FIRE SAFETY STRATEGY

Ivanhoe Estate - Building C1

Report Number:

172103_C1_Ivanhoe Estate - Building C1_FSS_04

Date:

05/10/2018

Fraser Property Australia Ltd

Suite 11 Lumiere Commercial

Level 12, 101 Bathurst Street NSW 2000

AFFINITY FIRE ENGINEERING

Affinity Fire Engineering (UK) Ltd
40 Bowling Green Lane
London, EC1R 0NE
+44 (0) 20 3384 0050
enquiries@affinity-eng.com

Affinity Fire Engineering
Suite 6.06, 6A Glen Street
Milsons Point NSW 2061
+61 2 9194 0590
enquiries@affinity-eng.com

Affinity Fire Engineering
Suite 123, 757 Bourke Street
Docklands VIC 3008
+61 3 8616 0686
enquiries@affinity-eng.com

REPORT DETAIL

Project: Ivanhoe Estate - Building C1
Document: Fire Safety Strategy
Report No. & Ref.: 172103_C1_Ivanhoe Estate - Building C1_FSS_04

Report Revision History

Rev	Date Issued	Comment	Prepared By	Reviewed By	Verified By
01	06/02/18	Draft Issue	**Wilfred Lau** *BE (Mechanical)* *Graduate Certificate in Fire Safety Engineering*	**Thomas O'Dwyer** *BE (Building), Grad Dip (Performance Based Building & Fire Codes)* *BPP0766*	
02	27/03/18	Final Issue			**Thomas O'Dwyer** *BE (Building), Grad Dip (Performance Based Building & Fire Codes)* *BPP0766* 
03	04/10/18	Final Issue: Rev A *Amendments to Masterplan Exhibition*			
04	05/10/18	Final Issue: Rev B *Updated masterplan image*			

EXECUTIVE SUMMARY

AFFINITY has been engaged by Fraser Property Australia Ltd to develop a preliminary Fire Safety Strategy for the residential development proposed to be located at Lot C1 at the Ivanhoe Estate. The project entails the construction of two separate towers sitting above a common basement car park and hence has been deemed to be a single united building. As the two towers are located on the same allotment, it is proposed that fire services infrastructure will be shared.

This Fire Safety Strategy (FSS) outlines the fire engineering principles that will be utilised in ensuring that the prescriptive non-compliances with the Deemed-to-Satisfy (DTS) provisions of the Building Code of Australia 2016 (BCA) [1], as noted herein, are resolved through a fire engineered Performance Solution in order to conform to the building regulations.

The complete fire engineered analysis will form the Fire Engineering Report, and as such is not documented herein. This Fire Safety Strategy does however outline the construction and management requirements considered necessary to achieve an acceptable level of life safety within the building and satisfy the Performance Requirements of the BCA.

CONTENTS

1 INTRODUCTION & SCOPE

1.1 Overview

This Fire Safety Strategy has been undertaken and nominates Performance Solutions for assessing compliance with the nominated Performance Requirements of the BCA [1] in accordance with the methodologies defined in the IFEG [3] and provide a workable and safe Fire Safety Strategy.

1.2 Fire Safety Objectives

The objective of the Fire Engineering Assessment is to develop a Fire Safety System, which satisfied the Performance Requirements of the NCC whilst maintaining an acceptable level of life safety, protection of adjacent property and adequate provisions for Fire Brigade intervention. At a community level, fire safety objectives are met if the relevant legislation and regulations are complied with. As stated in the NCC, *"Compliance with the NCC is achieved by satisfying the Performance Requirements"*. In addition to this, certain non-regulatory objectives exist as detailed below.

1.2.1 Building regulatory objectives

The following items are a summary of the fire and life safety objectives of the NCC:

- **Life safety of occupants -** the occupants must be able to leave the building (or remain in a safe refuge) without being subject to hazardous or untenable conditions. The objective of the Fire Engineering Assessment is to demonstrate that the proposed building design and fire safety systems would minimise the risk of exposing building occupants to hazardous or untenable conditions in an event of a fire.
- **Life safety of fire fighters -** fire fighters must be given a reasonable time to rescue any remaining occupants before hazardous conditions or building collapse occurs. The objective of the Fire Engineering Assessment is to demonstrate that the proposed building design and fire safety systems would facilitate fire brigade intervention and minimise the risk of exposing fire fighters to hazardous or untenable conditions in an event of a fire.
- **Protection of adjoining buildings** - structures must not collapse onto adjacent property and fire spread by radiation should not occur. The objective of the Fire Engineering Assessment is to demonstrate that the proposed building design and fire safety systems would minimise the risk of fire spreading from one building to another.

1.2.2 Fire brigade objectives

The overall philosophical Fire Brigade objectives throughout Australia are to protect life, property and the environment from fire, according to the Fire Brigade Intervention Model (FBIM) [11] as per the Fire Services State and Territory Acts and Regulations.

Over and above the requirements of the NCC, the Fire Brigade has functions with regard to property and environmental protection and considerations regarding occupational health and safety for its employees.

1.2.3 Non-prescribed objectives

Fire Engineering has an overarching benefit to many facets of the built environment where non-prescribed objectives can have an influence on the Fire Safety Strategy adopted. Although not assessed within, the following can be considered if requested.

- **Business continuity -** will the loss of a particular facility due to fire / smoke damage result in excessive financial impact on the client? For example, is the facility critical to business continuity?
- **Public perception -** should a fire occur within the facility is there likely to be questionable public perception about the safety and operation of the facility?
- **Environmental protection -** fires of excessive sizes can have significant effects on the environment which may require a detailed risk assessment to minimise such outcomes.
- **Heritage salvation -** buildings can have a heritage value for both cultural and educational purposes which can be destroyed by insufficient fire protection.
- **Risk mitigation / insurance limitations -** are there specific limitations on insurance with respect to risk mitigation and fire safety design? i.e. Does the relevant insurer have concerns with respect to open voids through the building?
- **Future proofing (isolation of systems) -** what flexibility is required in the overall design to allow for future development or changes in building layout?
- **Occupational Health and Safety (OHS) requirements -** buildings may have specific fire safety requirements pertaining to OHS requirements.

1.3 Regulatory Framework of the Fire Engineering Assessment

1.3.1 National Construction Code Series - Building Code of Australia

One of the goals of the NCC [1] is the achievement and maintenance of acceptable standards of safety from fire for the benefit of the community. This goal extends no further than is necessary in the public interest and is considered to be cost effective and not needlessly onerous in its application.

Section A0.2 of the NCC [1] outlines how compliance with the Performance Requirements can be satisfied. These are as follows:

(a) Performance Solution; or

(b) Deemed-to-Satisfy Solution; or
(c) Combination of (a) and (b).

Clause A0.5 of the NCC provides several different methods for determining that a Performance Solution complies with the Performance Requirements. These methods are summarised as follows:

(a) Evidence to support that the use of a material, form of construction or design meets a Performance Requirement or a Deemed-to-Satisfy Provision.
(b) Verification Methods such as:
    (i) the Verifications Methods in the NCC; or
    (ii) such other Verification Methods as the appropriate authority accepts for determining compliance with the Performance Requirements.
(c) Expert Judgment.
(d) Comparison with the Deemed-to-Satisfy Provisions.

Clause A0.7 of the NCC provides methods for complying with provisions A1.5 (to comply with Sections A to J of the NCC inclusive). The following method must be used to determine the Performance Requirements relevant to the Performance Solution: These methods are summarised as follows:

(a) Where a Performance Requirement is satisfied entirely by a Performance Solution:
    (i) Identify the relevant Performance Requirement from the Section or Part to which the Performance Solution applies.
    (ii) 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.
(b) Where a Performance Requirement is satisfied by a Performance Solution in combination with a Deemed-to-Satisfy Solution:
    (i) Identify the relevant Deemed-to-Satisfy Provisions of each Section or Part that is to be the subject of the Performance Solution.
    (ii) Identify the Performance Requirements from the same Sections or Parts that are relevant to the identified Deemed-to-Satisfy Provisions.
    (iii) 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 Deemed-to-Satisfy Provisions that are the subject of the Performance Solution.

1.3.2 International Fire Engineering Guidelines (IFEG)

The IFEG [3] document has been developed for use in fire safety design and assessment of buildings and reflects world's best practice. The document is intended to provide guidance for fire engineers as they work to develop and assess strategies that provide acceptable levels of safety.

The document is particularly useful in providing guidance in the design and assessment of Performance Solution against the Performance Requirements of the NCC. The prescribed methodology set out in the IFEG has been generally adopted in the Fire Engineering Report (FER).

1.3.3 Stakeholders

The Performance Solution has been developed collaboratively with the relevant stakeholders as identified in the table below:

Table 1-1: Relevant Stakeholders

Role	Name	Organisation
Client	Scott Clohessy	Fraser Property Australia Ltd
Architect	Luiz Maia	Candalepas
BCA/PCA	Vanessa Batty Darren Bugg	McKenzie Group
Building Services	Rob Beck Rebecca Fitzgerald	WSP
Registered Fire Safety Engineer	Thomas O' Dwyer (C10)	Affinity Fire Engineering
Fire Safety Consultant	Wilfred Lau	

It should be noted that at times some parties may have a vested interest in the outcome of the Fire Engineering assessment. Such parties can include local fire brigades, insurers, Environmental Protection Authority (EPA), project control groups, end users and community representatives. Although not always a legislative requirement, the design team should give due consideration to their inclusion in the Fire Engineering process. Where not required by legislation it is the client's decision to involve such parties, especially local fire brigade, to ensure a transparent and adequate fire safety solution for all. Where we are not notified of the inclusion of such parties it is assumed the client / representative has given due consideration to the above.

1.4 Sources of Information

The following sources of information have been relied upon in the preparation of this document:

- Architectural plans provided by Candalepas as indicated in Table 1-2.

Table 1-2: Drawings

DRAWING NO.	DESCRIPTION	ISSUE	DATE
DA 1050	Site Plan	P7	25-09-18
DA 1102	Basement 3 Floor Plan	P12	25-09-18
DA 1103	Basement 2 Floor Plan	P12	25-09-18
DA 1104	Basement 1 Floor Plan	P12	25-09-18
DA 1105	Lower Ground Floor Plan	-	-
DA 1106	Upper Ground Floor Plan	P14	25-09-18
DA 1107	Level 1 Floor Plan	P12	25-09-18
DA 1108	Level 2 Floor Plan	P12	25-09-18
DA 1109	Level 3 - 4 Floor Plan	P12	25-09-18
DA 1110	Level 5 - 12 Floor Plan	P12	25-09-18
DA 1111	Level 13 Floor Plan	P12	25-09-18
DA 1112	Level 14 - 19 Floor Plan	P12	25-09-18
DA 1113	Roof Plan	P11	25-09-18

1.5 Limitations and assumptions

In this instance, this Fire Safety Strategy has been developed based on applicable limitations and assumptions for the development which are listed as follows:

- This report is specifically limited to the project described in Section 2.
- This report is based on the information provided by the team as listed in Section 1.3.3.
- Building and occupant characteristics are as per Section 2 and 3 of this document. Variations to these assumptions may affect the Fire Engineering Strategy and therefore they should be reviewed by Affinity Fire Engineering should they differ.
- As per any building design, DtS or otherwise, the report is limited to the fire hazards and fuel loads as prescribed in Section 5. The report does not provide guidance in respect of areas, which are used for Dangerous Good storage, processing of flammable liquids, explosive materials, multiple fire ignitions or sabotage of fire safety systems.
- The development complies with the DtS provisions of the NCC [1] with all aspects relating to fire and life safety unless otherwise specifically stated in this report. Where not specifically mentioned, the design is expected to meet the NCC DtS requirements of all relevant codes and legislation at the time of construction and / or at the time of issue of this report.

- The assessment is limited to the objectives of the NCC and does not consider property damage such as building and contents damage caused by fire, potential increased insurance liability and loss of business continuity.
- Malicious acts or arson with respect to fire ignition and safety systems are limited in nature and are outside the objectives of the NCC. Such acts can potentially overwhelm fire safety systems and therefore further strategies such as security, housekeeping and management procedures may better mitigate such risks.
- This report is prepared in good faith and with due care for information purposes only, and should not be relied upon as providing any warranty or guarantee that ignition or a fire will not occur.
- This Fire Safety Strategy (FSS) is only applicable to the completed building. This report is not suitable, unless approved otherwise, to the building in a staged handover.
- Where parties nominated in Section 1.3.3 have not been consulted or legislatively are not required to be, this report does not take into account, nor warrant, that fire safety requirements specific to their needs have been complied with.

2 BUILDING CHARACTERISTICS

2.1 Overview

Building characteristics are assessed as part of the Fire Safety Strategy due the following:

1. The location can affect the time for fire brigade intervention and potential external fire exposure issues.
2. The structure will impact on the ability to resist a developing fire and support condition to allow occupants to escape the building and the fire brigade to undertake fire-fighting to the degree necessary.
3. The floor area determines the potential fire size and area required to be evacuated in the event of a fire.
4. BCA details such as Type of Construction, classification and height will dictate passive and active fire safety systems.

2.2 Introduction

This report supports a Development Application for Stage 1 of the Ivanhoe Estate redevelopment, a State Significant Development (SSD) submitted to the Department of Planning and Environment (DPE) pursuant to Part 4 of the Environmental Planning and Assessment Act 1979 (EP&A Act). It has been prepared for Aspire Consortium on behalf of NSW Land and Housing Corporation.

2.3 Background

In September 2015 the Ivanhoe Estate was rezoned by DPE as part of the Macquarie University Station (Herring Road) Priority Precinct, to transform the area into a vibrant centre that benefits from the available transport infrastructure and the precinct's proximity to jobs, retail and education opportunities within the Macquarie Park corridor.

The Ivanhoe Estate is currently owned by NSW Land and Housing Corporation and comprises 259 social housing dwellings. The redevelopment of the Ivanhoe Estate is part of the NSW Government Communities Plus program, which seeks to deliver new communities where social housing blends with private and affordable housing, with good access to transport, employment, improved community facilities and open space.

The Communities Plus program seeks to leverage the expertise and capacity of the private and non-government sectors. As part of this program, Aspire Consortium, comprising Frasers Property Australia and Mission Australia Housing, were selected as the successful proponent to develop the site in July 2017.

In September 2017, DPE issued the Secretary's Environmental Assessment Requirements for a comprehensive Masterplan application that will establish the framework for the staged redevelopment of the site. This Development Application for Stage 1 of the Ivanhoe Estate redevelopment represents the first stage of detailed works pursuant to the Ivanhoe Estate Masterplan.

2.4 Site Description

The Ivanhoe Estate site is located in Macquarie Park near the corner of Epping Road and Herring Road within the Ryde Local Government Area (LGA). The site is approximately 8.2 hectares and currently accommodates 259 social housing dwellings, comprising a mix of townhouse and four storey apartment buildings set around a cul-de-sac street layout. An aerial photo of the site is provided in the figure below.

Figure 2-1: Ivanhoe Estate site

Immediately to the north of the site are a series of four storey residential apartment buildings. On the north-western boundary, the site fronts Herring Road and a lot that is currently occupied by four former student accommodation buildings and is likely to be subject to redevelopment. Epping Road runs along

the south-western boundary of the site and Shrimptons Creek, an area of public open space, runs along the south-eastern boundary. Vehicle access to the site is via Herring Road.

Ivanhoe Estate comprised of 17 individual lots owned and managed by the NSW Land and Housing Corporation. The Masterplan site also incorporates adjoining land, being a portion of Shrimptons Creek and part of the commercial site at 2-4 Lyonpark Road. This land is included to facilitate a bridge crossing and road connection to Lyonpark Road.

2.5 Overview of the Proposed Development

The proposed Stage 1 Development Application seeks consent for the first stage of detailed works within the Ivanhoe Estate, pursuant to the Ivanhoe Estate Masterplan under Section 4.22 of the EP&A Act. The Masterplan establishes the planning and development framework against which this Stage 1 Development Application will be assessed.

The Stage 1 Development Application seeks approval for:

- Site preparation works, including tree removal, demolition of roads, services, and earthworks across the Ivanhoe Estate;
- The provision and augmentation of utilities and services infrastructure across the Ivanhoe Estate;
- The construction of all internal roads including public domain within the road reserves, and the bridge crossing and road connection to Lyonpark Road;
- The consolidation of existing lots and subdivision of the Ivanhoe Estate to reflect the revised road layout, open space, and provide superblocks corresponding to the Masterplan;
- The construction and use of Buildings A1 and C1 comprising residential uses (including social housing), a childcare centre, and retail / community spaces.

An image of the Masterplan, identifying Buildings A1 and C1 and illustrating the road network, is provided in Figure 2-2.

Figure 2-2: Ivanhoe Estate Master Plan

Figure 2-3: Estate Perspective

2.6 Building Description

The development consists of two separate towers sitting above a common basement carpark. As the two towers are located on the same site, it is proposed that the fire services infrastructure will be shared. The towers will be predominantly Class 2 residential apartments comprising of a mixture of 1, 2, 3-bedroom apartments and 4-bedroom terraces. The northern portions of the two towers shall be used for social housing while the southern portions shall be used for marketing dwellings. The building as a whole has an effective height greater than 50m.

It is noted that a community centre shall be located at C2 which adjoins the Building C1 where a future interface between Building C1 and the community centre will be provided.

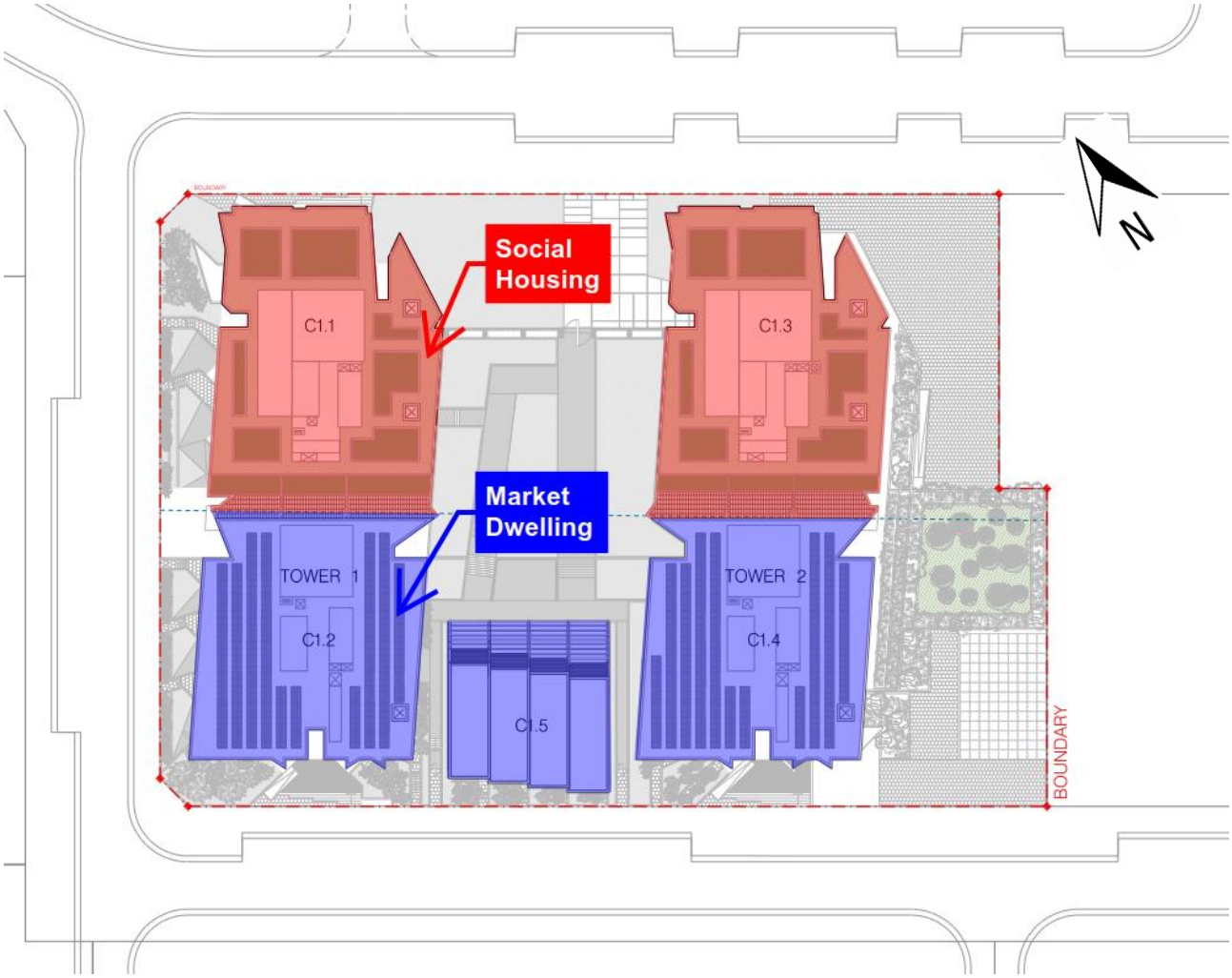


Figure 2-4: Site Layout

2.6.1 Common Basement Levels

The site as has three levels of basement level carparking and are separated accordingly to reflect carparking for the social housing and market dwellings. The basement carparking levels consists of storage cages, garbage room and end of trip facilities (on Basement 2).

Access into the carpark is via two entry points.

- The carpark entry for the social housing portion is located on the Lower Ground Floor and is accessed via the north-western side of the site. This carpark entry serves the two levels of social housing carparking on Basement 1 and 2.
- The carpark entry for the market dwellings and retail owner/employees is located on the Upper Ground Floor and is accessed at the southern corner of the site. This carpark entry serves two levels of market carparking on Basement 2 and 3.

2.6.2 Social Housing

The northern two portions located on the site shall be used primarily for residential use and social housing.

Social Housing Tower 1 (C1.1)

- Access into social housing tower 1 C1.1 is via Lower Ground Floor.
- Residential portions occur on Basement Level 1 to Level 12.
- Level 13 houses plant equipment such as domestic hot water plan, heat pump plant and stair pressurisation fan area.

Social Housing Tower 2 (C1.3)

- Access into social housing tower 2 C1.3 is via Lower Ground Floor.
- On Lower Ground Floor is a designated retail/community area and a loading dock.
- Residential portions occur on Lower Ground Floor to Level 12.
- Level 13 houses plant equipment such as domestic hot water plan, heat pump plant and stair pressurisation fan area.

2.6.3 Market Dwelling

The southern two portions located on the site shall be used primarily for residential use and market dwelling.

Market Dwelling Tower 1 (C1.2)

- Access into market dwelling tower 1 C1.2 is via Upper Ground Floor.
- Residential portions occur on Upper Ground Floor to Level 19.
- The hydrant pump room and the fire control room is located on Lower Ground Floor.
- Roof level houses plant equipment such as domestic hot water plan, stair pressurisation fan area and PV cells.

Market Dwelling Tower 2 (C1.4)

- Access into market dwelling tower 2 C1.4 is via Upper Ground Floor.
- Residential portions occur on Upper Ground Floor to Level 19.
- Roof level houses plant equipment such as domestic hot water plan, stair pressurisation fan area and PV cells.

Between Tower 1 and Tower 2 will be a four 3-storey four-bedroom terraces. Access into the four-bedroom terraces will be on grade to the road and on Upper Ground Floor.

The following Figures illustrate typical floor plans of the building.

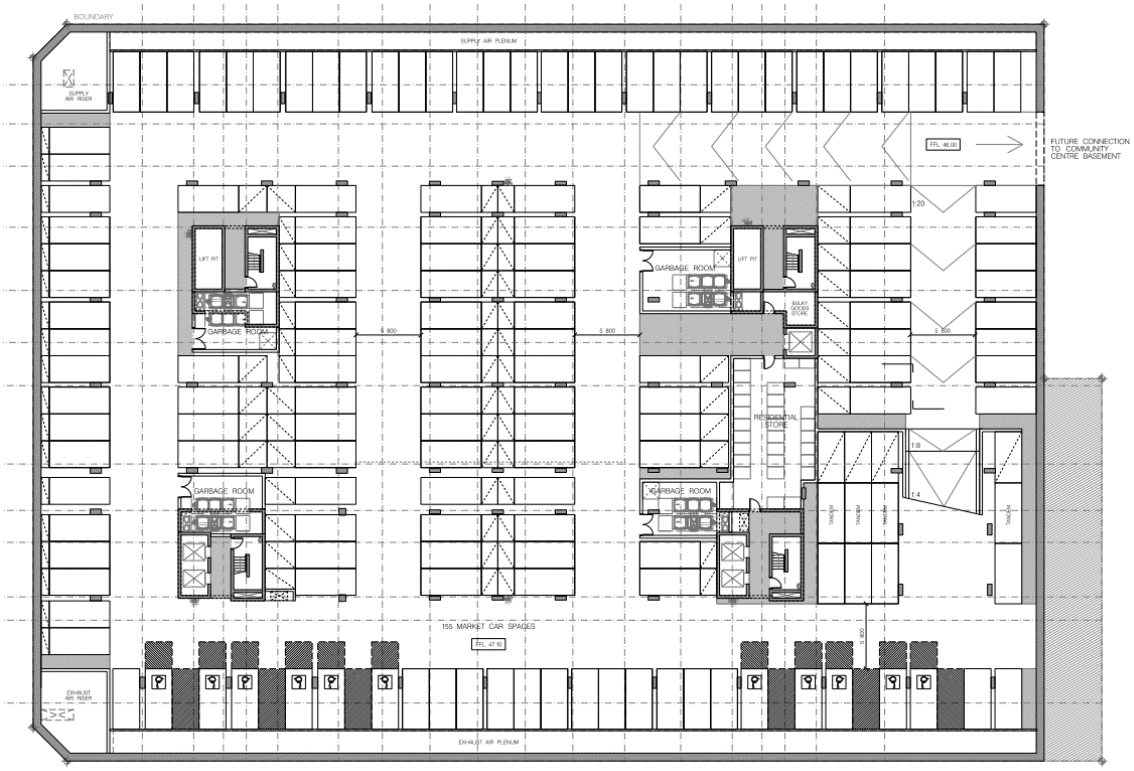


Figure 2-5: Basement 3 Floor Plan

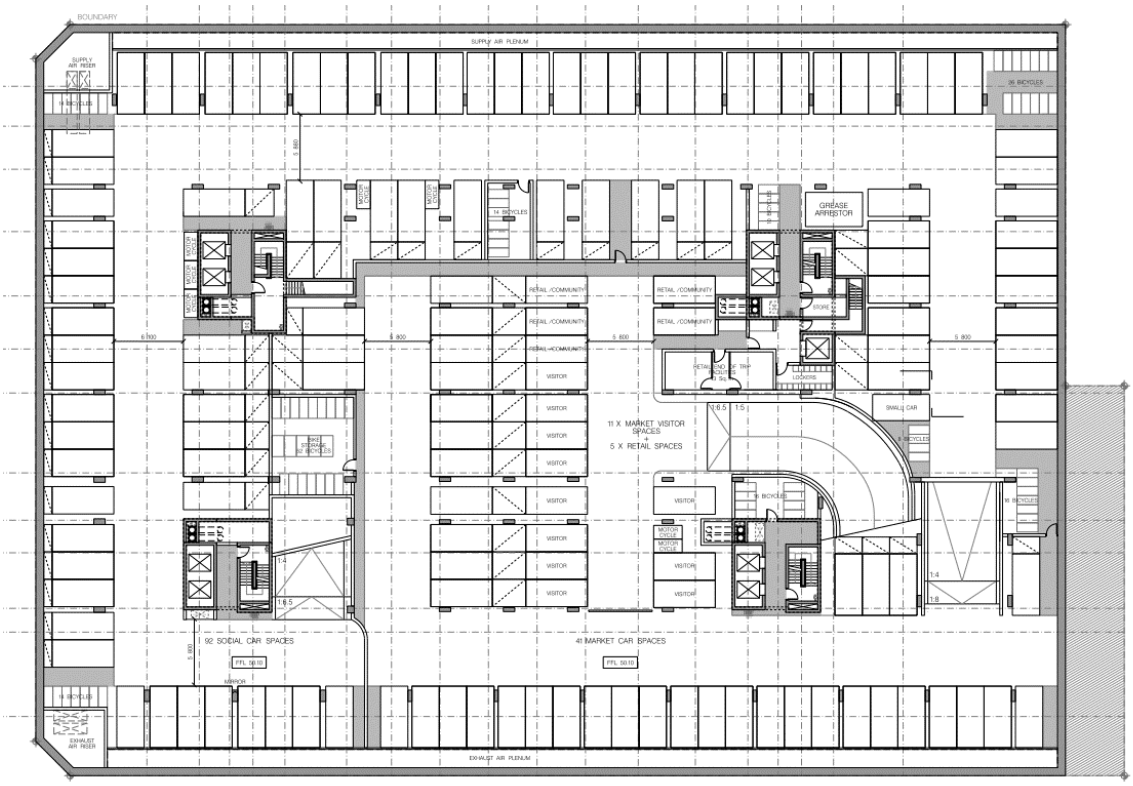


Figure 2-6: Basement 2 Floor Plan

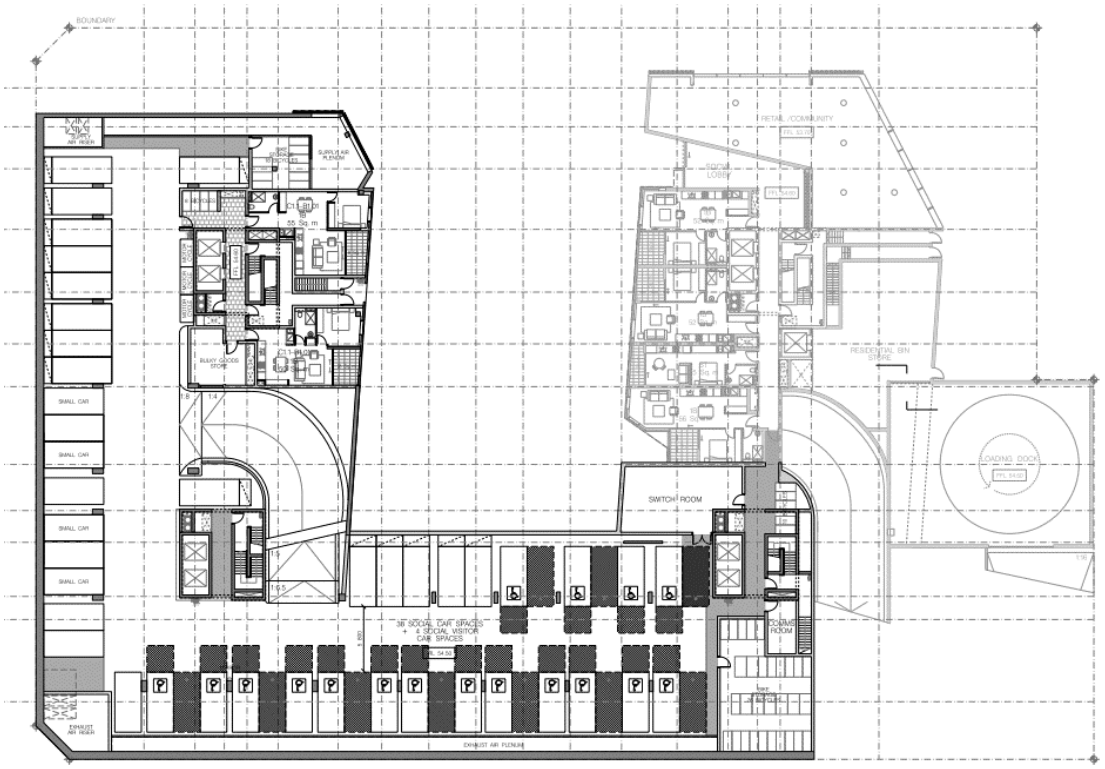


Figure 2-7: Basement 1 Floor Plan

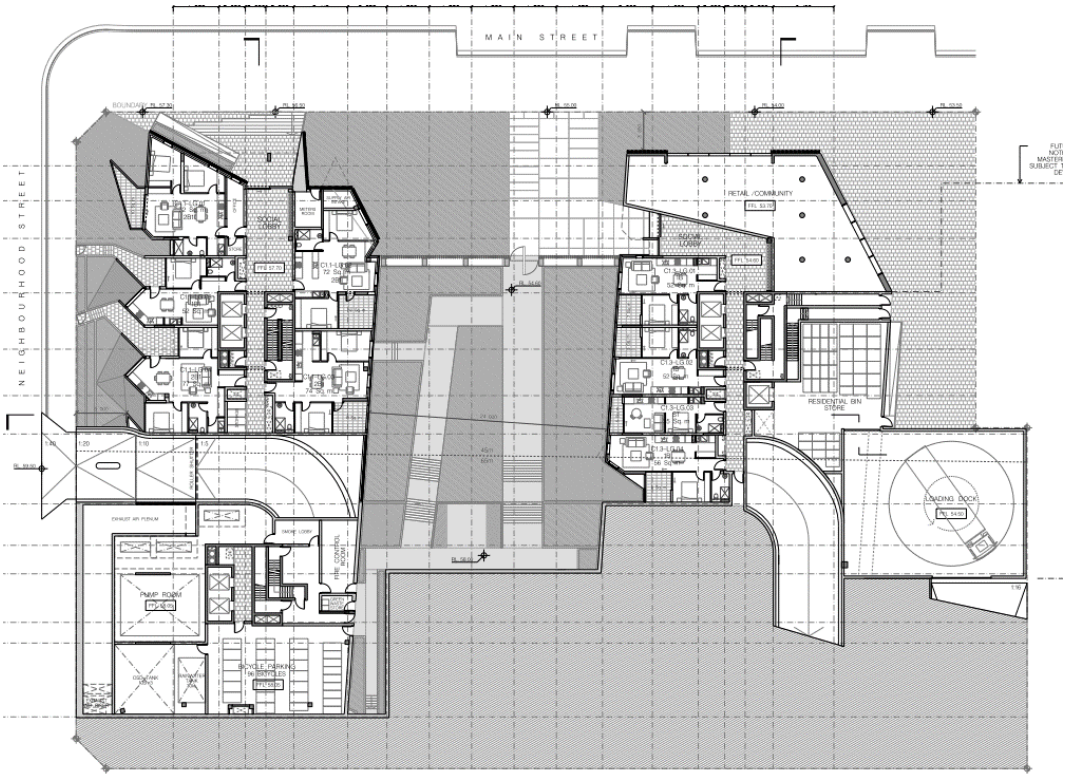


Figure 2-8: Lower Ground Floor Plan

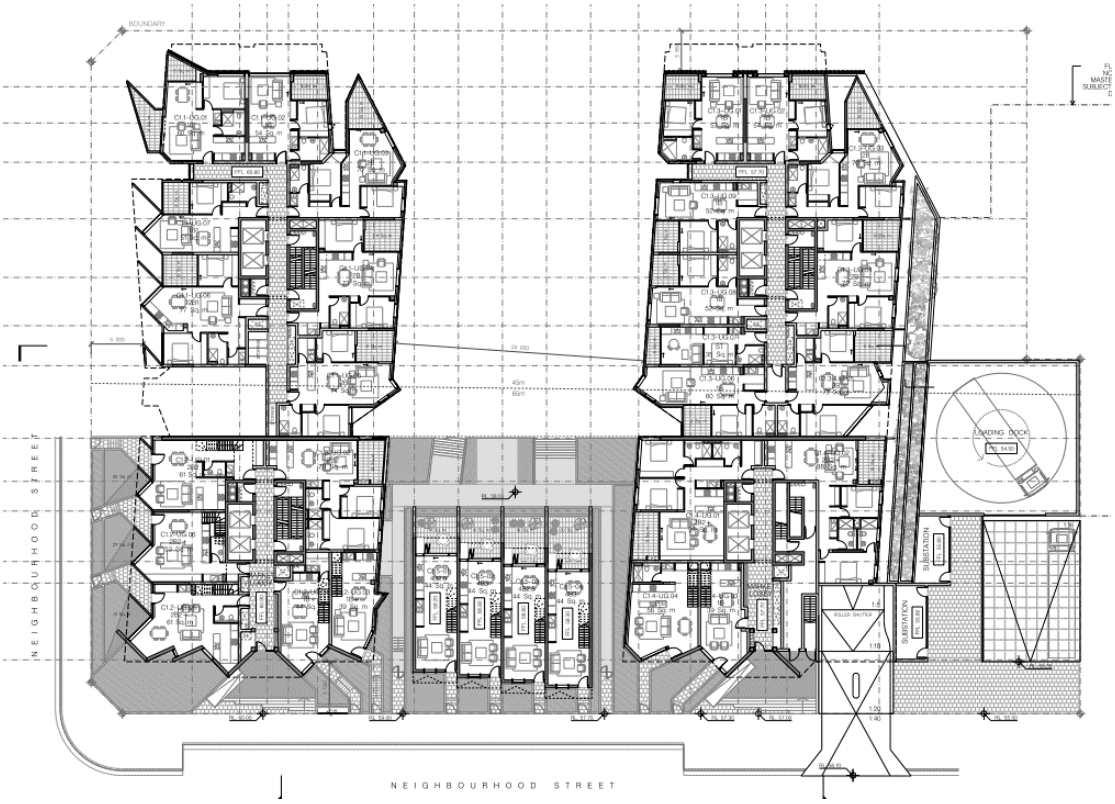


Figure 2-9: Upper Ground Floor Plan

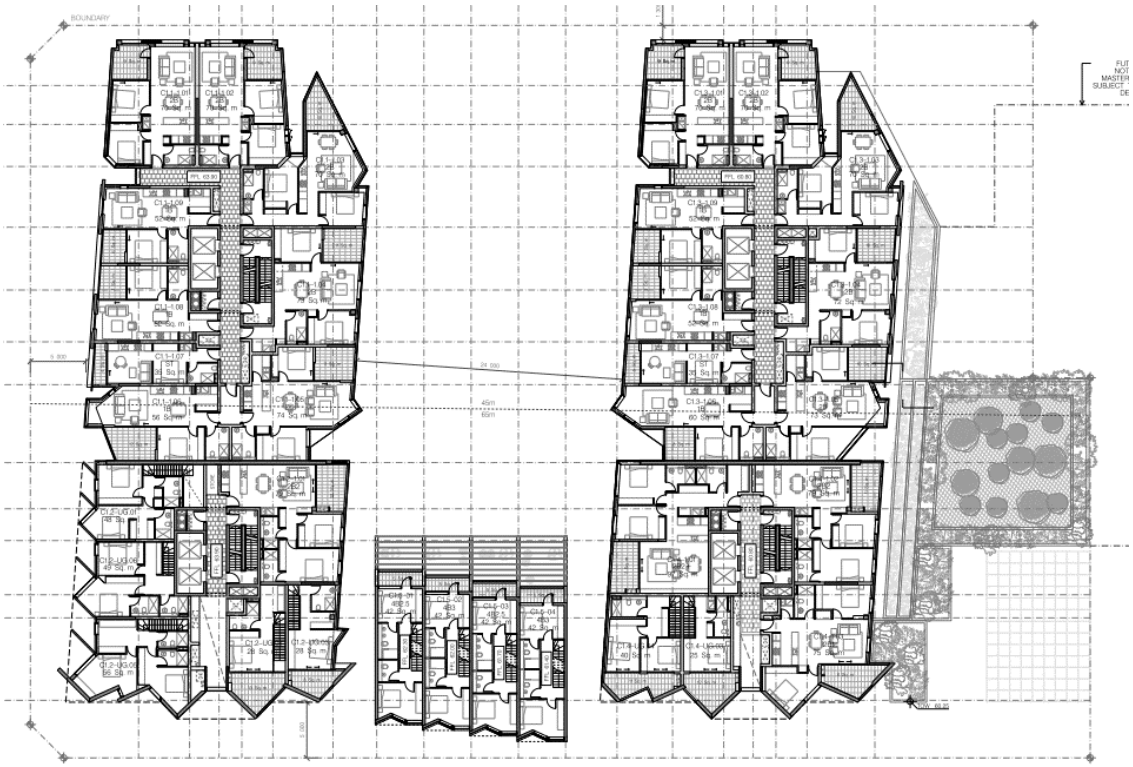


Figure 2-10: Level 1 Plan

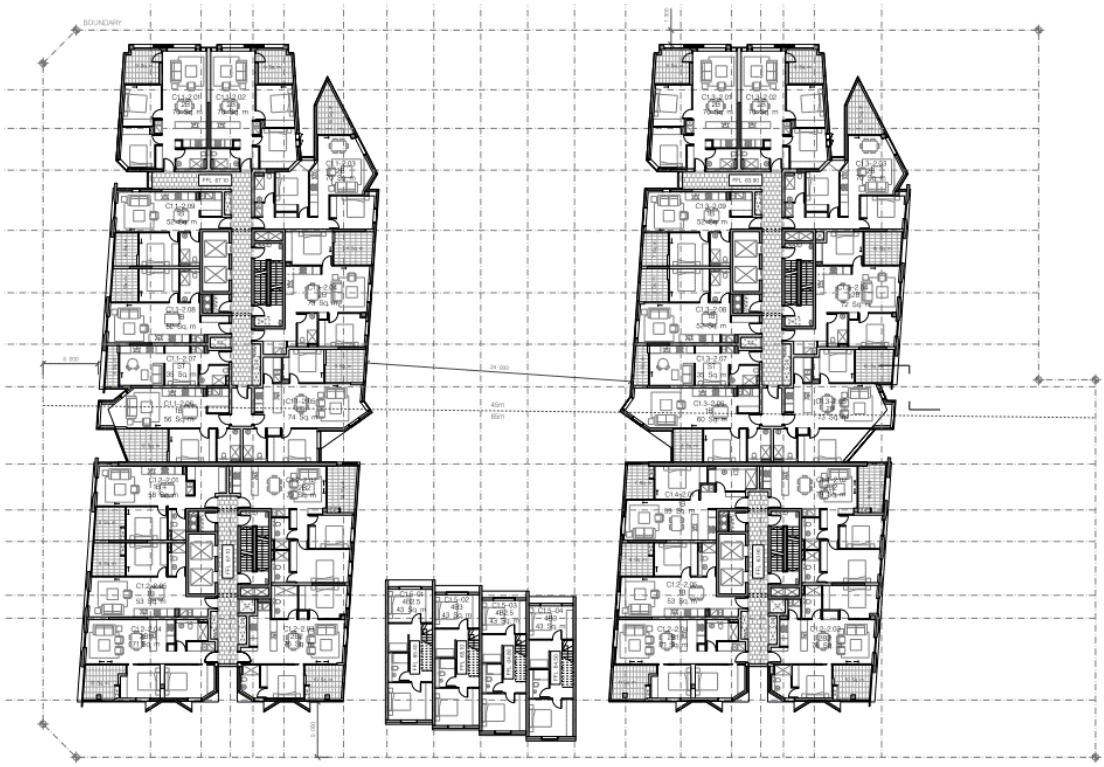


Figure 2-11: Level 2 Plan

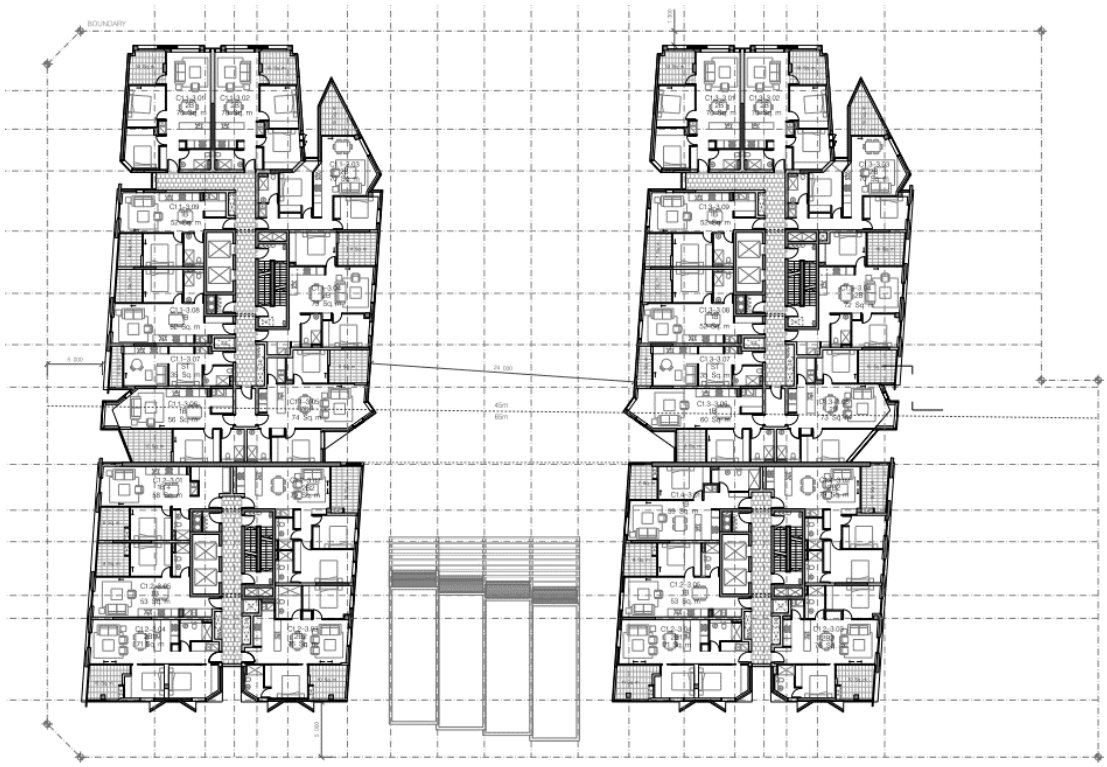


Figure 2-12: Level 3-4 Plan

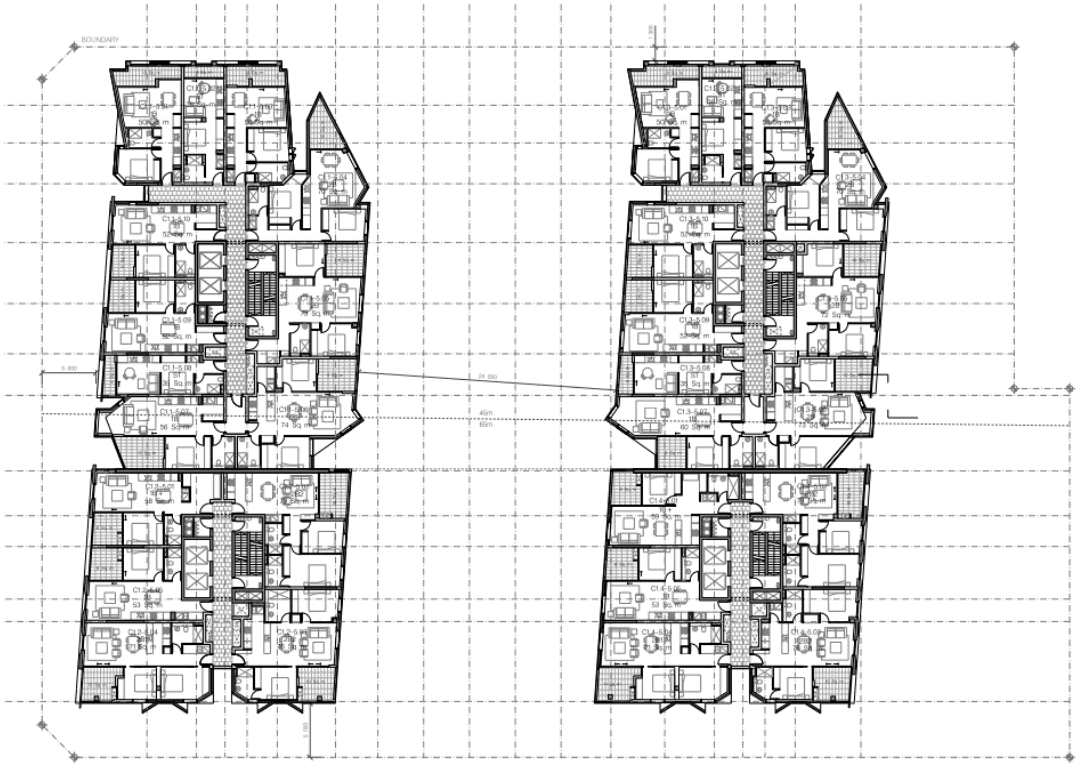


Figure 2-13: Level 5 – 12 Floor Plan

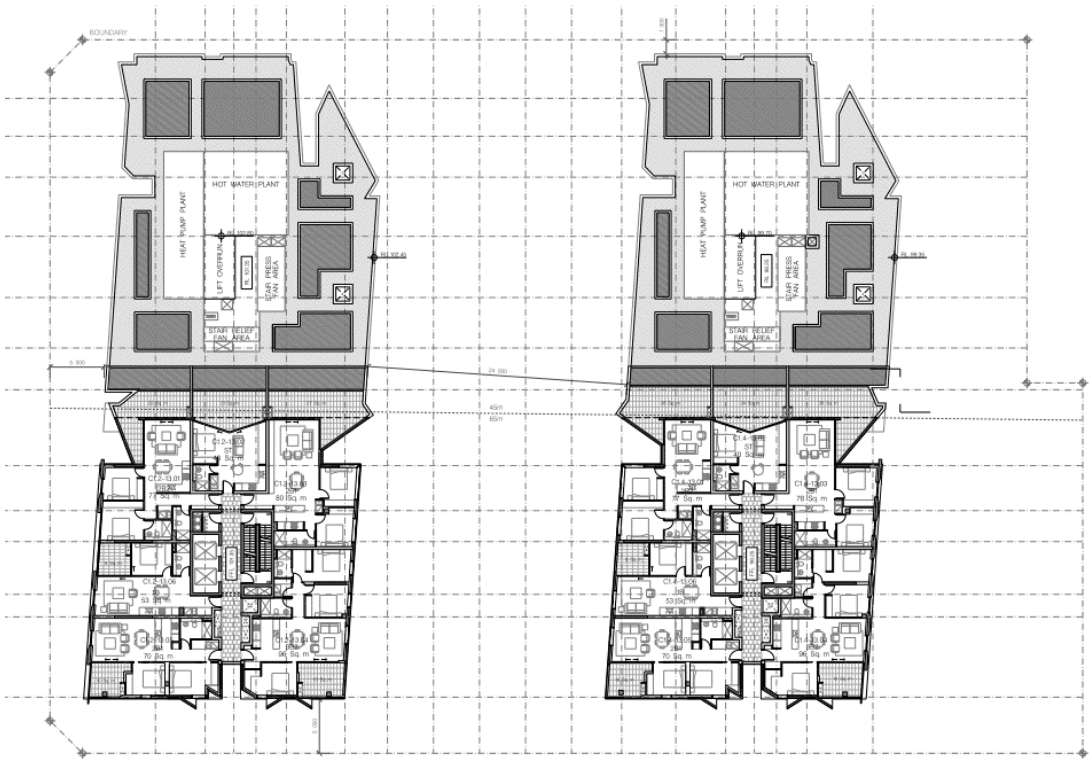


Figure 2-14: Level 13 Floor Plan

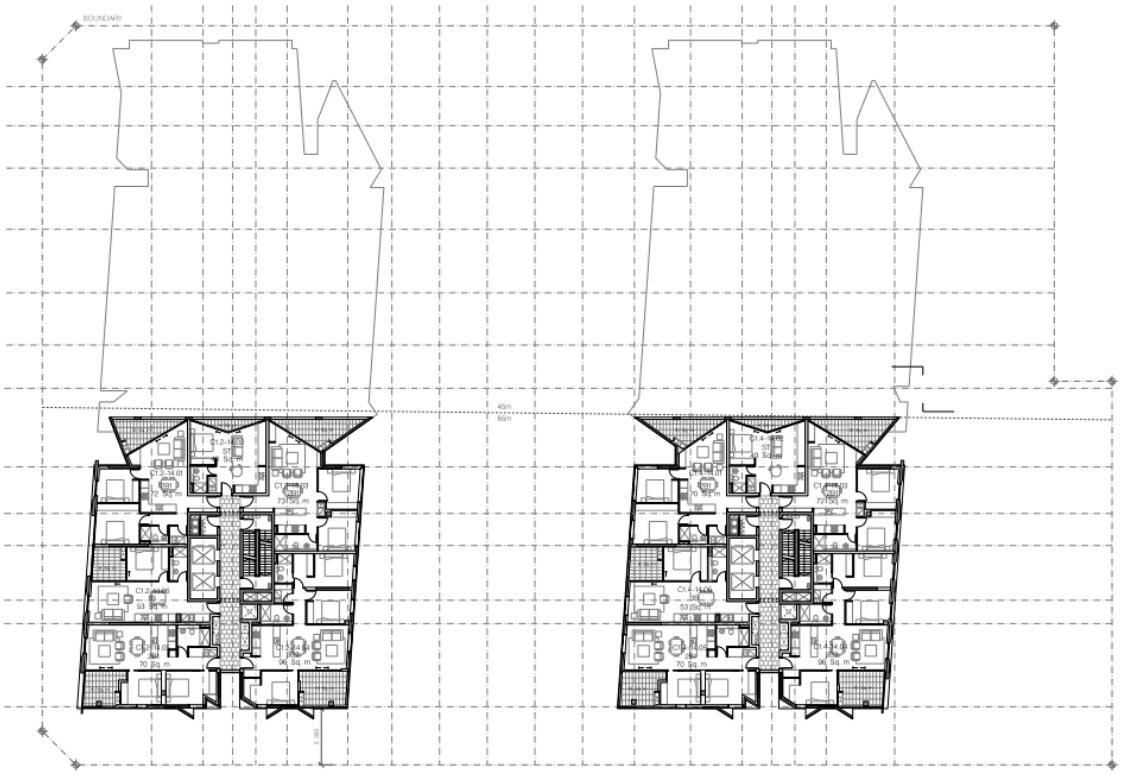


Figure 2-15: Level 14-15 Floor Plan

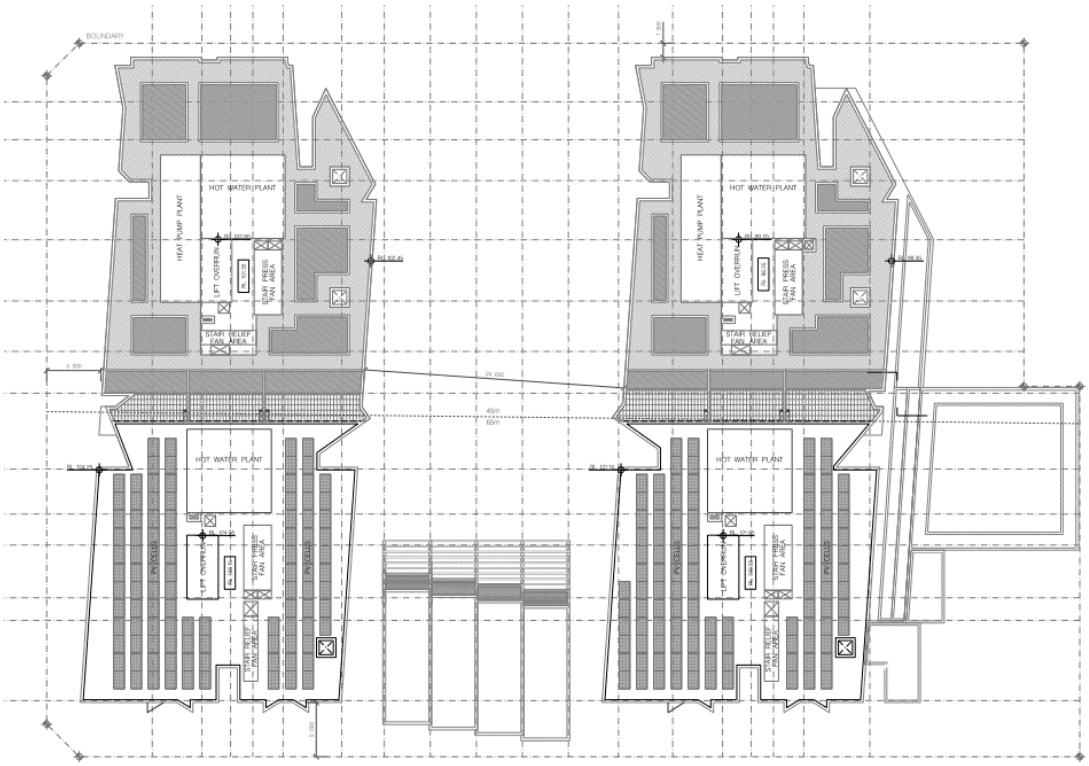


Figure 2-16: Roof Plan

Figure 2-17: 3D Render of the Building

Building Structure

The building is to be of Type A construction where materials used in construction will conform with the testing methodology outlined in the DTS provisions so as to avoid the spread of smoke and fire and minimise the risk to occupants and fire fighters.

2.8 Building Characteristic Assessment

The following table summarises the characteristics of the subject building, relevant to fire and life safety.

Table 2-1: Building characteristics assessment

Characteristic	Description
Location	The building is located in the Ivanhoe Estate, which is in the jurisdictional turnout area for fire and rescue NSW.
Effective height	The building has an effective height of greater than 50m.
NCC Classification	Class 2 – Residential Class 6 – Retail Class 7a – Car parking Class 7b – Storage
Type of Construction	Type A Construction

3 OCCUPANT CHARACTERISTICS

3.1 Overview

The occupant characteristics are assessed as part of the Fire Engineering Review due to the following:

1. Population numbers can dictate the time required to evacuate the building and the required life safety systems to be provided due to evacuation times.
2. Physical and mental attributes affects the occupants capacity to respond to various fire cues and react accordingly.
3. Familiarity of occupants can affect the time taken to evacuate the building and subsequent active/passive requirements.

3.2 Dominant Occupant Characteristics Assessment

Characteristic	Description
Occupant groups	The following occupant groups are expected in the building: • Residential occupants • Staff • Visitors • Firefighters • Maintenance personnel
Population numbers	Generally, the occupant numbers in the building is expected to equivalent to the occupant densities (m^2/person) listed in the NCC Table D1.13 for the various areas and the building layout which are listed as follows: • Retail: 3m^2/person • Carpark: 30 m^2/person The population within the residential apartments can be approximated by counting the number of bedrooms and assuming a conservative average of 2 persons per bedroom.
Physical and mental attributes	***Residential occupants*** • Occupants throughout the residential areas of the building will vary from alert and able bodied, to occupants who are asleep, affected by medication and or alcohol and people with disabilities. The occupant group generally represents the broader population, i.e. all age

Characteristic	Description
	groups, levels of mobility and disability are likely to be present. At times, a portion may be affected by alcohol, medication or other drugs that could inhibit their response time and actions/reactions in a fire emergency. ***Staff*** • Staff in the building are expected to be awake and alert at all times. Staff are expected to have a level of understanding where they can recognise an emergency situation and have the ability to take and implement decisions independently. In addition, staff are expected to respond at all times, and to be unaffected by physical or sensory disabilities. Staff are not expected to be mentally impaired by drugs, alcohol, fatigue or other adverse conditions to degrees greater than in other business places. ***Visitors*** • This occupant group is expected to be awake and alert. Visitors may also exhibit physical and mental disabilities to the degree and frequency of the general public. It should be noted that some visitors may consist of young children as well as elderly occupants and these occupant groups are expected to be accompanied by an adult. ***Firefighters*** • This occupant group will be equipped with breathing apparatus and specialist equipment to prevent them from being adversely affected by fire hazards. They are expected to be trained in emergency response and be capable of undertaking fire suppression and coordination of evacuation of the building. ***Maintenance personnel*** • This occupant group is expected to awake and alert at all times. Maintenance personnel are expected to be able-bodied individuals who are capable of making independent decisions and evacuate themselves.
Familiarity with the building	***Residential occupants*** • The majority of occupants within the building are expected to be residents. As such, a degree of familiarity with the building layout is

Characteristic	Description
	expected from the majority or occupants, with wayfinding assistance provided to visitors in an evacuation. ***Staff*** • Staff are expected to have a complete knowledge of the building layout and be able to coordinate evacuation of other occupant groups in an emergency. ***Visitors*** • Visitors may not have complete knowledge of evacuation routes in the subject building and are likely to choose to exit via the route they entered the building if not directed/guided by staff to the nearest exit. ***Firefighters*** • This occupant group is not expected to have any familiarity of the building layout, however are assumed to obtain the required information from the site block plans and tactical fire plans available prior to entering the building. Notwithstanding this, they will be equipped with breathing apparatus and specialist equipment to prevent them from being adversely affected by fire hazards. ***Maintenance personnel*** • This occupant group is expected to have a reasonable familiarity with the building as they would have to undergo site specific induction prior to commencement of work on site.
Pre-movement time	Pre-movement times can vary and is highly dependent on a combination of a variety of factors [4] such as: • Familiarity with building • Commitment to activity being undertaken at the time of fire ignition • Mental capabilities (ability to assess risks and make appropriate decisions, alertness) • Physical capabilities • Group dynamics • Occupant relationships / social affiliations • Frequency of false alarms Documents such as PD7974-6:2004 [6] and CIBSE Guide E [9] provide guidance on estimating pre-movement times for various occupancies.

Characteristic	Description
Travel speed	Travel speeds for individuals can vary depending on factors such as: • Age and sex, • Physical capabilities (ambulant, semi-ambulant, bed-ridden) • Occupant density / crowding • Perceived danger Based on a literature review of work carried out by Boyce et al. [12], Nelson and Mowrer [13], Pauls [13], Milinskii, Pelecheno [14], Pretechskii [15] and Shi et al. [16], the following travel speeds are adopted for an average horizontal travel speed: • 1.0m/s is assumed for an able-bodied adult, • 0.6m/s for semi-ambulant occupants (those requiring assistance to evacuate or wheelchair users).

4 HAZARDS AND PROTECTIVE MEASURES

4.1 Overview

The fire hazard analysis forms the basis for the review of non-compliances within the building. In assessing expected and statistically validated hazards, preventative and protective measures are developed commensurate with those expected risks. The following section reviews applicable hazards and recommends possible measures to address those risks. Furthermore, hazards identified can form a justified basis for selected scenarios in fire engineering assessments.

4.2 Fire hazards

4.2.1 Building layout and egress

Egress provisions from the building are generally in accordance with the BCA DtS requirements with the following exception of extended travel distances.

4.2.2 General activities

- The building houses a number of occupants in the residential levels with activities including cooking, using uncontrolled heating and electrical devices and smoking but to no greater extent than similar buildings of this type.
- Activities in the car park and retail areas are also not expected to be of any greater hazard than in other buildings of this type.

4.2.3 Fuel loads

Quantity of Materials

- Apartments: 300MJ/m^2 with isolated peak values reaching 600MJ/m^2
- Carpark: 200MJ/m^2 with isolated peak values reaching 400MJ/m^2
- Retail: 600MJ/m^2 with isolated peak values reaching 1200MJ/m^2

4.3 Review of relevant fire statistics

The following discussion is based on the fire statistics attached in APPENDIX A.

4.3.1 Residential (apartment) occupancies

Based on NFPA statistics published for the years 2007-2011 [28], 21% of all structure fires were apartments or multi-family homes. Residential fires accounted for a large percentage of civilian deaths and injuries compared to other occupancies, of which the majority was one/two family homes (similar to Class 1 with reference to Australian NCC/BCA). Apartment or multi-family home fires lead to 15% of the

civilian deaths and 28% of civilian injuries. The percentage of fires, civilian injuries and deaths that occurred in 2007-2011 are presented in the figure below.

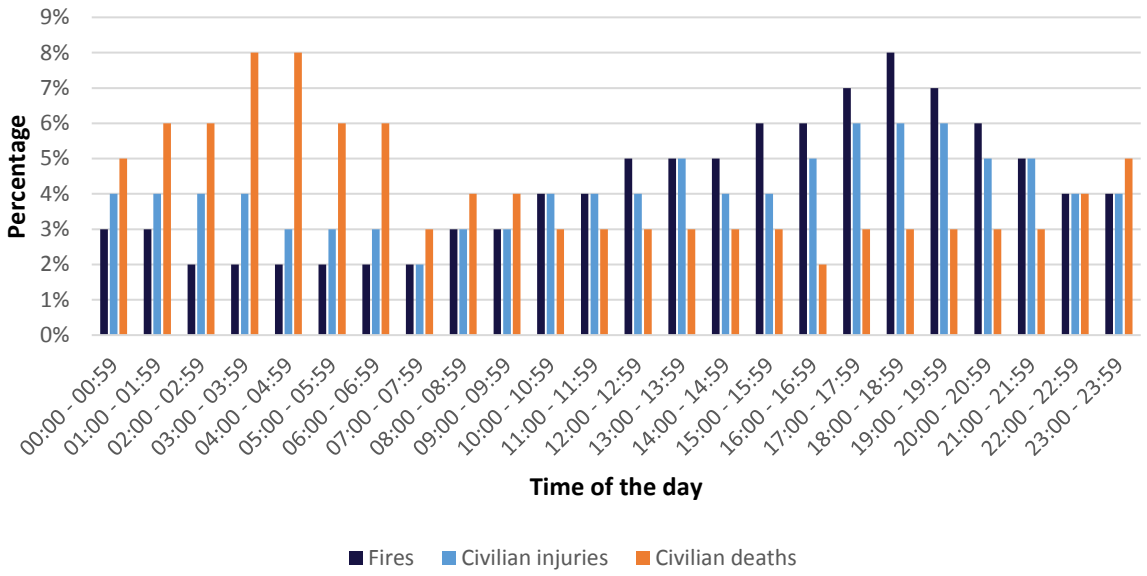


Figure 4-1: Percentage of fires, civilian injuries and deaths at different times of the day (apartments)

The following graph that shows the ratio of injuries and deaths to total number of fires has been developed from the above data presented in the previous figure. It can be noted that the number of fires during the day are almost twice as many as those during the night. The number of fires peak in the evening and are the lowest in the early hours of the day. This is likely due to the activities undertaken by occupants while they are at home which can involve ignition sources such as cooking, smoking, etc.

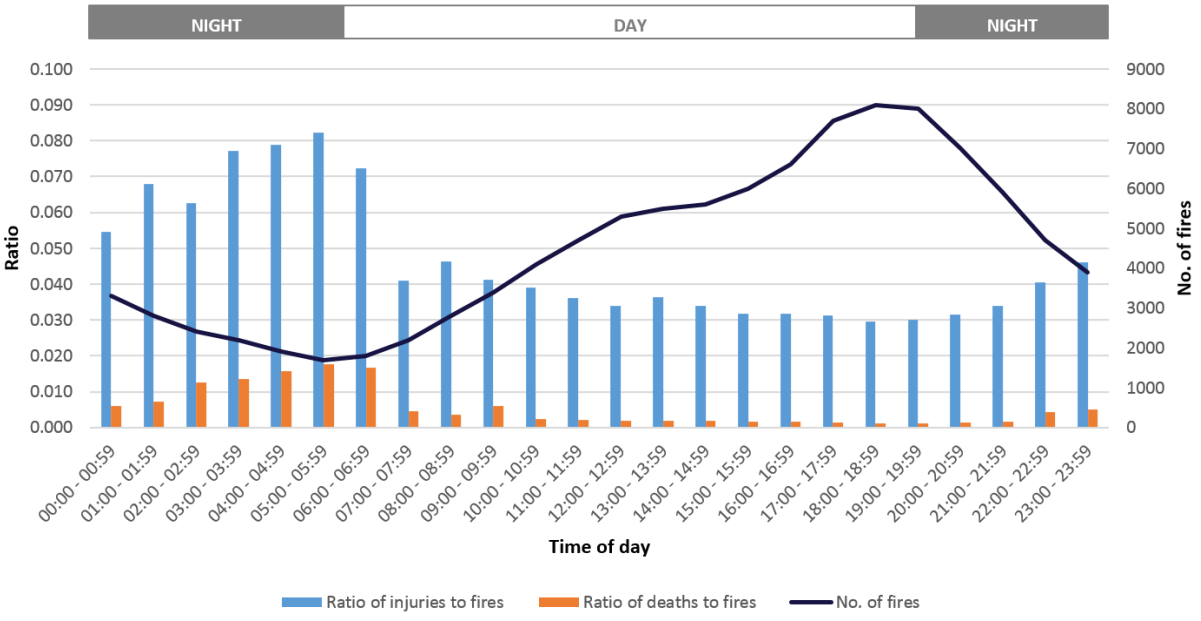


Figure 4-2: Number of fires, ratio of injuries/fires and deaths/fires for different times of the day (apartments)

The number of injuries and deaths are low during day and relatively much higher during night times. This is likely to be the result of awake and alert occupants being able to identify fire risks at an early stage such that fire ignition/development is avoided. However, during night times, when occupants are expected to be asleep, they are at a much higher risk as they are less capable of smelling smoke or be woken by sounds (depending on age, level of intoxication, etc.). This is consistent with data presented in other statistics published by the NFPA [29], where human factors for deaths and injuries are listed. It is noted that the largest proportion of civilian deaths occurred when occupants were:

- Asleep (28%)
- Physically disabled (15%)
- Possibly impaired by alcohol (11%)
- Unconscious (5%)
- Possibly mentally disabled (5%)
- Possibly impaired by other drug or chemical (5%)
- Unattended or unsupervised person (4%)
- Physically restrained (1%)

The most common ignition sources in order of likelihood in home structure fires are:

- Cooking equipment (46%)
- Heating equipment (16%)
- Electrical distribution and lighting equipment (9%)
- Intentional (8%)
- Smoking materials (5%)

The most common fire origins in order of likelihood in home structure fires are:

- Kitchen or cooking area (43%)
- Other known area of origin (16%)
- Bedroom (7%)
- Confined chimney or flue fire (6%)
- Living room, family room or den (4%)

From the above, it can be noted that cooking fires in kitchens are the most common. Fires as a result of heating equipment and other equipment such as lighting do not result in as many fires as cooking fires. Additionally, fires in bedrooms and living rooms are relatively low, however are likely locations of injuries/deaths as occupants may be less reactive/attentive or asleep in these areas

4.3.2 Car parking areas

Based on data supplied by the Melbourne Fire and Emergency Services Board (MFESB) and data on the number of car parks in Melbourne [20], the rate of fire starts in Melbourne CBD car parks is estimated to be 0.00007 fires reported to the fire brigade per car space per year.

The most common cause of fire in car parks in New Zealand is highlighted to be arson followed by electrical faults [22] as shown in Figure 4-3 . This is assumed to be representative of car parks in Australia.

As this building contains car parking areas that are for private use and are likely to be secured, it is expected that the chances of arson are reduced.

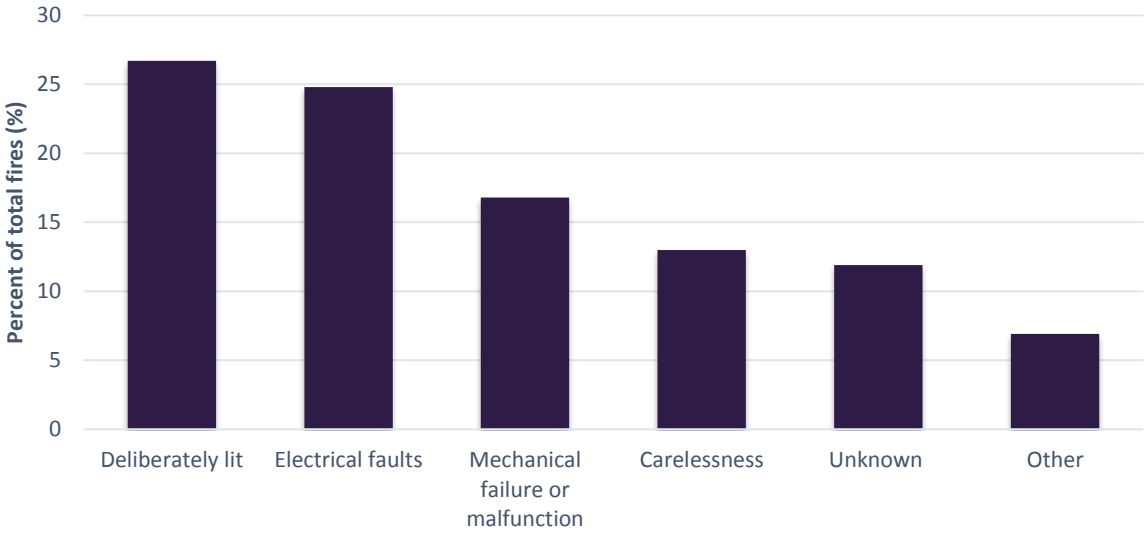


Figure 4-3: Causes of Car Park Fires

4.3.3 Retail

Based on NFPA statistics published for the years 2009-2013 [30], 2.8% of all structure fires were structure fires in stores and other mercantile properties. These, fires accounted for 0.4% of civilian deaths, 2.0% of civilian injuries and 6.1% of direct property damage associated with all structure fires in this time period. The percentage of fires, civilian injuries and deaths that occurred in 2009-2013 are presented in the figure below.

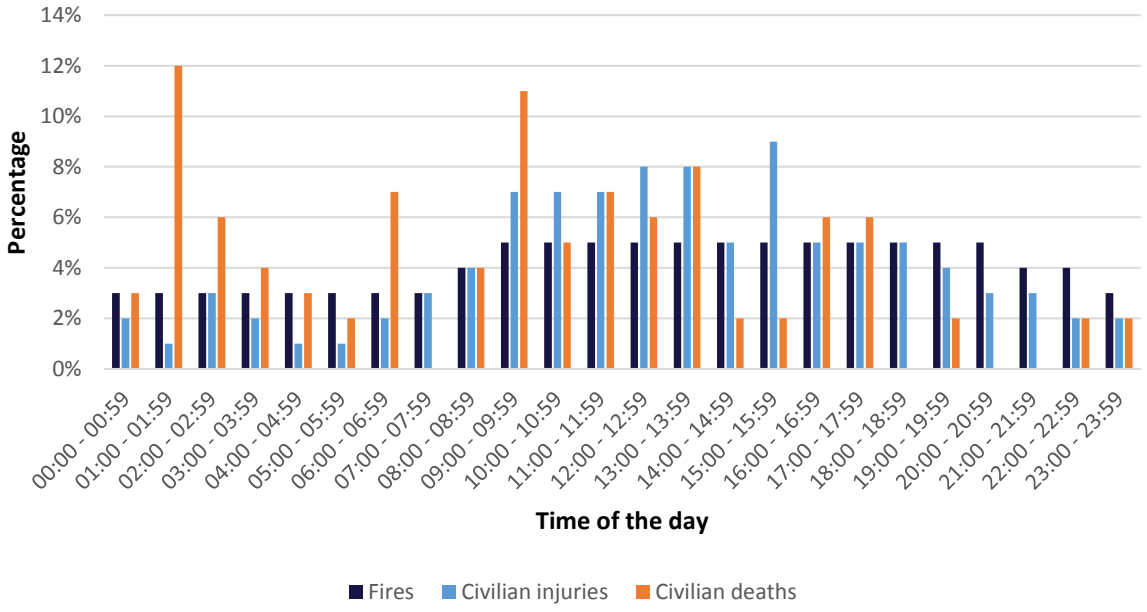


Figure 4-4: Percentage of fires, civilian injuries and deaths at different times of the day (retail)

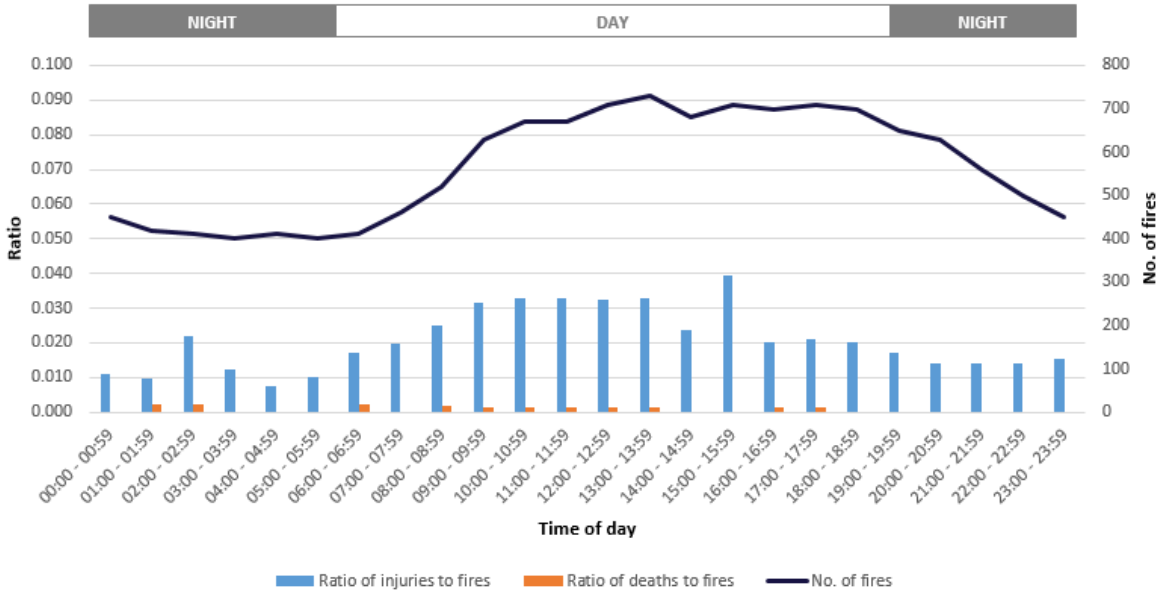


Figure 4-5: Number of fires, ratio of injuries/fires and deaths/fires for different times of the day (retail)

Ignition sources in order of likelihood in stores and mercantile properties:

- Cooking equipment (21%)
- Electrical distribution and lighting equipment (15%)
- Heating equipment (11%)
- Intentional (11%)
- Smoking materials (6%)
- Exposure fire (5%)

Fire origins in order of likelihood in stores and mercantile Properties:

- Kitchen or cooking area (17%)
- Laundry room or area (6%)
- Unclassified outside area (5%)
- Sales or showroom area (4%)
- Unclassified equipment or service area (4%)
- Sales or showroom area (4%)
- Unclassified equipment or service area (4%)
- Trash or rubbish chute, area or container (3%)
- Unclassified storage area (3%)
- Exterior wall surface (3%)
- Maintenance or paint shop area (3%)
- Lavatory, bathroom, locker room or check room (3%)
- Unclassified area of origin (3%)
- Exterior roof surface (3%)
- Office (3%)

5 BCA DTS NON-COMPLIANCE REVIEW

5.1 Overview

In this instance the BCA DTS non-compliances have been formulated based on a regulatory review undertaken by the project building surveyor and / or design team. Where not listed herein the building is required to achieve compliance with relevant DTS provisions and relevant codes, reports and Standards.

The following table lists the proposed departures from the DTS provisions of the BCA for the development and the analysis methodology proposed for the Fire Engineering assessment, which is to be generally in accordance with the IFEG [3].

5.2 BCA DTS Non-Compliance Assessment and Acceptance Criteria

Table 5-1: Summary of Performance Solutions

VARIATIONS, ASSOCIATED METHODOLOGY AND ACCEPTANCE CRITERIA
Item 1: Reduced FRL of Retail Tenancy
Relevant Regulatory Requirement: ▸ BCA Clause C1.1 requires that this building is of Type A construction. ▸ BCA Clause C2.8 requires that parts of different classification on the same storey must be separated by a fire-rated wall having the higher FRL prescribed in Specification C1.1 which requires an FRL of up to 180/180/180 (element dependent) for Class 6 parts of a building. Performance Requirement CP1 & CP2
Non-compliance with DTS provisions: ▸ The proposed retail tenancy located on Lower Ground Floor shall achieve a reduced FRL of 120/120/120 which is deemed to be non-compliant with the BCA requirements for Class 6 parts.
Relevant IFEG Sub-Systems: ABCDEF
Approaches and Method of Analysis: The compartment size, large glazed shopfront, expected fuel load and provision of a fire sprinkler system shall be utilised to demonstrate that a general FRL of 120/120/120 will be adequate for the expected fire duration and severity. The assessment methodology will be absolute and quantitative in accordance with BCA Clause A0.3(b)(i) and A0.5(b)(ii). The analysis shall demonstrate that the fire severity of a fire in the retail tenancy is unlikely to exceed the fire resistance of the surrounding construction.

VARIATIONS, ASSOCIATED METHODOLOGY AND ACCEPTANCE CRITERIA

Item 2: Protection of Carpark Driveway Connection

Relevant Regulatory Requirement:

BCA Clause C3.5 requires doorways in a firewall to be protected by fire doors or fire shutters achieving an FRL equivalent to the firewall requirements except that the insulation level is permitted to achieve 30 minutes.

The firewall separating the two carparks (between Lot C1 and Lot C2) requires a 120/120/120 FRL and therefore the fire rated roller shutter must prescriptively achieve a --/120/30 FRL per BCA Clause C3.5.

Performance Requirement CP2.

Non-compliance with DTS provisions:

In the Basement Level 3 carparking, it is proposed that a driveway connection be provided to Lot C2 i.e. the community centre basement. To separate the driveway connection, an automatic closing fire-rated roller shutter shall be provided which only achieves an FRL of --/120/-- in lieu of --/120/30.

Relevant IFEG Sub-Systems:
ABCDEF

Approaches and Method of Analysis:

An automatic closing fire-rated roller shutter is provided with wall-wetting sprinklers to both sides of the shutter which shall achieve the DTS required 30-minute insulation value.

Item 3: Number of Exits

Relevant Regulatory Requirement:

BCA Clause D1.2 states that a building having an effective height of more than 25m is required to have not less than 2 exits from each storey.

Performance Requirement DP2

Non-compliance with DTS provisions:

- Occupants in the 4-bedroom terraces are only provided with a single exit on Upper Ground Floor.

Relevant IFEG Sub-Systems:

ABCDEF

Approaches and Method of Analysis:

The single exit is considered appropriate due to the terraces being solely occupied by a single tenant (i.e. one family) and occupants having direct access to a road and open space at the point of discharge from the exit.

VARIATIONS, ASSOCIATED METHODOLOGY AND ACCEPTANCE CRITERIA

The assessment methodology will be absolute and qualitative in accordance with BCA Clauses A0.3(a)(ii) and A0.5(d) and demonstrate that occupant evacuation is not disadvantaged by the Performance Solution.

Item 4: Extended Travel Distances in Carpark Areas

Relevant Regulatory Requirement:

- BCA Clause D1.4 requires that travel distance to a point of choice and to the nearest exit is no greater than 20m and 40m respectively.
- BCA Clause D1.5 requires exits as an alternative means of egress must be no greater than 60m apart.

Performance Requirement DP4 & EP2.2.

Non-compliance with DTS provisions:

Occupants in the carpark areas have extended travel distances of up to up 30m to a point of choice, 50m to the nearest exit and 90m between alternative exits.

Relevant IFEG Sub-Systems:

ABCDEF

Approaches and Method of Analysis:

Fast response sprinkler heads will be installed within all car parking levels in lieu of DtS required standard response heads.

The assessment methodology will be comparative and quantitative in accordance with BCA Clauses A0.3(a)(ii) and A0.5(d). Alpert's correlation will be used for an RSET/RSET analysis comparing the Performance Solution with a DtS compliant design to demonstrate an equivalent level of safety.

Item 5: Extended Residential Travel Distances

Relevant Regulatory Requirement:

BCA Clause D1.4 requires the distance from the apartment entry door to a point of choice be not more than 6m.

Performance Requirement DP4 & EP2.2.

Non-compliance with DTS provisions:

Social-Housing

- Occupants on Upper Ground Floor to Level 12 have up to 12m to a point of choice in lieu of 6m.

Market- Dwelling

- Occupants on Level 02 to Level 19 have up to 7m to a point of choice in lieu of 6m.

VARIATIONS, ASSOCIATED METHODOLOGY AND ACCEPTANCE CRITERIA

Relevant IFEG Sub-Systems:

ABCDEF

Approaches and Method of Analysis:

The Performance Solution will rely upon improved conditions within the corridor during egress through the installation of smoke seals to doors opening into the affected corridors.

The assessment methodology will be quantitative and comparative in accordance with BCA Clause A0.3(a)(ii) and A0.5(d). The analysis shall demonstrate that the exposure dose to occupants due to smoke leakage into the affected corridors is compared to a DtS design. Additional assessment shall also be undertaken to review the number of exposures occupants must travel past en route to the exit.

Item 6: Separation of Alterative Exits

Relevant Regulatory Requirement:

BCA Clause D1.5 requires that the distance between alternative exits be no less than 9m.

Non-compliance with DTS provisions:

While scissor stairs have been provided to ensure two exits to all residential towers, the separation distance between the alternative exits is reduced to 4.3m.

Relevant IFEG Sub-Systems:

ABCDEF

Approaches and Method of Analysis:

The Performance Solution relies on the reduced separation distance between the two stairs not having a significant impact on occupant life safety, based on:

- The geometry of the building; and
- The limited fire load within the residential corridor portions of the building; and
- Smoke seals to doors opening into the affected corridors; and
- Provisions for fast response residential sprinklers allowing early alarm and egress opportunity for occupants as well as quick fire containment.

The assessment methodology will be absolute and qualitative in accordance with BCA Clause A0.3(b)(i) and A0.5(b)(ii). The analysis shall demonstrate that the risk associated with the arrangement of the two exits in the Performance Solution is no worse than that of a DTS compliant design.

Item 7: Roller Shutter Acting as an Exit

Relevant Regulatory Requirement:

VARIATIONS, ASSOCIATED METHODOLOGY AND ACCEPTANCE CRITERIA

BCA Clause D2.19 stipulates that a tilt-up or roller shutter door cannot be used as an exit unless the following conditions are satisfied:

- Where it serves a Class 6, 7 or 8 building or part with a floor area not more than 200m^2; and
  - The doorway is the only required exit from the building or part; and
  - It is held in the open position while the building or part is lawfully occupied.

Under the same Clause, power operated doors:

- Must be able to be opened manually with a force of not more than 110N in the event of power failure; and
- If it leads directly to a road or open space, it must open automatically in the event of a power failure or on the activation of a fire or smoke alarm anywhere in the fire compartment served by the door.

Non-compliance with DTS provisions:

The roller shutter serving the loading dock is used as an exit although it is not the only required exit and not locked in the open position while the building is lawfully occupied. In addition, roller shutter will not be able to be manually opened with a force less than 110N, nor will the shutter automatically open in the event of a power failure or alarm activation.

Relevant IFEG Sub-Systems:

ABCDEF

Approaches and Method of Analysis:

The roller shutter is to be fitted with the following provisions:-

- A mushroom push-button device shall be located on the internal side (i.e. loading dock) of the roller shutter door.
- A battery backup shall be provided to operate the push-button and roller shutter motor during periods of power failure.
- Additional exit signage is to be installed to assist in egress.

The assessment methodology shall be absolute and qualitative in accordance with BCA Clauses A0.3(a)(ii) and A0.5(d). The analysis shall demonstrate that occupant evacuation is not delayed or significantly obstructed by the operation of roller shutter.

Item 8: Location of Fire Hydrant Booster

Relevant Regulatory Requirement:

BCA Clause E1.3 states that a fire hydrant system must be installed in accordance with AS2419.1:2005 and requires the hydrant booster to be located within sight of the building's main entrance.

Performance Requirements EP1.3

Non-compliance with DTS provisions:

- The hydrant booster assembly is located near the western corner of the site (on Neighbourhood Street) and is not within sight of the four main entry lobbies into the building.

VARIATIONS, ASSOCIATED METHODOLOGY AND ACCEPTANCE CRITERIA

Relevant IFEG Sub-Systems:

ABCDEF

Approaches and Method of Analysis:

The booster location is easily accessible and being located off the main road and adjacent to the fire control room, the fire brigade is expected to be able to easily identify the booster on arrival to the site.

The assessment methodology will be absolute and qualitative in accordance with BCA Clauses A0.3(a)(i) and A0.5(b)(ii). The analysis shall demonstrate that the Performance Solution satisfies the Performance Requirements of the BCA and facilitates fire brigade intervention.

Item 9: Fire Hydrant Booster Fire Resisting Construction

Relevant Regulatory Requirement:

BCA Clause E1.3 states that a fire hydrant system must be installed in accordance with AS2419.1 which in turn requires that the booster must be either:-

- Located not less than 10 metres from the external wall of any building served; or
- If located in an external wall, must be separated from the building by construction having an FRL of 90/90/90 that extends not less than 2m each side and 3m above the upper hose connections of the booster assembly.

Performance Requirements EP1.3

Non-compliance with DTS provisions:

- The hydrant booster is located within 5m from the external wall of the building where glazed openings of the apartments do not prescriptive achieve an FRL of --/90/90.

Relevant IFEG Sub-Systems:

ABCDEF

Approaches and Method of Analysis:

The Performance Solution will rely upon the newest fire hydrant standard AS2419.1.-2017 that provides exemptions to allow the booster assembly to be unprotected where the building is protected throughout by an automatic fire sprinkler system.

The assessment methodology will be absolute and quantitative in accordance with BCA Clauses A0.3(a)(i) and A0.5(b)(ii). The analysis shall demonstrate that the openings will not impeded on fire brigade access and operation of the booster.

Item 10: Location of Fire Control Room

Relevant Regulatory Requirement:

VARIATIONS, ASSOCIATED METHODOLOGY AND ACCEPTANCE CRITERIA

BCA Specification Clause E1.8 requires that a fire control room must be located in a building that egress from any part of its floor, to a public road or open space, does not involve changes in level which in aggregate exceed 300 mm.

Performance Requirement EP1.6

Non-compliance with DTS provisions:

- The fire control room require a change in level of approximately 1m from street level.

Relevant IFEG Sub-Systems:

ABCDEF

Approaches and Method of Analysis:

Access to the fire control room is deemed acceptable for fire bridge activities and co-ordination.

The assessment methodology will be qualitative and absolute in accordance with BCA Clauses A0.3(a)(i) and A0.5(b)(ii). The analysis shall demonstrate that the location of the fire control room will not impede on fire bridge activities and co-ordination.

Item 11: Omission of Zone Smoke Control

Relevant Regulatory Requirement:

Table E2.2a of BCA requires a building with an effective height of more than 25m, Class 5, 6, 7b, 8 and 9b parts of the building must be provided with a zone smoke control system in accordance with AS/NZS 1668.1.
Performance Requirement EP2.2

Non-compliance with DTS provisions:

- In this instance, zone smoke control systems will not be provided in the retail/community area on Lower Ground Floor.

Relevant IFEG Sub-Systems:

ABCDEF

Approaches and Method of Analysis:

The Performance Solution does not require zone smoke control. Instead it relies upon the retail/community area being on the level of egress to a road or open space and the short travel distances involved in these enclosures to allow occupants to evacuate without be affected by smoke.

The assessment methodology shall be comparative and qualitative in accordance with BCA Clauses A0.3(a)(ii) and A0.5(d). The analysis shall demonstrate that the omission of zone smoke control within the retail/community area does not increase the risk of smoke spread and expose occupants to adverse conditions than expected in a DtS design.

6 PROPOSED FIRE SAFETY STRATEGY

The fire safety strategy outlined beow has been proposed to satisfy the fire and life safety objectives specified for this project by the relevant stakeholders. In addition, the fire safety strategy is required to adequately address the specific fire and life safety hazards identified for the proposed development, and as such have been generally derived from the preventative and protective measures outlined within the BCA, and fire engineering literature and research.

The specified fire safety strategy will undergo analysis as part of a Fire Engineering Report to ascertain whether the relevant Performance Requirements of the BCA are satisfied. The information herein is therefore pending completion of the fire engineering analysis and as such is possible to change and or modification through the detailed design phase of the project.

6.1 Passive Fire Construction

6.1.1 Fire Resisting Construction

The building structure including floors, walls, columns and shafts shall be constructed in accordance with the requirements of BCA Clause C1.1, Specification C1.1, Table 3 as applicable to Type A construction.

It is noted that BCA Clause A3.3 states that each part of a building must be classified separately, and where parts have different purposes – if not more than 10% of the floor area of a storey, being the minor use, is used for a purpose which is a different classification, the classification applying to the major use may apply to the whole storey. This provision do not apply when the minor use is a laboratory or Class 2, 3 or 4 part.

Different classifications in the same storey must achieve the most onerous FRL pertaining to the classifications or be separated by a fire wall achieving this FRL with the following exception permitted:-

Proposed Performance Solution

- The retail/ community area located on Lower Ground Floor shall achieve a reduced FRL of 120/120/120 which is deemed to be non-compliant with the BCA requirements for Class 6 parts.
  - I.e. any structural member located within this part that is required an FRL of 180 per BCA Table 5 in Specification C1.1, be it for the structural adequacy, integrity or insulation, shall be reduced to 120.
- In the Basement 3, it is proposed that a driveway connection be provided to Lot C2 i.e. the community centre. To separate the driveway connection, an automatic closing fire-rated roller shutter shall be provided which achieves an FRL of --/120/--.
  - As part of the Performance Solution, drenchers shall be provided to both sides of the roller shutter and shall include the following design measures: -

- Have water supplied from the fire hydrant system.
- Have a water supply that is adequate to allow simultaneous operation of the hydrant system and wall-wetting sprinklers in that part.
- Be provided with a dedicated isolation valve and flow switch to active the building alarm.
- The isolation valve shall be installed in a secure location that has direct access from outside (i.e. within a fire-isolated stair, hydrant pump room or at the hydrant booster assembly).

It should also be noted that all firewalls are to continue to the underside of the floor above or underside of the roof covering in accordance with BCA DtS Clause C2.7.

Classifications in different storeys shall be separated by a floor which has an FRL not less than that of the storey below.

6.1.2 Finishes and Linings

Where practicable, finishes, linings and materials used throughout the building should be non-combustible to reduce the spread of fire and the generation of toxic smoke products.

All wall, floor and ceiling, and roof and ceiling assemblies must be tested and rated for their fire hazard properties in accordance with the prescriptive requirements of BCA Clause C1.10 and Specification C1.10.

6.1.3 Separation of Equipment

Equipment as detailed below must be fire separated from the remainder of the building by 120/120/120 FRL construction with any door opening into that room consisting of a --/120/30 self-closing fire door.

- Lift motors and lift control panels (unless the lift installation does not have a machine-room);
- Emergency generators used to sustain emergency equipment operating in emergency mode;
- Central smoke control plant (other than smoke exhaust systems designed for high temperature operation);
- Boilers;
- Batteries installed in the building that have a voltage exceeding 24 volts and a capacity exceeding 10 ampere hours.

6.1.4 Smoke Seals

Medium (rubber) temperature smoke seals shall be installed to all various doors to assist in rationalising the Performance Solutions listed herein. The smoke seals shall–

- Be provided to all four (4) sides of the door frame/leaf.
- Be capable of resisting smoke in accordance with Specification C3.4 (200°C smoke for 30 minutes) and tested to AS1530.7 and AS6905.

As part of the Performance Solution smoke seals shall be provided to the following doors:

- To all rooms that open into a corridor serving a residential apartment with extended travel distances and reduced separation of alternative exits. The only doors excluded from this are the lift doors,

doors to fire stairs, water and gas services cupboards and cupboards containing portable fire extinguishers.

6.2 Egress Provisions

6.2.1 Evacuation Strategy

Activation of any sprinkler head or the public area smoke detector shall initiate the evacuation of all areas of the building to ensure that all clients, visitors, and staff are promptly evacuated.

6.2.2 Number of Exits

Not less than two (2) exits must be provided from each storey as the building has an effective height greater than 25m with the following exception:-

Proposed Performance Solution

- Occupants in the 4-bedroom terraces are only provided with a single exit on Upper Ground Floor.

6.2.3 Egress Provisions – Travel Distances

Egress in the Class 2 Residential Parts

With exception of the following items being addressed through a fire engineered Performance Solution, the travel distance from the apartment entry door to a point of choice must be not more than 6m and the distance between alternative exits must be no closer than 9m and no further apart than 45m.

Proposed Performance Solution

Within the residential levels, travel distances exceeds the DTS limitations as follows:

Social-Housing

- Occupants on Upper Ground Floor to Level 12 have up to 12m to a point of choice in lieu of 6m.

Market- Dwelling

- Occupants on Level 02 to Level 19 have up to 7m to a point of choice in lieu of 6m.

Egress in the Class 7a Carparking Parts

With exception of the following items being addressed through a fire engineered Performance Solution, travel distances to a point of choice or single exit to be not more than 20m, the distance to the nearest of two or more alternative exits must not exceed 40m and the distance between alternative exits must be no closer than 6m and no further apart than 60m.

Proposed Performance Solution

Within the car parking levels travel distances exceeds the DTS limitations as follows:

- Occupants in the carpark areas have extended travel distances of up to up 30m to a point of choice, 50m to the nearest exit, 90m between alternative exits.

6.2.4 Separation Distances of Alternative Exits

With exception of the following items being addressed through a fire engineered Performance Solution, exits that are required as alternative means of egress must be not less than 9m apart.

Proposed Performance Solution

- On the residential levels, the separation distance between the alternative exits is reduced to 4.3m.

6.2.5 Door Hardware, Operation and Mechanisms

All doors serving as required exits shall have hardware, door swings, latch operations and signage in accordance with the prescriptive requirements of BCA Clauses D2.19, D2.20, D2.21 and D2.23 with the following exception:-

Proposed Performance Solution

The roller shutter serving the loading dock is used as an exit although it is not the only required exit and not locked in the open position while the building is lawfully occupied. In addition, roller shutter will not be able to be manually opened with a force less than 110N, nor will the shutter automatically open in the event of a power failure or alarm activation.

The Performance Solution will require the following fire safety measures:-

- The roller shutter is to be fitted with the following provisions:-
  - A mushroom push-button device shall be located on the internal side (i.e. loading dock) of the roller shutter door.
  - A battery backup shall be provided to operate the push-button and roller shutter motor during periods of power failure.
  - Additional exit signage is to be installed to assist in egress.
- An additional door is to be provided between the residential bin store and loading dock.
  - A 1m wide egress path is to be maintained through the bin store to the door between the residential bin store and loading dock.

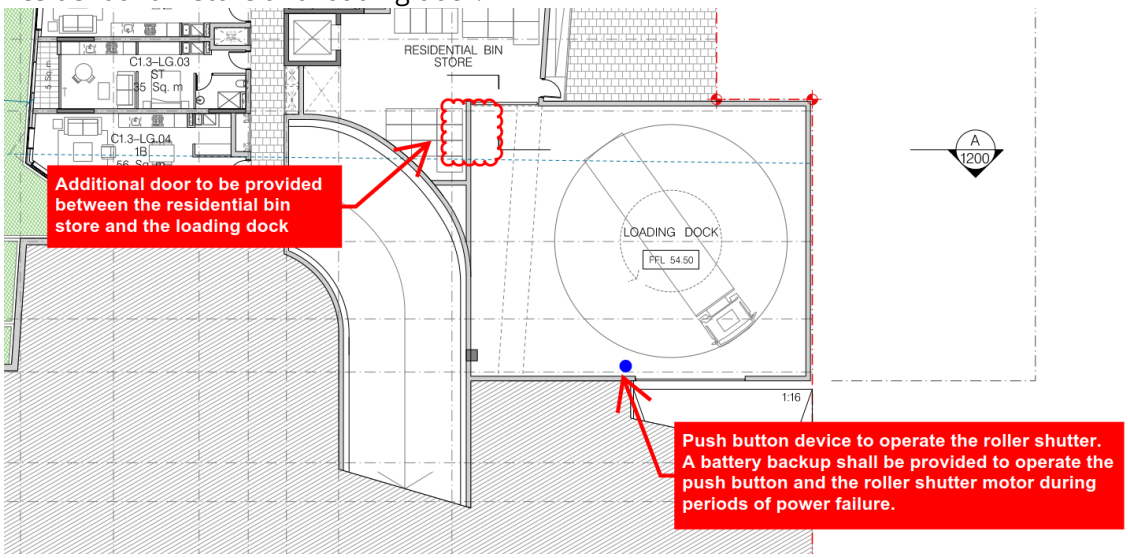


Figure 6-1: Additional door to be provided

6.2.6 Fire-Isolated Stair Re-Entry Provisions

Re-entry provisions are to be provided to each door of a fire-isolated stair that serves a level above 25m in effective height. This shall be designed and installed in accordance with the prescriptive DTS provision of BCA Clause D2.22.

6.2.7 Fire-Isolated Exits

A room must not open directly into a fire-isolated stair unless it is from a public corridor, a sole-occupancy-unit occupying the whole storey, or a sanitary compartment, airlock or the like.

6.2.8 Signage and Lighting

Exit and emergency lighting is to be provided throughout the building in accordance with the prescriptive DtS provisions of BCA Clause E4.2, E4.4, E4.5, E4.6, E4.8 and AS2293:2005.

- Exit signs are to be pictograph 'running man' signs as per the prescriptive requirements of AS2293.1:2005.
- All exit and directional exits signs are to power operated illuminated signs.

6.3 Active Fire Protection Systems

6.3.1 Combined Fire Sprinkler and Hydrant System

A combined fire hydrant and sprinkler system is to be provided throughout the building in accordance with the prescriptive DTS provisions listed in BCA Clauses E1.3, E1.5 and Specification E1.5 and AS2118.1:1999, AS2118.6:2012 and AS2419.1:2005.

The sprinkler system shall meet the following minimum requirements:

- Class A fault monitoring devices shall be provided except where not required by AS2118.6:2012 (i.e. not required in secure locations).
- Activation of any sprinkler head shall initiate the:-
    - Sound system and intercom system for emergency purposes.
    - An automatic link to an approved monitoring centre.
    - Release any hold-open door devices and unlatch any secure doors in the path of travel.
- The system shall have a Grade A water supply allowing for two independent water sources.
- Storage cages within the car park levels is to be provided with horizontal and vertical wire mesh restrictions to limit storage within 500mm of the sprinkler heads above (as per AS2118.1:1999).

The fire hydrant system shall meet the following minimum requirements:

- The system shall provide adequate connection points and facilities for fire brigade personnel to attach their equipment and reach all parts of the building's floor area.
- The system must be capable of providing coverage to all parts of the building based on hose lengths of 30-metres (internal hydrant connections) and 60-metres (external hydrant connections) with an additional allowance for a 10-metre water stream.

- All fire hydrants are to be fitted with Storz hose couplings to enable quick attachment by the fire brigade.
- The hydrant system shall be designed with a ring main (as the building is over 25m in effective height).
- The booster assembly shall be positioned parallel to the street, within 8m of the hardstand (i.e. Neighbourhood Street) and be located greater than 10m from the external wall of the building.
- Access to the fire pump room in the Basement Level shall be direct from a fire-isolated stair with a fire rated airlock to separate the pump room from the stair shaft.
- The system must be provided with a relay pump to assist in fire brigade operations.

As part of the Fire Engineering, the following provisions must be incorporated into the design:

- All sprinkler heads located within the carpark fire compartment are to be:-
  - Fast response type sprinkler heads with a Response Time Index (RTI) ≤ 50$m^{1/2}s^{1/2}$.
  - Designed on a 12m^2 area of coverage as per AS2118.1 for an ordinary hazard system (extended coverage sprinklers cannot be used in the carpark).

Proposed Performance Solution

- The hydrant booster assembly is located near the western corner of the site (on Neighbourhood Street) and is not within sight of the four main entry lobbies into the building.
- The hydrant booster is located within 5m from the external wall of the building where glazed openings of the apartment do not prescriptive achieve an FRL of --/90/90.

6.3.2 Building Alarm and Communication System

A Sound System and Intercommunication System for Emergency Purposes (SSISEP) shall be installed throughout the building. This shall be designed in accordance with the prescriptive requirements of Clause E4.9 of the BCA and AS1670.4:2015.

- The above system shall be interfaced with the sprinkler and smoke detection systems such that the activation of any sprinkler head or smoke detector unit will initiate the building alarm system.
- Where a cascading alarm is introduced into the design, this must be in accordance with AS1670.1 and AS1670.4 and be detailed within the Emergency Evacuation Plan.
- Internal speakers shall be provided within each SOU to ensure that an A-weighted 75 dB sound pressure level is achieved at the bedhead.

6.3.3 Fire Control Room

A Fire Control Room is to be provided in accordance with the prescriptive DTS provisions listed in BCA Clauses E1.8 and Specification E1.8.

The Fire Control Room shall-

- Be fire separated by 120/120/120 FRL construction that consists of concrete or masonry.
- Doors into the room shall be hinged to swing into the room and be self-closing with a --/120/30 FRL.
- Have access doors that are accessible with a 003-fire brigade key.
- Contain all fire services control equipment including (but not limited to) the fire indicator panel, fan control panel, alarm control panel remote switching controls for the gas and electrical supplies.
- Be ventilated by natural opens direct to outside or a mechanical pressurisation system in accordance with AS1668.1.

Proposed Performance Solution

- The fire control room require a change in level of approximately 1m from street level.

6.3.4 Carpark Mechanical Ventilation System

A mechanical ventilation system is to be provided to the car parking areas in accordance with the prescriptive DTS provisions listed in Clause E2.2, Table E2.2a of the BCA and AS1668.2:2012.

- The system shall be a fully ducted system with the impulse and jet fans only used in dead end corners of the floor plate (as permitted by AS1668.2).

6.3.5 Automatic Air Pressurisation System to Fire-Isolated Stair

An automatic air pressurisation system is to be provided to each of the fire-isolated stairs serving a part of the building above 25m in effective height and also any storey stair serving more than 2 below ground storeys not counted in the building's Rise In Storeys.

The system shall be designed in accordance with the prescriptive DTS provisions listed in Clause E2.2, Table E2.2a of the BCA and AS/NZS 1668.1:2015.

6.3.6 Fire Detection and Alarm System

A smoke detection and alarm system shall be provided throughout the building in accordance with BCA Clause E2.2, Specification E2.2a and AS1670.1:2015 and AS3786:1995.

The smoke detection system shall be programmed to –

- Activate the building alarm system.
- Release and security measures on doors in the egress path.
- Release any door hold-open devices.
- Activate the smoke hazard management systems (i.e. fire stair pressurization system, air handling shut down, air supply to pump rooms or fire control room etc.).
- Activate the brigade notification alarm signal.

The Main FIP shall be located in the Fire Control Room while mimic/sub FIPs shall be provided to each residential lobby.

6.3.7 Emergency Lifts

Emergency Lifts shall be provided such that each level is served by at least one lift in accordance with the prescriptive DTS provisions listed in Clause E3.4 of the BCA.

All emergency lifts shall be contained within a dedicated fire rated shaft that achieves a 120/120/120 FRL in accordance with the prescriptive DTS provisions listed in Clause C2.10 of the BCA.

6.3.8 Zone Smoke Control

With exception of the following items being addressed through a fire engineered Performance Solution, Class 5, 6, 7b, 8 and 9b parts of the building must be provided with a zone smoke control system in accordance with AS/NZS 1668.1.

Proposed Performance Solution

- Zone smoke control systems will not be provided in the retail/community area on Lower Ground Floor.

6.4 Building Management Procedures

The ongoing management of the building is as important in maintaining a high level of life safety as the provisions recommended during the design phase of the building.

6.4.1 Maintenance of Fire Safety Equipment

The fire detection systems, fire sprinkler systems, emergency warning systems, fire hydrants, hose reels, portable fire extinguishers, emergency lighting and any other fire safety equipment shall be tested and maintained in accordance with Australian Standard AS1851 or other relevant testing regulatory.

6.4.2 No Smoking Policy

A no-smoking policy shall be implemented and enforced through all internal areas of the building.

6.4.3 Fire Safety Manual

A fire safety manual shall be developed for the site to provide an overview of all fire safety procedures and systems within the building. The manual should also record false alarms, outcomes from alarm investigations and action plans to minimise nuisance alarm signals.

The manuals should be reviewed annually and lessons learned exercise undertaken.

6.4.4 Hot Works Policy

A hot works policy should be put in place and rigorously enforced to ensure that all hot works, including grinding and welding, are managed to avoid the accidental ignition of fires.

7 REFERENCES

1. Australian Building Codes Board, "NCC - Building Code of Australia – Volume One", Canberra ACT 2016."
2. Australian Building Codes Board, "NCC - Guide to Volume One", Canberra ACT 2016.
3. Australian Building Codes Board, "International Fire Engineering Guidelines", Canberra ACT 2005.
4. Society of Fire Protection Engineers, "The SFPE Handbook of Fire Protection Engineering", 4th edition, 2008.
5. Drysdale D, "An Introduction to Fire Dynamics", 3rd edition, John Wyley & Sons, UK, 2011.
6. PD7974-6:2004, "The application of fire safety engineering principles to fire safety design of buildings – Part 6: Human factors", BSI British Standards.
7. PD7974.7:2003, "Application of fire safety engineering principles to the design of buildings – Part 7: Probabilistic risk assessment", BSI British Standards.
8. Spearpoint, M., "Fire Engineering Design Guide", 3rd edition, New Zealand Centre for Advanced Engineering, May 2008.
9. The Chartered Institute of Building Services Engineers, "Fire Safety Engineering CIBSE Guide E", 3rd Edition, May 2010.
10. Drysdale D, "An Introduction to Fire Dynamics", 3rd edition, John Wiley & Sons, UK, 2011.
11. "Fire Brigade Intervention Model V2.2", Australasian Fire Authorities Council, October 2004.
12. Boyce, K., Shields, T., and Silcock, G., "Toward the Characterization of Building Occupancies for Fire Safety Engineering: Capabilities of Disabled People Moving Horizontally and on an Incline", Fire Technology, Vol. 35, No. 1, February 1999, pp. 51-67.
13. Nelson, H.E. "BUD" and Mowrer, F.W., "Emergency Movement", The SFPE Handbook of Fire Protection Engineering (3rd Edition), National Fire Protection Association, Quincy, MA 02269, 2002 pp. 3/367-380.
14. Pauls, J. L. "Movement of People in Building Evacuations", Human Response to Tall Buildings, Chap 21. Dowden, Hutchinson and Ross, Stroudsburg, PA, 1977.
15. Pelecheno N, Malkawi A, "Evacuation simulation models: Challenges in modelling high rise building evacuation with cellular autometa approaches", Automation in Construction Journal 2008 (Vol. 17), pp.377-385.
16. Predtechenskii, V.V. and Milinskii, A.I., Planning for foot traffic in buildings (translated from Russian). Stroizdat publishers, Moscow, 1969. English translation published for National Bureau of Standards and the National Science Foundation, Washington, by Amerind Publishing Co. Pvt. Ltd, New Delhi, India, 1978.
17. Shi, L, Xie, Q, Cheng, X, Chen, L, Zhou, Y, Zhang, R, "Developing a database for emergency evacuation model", pp. 1724-1729 Building and Environment, 2009.

18. Hall, J.R. “U.S. Experience with Sprinklers”, National Fire Protection Association, June 2013.
19. Turner, M. "Fire Brigade's Fight for Sprinklers in New Underground Car Park." Fire, 79 (972): 32-34, 1986.
20. Thomas, IR., “Fires in Carparks”, Fire Australia February 2004, Eastside Printing, 2004.
21. BHP Steel: Structural steel Development Group, Report No MRL/Ps69/89/006. “Fire Safety in Car Parks”.
22. Li, Y and Spearpoint, M. Analysis of vehicle fire statistics in New Zealand parking buildings. Fire Technology, Vol. 43, No. 2, 2007, pp.93-106.
23. BS EN 1991-1-2:2002, ‘Eurocode 1: Actions on structures – Part 1-2: General actions – Actions on structures exposed to fire’, British Standards, March 2009.
24. AS 1530.4, “Methods for fire tests on building materials, components and structures, Part 4: Fire resistance tests of elements of construction”, Standards Australia, 2005.
25. Bushfire CRC, “Window and Glazing Exposure to Laboratory-Simulated Bushfires”, Doc: 2006-205, May 2006.
26. Rakic J, “The Performance of Unit Entry Doors when Exposed to Simulated Sprinkler Controlled Fires”, Lorient International, Lindfield, NSW, Australia.
27. England JP, Chow V, Yunlong Liu, (2007) Modelling Smoke Spread through Barrier Systems Retrieved from http://www.yunlong.com.au/pdf/PEngland.pdf
28. Marty, A., ‘Home Structure Fires’, NFPA Research, September 2016.
29. Marry, A., ‘Characteristics of home fire victims’, NFPA Research, October 2014.
30. Campbell, R., ‘Structure Fires in stores and other mercantile properties’, NFPA Research, December 2015.
31. Marty, A., ‘Home Structure Fires’, NFPA Research, September 2016.

APPENDIX A FIRE STATISTICS

PROBABILITY OF FIRE STARTS

The probability of a fire start in a range of building uses, based on UK data, can be established using the data presented in Table 7-1 [7]; the applicable occupancy type is highlighted.

Table 7-1: Overall probability of fire starts for various occupancies, UK data

Occupancy	Probability Of Fire Starts (% Per Year)
Industrial	4.4
Storage	1.3
Offices	0.6
Assembly entertainment	12.0
Assembly non-residential	2.0
Hospitals	30.0
Schools	4.0
Dwellings	0.3

PROBABILITY OF CIVILIAN INJURY AND FATALITY

The probability of injuries and deaths for various occupancy types based on UK data [7] is presented in the following table.

Table 7-2: Probability of occupant injury and fatality by occupancy type, UK data averages for the years 1995 and 1997-1999

Type Of Occupancy	No Of Fires	Probability Of Occupant Injury Per Fire Event (%)	Probability Of Occupant Death Per Fire Event (%)
Further education	535	3.18	0.00
Schools	1669	3.06	0.00
Licensed premises	3317	7.90	0.08
Public recreational buildings	2581	1.86	0.05
Shops	5671	5.01	0.06
Hotels	1021	11.36	0.24
Hostels	1338	4.48	0.04
Hospitals	3063	3.69	0.11
Care homes	1616	8.04	0.28
Offices	1988	11.02	0.02
Factories	5299	5.40	0.08

APPENDIX B FIRE BEHAVIOUR

FIRE GROWTH RATE

As the fire increases in size, the rate of fire growth accelerates. The growth rate of a fire can result in various hazards for occupants due to the following:

- Protective and preventative measures may not be adequate
- Occupants may have insufficient time to evacuate
- Occupants may perceive a reduced threat from slow growing fires

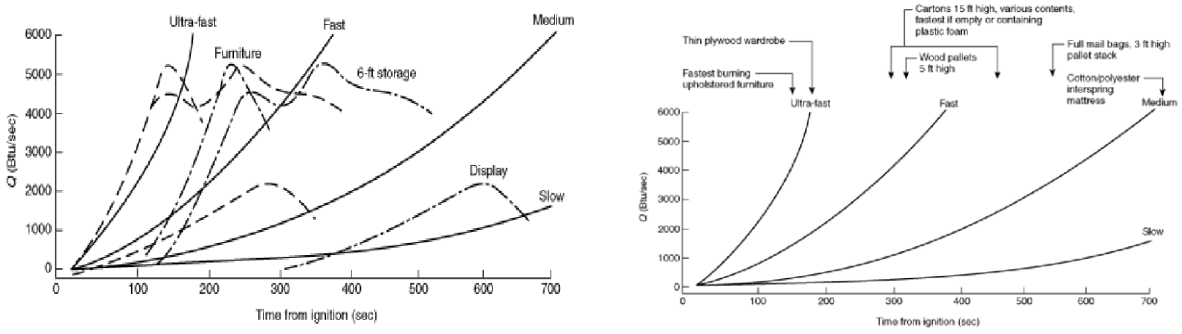
The rate of fire growth is generally expressed in terms of an energy release rate. The most commonly used relationship is what is commonly referred to as a quadratic t-squared fire. In such a fire, the rate of heat release is given by the expression:

$$Q = \left(\frac{t}{k}\right)^2$$

Where; t is time from ignition of the fire (seconds) and k is the growth time (seconds) for the fire to reach a heat output of 1.055 MW.

The continued growth of a fire defined by the above equation relies on both a sufficient source of fuel and air and assumes that flashover has not been reached. The rate of fire growth can be estimated from the results of a number of fire tests that have been performed on various fuel commodities.

National Fire Protection Association Standard NFPA 92B, provides information on the relevance of t-squared approximation to real fire as depicted in Figure 7-1.



(a) t-squared fire, rates of energy release (b) Relation of t-squared fires to some fire tests

Figure 7-1: NFPA 92B design fires and heat release rates

A slow fire growth is not considered to be the most challenging in terms of fire and life safety or fire brigade intervention. The continued growth of a fire defined by the above equation relies on both a sufficient source of fuel and air and assumes that flashover has not been reached. The rate of fire growth can be estimated from data published in CIBSE Guide E [9] and BS9999:2008 are listed below:

- Assembly hall seating : Medium-Fast
- Dwelling : Medium
- Office : Medium
- Hotel bedroom : Medium
- Hotel reception : Medium
- Meeting room : Medium
- Picture Gallery : Slow
- Reception area : Slow
- Restaurant/Canteen : Medium
- Shop : Fast
- Teaching laboratories : Fast
- Warehouse : Medium/Fast/Ultra-fast
- Waiting Room : Slow

From the above list, it can be concluded that the likely fire scenarios in the building may be approximated by the standard medium time-squared fire growth rate curve in the residential areas and fast time-squared fire growth rate curve in the retail areas.

APPENDIX C FIRE LOADS

The fire load within a room or compartment will influence the duration and severity of a fire and resultant hazard to occupants. The effective fire load for the building has been estimated by consideration of the typical spaces within the building.

The IFEG has published further fire load densities for broad occupancy groupings (extracted from CIB 1983) as provided in the table below. The CIB compilation emphasises that at least the 95% fractile should be selected for design purposes. The following fire loads have been extracted from the IFEG and are considered applicable to the subject building:

Table 7-3: Fuel load densities for different occupancy groups

Densities in mega-joules per square metre				
Occupancy	Mean	Percent fractile		
	(MJ/m^2)	80	90	95
Dwelling	780	870	920	970
Hospital	230	350	440	520
Hospital storage	2000	3000	3700	4400
Hotel bedroom	310	400	460	510
Offices	420	570	670	760
Shops	600	900	1100	1300
Manufacturing	300	470	590	720
Manufacturing and storage <150kg/m^2	1180	1800	2240	2690
Libraries	1500	2250	2550	-
Schools	285	360	410	450

DWELLING (U.S.A)

The following data has been extracted from the fire statistics data published by the NFPA for the years 2010-2014. The sum of each column of data may not equal totals due to rounding errors.

Table 7-4: Leading causes of reported apartment or multi-family housing structure fires (2010-2014 annual averages)

Cause	Fires	Civilian Deaths	Civilian Injuries
Cooking equipment	75,700 (70%)	100 (24%)	2,263 (53%)
Heating equipment	7,900 (7%)	40 (10%)	346 (8%)
Smoking materials	6,800 (6%)	130 (32%)	470 (11%)
Intentional	5,500 (5%)	50 (11%)	317 (7%)

Cause	Fires	Civilian Deaths	Civilian Injuries
Electrical distribution or lighting equipment	3,400 (3%)	60 (14%)	287 (7%)
Exposure	2,100 (2%)	0 (0%)	104 (2%)
Candles	2,000 (2%)	20 (4%)	262 (6%)
Clothes dryer or washer	2,000 (2%)	0 (0%)	13 (0%)

Based on the table above, it can be noted that the leading cause is generally equipment used by the building occupants. The following table indicates the majority of deaths and injuries occur in the kitchen, bedroom and living room areas.

Table 7-5: Reported apartment or multi-family housing structure fires by area of origin (2010-2014 annual averages)

Cause	Fires	Civilian Deaths	Civilian Injuries
Kitchen or cooking area	71,700 (67%)	80 (18%)	2,090 (49%)
Bedroom	4,700 (4%)	120 (28%)	840 (20%)
Living room, family room or den	2,500 (2%)	110 (26%)	420 (10%)
Exterior balcony or unenclosed porch	2,400 (2%)	10 (2%)	70 (2%)
Trash or rubbish chute, area or container	2,400 (2%)	0 (0%)	10 (0%)
Laundry room or area	2,000 (2%)	0 (0%)	80 (2%)
Bathroom or lavatory	1,900 (2%)	10 (1%)	90 (2%)
Unclassified area of origin	1,700 (2%)	0 (1%)	40 (1%)
Other known area of origin	18,400 (17%)	90 (23%)	640 (15%)

The following table lists the extent of fire spread in home structure fires and the corresponding number of civilian injuries.

Table 7-6: Reported apartment or multi-family housing structure fires by extent of fire spread (2010-2014 annual averages)

Extent Of Fire Spread	Fires	Civilian Deaths	Civilian Injuries
Confined fire identified by incident type	74,500 (69%)	0 (0%)	820 (19%)
Confined to object of origin	6,600 (6%)	20 (4%)	280 (7%)
Confined to room of origin	16,100 (15%)	150 (36%)	1,620 (38%)
Confined to floor of origin	3,500 (3%)	70 (16%)	580 (13%)
Confined to building of origin	6,200 (6%)	150 (36%)	870 (20%)
Extended beyond building of origin	800 (1%)	30 (8%)	120 (3%)
Total	107,800 (100%)	410 (100%)	4,280 (100%)
Fire spread extended beyond room of origin	10,500 (10%)	250 (59%)	1,560 (36%)