRL requirements, as specified on the structural drawings. Glulam columns and beams are designed to achieve the required FRL through timber charring.

Fire performance

Fire-resistance level: Submit evidence of conformity to the above

Testing authority's reports: Test reports certified by an independent testing authority showing compliance with the test criteria.

- Tests required: Fire testing reports for exposed timber elements
  Fire testing reports for exposed connection elements

Fire testing required either an FRL test, or assessment plus certification by a NATA Accredited Testing Laboratory that the FRL noted on the structural drawings is achieved including for CLT panel junction and junctions.

A glue line integrity test is required to ASTM PRG320 (US), GLIF (European) with a minimum or identical layup tested. Alternative testing on glue integrity may be considered on a case-by-case basis.

Lifting points: Do not place lifting attachments, holes and other temporary fixings for handling or temporary support purposes on faces visible upon completion.

Marking and labelling

Requirement: Durably mark or label each CLT element with the following minimum information:

- Identity of the manufacturer, by logo or name.
- Documented layup of panel.
- Production week and year, or traceability code.
- Adhesive type.
- Any timber treatment provided.
- Means for identifying each panel and for showing its correct location and orientation when installed.

4.2.2 FIRE PERFORMANCE

Fire-resistance of building elements

Standard: Tested to AS 1530.4 (2014).

Fire-resistance level (FRL): 120 minutes to all timber elements except roof elements

Combustibility

Non-combustible CLT elements: To the concession requirements of BCA (2022) C2D13.

Fire hazard properties

Group number: To AS 5637.1 (2015).

Insulation materials: Tested to AS/NZS 1530.3 (1999). Fire hazard indices as follows:

- Spread-of-Flame Index: ≤ 9.
- Smoke-Developed Index: ≤ 8 if Spread-of-Flame Index > 5.

4.2.3 CLT PANELS

Panel types

Solid panel: Finger jointed laminations of timber or wood-based products, glue laminated in layers to form a solid CLT panel.

Cassette panel: Two panels of solid CLT with a central layer of battens to form a void in the middle of the panel. The void can also be filled with insulation if required.

Ribbed panel: A solid CLT panel with solid timber or glue laminated timber ribs fixed to one side of the panel, typically suited to longer span floor or roof panels.

Shook Width

All timber shook widths on CLT and Glulam elements are to be 130mm maximum.

Product properties

Panel properties: Conform to the CLT panel property requirements, as documented.

Material properties: Conform to the timber material property requirements, as documented.

Acoustic systems

Requirement: Provide acoustic systems including insulation, linings and sealants, as documented, to the manufacturer's recommendations, after full weather-proofing of building is complete.

Site applied finish

External: Install cladding to all external faces of CLT panels, as documented. Provide temporary weather protection to all external faces until cladding is installed.

Internal: Prepare panel surface and apply finish, as documented, to the manufacturer's recommendations, after full weather-proofing of building is complete.

4.3.3 COMPLETION

General

Temporary attachments: Remove, seal and rectify temporary attachments after erection.

Protection from weather

Duration: Provide temporary protection for installed CLT elements until permanent covering is in place.

Damage

Requirement: Where damage to CLT panels is discovered, do not repair or rectify without written approval of proposed rectification method.

Operation and maintenance manuals

Requirement: Prepare a manual of maintenance procedures for the satisfactory long-term care and regular maintenance of the CLT panels.

Warranties

Requirement: Cover materials and workmanship in the terms of the warranty in the form of interlocking warranties from the supplier and installer.

4.4 ALTERNATIVE STRUCTURAL TIMBER SUPPLIER

CLT panels have been designed using size and material properties stated on the drawings. The panels have the following lamella build up:

Timberlink NX5-200 Panel 5 ply: 40/40/40/40/40

Timberlink NX7-260 Panel 7 ply: 40/30/40/40/40/30/40

Panels will be shipped to site in a combination of closed and open containers as required.

Alternative panel manufacturers may be considered provided material properties are similar and can achieve the fire resistance level as nominated on the structural drawings. If alternate manufacturer is proposed, the following information is required.

- Design values for timber to AS 1720 for Australian products
- Design values for timber to BS EN 1995-1 for European products
- Relevant test data to demonstrate all necessary structural and fire performance parameters are met

- Technical approvals for design of CLT
- Available range of panel thickness and lamella build up
- Shop Drawings
- Charring rates and fire design procedures

Any proposed alternates or variations to the design must clearly be identified by the timber contractors for review by the Structural Engineer and Architect. Any proposed alternatives must be reviewed and approved by the Structural Engineer and Architect prior to inclusion in the contractor's documentation.

Screw and nail edge distances and minimum spacings to be in accordance with AS1720, EN-1995-1-1, European Technical Approval no. ETA-11/0030, and manufacturers specifications.

Anchor points for installation to also comply with edge distance requirements.

Impact drills are not permitted under any circumstances.

Thread: Provide thread length at least four times the bolt diameter.

Holes: Drill bolt holes 2 mm or 10% larger than the bolt diameter.

Bolt diameter: To AS 1720.1 (2010) clause 4.4.

Washers

Standard: To AS 1720.1 (2010) Table 4.11.

Fabricated Steel Plates

General: To be corrosion free and protected with a minimum of 75 microns of zinc rich epoxy, or to be hot dipped galvanised.

Steel plates to be clean, untainted, and undamaged when erected in final position.

Includes but not limited to column baseplates, flitch plates, miscellaneous steel plate connectors.

All steel to be grade 350 minimum.

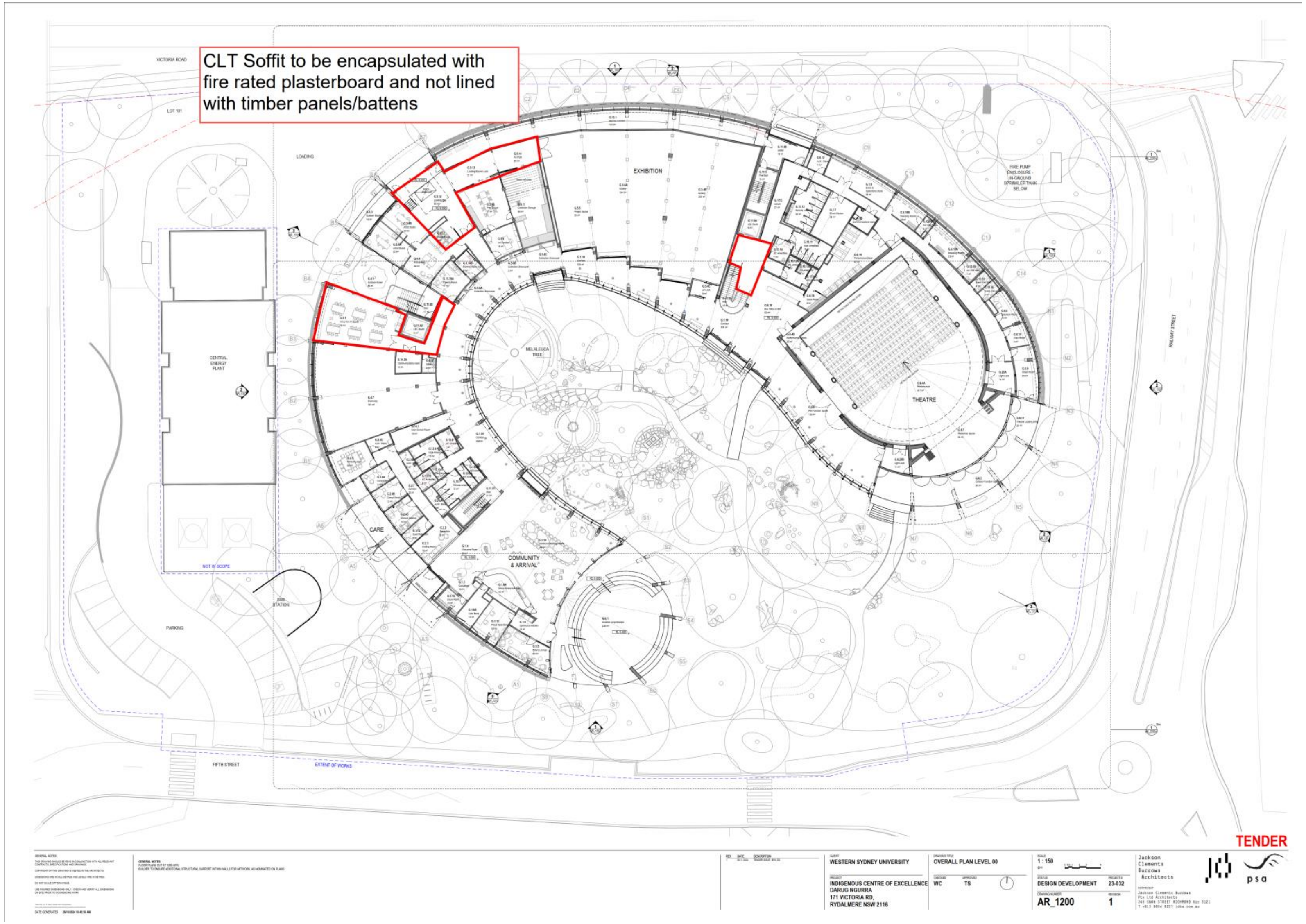
All steel connections are required to be fire protected. Fire protection to steel connectors to be at least equal to the FRL of connected timber elements. Where steel plates/connectors are not fully covered by a strip of timber with a thickness at least equal to the charring depth, allowance should be made for additional fire protection to the steel via intumescent paint or spray fire protection.

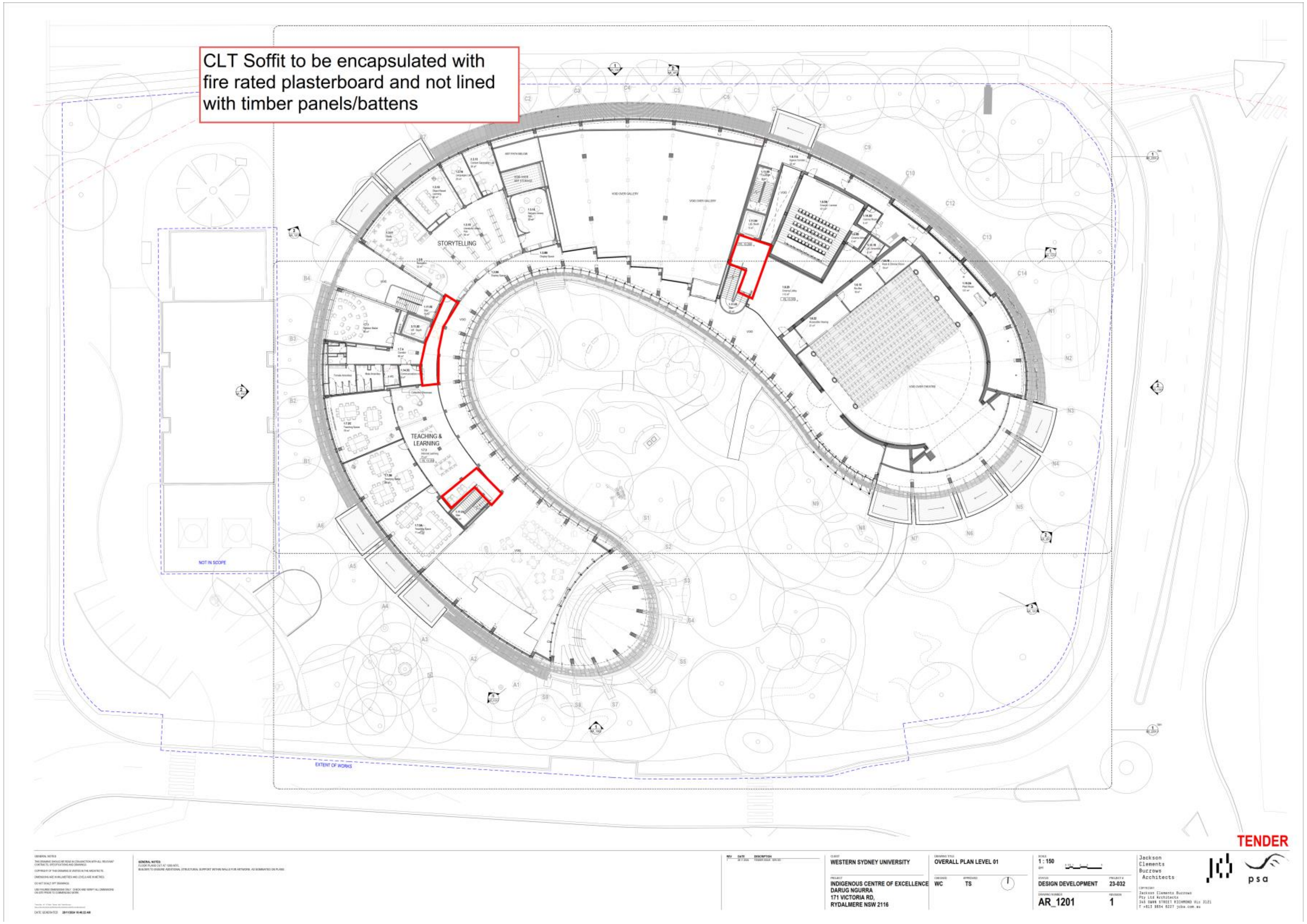
Proprietary Connections

General: The manufacture, supply and installation of connectors are to be in accordance with Eurocode 5 and the manufacturer's European Technical Approval (ETA) or other testing specifications. All connections are required to be fire protected.

Any propriety connector must be able to provide the allowable rotation at the joint as required by the project. The supplier must provide the maximum allowable rotation at the joint for each type of connector provided. Any connection without the allowable rotation may be rejected by the Structural Engineer.

Appendix J. CLT Soffit Encapsulation




CLT Soffit to be encapsulated with fire rated plasterboard and not lined with timber panels/battens
STORYTELLING
TEACHING & LEARNING
NOT IN SCOPE
EXTENT OF WORKS
TENDER
WESTERN SYDNEY UNIVERSITY
OVERALL PLAN LEVEL 01
INDIGENOUS CENTRE OF EXCELLENCE
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171 VICTORIA RD,
RYDALMERE NSW 2116
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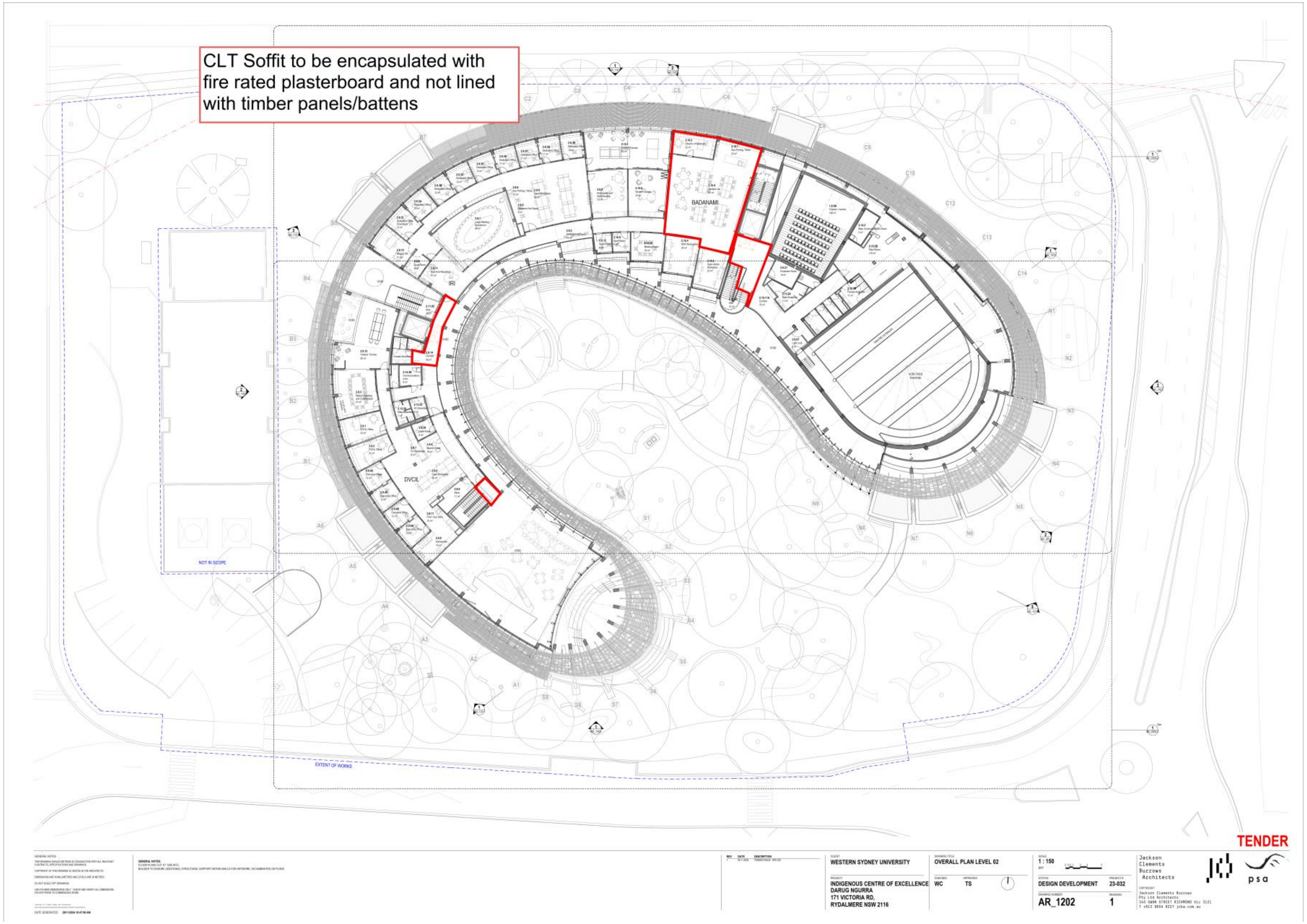
Clements
Burrows
Architects
psa


CLT Soffit to be encapsulated with fire rated plasterboard and not lined with timber panels/battens
BADANAMI
DVCIL
NOT IN SCOPE
EXTENT OF WORKS
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OVERALL PLAN LEVEL 02
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INDIGENOUS CENTRE OF EXCELLENCE
DARUG NGURRA
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RYDALMERE NSW 2116
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