IMG HOTEL

FIRE ENGINEERING UPGRADE STRATEGY REPORT

Federal Hotel 34 Inglis Street Mudgee, 2850

Project Number: 119722
Revision: Pub_FEUSR_1.1
Date: 10 January 2025

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Quality management

Rev	Issue Date	Issue Description	Prepared	Reviewed	Authorised
119722-Pub_FESR_1.0	19 December 2024	Issued for coordination	Michael Mason	Himanshu Gupta	Michael Mason
119722-Pub_FEUSR_1.1	10 January 2025	Fire Engineering Upgrade Strategy Report	Michael Mason	Himanshu Gupta	Michael Mason

Executive summary

Jensen Hughes Pty Ltd has been engaged to provide a Fire Engineering Upgrade Strategy Report (FEUSR) for Federal Hotel 34 Inglis Street Mudgee, 2850, in response to the BCA audit report by SWP reference 2024/1221R1.1 for upgrades to the existing premises.

This FESR presents fire engineering assessments of the proposed non-conformances and associated fire safety upgrades, to demonstrate the improvements in safety achieved to align with the key objectives of the BCA. The issues assessed are identified in Table 1.

The FESR should be reviewed whenever a change in use or future alterations and additions are proposed for the development as the objectives may require revision, the assumptions may become invalid, or the fire engineering analysis may not be applicable to the proposed alterations, additions or change of use.

This report is not a Design Compliance Declaration under the Design and Building Practitioners Act 2020 and is not to be used or construed as such.

The fire safety measures in section 5.0 must be incorporated into the design of the building, installed, commissioned and maintained in accordance with the Environmental Planning and Assessment (Development Certification and Fire Safety) Regulation 2021 and relevant Australian standards. These fire safety measures, and this report, must be listed on the fire safety schedule for the building.

If there are building alterations or additions, a change in use or changes to the fire safety system in the future, a reassessment will be needed to verify consistency with the assessment contained in this report

Table 1 DTS non-conformance assessed

No	Description of DTS non-conformance	DTS provision
1.	Existing construction is proposed to remain in lieu of BCA DTS fire resisting construction: + Existing pub ground floor ceiling is not a fire protective covering, RISF or 30/30/30 FRL system. The following ceiling types are proposed to remain: - Pressed metal pans. - Horsehair type plaster and lath. - Standard grade plasterboard (where previous refurbishment work was carried out). Note that any new ceiling installed in the pub shall be DTS “fire protective covering i.e. 16 mm fire rated plasterboard. + Existing class 3 bounding construction (e.g. bounding SOU’s and other rooms off the central corridor) is permitted to remain, being predominately single skin brick walls, with some lightweight parts of gypsum board over timber framing, in lieu of a system achieving -/60/60. + Existing class 3 bounding construction walls extend to a non-fire rated ceiling in lieu of a fire rated ceiling.	C2D2, C3D8, C3D10, Spec 5

No	Description of DTS non-conformance	DTS provision
2.	The pub and accommodation building proposed to retain the existing timber sash windows.	C2D10
3.	The path of travel from internal non-fire isolated stairway serving the Class 3 accommodation reduced to approximately 0.94 m instead of 1 m	D2D8
4.	Protection of egress path from SOU's differs from DTS provisions: + The accommodation rooms on level 1 are served by a public corridor. Although the corridor itself does not exceed 40 m the smoke separation intervals cannot be quantified due to the interconnection with the pub via the existing open stairway. + Existing solid core doors may not be "tight fitting". + Path of travel from SOU rooms 12 and 13 is along an external balcony passing by windows which are less than 1.5 m high. + Two non-fire isolated stairways provide egress from level 1 staff accommodation area. Both stairways are discharged to the ground floor of the pub. Although some separation is provided it may not be in full compliance with DTS smoke separation requirements.	C3D15 C4D12 D2D14(6)
5.	The heritage doors serving as a required exit for the pub is proposed to remain inward swinging door.	D3D25
6.	It is proposed to provide portable fire extinguishers in lieu of hose reels in the class 6 parts.	E1D3

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1.0 Introduction

1.1 SCOPE AND OBJECTIVE

Jensen Hughes Pty Ltd has been engaged to provide a Fire Engineering Upgrade Strategy Report (FEUSR) for Federal Hotel 34 Inglis Street Mudgee, 2850, in response to the BCA audit report by SWP reference 2024/1221R1.1 for upgrades to the existing premises.

This FESR presents fire engineering assessments of the proposed non-conformances and associated fire safety upgrades, to demonstrate the improvements in safety achieved align with the key objectives of the BCA.

1.2 REPORT OBJECTIVES, SCOPE AND EXTENT

This report is a Fire Engineering Upgrade Strategy Report (FESR). The purpose of this report is to:

+ Present the proposed BCA DTS non-conformances (identified by the BCA consultant) proposed to remain.
+ Describe new fire safety upgrades to be implemented.
+ Present the holistic context of the assessment, i.e. for the subject building or part thereof, the fire hazards, preventative and protective measures and occupant traits and activities.
+ Assess the proposed non-conformances and associated fire safety upgrades, to demonstrate the improvements in safety achieved.

The fire safety upgrade is based on Building Code of Australia fire safety provisions but does not target full compliance with the Performance Requirements, rather, an upgrade scope that can feasibly be implemented is proposed. This assessment has been undertaken generally in accordance with the process and methodology recommended in the Australian Fire Engineering Guidelines (AFEG)[1].

This document is not a Fire Engineering Report and does not include any Performance Solutions to the Performance Requirements of the BCA.

1 Australian Building Code Board; Australian Fire Engineering Guidelines; 2021.

2.0 Building characteristics

2.1 BUILDING DESCRIPTION

The fire safety upgrade is part of a larger project involving the following proposed works:

+ Alterations and additions to the existing two-storey pub (Building A).
+ Construction of a new two-storey hotel accommodation building (Building B).
+ Construction of a new single-storey bottle shop (Building C).

Table 2[2] shows the main characteristics of the building for determining compliance with the NCC.

Table 3 shows the proposed use and classification of the building in accordance with part A6 of the NCC.

This FESR pertains only to Building A pub existing part.

Future fire engineering performance solutions will be provided for Building A extension, and Building B and C are understood to comply fully with all DTS provisions.

Figure 1 Site location (courtesy Nearmap accessed on 03/12/2024)

2 Steven Watson & Partners, 30 September 2024, BCA assessment report, R2.0

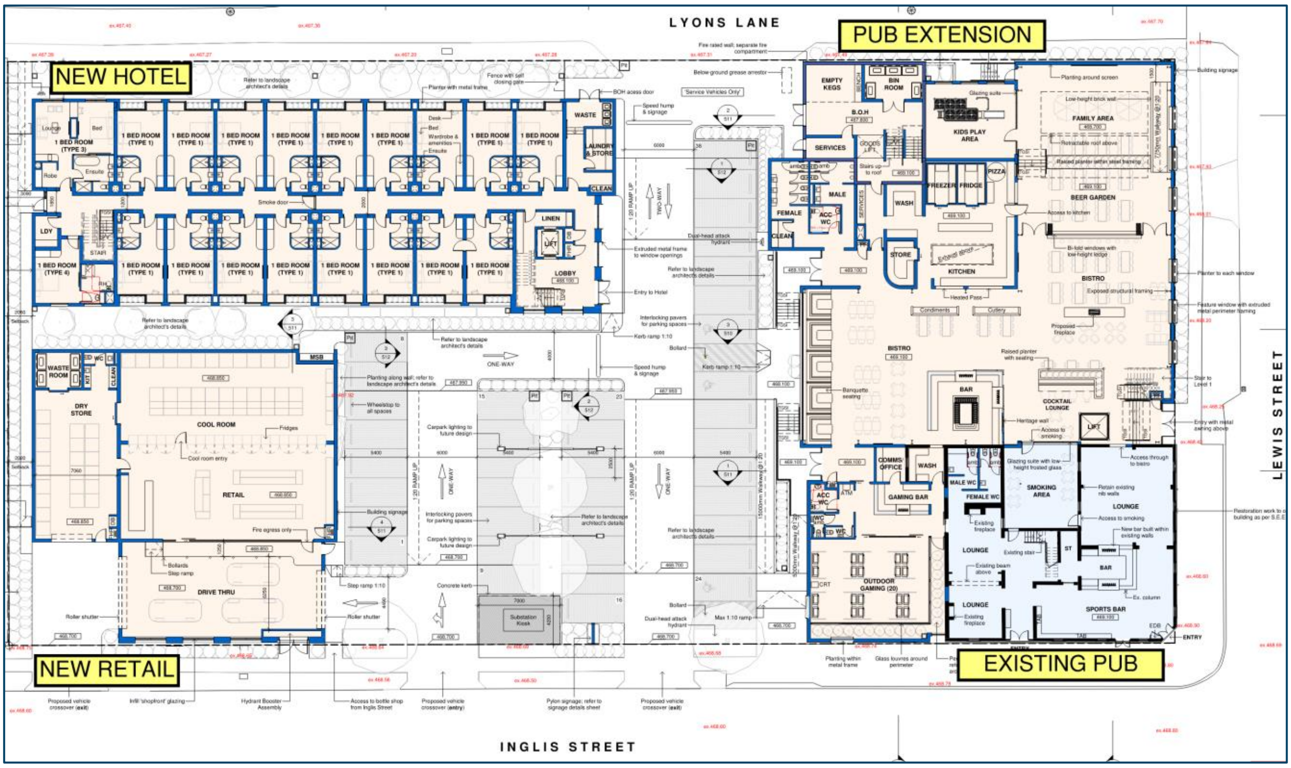


Figure 2: Site plan ground level

Table 2 Main building characteristics

Characteristic	NCC provision	Description
Effective height	Schedule 1	3.6 m
Type of construction required	C2D2 and C3D3	Type B
Rise in storeys	C2D3	2
Storeys contained	-	3

Table 3 Use and classification

Part of building	Use	Classification (A6)
Basement	Pub storage	Class 6
Ground floor	Pub	Class 6
Level 1	Staff accommodation	Class 3

2.2 GENERAL ARRANGEMENT AND EXITS

The discharge location of exits at street level are show in refer

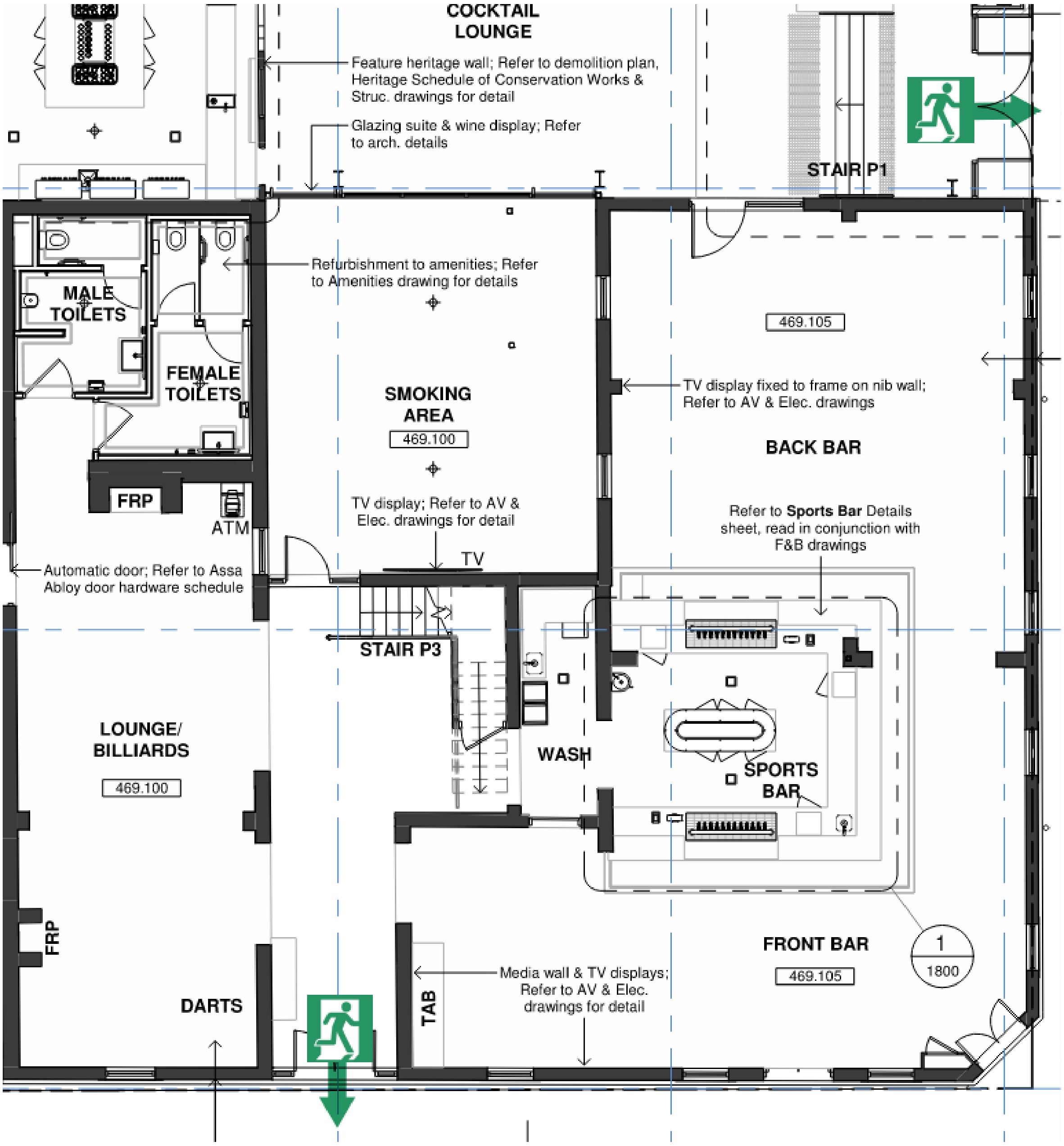


Figure 3: Floor layout and exit locations on the ground level building A

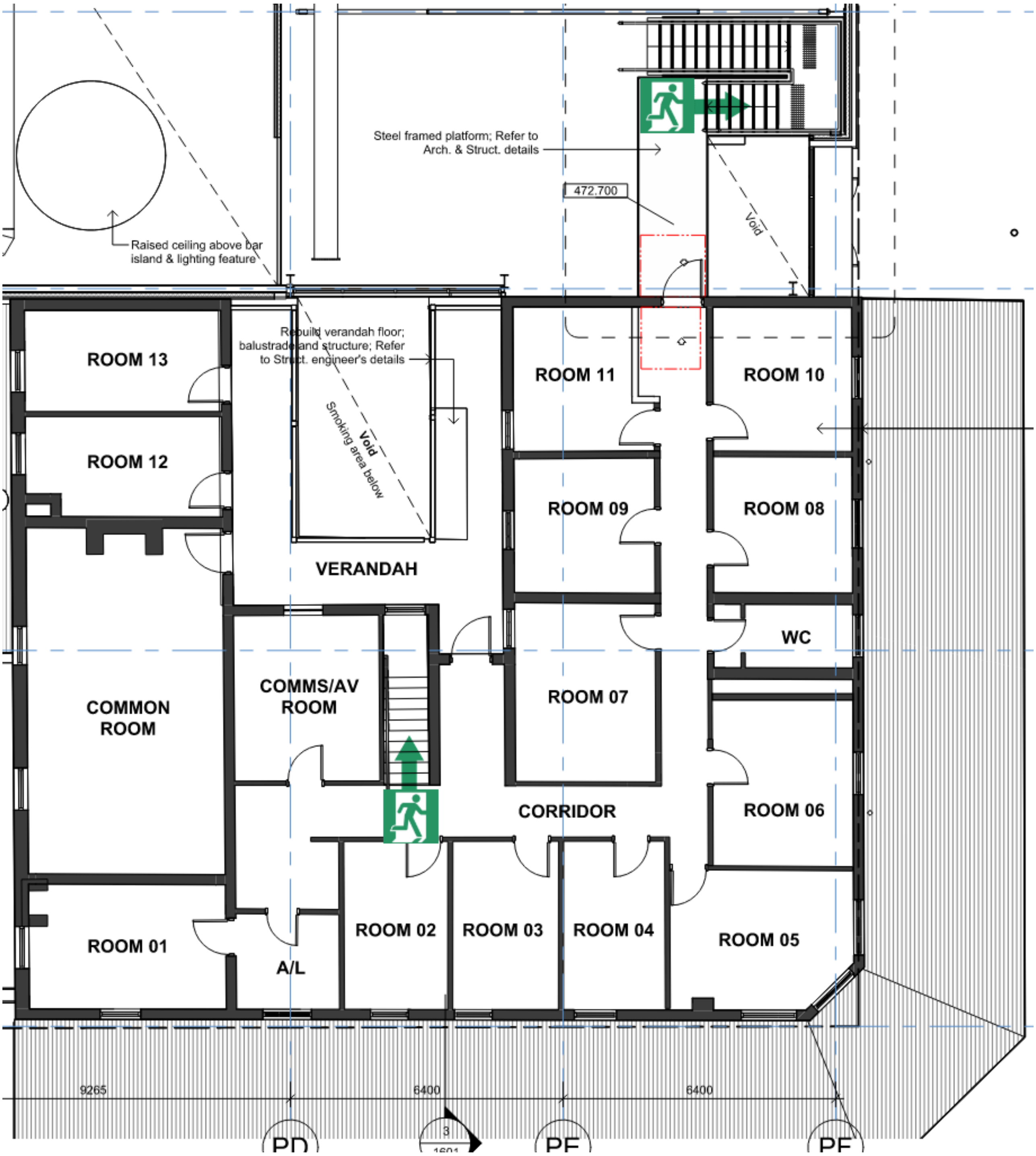


Figure 4: Floor layout and exit locations on the Level 1 building A

2.3 EXISTING PERFORMANCE SOLUTION APPLICABLE TO THE BUILDING

No previous performance solutions have been identified for the existing building.

3.0 Occupant characteristics

3.1 PHYSICAL AND MENTAL CHARACTERISTICS

The characteristics of the occupants expected to be in the building are listed in Table 4.

Table 4 Occupant characteristics

Characteristic	Use	Description
Familiarity	Residential	Residents are likely to be familiar with the building and exits. Visitors may have limited familiarity but will likely be accompanied by residents.
	Hotel	Residents / guests may have varying levels of familiarity. It is assumed that occupants are not familiar with the building.
Awareness	Retail	The public may be unfamiliar with the building and exits, but likely remember the entry they used. Staff are likely to be familiar with the building and exits.
	Residential / Hotel	Occupants may have varying levels of awareness. Occupants may be sleeping or unresponsive at the time of a fire.
	Retail	Occupants are expected to be awake and alert to a potential emergency event such as a fire in the building.
Mobility	Bar	Occupants are expected to be awake and alert to a potential emergency event such as a fire in the building. Some occupants may be focused on a performance and/or under the influence of alcohol or drugs. Staff will be present who are awake and aware of their surroundings.
Number of occupants	Residential / Hotel/Retail/Bar	Occupants are expected to have general mobility and be capable of evacuating independently. A limited number may require mobility aids or assistance due to reduced mobility. Similarly, a portion of occupants may have hearing or sight impairments. The proportion of occupants with disabilities is comparable to a DTS design. Therefore, this factor does not differentiate between performance solutions and DTS approach.

3.2 STAKEHOLDERS

The relevant stakeholders identified for the project are included in Table 5.

Table 5 Project stakeholders

Name	Role	Organisation
Andrew Turnbull	Client	IMG Hotel
Matt Milledge	Project Manager	Qualis Consulting
Tom Bergstrom, Elliot Oxley	Architect	Bergstrom
Andrew Connor	Town planner	Canberra Airport

Name	Role	Organisation
Greg Evans	Certifier	360 Certification
David Cartwright	BCA consultant	Steve Watson & Partners
Brett Petersen	Fire protection designer	MGP Building and Infrastructure Services
Michael Mason	Fire engineer	Jensen Hughes
TBC	Builder	TBC

4.0 Limitations and Assumptions

4.1 ASSUMPTIONS

1. The existing building complied with the applicable building standard at the time of construction or was deemed acceptable for occupation by the authority having jurisdiction. All new works comply with the DTS provisions of NCC 2022 relating to fire safety, except for the specific issues described in this report.
2. The building complies with the relevant requirements of previous fire engineering report(s) identified in section 2.3 except where superseded by this report.
3. All the fire safety systems are to be designed, installed, operated and maintained in accordance with the appropriate Australian standards, other design codes, legislation and regulations relevant to the project unless specifically stated otherwise.
4. This report considers fires involving a single ignition point. Our assessment does not cover arson or destructive acts involving:
    a. large amounts of accelerants which significantly change the expected burning behaviour of materials
    b. multiple ignition sources
    c. terrorism.
5. Occupants will become aware of the fire through fire cues, respond to the cue, cope with the cue and attempt to avoid the fire, as intended by the NCC for safe evacuation.
6. Occupants do not engage in major firefighting activities. However, occupants may engage in first aid firefighting. Any positive outcome from this will not be included in the analysis.

4.2 LIMITATIONS

1. The scope of this report is limited to the issues described in this report. We have not confirmed that every aspect of the building complies with the NCC and/or relevant Australian standards. It is the responsibility of other parties to ensure full compliance with the code and standards is achieved.
2. This report does not include assessment of the performance nor compliance for:
    a. The structural provisions of Part B of the NCC
    b. The design and/or operating capabilities of any proposed electrical, mechanical or hydraulic fire protection services (other than any specifically referred to within this report)
    c. Business protection, business continuity, public perception, tourism
    d. Energy efficiency
    e. Damp and weatherproofing
    f. Insurer's requirements
    g. Property protection, other than adjacent properties.
3. This report does not include assessment of special hazards or dangerous goods – including substances or materials that have explosive, flammable, toxic, infectious, or corrosive properties – unless specifically identified.
4. The scope of our work is limited to considering evacuation and fire safety issues for people with disabilities to the same degree as the DTS provisions of the NCC. The evacuation of people with disabilities under the provisions of the Disability Discrimination Act 1992 is specifically excluded.

5. The information in this report specifically relates to the building and must not be used for any other purpose.
6. The figures included in this report are provided for illustrative purposes only and may not reflect the latest design drawings. They should be read together with the latest drawings and other documentation prepared by the project team.
7. This report has been prepared based on information provided by others. Jensen Hughes has not verified the accuracy and/or completeness of this information and will not be responsible for any errors or omissions that may be incorporated into this report as a result.
8. Design and specification of fire safety measures, or any other building elements, remain the full responsibility of others and are beyond the scope of this report.
9. The documentation that forms the basis for this report is listed in 0

5.0 *Fire safety measures*

5.1 GENERAL

This section describes the fire safety measures relating to the issues assessed in this report. These measures must be designed, implemented, and maintained for the building to satisfy the performance requirements of the NCC.

This section does not provide a comprehensive list of all fire safety measures required for the building. The responsibility for confirming the full fire safety schedule remains with the Certifying Authority.

The fire safety measures in this section must be incorporated into the design of the building, installed, commissioned, certified, and maintained in accordance with the relevant Australian standards and the Environmental Planning and Assessment (Development Certification and Fire Safety) Regulation 2021. These fire safety measures, and this report, must be listed on the fire safety schedule for the building.

We recommend that all fire safety measures are periodically inspected, tested and maintained in accordance with AS 1851-2012.

5.2 FIRE RESISTANCE

1. Existing pub ground floor ceiling is not a fire protective covering, RISF or 30/30/30 FRL system. The following ceiling types are proposed to remain:
    a. Pressed metal pans
    b. Horsehair type plaster and lath
    c. Standard grade plasterboard (where previous refurbishment work was carried out)
2. Existing class 3 bounding construction (e.g. bounding SOU's and other rooms off the central corridor) is permitted to remain, being predominately single skin brick walls, with some lightweight parts of gypsum board over timber framing, in lieu of a system achieving FRL -/60/60.
3. Existing walls bounding class 3 parts extend to a non-fire rated ceiling in lieu of a fire rated ceiling system.
4. Any penetration in existing class 3 bounding construction or ground floor ceilings below class 3 shall be fire sealed where feasible, or smoke sealed in lieu.
5. Each class 3 SOU entry/exit door is to be retro-fitted with smoke seals complying with the following requirements:
    a. Be medium temperature rated – i.e. capable of resisting exposure to 200 °C for 30 minutes (tested to AS 1630.7-2007).
    b. Be fitted to the top and sides of the door frame.
6. Smoke separation between the existing pub part and level 1 accommodation shall be provided;
    a. Smoke baffle around the existing internal stairs on ground level as shown Figure 5. Depth of baffle to be as deep as reasonable possible without causing head clearance issue – nominally 2 m AFFL i.e. similar to a door frame height.
    b. Smoke baffle between the existing pub lounge part and new accessway to the north, by the following means, as shown in Figure 5: Depth of baffle to be as deep as reasonable possible without causing head clearance issue – nominally 2 m AFFL i.e. similar to a door frame height.

7. Smoke separation described above shall constitute as a minimum:
    a. Gypsum wall lings.
    b. Toughened glass.
    c. Solid core doors with smoke seals and self-closers.
    d. Other non-combustible construction
8. The enclosure beneath the existing stairway serving level 1 shall be deleted or provided with fire resisting bounding construction having FRL -/60/60 and self-closing fire door achieving an FRL of -/60/-30.

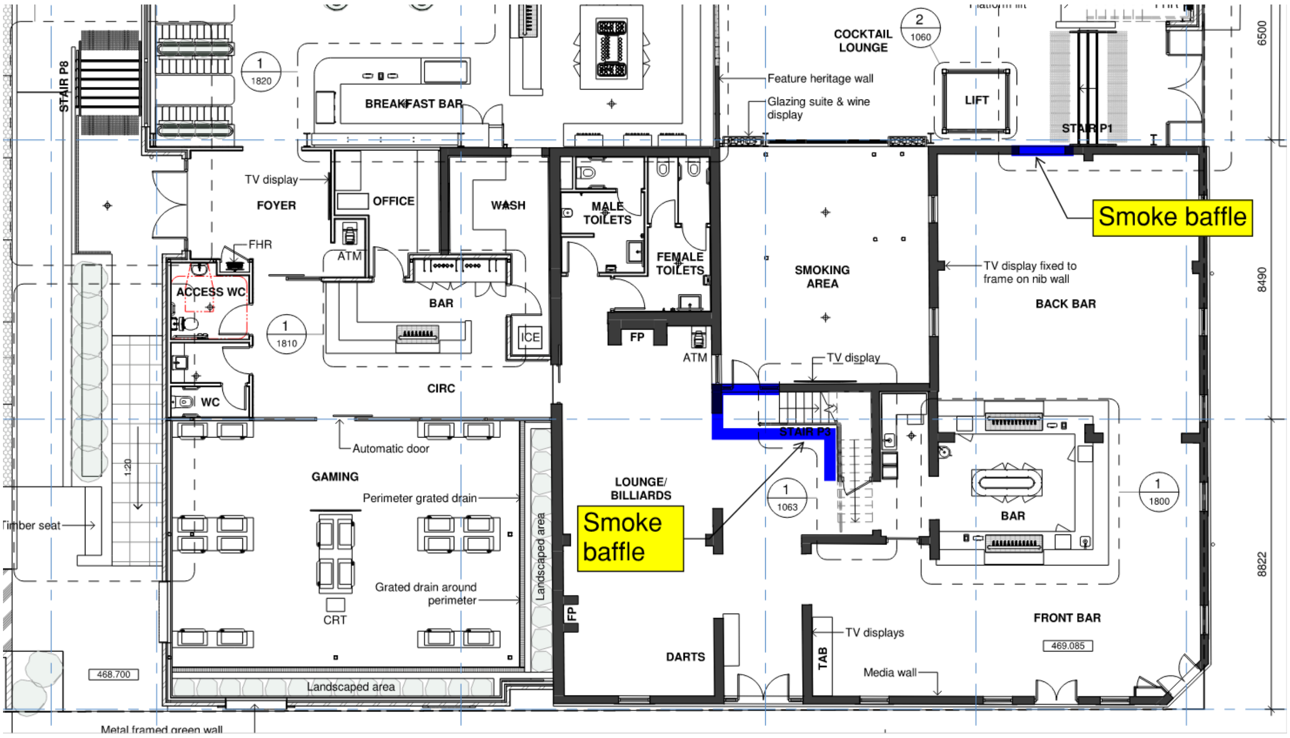


Figure 5: Mark-up showing the proposed smoke baffles

5.3 ACCESS AND EGRESS

9. The existing exit door serving as a required exit for the heritage pub may swing in the opposite direction of egress (i.e., inward).
10. The clear width of the non-fire isolated stairway serving the Class 3 accommodation is required to be a minimum of 900 mm (measured between handrails).

5.4 SMOKE DETECTION AND OCCUPANT WARNING SYSTEM

11. Smoke detection and occupant warning system in accordance with AS1670.1-2018 shall be provided throughout the pub (including pub, accommodation and back of house areas).
12. Smoke detection in the Class 3 accommodation areas shall be in accordance with BCA S20C4 – i.e. part of the building's AS1670.1 system and not separate AS3786 smoke alarms.
13. Alarm verification facilities may be provided in accordance with the DTS provisions of AS1670.1-2018.

5.5 FIRE HYDRANTS

14. Building A may be provided with fire hydrant coverage from the existing hydrant system serving the entire site.
15. The booster assembly for the site is in front of Building B facing Inglis Street. Hence, Building A is not provided with a separate hydrant booster.
16. Hydrant coverage to the pub is achieved from external hydrants on site.

5.6 AUTOMATIC FIRE SPRINKLER SYSTEM

17. An automatic sprinkler system is to be provided to serve the building, (ie all of Building A) and shall be generally in accordance with AS 2118.1-2017 with the following clarifications/modifications:
    a. Ordinary Hazard 1 in the pub and associated areas (per AS 2118.1-2017 A3.1(d)) and light hazard residential in the accommodation parts on level 1.
    b. All sprinkler heads, including ordinary hazard heads, must have an RTI no greater than 50 – i.e. fast response.
    c. The sprinkler system shall be provided with a full capacity storage tank. No direct connection of the sprinkler system to town main is required, other than facility to fill the full capacity tank in accordance with the provision of AS 2118.1-2017.
    d. The sprinkler system booster pump shall be a diesel pumpset.
    e. The sprinkler system tank and pump are located in Building C on site.
    f. The sprinkler booster assembly is located at the front of Building C, co-located with the site-wide hydrant system booster assembly.
    g. Large bore suction is not required to be provided to the sprinkler tank and booster assembly.
18. The sprinkler system shall be independent of the site hydrant system.
19. The sprinkler system shall be listed as a 'critical' measure on the AFSS. This requires system to be maintained every 6 months.

5.7 PORTABLE FIRE EXTINGUISHER

20. Fire extinguishers are to be provided within the pub area to AS2444-2001 in lieu of fire hose reels. Extinguishers are to be of Type ABE and have a minimum capacity of 4.5 kg.

5.8 SUMMARY OF KEY FIRE SAFETY SYSTEMS

The key fire safety measures relating to the assessments are summarised in Table 6. This identifies the standard of performance for design, installation, certification of the identified measures.

Table 6 Fire safety measures and standard of performance associated with the assessments

Fire safety measure	Standard of performance
Fire resisting construction	Jensen Hughes report reference 119722-Pub_FEUSR_1.1
Automatic fire detection and alarm system	NCC E2D3, NSW specification 20 AS 1670.1:2018 Jensen Hughes report reference 119722-Pub_FEUSR_1.1
Automatic sprinkler system	NCC E1D4, specification 17 AS 2118.1:2017 and AS 2118.6:2012 Jensen Hughes report reference 119722-Pub_FEUSR_1.1
Building occupant warning system	NCC clause S20C7 of specification 20 AS 1670.1:2018
Emergency evacuation plan	AS 3745:2010
Emergency lighting	NCC E4D2, E4D4 AS/NZS 2293.1:2018
Exit signs	NCC E4D5, E4D6, E4D7 (class 2 and 3), E4D8 AS/NZS 2293.1:2018
Fire hydrant system	NCC E1D2 AS 2419.1:2021
Portable fire extinguishers	Jensen Hughes report reference 119722-Pub_FEUSR_1.1
Smoke Seals	Jensen Hughes report reference 119722-Pub_FEUSR_1.1
Solid core doors	NCC C4D12 Jensen Hughes report reference 119722-Pub_FEUSR_1.1

6.0 Safety in design

Our scope of work is to assess the proposed fire safety upgrades. The fire safety measures in section 5.0 are partial performance specifications for other consultants to incorporate into their detailed designs. The other designers retain discretion over where and how systems and structures are installed and are therefore responsible for the safety in design for the detailed design.

With regards to a safety in design specific to elements nominated by this FESR, we have considered whether the recommended fire safety measures in section 5.0 could reasonably be expected to introduce unique or unusual hazards that would not otherwise be present in the construction, installation and/or maintenance of the building. This preliminary safety in design consideration has not identified any unique or unusual hazards for the solution that would not otherwise be present in the construction, installation.

System and building designers remain responsible for the identification and mitigation of any risks associated with the construction, installation, maintenance and decommissioning of systems described within this report. Designers are encouraged to contact Jensen Hughes if their safety in design review identifies issues for which modification to the FESR may be beneficial.

7.0 Assessment 1 –Fire resisting construction.

7.1 INTRODUCTION

The existing pub and level 1 accommodation is of heritage significance. It is proposed to retain the existing construction as described in Table 7.

Any new works shall be in accordance with DTS provisions, including ceilings and walls etc.

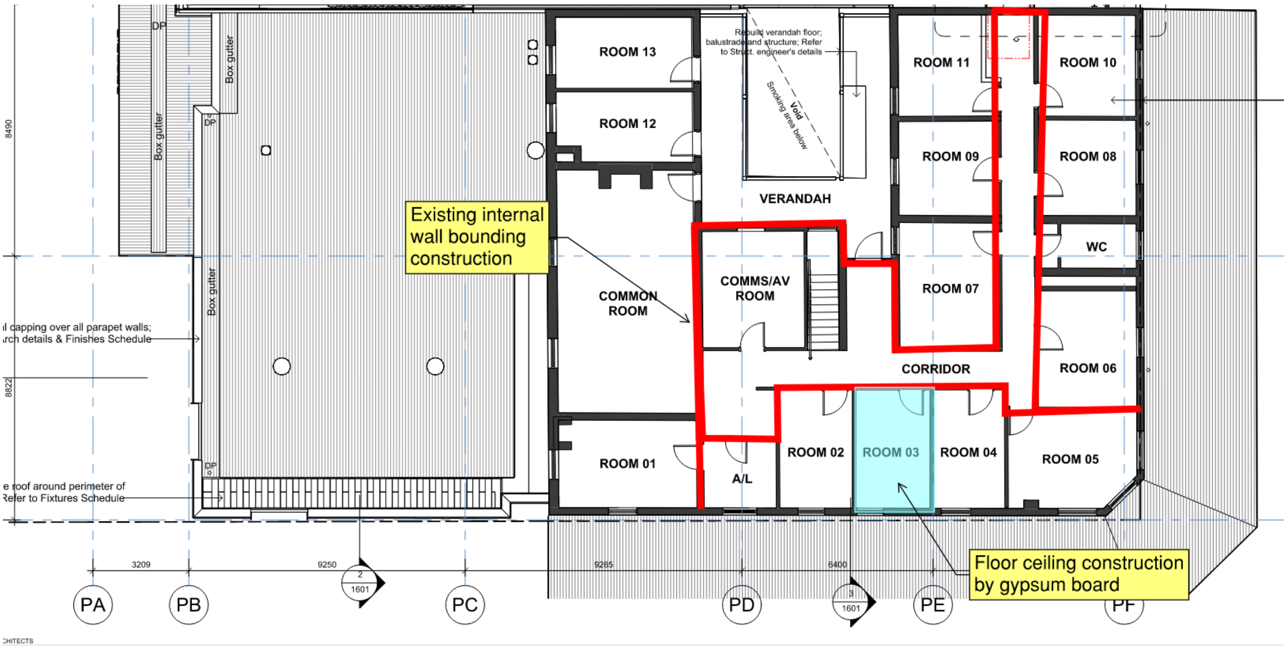


Figure 6: Level 1 construction

Table 7 Assessment overview

DTS departure	
Description	Existing construction is proposed to remain in lieu of BCA DTS fire resisting construction: + Existing pub ground floor ceiling is not a fire protective covering, RISF or 30/30/30 FRL system. The following ceiling types are proposed to remain: - Pressed metal pans. - Horsehair type plaster and lath. - Standard grade plasterboard (where previous refurbishment work was carried out). Note that any new ceiling installed in the pub shall be DTS "fire protective covering i.e. 16 mm fire rated plasterboard. + Existing class 3 bounding construction (e.g. bounding SOU's and other rooms off the central corridor) is permitted to remain, being predominately single skin brick walls, with some lightweight parts of gypsum board over timber framing, in lieu of a system achieving -/60/60. + Existing class 3 bounding construction walls extend to a non-fire rated ceiling in lieu of a fire rated ceiling.
NCC DTS clause	Clause C2D2, C3D8, C3D10, Spec 5
Methodology	
Assessment methodology	Comparison to the DTS provisions
Type of assessment	Quantitative and Qualitative, Comparative, Absolute and Probabilistic
Fire safety sub-systems addressed	Sub-system A – Fire initiation, development and control Sub-system C – Fire spread, impact and control Sub-system D – Fire detection, warning and suppression Sub-system E – Occupant evacuation and control Sub-system F – Fire services intervention

7.2 ACCEPTANCE CRITERIA

The assessment will be considered acceptable if it is demonstrated the subject building is less likely to suffer failure during a full burnout fire event than a DTS design

7.3 FIRE SCENARIOS

Quantitative probabilistic assessment considers a full burnout compartment fire. Quantitative fire characteristics are incorporated into the probabilistic assessment based on the compartment fire load density, compartment floor area and compartment opening area applicable to ventilation-controlled fires. Refer Appendix B

7.4 ANALYSIS

7.4.1 Introduction

The guide to the NCC states that 'the required type of construction of a building depends on risk levels as indicated by the class of building and the building's height as indicated by the rise in storeys. The class of building is a measure of the building's likely:

+ use.
+ fire load.
+ population; and
+ mobility of the occupants, such as whether they are sleeping or alert.

The height (rise in storeys) of the building is relevant as a measure of likely evacuation times and evacuation difficulty. The BCA guide also notes that other factors may need to be considered.

BCA DTS provisions prescribe specific construction methods and parameters for building elements and fire safety systems for the pub These work together as a system to achieve the below objectives:

- Provide a period of tenability suitable for occupant evacuation.
- Resist fire growth from the room of origin to elsewhere in the building.
- Resist catastrophic structural collapse to the degree necessary.

This assessment will quantitatively compare the DTS reference parameters to the subject building and demonstrate that comparable overall performance of these objectives is achieved when considered holistically as a fire safety system.

Table 8: DTS vs Proposed design

Building element / system	DTS reference building	Subject building	Comparison to DTS
Class 3 bounding construction	FRL 60/60/60 generally	Single skin brick – FRL nominal 60 minutes. 13 mm gypsum board over timber studs – FRL nominal 15 minutes[3].	Not DTS
Ceiling / floor system for a floor separating storey	Floor FRL 30/30/30, or Ceiling 60 minutes resistance to incipient spread of fire, or Ceiling fire protective covering i.e. 16 mm fire rated gypsum board.	Pressed metal pans – FRL zero Horsehair type plaster and lath – nominal FRL 60 minutes[3] Standard grade plasterboard – Nominal FRL 10 minutes[3]	Not DTS
External wall construction	Zero FRL (all walls are greater than 18 m from a fire source feature)	Zero FRL (all walls are greater than 18 m from a fire source feature)	DTS

3 International Building Code Table 722.2.1.4(2)

Building element / system	DTS reference building	Subject building	Comparison to DTS
Roof	Zero FRL	Zero FRL	DTS
Automatic sprinkler system	None	AS2118.1	Exceeds DTS

7.4.2 Quantitative probabilistic comparison

The high-level objective for providing fire resisting elements is that those elements should remain intact after a complete burnout of the fire compartment. Fire resistance levels are expressed in terms of minutes duration off a standard fire test – i.e. FRL.

The standard fire test provides a means of empirically determining the resistance of an assembly to a severe fire and comparing the performance of different assemblies. The standard heating regime does not represent the expected compartment temperatures expected for real fires. Heating regime of ‘real’ fires is a function of the fire load and compartment geometry. A fully developed fire in a compartment is likely to have higher peak temperatures than the standard fire but remain at these peak temperatures for a shorter duration.

To address the differences in expected compartment temperatures between real fires and the standard fire test, numerous correlations have been developed. These correlations aim to determine the severity of a real fire in comparison to the standard fire test. The most common method of determining this is to examine the expected maximum temperature of elements exposed to a real fire in comparison to elements exposed to a standard fire. This method defines the equivalent fire severity as the time of exposure to the standard fire test that would result in the same maximum temperature in an element exposed to the complete burnout of the fire compartment. This process is illustrated in Figure 7.

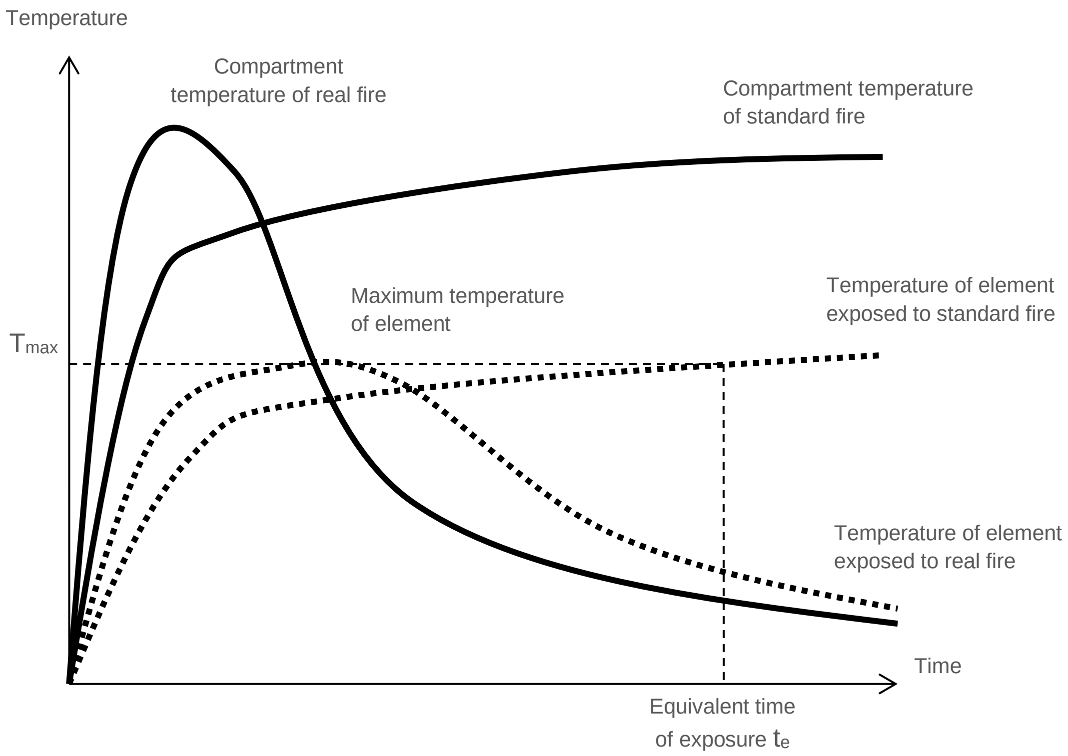


Figure 7 Equivalent fire severity

BCA DTS provisions assign minimum FRL's to specific building elements. The intent is that the building elements resist fire to the degree necessary, that in the event of a full burn out of the fire compartment the building does not suffer catastrophic collapse. BCA therefore limits the fire compartment sizes (to control the fuel load) and varies the minimum FRL's required based on building uses and rise in storeys.

BCA DTS Type B construction is somewhat unusual in that it prescribes varying FRL's for different elements in a class 3 building ranging from nil to 90 minutes. For the subject building, the lowest common denominator for DTS FRL is the floor separating storeys required to have an FRL of 30 minutes.

The subject building is also provided with varying wall types achieving different fire resistance. The lowest common denominator of the subject building is the ground floor pressed ceiling tiles which have zero FRL. The assessment calculations require a non-zero value therefore an FRL of 1 minute is assigned.

Using the above inputs a quantitative probabilistic comparison between the subject building and BCA DTS provisions, described above, has been undertaken and is presented in Appendix B The results predict the below failure rates for a full burnout event:

- DTS design 61 %
- Assessed design 2 %

The results demonstrate that the assessed design is less likely to suffer failure during a full burnout fire event than a DTS design. The acceptance criteria has therefore been fulfilled.

7.5 CONCLUSIONS

The above assessment has demonstrated the acceptance criteria have been fulfilled. The proposed fire safety upgrades are therefore considered appropriate.

8.0 Assessment 2 – Non-Combustible building elements

8.1 INTRODUCTION

The pub and accommodation building are a Type B construction, external walls and components incorporated within them are required to be non-combustible.

However, the pub and accommodation building propose to retain the existing windows as the timber framing does not meet the combustibility requirement as per NCC Clause C2D10.

Table 9 Assessment overview

DTS departure	
Description	The pub and accommodation building proposed to retain the existing timber sash windows.
NCC DTS clause	Clause C2D10
Methodology	
Assessment methodology	Other verification methods
Type of assessment	Qualitative
Fire safety sub-systems addressed	Sub-system A – Fire initiation, development and control Sub-system C – Fire spread, impact and control

8.2 ACCEPTANCE CRITERIA

The proposed solution is considered acceptable if it can be demonstrated that the existing timber sash windows within the wall system is not considered to adversely increase the risk of fire spread between the pub and the SOU's.

8.3 FIRE SCENARIOS

The following relevant fire scenarios have been identified for analysis:

+ The worst credible scenario is considered to be a fire originating within one of the SOUs comprising the timber sash windows. Fire parameters are not required to be determined based on the qualitative nature of the assessment.

8.4 ANALYSIS

According to Clause C2D10(1)(a) of the BCA 2022, external walls are required to be compromised entirely of non-combustible components. The Guide to the BCA states that the intent of this clause is "*to specify the non-combustibility for building elements and to permit the use of certain materials that are known to provide acceptable levels of fire safety where an element is required to be non-combustible".* Such restrictions on combustible products are to ultimately limit the potential size of a fire within a fire-compartment. If combustible elements are introduced, there is always a risk that these elements could contribute to the fire originating within a compartment and increase a fire size and intensity.

Due to the presence of timber the subject walls do not comply with Clause C2D10 of the BCA, as timber is combustible. Nevertheless, it is considered that the timber window frames within the wall system are not considered to adversely increase the risk of fire spread due to the following:

- As mentioned above, the primary requirement of Clause C2D10 of the BCA is to limit the potential size of a fire within a fire-compartment. The introduction of the timber windows within the subject wall systems will lead to minor increase the amount of fuel load within the building however this is considered to be insignificant to expected level of furnishing within the building. The addition of timber in certain location as part of the wall system is not expected to adversely affect the fuel load.
- The building is to be provided with a sprinkler system in accordance with specification 17 of the NCC and AS 2118.1:2017. The successful activation of the sprinklers is expected to provide the following benefits:
  - A reduction in the rate of burning and quantity of smoke produced, subsequently increasing the available safe egress time.
  - A reduced fire intensity and duration, which in turn reduces the severity of fire exposure to structural and fire separating elements.
  - A reduction in the chances of a fire spreading beyond the area of origin or flashover occurring.
- The successful operation of the sprinkler system is expected to have the following impact on compartment temperatures during a fire[4]:
  - The average temperatures outside the immediate area of operation of the sprinkler system will be below 100 °C.
  - The temperature in the localised area above the fire will be somewhat higher than the mean compartment temperature but is still unlikely to exceed 200 °C.
  - Full scale tests have shown that standard sprinklers can be expected to maintain tenable conditions in relation to temperature and toxicity outside the room where the fire started.

8.5 CONCLUSIONS

The above assessment has demonstrated the acceptance criteria have been fulfilled. The proposed fire safety upgrades are therefore considered appropriate.

4England JP, Young SA, Hui MC and Kurban N, 2000, Guide for the design of fire resistant barriers and structures, Warrington Fire Research Australia and Building Control Commission, Melbourne VIC.

9.0 Assessment 3 – Exit Width of internal stairway

9.1 INTRODUCTION

Clause D2D8(1)(a) of the NCC states that *'the unobstructed width of each required exit or path of travel to an exit, except for ladders provided in accordance with D2D21, D3D23 or I3D5, and doorways, must be not less than 1 m.'*

The unobstructed width of the path of travel from internal non-fire isolated stairway serving the Class 3 accommodation reduced to approximately 900 mm within the proposed design as shown in Figure 8.

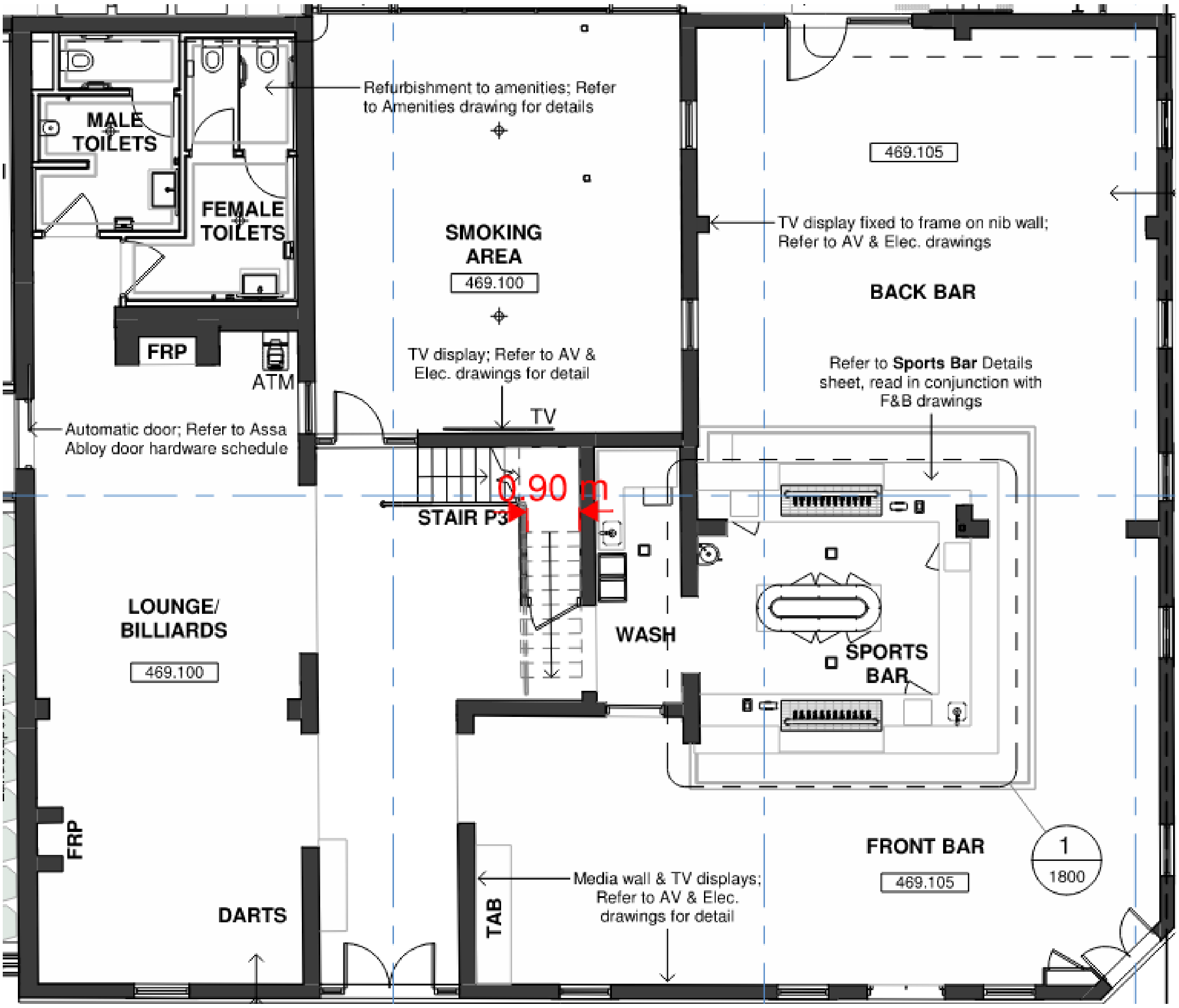


Figure 8: Reduced egress width in the stairway level

Table 10: Assessment overview

DTS departure	
Description	The path of travel from internal non-fire isolated stairway serving the Class 3 accommodation reduced to approximately 0.94 m instead of 1 m
NCC DTS clause	Clause D2D8
Methodology	
Assessment methodology	Other verification methods
Type of assessment	Qualitative, Absolute, Deterministic
Fire safety sub-systems addressed	Sub-system E – Occupant evacuation and control Sub-system F – Fire services intervention

9.2 ACCEPTANCE CRITERIA

The acceptance criteria for this assessment is that the reduced unobstructed width of The path of travel from internal non-fire isolated stairway serving the Class 3 accommodation does not impede or slow evacuation of occupants from the building.

9.3 HAZARDS AND PREVENTIVE MEASURES

9.3.1 Hazard identification

Table 11 identifies potential fire hazards associated with the departures from the DTS provisions of the NCC.

Table 11 Hazards and preventive / protective measures related to the assessment

Hazards	Preventive and protective measures
The reduced unobstructed width can potentially impede occupants negotiating a path of travel in an evacuation	+ Smoke detection in accordance with AS 1670.1-2018 + Sprinkler system installed in accordance with AS 2118.1-2017.

9.4 FIRE SCENARIOS

The following relevant fire scenarios have been identified for analysis:

+ A fire in level 1 requiring egress from the stairs with reduced width.

9.5 ANALYSIS

The intent of the BCA Clause D2D8 is to "*require exits and paths of travel to an exit to have dimensions to allow all occupants to evacuate within a reasonable time[5]"* and "*to allow safe exit of a given number of people expected in a particular building."*

The width of an exit pathway must be sufficient for a person to comfortably walk such that no delay would be expected during evacuation. This should take into account the physical size of the person and an amount of sideways sway while walking (including the boundary layers).

In passing through a location having a reduced width, the flow may be reduced due to either:

+ The width being greater than the shoulder breadth of an occupant such that there is sufficient width for an occupant to physically pass, but insufficient width to allow sideways sway while walking, or
+ The width being less than the shoulder breadth of an occupant, resulting in occupants having to rotate their body to pass through[6]

Such a change in the walking pattern may not be sustained for a significant distance; however, a single point location would be tolerated without a significant reduction in speed, due to the natural inclination to tilt the body sideways when passing through a localised area of reduced width such as a doorway. The is reflected in the allowance in the BCA for doorways to have an unobstructed width of 250 mm less than the unobstructed width required for the exit.

Where the width of a path of travel is sufficient for a person to comfortably walk but is not wide enough to permit occupants to walk side-by-side, occupants may take up a slightly staggered formation, thereby resulting in a slightly faster flow rate than when evacuating in single file.

The below table shows the mean dimensions of humans as a comparison to the stair widths using data in the Standards Australia Handbook(7) for British adults. However, a recent research by Ward(8) suggested that by using both the UK and USA data may be better, if designing for Australia, than the British data alone. Accordingly, the USA data(9) have also been included in the table for reference.

5 Australian Building Codes Board: National Construction code (NCC 2022)

6 Pedestrian Planning and Design, Revised Edition – Fruin, John J – 1987 – p19-20

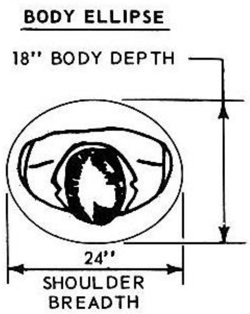
7 SAA HB 59, Handbook: Ergonomics-The human factor, A practical approach to work systems design, Standards Australia, Table 1, 94.

8 S. Ward, "Anthropometric data and Australian populations – do they fit?" HFESA 47th Annual Conference 2011, Ergonomics Australia- Special Edition.

9 Kodak's Ergonomic Design for People at Work, 2nd Ed. Table 1.5, pp 48 - 49.

Table 12: The mean dimensions of human as per UK and USA data.

Source of data		Male Percentiles			Female Percentiles		
		5th	50th	95th	5th	50th	95th
UK data	Hip Width	310 mm	360 mm	405 mm	310 mm	370 mm	435 mm
	Shoulder Width	420 mm	465 mm	510 mm	355 mm	395 mm	435 mm
USA data	Hip Width	310 mm	356 mm	402 mm	328 mm	380 mm	432 mm
	Shoulder Width	416 mm	454 mm	492 mm	348 mm	390 mm	432 mm



Studies undertaken by Fruin (10) for pedestrian planning and design for occupant queuing use an 18 by 24 inch (457 by 610 mm) body ellipse, representing a large male body and taking into account personal articles that may be being carried, body sway while standing, as well as natural psychological preferences to avoid bodily contact with other items or people. Fruin also cites studies undertaken that show a shoulder breadth of 20.7 inches (525.8 mm) for the 99th percentile of civilian men, with a recommended addition of 1.5 inches (38.1 mm) for heavy clothing. Similar studies of fully clothed male labourers gave a shoulder breadth of 22.8 inches (579.1 mm) for the 95th percentile.

Therefore, for the credible worst-case scenario, a body width of 580 mm is considered appropriate on which to base the physical size (breadth) of the moving occupant, without taking into account sideways sway while walking.

The effective width model developed from Pauls' study (11) takes into account the propensity of people to sway laterally as they walk. This model determines the width remaining once edge effects are deducted in from each wall boundary and handrail centreline.

Table 3-14.1 ***Boundary Layer Widths***

Exit Route Element	Boundary Layer (in.)	Boundary Layer (cm)
Stairways—wall or side of tread	6	15
Railings, handrails[a]	3.5	9
Theater chairs, stadium benches	0	0
Corridor, ramp walls	8	20
Obstacles	4	10
Wide concourses, passageways	<18	46
Door, archways	6	15

[a]Where handrails are present, use the value if it results in a lesser effective width.

Figure 9: Boundary layer width

Occupants egressing from the fire stair are provided with a wall on one side and handrail on the other. Therefore, the boundary layer will be reduced by 25 mm per handrail. Based on the details Figure 9, this results in a total boundary width of 215 mm (150 + 90 – 25). Considering a body width of 580 mm, the

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10 Pedestrian Planning and Design, Revised Edition – Fruin, John J – 1987 – p20

11 SFPE Handbook of Fire Protection Engineering, Fifth Edition, p 2124.

minimum unobstructed width for a person to comfortably walk without significantly reducing the flow within this path of travel for each area of reduced width is 795 mm which is less than the minimum 944 mm on the subject stairs.

Therefore, the reduced width of the path of travel is unlikely to affect safe movement of occupants and is adequate to allow occupants to safely evacuate in a fire emergency

9.5.1 Fire Brigade intervention

Additionally, it is noted that a DTS 1 m wide egress path also provides some opportunity for counter-flow – i.e. attending fire brigade personnel to pass by evacuating occupants. The reduced width of the corridor may not afford the same opportunity for counterflow however there is a second stairway which connects the pub area to the residential units which can be used by the brigade in case the stair is crowded with people evacuating making it difficult for the brigade to move through the crowd.

9.6 CONCLUSIONS

The above assessment has demonstrated the acceptance criteria have been fulfilled. The proposed fire safety upgrades are therefore considered appropriate.

10.0 Assessment 4 – SOU egress

10.1 INTRODUCTION

A number of existing non-conformances relating to egress from SOU to reach open space are to be resolved via provision of new fire safety systems.

Table 13 Assessment overview

DTS departure	
Description	Protection of egress path from SOU's differs from DTS provisions: + The accommodation rooms on level 1 are served by a public corridor. Although the corridor itself does not exceed 40 m the smoke separation intervals cannot be quantified due to the interconnection with the pub via the existing open stairway. + Existing solid core doors may not be "tight fitting". + Path of travel from SOU rooms 12 and 13 is along an external balcony passing by windows which are less than 1.5 m high. + Two non-fire isolated stairways provide egress from level 1 staff accommodation area. Both stairways are discharged to the ground floor of the pub. Although some separation is provided it may not be in full compliance with DTS smoke separation requirements.
NCC DTS clause	C3D15 C4D12 D2D14(6)
Methodology	
Assessment methodology	Other verification methods
Type of assessment	Qualitative
Fire safety sub-systems addressed	Sub-system B – Smoke development, spread and control Sub-system E – Occupant evacuation and control

10.2 ACCEPTANCE CRITERIA

The acceptance criteria for this assessment is that the design facilitates safe occupant evacuation.

10.3 FIRE SCENARIOS

The following relevant fire scenarios have been identified for analysis:

+ Fire in ground level pub area.
+ Fire within a unit.

10.4 ANALYSIS

10.4.1 Introduction

The intent of Clause D2D14 is "*to require that a person using a non-fire isolated stairway or ramp be provided with a safe evacuation path".* Similarly DTS clauses C3D15 and C4D12 are intended to protect egress paths from the effects of a fire inside an SOU. This assessment considers how the fire safety systems provided resist spread of smoke into the egress paths.

10.4.2 Fire in the pub area.

The non-fire isolated stairways connecting the ground (pub) and Level 1 (SOUs) are protected by smoke baffles, the path of smoke travel from the ground level to level 1 depends on the building layout and the location of the fire.

Smoke naturally rises due to the buoyancy effect, as the hot gases generated by a fire are less dense than the cooler surrounding air. When a fire starts on the ground floor, this rising smoke can move through stairwells, potentially spreading to upper levels and endangering occupants and escape routes.

To address this, smoke baffles are incorporated around the stair void on the ground and first levels. These baffles act as barriers to prevent smoke rising up to the level 1 egress path or from reaching the new egress stairs to the north of the pub. In the event of a fire in the pub the level 1 corridor and north exit from level 1are therefore protected from smoke during evacuation period.

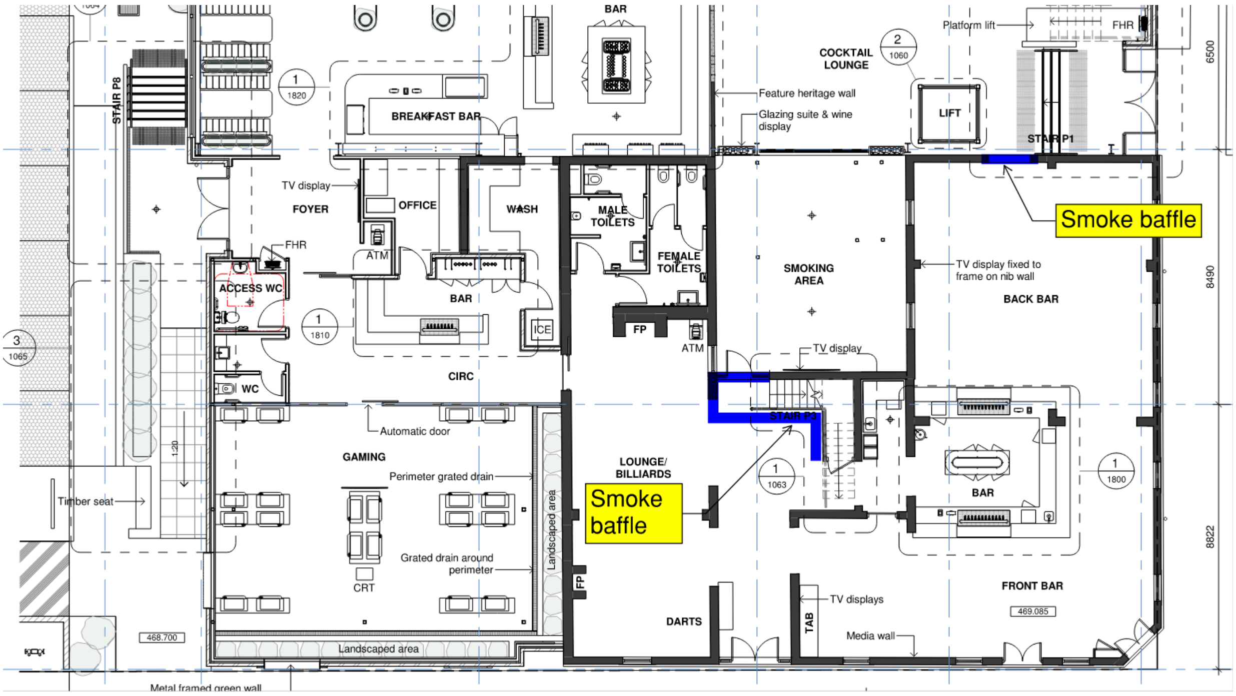

Figure 10: Smoke baffles proposed on ground floor.

10.4.3 Fire within a unit

The public corridor is separated from the SOUs by fire rated bounding construction and considered to have a low fire load. The building is provided with smoke detection system throughout and is sprinkler protected throughout. The sprinkler system can therefore be expected to maintain tenable conditions for evacuation in the fire-separated public corridors in the event of a fire within a unit.

Further, the building has multiple measures that will protect the multiple exit from being compromised in the event of a fire:

+ Sprinkler system to reduce fire size, reduce smoke production, and prevent fire spread beyond compartment of origin.
+ Smoke seals on SOU doors to prevent smoke spread. The effectiveness of smoke seals has been demonstrated to delay onset of untenable conditions with respect to smoke layer height, smoke layer temperature, and visibility by at least 14 minutes. Appendix C
+ Smoke seals to be for medium temperature smoke so that even if the sprinkler fails the smoke seals will still continue to prevent smoke spread.
+ To mitigate the potential blockage risk of the exit due to the fire, fuel storage restriction on all public lobbies will be proposed.

10.5 CONCLUSIONS

The above assessment has demonstrated the acceptance criteria have been fulfilled. The proposed fire safety upgrades are therefore considered appropriate.

11.0 Assessment 5 – Door swing in the pub area

11.1 INTRODUCTION

Clause D3D25(1)(b) of the NCC states that 'a swinging door in a required exit or forming part of a required exit must swing in the direction of egress unless –

(i) *it serves a building or part with a floor area not more than 200 m², it is the only required exit from the building or part, and it is fitted with a device for holding it in the open position; or*

(ii) *it serves a sanitary compartment or airlock (in which case it may swing in either direction).'*

It is proposed that the exit door serving as a required exit for the heritage pub is proposed to remain inward swinging opening to pub will not swing in the direction of egress.

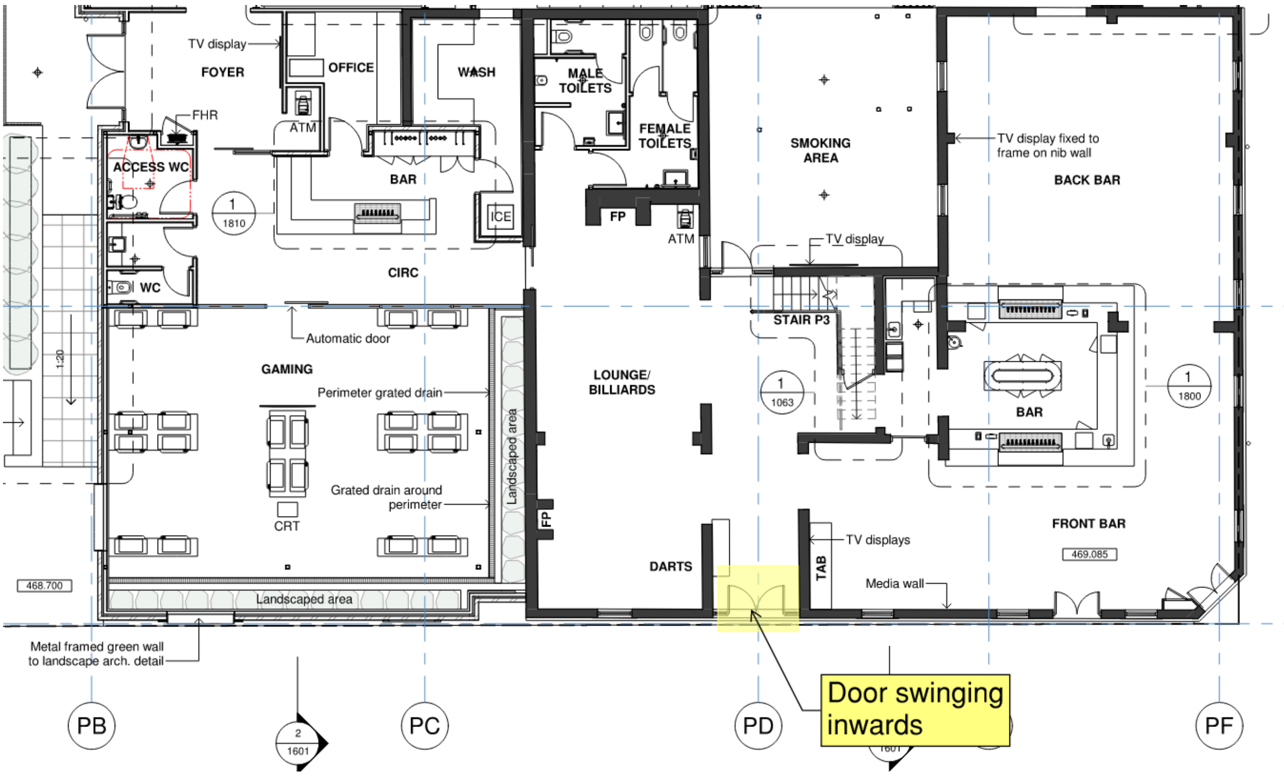

Figure 11: Door swing indicated in the existing pub area on ground level.

Table 14 Assessment overview

DTS departure	
Description	It is proposed that the exit door serving as a required exit for the heritage pub is proposed to remain inward swinging opening to pub will not swing in the direction of egress.
NCC DTS clause	Clause D3D25
Methodology	
Assessment methodology	Comparison to the DTS provisions
Type of assessment	Qualitative, Comparative
Fire safety sub-systems addressed	Sub-system E – Occupant evacuation and control

11.2 ACCEPTANCE CRITERIA

The acceptance criteria for this assessment is that the number of occupants required to evacuate through the exit is equivalent to a design complying with the DTS provisions of the NCC where an inward swinging door would be permitted.

11.3 FIRE SCENARIOS

11.3.1 Identification of fire scenarios

+ Fire in the southern portion of the building A.

11.4 ANALYSIS

The use of a door that opens against the direction of egress can slow down occupants as they must delay their movement through the doorway for the duration it takes to swing the door fully open. This motion can be further delayed in a crowded occupancy as other occupants surrounding the doorway may impede the opening of any doors.

Clause D3D25(1)(b) of the NCC grants an exemption for a building or a portion of a building less than 200 m^2 in floor area. The NCC considers that a floor area in excess of 200 m^2 will have a higher population, where the problems associated with doors swinging inwards are worsened by the number of occupants. The 200 m2 floor area limitation is a notional figure which covers all possible building designs and uses. Although the exemption is granted based on minimal population, the population that the criteria will limit a building or part of a building to is a function of both floor area and use.

The population of any area of a building complying with the DTS provisions of the NCC can be estimated using table D2D18 of the NCC. Table D2D18 of the NCC gives typical maximum population loads that could be expected for various occupancy types. The calculated populations are based upon a floor area of 200 m^2 and are summarised within Table 15.The calculations show that the maximum population expected for a floor area of 200 m^2 varies significantly for different building uses when calculated in accordance with table D2D18 of the NCC.

Table 15: Population based on floor area as per D2D18

Occupancy type	Population density specified by NCC table D2D18 (m²/person)	Population expected for a floor area of 200 m² in accordance with NCC table D2D18
Bar	1	200
Office	10	20
Retail	3-5	40-67

The maximum total population expected within the 250 m² is 250 people based on table D2D18 of the NCC, which specifies 1 m²/person for bar areas. This is more than the maximum population calculated in accordance with table D2D18 of the NCC for different building uses with a floor area of 200 m².

The nominated door is not the sole exit for this area. There are two additional doors provided, which comply with the Deemed-to-Satisfy (DTS) design requirements. Both of these doors have a clear width of 1 meter, ensuring adequate capacity for occupant evacuation Given the open layout of the building and the fact that the entry and exit doors are the same, occupants in this area would likely have a clear understanding of the available exits, as these are easily visible within the space. The inward-swinging door primarily serves an area of approximately 100 m², which includes the lounge and a portion of the tab area. This localized service ensures that the door's functionality aligns with the limited occupant load of the specific area, minimizing its impact on overall evacuation efficiency.

Additionally, alternative clear path of travel is available refer to Figure 12.

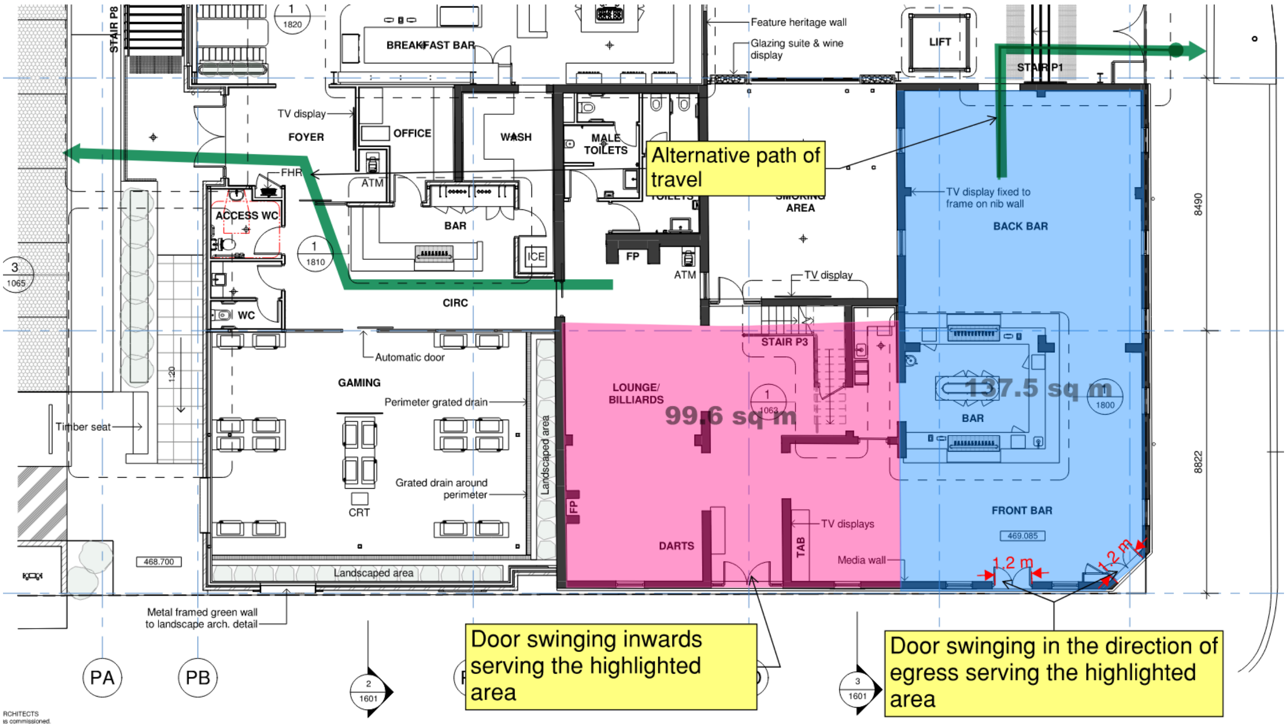

Figure 12: Alternative path of travel in the existing pub area.

11.5 CONCLUSIONS

The above assessment has demonstrated the acceptance criteria have been fulfilled. The proposed fire safety upgrades are therefore considered appropriate.

12.0 Assessment 6 – Portable fire extinguishers in lieu of fire hose reel

12.1 INTRODUCTION

It is proposed to omit fire hose reels from the Class 6 pub areas in Building A.

Table 16 Assessment overview

DTS departure	
Description	Portable fire extinguisher are provided in lieu of fire hose Class 6 pub areas
NCC DTS clause	Clause E1D3
Methodology	
Assessment methodology	Other verification methods
Type of assessment	Qualitative
Fire safety sub-systems addressed	Sub-system A – Fire initiation, development and control Sub-system D – Fire detection, warning and suppression

12.2 ACCEPTANCE CRITERIA

The proposed design is considered acceptable if it can be demonstrated that initial fire-fighting activities undertaken by occupants are not adversely affected by the omission of fire hose reels within the Class 6 area

12.3 FIRE SCENARIOS

The following fire scenarios will be considered in the analysis:

+ **Fire Scenario 1:** A Fire originating on the Class 6 pub area.

The assessment will be qualitative in nature and as such no specific quantitative fire characteristics will be established.

12.4 ANALYSIS

12.4.1 Timing for Occupant Intervention

With consideration of the fire scenario above, depending on the nature of the fire, occupants may only have a short time to pick up a fire hose (or extinguisher) and attack the growing fire. Of special concern is the hazard posed to occupants using a fire hose if they remain in the building for extended periods while the surrounding conditions deteriorate.

12.4.2 Extinguishers in lieu of fire hose reels

It is considered that fire extinguishers would be an appropriate alternative in lieu of fire hose reels with the appropriately installed in accordance with AS 2444-2001 for the following reasons:

+ Extinguishers or fire hose reels are generally intended for the use by occupants. It is understood that the BCA DTS Provisions allow occupants to fight a fire at its early stage with some expectation of extinguishment or some suppression may reduce the fire hazard.

- Portable fire extinguishers have the ability to be safely used to attack multiple types of fire hazard where water (hose reel) may be less efficient at extinguishing the fire. This is particularly important given the room in which the FHR is proposed to be omitted is an electrical / communications room, where water suppression is not considered to be safe for an occupant.
- Fire extinguishers, as a compact portable unit are more manoeuvrable than a hose reel connected to the wall, which means that occupants using an extinguisher can be expected to reach the fire, attack and evacuate more rapidly than occupants relying on a fire hose reel. Similarly, the finite supply of fire-fighting chemicals supplied by a fire extinguisher limits the temptation to carry on fighting a growing fire, instead of the unlimited supply from a hose reel which may enable occupants to attempt to fight a fire which is growing out of control and is unsafe.
- One disadvantage of fire extinguishers is that they have a limited capacity when compared to a fire hose reel. Therefore, it is considered that if a fire grows large enough, it may overcome the suppressing capabilities of the fire extinguisher. However, as fire extinguishers are intended for use in the initial stages of a fire, occupants would be expected to be engaging small fires, regardless of the size and fuel loads of the fire compartment. By the time the fire grows too large to be controlled by an extinguisher, occupants would be

12.4.3 Summary

Therefore, the proposed omission of fire hose reels is considered not to increase the risk to occupants being exposed to fire and smoke within the pub area. Reason being that under such scenario assessed above, the portable extinguishers are considered to be more effective than fire hose reels when engaging a fire at its early stage

12.5 CONCLUSIONS

The above assessment has demonstrated the acceptance criteria have been fulfilled. The proposed fire safety upgrades are therefore considered appropriate.

Appendix A - Drawings and information

Drawing title	Drawing no	Date	Drawn
Wall types	WD-700	06/2024	Bergstrom
GA Plan- LGF	WD-1030	06/2024	Bergstrom
GA Plan- GF	WD-1031	06/2024	Bergstrom
GA Plan- L1	WD-1032	06/2024	Bergstrom

Other information	Reference	Date	Prepared by
BCA Fire Safety Upgrade Report	2024/1221	13/12/2024	SWP

Appendix B - Probabilistic FRL assessment

B.1 INTRODUCTION

This assessment is a comparative probabilistic risk assessment(s) of the proposed design incorporating lower FRLs and an enhanced AS 2118.1 sprinkler system versus a DTS compliant reference design FRL's with no sprinkler system to demonstrate that the probability of failure of fire resisting elements is equivalent or lesser in the proposed design than a fire in a DTS compliant reference design.

B.2 METHODOLOGY

The methodology is as per the risk-based equivalence approach to fire resistance design by Yaping He and Stephen Grubits[12].

The probabilistic assessment approximates the probability of failure of an element of structure or fire resisting element based on the calculation of fire severity within the subject fire compartment. Essentially, the calculation of fire severity determines the fire exposure time of the subject element (required FRL) to determine whether the FRL of the element (Notional FRL) is exceeded. The fire severity within a fire compartment is approximated based on the estimated fuel load and available ventilation provided to the space. The fire severity and fire resistance levels (FRLs) are calculated based on the ISO standard fire curve.

The aim of the assessment is to provide a basis for comparison of the probability of failure for the Proposed Design incorporating active fire safety measures and a DTS compliant Reference Design incorporating the minimum required Fire Resistance Levels established in Specification 5 of the BCA.

In order to demonstrate equivalence with the BCA, it must be demonstrated that the Proposed Design results in equivalent or greater performance than a DTS compliant Reference Design. Accordingly, "equivalence" of active and passive fire protection must be approximated based on the probability of failure (i.e. the required fire resistance exceeds the available fire resistance (Notional FRL) of the subject element). Figure 13 illustrates sample probabilistic distributions for Required and Notional Fire Resistance Levels relevant to the Reference and Proposed Designs, respectively.

The Required FRL curve for the probabilistically defined DTS compliant Reference Design is approximated based on the distributions of a variety of building characteristics relevant to the subject occupancy classification as defined by the BCA, taking into consideration factors such as the fire load density, floor area, window height and window area. The Notional FRL curve for the Reference Design is based on the FRL prescribed in the BCA, expected product variations and determination uncertainty. Alternatively, a set value for the Notional FRL could be adopted and represented as a vertical line as noted by the mean in Figure 13.

The Required FRL curve for the Proposed Design is approximated based on the set building characteristics subject to the development and the probabilistic operation of the sprinkler system. Importantly, the fire load density adopted for fire severity calculations is reduced to 17% of the maximum for the compartment when sprinklers operate[13]. Therefore, the Required FRL curve results in two peaks related to the probability of

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12 He, Yaping and Grubits, Stephen, *Risk-based equivalence approach to fire resistance design in buildings*, Journal of Fire Protection Engineering 2010; 20; 5.

13 Poon, L., 2013, Assessing the reliance of sprinklers for active protection of structures, Procedia Engineering 62 (2013), page 618-628.

success or failure of the sprinkler system. The second peak is similar in shape to the Reference Design, reduced to reflect the much lower frequency of non-sprinkler controlled fires. The Notional FRL curve for the Proposed Design is based on the FRL proposed to be achieved by the subject elements, expected product variations and determination uncertainty. Alternatively, a set value for the Notional FRL could be adopted and represented as a vertical line as noted by the mean in Figure 13.

Failure occurs when the Notional FRL of the subject element is less than the Required FRL defined by the fire severity, i.e. the region of overlap between the curves. Thus the area of overlap represents the probability of failure. Therefore, the Proposed and Reference Designs are deemed to be equivalent when the probability of failure or region of overlap between curves is equal. Accordingly, the reduction in FRL between designs can be approximated by the difference in Notional FRL of the comparative designs when "equivalence" is reached between designs, as depicted in Figure 13.

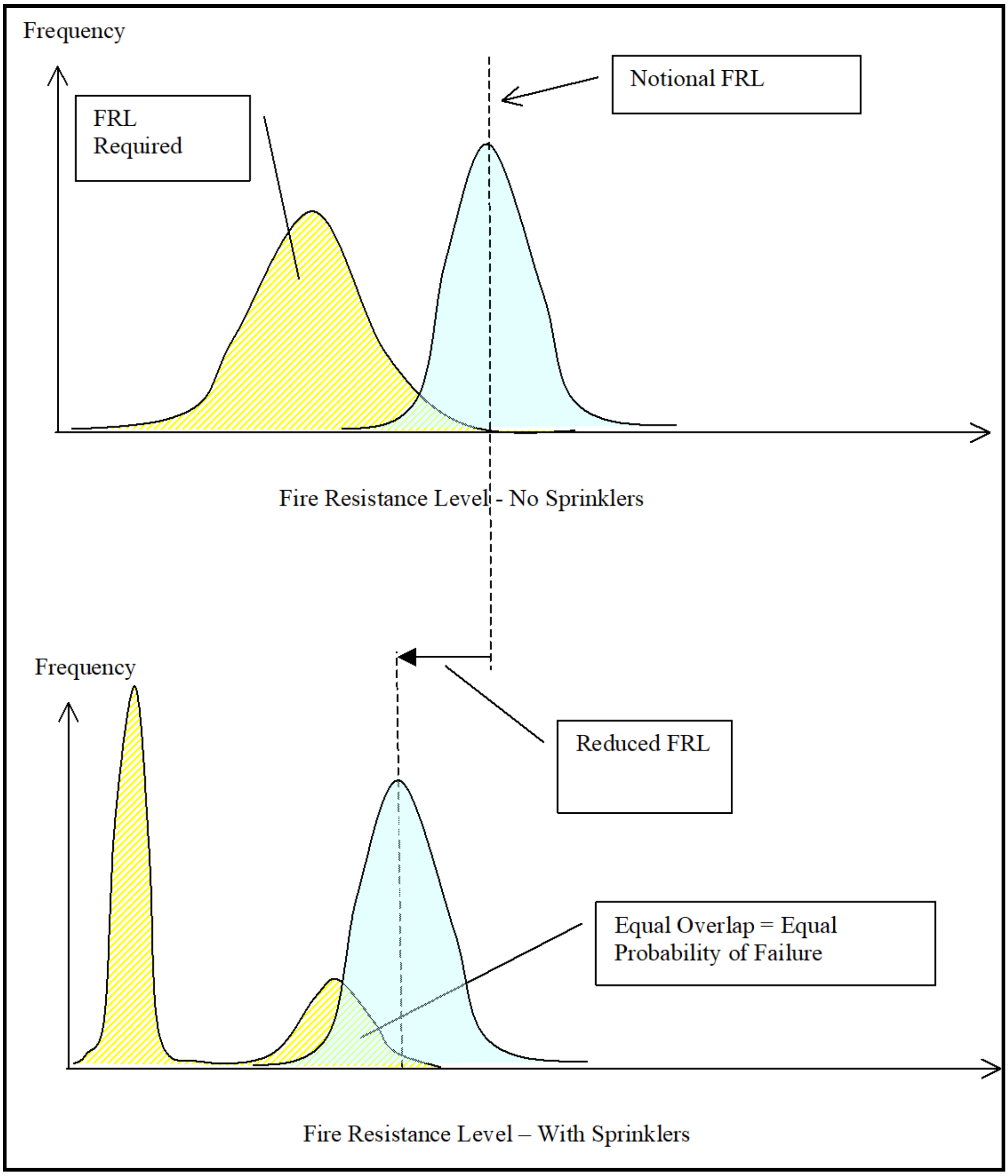

Figure 13: "Equivalence" concept between active and passive fire protection systems

A number of relationships have been developed to estimate the required FRL[14]. The median fire resistance value calculated by three relationships based on Thomas, Laws and Maholtra is used as the best estimate of the required fire resistance. The formulae used to calculate the required FRLs relate to the compartment fuel load, compartment floor area, compartment opening sizes, and the compartment bounding surface area applicable to ventilation-controlled fires and have as a common characteristic, that the FRL is dependent upon the ventilation factor $Ah^{1/2}$.

B.3 KEY ASSUMPTIONS AND INPUTS

B.3.1 Sprinkler reliability

The installation of a sprinkler system typically reduces the compartment temperature during a fire[15] [16]. and is effective in resisting fire growth beyond the compartment of origin[17], prevent fully developed flashover fires and reduce buoyancy driven smoke flow[18].

The installation of a fire sprinkler system has also demonstrated a high level of reliability through numerous statistical studies. Research conducted by Factory Mutual estimates a reliability rate of approximately 95%[19]. In a report[20] published by OneSteel, the effectiveness of sprinkler system is considered to be at least 98%. Budnick estimated mean reliability to be 93~96% based on 16 separate studies[21], noting that reliability is likely to be higher where sprinkler systems are regularly maintained. The credible range of reliability is therefore 93% to 98%, with reliability being a key factor in how effective a sprinkler system is.

14Drysdale, D., An Introduction to Fire Dynamics, Second Edition, John Wiley & Sons, 1999, pp354-360.

15 England, J., Young, S., Hui, M., & Kurban, N., “Guide for design of fire resistant barriers and structures”, Victoria: Warrington Fire Research (Aust) Pty Ltd and Building Control Commission, 2000.

16 CIBSE, “Relationships for smoke control calculations”, UK: Technical Memoranda TM:19:1995, 1995.

17 Thomas, I.R., “Effectiveness of fire safety components and systems”, Journal of Fire Protection Engineering, Volume 12, Society of Fire Protection engineers

18 Mowrer F. W et al, “Journal of Fire Protection Engineering - Volume 14”, United States of America, 2004.

19 B.G. Vincent, H-C Kung, and E.E. Hill, “Sprinklered executive office fire tests,” Fire Science & Technology, Vol. 8 No. 2, pp. 29-39, 1988.

20 Design of Sports Stand Buildings for Fire Safety, OneSteel – Market Mills, Australia, September 2006.

21 Budnick, E., “Automatic sprinkler system reliability”, Fire Protection Engineering, 7-9, 2001.

Table 1. Reasons for unsatisfactory sprinkler performance [18]

Sprinkler failure reason cited in NFPA statistic [18]	Most likely reason in NFIRS [19]	Percentage of 2,693 incidents
Water to sprinklers shut off	System shut off	41%
Inadequate water supply	Not enough agent released	12%
Inadequate maintenance	Lack of maintenance	10%
Obstruction to distribution	Agent (water) did not reach fire	10%
Hazard of occupancy (excluding explosion damaged system)	Inappropriate system or Other	9%
Hazard of occupancy/explosion damaged system	Component damaged	7%
Dry pipe (e.g., defective valve, poor design through excessive heads)	Agent did not reach fire, Not enough agent released, or Other	3%
Antiquated system (particularly pipe sizes or sprinkler spacing to old standard)	Inappropriate system, Component damaged, or Other	2%
Miscellaneous or unknown	Unknown or Other	2%
Exposure fire	Excluded as sprinklers not in fire area	2%
System frozen	Agent did not reach fire, Not enough agent released, Component damaged or Other	
Other defective operation	Other	1%

Figure 14 Sprinkler reliability factors.

B.3.2 Design fire parameters

A summary of the comparative inputs for the Proposed and Reference Designs is provided in Table 17. The subject building design is based on level 1, that being the largest compartment potentially affected.

Table 17: Proposed Design and Reference Design Comparison Summary

Item	Subject building design	DTS Reference Design
Fire resistance (as described in report section 5.0)	Lowest common denominator Zero FRL (1 minute FRL used as a non-zero input is required for the calculations)	Lowest common denominator 30 minutes ceiling FRL
Sprinkler Protection	AS2118.1 system	None
Floor Area (m^2)	165	Distribution of Type B floor area
Compartment height (m)	2.7	Distribution of compartment height
Window opening area (m^2)	10	Distribution of window opening height and width.
Fire load density (MJ/m^2)	400	Distribution of Class 3 fire load density in accordance with IFEG distribution factors, with 400 as the mean.

B.4 PROBABILISTIC ASSESSMENT RESULTS

All scenarios including the Proposed and Reference Designs were undertaken by running 10,000 simulations of the probabilistic assessment each, resulting in the approximation of required and realised FRLs. By comparing the required and realised FRLs for each design case, a probability of failure can be approximated for comparison with other design cases. The simulation outputs probability of failure for both cases are presented in Figure 15 and Figure 16.

- DTS design 61 %
- Subject building design 1.7 %

The results demonstrate that the assessed design is less likely to suffer failure during a full burnout fire event than a DTS design. In fact the subject building is twice as likely to achieve the fire resistance objectives as a DTS compliant building.

Probabilistic Assessment - Reference Design

Assumptions

Constructed FRL taken as 30 minutes - ie lowest common denominator being the fire protective covering to ceiling protecting the floor above.

Fire load range as per IFEG for various dwelling occupancies

INPUT

Fire Compartment Characteristics

		Realised Ave.		Distribution	Mean/Se	Std. Dev.	Min	Max
Floor Area of Compartment	Ac	1244	m^2	Normal	1400	600	50	2000
Height of Compartment	Hc	2.55	m	Normal	2.55	0.12	2.40	2.70
Height of Window Openings	Ho	1.24	m	Triangular	1.50		0.40	2.10
Total Width of Window Openings	Wo	83	m	Triangular	56		2	190
Total Surface Area	A	4173	m^2					
Calorific Value of Materials	CV	16.06	MJ/kg	Normal	16	5	5	32
Fire Load Density	Qt	403.39	MJ/m^2	Normal	400	120	120	800
Sprinklers		No						
Realised Fire Load Density	Qt	27.73	kg/m^2					

Fire Resistance Level

		Realised Ave.		Distribution	Mean/Se	Std. Dev.	Min	Max
Constructed FRL		30	mins					
FRL Distribution		44	mins	Normal	40	20	30	60
Law's Fire Resistance Time	t_1	58	mins					
Maholtra's Fire Resistance Time	t_2	67	mins					
Maholtra's Fire Resistance Time	t_3	60	mins					
Mean Required FR Time	t	62	mins					
Median Required FR Time		60	mins					

OUTPUT

Margin	**Δ**	**-15**	**mins**
Probability of Failure	**q**	**61.27**	**%**

Figure 15 DTS design probability of failure simulation results (10,000 sample size)

Probabilistic Assessment - Proposed Design

JENSEN HUGHES

Assumptions

Constructed FRL taken as 1 minute - ie pressed metal ceiling parts protecting the floor above.

INPUT

Fire Compartment Characteristics

		Realised Ave.		Distribution	Mean/Set	Std. Dev.	Min	Max
Floor Area of Compartment	Ac	2000	m²	Set Value	2000			
Height of Compartment	Hc	3.60	m	Set Value	3.60			
Height of Window Openings	Ho	1.80	m	Set Value	1.80			
Total Width of Window Openings	Wo	120	m	Set Value	120			
Total Surface Area	A	6805	m²					
Calorific Value of Materials	CV	16.00	MJ/kg	Set Value	16			
Fire Load Density	Qt	400.00	MJ/m²	Set Value	400			
Sprinklers		Yes	Reliability	98	%	Qt Red.	17	%
Realised Fire Load Density	Qt	4.61	kg/m²					

Fire Resistance Level

		Realised Ave.		Distribution	Mean/Set	Std. Dev.	Min	Max
Constructed FRL		1	mins					
FRL Distribution		15	mins	Normal	15	8	10	20
Law's Fire Resistance Time	t_1	8	mins					
Maholtra's Fire Resistance Time	t_2	8	mins					
Maholtra's Fire Resistance Time	t_3	8	mins					
Mean Required FR Time	t	8	mins					
Median Required FR Time		8	mins					

OUTPUT

Margin	**Δ**	**7**	**mins**
Probability of Failure	**q**	**1.72**	**%**

Figure 16 Subject design probability of failure simulation results (10,000 sample size)

Appendix C Effectiveness of smoke seals

In order to provide a higher level of fire and life safety to occupants it is proposed to provide ambient and medium temperature smoke seals to all doors. The smoke seals are to be applied to all four edges of the doors and are able to withstand smoke temperature of 200°C for 30 minutes with their smoke leakage rates is no higher than 3 m^3 per hour per metre of the door perimeter.

The smoke seals provided to all SOUs are expected to reduce the amount of smoke that leaks into the corridor. This is supported by the experiments conducted by Rakic[22] which is summarised in The improvement of the enclosed public corridors with respect to tenability by fitting the aforementioned smoke seals to doorsets can be found in the full-scale fire test investigation by Young and England () in which a detailed assessment was undertaken to compare the level of smoke leakage between doors provided with and without elevated temperature smoke seals to a corridor of 6.0 m long, 1.8 m wide and 2.4 m high. The investigation results summarised in Table 19 show that the provision of smoke seals could delay the onset of untenable conditions with respect to smoke layer height, smoke layer temperature and visibility by approximately 14 mins for an ISO fire curve.

Table 18. The experiments show that the amount of smoke that leaks via the door that is provided with smoke seals is significantly less than the amount of smoke that leaks through the door that is not provided with smoke seals.

The improvement of the enclosed public corridors with respect to tenability by fitting the aforementioned smoke seals to doorsets can be found in the full-scale fire test investigation by Young and England [(23)] in which a detailed assessment was undertaken to compare the level of smoke leakage between doors provided with and without elevated temperature smoke seals to a corridor of 6.0 m long, 1.8 m wide and 2.4 m high. The investigation results summarised in Table 19 show that the provision of smoke seals could delay the onset of untenable conditions with respect to smoke layer height, smoke layer temperature and visibility by approximately 14 mins for an ISO fire curve.

Table 18 Summary of medium temperature smoke seal test results

Cross-door Pressure Difference (Pa)	Total Leakage of AS2688 Solid Core Door with No Seals (m3/h)	Total Leakage of AS2688 Solid Core Door + Perimeter Smoke Seals (m3/h)
12.5	172.2	5.1
25	214.84	8.31
50	254.28	12.43
75	307.69	16.52

22 Maintaining Tenability of Exitways in Buildings in the Event of Fire – Literature Review, by BRANZ, study report No. 148 (2006).

Unit Entry Doors when Exposed to Simulated Sprinkler Controlled Fires – published in Fire Australia February 2000 P 24-28.

23 Young, S.A. and England, J.P., "The performance of doorsets to restrict the passage of smoke when exposed to simulated fully developed fires," Proceedings of the 8th Interflam Conference, Interscience Communications Limited, 1999.

Table 19 - Summary of smoke test seal results

Smoke seals fitted to door?	Smoke Layer Commenced Forming (min:sec)	Smoke Layer at approximately 2.0 m (min:sec)	Low Visibility in Corridor (min:sec)	No Visibility in Corridor (min:sec)
Yes	6:00	Not reported	19:10	21:30
No	3:30	5:35	5:45	6:15