BLACKETT
MAGUIRE+
GOLDSMITH

26 March 2015

RECEIVED
9 JUN 2015
PITTWATER COUNCIL

The General Manager
Pittwater Council
PO BOX 882
MONA VALE NSW 1660

Dear Sir / Madam,

REFERENCE: **DA NO. N0191/13 (AS AMENDED)**
2 DAYDREAM STREET, WARRIEWOOD NSW 2102
STAGE 3 CONSTRUCTION CERTIFICATE (AMENDED)

As required by Clause 142(2) of the EP&A Regulation 2000 (the Regulation) notice is hereby given that the following application for Construction Certificate has now been approved.

Applicant:	Livpac Developments Pty Ltd
Subject Address:	2 Daydream Street, Warriewood NSW 2102
Date Received:	11 March 2015
Date Determined:	4 June 2015

Please find undercover a copy of the Amended Construction Certificate No. CC-15057/A in relation to the subject development.

This Amended Construction Certificate has been issued for Danpalon and Alucobond wall cladding including revised Fire Safety Engineering Report.

We have also enclosed a copy of the following for Councils record:

+ Application form;
+ Fire Safety Schedule; and
+ Approved documentation and other documentation relied upon as indicated on the Construction Certificate.

Pursuant to Clause 263(2) Environmental Planning and Assessment Regulation 2000, please find enclosed a cheque to the sum of $36.00 for the submission of this Part 4A Certificate and request that a receipt for which is forwarded to our office.

If we have provided the approved documentation to you electronically on a USB storage device, we would like to advise you that this device is for transmittal purposes only and is not designed for long term storage, please transfer all documentation to a purpose designed form of storage media.

Please contact the undersigned should you have any further enquiries on 02 9211 7777.

Yours Sincerely,

Tony Heaslip
Director
Blackett Maguire + Goldsmith Pty Ltd

$36 REC: 379315 9/6/15

Address Suite 2.01, 22-36 Mountain St Ultimo NSW 2007
Postal PO Box 167 Broadway NSW 2007
ABN 18 408 985 851
Contact Ph: 02 9211 7777 Fax: 02 9211 7774 Email: admin@bmplusg.com.au

BLACKETT MAGUIRE+ GOLDSMITH

CONSTRUCTION CERTIFICATE (AMENDED)

Pursuant to Part 4A of the Environmental Planning & Assessment Act 1979

CERTIFICATE NO.:	CC-15057
TYPE:	☑ Building Work
DETERMINATION:	Approved
DATE OF DETERMINATION:	26 March 2015
DATE OF AMENDMENT A:	***04 June 2015***
SUBJECT LAND:	
Lot & DP	Lot 100 DP 1174851
Address	2 Daydream Street, WARRIEWOOD NSW 2102
LOCAL GOVERNMENT AREA:	Pittwater Council
APPLICANT:	
Name	Mark Livingstone
Company	Livpac Developments Pty Ltd
Address	PO BOX R215 , ROYAL EXCHANGE NSW 1225
Phone / Fax / Email	Phone: 02 8274 0400 Fax: 02 8274 0444 Email: mlivingstone@livgroup.com.au
OWNER:	
Name	Livpac Developments Pty Ltd
Address	PO BOX R215, ROYAL EXCHANGE NSW 1225
Phone / Fax / Email	Phone: 02 8274 0400 Fax: 02 8274 0444 Email: mlivingstone@livgroup.com.au
DESCRIPTION OF DEVELOPMENT:	CC3: Remaining building works ~~(excluding Danpalon and Alucobond wall cladding).~~ *Note: This Construction Certificate excludes any external ancillary services, structures or civil works required by relevant authorities.*
DESCRIPTION OF AMENDMENT A:	***Remaining building works associated with the Stage two development of an industrial and commercial complex including Danpalon and Alucobond wall cladding and associated revised Fire Safety Engineering Report.***
BCA CLASSIFICATION:	Class 5, 7a, 7b & 9b
DEVELOPMENT CONSENT:	
Development Application No. Date of Determination	N0191/13 dated 8 October 2013 amended by N0191/13/S96/1 dated 15 January 2015
APPROVED PLANS:	As listed in Schedule 1
STATUTORY CERTIFICATION:	

Work completed in accordance with documentation accompanying the application for the certificate (with such modifications verified by the certifying authority as may be shown on that documentation) will comply with the requirements of the Environmental Planning & Assessment Regulation 2000 as are referred to in section 81(A)5 of the Environmental Planning & Assessment Act 1979.

CONDITIONS:	Refer to Schedule 3
CERTIFYING AUTHORITY DETAILS:	
Certifying Authority	Blackett Maguire + Goldsmith Pty Ltd
Accreditation No.	ABC 4
SIGNATURE:	Date: 04/06/2015
SIGNED ON BEHALF OF BM+G:	Tony Heaslip Accreditation No. BPB0178

Address Suite 2.01, 22-36 Mountain St Ultimo NSW 2007
Postal PO Box 167 Broadway NSW 2007
ABN 18 408 985 851
Contact Ph: 02 9211 7777 Fax: 02 9211 7774 Email: admin@bmplusg.com.au

SCHEDULE 1

SCHEDULE OF DOCUMENTATION

+ Architectural Plans prepared by SBA Architects:

DRAWING NUMBER	REV	DATE	DRAWING NUMBER	REV	DATE
GA-100	A	8 August 2014	GA-101	G	20 March 2015
GA-102	M	18 February 2015	GA-110	C	17 March 2015
GA-210	M	18 March 2015	GA-211	Y	20 March 2015
GA-212	S	5 March 2015	GA-213	U	20 March 2015
GA-214	K	6 February 2015	GA-301	B	25 August 2014
GA-305	J	17 March 2015	GA-306	E	12 January 2015
GA-307	D	26 February 2015			

In conjunction with the above plans and specifications the following documentation was relied upon in issuing the Construction Certificate:

+ Other documents relied upon:

ITEM	DOCUMENTATION	PREPARED BY	DATE
1.	CC Application Form	Livpac Developments Pty Ltd	18 July 2014
2.	Staged CC Letter	Livpac Developments Pty Ltd	11 March 2015
3.	Design Compliance Statement	SBA Architects Pty Ltd	11 February 2015
4.	Letter regarding the Water Management Report	Worley Parson Consulting	10 March 2015
5.	Water Management Report – No. 301015-03566 Rev. 2	Worley Parson Consulting	10 March 2015
6.	Certification – Access	ILC Access	6 March 2015
7.	Access Audit Report	ILC Access	6 March 2015
8.	Energy Efficiency Evaluation Report No. 14085145	Partners Energy	26 August 2014
9.	Letter regarding landscaping	FDC Construction & Fitout Pty Ltd	18 March 2015
10.	Email correspondence regarding mezzanine	Appianway	23 March 2015
11.	Water Management Report submission	FDC Construction & Fitout Pty Ltd	11 March 2015
12.	FER Request for Initial Fire Safety Report	Fire & Rescue NSW	Undated
~~13.~~	~~Fire Engineering Report – Report No. 26664700-RPT01-7~~	~~Exova Warringtonfire Aus Pty Ltd~~	~~19 March 2015~~
14.	Receipt of lodgement of Notice of Design Change	Fire & Rescue NSW	26 March 2015
Amendment A			
15.	***CC Modification Application Form***	***Livpac Developments Pty Ltd***	***4 June 2015***
16.	***Fire Engineering Report - Report No. 26664700-RPT01-8***	***Exova Warringtonfire Aus Pty Ltd***	***8 April 2015***
17.	***Clause 144 Notice of Design Change submission***	***BM+G***	***29 May 2015***
18.	***Clause 144 Notice of Design Change acknowledgement***	***FRNSW***	***29 May 2015***

SCHEDULE 2

FIRE SAFETY SCHEDULE

Issued under Clause 168 of the Environmental Planning & Assessment Regulation 2000

ADDRESS:	2 Daydream Street, Warriewood
OWNER:	Livpac Developments Pty Ltd
DEVELOPMENT APPLICATION NO.:	N0191/13 (as amended)
CONSTRUCTION CERTIFICATE NO.:	CC-15057

The following essential fire safety measures shall be implemented in the whole of the building premises and each of the fire safety measures must satisfy the standard of performance listed in the schedule, which, for the purposes of Clause 168 of the Environmental Planning and Assessment Regulation 2000, is deemed to be the current fire safety schedule for the building.

SCHEDULE

[illegible]	[illegible]	[illegible]	[illegible]
Alarm Signalling Equipment	AS1670.3 – 2004	✓	✓
Automatic Fire Detection & Alarm System *Tenancy 1 (Amber Technology) &* *Level 2 of Stage 2 Development*	Clause 5 of BCA Specification E2.2a Fire Engineering Report prepared by Exova Warringtonfire, Report No. 2567602- RPT01-2, Revision 2 dated 22/12/2011 Fire Engineering Report prepared by Exova Warringtonfire, Report No. 26664700-RPT01-***8, Revision 8 dated 8/04/2015.***	✓	✓
Automatic Fire Suppression Systems *(Excluding Swim school tenancy)*	BCA Spec. E1.5 & AS 2118.1-1999 Fire Engineering Report prepared by Exova Warringtonfire, Report No. 26664700-RPT01-***8, Revision 8 dated 8/04/2015.***	✓	✓
Building Occupant Warning System activated by the Sprinkler System	Clause 8 of BCA Spec E1.5 & Clause 3.22 of AS 1670.1 – 2004	✓	✓
Emergency Lighting	BCA Clause E4.4 & AS 2293.1 - 2005	✓	✓
Exit Signs	BCA Clauses E4.5, E4.6 & E4.8 and AS 2293.1 - 2005	✓	✓
Fire Blankets	AS 3504 - 1995 & AS 2444 – 2001	✓	✓
Fire Dampers	BCA Clause C3.15, AS 1668.1 - 1998 & AS 1682.1 & 2 - 1990	✓	✓
Fire Doors	BCA Clause C2.12, C2.13, C3.2, C3.4, C3.5, C3.6, C3.7 & C3.8 and AS 1905.1 – 2005	✓	✓
Fire Hose Reels	BCA Clause E1.4 & AS 2441 – 2005	✓	✓
Fire Hydrant Systems	Clause E1.3 & AS 2419.1 - 2005	✓	✓
Fire Seals	BCA Clause C3.15, AS 1530.4 & AS4072.1 - 2005	✓	✓
Lightweight Construction	BCA Clause C1.8 & AS 1530.3 – 1999	✓	✓
Mechanical Air Handling Systems	BCA Clause E2.2, AS/NZS 1668.1 - 1998 & AS 1668.2 – 1991	✓	✓
Paths of Travel	EP & A Regulation Clause 186 and Fire Engineering Report prepared by Exova Warringtonfire, Report No. 26664700-RPT01-***8, Revision 8 dated 8/04/2015.***	✓	✓
Portable Fire Extinguishers	BCA Clause E1.6 & AS 2444 – 2001	✓	✓
Required Exit Doors (power operated)	BCA Clause D2.19(b)	✓	✓
Warning & Operational signs	Section 183 of the EP&A Regulations 2000, AS 1905.1 - 2005, BCA Clause C3.6, D2.23, E3.3	✓	✓

[illegible]	[illegible]	[illegible]	[illegible]
Fire Engineered Alternative Solution relating to fire resisting construction (allowing reduced FRL's from 4hrs to 2hrs)	BCA Performance Requirements CP1 & CP2 Stage 1: Fire Engineering Report prepared by Exova Warringtonfire, Report No. 2567600-RPT02-3, Revision 3 dated 6/10/2011. Stage 2: Fire Engineering Report prepared by Exova Warringtonfire, Report No. 26664700-RPT01-***8, Revision 8 dated 8/04/2015.***	✓	✓
Fire Engineered Alternative Solution relating to distances between alternative exits in Tenancy 1 (Amber Technology) comprising 75m in Lieu of 60m – *Stage 1 development*	Fire Engineering Report prepared by Exova Warringtonfire, Report No. 26664700-RPT01-***8, Revision 8 dated 8/04/2015.***	✓	
Fire Engineered Alternative Solutions for the Stage 2 Development relating to: ▪ To allow the provision of a 120/120/120 FRL fire walls, floors and columns in lieu of 240/240/240 FRL to the warehouse areas. ▪ To allow drencher protected glazing in lieu of 120/120/120 FRL to the Ground Floor entry lobby of the swim school and Stair 2. ▪ Fire isolation of Fire Stair 2, and separation of rising and descending stairs in fire isolated exits. ▪ Travel distance of up to 65m to an exit within the basement carpark in lieu of 40m. ▪ Travel distance of up to 120m between alternative exits within the car parking basement levels in lieu of 60m. ▪ Travel distance up to 25m to the single exit in lieu of 20m within the warehouse mezzanine. ▪ Travel distance of up to 30m to the single exit in lieu of 20m within the Level 2 office. ▪ Travel distance up to 70m between alternative exits within Tenancy G.3 in lieu of 60m. ▪ Travel distance within the childcare centre on Level 2 of up to 70m between alternative exits in lieu of 60m. ▪ To allow the travel path egress width within the swim school between columns and the pools is 820mm wide, in lieu of 1m. ▪ The non-provision of a sprinkler system to the swim school tenancy. ▪ The use of jet-fans in lieu of a conventional exhaust air system in the basement carpark where the jet-fans do not comply with the requirements and recommendations in clause 5.5 of AS/NZS 1668.1. ▪ ***The provision of Danpalon and Alucobond Plus, which are not considered "non-combustible", to form part of the external walls at various locations.***	BCA Performance Requirements CP1, CP2, DP4, DP5, EP1.4 & EP2.2 Fire Engineering Report prepared by Exova Warringtonfire, Report No. 26664700-RPT01-***8, Revision 8 dated 8/04/2015.***		✓

SCHEDULE 3

CONDITIONS OF CONSTRUCTION CERTIFICATE

There are no conditions pursuant to clause/s 144, 187 & 188 of the Environmental Planning & Assessment Regulation 2000 at the date of issue of this Construction Certificate.

Construction Certificate (Modification) Application

BLACKETT MAGUIRE+ GOLDSMITH

Information for the Applicant

+ A construction certificate has no effect if it is issued after the building work or subdivision work to which it relates is physically commenced on the land to which the relevant development consent applies.

APPLICANT

Note – This must be the person having the Benefit of the Development Consent. Cannot be the builder unless the builder is the owner of the property.

Company: Livpac Developments Pty Ltd

ABN (if applicable): 65 122 395 091

Applicant Name: Mark Livingstone

Applicant Postal Address: Level 8, 151 Macquarie Street, Sydney

Phone: 8274 0400

Fax: 8274 0444

Mobile:

Email:

Signature ×

Date: 4 JUNE 2015

SUBJECT LAND

Location and title details of the land where the building work or subdivision work is to be carried out.

Unit / Street No: 2

Street Name: Daydream Street

Suburb / Town: Warriewood

State: NSW

Postcode: 2102

Lot No.: 100

DP / SP No.: DP 1174851

PROPOSED DEVELOPMENT

Briefly describe the development including modifications to original CC.

Modified Description

Addition of revised fire engineering report to cover of the use of Alucobond and Danpalon cladding to the building

CC to be Modified: CC-15057

Existing BCA Classification: 5, 7a, 7b & 9b

Proposed BCA Classification: 5, 7a, 7b & 9b

Estimated Cost of Works including modifications (incl GST): $13.7million

The estimated cost of works is the contract price, or if there is no contract a genuine and accurate estimate, for all labour and material costs associated with all demolition and construction required for the development, including the cost of construction of any building and the preparation of the building for the purpose for which it is to be used (such as the costs of installing plant, fittings, fixtures and equipment). GST is also to be included.

OFFICE USE – RECEIPT OF APPLICATION

This Modification to Construction Certificate Application was received by Blackett Maguire + Goldsmith on:

(Please stamp 'Received' stamp or write date received in the space provided).

Date Received:

Received

04-Jun-15

Blackett Maguire + Goldsmith

DEVELOPMENT CONSENT

Development Consent No.	Date of Determination
N0191/13/S96/1	15/01/15
Consent Authority	**DA Applicant Name**
Pittwater council	Mark Livingstone

Has a Section 82a review of determination been submitted to Council?

☐ Yes ☑ No

Does the development relate to building work or subdivision?

☑ Building Work ☐ Subdivision

Does the application relate to a residential flat development which was required, under Clause 50(1A) of the EP&A Regulation, to be accompanied by a design verification from a qualified designer?

☐ Yes ☑ No

If yes, please provide a statement from a qualified designer which verifies that the plans and specifications achieve or improve the design quality of the development for which development consent was granted, having regard to the design quality principles set out in Part 2 of State Environmental Planning Policy No.65: Design Quality of Residential Flat Development (SEPP 65).

CONSENT OF OWNER - Authority to Enter and Inspect Land

A certifying authority must not issue a construction certificate for development on a site which affects an existing building unless the certifying authority (or an accredited certifier, Council or council authority on behalf of the certifying authority) has carried out an inspection of the site of the development.

OWNERS DETAILS

Company / Full Name Livpac Developments Pty Ltd ABN (if applicable) 65 122 395 091

Postal Address PO Box R215, Royal Exchange NSW 1225

Phone 8274 0400 Fax 8274 0444 Mobile

Email

DELIVERY OF THE APPLICATION

Applications for construction certificates must be delivered to the principal office of Blackett Maguire + Goldsmith by one of the following methods:

- **By hand;**
- **By post; or**
- **Transmitted electronically.**

Applications MAY NOT be sent by fax.

REQUIRED DOCUMENTATION

Please refer to the CC Requirements list issued separately for all documentation required to be forwarded to our office to support this application and facilitate the approval of the Construction Certificate.

Exova
Warringtonfire

FIRE ENGINEERING REPORT

Peninsula Business Estate - Stage 2
2 Daydream Street
Warriewood NSW 2102

Report Number: 26664700-RPT01-8
Date: 8th April, 2015

Client:

FDC Construction and Fitout Pty Ltd

22-24 Junction Street
Forest Lodge NSW 2037

Testing. Advising. Assuring.

AUTHORISATION

No.	Comment / Reason for Issue	Issue Date	Prepared By*	Reviewed By*
8	Revised report based on additional alternative solution relating to the provision of Alucabond and Danpalon at various locations of the external walls.	8/4/2015	Vinh Dang	James Dominguez C10 Accredited Fire Engineer – BPB0607

REVISION HISTORY

No.	Comment / Reason for Issue	Issue Date	Prepared By*	Reviewed By*
1	Initial issue	28/08/2014	Vinh Dang	James Dominguez
2	Revised report based on stakeholder comments.	22/09/2014	Vinh Dang	James Dominguez
3	Revised report based on minor stakeholder comments.	23/09/2014	Vinh Dang	James Dominguez
4	Revised report based on additional alternative solutions relating to fire resisting construction to the roof, vertical separation of openings in external walls and system used to satisfy the smoke management provisions, arising from the non-provision of sprinklers to the swim school.	2/12/2014	Vinh Dang	James Dominguez
5	Revised report based on additional alternative solutions relating to the provision of jet fans within Basement Carpark.	20/02/2015	Vinh Dang	Simon Krishnan
6	Revised report based on additional alternative solutions relating to exit widths within the swim school and provision of drencher protected glazing to Stair 1.	18/03/2015	Vinh Dang	Simon Krishnan
7	Revised report reflecting updated floor plans and based on comments provided by stakeholders.	19/03/2015	Vinh Dang	Simon Krishnan

* For and on behalf of Exova Warringtonfire Aus Pty Ltd.

CONTACT INFORMATION

Exova Warringtonfire Aus Pty Ltd

Victoria

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Australia

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W: http://www.exova.com

E: market.pacific@exova.com

OVERVIEW

Exova Warringtonfire Aus Pty Ltd has been engaged by FDC Construction and Fitout Pty Ltd for professional fire engineering services to formulate a fire safety design solution against stakeholder-agreed fire safety objectives defined in the Fire Engineering Brief process. This is in relation to the following matters involving the Peninsula Business Estate - Stage 2 development at 2 Daydream Street, Warriewood NSW 2102:

- variation to fire resistance levels of the warehouse areas
- variation to fire resisting construction to entry lobby of swim school and Stair 2 on Ground Floor and variation to openings in fire isolated stairways for Stair 1 on Ground Floor, Level 1 and Level 2.
- The provision of Danpalon and Alucobond Plus, which are not considered "non-combustible", to form part of the external walls
- non-provision of fire-isolated stairways and separate rising and descending stair flights
- exit travel distances to carpark
- distances between alternative exits within carpark
- exit travel distances to warehouse mezzanine
- exit travel distances to Level 2 office
- distances between alternative exits within warehouse
- distances between alternative exits within child-care centre
- Travel path egress width within swim school
- variation to fire resisting construction to the roof, vertical separation of openings in external walls and system used to satisfy the smoke management provisions, arising from the non-provision of sprinklers to the swim school.
- provision of jet fans to the basement carpark in lieu of an air exhaust system.

A Fire Engineering Brief (FEB) was prepared and agreed upon by the relevant stakeholders and Authorities Having Jurisdiction. This was conducted generally as described in the International Fire Engineering Guidelines 2005 and documented in Fire Engineering Brief FEBQ Warriewood Stage 2 1 dated 7/08/2014. Comments and recommendations arising from this Brief have been incorporated into this Fire Engineering Report.

The Fire Engineering Brief process involved the collaborative development and agreement of an appropriate methodology, structure and trial design concept(s) by all the relevant stakeholders and formed the basis for the detailed fire safety analysis and design presented in this Fire Engineering Report.

It is the responsibility of the client to verify that the fire safety design strategy in this report is implemented as part of the design documentation and construction stages for this project.

The recommendations of this fire engineering report are presented in section 6 "Fire Safety Design" and section 7.4 "Standards of Construction, Commissioning, Management and Maintenance".

This report is not a compliance certificate in accordance with clause 144A of the Environmental Planning & Assessment Regulation 2000.

CONTENTS

1 INTRODUCTION

1.1 Project

The proposed development relates to the Stage 2 extension to the Peninsula Business Estate.

1.2 Client

FDC Construction and Fitout Pty Ltd, 22-24 Junction Street, Forest Lodge NSW 2037.

1.3 Project Address

2 Daydream Street, Warriewood NSW 2102.

1.4 Description of Work

Exova Warringtonfire Aus Pty Ltd (Exova) has been engaged to facilitate a performance-based design approach in formulating a fire safety strategy that satisfies stakeholder objectives as they relate to the Peninsula Business Estate - Stage 2 works.

This report presents the formulation of a fire safety design solution and includes analysis of the fire safety design against stakeholder-agreed fire safety objectives, as developed in the Fire Engineering Brief process.

1.5 Scope and Limits of Report

Tony Heaslip, of Blackett Maguire + Goldsmith Pty Ltd, is the Authority Having Jurisdiction for the purposes of considering an application for a construction certificate relating to building and construction works in accordance with the relevant statutory provisions. In considering that application, the matters described in the Fire Engineering Brief were identified during the Fire Engineering Brief process as varying from deemed-to-satisfy provisions of the Building Code of Australia.

The client has requested that these issues be addressed in accordance with appropriate methodologies and procedures agreed upon during the Fire Engineering Brief process.

This Fire Engineering Report includes an opinion of the fire safety design against regulatory objectives set out in the Fire Engineering Brief that the relevant authority may take into consideration in their approval of the construction certificate for the subject building and construction works in accordance with the relevant statutory provisions.

The analysis does not specifically consider arson (other than as a source of initial ignition), multiple simultaneous ignition sources, acts of terrorism, protection of property (other than adjoining property), business interruption or losses, or personal or moral obligations of the owner/occupier.

Exova has developed a fire safety strategy for this building taking note of our duty as designers of workplaces under the relevant workplace safety legislation. Other practitioners documenting these designs may also have a duty under such legislation which they must discharge in preparing their designs.

This report is limited to the fire safety provisions of the Building Code of Australia (Sections C, D and E) and does not consider amenity or non-fire health issues in the building.

This report is not a compliance certificate in accordance with clause 144A of the Environmental Planning & Assessment (EPA) Regulation 2000.

It should be noted that it is not possible to totally eradicate the risk from fire in, or from, a building.

1.6 Regulatory Framework

The following legislation has been considered in the formulation of this fire engineering report:

1. NSW Environmental Planning and Assessment Act, 1979.
2. NSW Environmental Planning and Assessment Regulation, 2000.
3. Building Code of Australia 2014, Australian Building Codes Board, 2014.

1.7 Information Considered for Fire Engineering Report

The following information has been considered in the formulation of this fire engineering report:

1. Email received from Blackett Maguire + Goldsmith Pty Ltd, describing the extent of BCA non-compliance relating to the provision of the external wall linings, dated 20th March 2015.
2. Email received from FDC Construction & Fitout Pty Ltd requesting an additional alternative solution relating to the provision of drencher-protected glazed doors in lieu of fire doors to the fire-isolated Stair 1, dated 16th March 2015.
3. Email received from FDC Construction & Fitout Pty Ltd requesting an additional alternative solution relating to the variation to exit width to the swim school, 10th March 2015.
4. Email received from FDC requesting Alternative Solution relating to the provision of jetfans to Basement Carpark, dated 10 November 2014.
5. Revised BCA Reference Report, prepared by Blackett Maguire + Goldsmith Pty Ltd, dated 20 October 2014.

   N.B. BCA Report incorporates additional matters to be subject to fire engineering arising from the non-provision of sprinklers to the swim school.
6. Fire Engineering Brief Questionnaire document, prepared by Exova Warringtonfire (Aus) Pty Ltd FEBQ Warriewood Stage 2 1, dated 7/08/2014.
7. BCA Reference Report, prepared by Blackett Maguire + Goldsmith Pty Ltd, dated 7 July 2014. N.B. It has been advised that an Alternative Solution for fire hose reels passing through drencher protected doors is not required.
8. Architectural drawings prepared by SBA Architects Pty Ltd (Project Number 14174), as listed in Table 1.1.

Table 1.1 – Referenced architectural drawings

Number	Title	Revision	Date
GA-101	Site Plan – Overall	D	June 2014
GA-102	Site Plan – Stage 2 works	M	18 February 2015
GA-110	Fire Compartments Stages 1 & 2	C	17 March 2015
GA-210	Basement Plan	M	18 March 2015
GA-211	Ground Floor Plan	X	18 March 2015
GA-212	Level 1 Floor Plan	C	June 2014
GA-213	Level 2 Floor Plan	T	17 March 2015
GA-214	Roof Plan	C	June 2014
20356-M101	Basement Layout – Mechanical Services Duct and Equipment Layout – 1 of 2	B	November 2014
20356-M102	Basement Layout – Mechanical Services Duct and Equipment Layout – 1 of 2	B	November 2014
GA-240	Plan Level 2 Childcare Centre	E	16 March 2015

1.8 Legislative Requirements

For the proposed development works, compliance with the BCA is mandated by the Environmental Planning & Assessment Regulation 2000. As noted within the referenced BCA assessment report, the relevant BCA edition for this project is 2014.

Pursuant to BCA clause A0.4, a building solution will comply with the BCA if it satisfies the performance requirements, which can only be achieved through one of the methods listed in clause A0.5, being as follows:

(a) complying with the Deemed-to-Satisfy Provisions; or
(b) formulating an Alternative Solution which—
(i) complies with the Performance Requirements; or
(ii) is shown to be at least equivalent to the Deemed-to-Satisfy Provisions; or
(c) a combination of (a) and (b).

The proposed method of BCA compliance for the subject development is A0.5(c), comprising a combination of prescriptive-based and performance-based design. For the performance-based

component of the design the subject of this report, the proposed methods of compliance to be used for each alternative solution are listed in Table 5.1.

For the assessment of alternative solutions, BCA clause A0.8 stipulates that assessment must be undertaken in accordance with one or more of the methods outlined in clause A0.9, with BCA compliance only being achieved where the assessment methods have been satisfied. The various assessment methods listed in clause A0.9 are:

(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 as described in A2.2.
(b) Verification Methods such as—
(i) the Verification Methods in the BCA; or
(ii) such other Verification Methods as the appropriate authority accepts for determining compliance with the Performance Requirements.
(c) Comparison with the Deemed-to-Satisfy Provisions.
(d) Expert Judgement.

The proposed assessment methods to be used for each alternative solution are listed in Table 5.1.

1.9 Fire Engineering Brief Stakeholders

The persons listed in Table 1.2 were involved in the development and agreement of the Fire Engineering Brief.

Table 1.2 – Project stakeholders

Name	Organisation	Role
Joel Andonopoulos	FDC Construction and Fitout Pty Ltd	Client / project manager / developer representative
Tony Heaslip	Blackett Maguire + Goldsmith Pty Ltd	Authority having jurisdiction
Team leader of alternative solutions	Fire and Rescue NSW	Statutory review agency
Vinh Dang James Dominguez Simon Krishnan	Exova Warringtonfire Aus Pty Ltd	Fire safety engineer

PART A – FIRE ENGINEERING BRIEF

2 PRINCIPAL BUILDING CHARACTERISTICS

2.1 LOCATION

2.1.1 *General Site Description*

The subject development is located at Warriewood, approximately 26 km north of Sydney's central business district.

As shown in Table 2.1, this project relates to the proposed Stage 2 extension of a three-storey commercial/industrial building at Warriewood. The subject building will be bounded by roadways to the north and east. Neighbouring property is located to the south and undeveloped land to the west. Pedestrian access will be provided via Daydream Street on the east side of the complex

Vehicular access will be provided via Daydream Street described above.

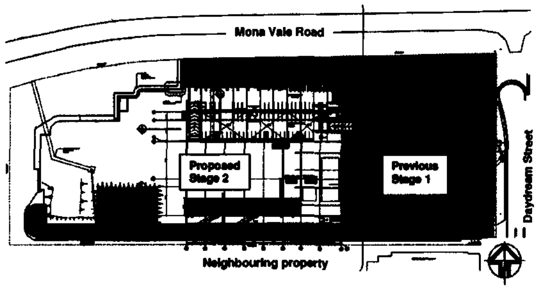

Figure 2.1 – Indicative site location[1]

2.1.2 *Proximity to Boundaries and Buildings*

The subject development is bounded by Mona Vale Road to the north, Daydream Street to the east, a neighbouring property to the south and undeveloped land to the west.

2.1.3 *Proximity to Hazards*

There are no significant hazards known near the subject building such as electrical, dangerous goods storage or hazardous structures etc.

2.1.4 *Proximity to Buildings of High Importance*

The subject building is not situated next to any buildings that are of high importance such as disaster recovery facilities (i.e. emergency and health-care facilities).

2.1.5 *Fire Brigade Access and Locations*

Fire brigades access into the building is available from the bounding roadway on the eastern side of the building.

The proximities of fire stations available to provide a response to the site are given in Table 1. This is based on the Fire and Rescue NSW alarm response protocol involving a two-pumper (i.e. two fire stations) response[2] and the location of the two closest fire stations to the development[3].

1 Illustration courtesy of Google Maps (www.maps.google.com), dated 13/08/14
2 Fire and Rescue NSW, FRNSW Abridged Alarm Response Protocol, Sydney, NSW, Fire and Rescue NSW, 2012.
3 Fire and Rescue NSW, Contact Details, website link:

Table 2.1 – Location of responding fire stations near subject development

Fire station	Location (road distance)	Staffing
Mona Vale Fire Station	Mona Vale Fire Station, which is located at 6 Harkeith Street, Mona Vale, NSW, is a travel distance of approximately 2.3 km from the building	Permanent
Narrabeen Fire Station	Narrabeen Fire Station, which is located at 9 Ocean Street, Narrabeen, NSW, is a travel distance of approximately 6.6 kilometres from the building	Permanent

These stations are manned by full time crews.

2.2 BUILDING SIZE AND SHAPE

The proposed building consists of basement carparking, a swim school and a single-storey warehouse containing a mezzanine to Ground Floor, offices to Level 1 and offices and a child care centre to Level 2. The building contains largely a rectangular footprint.

Stage 2 comprises a total floor are of 13,570 m² and a height of less than 12 metres.

The extension features pedestrian access to two lobby areas and serviced by three lift cores.

2.3 FUNCTION OR USE OF THE BUILDING

The building features a mixture of uses including Class 5 (office), class 7a (carpark) and Class 7b (warehouse) and Class 9b (swim school and childcare centre). Level 1 will be used for office accommodation, whilst the ground floor will be utilised as warehouse, office and undercroft carpark areas. The ground floor will feature the main pedestrian access to the different parts of the building.

2.4 BCA DEEMED-TO-SATISFY PROVISION REFERENCE CRITERIA

Table 2.2 below outlines key classification criteria in accordance with the Building Code of Australia 2014 in relation to the building, as advised by Blackett Maguire + Goldsmith Pty Ltd.

Table 2.2 - BCA deemed-to-satisfy provision reference criteria

BCA clause		Description or requirement
A1.1	Effective height	Less than 12 m
A3.2	Occupancy classification	The building has the following classification: • Class 5 (offices) • Class 7a (carpark) • Class 7b (storage) • Class 9b (swim school / childcare centre)
C1.1	Minimum type of construction	Type A construction is applicable.
C1.2	Rise in storeys	The building has a rise in storeys of three.
C2.2	Fire compartment floor area and volume	The limitations of Table C2.2 for Class 5 and Class 9b occupancies are 8,000 m² and 48,000 m³ for Type A construction. The limitations of Table C2.2 for Class 7a and Class 7b occupancies are 5,000 m² and 30,000 m³ for Type A construction. The fire compartment area and volumes have not been exceeded.
C2.3	Large isolated building	Not applicable.

http://www.fire.nsw.gov.au/stations.php?search=sydney&Submit=Search, accessed 14/02/2014.

2.5 STRUCTURE

2.5.1 *Structural Characteristics*

The proposed extension will feature the following structural characteristics:

- Floors: Reinforced concrete floor slabs.
- Vertical structure: loading-bearing structure comprising masonry construction; and internal office walls consisting of steel stud-framed construction with plasterboard.
- Roof: Metal roof sheeting.

2.5.2 *Coverings and Linings*

All building materials and linings will comply with the fire hazard property provisions of Part C1 of the BCA and are expected to consist of a range of materials, such as painted plasterboard, architrave/skirtings, ceramic/porcelain tiling, carpet, timber flooring and other potentially combustible linings.

2.5.3 *Openings, Shafts and Voids*

This development does not feature any unusual shafts or voids within the building design. The warehouse tenancy is full height.

2.5.4 *Ventilation and Air Movement*

The building will be provided with ventilation and air movement in accordance with BCA Deemed-to-Satisfy provisions, including car park areas being provided with mechanical ventilation.

3 DOMINANT OCCUPANT CHARACTERISTICS

3.1 OCCUPANT GROUPS

Occupant characteristics and their interaction with their environment are of equal importance as are the characteristics of the building.

Occupants within the development generally comprise the following distinct groups:

- Staff members
- Maintenance / cleaning staff
- Visitors

Measures to manage any evacuation procedures and training will be considered as part of the fire engineering analysis.

3.2 DISTRIBUTION

Considering the proposed use being for storage, and office accommodation, the occupants are expected to be located within these areas of the facility the majority of the time and only occasionally within the car park. They will be reasonably well-distributed across the building.

The occupant number to be considered in the fire engineering assessment is based on the floor areas within the building and Clause D1.13 of the BCA, as shown in Table 3.1 below.

Table 3.1 – Population provided by Blackett Maguire + Goldsmith

Section of Building	Population based on BCA Clause D1.13
Basement	~100 people
Tenancy G.1 (swim school)	~ 320 people
Tenancy G.2 (warehouse)	~ 20 people
Tenancy G.3 (warehouse)	~ 60 people
Office	~ 122 people
Tenancy G.3 (warehouse mezzanine)	~ 10 people
Tenancy 1 (office)	~ 48 people
Tenancy 2 (office)	~ 48 people
Childcare centre	~ 100 people

3.3 STATE

Staff members are expected to be awake and conscious of their surroundings, be generally familiar with building layout and, for selected staff members, have emergency response training and the ability to provide assistance to children and visitors during an emergency evacuation.

Children may be preoccupied with activities at the time of an incident. They are expected to be less responsive to indirect detection cues associated with fire and may rely to some degree on trained staff members for initiation of an orderly evacuation.

With the exception of the swimschool, it is expected that visitors would be low in number and are awake, conscious of their surroundings and be generally familiar with building layout.

3.4 PHYSICAL ATTRIBUTES

Occupants within the warehouse area are more likely to be able-bodied, based on the physical nature of activities associated with industrial-based work.

Members of staff are expected to be mobile and have normal hearing and visual abilities and are generally expected to be capable of hearing emergency evacuation warning alarms and evacuating without assistance (and being capable of assisting children as part of a managed evacuation process in a fire warden role where nominated).

Infants and children will not have the same physical ability and mobility as adults and, therefore, may require physical guidance and assistance during an emergency evacuation.

Cleaners and maintenance personnel are expected to be mobile and have normal hearing and visual abilities, as would be expected for those working in such a capacity.

3.5 Mental Attributes

Staff are expected to have an understanding of the need to respond in an organised manner in the event of an emergency in the building, based on ongoing evacuation training procedures. Infants and young children are not expected to understand how to respond appropriately to fire cues to make the required decisions and will therefore rely heavily on any adults present for guidance.

Visitors are not expected to be familiar with the building layout nor the locations of the exits.

For occupants located within close proximity of a fire, fire detection is expected to initially occur as a result of receipt of a clear visual cue, where occupants are prompted to evacuate prior to the activation of the detection system. Conversely, for a fire occurring at a more remote point, where occupants may not be made aware of the fire for some time, fire detection is expected to initially occur as a result of receipt of an automatic cue from the occupant warning system, initiated by the smoke detection system.

3.6 Group Roles

Staff and children within the child care area and staff from the other tenancies will have particular group roles with each other. Visitors may not be related. It is likely that such occupants will attempt to support others during the evacuation process (although this is a more likely action to be taken by females, with males more likely to attempt first-aid fire-fighting[4]) by alerting them to the threat of a fire and assisting them where it is felt safe to do so.

3.7 Emergency Response Training & Roles During an Emergency Incident

Although members of the public are not expected to have any emergency response training, selected staff members are expected to be suitably trained in emergency management procedures, in accordance with the principles of AS 3745–2010.

It is therefore considered that trained staff will have an understanding of the processes involved, will be aware of emergency procedures specific to the alarm or hazard and will be relatively familiar with the environment, such that the time associated with emergency way-finding will be minimised as staff take ownership of the evacuation process during emergency incidents utilising the system of wardens proposed in AS 3745–2010.

3.8 Familiarity with Building

For staff members, medium to long-term occupation is generally anticipated. They are expected to be familiar with their surroundings and the building layout in general, including the exit pathways from each floor.

Children may be familiar with parts of the building they are situated in or areas they frequent. However, they may not be aware of the exit locations nor have a comprehensive understanding of the building layout. Furthermore, due to their age, familiarity with the building may not be a significant contributing factor in their ability to evacuate without assistance.

Visitors may not be aware of the exit locations nor have a comprehensive understanding of the building layout.

3.9 Level of Assistance Required & Available

The lifts within the building are not intended to be used in addition to the required exits to assist occupants to evacuate the building safely.

Egress for people with disabilities within the building should be addressed via the implementation of an emergency evacuation plan for all occupants, including people with disabilities, in accordance with AS 3745–2010. This may include specific evacuation strategies for people with disabilities including assistance, alternative means of communicating emergency information and warnings to people with disabilities, and the subsequent training of staff.

4 Bryan, J., Behavioural Response to Fire and Smoke, The SFPE Handbook of Fire Protection Engineering, National Fire Protection Association, 3rd Edition, National Fire Protection Association, Quincy, Massachusetts, 2002.

4 FIRE SAFETY DESIGN OBJECTIVES

4.1 Client Objectives

The Client has not indicated any additional fire safety objectives to that required by the relevant statutory requirements, as described in the BCA. Therefore, asset protection and community impact of fire are excluded from the analysis outcomes.

4.2 Loss Control Objectives

Consideration of specific issues such as property and asset protection, business interruption, insurance related risks or community impact as a result of fire losses have not been included by the client and are therefore beyond the scope of this report, as identified in Section 1.5.

While arson as a single point of ignition may be considered in the analysis, simultaneously multiple ignition sources, use of accelerants, sabotage of fire protection systems or terrorism are not included as part of the report scope.

It should, however, be noted that due to the client's request to develop alternative solutions for the project, fire and smoke damage may vary when compared to a building design that complies with the BCA DTS provisions. The building has not been identified during the Fire Engineering Brief process as a likely target for terrorism.

It is recommended that the building owner/operator liaise with its relevant insurers on this matter.

4.3 Regulatory Objectives

To meet the regulatory requirements, the design is to be in accordance with the Building Code of Australia 2014. Compliance with the fire safety objectives in the BCA is achieved by satisfying the relevant BCA performance requirements, as determined by the authorities having jurisdiction.

The general objectives for the fire safety assessment contained herein are consistent with those set out within Sections C and D Part E1 and Part E2 of the Building Code of Australia, of which this analysis specifically relates to, being as follows:

Section C objective CO1:

The Objective of this Section is to:
(a) safeguard people from illness or injury due to a fire in the building; and
(b) safeguard occupants from illness or injury while evacuating a building during a fire; and
(c) facilitate the activities of emergency services personnel; and
(d) avoid the spread of fire between buildings; and
(e) protect other property from physical damage caused by structural failure of a building as a result of fire.

Section D objective DO1:

The Objective of this Section is to:
(a)...N/A (access-related)
(b) safeguard occupants from illness or injury while evacuating in an emergency.

Part E1 objective EO1:

The Objective of this Part is to:
(a) safeguard occupants from illness or injury while evacuating during a fire; and
(b) provide facilities for occupants and the fire brigade to undertake fire-fighting operations; and
(b) prevent the spread of fire between buildings.

Part E2 Objective E02

The Objective of this Part is to:
(a) safeguard occupants from illness by warning them of a fire so that they may safely evacuate; and
(b) safeguard occupants from illness or injury while evacuating during a fire.

4.4 Fire Brigade Objectives

General fire brigade objectives are addressed in the relevant performance clauses under fire brigade intervention. The fire brigade objective throughout Australia is to protect human life and property.

Other brigade responsibilities that may be contained within their statutory act or other objectives are beyond the scope of this report.

General fire brigade objectives are addressed in the relevant performance clauses under fire brigade intervention. Other Brigade responsibilities that may be contained within their Statutory Act or other objectives are beyond the scope of this report.

5 BCA ANALYSIS INFORMATION

The variations from the DtS provisions of the BCA, as advised by Blackett Maguire + Goldsmith Pty Ltd, are to form the basis of the fire engineering analysis and are the subject of the proposed alternative solutions. The proposed alternative solutions are described in Table 5.1 below, along with details of the relevant BCA performance requirements and BCA assessment methods.

The relevant performance requirements have been identified in conjunction with Blackett Maguire + Goldsmith Pty Ltd and in accordance with BCA clause A0.10, the latter requiring consideration of any relevant performance requirement from parts of the BCA other than those where the DtS variation is to be found.

All other items of fire and life safety are to be provided in compliance with the DtS provisions of the BCA.

Table 5.1 – Summary of BCA DtS provision departures and proposed alternative solutions

<table>
<tr><th colspan="2">BCA DtS provision</th><th>Proposed alternative solution</th></tr>
<tr><td colspan="2">BCA Specification C1.1 stipulates that building elements are to have fire resistance levels (FRLs) in accordance with Table 3 of Specification C1.1, being, for the subject development, 240/240/240 FRLs to the warehouse areas, 120/120/120 FRLs to the office areas and 60/60/60 FRLs to the sprinkler-protected car parking areas</td><td rowspan="4"><u>Alternative solution 1</u>
The proposed alternative solution is based on:
(i) The provision of a 120/120/120 FRL fire walls, floors and columns in lieu of 240/240/240 FRL to the warehouse areas;
(ii) The presence of an automatic sprinkler system within the building, except for the swim school;
(iii) The low-rise design of the building; and
(iv) The significant distance from neighbouring buildings</td></tr>
<tr><td>BCA Clause</td><td>C1.1 and Spec. C1.1.</td></tr>
<tr><td>Relevant performance requirement(s)</td><td>CP1 and CP2.</td></tr>
<tr><td>Assessment method</td><td>A0.9(b)(ii) "other Verification Methods".</td></tr>
</table>

BCA DtS provision		Proposed alternative solution
Clause C1.1 nominates compliance with Specification C1.1, which, for a Class 7a and 9b occupancy of Type A construction, stipulates an FRL of 120/120/120 FRL fire resisting lift and stair shafts. Clause C2.7(b)(ii) stipulates that any openings in a fire wall must not reduce the FRL required by Specification C1.1 for the fire wall, except where permitted by the Deemed-to-Satisfy Provisions of Part C3. Clause C2.8 of the BCA stipulates that if a building has parts of different classifications located alongside one another in the same storey, each building element must have a higher FRL prescribed in spec. C1.1. Clause C3.8 of the BCA stipulates that doorways which open into fire-isolated exits must be protected by -/60/30 fire doors that are self-closing or automatic-closing in accordance with C3.8(a).		***Alternative solution 2*** The proposed alternative solution is based on: (i) The provision of a drencher-protected glazing in lieu of 120/120/120 FRL to the ground floor entry lobby of the swim school and Stair 2; (ii) The provision of drencher-protected glazed doors to Stair 1 in lieu of fire doors; and (iii) The presence of an automatic sprinkler system within the building, except for the swim school.
BCA Clause	C1.1, C2.7(b)(ii), Clause C2.8 and Clause C3.8.	
Relevant performance requirement(s)	CP2.	
Assessment method	A0.9(b)(ii) "other Verification Methods".	
Clause C1.1 of the BCA refers to Clause 3.1(b) of Spec. C1.1 which stipulates that external walls must be non-combustible. Clause 2.4(a)(i) of BCA Spec. C1.1 & Clause C1.10 stipulates that linings / attachments to external walls are required to comply with the fire hazard properties provisions of Specification C1.10.		***Alternative solution 3*** The proposed alternative solution is based on: (i) The provision of Danpalon and Alucobond Plus as cladding to various parts of the external walls, which have not been tested as "non-combustible" in accordance with AS 1530.1; and (ii) The presence of an automatic sprinkler system within the building, except for the swim school.
BCA Clause	C1.1 and BCA Spec. C1.1.	
Relevant performance requirement(s)	CP2.	
Assessment method	A0.9(b)(ii) "other Verification Methods".	

BCA DtS provision		Proposed alternative solution
Clause D1.3 of the BCA stipulates that for Class 5 to 9 buildings, every stairway serving as a required exit must be fire-isolated unless it connects, passes through or passes by not more than three consecutive storeys if the building has a sprinkler system. Clause D2.4 of the BCA stipulates that if a stairway serving as an exit is required to be fire-isolated, there must be no direct connection between a flight rising from the storey below the lowest level of access to a road or open space and a flight descending from a storey below that level.		***Alternative solution 4*** The proposed alternative solution is based on: (i) Stair 1 which is fire-isolated and does not feature separation via rising and descending stair flights. (ii) Stair 2 which is not fire-isolated and does not feature separation via rising and descending stair flights; (iii) The presence of an automatic sprinkler system within the building, except for the swim school; (iv) The 2 hour fire separation provide between the stairways and basement carpark level; and (v) Occupants travelling a maximum of two levels to evacuate.
BCA Clause	D1.3 and D2.4.	
Relevant performance requirement(s)	DP5 and EP2.2.	
Assessment method	A0.9(c) "Comparison with the Deemed-to Satisfy Provisions".	
Clause D1.4 of the BCA stipulates that no point on a floor must be more than 20 m to a point from which travel in different directions to two exits is available, in which case the maximum travel distance to one of those exits must not exceed 40 m. Clause D1.5 of the BCA stipulates that exits that are required as alternative means of egress must be not more than 60 m apart in Class 7a.		***Alternative solution 5*** The proposed alternative solution is based on: (i) Travel distance of up to 65 metres to an exit within the basement carpark, in lieu of 40 metres; (ii) Travel distance of up to 120 metres between alternative exits within the carparking basement levels, in lieu of 60 metres; (iii) A sprinkler system with listed fast-response heads (activation temperature of 68°C and RTI 50 $m^{1/2}s^{1/2}$) and maximum coverage of 12 m^2 per sprinkler for ordinary hazard throughout the basement car park level, in accordance with BCA Specification E1.5, which includes compliance with the relevant parts of AS2118–1999; and (iv) A building occupant warning system featuring an automatic voice-messaging function.
BCA Clause	D1.4.	
Relevant performance requirement(s)	DP4 and EP2.2.	
Assessment method	A0.9(c) "Comparison with the Deemed-to Satisfy Provisions". A0.9(b)(ii) "other Verification Methods".	
Clause D1.4 of the BCA stipulates that no point on a floor must be more than 20 m from an exit, or a point from which travel in different directions to two exits is available		***Alternative solution 6*** The proposed alternative solution is based on: (i) Travel distance of up to 25 metres to the single exit in lieu of 20 m within the warehouse mezzanine;

BCA DtS provision		Proposed alternative solution
BCA Clause	D1.4.	(ii) A building occupant warning system featuring an automatic voice messaging function; (iii) The presence of an automatic sprinkler system; (iv) The low population expected within the mezzanine; and (v) The open-plan layout of the mezzanine which provides maximum visual access to exit location.
Relevant performance requirement(s)	DP4 and EP2.2.	
Assessment method	A0.9(c) "Comparison with the Deemed-to Satisfy Provisions".	
Clause D1.4 of the BCA stipulates that no point on a floor must be more than 20 m from an exit, or a point from which travel in different directions to two exits is available		***Alternative solution 7*** The proposed alternative solution is based on: (i) Travel distance of up to 30 metres to the single exit in lieu of 20 m within the level 2 office. (ii) Provision of a smoke detection system in accordance with AS 1670.1-2004; and (iii) A building occupant warning system featuring an automatic voice messaging function.
BCA Clause	D1.4.	
Relevant performance requirement(s)	DP4 and EP2.2.	
Assessment method	A0.9(c) "Comparison with the Deemed-to Satisfy Provisions".	
Clause D1.5 of the BCA stipulates that exits that are required as alternative means of egress must be not more than 60 m apart in Class 7b occupancies.		***Alternative solution 8*** The proposed alternative solution is based on: (i) Travel distance of up to 70 metres between alternative exits within Tenancy G.3, in lieu of 60 metres; (ii) A sprinkler system in accordance with BCA Specification E1.5, which includes compliance with the relevant parts of AS2118–1999; (iii) A building occupant warning system featuring an automatic voice messaging function; and (iv) The significant reservoir size for the smoke to fill.
BCA Clause	D1.5.	
Relevant performance requirement(s)	DP4.	
Assessment method	A0.9(c) "Comparison with the Deemed-to Satisfy Provisions".	
Clause D1.5 of the BCA stipulates that exits that are required as alternative means of egress must be not more than 60 m apart in Class 9 buildings		***Alternative solution 9*** The proposed alternative solution is based on: (i) Travel distance of up to 70 metres between alternative exits within the child care centre on Level 2, in lieu of 60 metres; (ii) Provision of a 30 m^2 refuge area to Level 2 adjacent to the lift lobby and fire stair with the bounding walls being lined with fire resisting plasterboard to achieve a -/120/120 FRL and extending to the underside of the roof covering or a 120/120/120 FRL ceiling; (iii) The distance between exists and refuge area not exceeding 80 metres.
BCA Clause	D1.5.	
Relevant performance requirement(s)	DP4.	
Assessment method	A0.9(b)(ii) "other Verification Methods".	
Clause D1.6 of the BCA nominates a clear, minimum width of 1,000 mm for exits and paths of travel to exits.		***Alternative solution 10*** The proposed Alternative Solution is based on the travel path egress width within the swim school between columns and the pools is 820mm wide, in lieu of 1 m.
BCA Clause	D1.6.	

BCA DtS provision		Proposed alternative solution
Relevant performance requirement(s)	DP4.	
Assessment method	A0.9(c) "Comparison with the Deemed-to Satisfy Provisions".	
Clause C1.1 of the BCA which refers to Clause 3.5 of Spec. C1.1 stipulates that the roof of a building need not have an FRL of 120/60/30 if its covering is non-combustible and the building is sprinkler protected throughout. Clause C2.6(b) of the BCA stipulates that the requirements of Clause C2.6(b) for vertical separation do not apply to a building which has a sprinkler system installed throughout. Clause E2.2 of the BCA refers to Table E2.2a which stipulates that, for the subject building, an automatic smoke detection system or sprinkler system is provided throughout to satisfy the smoke hazard management provisions.		***Alternative solution 11*** The proposed alternative solution is based on: (i) The non-provision of a sprinkler system to the swim school; (ii) The swim school being a separate fire compartment from the remainder of the building; (iii) The non-provision of a roof over the building having an FRL of 120/60/30; (iv) The non-provision of separation between vertical openings in external walls; (v) The provision of a sprinkler system throughout the building with the exception of the swim school; and (vi) The provision of a beam type automatic fire detection system to the swim school.
BCA Clause	C1.1, Spec. C1.1, C2.6, E2.2.	
Relevant performance requirement(s)	CP1, CP2, EP1.4 and EP2.2.	
Assessment method	A0.9(b)(ii) "other Verification Methods".	
Table E2.2a of BCA Clause E2.2a stipulates that a Class 7a building, including a basement, provided with a mechanical ventilation system in accordance with AS 1668.2 must comply with clause 5.5 of AS/NZS 1668.1.		***Alternative Solution 12*** The proposed Alternative Solution is based on: (i) The use of jet-fans in lieu of a conventional exhaust air system in the basement carpark where the jet-fans do not comply with the requirements and recommendations in clause 5.5 of AS/NZS 1668.1; (ii) The provision of an automatic sprinkler system with fast response heads in lieu of a standard sprinkler system in the basement carpark; (iii) The provision of manual controls by the fire fan control and indication panel (FFCP) at the fire indicator panel which override the automatic operation of the jet-fans; (iv) An additional detector(s) being located on the downstream side of each jet fan for auto shutdown; and (v) The jet fans located above driveways and access ways.
BCA Clause	E2.2a.	
Relevant performance requirement(s)	EP1.4 and EP2.2.	
Assessment method	A0.9(c) "Comparison with the Deemed-to Satisfy Provisions".	

6 HAZARDS

A review of fire hazards is to be carried out as part of the fire safety assessment. This review can assist in providing an insight into the inherent fire risks associated with the subject building that may need to be considered in the assessment.

The potential sources of ignition are not critical to this assessment, as it is to be deterministic in nature (based on ignition occurring, followed by the nominated fire scenarios). Thus, a detailed review of ignition sources is not considered necessary in the context of the assessment.

6.1 GENERAL BUILDING LAYOUT

Hazards to occupants relating to this building layout may arise in association with:

- Exit travel distances within the office areas.
- Exit travel distances within the car park.
- Exit travel distances within warehouse area.

Although there are variations to the travel distances, adequate number and distribution of exits are provided in accordance to DtS provisions of the BCA, given occupant numbers and size of the building.

The above issues are to be considered in detail as part of the fire engineering assessment

6.2 ACTIVITIES

Car Park Areas

The primary activity being undertaken within the car park is the movement/parking of motor vehicles. Associated hazards that could result in initiation of a fire are as follows:

- Vehicle accidents (albeit slow-speed accidents).
- Mechanical or electrical failure of vehicle parts.

Swimming / childcare areas

Given the area being used comprise mostly activity rooms, this area will be used predominantly by children under the supervision of staff and visiting adults. Various activities are expected including art, music and sport related classes. As such, no unusually high fire safety hazards are present in comparison to the ignition and evacuation issues associated within the facility.

Warehousing areas

Potential hazards associated with activities within the storage areas relate to the presence and use of electrical and communication equipment throughout most areas; smoking; cooking activities undertaken by occupants; and attempted arson events. The storage of equipment and waste also has an effect on the incidence of fire starts, which would include not only industrial storage areas (back-of-house waste facilities) but house-keeping and rubbish treatment within the office areas.

Marryatt [5] lists the most common hazards associated with office occupancies as being air-conditioning equipment, vertical ducts, electrical equipment, elevators, escalators, electrical appliances, plastics in furniture, synthetic carpets, rubbish collection and dispatch.

Repair and maintenance activities can also pose an intermittent fire safety hazard where hot works are involved. However, the risks associated with such activities can be mitigated by the implementation of a hot-works risk-control policy.

Office areas

Potential hazards associated with activities within the office areas relate to the presence and use of electrical and communication equipment throughout most areas; smoking; cooking activities undertaken by occupants; and attempted arson events. The storage of equipment and waste also has an effect on the incidence of fire starts, which would include not only industrial storage areas (back-of-house waste facilities) but housekeeping and rubbish treatment within the office tenancy areas

5 Marryatt, H. W., Fire: A Century of Automatic Sprinkler Protection in Australia and New Zealand 1886-1986, 1988.

6.3 IGNITION SOURCES

Car park areas

A number of potential ignition sources and fire hazards have been identified for the building, based on a literature review of similar occupancies (Rahikainen[6], Marryatt[7], BHP[8], FCRC[9] and Thomas[10]). The potential ignition sources and fire hazards in the car park areas include vehicles, electrical equipment and arson.

A review of fire statistics in car parks[11] by BHP Melbourne Research Laboratories (MRL) has reported the following:

- There have been no death or serious injuries recorded for fires in car parks in Australia.
- The American Iron and Steel Institute (AISI) survey of US and Canadian car parks has indicated that fire safety risks within car parks are not significant, as there has been no recorded loss of life from a fire in a car in the car park over a survey period of 60 years. Car parks are generally not a source of death or personal injury.
- The National Fire Protection association analysed fire loss from US and Canadian car parks from 1982 to 1986 and concluded that there is an extremely low fire safety hazard in car parks.

The referenced AISI report concluded with the following statement "It is clear from the available fire record that fires in car parks represent little risk to life or of injury, and very low monetary losses, possibly because of a very low frequency of fire starts in this type of building. Accordingly, the requirements for fire protection should not be excessive".

Swimming / child care areas

The fire incident statistics in assembly buildings in Australia and the United Kingdom could identify significant trends and provide an insight of the inherent fire risk of education buildings, such as the building under investigation. However, it should be noted that the statistical evaluation is based on a large range of building types and that the results should only be used to derive typical trends that may be applicable to the subject development and not as the sole basis of a fire safety strategy, due to the potential variations in building conditions, age, fire safety measures installed, etc.

Australian Fire Incident Statistics, prepared by CSIRO[12], provides an overview of fire starts across the entire spectrum of fixed property use in the period of 1989–1994. The most common sources of ignition for educational buildings, according to Australian Fire Incident Statistics, are electrical equipment (short circuits etc), smoking materials (cigarettes, matches, lighters etc) and cooking equipment. At approximately 20 per cent, arson contributes to a relatively large percentage of fires in educational properties, although it should be noted that arson is a common contributing factor in fire initiation in all building classifications, with, for example, suspicious or incendiary conditions being associated with approximately 10 per cent of fires in retail and public assembly buildings.

Statistics provided by NSW Fire Brigades (NSWFB) in its annual report for 2006/2007[13] also indicate that common contributing factors to fire starts comprise electrical equipment (heaters, dryers, fans etc) and cooking equipment. For a large number of fires (86 of 113) the equipment involved in ignition was undetermined, indicating that many of these fires may be arson-based, with ignition details difficult to determine. The most common areas of the building for fire initiation comprise storage spaces (17 per cent), followed by assembly areas (15 per cent), circulation spaces / kitchen / cooking areas (9 per cent each) and external surfaces, such as walls, roofs and balconies (9 per cent).

According to statistics provided by Marryatt[14], the most common contributing factors to fire starts in school buildings in Australia are electrical equipment and smoking materials.

6 Rahikainen, J. and Keski-Rahkonen, O. (1998) Determination of Ignition Frequency of Fires in Different Premises in Finland", Fire Engineers Journal, Nov 1998.
7 Marryatt H. W. (1988), Fire - A Century of Automatic Fire Protection in Australia and New Zealand 1886-1996, FPAA, Australia.
8 BHP (1998) 'Design of Sports Stand Buildings for Fire Safety, BHP Integrated Steel, June 1998.
9 FCRC (1998) Fire Safety in Shopping Centres, Final Research Report - Project 6, Fire Code Reform Centre Ltd, Sydney, Australia.
10 Thomas, I. R. Analysis of US Retail Fires (Fire Code Reform Centre Project 6), BHP Research Report No. BHPR/SM/R/G/056, February 1997.
11 I.D. Bennetts, I.R., Thomas, K.H., Almand, D.J., Proe and R.R Lewins, "Fire in Carparks", BHP Melbourne Research Laboratories Report Number MRL/PS69/78/006, August 1989.
12 King, M., Australian Fire Incident Statistics 1992-1993 Technical Report 95/1, CSIRO Division of Building, Construction and Engineering, 1995.
13 NSW Fire Brigades, New South Wales Fire Brigades Annual Statistical Report 2006/2007, Sydney, 2007.
14 Marryatt, H. W., Fire: A Century of Automatic Sprinkler Protection in Australia and New Zealand 1886-1986, 1988.

Statistics from the United States[15] paint a similar picture to those given above, with a high number of fire starts being attributed to being arson (28 per cent). Causes of ignition appear to involve students in many cases, as fires are prevalent on week days during school term. The most common areas of the building for fire initiation are toilets (28 per cent), followed by corridors (11 per cent), multi-purpose rooms (10 per cent) and kitchens (6 per cent). The most common form of material first ignited was rubbish (19 per cent), followed by magazines / newspapers (12 per cent), electrical wires (10 per cent) and cooking materials (6 per cent).

Warehousing areas

Australian Fire Incident Statistics has also identified the common ignition factors for warehouse buildings, which are mechanical failure and equipment malfunction (26%), misuse of heat of ignition (15%), operational deficiency (14%) and misuse of material ignited (7%). However, a number of fire incidents are classified as incendiary acts (5%) or of suspicious nature (6%), indicating that arson is a not-insignificant ignition factor. Examples of misuse of heat of ignition are improper disposal of hot materials, inadequate control of open fire and welding too close to flammable materials while misuse of material ignited includes placing combustible materials too close to a heat source

Office areas

A number of potential ignition sources and fire hazards have been identified for the building, these being cooking equipment, electrical equipment (including lighting) and smoking materials (matches, lighters etc), based on a literature review of similar occupancies [Rahikainen[16], Marryatt[17], BHP[18], FCRC[19], NSW Fire Brigades and Thomas[20]].

6.4 FUEL SOURCES

As the building is a mixed used development, fuel loads will not be uniformly distributed across the building.

Car park areas

The fuel load will be limited generally to the presence of parked vehicles (i.e. flammable liquids from vehicles and other materials including plastics, rubber etc), with driveway areas expected to be clear for vehicular access.

Swimming / child care areas

The use of the swimming area and child care area may result in a low fuel load resulting from the majority of the contents being light commercial furnishings (seating, tables, stages, platforms, etc) and water / swimming pools.

Warehousing areas

The use of the building largely for storage purposes may result in a relatively high fuel load resulting from the type and extent of goods contained.

The primary fuel sources for the analysis in the warehouse areas will be based on the tenancy supplies and rack storage. The fuels may present a wide variety of combustibles including combinations of plastics and cellulosic materials.

Office areas

Typical fuel loads associated with commercial office accommodation consist of office furnishings, such as timber- and plastic-based furniture, combustible drapes, electronic office machinery and carpet and timber floor linings.

Interactions Between Ignition and Fuel Sources

The fire safety concepts tree NFPA 550[21] considers the interaction of individual elements as part of an overall fire safety system. It recommends that one of the means of mitigating the fire risk is to

15 U.S. Fire Administration, Topical Fire Research Series, School Fires, Volume 2, Issue 9, October, 2001 (revised March 2002).
16 Rahikainen, J. and Keski-Rahkonen, O. (1998) Determination of Ignition Frequency of Fires in Different Premises in Finland", Fire Engineers Journal, Nov 1998.
17 Marryatt H. W. (1988), Fire - A Century of Automatic Fire Protection in Australia and New Zealand 1886-1996, FPAA, Australia.
18 BHP (1998) 'Design of Sports Stand Buildings for Fire Safety, BHP Integrated Steel, June 1998.
19 FCRC (1998) Fire Safety in Shopping Centres, Final Research Report - Project 6, Fire Code Reform Centre Ltd, Sydney, Australia.
20 Thomas, I. R. Analysis of US Retail Fires (Fire Code Reform Centre Project 6), BHP Research Report No. BHPR/SM/R/G/056, February 1997.
21 NFPA 550, Guide to the Fire Safety Concepts Tree, 2002.

eliminate/control the source of heat, ignition and fuel, as shown by the concepts tree in Figure 2. The concept is considered applicable for this type of development.

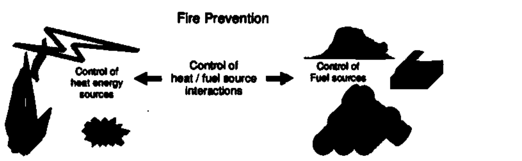

Figure 2 – Fire safety concepts from NFPA 550

To mitigate these events, site-specific policies can be developed and implemented to address for the purposes of minimising the risk of fire initiation, based on maintenance, planning, housekeeping and training, as discussed in detail this document.

6.5 INTERACTIONS BETWEEN IGNITION AND FUEL SOURCES

The fire safety concepts tree NFPA 550[22] considers the interaction of individual elements as part of an overall fire safety system. It recommends that one of the means of mitigating the fire risk is to eliminate/control the source of heat, ignition and fuel, as shown by the concepts tree in Figure 6.1. The concept is considered applicable for this type of development.

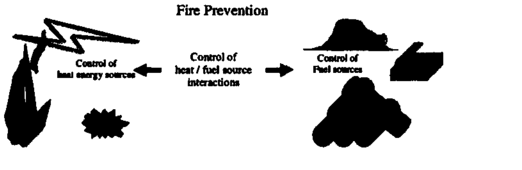

Figure 6.1 – Fire safety concepts from NFPA 550

To mitigate these events, site-specific policies can be developed and implemented to address for the purposes of minimising the risk of fire initiation, based on maintenance, planning, housekeeping and training, as discussed in detail in Section 6.8.

6.6 UNUSUAL FEATURES

The Fire Engineering Brief process has not identified specific issues relating to BCA deemed-to-satisfy provisions E1.10 and E2.3.

Any dangerous goods to be stored in the property are to be addressed by way of adherence with the relevant codes and standards, noting that the client has not advised that any are expected.

6.7 HAZARDS SUMMARY

As the above statistical evaluation is based on a large range of buildings types, the results should only be used to derive typical trends that may be applicable to the subject development and not as the sole basis of a fire safety strategy, due to the potential variations in building conditions, age, fire safety measures installed etc.

22 NFPA 550, Guide to the Fire Safety Concepts Tree, 2002.

Based on the information and statistical data presented in relation to potential hazards, a number of conclusions can be tentatively drawn that are relevant to the proposed fire safety strategy. These are summarized hereunder:

(i) Fires in assembly buildings accounted for a relatively large proportion of the fire incidents that occurred in all building types. As such, the large number of fire starts for these buildings supports the need for a fire safety assessment of the potential for fire spread, based on the specific circumstances involved.

(ii) The main causes of ignition in storage buildings appeared to be open flames, sparks and equipment capable of generating heat. The occurrence of fire can be further reduced by the implementation of appropriate policies and procedures to control ignition sources, such as no smoking policies, hot work permits, etc. Electrical equipment arcing and overloading was also a significant source of ignition. Occupants should be aware of the maximum capacities of these equipment and inspections should be carried out frequently to detect defects and potential hazards.

(iii) The main causes of ignition in commercial office buildings appeared to be electrical equipment and electrical system faults, cigarettes, combustible fuels, arson and trades activities, such as welding and painting.

(iv) Arson (fire of suspicious nature) has been identified as a common ignition factor for the building, as is the case for most occupancy types. This can be minimized by the implementation of suitable building security measures.

6.8 Preventative and Protective Measures

The measures that may be considered in the management of the hazards identified above are summarised within Table 6.1 below, based on categorisation into the following IFEG[23] sub-systems:

- Sub-system A – Fire Initiation and Development and Control
- Sub-system B – Smoke Development and Spread and Control
- Sub-system C – Fire Spread and Impact and Control
- Sub-system D – Fire Detection, Warning and Suppression
- Sub-system E – Occupant Evacuation and Control
- Sub-system F – Fire Services Intervention

Note that these preventative and protective measures are also formalised as part of the proposed fire safety strategy by inclusion in section 8.

Although this assessment considers that a fire will start within the building, thereby forming the basis of a deterministic fire engineering assessment, these risk mitigation measures are included as recommendations for the purpose of minimising the likelihood of fire start in the building and the ensuing threat to occupant safety.

23 Australian Building Codes Board, ABCB, International Fire Engineering Guidelines Edition 2005, Australian Building Codes Board, Australia, 2005.

Table 6.1 – Preventative and protective measures

Sub-system	Preventative and protective measures
Sub-system A – Fire Initiation and Development and Control	Applicable mitigating measures are as follows: • An automatic fire sprinkler system with fast response heads to the carpark will be provided throughout the building, which will serve to control the size of a fire. • The building materials and linings will comply with the fire hazard property provisions of the BCA to minimise the ignitability of materials and the potential for rapid development of fire / spread of flame and development of smoke during the early stages of a fire's growth. • Appropriate policies and procedures will be implemented the control of ignition sources, such as a non-smoking policy, a hot-work permits policy and maintenance policies. • A housekeeping policy will be adopted to minimise the likelihood of fire-related incidents occurring and to maintain exits and paths of travel to exits free of furnishings, clutter and general combustibles and rubbish, in order to reduce the likelihood of fire development, should one initiate within one of these areas.
Sub-system B – Smoke Development and Spread and Control	Applicable mitigating measures are as follows: • An automatic fire sprinkler system with fast response heads to the carpark will be provided throughout the building, with the exception of the swim school, which will serve to control the size of a fire and reduce the quantity of smoke produced. • The building materials and linings will comply with the fire hazard property provisions of the BCA to reduce the incidence of rapid smoke development in the early stages of a fire when occupants will be evacuating. • The presence of fire compartmentation will limit the spread of smoke between different occupant classifications.
Sub-system C – Fire Spread and Impact and Control	Applicable mitigating measures are as follows: • An automatic fire sprinkler system with fast response heads to the carpark will be provided throughout the building, with the exception of the swim school, which will serve to control the size of a fire and reduce the quantity of smoke produced. • The building materials and linings will comply with the fire hazard property provisions of the BCA to reduce the incidence of rapid fire spread and significant smoke production during the early stages of a fire. • The presence of fire compartmentation will limit the spread of fire between different occupant classifications.
Sub-system D – Fire Detection, Warning and Suppression	Applicable mitigating measures are as follows: • An automatic smoke detection and alarm system will be provided throughout the Level 2 office area and swim school for enhanced warning to occupants. • An automatic fire sprinkler system will be provided throughout the building, with the exception of the swim school and fast response heads to the carpark for fire detection and warning to occupants. • Portable fire extinguishers (to the extent nominated by BCA clause E1.6) and a fire hose reel system will be provided for use by occupants in attempting first-aid fire-fighting prior to arrival of fire-fighters.
Sub-system E – Occupant Evacuation and Control	Applicable mitigating measures are as follows: • Exit signs, emergency lighting and additional signage will be provided to assist in wayfinding. • A housekeeping policy will be adopted to maintain exits and paths of travel to exits free of furnishings, clutter and general combustibles and rubbish, in order to reduce the risk of obstruction during evacuation.

Sub-system	Preventative and protective measures
Sub-system F – Fire Services Intervention	Applicable mitigating measures are as follows: • A fire hydrant system will be provided for use by fire-fighters undertaking fire-fire-fighting or search and rescue activities. • An automatic fire sprinkler system will be provided throughout the building, with the exception of the swim school, with fast response heads to the carpark, which will assist in reducing the size and severity of a fire thus minimising the risk of exposure for attending fire-fighters. • The presence of fire compartmentation between classifications will limit the spread of fire and smoke, which will assist in reducing the size and severity of a fire thus minimising the risk of exposure for attending fire-fighters. • The building is provided with appropriate access points suitable for fire brigade access. • A full-time fire service being available to respond to fire incidents in the Sydney metropolitan region.

7 TRIAL CONCEPT FIRE SAFETY STRATEGY

The following is a summary of the fire safety design in relation to the proposed alternative solution detailed in section 5, which is the subject of the detailed fire engineering assessment.

7.1 Construction, Fire Resistance & Compartmentation

Table 7.1 summarise the fire resistance and compartmentation construction measures that are to be implemented as part of the proposed fire safety strategy.

Table 7.1 – Proposed construction measures

Item no.	Measure	Description of construction measure
1.	Compliance with BCA DtS provisions	With the exception of the proposed alternative solutions described within this document, the proposed development is to comply with the DtS provisions of Section C of the BCA.
2.	Fire separation	The two exit stairs (Stair 1 and Stair 2) are to be fire separated via the 2 hour fire resisting construction on the basement carpark level, as shown in Figure 7.1.
3.	Drencher-protected glazed construction	The glazing shown in Figure 7.1 below, which is to be protected by a wall-wetting drencher system in accordance with the drencher system provisions described in below, is to comply with the following: (i) glazed door leaves are to be full height (i.e. extend to the top of the drencher-protected glazing) and self-closing or frameless and self-closing; and (ii) suitable barriers or other means, such as signage provided adjacent to the glazed construction, stating: "No storage adjacent to glazing or fixing of items to glazing for fire safety purposes" not less than 20 mm high in a colour contrasting with the background and permanent construction are to be provided to prevent the placement of either storage or furnishings adjacent to the glazing that may obstruct the flow of water. As well as the above requirements, the glazing is to comply with (i) or (ii) below, depending upon whether it is to be protected by Tyco Model WS drenchers or an alternative system: (i) any glazing protected by the Tyco Model WS drencher system is to comply with the glazing requirements outlined within the Tyco Model WS drencher specification noting that although the inclusion of (self-closing) doors as part of the drencher-protected construction is inconsistent with the product specification, such doors are considered acceptable as part of the Alternative Solution; or (ii) any glazing not protected by the Tyco Model WS drencher system is to comply with the following: a) horizontal mullions are not to be incorporated in the glazing on the sides of the glazing where the drenchers are to be provided, as the flow of water may be obstructed; b) drencher-protected glazing construction is to feature toughened glazing construction, with a minimum thickness of 6 mm; and c) fixed glazing is to be supported by aluminium, timber or steel framing elements, which provide allowance for the expansion of the glass by the use of flexible seals.
4.	Refuge area	As part of the child care centre fitout works, a 30 m² refuge area, shown in Figure 7.5 is to be provided to Level 2 adjacent to the lift lobby and fire stair. The bounding walls are to be lined with fire resisting plasterboard to achieve a -/120/120 FRL and extend to the underside of the roof covering or a 120/120/120 FRL ceiling. The doors are to be -/120/30 FRL self-closing or automatic-closing fire doors with smoke seals.

Item no.	Measure	Description of construction measure
5.	Smoke seals	Medium-temperature smoke seals are to be provided to the doors to the refuge area described above. The smoke seals shall be selected such that when fitted to a fire door and tested in accordance with AS 1530.7-2007, they achieve a maximum total leakage rate of 25 m3/h, corrected to STP, at a pressure differential of 25 Pa after more than 30 minutes exposure to 200°C (as per AS 6905-2007).
6.	Fire compartmentation	Fire resisting walls and floors are to be provided in accordance with drawing GA-110, as shown in Figure 7.4 below (prepared by SBA Architects), to separate fire compartments within Stage 2 and to separate Stage 2 from Stage 1. Note: The swim school on Ground Floor is to form a separate fire compartment.

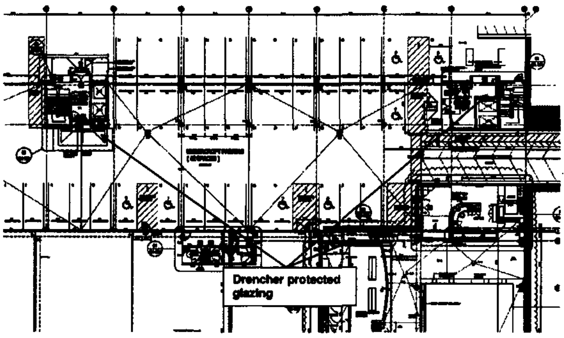

Figure 7.1 – Location of proposed drencher protected glazing and fire separation on Ground Floor

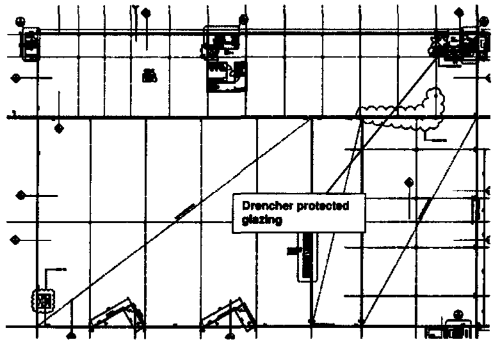

Figure 7.2 – Proposed Drencher-protected glazing on Level 1

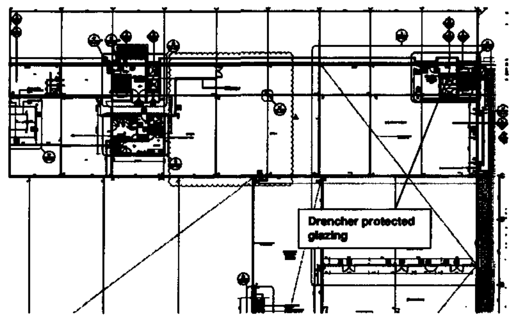

Figure 7.3 – Proposed Drencher-protected glazing on Level 2

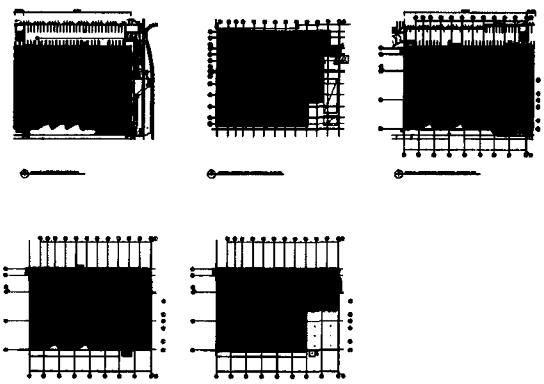

Figure 7.4 – Proposed fire compartmentation to Stage 2

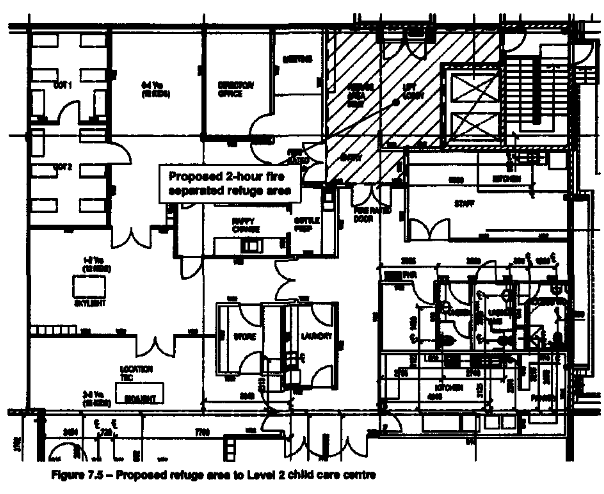

Figure 7.5 – Proposed refuge area to Level 2 child care centre

7.2 Egress

Table 7.2 below summarises the egress measures that are to be implemented as part of the proposed fire safety strategy.

Table 7.2 – Proposed egress measures

Item no.	Measure	Description of egress measure
1.	Compliance with BCA DtS provisions	With the exception of the proposed alternative solutions described within Table 5.1, the proposed development is to comply with the DtS provisions of Section D of the BCA.
2.	Travel path egress width	The travel path egress width within the swim school between columns and the pools is 820 mm wide, in lieu of 1 m.

7.3 Fire Services & Equipment

Table 7.3 below summarises the fire protection systems that are to be provided as part of the proposed fire safety strategy for the development.

Figure 7.6 indicates the various infrastructure locations for the fire protection systems.

Table 7.3 – Proposed fire protection systems

Item no.	Measure	Description of fire protection system
1.	Compliance with BCA DtS provisions	With the exception of the proposed Alternative Solutions described within this document, the proposed development is to comply with the DtS provisions of Section E of the BCA.

Item no.	Measure	Description of fire protection system
2.	Automatic smoke detection system	An automatic fire detection system is to be provided to the Level 2 office tenancy and Ground Floor swim school in accordance with clause 4 of BCA Specification E2.2a and AS 1670.1-2004.
3.	Automatic fire suppression system	With the exception of the swim school fire compartment, an automatic fire sprinkler system is to be provided throughout the building in accordance with clause E1.5 of the BCA and AS 2118.1-1999. In addition, fast-response heads (activation temperature of 68°C and RTI 50 $m^{1/2}s^{1/2}$) are to be provided throughout the car park levels, and maximum coverage of 12 m^2 per sprinkler for ordinary hazard is to be provided throughout the basement car park level, in accordance with BCA Specification E1.5, which includes compliance with the relevant parts of AS2118–1999. Class A or B monitoring devices are to be fitted to the main stop valves, as detailed within Clause 3.4.2 of AS 2118.1.
4.	Automatic wall-wetting drenchers	Automatic drenchers are to be provided to the carpark side of the glazed installations on Ground Floor, to the office side on Level 1 and to the childcare centre side on Level 2, as shown in Figure 7.1 , Figure 7.2 and Figure 7.3 incorporating the following: (i) drenchers are to be fed from the fire hydrant system, using a monitored isolation valve that is clearly labelled at the valve itself, on the hydrant block plan, and is accessible without the need for a ladder; (ii) a design is to be used that is capable of fully wetting the glazing, including any self-closing / automatic-closing doors when in the closed position, with no dry spots or a proprietary system, unless an alternative system can be shown as being appropriate for the application. Note that in the case of adoption of the Tyco Model WS system, although the inclusion of self-closing doors within the drencher-protected installations is inconsistent with the product specification, such doors are considered acceptable as part of this alternative solution; and (iii) the design to be capable of supplying the required flow and pressure for the simultaneous operation of the drenchers to one side of one of the protected glazing installation and the fire hydrant system.
5.	Building occupant warning system	A building occupant warning system is to be provided throughout the building in accordance with the following: (i) Clause 6 of Specification E2.2a, which includes compliance with the relevant parts of AS1670.1–2004. (ii) Clause 4.3.5 of AS1670.4–2004, relating to the use of an automatic voice messaging system.

Item no.	Measure	Description of fire protection system
6.	Carpark air exhaust system	With the exception of the proposed Alternative Solutions regarding the use of jet-fan system discussed in section 5 of this report the system is to comply with Table E2.2a of BCA Clause E2.2a. The following requirements are to be adhered to in relation to the jet-fans: (i) Dedicated detectors are to be located within 2-3 metres of each jet-fan on the downstream side of the fan and in the supply intake of each jet-fan. Activation of a detector is to shut-down the adjacent jet-fan prior to the operation of the sprinkler system. Detector type(s) are to be selected by the fire services engineer to maximise sensing performance whilst considering the environment associated with the carpark and the risk of false alarms occurring. (ii) Any sprinkler head in the air-stream of a jet-fan in the downstream direction is to be located a minimum of 2.5 metres from the jet-fan. (iii) The jet-fans are to be located along the driveways and oriented such that the jet-stream is parallel to the driveways. (iv) Jet-fans are to be monitored and controlled by the main jet-fan controller, which is to be linked to the fire indication panel. (v) Fire resisting cable recommended for the fire trip to the jet-fan panel from the Fire Indicating Panel (FIP) unless it has a fail-safe switch which switches it off should the connection be severed by a fire. (vi) Manual operation of the jet-fans from the main controller or fire indication panel is proposed. (vii) The proposed jet-fan model is shown in Appendix F.
7.	Fire hydrant system	A fire hydrant system is to serve the building in accordance with BCA clause E1.3, which includes compliance with AS2419–2005.
8.	Fire hose reel system	A fire hose reel system is to be provided in accordance with BCA clause E1.4 and AS 2441–2005.
9.	Portable fire extinguishers	Portable fire extinguishers are to be provided in accordance with BCA clause E1.6 to cover Class A risks within the building in accordance with AS 2444–2001.
10.	Emergency lighting	Emergency lighting is to be provided in compliance with AS2293.1–2005 to the parts of the building nominated by BCA Part E4.
11.	Exit signage	Exit signage is to be provided in compliance with AS2293.1–2005 to the locations nominated by BCA Part E4.

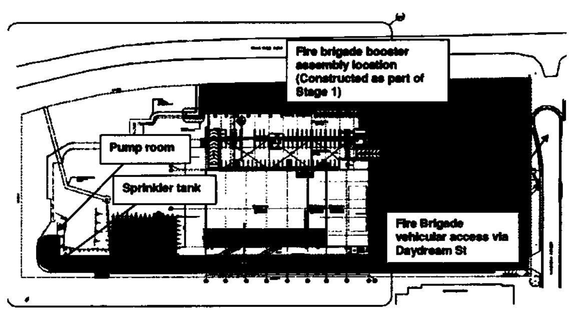

Figure 7.6 – Fire services infrastructure layout

7.4 Standards of Construction, Commissioning, Management and Maintenance

7.4.1 *Construction*

Building works associated with the installation of the proposed fire safety measures and construction elements are to be undertaken by appropriately qualified persons. Coordination of such works is to be undertaken by a project manager and / or construction manager nominated for the project.

7.4.2 *Commissioning*

Fire safety measures are to be the subject of any testing and commissioning requirements specified within the relevant Australian design and installation standards, which include the following:

(i) wall-wetting drencher system – section 5 of AS 2118.2

(ii) fife hydrant system – section 10 of AS 2419.1

(iii) fire hose reel system – section 12 of AS 2441

(iv) fire doors – Appendix E of AS 1905.1

(v) fire sprinkler system – AS 2118.10

(vi) portable fire extinguishers– schedule of installed equipment (type, capacity, rating and locations)

(vii) automatic fire detection system – AS 1670.1 (section 7 and Appendices E and F) as well as a record of an interface test

(viii) fire stopping (schedule of locations, types and details)

(ix) illuminated exit signs and emergency lighting – AS 2293.2 (same as six monthly test, except for 120 minutes instead of 90 minutes)

The following inspections of the completed building works are to form part of the commissioning phase of the building:

1. Inspections by the project stakeholders, where necessary, to facilitate certification of the fire safety installations and architectural features with the fire safety strategy presented as the basis of the fire engineering report.

2. An inspection by Fire and Rescue NSW to facilitate a final fire safety report, pursuant to Clause 152 of the EP&A Regulation 2000, specifying whether or not the commissioner is satisfied that the building complies with the category 2 fire safety provisions of the EP&A

Regulation; specifying that the fire hydrants in the fire hydrant system will be accessible for use by Fire and Rescue NSW; and specifying that the couplings in the fire hydrant system will be compatible with those of the fire appliances and equipment used by Fire and Rescue NSW.

3. An inspection(s) by the project fire engineer and review of relevant documentation to confirm that the building works relating to the alternative solution, as detailed in the fire engineering report, have been completed and are consistent with that alternative solution. Activities to be undertaken or witnessed by the fire engineer may include the following:

a) review of design and installation certificates, together with the fire safety schedule and final fire safety certificate that incorporate the details of the fire engineering report

b) visual inspection of fire-resisting elements of construction, including any drencher-protected glazing and fire doors (tagged with self-closers or automatic-closers)

c) visual inspection of fire hose reels, portable fire extinguishers, emergency lighting and exit signs

d) simulation of sprinkler system flow switch activation, visual inspection of remote test valves, visual inspection of water supply infrastructure (alarm valves / main stop valves in secure enclosure, fire pumps, water storage tanks, fire brigade booster assembly and block plans), visual inspection of spare sprinkler heads and visual inspection of sprinkler heads

e) visual inspection of automatic drenchers

f) visual inspection of fire hydrant system signage and water supply infrastructure (fire pumps, water storage tanks, fire brigade booster assembly and block plans) and visual inspection of fire hydrants

g) visual inspection of fire detectors and operation of the fire detection and alarm system (by others) by activating a smoke detector and witnessing the operation of the occupant warning system (including verbal messaging) and the shutdown of jetfans in the basement carpark.

h) witnessing of power failure for operation of emergency lighting

i) visual check of accessibility of exits

The details of the fire engineering report are to be included within the building's final fire safety certificate to assist future essential services maintenance and auditing of the building.

7.4.3 *Management-and-Use*

The following management procedures and policies are to be implemented on an on-going basis to enable the basis of the fire safety design analysis to be satisfied:

(i) A house-keeping policy is to be implemented, based on avoiding the accumulation of rubbish or storage within the common areas, including the exits and the paths of travel to the exits, so that the exit routes remain free from obstructions.

(ii) A non-smoking policy is to be implemented, supported by signage placed in appropriate locations.

(iii) An emergency management policy, including staff training and regular evacuation drills, is to be implemented in accordance with the principles of AS 3745:2010.

(iv) A hot works permit policy is to be adopted to address the undertaking of hot works within the building, which can present as a potential ignition source. A permit is to be submitted to building management for any hot works process involving cutting, welding, heating, angle grinding or any other related practices and returned to the authorising person upon completion of the associated works, addressing:

a) risks associated with exposure of adjacent combustibles;

b) working within confined spaces;

c) fire watch procedures; and

d) gas testing requirements.

7.4.4 Maintenance

A maintenance regime is to be implemented for the proposed fire safety measures, as follows:

(i) The fire safety design strategy nominated within section 8 of this report is to be maintained. The essential fire safety measures within the building are to be maintained on an on-going basis in accordance with the EP&A Regulation 2000, using AS 1851–2012 and AS 2293.2–1995 as a guide.

(ii) The drencher-protected glazing assemblies are to be maintained to the relevant design and installation standards, including routine inspections to ascertain that the glazing is relatively dust and grease free, with no foreign materials such as notices, stickers etc affixed onto or hanging in front of it (other than any required safety glazing-related decals) and that the framing is not subjected to stresses. Any replacement glazing should be fitted in accordance with the original design.

(iii) Electrical and process equipment is to be the subject of any statutory requirements for inspection and maintenance, which is to be undertaken by a qualified electrician.

8 PROPOSED APPROACH AND METHOD OF ANALYSIS

8.1 General

The Building Code of Australia allows adoption of one or more of the assessment methods defined in clause A.09, as follows:

[redacted]

The International Fire Engineering Guidelines[24] (IFEG) identifies a number of approaches to undertaking the fire engineering analysis and assessment as follows:

- Absolute or comparative
- Qualitative or quantitative
- Deterministic or probabilistic

These approaches are not mutually exclusive and a combination of approaches may be adopted.

As discussed in the IFEG:

- a "comparative" assessment involves utilisation of the same assumptions, models, calculations and input data for both the benchmark design and the alternative solution; and
- an "absolute" assessment involves the assessment of the alternative solution directly against the relevant performance requirements, using the agreed acceptance criteria. With respect to the concept of an "absolute" assessment, the IFEG states that "the fire related performance requirements of the BCA set out to provide a benchmark with respect to the risk of fatality, injury and loss of adjacent structures through fire".

A comparative approach satisfies A0.9(c), while an absolute approach may satisfy either A0.9(b) or (d), subject to agreement by the nominated design and review stakeholders.

Analysis of the proposed trial concept design against the relevant fire safety design objectives will be achieved by deterministic engineering analysis either against the relevant BCA performance requirements or on a comparative basis against a BCA deemed-to-satisfy compliant design, as outlined in Table 8.1 below (i.e. both "absolute" and comparative" approaches will be utilised, as appropriate for each assessment). The nominated assessment method for the absolute assessments is A0.9(b)(ii) "other verification methods", which comprises the method of analysis outlined below for each alternative solution.

Engineering judgement will be used as the basis for expert judgment and will be typically used to determine or define parameters associated with quantitative and qualitative assessment.

8.2 Analysis Strategy

For the alternative solutions under consideration, as identified in Table 5.1, the analysis strategy in Table 8.1 is proposed.

24 Australian Building Codes Board, ABCB, International Fire Engineering Guidelines, Edition 2005, Australian Building Codes Board, Australia, 2005.

Table 8.1 - Analysis strategy for alternative solutions under consideration

<table>
<tr><th>No.</th><th>Alternative solution</th><th>Method of analysis</th></tr>
<tr><td>1</td><td>Fire resisting construction of warehouse areas</td><td>
<table>
<tr><td>X</td><td>Absolute</td><td></td><td>Comparative</td></tr>
<tr><td>X</td><td>Deterministic</td><td></td><td>Probabilistic</td></tr>
<tr><td>X</td><td>Quantitative</td><td>X</td><td>Qualitative</td></tr>
</table>
Relevant IFEG sub-systems are:
• Sub-system A – Fire Initiation and Development and Control
• Sub-system B – Smoke Development and Spread and Control
• Sub-system C – Fire Spread and Impact and Control
• Sub-system D – Fire Detection, Warning and Suppression
• Sub-system E – Occupant Evacuation and Control
• Sub-system F – Fire Services Intervention
Based on a direct assessment against the performance requirements, the methods of analysis to be undertaken will comprise:
(i) Calculation of the evacuation time for the occupants of the affected warehouse areas as follows:
a. detection time – based on either the occurrence of a visual cue upon formation of a layer of smoke across the enclosure that is at least 5 per cent of the height of the enclosure[25] or activation of the sprinkler system.
b. pre-movement time – based on the recommendations of Frantzich[26] for open plan buildings for open areas or Sime[27] for compartmented areas.
c. movement time – based on the methodologies and recommendations of Mowrer[28], Pauls[29] and Sime[30]. For a person with an average mobility, an unobstructed evacuation speed of 1.19 m/s has been reported by Nelson & Mowrer, whilst for people with disabilities such as a walking frame, an evacuation speed of 0.57 m/s has been reported by Pauls. A maximum specific flow through a door of 1.3 (persons/s.m) and an evacuation speed of 0.5 m/s down a stair are reported by Proulx. These unobstructed speeds and flows are considered to be appropriate, as the occupant densities will be less than 0.54 persons/m^2, however, as the building may contain some occupants with disabilities, an evacuation speed of 0.8 m/s will be used.
(ii) Determination of the potential time at which the proposed structural elements could fail in the unlikely event of a fully-developed fire.
(iii) Comparison of the potential time of structural failure with the occupant evacuation time.
</td></tr>
</table>

25 Microeconomic Reform: Fire Regulation; An explanatory describing developments leading to more effective regulations for fire safety in buildings; Building Regulation Review Task Force May 1991, pg 77-78.
26 Frantzich, H., Occupant Behaviour and Response Time – Results from Evacuation Experiments, Conference Proceedings to the 2nd International Symposium on Human Behaviour in Fire. Interscience Communications, 159-165, Boston, MA, 2001
27 Sime, J. D., Assessing Occupant Response Time: A Key Issue for Fire Engineering. In R. Barham (ed) Fire and Emergency Planning: Research and Applications, E & F N Spon, London (48, pp442-449), 1996.
28 Nelson HE & Mowrer FW, Emergency Movement, The SFPE Handbook of Fire Protection Engineering, 3rd ed, National Fire Protection Association, US, 2002.
29 Proulx G, Movement of People: The Evacuation Timing, The SFPE Handbook of Fire Protection Engineering, 3rd ed, National Fire Protection Association, US, 2002.
30 Sime J D (1996), Assessing Occupant Response Time: A Key Issue for Fire Engineering, In R. Barham (ed) Fire and Emergency Planning: Research and Applications, E & F N Spon, London (48, pp 442-449).

<table>
<tr><th>No.</th><th>Alternative solution</th><th>Method of analysis</th></tr>
<tr><td>2</td><td>Drencher-protected glazed wall assemblies and openings in fire-isolated exits</td><td>
<table>
<tr><td></td><td>Absolute</td><td>X</td><td>Comparative</td></tr>
<tr><td>X</td><td>Deterministic</td><td></td><td>Probabilistic</td></tr>
<tr><td>X</td><td>Quantitative</td><td>X</td><td>Qualitative</td></tr>
</table>
Relevant IFEG sub-systems are:
• Sub-system A – Fire Initiation and Development and Control
• Sub-system B – Smoke Development and Spread and Control
• Sub-system C – Fire Spread and Impact and Control
• Sub-system D – Fire Detection, Warning and Suppression
• Sub-system E – Occupant Evacuation and Control
• Sub-system F – Fire Services Intervention
Based on a direct assessment against the performance requirements, the methods of analysis to be undertaken will be qualitative and quantitative in nature and will comprise:
(i) a determination of the extent of fire spread between areas separated via the drencher protected glazing, based on review of test data for barrier systems in relation to the integrity of glazing systems during exposure to elevated temperatures commensurate with the nominated fire scenarios and calculation of potential radiant heat flux values in relation to radiant heat transmission through glazed barrier systems, considering the protection of the glazing by an automatic drencher system; and
(ii) a review of the adequacy of operable elements (i.e. doors) in the glazed installations.
</td></tr>
<tr><td>3</td><td>External wall linings</td><td>
<table>
<tr><td>X</td><td>Absolute</td><td></td><td>Comparative</td></tr>
<tr><td>X</td><td>Deterministic</td><td></td><td>Probabilistic</td></tr>
<tr><td>X</td><td>Quantitative</td><td></td><td>Qualitative</td></tr>
</table>
Relevant IFEG sub-systems are:
• Sub-system A – Fire Initiation and Development and Control
• Sub-system B – Smoke Development and Spread and Control
• Sub-system C – Fire Spread and Impact and Control
• Sub-system D – Fire Detection, Warning and Suppression
Based on an absolute assessment, the method of analysis to be undertaken will comprise a qualitative review and determination of the extent of fire spread between buildings and vertical fire spread between storeys via the facade, based on the presence of a sprinkler system throughout the building (except for the swim school), the location of the wall linings and the proximity of the wall linings to other combustibles and occupants.
</td></tr>
</table>

No.	Alternative solution	Method of analysis
4	Non-provision of fire-isolated stairways and separate rising and descending stair flights	☐ Absolute ☒ Comparative ☒ Deterministic ☐ Probabilistic ☒ Quantitative ☒ Qualitative Relevant IFEG sub-systems are: • Sub-system A – Fire Initiation and Development and Control • Sub-system B – Smoke Development and Spread and Control • Sub-system C – Fire Spread and Impact and Control • Sub-system D – Fire Detection, Warning and Suppression • Sub-system E – Occupant Evacuation and Control • Sub-system F – Fire Services Intervention Based on a comparative assessment, the methods of analysis to be undertaken will comprise: (i) Determination for the potential for fire and smoke spread via the stairway between storeys and between rising and descending stair flights, based on the fire compartmentation provided from the basement carpark level. (ii) Determination of the potential exposure of occupants to fire during evacuation via the stairway, based occupants travelling a maximum of two storeys to evacuate. (iii) Comparison with a BCA DtS design comprising a three-storey, sprinklered building complying with D1.3(b)(iii)(A) and inter-connection of three storeys by internal non-fire-isolated stairways. (iv) Review of the ability for occupants to navigate out of the stairway during a fire in proximity to the stairway, based on visual wayfinding associated with the transparent (glazed) stairway construction.

No.	Alternative solution	Method of analysis
5	Exit travel distances and travel distances between alternative exits (car park)	☐ Absolute ☒ Comparative ☒ Deterministic ☐ Probabilistic ☒ Quantitative ☒ Qualitative Relevant IFEG sub-systems are: • Sub-system A – Fire Initiation and Development and Control • Sub-system B – Smoke Development and Spread and Control • Sub-system C – Fire Spread and Impact and Control • Sub-system D – Fire Detection, Warning and Suppression • Sub-system E – Occupant Evacuation and Control • Sub-system F – Fire Services Intervention Based on a comparative assessment, the method of analysis will comprise a quantitative review of the evacuation time of occupants from SOUs between the proposed Alternative Solution and a similar BCA DtS compliant design, consisting of: (i) Detection time (i.e. based on activation of automatic fire suppression system). (ii) Pre-movement time (i.e. based on pre-movement time from PD 7974-6:2004[31]). (iii) Movement time (i.e. based on methodologies and recommendations of Gwynne and Rosenbaum[32]). (iv) Comparison of the evacuation time for the proposed design with that of the DtS-compliant design which do not comprise fast response sprinkler heads.

31 British Standards, PD 7974-6:2004, The application of fire safety engineering principles to fire safety design of building – Part 6: Human factors: Life safety strategies – occupant evacuation, behaviour and condition (sub-system 6), British Standards Institution. 2004, p 1-50.
32 Gwynne, S. M. V. and Rosenbaum, E. R., Employing the Hydraulic Model in Assessing Emergency Movement, Section 3-Chapter 14, The SFPE Handbook of Fire Protection Engineering, 4th edition, National Fire Protection Association, Quincy, Massachusetts, 2008, pp. 3-373–3-396.

No.	Alternative solution	Method of analysis
6	Exit travel distances (Tenancy G.3. Mezzanine)	☐ Absolute ☒ Comparative ☒ Deterministic ☐ Probabilistic ☒ Quantitative ☒ Qualitative Relevant IFEG sub-systems are: • Sub-system A – Fire Initiation and Development and Control • Sub-system B – Smoke Development and Spread and Control • Sub-system C – Fire Spread and Impact and Control • Sub-system D – Fire Detection, Warning and Suppression • Sub-system E – Occupant Evacuation and Control • Sub-system F – Fire Services Intervention Based on a comparative assessment, the method of analysis will comprise a quantitative review of the evacuation time of occupants from Tenancy G.3. mezzanine between the proposed Alternative Solution and a similar BCA DtS compliant design, consisting of: (i) Detection time (based on activation of automatic fire suppression system). (ii) Pre-movement time (i.e. based on pre-movement time from PD 7974-6:2004[33]). (iii) Movement time (i.e. based on methodologies and recommendations of Gwynne and Rosenbaum[34]). (iv) Comparison of the evacuation time for the proposed design with that of the DtS-compliant design which does not incorporate a voice messaging system.

33 British Standards, PD 7974-6:2004, The application of fire safety engineering principles to fire safety design of building – Part 6: Human factors: Life safety strategies – occupant evacuation, behaviour and condition (sub-system 6), British Standards Institution. 2004, p 1-50.
34 Gwynne, S. M. V. and Rosenbaum, E. R., Employing the Hydraulic Model in Assessing Emergency Movement, Section 3-Chapter 14, The SFPE Handbook of Fire Protection Engineering, 4th edition, National Fire Protection Association, Quincy, Massachusetts, 2008, pp. 3-373–3-396.

No.	Alternative solution	Method of analysis
7	Exit travel distances (Level 2 office)	☒ Absolute ☐ Comparative ☒ Deterministic ☐ Probabilistic ☒ Quantitative ☒ Qualitative Relevant IFEG sub-systems are: • Sub-system A – Fire Initiation and Development and Control • Sub-system B – Smoke Development and Spread and Control • Sub-system C – Fire Spread and Impact and Control • Sub-system D – Fire Detection, Warning and Suppression • Sub-system E – Occupant Evacuation and Control • Sub-system F – Fire Services Intervention Based on a comparative assessment, the method of analysis will comprise a quantitative review of the evacuation time of occupants from Level 2 office between the proposed Alternative Solution and a similar BCA DtS compliant design, consisting of: (i) Detection time. (i.e. based on activation of automatic fire detection system). (ii) Pre-movement time (i.e. based on pre-movement time from PD 7974-6:2004[35]). (iii) Movement time (i.e. based on methodologies and recommendations of Gwynne and Rosenbaum[36]). (iv) Comparison of the evacuation time for the proposed design with that of the DtS-compliant design incorporating extended spaced detectors.
8	Distances between alternative exits (Tenancy G.3.)	☒ Absolute ☐ Comparative ☒ Deterministic ☐ Probabilistic ☒ Quantitative ☒ Qualitative Relevant IFEG sub-systems are: • Sub-system A – Fire Initiation and Development and Control • Sub-system B – Smoke Development and Spread and Control • Sub-system C – Fire Spread and Impact and Control • Sub-system D – Fire Detection, Warning and Suppression • Sub-system E – Occupant Evacuation and Control • Sub-system F – Fire Services Intervention Based on a comparative assessment approach, the methods of analysis to be undertaken will comprise: (i) Calculation of the available safe evacuation time (ASET) for the proposed alternative solution based on zone modelling. (ii) Calculation of the ASET for a BCA DtS-compliant benchmark design which could have a ceiling height of 2.4 metres; and travel distances of 20 / 40 / 60 m. (iii) Comparison of the ASET for both the alternative solution and the BCA DtS-compliant benchmark design. (iv) Determination of the impact of the additional travel time that occupants may need to reach an alternative exit and the period during which improved tenability could be expected during the evacuation period.

35 British Standards, PD 7974-6:2004, The application of fire safety engineering principles to fire safety design of building – Part 6: Human factors: Life safety strategies – occupant evacuation, behaviour and condition (sub-system 6), British Standards Institution. 2004, p 1-50.
36 Gwynne, S. M. V. and Rosenbaum, E. R., Employing the Hydraulic Model in Assessing Emergency Movement, Section 3-Chapter 14, The SFPE Handbook of Fire Protection Engineering, 4th edition, National Fire Protection Association, Quincy, Massachusetts, 2008, pp. 3-373–3-396.

<table>
<tr><th>No.</th><th>Alternative solution</th><th>Method of analysis</th></tr>
<tr><td>9</td><td>Distances between alternative exits (child care centre)</td><td>
<table>
<tr><td>X</td><td>Absolute</td><td></td><td>Comparative</td></tr>
<tr><td>X</td><td>Deterministic</td><td></td><td>Probabilistic</td></tr>
<tr><td>X</td><td>Quantitative</td><td>X</td><td>Qualitative</td></tr>
</table>
Relevant IFEG sub-systems are:

Sub-system A – Fire Initiation and Development and Control
Sub-system B – Smoke Development and Spread and Control
Sub-system C – Fire Spread and Impact and Control
Sub-system D – Fire Detection, Warning and Suppression
Sub-system E – Occupant Evacuation and Control
Sub-system F – Fire Services Intervention

Based on a comparative assessment approach, the methods of analysis to be undertaken will comprise:
(i) Consideration the fire separation provided by the proposed refuge area which reduces the distances between alternative exits.
(ii) Determination of the impact of the additional travel time that occupants may need to reach an alternative exit and the presence of the refuge area and the outdoor area.
</td></tr>
<tr><td>10</td><td>Swim school egress width</td><td>
<table>
<tr><td></td><td>Absolute</td><td>X</td><td>Comparative</td></tr>
<tr><td>X</td><td>Deterministic</td><td></td><td>Probabilistic</td></tr>
<tr><td></td><td>Quantitative</td><td>X</td><td>Qualitative</td></tr>
</table>
Relevant IFEG sub-system is Sub-system E – Occupant Evacuation and Control
Based on a comparative assessment approach, the method of analysis to be undertaken will comprise an anthropometric assessment to determine the ability for the exit width to adequately facilitate the single-file passage of occupants to the exits, utilising anthropometric data from Littlefield[37] and Pheasant[38]. The comparative assessment will consider for both the proposed design and the BCA DtS-compliant design:
(i) the number of occupants served; and
(ii) the occupant movement time.
</td></tr>
</table>

37 Littlefield, D., Metric Handbook, Planning and Design Data, third edition, Architectural Press, Oxford, UK, 2008.
38 Pheasant, S., Bodyspace – Anthropometry, Ergonomics and the Design of Work, Third Edition, Taylor & Francis Group, 2006.

<table>
<tr><th>No.</th><th>Alternative solution</th><th>Method of analysis</th></tr>
<tr><td>11</td><td>Variation to roof FRL, spandrel separation and smoke hazard management</td><td>
<table>
<tr><td>X</td><td>Absolute</td><td></td><td>Comparative</td></tr>
<tr><td>X</td><td>Deterministic</td><td></td><td>Probabilistic</td></tr>
<tr><td></td><td>Quantitative</td><td>X</td><td>Qualitative</td></tr>
</table>
Relevant IFEG sub-systems are:

Sub-system A – Fire Initiation and Development and Control
Sub-system B – Smoke Development and Spread and Control
Sub-system C – Fire Spread and Impact and Control
Sub-system D – Fire Detection, Warning and Suppression
Sub-system E – Occupant Evacuation and Control
Sub-system F – Fire Services Intervention

Based on a direct assessment against the performance requirements, the methods of analysis to be undertaken will be qualitative and quantitative in nature and will comprise:
(i) Review of the potential for fire spread from the subject building to the adjoining buildings.
(ii) Review and determination for the potential for fire spread from the swim school to the adjacent areas within the building.
(iii) Review and determination of the potential for fire spread between storeys via external openings.
(iv) Review of the proposed smoke hazard management system for the building which comprises a combination of an automatic sprinkler system and smoke detection system.
</td></tr>
<tr><td>12</td><td>Mechanical ventilation system</td><td>
<table>
<tr><td></td><td>Absolute</td><td>X</td><td>Comparative</td></tr>
<tr><td>X</td><td>Deterministic</td><td></td><td>Probabilistic</td></tr>
<tr><td>X</td><td>Quantitative</td><td>X</td><td>Qualitative</td></tr>
</table>
Relevant IFEG sub-systems are:

Sub-system A – Fire Initiation and Development and Control
Sub-system B – Smoke Development and Spread and Control
Sub-system C – Fire Spread and Impact and Control
Sub-system D – Fire Detection, Warning and Suppression
Sub-system E – Occupant Evacuation and Control
Sub-system F – Fire Services Intervention

Based on a comparative assessment approach, the methods of analysis to be undertaken will comprise:
(i) CFD modelling to predict the local effect of a jet-fan on sprinkler activation times (fast response and conventional sprinklers) during a fire;
(ii) comparison of the sprinkler detection time for both the Alternative Solution and the BCA DtS-compliant benchmark design
(iii) comparison of the visibility and temperature for both the Alternative Solution and the BCA DtS-compliant benchmark design in relation to the movement of smoke.
(iv) Assessment will also involve a qualitative review of smoke spread and building design to mitigate the risk or occupants to reach a place of safety considering the building layout.
</td></tr>
</table>

8.3 Sensitivity Studies

Where a particular fire safety measure or input parameter for the fire safety assessment is found to play a critical role in the outcome of the analysis, a sensitivity study will be conducted to assess the impact of a variation in performance of such system or parameter on the design.

For the Level 2 exit travel distance assessment, a fast t^2 fire will be considered in addition to the standard medium t^2 fire.

8.4 Redundancy Studies

The design strategy includes evaluation of sub-system failure and fire brigade intervention, where appropriate. If a sub-system operation is shown to be essential for the proposed fire safety design solution, the system will be assessed for adequate reliability and performance.

Fire protection systems such as fire hydrants, fire hose reels and fire extinguishers will facilitate fire brigade and occupant intervention in the development of a fire and facilitate redundancy in a qualitative manner when considering that the fire safety assessment does not rely directly on these systems.

However, it should be noted that for the alternative solutions that are to be reviewed on the basis of a comparative assessment, redundancy involving fire safety measures is not applicable, as this will not directly affect the outcome, as they would all apply equally to both the proposed and benchmark, DtS-compliant designs, as they will feature similar passive and active elements of design.

Redundancy of direct path of travel will be considered given that occupants can manoeuvre around within the storage tenancy layout and seek an alternative path to reach the 2nd exit.

The safety margins used throughout the analysis will also form part of the redundancy considerations.

9 ACCEPTANCE CRITERIA

9.1 Judgement of Acceptance Criteria

A deterministic analysis will be undertaken generally as described in the International Fire Engineering Guidelines.[39] The analysis will comprise a range of likely fire scenarios to evaluate the interaction between sub-systems, and include system reliability and effectiveness.

The fire engineering analysis will detail and show how the relevant fire-safety objectives have been demonstrated to the degree necessary.

9.2 Acceptance Criteria for the Analyses

Consideration of the individual parameters identified for each relevant BCA performance requirement will be achieved by qualitative and/or quantitative analysis, commensurate with the fire hazard for buildings possessing similar construction and occupancy characteristics.

Appropriate design margins will be incorporated; however, a generally conservative analysis, coupled with redundancy in the design, is considered to provide an initial level of safety prior to the application, if necessary, of a numerical design margins.

For the case of an acceptance criteria based on a comparative assessment approach (based on comparison with the BCA deemed-to-satisfy provisions as a benchmark for life safety), the International Fire Engineering Guidelines states that:

> *...it should not be necessary to include explicit factors of safety because the same methods and assumptions for the analysis would be used for both the deemed-to-satisfy or prescriptive design and the proposed design.*

For the case of an acceptance criteria based on an "absolute" assessment approach, it should be noted that the IFEG states that:

> *It is not intended that this benchmark should be "absolute safety" or "zero risk" because these concepts are not achievable and the benchmark risk needs to take into account what the community expects and the cost to the community, which may be determined by a cost benefit analysis.*

The nominated acceptance criteria for each of the proposed alternative solutions are detailed within Table 9.1 below.

Table 9.1 – Acceptance Criteria

<table>
<tr><th>No.</th><th>Alternative solution</th><th>Acceptance criteria</th></tr>
<tr><td>1</td><td>Fire resisting construction of warehouse areas</td><td>Absolute acceptance criteria are to be adopted, being that structural failure and the spread of fire to the non-fire-affected sides of the compartment barrier and collapse onto adjacent buildings is mitigated by the performance of the sprinkler system, the fire-resisting wall construction with the fire brigade intervention time and evacuation time occurring prior to possible structural failure time.</td></tr>
<tr><td>2</td><td>Drencher-protected glazed wall assemblies and openings in fire-isolated exits</td><td>Absolute acceptance criteria are to be adopted, being as follows:
(i) For the glazed barrier construction, the radiant heat flux received on the non-fire-affected side of the barrier where combustibles may be located does not exceed 10 kW/m^2.
(ii) The operable elements (i.e. doors) will not affect the performance of the glazed barrier.</td></tr>
<tr><td>3</td><td>External wall linings</td><td>Absolute acceptance criteria are to be utilised, whereby:
(i) The potential for fire spread to and from neighbouring buildings via the external walls will be mitigated by way of the design and location of the proposed linings.
(ii) The potential for fire spread between storeys will be mitigated by way of the design and location of the proposed linings.</td></tr>
</table>

39 Australian Building Codes Board, ABCB, International Fire Engineering Guidelines, Edition 2005, Australian Building Codes Board, Australia, 2005.

No.	Alternative solution	Acceptance criteria
4	Non-provision of fire-isolated stairways and separate rising and descending stair flights	A comparative acceptance criterion is to be adopted, whereby the proposed alternative solution is at least equivalent to (i.e. not greater than) that of the benchmark, BCA DtS-compliant design, based on: (i) The potential for fire and smoke spread via the stairway between storeys and between rising and descending flights will be mitigated, based on the fire separation provided at the basement level. (ii) The potential exposure of occupants to fire as they evacuate via the stairway will be mitigated, based on the need to travel only two levels to evacuate.
5	Exit travel distances and travel distances between alternative exits (car park)	A comparative acceptance criterion is to be adopted, being that the occupant evacuation time for the proposed Alternative Solution from the subject car parking areas is at least equivalent to (i.e. not greater than) that of the benchmark, BCA DtS-compliant design.
6	Exit travel distances (Tenancy G.3. Mezzanine)	A comparative acceptance criterion is to be adopted, being that the occupant evacuation time for the proposed Alternative Solution from the subject mezzanine is at least equivalent to (i.e. not greater than) that of the benchmark, BCA DtS-compliant design.
7	Exit travel distances (Level 2 office)	A comparative acceptance criterion is to be adopted, being that the occupant evacuation time for the proposed Alternative Solution from the subject Level 2 office is at least equivalent to (i.e. not greater than) that of the benchmark, BCA DtS-compliant design.
8	Distances between alternative exits (Tenancy G.3.)	A comparative acceptance criterion is to be adopted, being that the potential for occupants to be exposed to the products of combustion for the proposed design is at least equivalent to (i.e. not greater than) that associated with the BCA DtS-compliant benchmark design, based on the increased ASET (being the result of the larger reservoir for smoke filling) compensating for the reduced RSET (being a result of the longer travel distances).
9	Distances between alternative exits (Child care centre)	*A comparative acceptance criterion is to be adopted whereby* the occupant evacuation time will be at least equivalent to a BCA DtS-compliant design based on the provision of a fire separated refuge area which results in distances between places of relative safety not exceeding 60 m.
10	Swim school egress width	Comparative acceptance criteria are to be adopted, whereby: (i) The ability for the proposed exit and pathway widths forming the basis of the Alternative Solution to facilitate the single-file passage of a 95th-percentile person is at least equivalent to that associated with the nominated, BCA DtS-compliant benchmark design. (ii) The occupant movement time from the swim school is at least equivalent to that associated with the nominated, BCA DtS-compliant benchmark design.

No.	Alternative solution	Acceptance criteria
11	Variation to roof FRL, spandrel separation and smoke hazard management	Absolute acceptance criteria are to be adopted, being as follows: (i) The potential for fire spread from the subject building to the adjoining buildings is mitigated based on the provision of an automatic sprinkler system throughout the building except for the swim school, which is located on Ground Floor. (ii) The potential for fire spread from the swim school to the adjacent areas within the building is mitigated based on the provision of an automatic sprinkler system throughout the building except for the swim school, which is located on Ground Floor. (iii) Fire spread between vertical openings is mitigated, based on an automatic sprinkler system provided throughout the building except for the swim school which do not comprise any vertical openings to its external walls. (iv) The combination of an automatic sprinkler system and smoke detection system will not adversely affect the smoke hazard management system.
12	Clause E2.2 – Mechanical ventilation system	A comparative acceptance criterion is to be adopted, whereby: (i) The performance of the sprinkler system with the jet-fans installed is equivalent to that of the BCA DtS compliant design without jet-fans, based on the sprinkler activation time; and (ii) Conditions in the carpark with jet-fans is at least equivalent than that of the BCA DtS compliant design without jet-fans, based on the operation of the sprinklers and shutdown of the jet-fans.

9.3 Environmental and Loss Control Acceptance Criteria

The building owner or any other stakeholders have not identified any specific environmental or loss control acceptance criteria.

10 Fire Scenarios, Occupant Egress Scenarios and Analysis Scenarios

This section presents the fire scenarios and occupant egress scenarios proposed for assessment of the alternative solutions against the relevant BCA performance requirements.

10.1 General Overview of Fires

The types of fire scenarios for consideration can be categorised into three groups:

(i) Smouldering fires

(ii) Flaming fires

(iii) *Fully-developed fires*

Each of these fire scenarios can generally be described as follows.

10.1.1 *Smouldering fire*

The IFEG[40] defines a smouldering fire as *'the solid phase combustion of a material without flames but with smoke and heat production'*. When considering general building contents anticipated within the building, the context of smouldering combustion would generally occur prior to flaming combustion and represent a slower development (i.e. heat release rate) and generally less significant fire than a flaming fire. For this reason, a flaming fire scenario with a higher heat release rate and exclusion of incipient stage development is considered to be more onerous than a smouldering fire.

10.1.2 *Flaming Fire*

A flaming fire is a fire that has developed beyond the smouldering phase to involve a non-flashover burning regime. Fully-developed conditions are unlikely to occur due to either occupant intervention or the operation of sprinklers, which are designed to suppress or control a fire to the area or room where ignition first occurs. Smoke spread within the compartment of fire origin is possible and will be considered in the analysis, with the extent of spread depending upon the location and size of the fire.

10.1.3 *Fully-Developed Fire*

A fully developed fire scenario involves fire growth without timely intervention by occupants, fire fighters or automatic sprinklers. This type of fire is usually controlled by the available ventilation or fuel within the compartment. Based on studies, the onset of a flashover condition is approximated when the ceiling temperatures of 600°C[41] or having a floor irradiance of 20 kW/m^2 [42].

10.2 Sprinkler Reliability and Performance

As the assessment to be undertaken will place some reliance on the performance of the proposed automatic sprinkler system, review needs to be made of the expected reliability of such a system to demonstrate that a sprinkler-controlled fire scenario is a reasonable expectation.

A fire scenario coincident with sprinkler failure is considered to be rare event, as reported in literature for correctly designed, commissioned and maintained sprinkler systems.

England and Young[43] estimated the reliability of automatic sprinkler systems to be approximately 95 per cent, based on Australian fire incident statistics collected by the Australasian Fire Authorities Council (AFAC) for the period 1989/90–1993/94. The same document also reported that the fire size was too small to operate the sprinkler heads in 77 per cent of the cases.

NSW data collected by FRNSW [44] in its Annual Statistical Report 2001/2002 indicates that for incidents where sprinklers were present and operated, the fire was extinguished in 70 per cent of cases and was prevented from spreading in a further 26 per cent of cases – for storage premises, all incidents involved extinguishment or control of the fire.

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40 Australian Building Codes Board, 2005, International Fire Engineering Guidelines (IFEG), Australia.
41 Drysdale, D., An Introduction to Fire Dynamics, Second Edition, John Wiley & Sons, West Sussex, England, 1998, p 298
42 Babrauskas V, Upholstered Furniture Room Fires – Measurements, comparison with furniture calorimeter data, and flashover predictions, Journal of Fire Sciences, Vol. 2, No. 1, 5-19, 1984.
43 England, J.P. & Young, S. A., Fire Risk Management for Buildings with Aged Accommodation, Fire Australia Proceedings, 1998.
44 New South Wales Fire Brigades (NSWFB), Annual Statistical Report 2001/2002 incorporating a Ten Year Review 1989/90 to 1998/99, ISSN 1035 9605 New South Wales Fire Brigades, 2003.

This is consistent with data from the United States, where Deal[45] reported that insurers assume the reliability figure for sprinklers to be in the range 92–97 per cent and Rohr[46] reported that sprinklers were effective in controlling 98 per cent of all property fires over the period 1999-2000.

Key reliability factors for sprinkler systems in Australia[47] include the protection of concealed spaces (roof and ceiling spaces), adequate maintenance of the system and the provision of stop valve monitoring devices. All these items are addressed either by stipulation in AS 2118.1 or by the fire safety strategy.

As a result, a high level of performance is expected to be achieved by the sprinkler system.

10.3 Proposed Fire Scenarios

Based on the information presented above in relation to fuel loads and ignition sources, the fire scenarios are detailed in Table 10.1 for the assessment of the proposed Alternative Solution against the relevant BCA performance requirement.

This scenarios are nominated based on being the most relevant for the fire safety issue being assessed (they have the greatest impact on the design) and the most credible, given the building designs, the fire protection systems and the fuel load. The scenarios are considered appropriate to assess occupant life safety during credible fire events of significant consequence.

No allowance is made for occupant or fire brigade intervention in the development of the fire.

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45 Deal, S., Evaluating Small Board and Care Homes Sprinklered vs Non Sprinklered Fire Protection, NIST, 1993.
46 Rohr, K. D., & Hall, J.R., US Experience with Sprinklers and Other Fire Extinguishing Equipment, Fire Analysis and Research Division, National Fire Protection Association (NFPA), Quincy, MA, 2005.
47 Marryatt, H. W., Fire: A Century of Automatic Sprinkler Protection in Australia and New Zealand 1886-1986, Australia, 1988.

Table 10.1 – Fire Scenarios

Fire Location	Fire Scenario and Design Parameters
Carpark fire scenario	The most relevant fire scenarios involve the ignition of a fire within the carpark. Discounting any allowance for the effects of occupant or fire brigade intervention in the development of fire, a fire involving a vehicle has a unique growth pattern, with spread typically occurring from within the vehicle body prior to breaking through into the front and rear sections of the vehicle. The extent of smoke spread across the floor is dependent on the location of the fire. Spread from the vehicle of fire origin is possible after some time, based on testing carried out on fires involving passenger vehicles.[48 49] Thick, dense smoke was reported to have been created as a result of these vehicle fires. Fire spread to the storeys above would not readily occur, based on the fire compartmentation and the protection of the building by an automatic sprinkler system for control of fire and mitigation of fire spread. A multi-car fire is considered a worst credible case fire scenario for the carpark levels. The fire size is based on published experimental data of full scale fire tests in closed carparks[50], which incorporated fire spread to two cars. Spread from the vehicle of fire origin is possible after some time, based on testing carried out on fires involving passenger vehicles[51 52]. Thick, dense smoke was reported to have been created as a result of these vehicle fires. The occurrence of flashover within the car park is unlikely to occur, due to the large open design of the car park, such that the ability for heat and smoke to be contained and confined to a small area of the floor to create pre-flashover conditions is limited. The degree of smoke spread will be dependent upon the size of the fire but could involve the majority of the storey. Some smoke spread to the floor above could occur via natural leakage paths formed by building services risers and lift and stair shafts. Initiation of the sprinkler system would result in activation of building occupant warning system throughout the building. The fire growth rate would be based on published experimental data of a typical car fire involving two vehicles.[53] Comparison of this growth rate to a conventional t^2 growth rate indicates that medium t^2 growth is the most representative, being moderately more severe. As such, a medium t^2 fire with a peak heat release rate (HRR) determined by ventilation or fuel controlled conditions is considered to be appropriate for a fire initiating within the basement car park.
Swim school fire scenario	A flaming fire would be restricted to the area local to the seat of the fire and the item first ignited, either due to the isolated nature of the items involved and/or human (i.e. occupant or fire-fighter), which would result in both the avoidance of the occurrence of flashover approximately 600°C across the enclosure[54]), and fully-developed compartment fire conditions The likelihood of fully-developed conditions occurring is low based on the minimal fuel load associated with typical swimming pools. Smoke spread could occur throughout various parts of the floor of fire origin and spread to an upper level. Fire and smoke would spread to activate the smoke detectors to initiate the occupant warning system, alerting the building occupants to evacuate from the building.

48 Takayuki Kitano, Osami Sugewa, Hideaki Masuda, Takeo Avel, Hideki Uesugi. Large Scale Fire Tests of four storey Type Car Parks. Part 1: Behaviour of structural frame exposed to the fire at the deepest part of the 1st floor, 2000
49 Bennetts, I.D., Poh, K.W., Thomas I.R., Economical Carparks – A Guide to Fire Safety BHP Steel Australia, March 1999.
50 Profil ARBED Recherches, Development of Design Rules for Steel Structures Subjected to Natural Fires in Closed Car Parks, 1997.
51 Takayuki Kitano, Osami Sugewa, Hideaki Masuda, Takeo Avel, Hideki Uesugi. Large Scale Fire Tests of four storey Type Car Parks. Part 1: Behaviour of structural frame exposed to the fire at the deepest part of the 1st floor.
52 Bennetts, I.D., Poh, K.W., Thomas I.R., Economical Carparks – A Guide to Fire Safety BHP Steel Australia, March 1999.
53 Cullinan R, Parking Lessons, Fire Risk Management Journal, April 2010.
54 Drysdale, D., An Introduction to Fire Dynamics, Second Edition, p. 292, John Wiley & Sons, West Sussex, England, 1998.

Fire Location	Fire Scenario and Design Parameters
Office fire scenario	The most relevant fire scenario within the building involves a fire initiating within an office area, typically occurring as a result of electrical equipment overheating, electrical system faults, arson or smoking[55 56]. Based on a well-distributed fuel load within each level (office furnishings comprising tables, chairs, electrical equipment and various cellulosic materials), fire spread from a fire that is not able to be controlled by occupants or fire fighters could occur throughout the floor of origin. Sufficient smoke generation is expected to result in activation of the fire detection system for initiation of the building occupant warning system, with smoke spread throughout various parts of the floor of fire origin being possible. The rate of growth of the fire's heat release can be approximated using a standard $(t/k)^2$ rate of growth of the heat release rate (t = elapsed time, k = constant), typically reflecting the early growth stages of fires involving a wide range of stored/stacked cellulosic and plastic commodities. A medium t^2 growth rate ($k = 300$) is considered to be appropriate for a fire initiating within an office. Use of this design fire is based on research findings by Sardqvist[57] and NIST[58] for fire growth rates for typical office furnishings, where a number of fires involving typical office furnishings, such as workstations and the like, approximated a medium t^2 growth rate. Fire development would be governed primarily by the arrangement of fuels and the operation of the sprinkler system, which is expected to be activated once the fire reaches a size adequate to limit further fire growth and minimise the propensity for a fully-developed fire. Initiation of the fire detection system would result in activation of the emergency warning system throughout the building. The likelihood of fully-developed conditions occurring is low based on the presence of an automatic sprinkler system.

55 Marryatt H. W. (1988), Fire - A Century of Automatic Fire Protection in Australia and New Zealand 1886-1996, FPAA, Australia.
56 NSW Fire Brigades, New South Wales Fire Brigades Annual Statistical Report 2001/02, Sydney, 2003.
57 Sardquist, S., Initial Fires, RHR, Smoke production and CO Generation from Single Items and Room Fire Tests, Lund, 1993.
58 National Institute of Standards and Technology (NIST), Fire on the Web, Fire Experiment Results, web pages http://fire.nist.gov/fire/fires/fires.html and http://www.fire.nist.gov/fire/fires/fires2.html, accessed 19/05/09.

Fire Location	Fire Scenario and Design Parameters
Warehouse fire scenario	<u>Flaming fire</u> The most relevant fire scenarios involve the ignition of a fire within the storage warehouse, which could involve electrical equipment overheating cooking equipment, electrical malfunction or arson or smoking[59 60]. Fire development would be governed primarily by the arrangement of fuels and the operation of the sprinkler system, which, in the most likely case, would be activated once the fire reaches an adequate size to limit further fire spread. A flaming fire would be restricted to the area local to the seat of the fire and the item first ignited, either due to the isolated nature of the items involved and/or human (i.e. occupant or fire-fighter) or automatic (i.e. fire sprinkler system) intervention, which would result in both the avoidance of the occurrence of flashover approximately 600°C across the enclosure[61]), and fully-developed compartment fire conditions. The rate of growth of the fire's heat release can be approximated using a standard $(t/k)^2$ rate of growth of the heat release rate (t = elapsed time, k = constant), typically reflecting the early growth stages of fires involving a wide range of stored/stacked cellulosic and plastic commodities. A fast t^2 growth rate ($k = 300$) is considered to be appropriate for a fire initiating within the subject building. Use of this design fire is based on research findings by Sardqvist[62] and NIST[63] for fire growth rates for typical storage items. Smoke spread could occur throughout various parts of the floor of fire origin. <u>Fully-developed fire</u> Flashover conditions are not considered likely during a sprinkler-controlled fire. However, although unlikely based on the performance of sprinkler systems discussed previously, a fire could become fully developed within a short period of time without intervention by occupants or fire fighters, with localised flashover or fully-developed conditions being possible. A post-flashover fire would result in compartment temperatures exceeding 600°C, with temperatures as high as 900-1000°C being possible during a fully-developed compartment fire[64] as well as damage to structural elements, the degree being dependent upon the fire-resistance of the element.

59 Marryatt H. W. (1998), Fire – A Century of Automatic Fire Protection in Australia and New Zealand 1886-1996, FPAA, Australia.
60 FCRC (1998) Fire Safety in Shopping Centres, Final Research Report – Project 6, Fire Code Reform Centre Ltd., Sydney, Australia.
61 Drysdale, D., An Introduction to Fire Dynamics, Second Edition, p. 292, John Wiley & Sons, West Sussex, England, 1998.
62 Sardquist, S., Initial Fires, RHR, Smoke production and CO Generation from Single Items and Room Fire Tests, Lund, 1993.
63 National Institute of Standards and Technology (NIST), Fire on the Web, Fire Experiment Results, web pages http://fire.nist.gov/fire/fires/fires.html and http://www.fire.nist.gov/fire/fires/fires2.html, accessed 19/05/09.
64 Babrauskas, V., Temperatures in Flames and Fires, Fire Science and Technology Inc., Issaquah, WA, 1997.

Fire Location	Fire Scenario and Design Parameters
Child care centre fire scenario	<u>Flaming fire</u> Fire development within the child care centre would be governed by the arrangement of fuels and the ability for either occupants or fire fighters to intervene to control the fire and limit further fire spread which could occur throughout the floor of origin. Intervention would result in avoidance of flashover (approximately 600°C throughout the enclosure, which is also reliant on sufficient ventilation being available to the enclosure, is a phenomenon where all the combustibles within the room of origin are involved in fire[65]) and fully-developed conditions, which is the most likely scenario for the subject development, based on the fire spread statistics presented previously. A flaming fire would be restricted to the area local to the seat of the fire and the item first ignited, either due to the isolated nature of the items involved or by occupants or fire fighters, which would result in both the avoidance of the occurrence of flashover across the enclosure[66]), and fully-developed compartment fire conditions. Smoke spread could occur throughout various parts of the floor of fire origin. <u>Fully-developed fire</u> A fire initiating within the child care centre could become fully developed in a short period of time without intervention by occupants or fire fighters, with flashover conditions being possible within the enclosure of fire origin, given the size of the rooms, combustible furnishings contained therein and the available ventilation through the external openings. Conditions resulting from flashover could include temperatures reaching 900-1000°C[67] within the enclosure of fire origin and glass breakage to the external openings. However, the likelihood of fully-developed conditions occurring is low based on the minimal fuel load associated with typical playrooms. The potential for external fire spread would generally be limited to the transmission of radiant heat from the openings of the compartment of fire origin.
External fire scenario	The external areas to the building by nature will have limited fire load, based on the space being landscaping and being used as a circulation path for vehicles. It is expected that furnishings would be typically limited to the internal areas of the building.
Neighbouring building fire scenario	A fire scenario involving a neighbouring building could involve a range of growth rates, fire sizes and fire severities, varying from non-flashover to fully-developed, dependent upon the building geometry and fuel load arrangements. Consideration of the most severe, probable fire scenario will be given, which involves a fully-developed fire. Review of the impact of the nominated fire scenarios on the alternative solution for the combustible external wall construction is to be generally undertaken on a qualitative basis.

10.4 Discounted Fire Scenarios

A smouldering fire scenario is not considered, based on the low hazard posed. It is considered that a small fire that generates a moderate a small quantity of smoke over an extended period of time is not a hazard that would readily facilitate fire spread to the extent that the more severe design fire could.

10.5 Arson

Arson has been statistically shown to contribute to fires in buildings, and can occur during business hours when a building is occupied or after hours, when the building is unoccupied.

Arson in this report is only considered from an occupant life safety perspective in accordance with the BCA DtS provisions. Hence, only incidents of minor forms of arson from a single ignition source

65 Babrauskas, V., Temperatures in Flames and Fires, Fire Science and Technology Inc., Issaquah, WA, 1997, p. 292.
66 Drysdale, D., An Introduction to Fire Dynamics, Second Edition, p. 292, John Wiley & Sons, West Sussex, England, 1998.
67 Babrauskas, V., Temperatures in Flames and Fires, Fire Science and Technology Inc., Issaquah, WA, 1997

are considered in this report in accordance with the Engineers Australia Society of Fire Safety Code of Practice[68].

The above mentioned fire scenarios are considered to be representative of an arson fire from a single ignition source in terms of fire severity. Major incidents of arson, involving accelerants and/or multiple ignition sources, are beyond the scope of this analysis, and are excluded from this report.

68 Engineers Australia, Society of Fire Safety, Code of Practice for Fire Safety Design, Certification and Peer Review (2003). Available on www.sfs.au.com/publications.

PART B – FIRE ENGINEERING ANALYSIS

11 ALTERNATIVE SOLUTION 1 – FIRE RESISTING CONSTRUCTION TO WAREHOUSE AREAS

11.1 ASSESSMENT CRITERIA

Table 11.1 provides a summary of the criteria for consideration as the basis of this Alternative Solution.

Table 11.1 – Assessment criteria

Consideration	Criterion
Applicable BCA DtS provisions	BCA Specification C1.1 stipulates that building elements are to have fire resistance levels (FRLs) in accordance with Table 3 of Specification C1.1, being, for the subject development, 240/240/240 FRLs to the warehouse areas, 120/120/120 FRLs to the office areas, 60/60/60 FRLs to the sprinkler-protected car parking areas.
Proposed Alternative Solution	The proposed alternative solution is based on: (i) the provision of a 120/120/120 FRL fire walls, floors and columns in lieu of 240/240/240 FRL to the warehouse areas; (ii) the presence of an automatic sprinkler system within the building, except for the swim school; (iii) The low-rise design of the building; and (iv) The significant distance from neighbouring buildings
BCA assessment method	Qualitative assessment based on BCA A0.5b(i) "formulating an Alternative Solution which complies with the Performance Requirements" and A0.9(b)(ii) "such other Verification Methods as the appropriate authority accepts for determining compliance with the Performance Requirements".
Methods of analysis	Based on a direct assessment against the performance requirements, the methods of analysis to be undertaken will comprise: (i) Calculation of the evacuation time for the occupants of the affected office and mezzanine areas as follows: -detection time – based on either the occurrence of a visual cue upon formation of a layer of smoke across the enclosure that is at least 5 per cent of the height of the enclosure or activation of the sprinkler system. -pre-movement time – based on the recommendations of Frantzich for open plan buildings for open areas or Sime for compartmented areas. -movement time – based on the methodologies and recommendations of Nelson & Mowrer, Pauls and Sime. For a person with an average mobility, an unobstructed evacuation speed of 1.19 m/s has been reported by Nelson & Mowrer[47], whilst for people with disabilities such as a walking frame, an evacuation speed of 0.57 m/s has been reported by Pauls[48]. A maximum specific flow through a door of 1.3 (persons/s.m) and an evacuation speed of 0.5 m/s down a stair are reported by Proulx[46]. These unobstructed speeds and flows are considered to be appropriate, as the occupant densities will be less than 0.54 persons/m^2 [44], however, as the building may contain some occupants with disabilities, an evacuation speed of 0.8 m/s will be used. (ii) Determination of the potential time at which the proposed structural elements could fail in the unlikely event of a fully-developed fire. (iii) Comparison of the potential time of structural failure with the occupant evacuation time. (iv) Consideration of approximation of the likely fire brigade intervention time to application of water.
Acceptance criteria	Absolute acceptance criteria are to be adopted, being that structural failure and the spread of fire to the non-fire-affected sides of the compartment barrier and collapse onto adjacent buildings is mitigated by the performance of the sprinkler system, the fire-resisting wall construction with the fire brigade intervention time and evacuation time occurring prior to possible structural failure time.

Consideration	Criterion
IFEG sub-systems	The relevant sub-system from the International Fire Engineering Guidelines[69] are considered to be: • Sub-system A – Fire Initiation and Development and Control • Sub-system B – Smoke Development and Spread and Control • Sub-system C – Fire Spread and Impact and Control • Sub-system D – Fire Detection, Warning and Suppression • Sub-system E – Occupant Evacuation and Control • Sub-system F – Fire Services Intervention
Relevant performance requirement	CP1 and CP2.

11.2 FIRE ENGINEERING ASSESSMENT

11.2.1 *Intent of the DtS Provisions for Fire Resistance Levels*

In relation to fire resistance levels for various elements of construction, the BCA DtS provisions match specific fire resistance levels with each occupancy class, with those that are considered to feature higher fuel loads, such as retail and industrial use, given higher FRLs (3-4 hours) and those that are considered to feature lower fuel loads, such as residential, health care and office use, given lower FRLs (1-2 hours).

The intent can be seen to allow a building to adequately resist the impact of fire to limit the potential for the spread of fire between fire compartments, buildings and classifications having different FRLs, reflecting the Objective of Section C of the BCA, CO1.

This recognises the need to address life safety, fire brigade intervention and adjacent property, as outlined by objective C01 of the BCA, as follows:

(a) safeguard people from illness or injury due to a fire in a building; and
(b) safeguard occupants from illness or injury while evacuating a building during a fire; and
(c) facilitate the activities of emergency services personnel; and
(d) avoid the spread of fire between buildings; and
(e) protect other property from physical damage caused by structural failure of a building as a result of fire.

The intent of FRLs for Type A construction has been discussed in Fire Code Reform Centre's Project 3 Part 1[70] as enabling the building or compartment of fire origin to "survive burnout and (the) occupants (to) escape to a place of safety". As such, the intent of BCA Specification C1.1 with respect to FRLs and the associated FRLs assigned to elements separating different classifications is considered to be to allow the building to adequately resist the effects of a fire, thereby limiting the potential for extensive fire spread and structural collapse.

11.2.2 *Proposed Alternative Solution*

The proposed alternative solution is based on the provision of 120/120/120 FRL fire walls, floors and columns in lieu of 240/240/240 FRL to the warehouse areas and the presence of an automatic sprinkler system throughout the building.

11.2.3 *Exposure of Structural Elements to Fire*

Generally

A detailed assessment has been made of the potential for the structural elements of the building to be adversely affected in the event of exposure to a fire. The potential for structural failure will largely be based on the severity of the fire, this being a factor of the performance of the automatic sprinkler system and the intensity of an uncontrolled fire.

69 Australian Building Codes Board, ABCB, International Fire Engineering Guidelines Edition 2005, Australian Building Codes Board, Australia, 2005.
70 Fire Code Reform Centre (FCRC), Project 3 Fire Resistance and Non-Combustibility Part 1 Objectives & Performance Levels for Fire Resistance, FCRC, October, 1996.

The assessment relates to the fire walls, floors and columns of the warehouse (Tenancy G3).

Non-flashover fire

An automatic sprinkler system is to be installed in accordance with BCA Specification E1.5 & AS 2118.1–1999, to all parts of the building incorporating the following design:

(i) Fast response sprinklers to the basement carpark.

(ii) Monitoring is to be undertaken by a NSWFB-approved Automatic Fire Alarm Service Provider (AFASP) via automatic signalling Equipment (ASE).

(iii) Procedures are to be in place to deal with planned and unplanned system outages.

Fire severity within the warehouse areas will primarily be influenced by the performance of the proposed automatic fire sprinkler system, which, based on the statistics discussed previously, is expected to control the outbreak and spread of fire for at least 95 per cent of incidents where the fire is of a size that is sufficient to activate the sprinklers.

A non-flashover fire, being one that is either insufficient in severity to operate the sprinkler system or one that is able to be controlled by the sprinkler system, would result in relatively low enclosure temperatures within the building. Research by NIST [71] has demonstrated that temperatures associated with a sprinkler-protected enclosure can be expected to be in the order of 100–200°C. Such conditions are unlikely to cause structural damage to the load-bearing framework, as the minimum fire rating of two hours will have been achieved as a result of exposure to a temperature of 1050°C, as shown below in Figure 11.1.

It is also considered that the likelihood of a fully-developed fire occurring is lower during occupied hours, due to the presence of trained staff members that could undertake either first-aid fire-fighting or raise an alarm during the early stages of a fire.

In the event that the fire is not sprinkler-controlled but was able to be prevented from becoming fully-developed as a result of manual intervention or an insufficient fuel load, such a scenario would result in relatively-low enclosure temperatures within the building, as flashover conditions requiring a temperature of at least 600°C throughout the enclosure would not have been reached.

The likelihood of the subject structural elements being affected structurally by such conditions is remote, based on the ability for an FRL 120/120/120 element to adequately resist the spread of fire and structural collapse during exposure to the heating regime of AS 1530.4 [72] for two hours, respectively – review of the time-temperature curve, shown below in Figure 11.1, for this test indicates that after 60 minutes of exposure, the furnace temperature has reached 950°C, which is reflective of post-flashover conditions that have a severity significantly greater than that of a non-flashover fire.

As such, the proposed, FRL 120/120/120 elements to the warehouse are expected to maintain their structural adequacy and resist the spread of fire, based on the fire-resistance level and the relatively low temperatures associated with this scenario.

71 National Institute of Standards and Technology (NIST), NISTIR 5240 – Measurement of Room Conditions and Response of Sprinklers and Smoke Detectors During a Simulated Two-bed Hospital Patient Room Fire, Gaithersburg, MD, July 1993.

72 Standards Association of Australia (SAA), AS 1530.4-1997 – Methods for fire tests on building materials, components and structures Part 4: Fire-resistance tests of elements of building construction, Homebush, Australia, 1997.

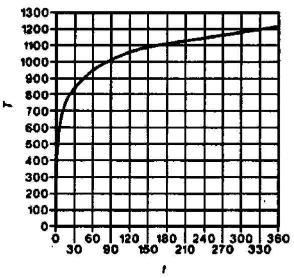


Figure 11.1 – Rise curve showing relationship between furnace temperature (T) and time (t)

Flashover (non-sprinkler-controlled) fire

Consideration has been given below of the impact of an uncontrolled fire on the ability of the occupants to evacuate safely, as a severe fire could result in some damage to the structural framework.

A fully-developed fire is capable of causing rapid damage to the building's structural elements where they are not protected by suitably fire-resistant materials, and damage over an extended period of time to protected elements.

The fire-resisting elements are likely to resist failure for some time, based on the ability for an FRL 120/120/120 element to adequately resist the structural collapse during exposure to the heating regime of AS 1530.4 [73] for two hours.

It is noted that the time-temperature curve for standard fire test features a temperature of at least 1050°C after 120 minutes, which is reflective of post-flashover conditions that have a severity significantly greater than that of a non-flashover fire. The likelihood of flashover occurring is remote, as a temperature of in excess of 600°C would need to be reached consistently across the enclosure [74]. As such, the potential for a lower fire severity within the subject warehouse area over an extended period indicates that the structural elements are likely to be capable of withstanding a real compartment fire for at least the period of time achieved during the AS 1530.4 test.

It is therefore expected that the proposed structural elements to the warehouse would be capable of resisting the effects of a post-flashover for fire a period of approximately two hours. Some variation in performance may occur due to the range of possible fire growth rates and severities associated with a realistic compartment fire arising from the characteristics of the enclosure, including the geometry and available ventilation. This variation cannot accurately be determined quantitatively due to the relatively large volumes of the affected retail and carpark compartments.

11.2.4 *Occupant Evacuation*

The performance of the building's structural elements may affect the safety of the occupants, as appropriate structural stability is required during the evacuation process to enable occupants to reach a place of safety prior to untenable conditions (including structural failure) being achieved.

Occupants within the warehouse would move away from the seat of the fire well prior to conditions being achieved that could result in structural failure. Considering the detection time, pre-movement time and movement time, occupants are capable of evacuating from the warehouse within a time of

73 Standards Association of Australia (SAA), AS 1530.4-1997 – Methods for fire tests on building materials, components and structures Part 4: Fire-resistance tests of elements of building construction, Homebush, Australia, 1997.

74 Babrauskas, V., Temperatures in Flames and Fires, Fire Science and Technology Inc., Issaquah, WA, 1997.

approximately 12 minutes, based on the following three evacuation components outlined within the IFEG (refer to Appendix A for the evacuation calculations): [75]

(i) Detection time – a smoke detector or sprinkler is capable of operating within 5 minutes of a fire growing at either a fast t^2 rate.

(ii) Pre-movement time – it is estimated that occupants would commence movement within approximately 3 minutes of detection cues being received (using the pre-calculated pre-movement time given for warehouse occupancies by Sime [76]).

(iii) Movement time –For a person with an average mobility, such as a staff member or visitor, an unobstructed evacuation speed of 1.19 metres/s has been reported [77] and occupant evacuation can take up to approximately 4 minutes. (a walking speed of 0.54 m/s has been considered for the sensitivity analysis)

Based on the large margin between the evacuation time and the time at which the structural elements could either begin suffering structural damage or be unable to resist the spread of fire during a severe incident, safe occupant evacuation from the warehouse areas is facilitated. It is therefore considered that structural collapse will be restricted to a degree that results in mitigation of the fire hazard posed to the occupants, to the extent necessary for facilitation of evacuation in a timely manner.

As a result, occupant safety and the mitigation of fire hazard during evacuation are considered to be addressed with respect to the structural performance of the subject warehouse areas.

Note that as the building will have a rise in storeys of only three, being well under 25 metres in effective height such that it is not considered to fall within the definition of a high-rise structure, fire safety risks relating to the "height of the building" and the "number of storeys", as referred to in performance requirements CP1 and CP2 (i.e. reduced provision for external access for fire fighters etc), are not present in the design and do not require further consideration.

11.2.5 *Fire Spread between buildings*

Consideration is given to the impact of a "severe", fully-developed fire within the subject building, which could result in enclosure temperatures of up to approximately 830°C. The potential for fire spread to a neighbouring building will be reliant on a number of outcomes, being:

- Failure of the internal structural elements in the subject building;
- Instability and failure of the structural roof elements, leading to displacement of the roof cladding; and
- Exposure of the neighbouring building to the compartment fire of the subject building.

Such a severe fire would involve the generation of a number of cues, such that occupants within the subject and neighbouring buildings could be expected to be aware of the conflagration prior to the point that the roof of the building were to be substantially damaged. Thus, the risk of exposure of occupants to such a fire would be limited by the warning cues available.

Further to this, the southern portion of the building and the closest southern neighbouring building is located at least 10 metres away; the likelihood of fire spread between buildings as a result of uncontrolled conditions that are not attended to by fire fighters is remote.

75 Australian Building Codes Board, ABCB, International Fire Engineering Guidelines Edition 2005, Australian Building Codes Board, Australia, 2005.

76 Sime, J. D., (1996), Assessing Occupant Response Time: A Key Issue for Fire Engineering. In R. Barham (ed) Fire and Emergency Planning: Research and Applications, E & F N Spon, London (48, pp442-449).
Ion Experiments, Conference Proceedings to the 2nd International Symposium on Human Behaviour in Fire. Interscience Communications, 159-165, Boston, MA, 2001.

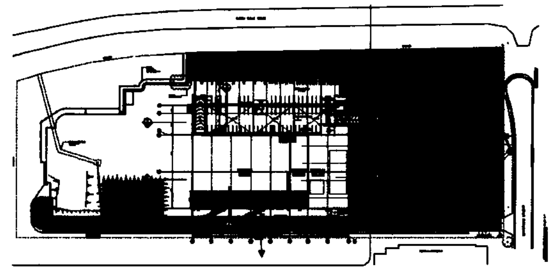


Figure 11.2 – Proximity of Subject Building to Neighbouring Buildings

11.2.6 *Fire Brigade Intervention*

Assessment of the effects on fire brigade intervention of the proposed alternative solution has been made to ascertain that the design does not adversely affect fire-fighting activities.

The assessment undertaken above has determined that the exposure of structural elements to a fire in most cases is mitigated by the proposed fire safety strategy. The reliability of sprinkler systems in Australia results in fire brigade intervention being required in the large majority of incidents to only address occupant evacuation and fire-fighting during occurrence of small, controlled fires.

It is only in the rare case of a severe, uncontrolled fire, where the occupants have not been able to intervene with the available first-aid fire-fighting equipment and sprinklers have not been able to contain the fire that fire fighters will need to attempt to evacuate occupants that may have been exposed to the effects of the fire, however, the reliability of the sprinkler system has been discussed previously as being in excess of 95%.

Due to the mitigation of fire spread, as discussed, fire brigade intervention activities will therefore not be adversely affected by the proposed alternative solution, involving variations in FRLs to the subject warehouse area.

Furthermore, as determined within Appendix C, the total time required for fire-fighters to respond, set-up and carry out the necessary activities to commence fire-fighting (application of water) is 1,376 seconds (23 minutes) for Mona Vale Fire Station and 1,954 seconds (~33 minutes) for Narrabeen Fire Station. Fire brigade notification is able to occur via the sprinkler system, which is connected to FRNSW via a link to an approved monitoring service. Based on the discussions detailed above, there is a sufficient margin of safety associated with the likely performance of the 90-minute structural elements such that they are considered to be adequate to allow for a full evacuation of the building and for FRNSW to undertake the required activities up to the commencement of fire-fighting.

11.3 Summary

The assessment undertaken above demonstrates that the proposed FRLs to the building are adequate to restrict fire spread and structural collapse to allowing occupants to evacuate in the event of an emergency and fire brigade, based on the fire safety strategy that includes the proposed FRLs and sprinkler system.

It is therefore considered that the proposed design will satisfy the acceptance criteria nominated for this assessment in section 9.

12 ALTERNATIVE SOLUTION 2 – DRENCHER-PROTECTED GLAZED WALL ASSEMBLIES AND OPENINGS IN FIRE ISOLATED EXITS

12.1 ASSESSMENT CRITERIA

Table 11.1 provides a summary of the criteria for consideration as the basis of this Alternative Solution.

Table 12.1 – Assessment criteria

Consideration	Criterion
Applicable BCA DtS provisions	Clause C1.1 nominates compliance with Specification C1.1, which, for a Class 7a and 9b occupancy of Type A construction, stipulates an FRL of 120/120/120 FRL fire resisting lift and stair shafts. Clause C2.7(b)(ii) stipulates that any openings in a fire wall must not reduce the FRL required by *Specification C1.1 for the fire wall, except where permitted by* the Deemed-to-Satisfy Provisions of Part C3. Clause C2.8 of the BCA stipulates that if a building has parts of different classifications located alongside one another in the same storey, each building element must have a higher FRL prescribed in spec. C1.1. Clause C3.8 of the BCA stipulates that doorways which open into fire-isolated exits must be protected by -/60/30 fire doors that are self-closing or automatic-closing in accordance with C3.8(a).
Proposed Alternative Solution	The proposed alternative solution is based on: (i) The provision of a drencher-protected glazing in lieu of 120/120/120 FRL to the ground floor entry lobby of the swim school and Stair 2; (ii) The provision of drencher-protected glazed doors to Stair 1 in lieu of fire doors; and (iii) The presence of an automatic sprinkler system within the building, except for the swim school.
BCA assessment method	Qualitative assessment based on BCA A0.5b(i) "formulating an Alternative Solution which complies with the Performance Requirements" and A0.9(b)(ii) "such other Verification Methods as the appropriate authority accepts for determining compliance with the Performance Requirements".
Methods of analysis	Based on a direct assessment against the performance requirements, the methods of analysis to be undertaken will be qualitative and quantitative in nature and will comprise: (i) a determination of the extent of fire spread between areas separated via the drencher protected glazing, based on review of test data for barrier systems in relation to the integrity of glazing systems during exposure to elevated temperatures commensurate with the nominated fire scenarios and calculation of potential radiant heat flux values in relation to radiant heat transmission through glazed barrier systems, considering the protection of the glazing by an automatic drencher system; and (ii) a review of the adequacy of operable elements (i.e. doors) in the glazed installations.
Acceptance criteria	Absolute acceptance criteria are to be adopted, being as follows: (i) for the glazed barrier construction, the radiant heat flux received on the non-fire-affected side of the barrier where combustibles may be located does not exceed 20 kW/m²; (ii) The operable elements (i.e. doors) will not affect the performance of the glazed barrier.

Consideration	Criterion
IFEG sub-systems	The relevant sub-system from the International Fire Engineering Guidelines[78] are considered to be: • Sub-system A – Fire Initiation and Development and Control • Sub-system B – Smoke Development and Spread and Control • Sub-system C – Fire Spread and Impact and Control • Sub-system D – Fire Detection, Warning and Suppression • Sub-system E – Occupant Evacuation and Control • Sub-system F – Fire Services Intervention
Relevant performance requirement	CP2.

12.2 FIRE ENGINEERING ASSESSMENT

12.2.1 *Intent of the DtS Provisions for Fire Resistance Levels*

In relation to fire resistance levels for various elements of construction, the BCA DtS provisions match specific fire resistance levels with each occupancy class, with those that are considered to feature higher fuel loads, such as retail and industrial use, given higher FRLs (2-3 hours) and those that are considered to feature lower fuel loads, such as residential, health care and office use, given lower FRLs (1-2 hours).

This recognises the need to address life safety, fire brigade intervention and adjacent property, as outlined by Objective CO1 of the BCA, as follows:

(a) safeguard people from illness or injury due to a fire in a building; and
(b) safeguard occupants from illness or injury while evacuating a building during a fire; and
(c) facilitate the activities of emergency services personnel; and
(d) avoid the spread of fire between buildings; and
(e) protect other property from physical damage caused by structural failure of a building as a result of fire.

The intent of FRLs for Type A construction has been discussed in Fire Code Reform Centre's Project 3 Part 1[79] as enabling the building or compartment of fire origin to "survive burnout and (the) occupants (to) escape to a place of safety". As such, the intent of BCA Specification C1.1 with respect to FRLs and the associated FRLs assigned to elements separating different classifications is considered to be to allow the building to adequately resist the effects of a fire, thereby limiting the potential for extensive fire spread and structural collapse.

12.2.2 *Intent of the BCA DtS Provisions for Fire-Isolated Exits*

The Guide to the BCA[80], states that the intent of Clause C3.8 is:

To maintain the integrity of a fire-isolated exit and to protect people using fire-isolated exits by provided adequately protected door and window openings.

Therefore, the performance of the design to be assessed hereunder is that relating to the propensity for occupant from exposure to fire and smoke whilst evacuating via the fire-isolated stair.

12.2.3 *Proposed Alternative Solution*

The proposed alternative solution is based on the provision of a drencher-protected glazing in lieu of 120/120/120 FRL to the ground floor entry lobby of the swim school, Stair 1 and Stair 2.

78 Australian Building Codes Board, ABCB, International Fire Engineering Guidelines Edition 2005, Australian Building Codes Board, Australia, 2005.
79 Fire Code Reform Centre (FCRC), Project 3 Fire Resistance and Non-Combustibility Part 1 Objectives & Performance Levels for Fire Resistance, FCRC, October, 1998.
80 Australian Building Codes Board (ABCB), BCA 2014 Class 2 to 9 Buildings, Australian Building Codes Board, Canberra, Australia.

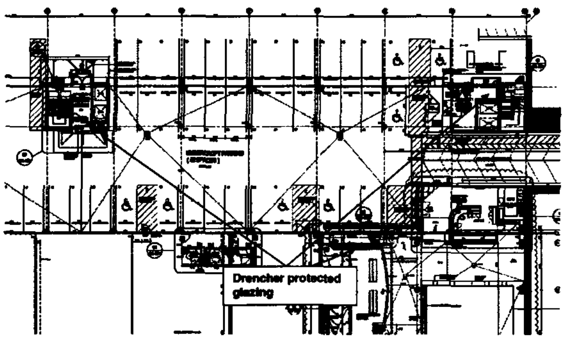


Figure 12.1 – Proposed Drencher-protected glazing on Ground Floor

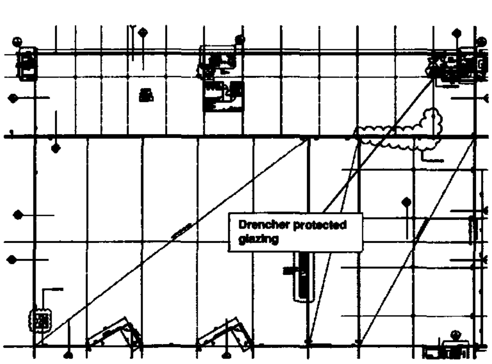


Figure 12.2 – Proposed Drencher-protected glazing on Level 1

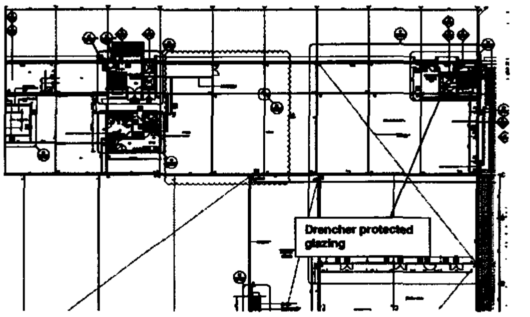


Figure 12.3 – Proposed Drencher-protected glazing on Level 2

12.2.4 *Assessment of Fire Spread via Drencher-Protected Glazed Construction*

The risk of fire spread the ground floor entry lobby of the swim school via the carpark area and to Stair 1 and Stair 2 via the adjacent areas (office area and childcare centre) to is to be assessed for the glazed, drencher-protected portion. The wall separating the ground floor entry lobby of the swim school, Stair 1 and Stair 2 comprises a combination of fire resisting construction and glazed construction components providing a complete physical barrier to the ground floor entry lobby of the swim school, Stair 1 and Stair 2.

The risk of furnishings and other combustibles being situated in proximity to the drencher-protected, glazed bounding construction and compromising the flow of water down the face of the glazing will be mitigated as the adjacent spaces comprise an undercroft carpark and lobby areas where *furnishings would be neither proposed nor suitable for the area.*

The drenchers will be located on the carpark side and lobby side of the glazing, designed to cover the entire glazed areas with water at a design density sufficient to prevent the breakage of the glass and the passage of fire through the barrier.

The effectiveness of the drencher system will be dependent upon the design of the glazing, including the support structure of the walls. Standard float plate glass is prone to failure at temperatures as low as approximately 120°C[81], which will generally be inconsistent with the performance capability of an automatic drencher system with respect to minimum drencher head activation temperatures. As a result, glass that is not susceptible to failure at such low temperatures is to be provided, with toughened glass satisfying this requirement.

The support structure for the glazing is required to be considered for reasons of expansion under elevated temperatures. The elevated temperatures that could be experienced during a fire within the building could result in the heating and expanding of the glazing and its framing system, despite the action of the drenchers in cooling the surface. As the glazing is to be provided with flexible seals between the head/bottom of the glass panels and the frame, adequate levels of expansion are expected to be catered for under the elevated temperatures expected.[81]

Consideration needs to be made in the alternative solution of the potential for the spread of fire from one side of the glass to the other by way of radiation, which is transmitted through the glazing and received at locations on the adjacent area where combustible linings or furnishings may be found. Research has demonstrated a reduction in transmitted radiant heat through non-drencher-protected glazing of 35-45 per cent and a reduction through drencher-protected glazing of at least 90 per

81 England, J.P., Young, S.A., Hui, M.C., Kurban, N., Guide for the Design of Fire Resistant Barriers and Structures, Building Control Commission, Melbourne, 2000.

cent.[82,83] As the levels of incident flux at which timber and cotton fabric will ignite by non-piloted ignition are 28 kW/m²[84] and 25 kW/m²[85] a radiant heat flux of at least 25 kW/m² is considered to be necessary to cause spontaneous ignition of combustible furnishings that may be located within the tenancy.

For the most probable design fire involving a sprinkler-controlled fire from the carpark, the exposure at the glazing will be minimal. Referring to the calculation presented in Figure 12.4 utilising the Radiation sub-routine within FireCalc[86], radiant heat flux will be mitigated as a result of the low temperatures and radiant heat flux commensurate with such conditions. That is, a temperature of up to 200°C would result in a radiant heat flux of less than 3 kW/m² at the source, which does not exceed the ignition criteria of 20 kW/m². This exposure will be further reduced by the operation of the wall-wetting drencher system if sufficient heat were to result in actuation of the drencher heads.

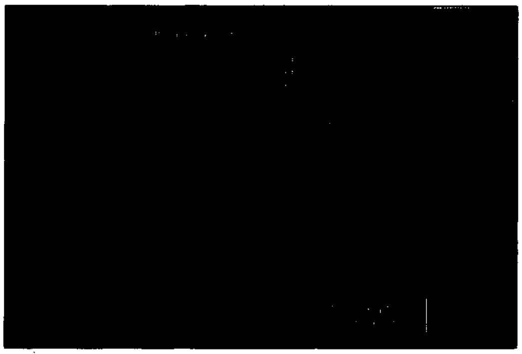


Figure 12.4 – Radiant Heat Flux received at Drencher Protected Glazing

Further consideration is given to severe scenario as part of a sensitivity analysis. A film of water provided to the glazing will enable the glazing to resist breakage and fall out. A temperature correlating with enclosure flashover of 600°C (or ~ 32 kW/m², based on a severe scenario where the radiation source consists of a black body), would result in a transmitted radiant heat flux within the adjoining areas of approximately 3 kW/m², where the glazing acts to reduce transmission through the glass by up to 90 per cent, as discussed above. It is therefore unlikely that the level of transmitted radiant heat flux could result in spontaneous ignition occurring within the adjoining areas noting that there is little in the way of combustibles in this location.

Based on the maximum radiation flow of 2.8 kW/m² (0.28 W/cm²), a tolerance time of at least 5 seconds is provided, based on the data provided by The SFPE Handbook of Fire Protection Engineering[87], as shown in Figure 12.5 below. However, occupants are expected to be exposed to

82 Moulen, A.W. and Grubits, S. J., Water Curtains to Shield Glass from Radiant Heat from Building Fires, Technical Record 422, Experimental Building Station, Department of Housing and Construction, New South Wales, 1975.
83 Richardson, J.K., & Oleszkiewicz, I., Fire Tests on Window Assemblies Protected by automatic Sprinklers, National Research Council Canada, Published in Fire Technology, 1987.
84 Drysdale, D., An Introduction to Fire Dynamics, Second Edition, University of Edinburgh, UK, 1999.
85 Standards Australia, AS 1530.4-1997 Methods for fire tests on building materials, components and structures Part 4: Fire-resistance tests of elements of building construction, Homebush, Australia, 1997.
86 CSIRO, FIRECALC, Version 2.3, CSIRO Division of Building Construction and Engineering, 1993.
87 SFPE Handbook of Fire Protection Engineering, Third Edition, Society of Fire Protection Engineers and National Fire Protection Association, 2002.

the opening for not more than a few seconds as they evacuate past the opening. It is therefore expected that the subject drencher protected openings to Stair 1 would be capable of mitigating the radiant heat to evacuating occupants and allowing sufficient time before occupants are affected by erythema.

Table 3-4.19 *Data on the Effects of Exposure to Radiant Heat*

Reference Source	Heat Flux W/cm²	Time to Effect(s): Erythema (or pain)	Burn	Full Burn	Letter in Figure 3-4.20
[illegible] et al.	15	1	2.5	4	
	10	2	4	6	
	5	4	7	>15	
	4	4.5	9	>15	A
	3.5	5	9.5	>15	A
	3	6	10	>15	A
Buettner	[illegible]	[illegible]			B
	1.65	6			B
	[illegible]	40			B
[illegible]			Blisters		
	[illegible]		30		C
[illegible] and [illegible]		Unbearable pain			
	[illegible]	[illegible]			
	[illegible]	30 to 60			D
[illegible]	[illegible]	Lower limit for pain after a long period			
	[illegible]	5			E
	[illegible]	10			E
[illegible] and [illegible]	[illegible]	Limit for blood to carry away heat			
[illegible]	[illegible]	Tenability limit			

Figure 12.5 – Exposure data from SFPE Handbook of Fire Protection Engineering

The provision of an appropriately-designed glazing system, protected with drenchers as discussed, is therefore expected to be capable of restricting the spread of fire by modes of either conduction / convection (physical failure of the barrier) or radiative heat flux.

In the case of use of the Tyco Model WS drencher system is limited to designs that feature "non-operable" glazing, as noted in the drencher system's installation brochure[88]. However, the design will feature moveable glazing elements (i.e. doors) but is not expected to affect the performance of the drencher system as the doors will be subject to the requirement for automatic closing after initiation of a fire alarm.

In addition, within the exception of the swim school, the building is to be provided with an automatic sprinkler system as discussed above. A high level of performance can be associated with the sprinkler system. Sprinkler activation and control will generally serve to prevent flashover occurring and restrict the potential for the rapid fire spread throughout an enclosed area or to an adjacent area, such as to an open plan space or to adjacent areas.

Note that as the building will have a rise in storeys of only three, being well under 25 metres in effective height such that it is not considered to fall within the definition of a high-rise structure, fire safety risks relating to the "number of storeys", as referred to in performance requirement CP2 (i.e. reduced provision for external access for fire fighters etc), are not present in the design and do not require further consideration.

Note also that the glazed bounding construction is non-load bearing, failure of the construction will not directly affect the performance of any of the buildings structural elements.

88 Tyco Fire Products, Installation brochure TFP620 "Tyco Model WSTM — 5.6 K-factor Specific Application Window Sprinklers, Horizontal and Pendent Vertical Sidewall", Tyco Fire Products, Pennsylvania, 2005.

12.2.5 *Fire Spread between buildings*

Consideration is given to the impact of a "severe", fully-developed fire within the subject building, which could result in enclosure temperatures of up to approximately 830°C. The potential for fire spread to a neighbouring building will be reliant on a number of outcomes, being:

- Failure of the internal structural elements in the subject building;
- Instability and failure of the structural roof elements, leading to displacement of the roof cladding; and
- Exposure of the neighbouring building to the compartment fire of the subject building.

Such a severe fire would involve the generation of a number of cues, such that occupants within the subject and neighbouring buildings could be expected to be aware of the conflagration prior to the point that the roof of the building were to be substantially damaged. Thus, the risk of exposure of occupants to such a fire would be limited by the warning cues available.

Further to this, the southern portion of the building and the closest southern neighbouring building is located at least 10 metres away; the likelihood of fire spread between buildings as a result of uncontrolled conditions that are not attended to by fire fighters is remote.

12.2.6 *Occupant evacuation*

The design of the building with respect to mitigation of fire spread between the swim school and the carpark, Stair 2 and the carpark, Stair 1 and the carpark, Stair 1 and the Level 1 office and Stair 1 and the childcare facility is required to be assessed in terms of its impact on occupant life safety in the event of a fire.

It has been demonstrated above that the provision of the drencher glazing system, will enable the spread of fire between the subject areas to be mitigated. As such, the period of time available for evacuation and, therefore, the fire hazard imposed on the occupants, will not be affected by the proposed alternative solution.

12.2.7 *Fire Brigade Intervention*

Assessment of the effects on fire brigade intervention of the proposed alternative solution has been made to ascertain that the design does not adversely affect fire-fighting activities.

The assessment undertaken above has determined that the uncontrolled spread of fire in most cases is mitigated by the proposed fire safety strategy, as a result of the drencher-protected glazing and automatic sprinkler system provided throughout the building. The reliability of sprinkler systems in Australia results in fire brigade intervention being required in the large majority of incidents to only address occupant evacuation and fire-fighting during occurrence of small, controlled fires.

It is only in the rare case of a severe, uncontrolled fire, where the occupants have not been able to intervene with the available first-aid fire-fighting equipment and sprinklers have not been able to contain the fire that fire fighters will need to attempt to evacuate occupants that may have been exposed to the effects of the fire, however, the reliability of the sprinkler system has been discussed previously as being in excess of 95%.

Due to the mitigation of fire spread, as discussed, fire brigade intervention activities will therefore not be adversely affected by the proposed alternative solution, involving the subject variations in FRLs to the stair and lobby fire compartmentation.

12.3 Summary

The assessment undertaken above demonstrates that the proposed glazed barrier construction to the ground floor entry lobby of the swim school and Stair 2 and the provision of an automatic sprinkler system to the building is considered to facilitate an acceptable level of fire and life safety in minimising the risk of fire spread between the ground floor entry lobby of the swim school and Stair 2 resulting from the proposed construction comprising drencher protected glazing.

It is therefore considered that the proposed design will satisfy the acceptance criteria nominated for this assessment in section 9.

13 ALTERNATIVE SOLUTION 3 – EXTERNAL WALL LINING

13.1 Assessment Criteria

Table 13.1 provides a summary of the criteria for consideration as the basis of this Alternative Solution.

Table 13.1 – Assessment criteria

Consideration	Criterion
Applicable BCA DtS Provisions	Clause C1.1 of the BCA refers to Clause 3.1(b) of Spec. C1.1 which stipulates that external walls must be non-combustible. Clause 2.4(a)(i) of BCA Spec. C1.1 & Clause C1.10 stipulates that linings / attachments to external walls are required to comply with the fire hazard properties provisions of Specification C1.10.
Proposed Alternative Solution	The proposed alternative solution is based on: (i) The provision of Danpalon, and Alucobond Plus as cladding to various parts of the external walls, which have not been tested as "non-combustible" in accordance with AS 1530.1; and (ii) The presence of an automatic sprinkler system within the building, except for the swim school.
BCA assessment method	Qualitative and quantitative assessment, based on BCA A0.5(b)(i) "formulating an Alternative Solution which complies with the Performance Requirements" and A0.9(b)(ii) "other Verification Methods".
Methods of analysis	Based on an absolute assessment, the method of analysis to be undertaken will comprise a qualitative review and determination of the extent of fire spread between buildings and vertical fire spread between storeys via the facade, based on the presence of a sprinkler system throughout the building (except for the swim school), the location of the wall linings and the proximity of the wall linings to other combustibles and occupants.
Acceptance criteria	Absolute acceptance criteria are to be utilised, whereby: (i) The potential for fire spread to and from neighbouring buildings via the external walls will be mitigated by way of the design and location of the proposed linings. (ii) The potential for fire spread between storeys will be mitigated by way of the design and location of the proposed linings.
IFEG sub-systems	The relevant sub-system from the International Fire Engineering Guidelines[89] are considered to be: • Sub-system A – Fire Initiation and Development and Control • Sub-system B – Smoke Development and Spread and Control • Sub-system C – Fire Spread and Impact and Control • Sub-system D – Fire Detection, Warning and Suppression
Relevant Performance Requirement	CP2.

89 Australian Building Codes Board, ABCB, International Fire Engineering Guidelines Edition 2005, Australian Building Codes Board, Australia, 2005.

13.2 Fire Engineering Assessment

13.2.1 *Intent of the BCA DtS Provisions for Fire Hazard Properties*

Specification C1.1 of the BCA includes provisions to limit the combustibility of a number of elements of construction for buildings of Type A construction.

The requirement relating to the non-combustibility of external walls can be linked to the potential for vertical fire spread between storeys in the same building and the potential for fire spread between buildings.

As such, the performance of the design to be assessed hereunder is that relating to the ability of the combustible external walls to avoid the spread of fire between storeys and from the neighbouring allotments.

13.2.2 *Proposed Alternative Solution*

The proposed alternative solution is based on the provision of Danpalon and Alucobond Plus to form part of the external wall, which have not been tested as "non-combustible" in accordance with AS 1530.1.

It is noted that the Codemark certification for this product states that when used in buildings of Type A Construction, the building must be sprinkler protected throughout, as shown in Appendix G. The subject development is sprinkler protected throughout with the exception of the swim school tenancy.

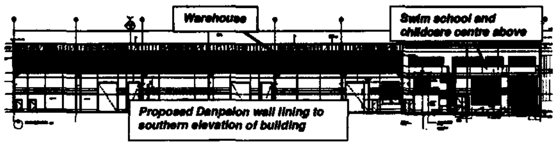


Figure 13.1 – Location of proposed Danpalon wall lining

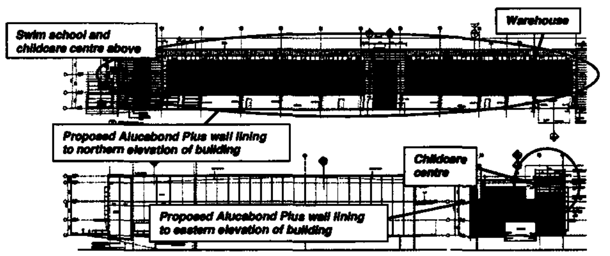


Figure 13.2 – Location of proposed Alucobond Plus wall lining

13.2.3 *Vertical Fire Spread*

__*Fire in Subject Development Initiating Internally*__

Fire severity within the building will primarily be influenced by the performance of the proposed automatic fire sprinkler system, which, based on the statistics discussed previously, is expected to

control the outbreak and spread of fire for at least 95 per cent of incidents where the fire is of a size that is sufficient to activate the sprinklers.

A non-flashover fire, being one that is either insufficient in severity to operate the sprinkler system or one that is able to be controlled by the sprinkler system, would result in relatively low enclosure temperatures within the building.

For the Alucobond plus composite sandwich panel lining, the non-combustible (aluminium) cladding *will protect the combustible core from direct exposure, further limiting the possibility of ignition. The* Alucobond Plus is also cladded onto concrete, mitigating the risk of fire spread into the building.

It is also considered that the likelihood of a fully-developed fire occurring is lower during occupied hours, due to the presence of trained staff members that could undertake either first-aid fire-fighting or raise an alarm during the early stages of a fire.

Fire severity within the swim school will primarily be influenced by the expected low fuel loads. The classification of the building is assembly related (i.e. typically dining, social activities and educational training), which results in a relatively low fuel load. However, the use of the subject building primarily relates to a swim school, with lobby areas and change rooms having minimal combustibles and fuel load. Fuel loads within the swim school may comprise fixed furniture being the reception desk, chairs and benches. Furnishings typically associated with the majority of class 9b assembly buildings, comprising items such as tables, chairs and kitchen equipment will therefore be limited.

__*Fire in Subject Development Initiating Externally*__

The likelihood and potential development of an external fire that involves the wall linings of the subject building will be minimised by the following features:

- The area immediately around the building to the southern facade is dedicated to circulation and access space, restricting the ability for storage or accumulation of rubbish within immediate proximity of the façade.
- The area immediately around the building to the northern facade comprises landscaping and is generally non-accessible to occupants.
- The eastern façade where the Alucobond Plus is proposed is only over a single level on the topmost storey. *Fire spread between levels is therefore mitigated based on the fire dissipating* above the roof.

It should also be noted that the risk of a fire originating on an external wall of the building is statistically very low. Data from NSW Fire Brigades for fires over the period 2005/2006 indicates that of the 458 fires initiating in shop/store/office buildings, just 3 per cent (13 fires) featured as the "area of origin" the exterior wall surface (for the period 2006/2007, this fell to 2 per cent, or 11 of 466 fires).

13.2.4 *Fire Spread Between Buildings*

The risk of fire spread occurring between properties is largely dependent upon the following factors:

(i) the likely size and severity of a fire, which, in turn, is influenced by fire compartment size, fuel load and fire suppression systems

(ii) proximity to neighbouring properties

(iii) the extent of openings in the external envelope of the building

These factors are reviewed hereunder.

__*Fire Spread from Neighbouring Buildings*__

As discussed within Fire Code Reform Centre Project 3[1], the original intent of control of external wall combustibility was not intended to address direct flame impingement from adjoining buildings but to address radiant heat exposure only.

There is minimal exposure to adjoining properties for facilitation of fire spread, as the proposed development adjoins:

- a public roadway to the north
- the Stage 1 development to the east

[1] Fire Code Reform Centre (FCRC), Fire Resistant and Non-Combustibility, Evaluation of Non Combustibility Requirements, FCRC Project 3 Part 4, Fire Code Research Reform Program, February 2000.

- the southern neighbouring building located 10 metres away from the subject building

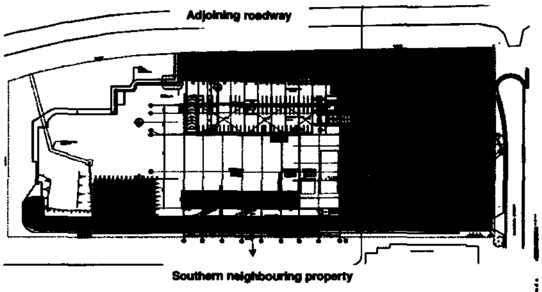


Figure 13.3 – Proximity of Subject Building to Neighbouring Buildings

Direct flame impingement is therefore extremely unlikely to occur, based on the closest buildings being more than 10 metres away and the Alucobond comprising a non-combustible facing protecting the combustible core, which further reduces the potential for ignition of the cladding when exposed to a fire in another building.

The potential for the spread of fire by way of radiation is dependent upon the locations where combustible linings or furnishings may be found. The propensity for fire spread from a neighbouring building via radiant heat is therefore unaffected by the inclusion of the proposed, Alucobond and Danpalon wall lining, based on the potential for exposure of combustibles at the façade locations being mitigated via setbacks of the neighbouring property and the wall linings being clad onto concrete construction. Further to this, the lack of any limitation on size of external openings in the subject external walls is expected to be the governing factor in relation to the potential for fire spread from a neighbouring building and the ensuing propagation of fire vertically along the external cladding. This is supported by the following research findings of Fire Code Research Centre's Project 2 B-2[6], which indicate that a fire in the subject building is likely to result in a greater exposure severity than a fire in another building:

> *"Exposure of combustible cladding to a fire source feature (e.g. exposure due to fire in an adjacent building) is also unlikely to be a governing consideration for vertical fire spread as the expected received heat fluxes on the cladding due to a fire source feature are likely to be less than that produced by a external window fire plume in the region of the lintel. Thus addressing the vertical fire spread problem due to a window plume is likely to also deal with vertical fire spread resulting from an ignition due to an adjacent fire source feature."*

As a result, the combustibility of the proposed wall linings is not considered to have an impact on the propensity for fire to spread from neighbouring buildings to the subject development to facilitate vertical fire spread.

Note that in relation to the impact of fire suppression systems, the building's fuel load and the fire compartment size, these factors do not affect the propensity for fire spread from the neighbouring buildings, only to the neighbouring buildings, which is to be considered below.

__*Fire Spread to Neighbouring Buildings*__

For the unlikely case involving a fully-developed fire, the contribution of the combustible external cladding to fire spread to a neighbouring building will be mitigated based on the wall lining being clad to concrete construction.

[6] Fire Code Reform Centre (FCRC), Project Report FCRC PR 00-03 "Fire Performance of Exterior Claddings, FCRC Project 2 B-2, Fire Performance of Materials, Fire Code Research Reform Program, FCRC, April, 2000.

As discussed above, the extent of exposure of neighbouring buildings to a fire in the subject building will be largely dependent upon the severity of conditions possible within the building envelope and the ensuing compartment temperatures and external flaming possible through the external openings, these being influenced by the presence of an automatic sprinkler throughout the building with the exception of the swim school. As the building is to be sited approximately 10 metres from the neighbouring buildings, the risk of fire spread between properties is mitigated.

13.2.5 *Fire Hazard Properties of the Proposed Alucobond Plus*

It is noted that the Alucobond complies as a group 1 material, as defined in Specification C1.10 of the BCA, based on the results of the attached test report in Appendix H. The test report describes the test method as being conducted in accordance with ISO 9705-1993 with the heat output level of the burner being at 100 kW from 1-10 minutes and 300 kW at 10-20 minutes, with the result being that flashover did not occur. The proposed lining is therefore considered to comply with Clause 2.4(a)(i) of Specification C1.1 in relation to the fire hazard properties nominated in Specification C1.10.

13.2.6 *Impact of Proposed Danpalon and Alucobond Location on the Risk of Occupant Evacuation*

Other mitigating factors include the presence of an automatic sprinkler system throughout the building except for the swim school, the low fuel loads expected within the swim school and the concrete walls behind the proposed wall linings which contribute to the unlikelihood of impact to occupant evacuation.

Furthermore, in the unlikely event where either the Danpalon or Alucobond Plus claddings are exposed to a fire which results in smoke development and spread from the subject wall linings, smoke is expected to be dissipated externally without building up within the building enclosure.

13.2.7 *Fire Brigade Intervention*

The assessment undertaken above has determined that the spread of smoke of the wall lining is mitigated by the proposed fire safety strategy, as a result of the presence of an automatic sprinkler system throughout the building, with the exception of the swim school, the low fuel loads to the swim school and the location of the proposed wall linings which do not result in the spread of smoke between levels as part of the proposed alternative solution.

It is only in the rare case of a severe, uncontrolled fire, where the Danpalon and Alucobond is exposed to a fire which results in smoke development and spread from the subject wall lining. However, as discussed above, smoke is expected to be dissipated if the material fails during a fire and results in an opening forming in the external wall where it is located, to avoid it building up within the enclosure as it would in an normally unventilated part of the building and is not likely to impact fire brigade intervention.

13.3 Summary

The assessment undertaken above demonstrates that for the proposed Danpalon and Alucobond Plus wall lining within the building, the potential for vertical fire spread and the potential for fire spread between buildings will be mitigated, based on the presence of an automatic sprinkler system to throughout the building (except the swim school), the location of the wall lining and the proximity of the wall lining to other combustibles and occupants.

It is therefore considered that the proposed design will satisfy the acceptance criteria nominated for this assessment in Section 9.

14 ALTERNATIVE SOLUTION 4 – NON-PROVISION OF FIRE-ISOLATED STAIRWAYS AND SEPARATE RISING AND DESCENDING STAIR FLIGHTS

14.1 Assessment Criteria

Table 11.1 provides a summary of the criteria for consideration as the basis of this Alternative Solution.

Table 14.1 – Assessment criteria

Consideration	Criterion
Applicable BCA DtS provisions	Clause D1.3 of the BCA stipulates that for Class 5 to 9 buildings, every stairway serving as a required exit must be fire-isolated unless it connects, passes through or passes by not more than three consecutive storeys if the building has a sprinkler system. Clause D2.4 of the BCA stipulates that if a stairway serving as an exit is required to be fire-isolated, there must be no direct connection between a flight rising from the storey below the lowest level of access to a road or open space and a flight descending from a storey below that level.
Proposed Alternative Solution	The proposed alternative solution is based on: (i) Stair 1 which is not fire-isolated and does not feature separation via rising and descending stair flights (ii) Stair 2 which is not fire-isolated and does not feature separation via rising and descending stair flights; (iii) The presence of an automatic sprinkler system within the building, except for the swimschool; (iv) The 2 hour fire separation provide between the stairways and basement carpark level; and (v) Occupants travelling a maximum of two levels to evacuate.
BCA assessment method	Qualitative and quantitative analysis, based on BCA A0.5(b)(ii) "is shown to be at least equivalent to the Deemed-to-Satisfy Provisions" and A0.9(c) "Comparison with the Deemed-to-Satisfy Provisions".
Methods of analysis	Based on a comparative assessment, the methods of analysis to be undertaken will comprise: (i) Determination for the potential for fire and smoke spread via the stairway between storeys and between rising and descending stair flights, based on the fire compartmentation provided from the basement carpark level. (ii) Determination of the potential exposure of occupants to fire during evacuation via the stairway, based occupants travelling a maximum of two storeys to evacuate. (iii) Comparison with a BCA DtS design comprising a three-storey, sprinklered building complying with D1.3(b)(iii)(A) and inter-connection of three storeys by internal non-fire-isolated stairways. (iv) Review of the ability for occupants to navigate out of the stairway during a fire in proximity to the stairway, based on visual wayfinding associated with the transparent (glazed) stairway construction.
Acceptance criteria	A comparative acceptance criterion is to be adopted, whereby the proposed alternative solution is at least equivalent to (i.e. not greater than) that of the benchmark, BCA DtS-compliant design, based on: (i) the potential for fire and smoke spread via the stairway between storeys and between rising and descending flights will be mitigated, based on the fire separation provided at the basement level; and (ii) the potential exposure of occupants to fire as they evacuate via the stairway will be mitigated, based on the need to travel only two levels to evacuate.

Consideration	Criterion
IFEG sub-systems	The relevant sub-system from the International Fire Engineering Guidelines[90] are considered to be: • Sub-system A – Fire Initiation and Development and Control • Sub-system B – Smoke Development and Spread and Control • Sub-system C – Fire Spread and Impact and Control • Sub-system D – Fire Detection, Warning and Suppression • Sub-system E – Occupant Evacuation and Control • Sub-system F – Fire Services Intervention
Relevant performance requirement	DP5 and EP2.2.

14.2 Fire Engineering Assessment

14.2.1 *Intent of the DtS Provisions for Fire Isolated Stairways*

The BCA DtS provision for the protection of stairways relates to both the nature of the occupancy and the number of storeys that occupants must pass to reach a final exit from the building.

The Guide to the BCA[91] states that the intent of clause D1.3 is:

> *To indicate when fire-isolated stairways and ramps are required to enable safe egress in case of a fire.*

The BCA generally permits two storeys to be connected via non-fire-isolated stairways and three storeys in the case that the building is sprinkler-protected throughout or fire separation of the stairway. Where an additional storey is served by a stairway, the BCA addresses the additional time required for occupants to evacuate by the effectiveness of the sprinkler system in controlling the fire or minimise the potential for occupants to be exposed to fire and smoke during evacuation.

The Guide to the BCA[92] states that for a Class 5-9 building, other than Class 9a:

> *An extra storey of any classification may be included under certain circumstances where the fire risk associated with the extra storey is low. The circumstances are:*
>
> - *where the extra storey is used for a carpark or other ancillary purposes. In Class 2 buildings a carpark usually represents a low fire risk, and is unlikely to have many occupants for any length of time. The inclusion of the extra storey applies when the building only consists of a Class 2 building and a carpark. The building may also include a Class 3 part, however in such a case, the Class 3 portion of the building would control the number of storeys connected by a non-fire-isolated exit (see comments on D1.3(a)(ii)); and*
> - *where the building contains a sprinkler system. This concession recognises the ability of sprinkler systems to extinguish or contain a fire thereby allowing additional time for occupants to escape; and*
>
> *where the exit is separated from the extra storey by walls having an FRL consistent with those required for a public corridor in a Class 2 or 3 building. By having separating walls with an FRL and by preventing any connection to the extra storey for the purpose of providing access to or egress for that storey, the non-fire-isolated exit is protected from the fire risk associated with the extra storey.*

The Guide to the BCA[93] states that the intent of clause D2.4 is:

> *To minimise the risk that an occupant mistakenly passes the lowest storey providing escape when evacuating.*

90 Australian Building Codes Board, ABCB, International Fire Engineering Guidelines Edition 2005, Australian Building Codes Board, Australia, 2005.
91 Australian Building Codes Board (ABCB), Guide to the BCA 2014, Australia, 2014.
92 Australian Building Codes Board (ABCB), Guide to the BCA 2014, Australia, 2014.
93 Australian Building Codes Board (ABCB), Guide to the BCA 2014, Australia, 2014.

14.2.2 *Details of the DtS-Compliant Design Benchmark*

The hypothetical, DtS-compliant benchmark design is based on the following provisions:

(i) a three-storey, sprinklered building complying with D1.3(b)(iii)(A);

(ii) the inter-connection of three storeys by internal non-fire-isolated stairways; and

(iii) an automatic fire sprinkler system being provided throughout the building, as described above.

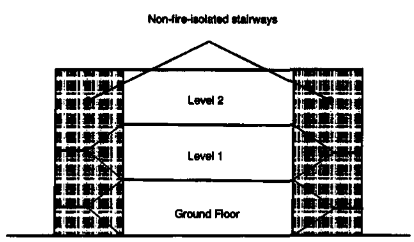


Figure 14.1 – BCA DtS-compliant benchmark design

14.2.3 *Details of the Proposed Alternative Solution*

The proposed alternative solution is based on the following provisions:

(i) Two stairs (Stair 1 and Stair 2) which does not feature separate rising and descending stair flights;

(ii) The presence of an automatic sprinkler system within the building;

(iii) The 2 hour fire separation provide between the stairways and basement carpark level, as shown in Figure 14.3; and

(iv) Occupants travelling a maximum of two levels to evacuate, as shown in Figure 11.2.

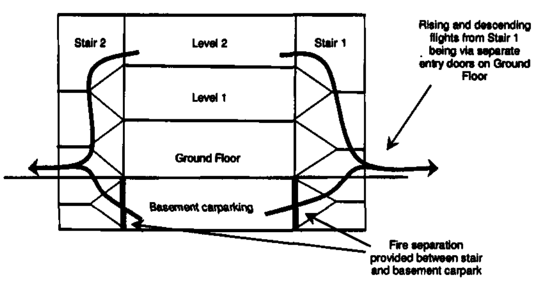


Figure 14.2 – Proposed alternative solution

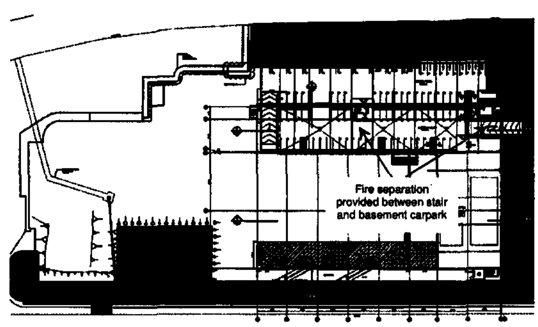


Figure 14.3 – Proposed alternative solution

14.2.4 *Fire and Smoke Spread*

BCA-DtS compliant design

A hypothetical design that complies with the BCA DtS provisions will be used as the "benchmark" scenario for assessment of the proposed design. This BCA DtS compliant design would comprise non-fire isolated stairs connecting three storeys.

An automatic sprinkler system would be installed throughout the building, mitigating the risk of significant fire development and spread in the event that control is unable to be facilitated by the occupants prior to arrival at the scene by fire-fighting crews.

Fire severity within the building would primarily be influenced by the performance of the sprinkler system, which, based on the statistics discussed previously, is expected to control the outbreak and spread of fire for at least 95 per cent of incidents where the fire is of a size that is sufficient to activate the sprinklers.

Alternative solution

Referring to Figure 14.3 the fire-isolated Stair 1 and the non fire-isolated Stair 2 extends from the basement carpark level to the highest level of the building. However, the stairs are provided with 2 hour fire separation from the basement carpark, such that the stairs do not directly connect more than three storeys.

Similarly to the BCA DtS-compliant design, an automatic sprinkler system forms part of the alternative solution. A high level of performance can be associated with the sprinkler system, as previously discussed.

The risk of fire and smoke spread via the subject stairways is therefore limited to three storeys for both the DtS-compliant design and the proposed alternative solution. Smoke leakage from basement carpark doorways are considered to be minor and can vent directly to open space at Ground Floor. Rising and descending stair flights are not considered to be required in this instance based on the similar level of fire separation provided for the BCA DtS design and alternative solution.

14.2.5 *Occupant Evacuation*

The assessment above demonstrates that the risk of the spread of fire and smoke to the subject fire-isolated exit stair is limited to three storeys only, as the basement carpark is separate – this is similar to the benchmark, DtS-compliant design, whereby a non-fire isolated stairway can serve two storeys and an extra storey of any classification given that the building is sprinkler protected.

In both the BCA DtS compliant benchmark case and the alternative solution, occupants will be required to travel a maximum of two levels beyond the floor of fire origin to evacuate.

The potential exposure of occupants located on a non-fire-affected floor to the effects of fire will therefore also be mitigated to an extent equivalent to the DtS-compliant design.

The exposure of occupants to fire and smoke is considered to be equivalent for both designs based on the alternative solution comprising fire separation at the stair on basement level.

Due to the glazing construction, occupants will be able to see the lobby outside the stair and identify the level of discharge. Similar to normal wayfinding, occupants will be able to follow the exit signage within the stair.

Thus, the proposed design is considered to result in an evacuation time and fire hazard to the occupants that is at least equivalent to that of the DtS-compliant design.

14.2.6 *Fire Brigade Intervention*

The use of the subject fire-isolated stairway for the proposed building does not increase the risk of smoke spread into the stair compared to the existing, DtS-compliant situation where non-fire-isolated stairways serve three storeys.

As such, the risk of exposure of fire-fighters to untenable conditions within the stairways is considered to be equivalent to a DtS-compliant design.

14.3 SUMMARY

The assessment undertaken above demonstrates that the alternative solution, which comprise non-fire-isolated Stair 2, does not feature separation of rising and descending flights is capable of facilitating occupant evacuation and fire-brigade intervention as a result of fire and smoke spread mitigation to an extent that is at least equivalent to that of the benchmark, DtS-compliant design.

It is therefore considered that the proposed design will satisfy the acceptance criteria nominated for this assessment in section 9.

15 ALTERNATIVE SOLUTION 5 – EXIT TRAVEL DISTANCES AND DISTANCE BETWEEN ALTERNATIVE EXITS (CARPARK)

15.1 ASSESSMENT CRITERIA

Table 11.1 provides a summary of the criteria for consideration as the basis of this Alternative Solution.

Table 15.1 – Assessment criteria

Consideration	Criterion
Applicable BCA DtS provisions	Clause D1.4 of the BCA stipulates that no point on a floor must be more than 20 m to a point from which travel in different directions to two exits is available, in which case the maximum travel distance to one of those exits must not exceed 40 m. Clause D1.5 of the BCA stipulates that exits that are required as alternative means of egress must be not more than 60 m apart in Class 7a.
Proposed Alternative Solution	The proposed alternative solution is based on: (i) travel distance of up to 65 metres to an exit to the basement carpark, in lieu of 40 metres; (ii) travel distance of up to 120 metres between alternative exits within the carparking basement levels, in lieu of 60 metres; (iii) A sprinkler system with listed fast-response heads (activation temperature of 68°C and RTI 50 $m^{1/2}s^{1/2}$) and maximum coverage of 12 m^2 per sprinkler for ordinary hazard throughout the basement car park level, in accordance with BCA Specification E1.5, which includes compliance with the relevant parts of AS2118–1999; and (iv) A building occupant warning system featuring an automatic voice messaging function.
BCA assessment method	Qualitative and quantitative analysis, based on BCA A0.5(b)(ii) "is shown to be at least equivalent to the Deemed-to-Satisfy Provisions" and A0.9(c) "Comparison with the Deemed-to-Satisfy Provisions".
Methods of analysis	Based on a comparative assessment, the method of analysis will comprise a quantitative review of the evacuation time of occupants from SOUs between the proposed Alternative Solution and a similar BCA DtS compliant design, consisting of: (i) Detection time (i.e. based on activation of automatic fire suppression system). (ii) Pre-movement time (i.e. based on pre-movement time from PD 7974-6:2004[94]). (iii) Movement time (i.e. based on methodologies and recommendations of Gwynne and Rosenbaum[95]). (iv) Comparison of the evacuation time for the proposed design with that of the DtS-compliant design which do not comprise fast response sprinkler heads.
Acceptance criteria	A comparative acceptance criterion is to be adopted, being that the occupant evacuation time for the proposed Alternative Solution from the subject car parking areas is at least equivalent to (i.e. not greater than) that of the benchmark, BCA DtS-compliant design.

94 British Standards, PD 7974-6:2004, The application of fire safety engineering principles to fire safety design of building – Part 6: Human factors: Life safety strategies – occupant evacuation, behaviour and condition (sub-system 6), British Standards Institution, 2004, p 1-50.

95 Gwynne, S. M. V. and Rosenbaum, E. R., Employing the Hydraulic Model in Assessing Emergency Movement, Section 3-Chapter 14, The SFPE Handbook of Fire Protection Engineering, 4th edition, National Fire Protection Association, Quincy, Massachusetts, 2008, pp. 3-373–3-396.

Consideration	Criterion
IFEG sub-systems	The relevant sub-system from the International Fire Engineering Guidelines[96] are considered to be: • Sub-system A – Fire Initiation and Development and Control • Sub-system B – Smoke Development and Spread and Control • Sub-system C – Fire Spread and Impact and Control • Sub-system D – Fire Detection, Warning and Suppression • Sub-system E – Occupant Evacuation and Control • Sub-system F – Fire Services Intervention
Relevant performance requirement	DP4 and EP2.2.

15.2 FIRE ENGINEERING ASSESSMENT

15.2.1 *Intent of the BCA DtS Provisions for Exit Travel Distances and Distances between Alternative Exits*

The Guide to the BCA[97] states the intent behind the distance between alternative exits is specified for the following reason:

> *To require that if an exit is inaccessible, access to any required alternative exit must be available within a reasonable distance*

And:

> *Where a building requires multiple exits, the exits maximise the choices of a person evacuating, in case one exit becomes blocked.*

Furthermore, the provision of multiple exits is considered:

> *To maximise the choices of a person evacuating, in case one exit becomes blocked.*

The Guide to the BCA[97] states that distances to exits "are based on an assumption of what is considered 'reasonable' distances to be travelled by occupants in reaching an exit".

15.2.2 *Details of the BCA DtS Compliant Design*

A BCA DtS compliant design will be used as the "base case" scenario for comparative assessment of the proposed design. The level of fire safety performance measured for the BCA DtS compliant design will be determined and measured against the performance measured for the Alternative Solution.

The BCA DtS compliant design for the building would comprise the following:

(i) Travel distance to the nearest exit of up to 40 metres within the basement car park.

(ii) Travel distances between alternative exits of up to 60 metres within the basement car park.

(iii) An automatic sprinkler system with standard response heads throughout the basement car park.

15.2.3 *Details of the Proposed Alternative Solution*

The proposed Alternative Solution will comprise the following features:

(i) travel distance of up to 65 metres to an exit to the basement carpark, in lieu of 40 metres.

(ii) travel distance of up to 120 metres between alternative exits within the carparking basement levels, in lieu of 60 metres

(iii) a sprinkler system with listed fast-response heads (activation temperature of 68°C and RTI 50 $m^{1/2}s^{1/2}$) and maximum coverage of 12 m^2 per sprinkler for ordinary hazard is to be provided

96 Australian Building Codes Board, ABCB, International Fire Engineering Guidelines Edition 2005, Australian Building Codes Board, Australia, 2005.

97 Australian Building Codes Board (ABCB), Guide to the BCA 2014, Australia, 2014.

throughout the basement car park level, in accordance with BCA Specification E1.5, which includes compliance with the relevant parts of AS2118–1999.

(iv) a building occupant warning system featuring an automatic voice messaging function.

15.2.4 *Occupant Evacuation*

A comparative assessment between a BCA DtS compliant design and the proposed Alternative Solution is undertaken to investigate the difference in evacuation time associated with travel distance between alternative exits. It is considered that in both cases, the basement car park features an equivalent floor area, fuel loads, occupant characteristics and fire scenarios.

The travel distances specified under BCA clause D1.4 are based on the characteristics of the occupants. The BCA nominates different travel distance provisions for Class 2 & 3 buildings and Class 5 to 9 buildings, based on the alertness of occupants (asleep or awake) and the potential confusion and delays arising from being awoken during a fire alarm. This also applies to the travel distance between alternative exits in the event that the nearest exit is inaccessible and alternative exit needs to be sought for evacuation. For Class 7a car parks, the BCA DtS provisions stipulate a travel distance to the nearest exit of up to 40 metres and 60 metres between alternative exits.

The concept of travel distance between alternative exits is illustrated in Figure 15.1[98]. Occupants from point C will initially move towards Exit A as the nearest exit. As the occupants reach closer to this exit, they will realise that the exit is blocked by a fire resulting in the occupants to egress via Route 2 to reach an alternative exit (i.e. Exit B). Pursuant to the BCA, the traditional method of measurement to determine the distance between alternative exits based on the total travel distance travelled via both Route 1 to the nearest exit (Exit A) and route 2 to alternative exit (Exit B) by via Route 2 to reach the second exit (Exit B).

In the event of a fire within the subject car parking areas, transient occupants are expected to evacuate using the multiple alternative exits provided throughout the space. Since the occupants can easily identify that Exit A is blocked from the clear visibility associated with open plan layout of the car park (such as the subject carpark shown in Figure 15.2) and without having to travel the whole distance to the exit, they are likely to seek the shortest route to Exit B (i.e. Route 3). Notwithstanding the above, the following evacuation calculations will be based on the traditional BCA method of measurement through the point of choice, resulting in a BCA DtS compliant design for Class 7a (car park) areas featuring up to 100 metres (i.e. 40 m to the nearest exit and 60 m to reach the second exit) and the Alternative Solution featuring up to 185 metres (i.e. 65 m to the nearest exit and 120 m to reach the second exit).

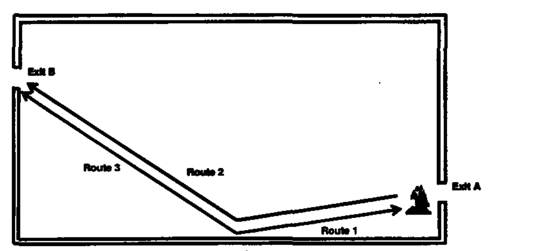


Figure 15.1 – Measurement of distance between alternative exits

98 CIBSE Guide E, Fire Engineering, 3rd ed., CIBSE, 2003, p 7-12.

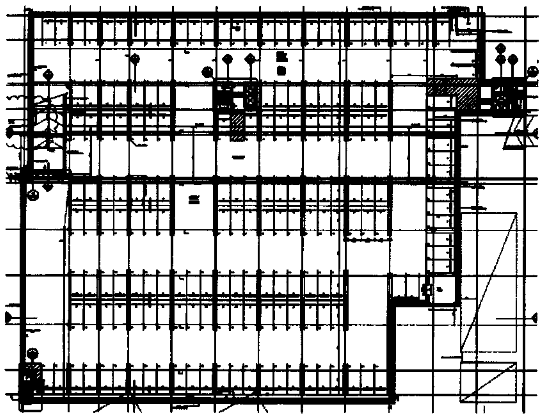


Figure 15.2 – Open layout of basement carpark

The total evacuation time is determined to be the summation of detection time, pre-movement time and movement time. In this case, the only variable is the detection and movement times (i.e. pre-movement time is considered to be equivalent in both scenarios).

Detection Time

For the occupants located within close proximity of a fire, fire detection is expected to initially occur as a result of receipt of a clear visual cue and occupants are prompted to evacuate prior to the activation of the fire detection system. Conversely, for a fire occurring at a more remote point, fire detection is expected to initially occur as a result of receipt of an automatic cue from occupant warning system, initiated by the fire detection system.

As the automatic detection time received by the remote occupants will be longer than the detection time of occupants within proximity to a fire, the automatic detection time will be used as the basis of the assessment.

For Class 7a areas, the BCA DtS compliant design consists of an automatic sprinkler system with standard response sprinkler heads throughout the car park levels. To provide quicker detection time and control of fire, the alternative solution is to provide fast-response sprinkler heads. For ordinary hazard sprinkler classification utilising a sprinkler coverage of 12 m^2, this gives an approximate radial distance to the first row sprinkler heads of 2.5 metres (as per AS2118.1–1999). The detection times are summarised within Table 15.2.

Table 15.2 – Detection time

BCA DtS compliant design (s)	Alternative Solution (s)
313	225

Pre-movement Time

As part of the alternative solution and a BCA DtS compliant design, the occupant warning system is to include an automatic voice-messaging function and equivalent sound pressure level.

As the alternative solution features a voice messaging system, a pre-movement time of 3 minutes is considered suitable. This time was taken from Table 3-12.1 of the SFPE[99] based on pre-recorded verbal messaging being available in addition to the standard alarm tone.

As the BCA DtS Design compliant design comprises a no voice messaging system, a pre-movement time of 4 minutes is considered suitable. This time was taken from Table 3-12.1 of the SFPE[100] based on a standard alarm tone.

The pre-movement time is expected to be equivalent in both cases as listed in Table 15.3.

Table 15.3 – Pre-movement time

BCA DtS compliant design (s)	Alternative Solution (s)
240	180

Movement Time to Reach an Alternative Exit

The movement time is the time interval between the commencement of evacuation and the completion of evacuation to a specified point. In the event that an exit is unavailable for egress, this assessment is concerned with the movement times to reach an alternative exit. The total travel distance measured through the point of choice is 100 metres for a BCA DtS compliant design (i.e. 40 metres to the nearest exit and 60 metres to the second exit) and 185 metres for the alternative solution (i.e. 65 metres to the nearest exit and additional 120 metres to the second exit).

With reference to Appendix A the movement times are governed by walking time to reach an alternative exit, as summarised in Table 15.4 below. Note again that the calculations allow for travel all the way to the first exit and then back to the second exit, which is considered unlikely to occur in practice, due to the open plan nature of the carpark.

Table 15.4 – Movement time

BCA DtS compliant design (s)	Alternative Solution (s)
155	84

Comparison of Evacuation Times

In terms of the evacuation times within the basement car park, the provision of a voice messaging system and fast-response sprinkler heads when compared to the standard response sprinkler heads provides quicker detection time (for those who are not in the vicinity of the fire to receive a direct cue and promptly move away from the fire), hence resulting in a smaller fire size. Furthermore, the basement car park levels feature an open layout with various egress paths around or through the car park spaces is possible whereby the occupants are unlikely to be trapped by the seat of the fire.

Comparison of the evacuation times between a BCA DtS compliant design and the proposed Alternative Solution are summarised in Table 15.5 below.

Table 15.5 – Evacuation times

BCA DtS compliant design (s)	Alternative Solution (s)
Detection time = 207 Pre-movement time = 240 Movement time = 155 Total = 602 seconds	Detection time = 294 Pre-movement time = 180 Movement time = 84 Total = 558 seconds

99 The SFPE Handbook of Fire Protection Engineering, 3rd ed, National Fire Protection Association, US, 2002.
100 The SFPE Handbook of Fire Protection Engineering, 3rd ed, National Fire Protection Association, US, 2002.

As previously mentioned in section 6, a review of fire statistics in car parks[101] by BHP Melbourne Research Laboratories (MRL) has reported the following:

- There have been no death or serious injuries recorded for fires in car parks in Australia.
- The American Iron and Steel Institute (AISI) survey of US and Canadian car parks has indicated that fire safety risks within car parks are not significant, as there has been no recorded loss of life from a fire in a car in the car park over a survey period of 60 years. Car parks are generally not a source of death or personal injury.
- The National Fire Protection association analysed fire loss from US and Canadian car parks from 1982 to 1986 and concluded that there is an extremely low fire safety hazard in car parks.
- The referenced AISI report concluded with the following statement "It is clear from the available fire record that fires in car parks represent little risk to life or of injury, and very low monetary losses, possibly because of a very low frequency of fire starts in this type of building. Accordingly, the requirements for fire protection should not be excessive".

Based on the active fire protection system being installed for the subject building, fire hazard related to variation of travel distance between alternative exits such as the risk of exposure to the products of combustion, including elevated temperatures, toxic gases and levels of visibility is also considered to be similar to a BCA DtS compliant design.

With reference to the assessment presented above, the total evacuation time to reach an alternative exit for the alternative solution is expected to be shorter than that associated with the BCA DtS compliant design. Thus, the level of safety during the travel distance by way of the proposed fire safety strategy that forms the basis of the alternative solution is considered to be at least equivalent to that of the similar BCA DtS compliant design.

Note that as the building will have a rise in storeys of only three, being less than 25 metres in effective height such that it is not considered to fall within the definition of a high-rise structure, fire safety issues relating to the "height of the building", as referred to in performance requirement DP4 (i.e. reduced provision for external access for fire fighters etc), are not relevant to this assessment. Furthermore, although a part of the building is situated below ground level (i.e. the carpark), fire safety issues relating to "whether an exit is from … below ground level", as referred to in performance requirement DP4 (i.e. a potential lack of external access to a basement area, potentially minimal external ventilation etc). are not directly affected by the assessment as the carpark is not required to be provided with fire-isolated exits, and the risk of fire and smoke spread to the exits has been determined as being equivalent to the benchmark, BCA DtS-compliant design.

15.2.5 *Fire Brigade Intervention*

Assessment of the effects on fire brigade intervention of the subject, exit travel distances and distance between alternative exits has been undertaken, in order to ascertain that fire brigade intervention activities will be at least equivalent to that of the similar BCA DtS compliant design.

The Guide to the BCA[102] states the intent of BCA in relation the maximum distances between alternative exits is "to improve the level of safety when evacuating". In terms of hazard to the fire-fighters, variation to the distance between alternative exits does not affect fire brigade intervention activities during the set-up phase of the incident nor affect the time required to undertake search and rescue.

The most likely fire scenario is based on a sprinkler-controlled fire within the car park, which involves containment of fire to the region of fire origin such that the building is not affected structurally. The extent of fire-fighting activities required in this instance will be minimal, with the objective of the automatic sprinkler system being "to contain and extinguish fire", as stated in the Guide to the BCA[102]. This is further elaborated stating that:

> *When an automatic fire suppression system operates, it not only controls or limits the fire development, but statistics show that, in most cases, the fire is extinguished before the fire brigade arrives at the building.*

As such, the ability for fire-fighters to carry out fire-fighting operations is at least equivalent to that of the similar BCA DtS compliant design.

101 I.D. Bennetts, I.R., Thomas, K.H., Almand, D.J., Proe and R.R Lewins, "Fire in Carparks", BHP Melbourne Research Laboratories Report Number MRL/PS69/78/006, August 1989.
102 Australian Building Codes Board (ABCB), Guide to the BCA 2014, Australia, 2014.

15.3 SUMMARY

The assessment undertaken above demonstrates that the evacuation time arising from the proposed exit travel distance and travel distance between alternative exits that form the basis of the alternative solution is at least equivalent to that of the similar BCA DtS compliant design.

It is therefore considered that the proposed design will satisfy the acceptance criteria nominated for this assessment in section 9.

16 ALTERNATIVE SOLUTION 6 – EXIT TRAVEL DISTANCES TO A SINGLE EXIT (TENANCY G3 MEZZANINE)

16.1 Assessment Criteria

Table 11.1 provides a summary of the criteria for consideration as the basis of this Alternative Solution.

Table 16.1 – Assessment criteria

Consideration	Criterion
Applicable BCA DtS provisions	Clause D1.4 of the BCA stipulates that no point on a floor must be more than 20 m from an exit, or a point from which travel in different directions to two exits is available.
Proposed Alternative Solution	The proposed alternative solution is based on: (i) travel distance of up to 25 metres to the single exit in lieu of 20 m (ii) A building occupant warning system featuring an automatic voice messaging function; (iii) The presence of an automatic sprinkler system; (iv) The low population expected within the mezzanine; and (v) The open-plan layout of the mezzanine which provides maximum visual access to exit location
BCA assessment method	*Qualitative and quantitative analysis, based on BCA A0.5(b)(ii) "is shown to be at least equivalent to the Deemed-to-Satisfy Provisions" and A0.9(c) "Comparison with the Deemed-to-Satisfy Provisions".*
Methods of analysis	Based on a comparative assessment, the method of analysis will comprise a quantitative review of the evacuation time of occupants from Tenancy G.3. mezzanine between the proposed Alternative Solution and a similar BCA DtS compliant design, consisting of: (i) Detection time. (ii) Pre-movement time (i.e. based on pre-movement time from PD 7974-6:2004[103]). (iii) Movement time (i.e. based on methodologies and recommendations of Gwynne and Rosenbaum[104]).
Acceptance criteria	A comparative acceptance criterion is to be adopted, being that the occupant *evacuation time for the proposed Alternative Solution from the subject* mezzanine is at least equivalent to (i.e. not greater than) that of the benchmark, BCA DtS-compliant design.
IFEG sub-systems	The relevant sub-system from the International Fire Engineering Guidelines[105] are considered to be: • Sub-system A – Fire Initiation and Development and Control • Sub-system B – Smoke Development and Spread and Control • Sub-system C – Fire Spread and Impact and Control • Sub-system D – Fire Detection, Warning and Suppression • Sub-system E – Occupant Evacuation and Control • Sub-system F – Fire Services Intervention
Relevant performance requirement	DP4 and EP2.2.

103 British Standards, PD 7974-6:2004, The application of fire safety engineering principles to fire safety design of building – Part 6: Human factors: Life safety strategies – occupant evacuation, behaviour and condition (sub-system 6), British Standards Institution. 2004, p 1-60.
104 Gwynne, S. M. V. and Rosenbaum, E. R., Employing the Hydraulic Model in Assessing Emergency Movement, Section 3-Chapter 14, The SFPE Handbook of Fire Protection Engineering, 4th edition, National Fire Protection Association, Quincy, Massachusetts, 2008, pp. 3-373–3-396.
105 Australian Building Codes Board, ABCB, International Fire Engineering Guidelines Edition 2005, Australian Building Codes Board, Australia, 2005.

16.2 Fire Engineering Assessment

16.2.1 *Intent of the BCA DtS Provisions for Exit Travel Distances*

Limitations are placed on the maximum distances that occupants are required to travel in order to reach a "safe" place, such as an exit stairway or a final exit doorway to open space.

The deemed-to-satisfy provisions, in part, attempt to limit the exposure of occupants to a fire by stipulating these maximum travel distances. The potential for occupants within the floor of fire origin to be exposed to the fire is addressed as follows:

- In relation to being trapped by the seat of the fire, limitations are placed on the maximum travel distance along a single exit path prior to a point of choice between exits being reached. The provision of multiple exits maximises the choice occupants have in the case that one exit becomes blocked.
- In relation to being exposed to the products of combustion generally, limitations are placed on the maximum travel distance to an exit from the storey, as well as the maximum travel distance to an alternative exit, should the closest exit be unavailable.

The Guide to the BCA[106] supports this viewpoint, stating that multiple exits are specified for the following reason:

To require that if an exit is inaccessible, access to any required alternative exit must be available within a reasonable distance" and "Where a building requires multiple exits, the exits.

Further, the provision of multiple exits is considered to:

maximise the choices of a person evacuating, in case one exit becomes blocked.

16.2.2 *Details of the BCA DtS Compliant Design*

A BCA DtS compliant design will be used as the "base case" scenario for comparative assessment of the proposed design. The level of fire safety performance measured for the BCA DtS compliant design will be determined and measured against the performance measured for the Alternative Solution.

The BCA DtS compliant design for the building would comprise the following:

(i) Travel distance to the nearest exit of up to 20 metres within the warehouse mezzanine;
(ii) A building occupant warning system with no voice messaging system; and
(iii) *An automatic sprinkler system.*

16.2.3 *Details of the Proposed Alternative Solution*

The proposed Alternative Solution will comprise the following features:

(i) Travel distance of up to 25 metres to an exit in lieu of 20 m;
(ii) A building occupant warning system featuring an automatic voice messaging function;
(iii) The presence of an automatic sprinkler system;
(iv) The low population expected within the mezzanine; and
(v) The open-plan layout of the mezzanine which provides maximum visual access to exit location, as shown in Figure 16.1.

106 Australian Building Codes Board (ABCB), Guide to the BCA Class 2 to Class 9 Buildings, Australian Building Codes Board, Canberra, Australia, 2014.

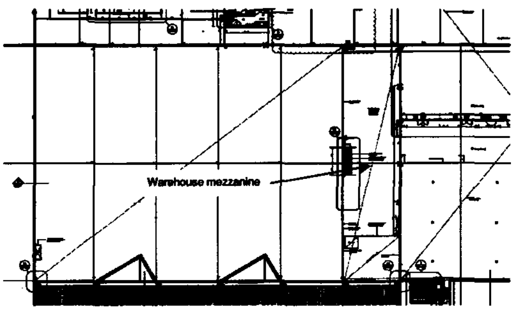


Figure 16.1 – Open layout of warehouse mezzanine (Level 2)

16.2.4 *Occupant Evacuation*

A comparative assessment between a BCA DtS compliant design and the proposed alternative solution is undertaken to investigate the difference in evacuation time associated with travel distance between alternative exits. It is considered that in both cases, the warehouse features an equivalent floor area, fuel loads, occupant characteristics and fire scenarios.

The travel distances specified under BCA clause D1.4 are based on the characteristics of the occupants. The BCA nominates different travel distance provisions for Class 2 & 3 buildings and Class 5 to 9 buildings, based on the alertness of occupants (asleep or awake) and the potential confusion and delays arising from being awoken during a fire alarm. This also applies to the travel distance between alternative exits in the event that the nearest exit is inaccessible and alternative exit needs to be sought for evacuation. For Class 7b car parks, the BCA DtS provisions stipulate a travel distance to an exit of up to 20 metres.

The total evacuation time is determined to be the summation of detection time, pre-movement time and movement time. In this case, the only variable is the detection and movement times (i.e. *pre-movement time is considered to be equivalent in both scenarios).*

Detection Time

For the occupants located within close proximity of a fire, fire detection is expected to initially occur as a result of receipt of a clear visual cue and occupants are prompted to evacuate prior to the activation of the fire detection system or sprinkler system. Conversely, for a fire occurring at a more remote point, fire detection is expected to initially occur as a result of receipt of an automatic cue from occupant warning system, initiated by the fire detection system or sprinkler system.

For Class 7b areas, the BCA DtS compliant design consists of an automatic sprinkler system with standard response sprinkler heads throughout. The detection times are considered to be similar for the BCA DtS compliant design and alternative solution as summarised in Table 15.2.

Table 16.2 – Detection time

BCA DtS compliant design (s)	Alternative Solution (s)
Equivalent	Equivalent

Pre-movement Time

As part of the alternative solution, the occupant warning system is to include an automatic voice-messaging function.

As the alternative solution features a voice messaging system, a pre-movement time of 3 minutes is considered suitable. This time was taken from Table 3-12.1 of the SFPE[107] based on pre-recorded verbal messaging being available in addition to the standard alarm tone.

As the BCA DtS Design compliant design does not feature a voice messaging system, a pre-movement time of 4 minutes is considered suitable. This time was taken from Table 3-12.1 of the SFPE[108] based on a standard alarm tone.

The pre-movement times for both cases are summarised below in Table 16.3.

Table 16.3 – Pre-movement time

BCA DtS compliant design (s)	Alternative Solution (s)
240	180

Movement Time to Reach an Alternative Exit

The movement time is the time interval between the commencement of evacuation and the completion of evacuation to a specified point. The travel distance measured to an exit is 20 metres for a BCA DtS compliant design and 25 metres for the alternative solution.

The movement time for both cases are summarised below in Table 16.4.

Table 16.4 – Movement time

BCA DtS compliant design (s)	Alternative Solution (s)
17	21

Comparison of Evacuation Times

In terms of the evacuation times within the warehouse mezzanine, the provision of a voice messaging system provides an improved pre-movement time. Furthermore, the mezzanine level feature an open layout whereby the occupants are unlikely to be trapped by the seat of the fire.

Comparison of the evacuation times between a BCA DtS compliant design and the proposed Alternative Solution are summarised in Table 15.5 below.

Table 16.5 – Evacuation times

Location	BCA DtS compliant design (s)	Alternative Solution (s)
Class 7a	Detection time = Equivalent Pre-movement time = 240 Movement time = 17 Therefore, BCA DtS compliant is at least 56 seconds longer than the Alternative Solution due to longer pre-movement time.	Detection time = Equivalent Pre-movement time = 180 Movement time = 21 Therefore, Alternative is at least 56 seconds shorter than the BCA DtS design due to shorter pre-movement time.

Based on the active fire protection system being installed for the subject building, fire hazard related to variation of travel distance to an exit such as the risk of exposure to the products of combustion, including elevated temperatures, toxic gases and levels of visibility is also considered to be similar to a BCA DtS compliant design.

Note that as the building will have a rise in storeys of only three, being less than 25 metres in effective height such that it is not considered to fall within the definition of a high-rise structure, fire safety issues relating to the "height of the building", as referred to in performance requirement DP4 *(i.e. reduced provision for external access for fire fighters etc), are not relevant to this* assessment. Furthermore, although a part of the building is situated below ground level (i.e. the carpark), fire safety issues relating to "whether an exit is from … below ground level", as referred to in performance requirement DP4 (i.e. a potential lack of external access to a basement area, potentially minimal external ventilation etc). are not directly affected by the assessment as the

107 The SFPE Handbook of Fire Protection Engineering, 3rd ed, National Fire Protection Association, US, 2002.
108 The SFPE Handbook of Fire Protection Engineering, 3rd ed, National Fire Protection Association, US, 2002.

carpark is not required to be provided with fire-isolated exits, and the risk of fire and smoke spread to the exits has been determined as being equivalent to the benchmark, BCA DtS-compliant design.

16.2.5 *Fire Brigade Intervention*

Assessment of the effects on fire brigade intervention of the subject, exit travel distances has been undertaken, in order to ascertain that fire brigade intervention activities will be at least equivalent to that of the similar BCA DtS compliant design.

The Guide to the BCA[109] states the intent of BCA in relation the maximum distances between alternative exits is "to improve the level of safety when evacuating". In terms of hazard to the fire-fighters, variation to the exit travel distance does not affect fire brigade intervention activities during the set-up phase of the incident nor affect the time required to undertake search and rescue.

The most likely fire scenario is based on a sprinkler-controlled fire within the warehouse, which involves containment of fire to the region of fire origin such that the building is not affected structurally. The extent of fire-fighting activities required in this instance will be minimal, with the objective of the automatic sprinkler system being "to contain and extinguish fire", as stated in the Guide to the BCA[102]. This is further elaborated stating that:

> *When an automatic fire suppression system operates, it not only controls or limits the fire development, but statistics show that, in most cases, the fire is extinguished before the fire brigade arrives at the building.*

As such, the ability for fire-fighters to carry out fire-fighting operations is at least equivalent to that of the similar BCA DtS compliant design.

16.3 SUMMARY

The assessment undertaken above demonstrates that the evacuation time arising from the proposed exit travel distance that forms the basis of the alternative solution is at least equivalent to that of the similar BCA DtS compliant design.

It is therefore considered that the proposed design will satisfy the acceptance criteria nominated for this assessment in section 9.

109 Australian Building Codes Board (ABCB), Guide to the BCA 2014, Australia, 2014.

17 ALTERNATIVE SOLUTION 7 – EXIT TRAVEL DISTANCES TO A SINGLE EXIT (LEVEL 2 OFFICE)

17.1 ASSESSMENT CRITERIA

Table 11.1 provides a summary of the criteria for consideration as the basis of this Alternative Solution.

Table 17.1 – Assessment criteria

Consideration	Criterion
Applicable BCA DtS provisions	Clause D1.4 of the BCA stipulates that no point on a floor must be more than 20 m from an exit, or a point from which travel in different directions to two exits is available.
Proposed Alternative Solution	The proposed alternative solution is based on: (i) travel distance of up to 30 metres to the single exit in lieu of 20 m (ii) Provision of smoke detection system in accordance with AS 1670.1-2004 (iii) A building occupant warning system featuring an automatic voice messaging function
BCA assessment method	Qualitative and quantitative analysis, based on BCA A0.5(b)(ii) "is shown to be at least equivalent to the Deemed-to-Satisfy Provisions" and A0.9(c) "Comparison with the Deemed-to-Satisfy Provisions".
Methods of analysis	Based on a comparative assessment, the method of analysis will comprise a quantitative review of the evacuation time of occupants from Level 2 office between the proposed Alternative Solution and a similar BCA DtS compliant design, consisting of: (i) Detection time. (i.e. based on activation of automatic fire detection system) (ii) Pre-movement time (i.e. based on pre-movement time from PD 7974-6:2004[110]). (iii) Movement time (i.e. based on methodologies and recommendations of Gwynne and Rosenbaum[111]).
Acceptance criteria	A comparative acceptance criterion is to be adopted, being that the occupant evacuation time for the proposed Alternative Solution from the subject Level 2 office is at least equivalent to (i.e. not greater than) that of the benchmark, BCA DtS-compliant design.
IFEG sub-systems	The relevant sub-system from the International Fire Engineering Guidelines[112] are considered to be: • Sub-system A – Fire Initiation and Development and Control • Sub-system B – Smoke Development and Spread and Control • Sub-system C – Fire Spread and Impact and Control • Sub-system D – Fire Detection, Warning and Suppression • Sub-system E – Occupant Evacuation and Control • Sub-system F – Fire Services Intervention
Relevant performance requirement	DP4 and EP2.2.

110 British Standards, PD 7974-6:2004, The application of fire safety engineering principles to fire safety design of building – Part 6: Human factors: Life safety strategies – occupant evacuation, behaviour and condition (sub-system 6), British Standards Institution. 2004, p 1-60.
111 Gwynne, S. M. V. and Rosenbaum, E. R., Employing the Hydraulic Model in Assessing Emergency Movement, Section 3-Chapter 14, The SFPE Handbook of Fire Protection Engineering, 4th edition, National Fire Protection Association, Quincy, Massachusetts, 2008, pp. 3-373–3-396.
112 Australian Building Codes Board, ABCB, International Fire Engineering Guidelines Edition 2005, Australian Building Codes Board, Australia, 2005.

17.2 FIRE ENGINEERING ASSESSMENT

17.2.1 *Intent of the BCA DtS Provisions*

The Guide to the BCA[113], in discussing the issue of travel distances pursuant to performance requirement DP4, states that the intent of clause D1.4 is:

> *To maximise the safety of occupants by enabling them to be close enough to an exit to safely evacuate.*

The BCA stipulates the maximum distances that occupants are required to travel in order to reach a "safe" place, such as an exit stairway or a final exit doorway to open space. The BCA DtS Provisions partly attempt to limit the exposure of occupants to a fire by controlling the maximum travel distances to final exit points.

The potential for occupants within the floor of fire origin being exposed to a fire is addressed within the BCA as follows:

- In relation to being trapped by the seat of the fire, limitations are placed on the maximum travel distance along a single exit path prior to a point of choice between exits being reached. The provision of multiple exits maximises the choice occupants have in the case that one exit becomes blocked.
- In relation to being exposed to the products of combustion generally, limitations are placed on the maximum travel distance to an exit from the storey, as well as the maximum travel distance to an alternative exit, should the closest exit be unavailable.

The Guide to the BCA[114] states that distances to exits "are based on an assumption of what is considered 'reasonable' distances to be travelled by occupants in reaching an exit".

17.2.2 *Details of the BCA DtS Compliant Design*

A BCA DtS compliant design will be used as the "base case" scenario for comparative assessment of the proposed design. The level of fire safety performance measured for the BCA DtS compliant design will be determined and measured against the performance measured for the Alternative Solution.

The BCA DtS compliant design for the building would comprise the following:

(i) Travel distance of up to 20 metres to a single exit;

(ii) An automatic smoke detection system throughout the building (note that this not required, however, 1668.1 is included for consistency); and

(iii) A building occupant warning system with no voice messaging system.

17.2.3 *Details of the Proposed Alternative Solution*

The proposed Alternative Solution involves the following elements:

(i) travel distance of up to 30 metres to an exit in lieu of 20 m (note that an allowance has been made for the office area to comprise two separate tenancies, as shown in Figure 17.1);

(ii) Provision of smoke detection system in accordance with AS 1670.1-2004 to the office areas; and

(iii) A building occupant warning system featuring an automatic voice messaging function.

113 Australian Building Codes Board (ABCB), Guide to the BCA 2014, Australia, 2014.
114 Australian Building Codes Board (ABCB), Guide to the BCA 2014, Australia, 2014.

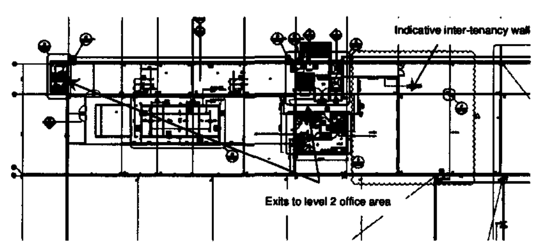


Figure 17.1 – Exits to level 2 office area

17.2.4 *Comparative Assessment*

The Guide to the BCA states that distances to exits "are based on an assumption of what is considered 'reasonable' distances to be travelled by occupants in reaching an exit".

However, the distances specified in BCA Clause D1.4 are only based on the characteristics of the occupants. The Guide to the BCA divides provisions for Class 2 & 3 buildings from provisions for Class 5 to 9 buildings, based on the alertness of occupants (asleep or awake) and the potential confusion arising from being awoken during a fire alarm. For Class 5, BCA DtS provisions stipulate that the distance of travel to an exit is 20 metres.

For this comparative assessment, it is considered that both the BCA DtS compliant design and the proposed alternative solution feature the same building design. This includes equivalent floor area, fuel loads, total heat output, occupant characteristics and fire scenarios.

The total evacuation time is determined to be the summation of detection time, pre-movement time and movement time. In this case, the only variable is the detection and movement time (i.e. pre-movement time is considered to be equivalent in both scenarios).

<u>*Detection time*</u>

Occupants are expected to receive a visual cue within a short period of time given the floor area of the room. In the case that a visual cue is not initially received, the fire detection system would provide building occupant warning in the initiation of a fire within the building.

The detection time for the Alternative Solution is expected to be shorter, based on the 10.2 metre spacing of the detectors associated with the proposed AS 1670.1-2004 system, which contrasts with the 20.4 metre spacing as stipulated in AS 1668.1-1998. The detection times are summarised within Table 17.2.

Table 17.2 – Detection time

BCA DtS compliant benchmark	Alternative Solution
157	113

<u>*Pre-movement time*</u>

As part of the alternative solution, the occupant warning system is to include an automatic voice-messaging function.

As the alternative solution features a voice messaging system, a pre-movement time of 3 minutes is considered suitable. This time was taken from Table 3-12.1 of the SFPE[115] based on pre-recorded verbal messaging being available in addition to the standard alarm tone.

As the BCA DtS Design compliant design does not feature a voice messaging system, a pre-movement time of 4 minutes is considered suitable. This time was taken from Table 3-12.1 of the SFPE[116] based on a standard alarm tone.

115 The SFPE Handbook of Fire Protection Engineering, 3rd ed, National Fire Protection Association, US, 2002.
116 The SFPE Handbook of Fire Protection Engineering, 3rd ed, National Fire Protection Association, US, 2002.

The pre-movement times for both cases are summarised below in Table 17.3.

Table 17.3 – Pre-movement time

Alternative Solution (s)	BCA DtS compliant benchmark (s)
180	240

Movement time to reach a point of choice

The movement time is the time interval between the commencement of evacuation and the completion of evacuation to a specified point. This assessment is concerned with the movement times to reach a point of choice.

The time to travel 30 metres in the level 2 office to the exit is approximately 25 seconds. The movement times to reach a single exit are summarised in Table 17.4 below.

Table 17.4 – Movement time to reach a point of choice

Alternative Solution (s)	BCA DtS compliant benchmark (s)
25	17

Comparison of Evacuation Times to Point of Choice

Comparison of the evacuation times between a BCA DtS compliant design and the proposed Alternative Solution are summarised in Table 17.5 below.

Table 17.5 – Evacuation times for the BCA DtS design and Alternative Solution

Alternative Solution (s)	BCA DtS compliant benchmark (s)
Detection time = 113 Pre-movement time = 180 Movement time = 25	Detection time = 157 Pre-movement time = 240 Movement time = 17
Total = 318 s	Total = 414 s

As a result of the assessment presented above, the total evacuation time to reach an exit for the alternative solution is expected to be shorter than that associated with the BCA DtS compliant design. Thus, the level of safety during travel to an exit, by way of the proposed fire safety strategy that forms the basis of the alternative solution, is considered to be consistent to the BCA DtS compliant design.

Note that as the building will have a rise in storeys of only three, being less than 25 metres in effective height such that it is not considered to fall within the definition of a high-rise structure, fire safety issues relating to the "height of the building", as referred to in performance requirement DP4 *(i.e. reduced provision for external access for fire fighters etc), are not relevant to this* assessment. Furthermore, although a part of the building is situated below ground level (i.e. the carpark), fire safety issues relating to "whether an exit is from ... below ground level", as referred to in performance requirement DP4 (i.e. a potential lack of external access to a basement area, potentially minimal external ventilation etc). are not directly affected by the assessment as the carpark is not required to be provided with fire-isolated exits, and the risk of fire and smoke spread to the exits has been determined as being equivalent to the benchmark, BCA DtS-compliant design

17.2.5 ***Supporting Assessments***

The primary assessment of comparison of evacuation times for both the proposed and DtS compliant designs has been carried out above. However, two additional assessments are to be provided below in support of this.

As the supporting assessments below will place some reliance on the performance of the automatic sprinkler system, review will be made of the expected reliability of such a system, in order to demonstrate that the level of life safety associated with sprinkler-controlled conditions is a reasonable expectation.

A fire scenario coincident with sprinkler failure is considered to be rare event, as reported in literature for correctly designed, commissioned and maintained sprinkler systems.

England and Young[117] estimated the reliability of automatic sprinkler systems to be approximately 95 per cent, based on Australian fire incident statistics collected by the Australasian Fire Authorities Council (AFAC) for the period 1989/90–1993/94. The same document also reported that the fire size was too small to operate the sprinkler heads in 77 per cent of the cases.

NSW data collected by NSWFB[118] in its Annual Statistical Report 2001/2002 indicates that for incidents where sprinklers were present and operated, the fire was extinguished in 70 per cent of cases and was prevented from spreading in a further 26 per cent of cases – for storage premises, all incidents involved extinguishment or control of the fire.

This is consistent with data from the United States, where Deal[119] reported that insurers assume the reliability figure for sprinklers to be in the range 92–97 per cent and Rohr[120] reported that sprinklers were effective in controlling 96 per cent of all property fires over the period 1999-2000.

Key reliability factors for sprinkler systems in Australia[121] include the protection of concealed spaces (roof and ceiling spaces), adequate maintenance of the system and the provision of stop valve monitoring devices. All these items are addressed either by stipulation by AS 2118 or by inclusion within the fire safety design strategy specified in this report.

As a result, a high level of reliability is expected to be achieved by the sprinkler system.

Comparison with Low-Rise DtS Compliant Design

The maximum travel distances permitted by the DtS provisions for the subject, office building, being 20 metres to a single exit, would also apply to a similar low-rise office building.

The low-rise building would generally not be required to feature the same fire safety measures that are required in the subject building, such as:

- an automatic sprinkler system
- a smoke detection system

As a result, the comparison of the two solutions could include a DtS compliant design that does not incorporate automatic sprinkler protection. The level of safety possible for the alternative solution, with a marginally longer travel distance to a single exit but lower overall evacuation time to an exit and the inclusion of sprinkler protection, is substantially higher than the non-sprinklered, BCA DtS compliant low-rise design case. The high reliability of sprinkler systems has been discussed above. It should be noted that the level of reliability of the sprinkler system relates to the ability of the system to control a fire and, therefore, reduce the possibility of occupants being either trapped by a large fire seat or overcome by smoke and toxic combustion products.

As a result, the exposure of occupants in the alternative solution to a fire whilst travelling to a single exit is expected to be lower than for the DtS compliant design, as the generation of products of combustion will not be as extensive during the shorter evacuation time. This is based on the fire growing at the same rate for both designs, based on identical fuel loads and the commonality of an automatic sprinkler system.

Supporting Non-Comparative Assessment

In addition to demonstrating an equivalent level of fire safety to that of the BCA DtS compliant benchmark, as has been the focus of this report, it is also desirable to demonstrate that the proposed design is intrinsically safe in an absolute sense.

Both the BCA DtS compliant building and the subject building include an automatic fire sprinkler system.

A high level of performance can be associated with the sprinkler system, this being substantiated by statistics from both Australian and overseas sources. Marryatt[122] data indicate that no deaths have occurred in sprinklered office buildings in Australia or New Zealand during the 100 years of sprinkler

117 England, J.P. & Young, S. A., Fire Risk Management for Buildings with Aged Accommodation, Fire Australia Proceedings, 1998.
118 New South Wales Fire Brigades (NSWFB), *Annual Statistical Report 2001/2002 incorporating a Ten Year Review 1989/90 to 1998/99*, ISSN 1035 9605 New South Wales Fire Brigades, 2003.
119 Deal, S., Evaluating Small Board and Care Homes Sprinklered vs Non Sprinklered Fire Protection, NIST, 1993.
120 Rohr, K. D., & Hall, J.R., US Experience with Sprinklers and Other Fire Extinguishing Equipment, Fire Analysis and Research Division, National Fire Protection Association (NFPA), Quincy, MA, 2005.
121 Marryatt, H. W., Fire: A Century of Automatic Sprinkler Protection in Australia and New Zealand 1886-1986, Australia, 1988.
122 Marryatt, H. W., Fire: A Century of Automatic Sprinkler Protection in Australia and New Zealand 1886-1986, 1988.

protection in these countries (it should be noted that data excludes fire where the sprinklers failed to operate).

In addition, statistics from the United States[123] disclose the number of deaths that occurred within both sprinklered and unsprinklered office buildings over the period 1994 to 1998. There were 0 deaths per 1,000 fires for the sprinklered buildings over this time, whilst there were 0.3 deaths per 1,000 fires within the unsprinklered buildings.

The control of fire development and spread by automatic sprinklers serves to safeguard the occupants whilst they are evacuating. In many cases, where effective control of the seat of the fire can be established, temperatures and toxicity levels may be maintained that allow occupants to remain within the building for some time without being exposed to life threatening conditions, as reflected by the above statistics.

Sprinkler activation and control will generally serve to prevent flashover occurring and restrict the potential for the rapid fire spread throughout an enclosed area or to an adjacent area, such as to an open plan space or to adjacent offices.

The risk of death or injury to the occupants can therefore be seen as being minimal for the subject occupancy. As such, the proposed Alternative Solution is one that is not only considered to be at least equivalent to the BCA DtS complying design (as discussed in the evacuation assessment in this report above) but is one that features an inherently low level of fire safety risk for the occupants.

17.2.6 ***Fire Brigade Intervention***

Assessment of the effects on fire brigade intervention of the subject variation to exit travel distances has been undertaken, in order to ascertain that the design does not adversely affect fire brigade intervention activities.

Fire brigade intervention is considered to be primarily affected by the difficulty in entering a building or part of a building, the structural stability of the building, the fuel load and fuel load energy density and the number of occupants that may need rescuing or assistance.

In this case, the alternative solution relates specifically to exit travel distances for occupants evacuating from the level 2 office, does not affect any of these factors and the impact of the design on fire brigade intervention (i.e. on search and rescue and fire-fighting activities) is therefore considered to be insignificant. As fire-fighters are typically entering a building during a fire rather than exiting from it, the exit travel distances will primarily affect building occupants rather than fire-fighters.

As such, the ability for fire-fighters to carry out fire-fighting operations is at least equivalent to that of the similar BCA DtS compliant design. It is also expected that the ability for fire-fighters to carry out fire-fighting operations will not be adversely affected.

17.3 **Summary**

The assessment undertaken above demonstrates that the evacuation time arising from the proposed exit travel distance within the level 2 office that form the basis of the alternative solution is at least equivalent to that of a similar BCA DtS compliant design.

It is therefore considered that the proposed design will satisfy the acceptance criteria nominated for this assessment in section 9.

123 Ahrens, M., The U.S. Fire Problem Overview Report – Leading Causes and Other Patterns and Trends, NFPA, Fire Analysis and Research Division, MA, 2003.

18 ALTERNATIVE SOLUTION 8 – TRAVEL DISTANCES BETWEEN ALTERNATIVE EXITS (TENANCY G3)

18.1 Assessment Criteria

Table 11.1 provides a summary of the criteria for consideration as the basis of this Alternative Solution.

Table 18.1 – Assessment criteria

Consideration	Criterion
Applicable BCA DtS provisions	*Clause D1.5 of the BCA stipulates that exits that are required as alternative* means of egress must be not more than 60 m apart in Class 7b occupancies.
Proposed Alternative Solution	The proposed alternative solution is based on: (i) travel distance of up to 70 metres between alternative exits within Tenancy G.3, in lieu of 60 metres. (ii) A sprinkler system in accordance with BCA Specification E1.5, which includes compliance with the relevant parts of AS2118–1999. (iii) A building occupant warning system featuring an automatic voice messaging function. (iv) The significant reservoir size for the smoke to fill.
BCA assessment method	Qualitative and quantitative analysis, based on BCA A0.5(b)(ii) "is shown to be at least equivalent to the Deemed-to-Satisfy Provisions" and A0.9(c) "Comparison with the Deemed-to-Satisfy Provisions".
Methods of analysis	Based on a comparative assessment approach, the methods of analysis to be undertaken will comprise: (i) Calculation of the available safe evacuation time (ASET) for the proposed alternative solution based on zone modelling. (ii) Calculation of the ASET for a BCA DtS-compliant benchmark design which could have a ceiling height of 2.4 metres; and travel distances of 20 / 40 / 60 m. (iii) *Comparison of the ASET for both the alternative solution and the BCA* DtS-compliant benchmark design. (iv) Determination of the impact of the additional travel time that occupants may need to reach an alternative exit and the period during which improved tenability could be expected during the evacuation period.
Acceptance criteria	A comparative acceptance criterion is to be adopted, being that the potential for occupants to be exposed to the products of combustion for the proposed design is at least equivalent to (i.e. not greater than) that associated with the BCA DtS-compliant benchmark design, based on the increased ASET (being the result of the larger reservoir for smoke filling) compensating for the reduced RSET (being a result of the longer travel distances).
IFEG sub-systems	The relevant sub-system from the International Fire Engineering Guidelines[124] are considered to be: • Sub-system A – Fire Initiation and Development and Control • Sub-system B – Smoke Development and Spread and Control • Sub-system C – Fire Spread and Impact and Control • Sub-system D – Fire Detection, Warning and Suppression • Sub-system E – Occupant Evacuation and Control • Sub-system F – Fire Services Intervention
Relevant performance requirement	DP4.

124 Australian Building Codes Board, ABCB, International Fire Engineering Guidelines Edition 2005, Australian Building Codes Board, Australia, 2005.

18.2 Fire Engineering Assessment

18.2.1 *Intent of the DtS Provisions for Exit Travel Distances*

Limitations are placed on the maximum distances that occupants are required to travel in order to reach a "safe" place, such as an exit stairway or a final exit doorway to open space.

The deemed-to-satisfy provisions, in part, attempt to limit the exposure of occupants to a fire by stipulating these maximum travel distances. The potential for occupants within the floor of fire origin to be exposed to the fire is addressed as follows:

- In relation to being trapped by the seat of the fire, limitations are placed on the maximum travel distance along a single exit path prior to a point of choice between exits being reached. The provision of multiple exits maximises the choice occupants have in the case that one exit becomes blocked.
- In relation to being exposed to the products of combustion generally, limitations are placed on the maximum travel distance to an exit from the storey, as well as the maximum travel distance to an alternative exit, should the closest exit be unavailable.

The Guide to the BCA[125] supports this viewpoint, stating that multiple exits are specified for the following reason:

To require that if an exit is inaccessible, access to any required alternative exit must be available within a reasonable distance" and "Where a building requires multiple exits, the exits.

Further, the provision of multiple exits is considered to:

maximise the choices of a person evacuating, in case one exit becomes blocked.

18.2.2 *Details of the Proposed Alternative Solution*

The proposed Alternative Solution involves the following elements:

(i) travel distance of up to 70 metres between alternative exits within Tenancy G.3, in lieu of 60 metres.

(ii) A sprinkler system in accordance with BCA Specification E1.5, which includes compliance with the relevant parts of AS2118–1999.

(iii) A building occupant warning system featuring an automatic voice messaging function.

(iv) The significant reservoir size for the smoke to fill for the alternative solution, as shown in Figure 18.1.

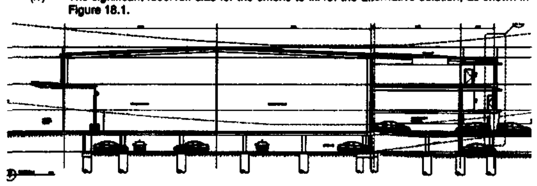


Figure 18.1 – Cross section of warehouse

18.2.3 *Details of the DtS-Compliant Benchmark Design*

A BCA DtS-compliant design has been used as the "benchmark" scenario for assessment of the proposed exit travel distances. This design is identical to the alternative solution, with the following exceptions:

(i) travel distances of up to 40 metres to an exit or point of choice and up to 60 metres between alternative exits through the point of choice;

125 Australian Building Codes Board (ABCB), Guide to the BCA Class 2 to Class 9 Buildings, Australian Building Codes Board, Canberra, Australia, 2014.

(ii) a ceiling height of 2.4 metres throughout (as permitted under clause F3.1 for Class 7 occupancies).

18.2.4 *Warehouse Comparative Assessment*

Occupants evacuating from a warehouse tenancy will need to travel a distance of up to 40 metres to reach an exit and up to 70 metres to reach an alternative exit after having travelled to the first exit.

Occupants will take approximately 34 seconds to reach an exit and 59 seconds to reach an alternative exit, based on an unobstructed evacuation speed of 1.19 m/s for an able-bodied person. This results in an additional 9 seconds to reach an alternative exit for the proposed design compared to the BCA DtS-compliant design.

<u>*Impact of Warehouse Geometry on Likely Conditions During Evacuation*</u>

A number of considerations need to be taken into account when assessing the likelihood of occupant exposure to smoke during evacuation, being:

(i) Floor area – the BCA DtS provisions do not stipulate a minimum or maximum floor area for an the tenancy, which could result in a significantly larger floor plate, requiring smoke to travel a much greater distance across the floor to reach an opening in one of the naturally ventilated external walls, such that smoke accumulation could be considerable greater, along with enclosure temperatures and reduced visibility associated with rapid layering and smoke descent.

(ii) Ceiling height – the warehouse space has an average floor to ceiling height of 10 metres. In comparison, the BCA DtS-compliant design could feature a clear height of just 2.4 metres throughout.

It is considered that the likely amount of smoke accumulation within the warehouse tenancy during a fire event would not be greater than that of the BCA DtS-compliant design and is, in fact, likely to lead to improved conditions for a longer period of time, due to the higher ceiling height providing a larger reservoir for smoke accumulation.

In order to demonstrate that the conditions are likely to improve as a result of the proposed geometry to result in a longer period of tenability for evacuating occupants, a zone modelling analysis has been undertaken, with the details presented within Appendix B.

The modelling results indicate that the lower enclosure associated with the BCA DtS-compliant designs lead to a more rapid descent of smoke.

Smoke height for the alternative solution is generally above the height required for tenable conditions to be sustained (i.e. 2.4 metres).

Table 18.2 – Comparison of ASET / ASET values

Fire Scenario	Temperature to reach 183°C	Smoke layer height to reach below 2.1 m
Alternative Solution	Approx. 700 s	Approx. 600 s
BCA DtS compliant design	Approx. 100 s	Approx. 100 s

N.B. The ASET values correspond to the time when the visibility at a height of 2.1 metres from the floor and air / smoke temperature reaches 183°C (approximately equivalent to 2.5kW/m²) consistently across the entire fire enclosure at any height.

<u>*Impact of Enclosure Conditions and Exit Design on Occupant Evacuation*</u>

For consideration of the above results and the proposed egress design against the ability for occupants to safely evacuate as part of the alternative solution when compared to the BCA DtS-compliant design, consideration is given to the following factors:

(i) In the event of a fire, occupants are able to move directly away from the seat of the fire within a short distance, due to a number of exits being available that are well-distributed and travel distances to a point of choice not exceeding the 20-metre allowance nominated by the BCA DtS provisions. The propensity for occupants to be trapped by the seat of the fire is therefore low (and equivalent to the DtS-compliant design).

(ii) The additional travel time that occupants may need to reach an exit or an alternative exit of up to 9 seconds compares favourably to the period during which improved tenability is expected to be experienced during the evacuation period, based on the modelling indicating that the geometry of the alternative solution allows a greater volume for smoke to accumulate prior to descending to the height of the occupants.

The BCA DtS-compliant design, which permits a general clear enclosure height of 2.4 metres, no limitations on floor area, would significantly reduce the available reservoir for smoke accumulation and result in a significantly shorter period of time being available prior to untenable conditions being reached. The proposed design contrasts favourably to this, based on well-distributed exits and a greater volume (based on the ceiling height) for smoke accumulation.

The additional travel time of up to 9 seconds is therefore accounted for by way of the increased available egress time facilitated by the design of the warehouse, such that the proposed alternative solution provides an equivalent level of fire safety to that of the assessed, BCA DtS-compliant base-case designs.

Note that as the building will have a rise in storeys of only three, being less than 25 metres in effective height such that it is not considered to fall within the definition of a high-rise structure, fire safety issues relating to the "height of the building", as referred to in performance requirement DP4 (i.e. reduced provision for external access for fire fighters etc), are not relevant to this assessment. Furthermore, although a part of the building is situated below ground level (i.e. the carpark), fire safety issues relating to "whether an exit is from … below ground level", as referred to in performance requirement DP4 (i.e. a potential lack of external access to a basement area, potentially minimal external ventilation etc). are not directly affected by the assessment as the carpark is not required to be provided with fire-isolated exits, and the risk of fire and smoke spread to the exits has been determined as being equivalent to the benchmark, BCA DtS-compliant design

18.2.5 *Fire Brigade Intervention*

Assessment of the effects on fire brigade intervention of the subject variation to travel distances between alternative exits has been undertaken, in order to ascertain that the design does not adversely affect fire brigade intervention activities.

Fire brigade intervention is considered to be primarily affected by the difficulty in entering a building or part of a building, the structural stability of the building, the fuel load and fuel load energy density and the number of occupants that may need rescuing or assistance.

In this case, the alternative solution relates specifically to travel distances between alternative exits for occupants evacuating from the warehouse tenancy, does not affect any of these factors and the impact of the design on fire brigade intervention (i.e. on search and rescue and fire-fighting activities) is therefore considered to be insignificant. As fire-fighters are typically entering a building during a fire rather than exiting from it, the exit travel distances will primarily affect building occupants rather than fire-fighters.

As such, the ability for fire-fighters to carry out fire-fighting operations is at least equivalent to that of the similar BCA DtS compliant design. It is also expected that the ability for fire-fighters to carry out fire-fighting operations will not be adversely affected.

18.3 Summary

The assessment undertaken above demonstrates that the available safe egress time arising from the proposed travel distances between alternative exits within the warehouse that form the basis of the alternative solution is at least equivalent to that of a similar BCA DtS compliant design.

It is therefore considered that the proposed design will satisfy the acceptance criteria nominated for this assessment in section 9.

19 ALTERNATIVE SOLUTION 9 – DISTANCES BETWEEN ALTERNATIVE EXITS (CHILD CARE CENTRE)

19.1 Assessment Criteria

Table 11.1 provides a summary of the criteria for consideration as the basis of this Alternative Solution.

Table 19.1 – Assessment criteria

Consideration	Criterion
Applicable BCA DtS provisions	Clause D1.5 of the BCA stipulates that exits that are required as alternative means of egress must be not more than 60 m apart in Class 9 buildings
Proposed Alternative Solution	The proposed alternative solution is based on: (i) Travel distance of up to 70 metres between alternative exits within the child care centre on Level 2, in lieu of 60 metres; (ii) Provision of a 30 m² refuge area to Level 2 adjacent to the lift lobby and fire stair with the bounding walls being lined with fire resisting plasterboard to achieve a -/120/120 FRL and extending to the underside of the roof covering or a 120/120/120 FRL ceiling; (iii) The distance between exists and refuge area not exceeding 60 metres.
BCA assessment method	Qualitative assessment based on BCA A0.5b(i) "formulating an Alternative Solution which complies with the Performance Requirements" and A0.9(b)(ii) "such other Verification Methods as the appropriate authority accepts for determining compliance with the Performance Requirements".
Methods of analysis	Based on a comparative assessment approach, the methods of analysis to be undertaken will comprise: (i) Consideration the fire separation provided by the proposed refuge area which reduces the distances between alternative exits. (ii) Determination of the impact of the additional travel time that occupants may need to reach an alternative exit and the presence of the refuge area and the outdoor area.
Acceptance criteria	A comparative acceptance criterion is to be adopted whereby the occupant evacuation time will be at least equivalent to a BCA DtS-compliant design based on the provision of a fire separated refuge area which results in distances between places of relative safety not exceeding 60 m.
IFEG sub-systems	The relevant sub-system from the International Fire Engineering Guidelines[126] are considered to be: • Sub-system A – Fire Initiation and Development and Control • Sub-system B – Smoke Development and Spread and Control • Sub-system C – Fire Spread and Impact and Control • Sub-system D – Fire Detection, Warning and Suppression • Sub-system E – Occupant Evacuation and Control • Sub-system F – Fire Services Intervention
Relevant performance requirement	CP1 and CP2.

126 Australian Building Codes Board, ABCB, International Fire Engineering Guidelines Edition 2005, Australian Building Codes Board, Australia, 2005.

19.2 Fire Engineering Assessment

19.2.1 *Intent of the DtS Provision for Travel Distance*

Limitations are placed on the maximum distances that occupants are required to travel in order to reach a "safe" place, such as the entry doorway to a fire-isolated exit.

The DtS Provisions, in part, attempt to limit the exposure of occupants to a fire by stipulating these maximum travel distances. In relation to being trapped by the seat of the fire, limitations are placed on the maximum travel distance along a single exit path prior to a point of choice between exits being reached. The provision of multiple exits maximises the choice occupants have in the case that one exit becomes blocked; and

The Guide to the BCA[127] supports this viewpoint, stating that multiple exits are specified for the following reason:

> *To require that if an exit is inaccessible, access to any required alternative exit must be available within a reasonable distance" and "Where a building requires multiple exits, the exits maximise the choices of a person evacuating, in case one exit becomes blocked"*

Further, the provision of multiple exits is considered to:

> *maximise the choices of a person evacuating, in case one exit becomes blocked.*

19.2.2 *Proposed Alternative Solution*

The Alternative Solution for the building would comprise the following:

(i) Travel distance of up to 70 metres between alternative exits within the child care centre on Level 2, in lieu of 60 metres;

(ii) Provision of a 30 m^2 refuge area to Level 2 adjacent to the lift lobby and fire stair. The bounding walls are to be lined with fire resisting plasterboard to achieve a -/120/120 FRL and are to extend to the underside of the roof covering or a 120/120/120 FRL ceiling;

(iii) Distance between exits and refuge area not exceeding 60 metres; and

127 Australian Building Codes Board (ABCB), Guide to the BCA Class 2 to Class 9 Buildings, Australian Building Codes Board, Canberra, Australia, 2014.

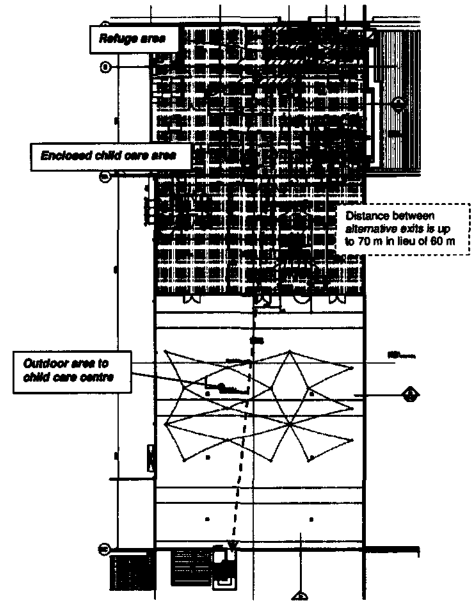


Figure 19.1 – Travel distance between alternative exits

19.2.3 *Details of the BCA DtS-compliant Benchmark Design*

A BCA DtS compliant design will be used as the "base case" scenario for comparative assessment of the proposed design. The level of fire safety performance measured for the DtS compliant design will be determined and measured against the performance measured for the alternative solution.

The BCA DtS compliant design for the building could comprise a distance between alternative exits of up to 60 metres on a floor containing non-fire-separated areas.

19.2.4 *Layout of the Child Care Centre*

The child care centre comprises an indoor area and an outdoor area as shown in Figure 19.1 above.

The open plan design of the non-enclosed outdoor area results in an environment where cues from a fire will be able to be readily identified by the occupants in the early stages of the fire's development.

A 30 m^2 refuge area adjacent to the lift lobby and fire stair is to be provided, as shown in the figure above. The bounding walls are to be lined with fire resisting plasterboard to achieve a -/120/120 FRL and are to extend to the underside of the roof covering or a 120/120/120 FRL ceiling.

In addition to this, the building is considered to have high "building legibility" based on its simple layout. Way finding is expected to be minimal and the exit is relatively easy to identify without much guidance due to the following items:

(i) ease at which occupants can familiarise themselves within the child care centre; and

(ii) easy identification of the main exit and entry into the child care centre.

19.2.5 *Fire Hazard*

The likelihood of a fully-developed fire occurring is low during occupied hours, due to the presence of trained staff who could undertake first-aid fire fighting.

The floor is also constructed of concrete. The ability for the floor to withstand the effects of a fire for a period of time will provide a structurally stable environment for facilitation of occupant evacuation within the childcare centre.

The fire hazard is considered to be the same for both the Alternative Solution and the BCA DtS-compliant benchmark design.

19.2.6 *Occupant Evacuation*

Staff members are expected to be awake and conscious of their surroundings and will be generally familiar with the building layout based on their roles. Children are expected to be assisted by staff. Visitors may be present and may not be familiar with the building. However, confusion during an emergency evacuation is expected to be minimised due the presence of staff members who will most likely be accompanying the visitors.

The Guide to the BCA limits the travel distance to a point of choice in order to maximise the safety of occupants by enabling them to be close enough to an exit to safely evacuate. The BCA nominates a travel distance of 20 m travel distance to a point of choice on a "floor". A "floor area" is the area of a storey, a room, a fire compartment or an atrium, as defined in the BCA. The subject non-enclosed area is a rooftop and is not considered to fall under any of these categories. The maximum travel distance from the furthest point within the fire separated enclosed area is 35 m. In terms of exposure to the effects of fire, this level of safety is considered at least equivalent to a BCA DtS-compliant benchmark design based on the maximum permitted exit travel distance of 20 m to an exit on a "floor". The intention for the limitations on the exit travel distances is also partly to maximise the safety of occupants by enabling them to be close enough to an exit to safely evacuate.

In addition, a refuge area is to be provided to the child care centre which will provide a distance of less than 60 m between the refuge area and the alternative exit.

In addition, for a fire occurring either within or outside the enclosed area, occupants are likely to receive visual or olfactory cues due to the formation of smoke and the non-enclosed rooftop area can act as a holding / assembly area. In the event of a fire blocking the egress stairway, occupants could remain within the rooftop area by adopting a "defend in place strategy" while waiting for fire brigade intervention to occur.

Note that as the building will have a rise in storeys of only three, being less than 25 metres in effective height such that it is not considered to fall within the definition of a high-rise structure, fire safety issues relating to the "height of the building", as referred to in performance requirement DP4 (i.e. reduced provision for external access for fire fighters etc), are not relevant to this assessment. Furthermore, although a part of the building is situated below ground level (i.e. the carpark), fire safety issues relating to "whether an exit is from ... below ground level", as referred to in performance requirement DP4 (i.e. a potential lack of external access to a basement area, potentially minimal external ventilation etc). are not directly affected by the assessment as the childcare centre is not affected by the subject alternative solution.

19.2.7 *Fire Brigade Intervention*

Assessment of the effects on fire brigade intervention of the proposed design involving variations to distances between alternative exits within the proposed development is to be made, in order to ascertain that the design does not increase the risk associated with fire fighting activities in comparison to that of the similar, BCA DtS compliant design.

The primary design measure to impact on effective fire brigade intervention relates to the provision of fire compartmentation. This measure is provided in compliance with the BCA DtS Provisions for the subject development, providing an equivalent level of safety compared to a BCA DtS-compliant benchmark design.

Fire fighters will also not have to travel for a greater distance internally than what is prescribed by the BCA DtS provisions distance to reach all parts of the "floor", based on the extent of external space within the child care facility.

The floor areas for the alternative solution are also at least equivalent to a BCA DtS-compliant benchmark design, such that the fuel load is not greater than the DtS-compliant design.

As it has been shown above that the fire safety strategy for the building, including provision for fire fighting and compartmentation is not affected by the proposed travel distances, it is considered that the alternative solution will not adversely affect fire brigade intervention activities within the building.

As such, it is considered that the alternative solution, involving variation distances between alternative exits within the child care centre, will facilitate fire brigade intervention to a degree that is equivalent to that of the BCA DtS design.

19.3 Summary

As a result of the above assessment, it is considered that the proposed Alternative Solution, involving distances between alternative exits being up to 70 m, will not adversely affect occupant evacuation or *fire-fighting activities within the building, based on the provision of a refuge area which provides a* maximum distance between this area and an alternative exit being within 60 metres and a portion of the area of travel being a non-enclosed area.

It is therefore considered that the proposed design will satisfy the acceptance criteria given for this assessment within section 9.

20 ALTERNATIVE SOLUTION 10 – EXIT WIDTH WITHIN SWIMSCHOOL

20.1 Assessment Criteria

Table 20.1 provides a summary of the criteria for consideration as the basis of this Alternative Solution.

Table 20.1 – Assessment criteria

Consideration	Criterion
Applicable BCA DtS provisions	Clause D1.6 of the BCA nominates a clear, minimum width of 1,000 mm for exits and paths of travel to exits.
Proposed Alternative Solution	The proposed Alternative Solution is based on the egress width within the swimschool between columns and the pools is 820 mm wide, in lieu of 1 m.
BCA assessment method	Qualitative and quantitative analysis, based on BCA A0.5(b)(ii) "is shown to be at least equivalent to the Deemed-to-Satisfy Provisions" and A0.9(c) "Comparison with the Deemed-to-Satisfy Provisions".
Methods of analysis	Based on a comparative assessment approach, the method of analysis to be undertaken will comprise an anthropometric assessment to determine the ability for the exit width to adequately facilitate the single-file passage of occupants to the exits, utilising anthropometric data from Littlefield[128] and Pheasant[129]. The comparative assessment will consider for both the proposed design and the BCA DtS-compliant design: (i) the number of occupants served; and (iii) the occupant movement time.
Acceptance criteria	Comparative acceptance criteria are to be adopted, whereby: (i) The ability for the proposed exit and pathway widths forming the basis of the Alternative Solution to facilitate the single-file passage of a 95th-percentile person is at least equivalent to that associated with the nominated, BCA DtS-compliant benchmark design. (ii) The occupant movement time from the swimschool is at least equivalent to that associated with the nominated, BCA DtS-compliant benchmark design.
IFEG sub-systems	The relevant sub-system from the International Fire Engineering Guidelines[130] are considered to be: • Sub-system E – Occupant Evacuation and Control • Sub-system F – Fire Services Intervention
Relevant performance requirement	DP4.

20.2 Fire Engineering Assessment

20.2.1 *Intent of the DtS Provision for Exit Width*

The intent of BCA D1.6 in relation to dimensions of exits and paths of travel to exits is based on facilitating occupant evacuation from a building within a satisfactory time period. This includes allowing the occupants to evacuate without having to spend an excessive time travelling through exits that may not be of sufficient dimension to prevent the formation of highly dense crowds, panic and potential crushes. The Guide to the BCA[131], which states that the intent of nominating dimensions of exits and paths of travel to exits is:

128 Littlefield, D., Metric Handbook, Planning and Design Data, third edition, Architectural Press, Oxford, UK, 2008.
129 Pheasant, S., Bodyspace – Anthropometry, Ergonomics and the Design of Work, Third Edition, Taylor & Francis Group, 2006.
130 Australian Building Codes Board, ABCB, International Fire Engineering Guidelines Edition 2005, Australian Building Codes Board, Australia, 2005.
131 Australian Building Codes Board (ABCB), BCA 2014 Class 2 to 9 Buildings, Australian Building Codes Board, Canberra, Australia, 2014.

> *To require exits and paths of travel to an exit to have dimensions to allow all occupants to evacuate within a reasonable time.*

The performance of the design to be assessed hereunder is therefore that relating to the evacuation time from the building. The time taken for occupants to evacuate for the Alternative Solution should be at least equivalent to that of a BCA DtS compliant design when considering the exit widths.

20.2.2 *Details of the BCA DtS Compliant Design*

A BCA DtS compliant design will be used as the "base case" scenario for comparative assessment of the proposed design. The level of fire safety performance measured for the BCA DtS compliant design will be determined and measured against the performance measured for the Alternative Solution.

A BCA DtS compliant design could comprise an unobstructed clear width of 1000 mm. Occupant numbers are considered to be similar for both designs.

20.2.3 *Details of the Proposed Alternative Solution*

The Alternative Solution comprises an unobstructed clear width of 820 mm within the swim school, as shown below in Figure 20.1. Occupant numbers are considered to be similar for both designs.

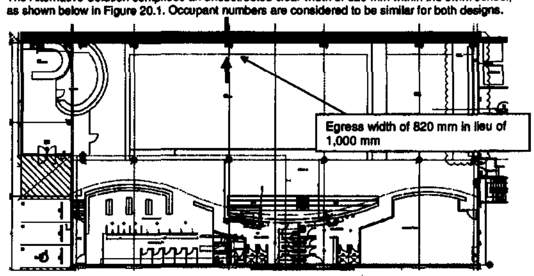


Figure 20.1 – Egress widths to swim school

20.2.4 *Anthropometric Assessment*

An assessment is to be made of the dimensions the subject stairway that is less than the minimum, DtS-compliant width of 1000 mm, studying anthropometric data to ascertain whether or not the occupants can generally move comfortably through the egress pathways and in a manner at least equivalent to that commensurate with the DtS-compliant, benchmark design.

Data presented by Pheasant[132], based on British and American adults aged 19-65, indicates that the 95th percentile of the studied population does not exceed the following dimensions:

- males – a shoulder breadth of 510 mm (shoulder width being the limiting factor)
- females – a hip breadth of 435 mm (hip breadth being the limiting factor)

Further to this, Pheasant[133] gives similar data, which indicates the following maximum body depth dimensions:

- Males are between 255 to 330 mm.
- Females are between 225 to 325 mm.

132 Pheasant, S., Bodyspace – Anthropometry, Ergonomics and the Design of Work, Third Edition, Taylor & Francis Group, 2006.
133 Littlefield, D., Metric Handbook, Planning and Design Data, third edition, Architectural Press, Oxford, UK, 2008.

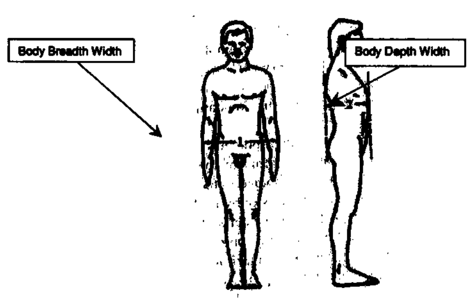


Figure 20-2 – Body dimensions for various positions

Further to this, ergonomic data published by Littlefield[134] indicates that a single male can move or walk comfortably within a pathway width of 550-600 mm. Pheasant[132] gives similar data to this, suggesting that a person is able to walk normally along a pathway width of 650 mm. Historically, as discussed in a NIST review of international regulations for egress system design[135]; this has been reflected in the United States by the adoption of the standard-unit exit width of 22 inches (550 mm) for single-file passage, which becomes 1,100 mm for side-by-side movement for two persons.

As a result, the occupants should be able to move with comfort and ease through the subject 820 mm exit path between the pools and columns within the swimschool.

Consideration is to be given to the hypothetical, BCA DtS compliant stairway, where the ergonomic data indicates that a continuous width of 1000 mm would be insufficient to allow for side-by-side movement. Pheasant and Littlefield give minimum widths for two, 95th-percentile males walking shoulder-to-shoulder that exceed 1000 mm (i.e. they range from 1,050 mm to 1,350 mm).

It is of note that the standard, US minimum exit width of 550 mm for single-file movement mentioned above (which becomes 1,100 mm for the side-by-side movement of two people) is consistent with the referenced ergonomic data. The need for a minimum exit width for passage of two people side-by-side of at least 1,100 mm is discussed in the aforementioned NIST review[136] where it states:

> *Clearly, the current 44 in (1100 mm) minimum exit stair width is intended to support two, 22 in queues of occupants either standing still or moving down the stair. Challenges to the adequacy of the 22 in dimension include the need to provide for body sway as people move down the stair (Pauls) and the need to allow for some personal space (Fruin, Predtechenskii and Milinskii).*

As such, a DtS-compliant egress path width of 1000 mm would be insufficient to accommodate side-by-side movement and its capacity would therefore not significantly differ from the proposed 820 mm exit widths. In any scenario where occupants are grouped or bunched up, it is anticipated that they would move through the pathways in a staggered formation if necessary. Based on this, it is considered that the proposed stair width will be sufficient to allow occupants to move comfortably in single-file motion to the exit in each case, in a manner equivalent to the benchmark, DtS-compliant design.

For both the Alternative Solution and the BCA DtS compliant design, it is anticipated that occupants will move through the stairway in a staggered formation, with fire fighter access requiring occupants to flatten out to one side of the pathway to travel against the flow.

134 Littlefield, D., Metric Handbook, Planning and Design Data, third edition, Architectural Press, Oxford, UK, 2008.
135 Bukowski, R. W., Emergency Egress from Buildings, Part 1: History and Current Regulations for Egress Systems Design, NIST Building and Fire Research Laboratory, Gaithersburg, Maryland, USA, paper in Proceedings of the 7th International Conference on Performance-Based Codes and Fire Safety Design Methods, SFPE, Auckland, NZ, 2008, pp. 187-191.
136 Ibid

Based on the above, it is considered that the proposed 820 mm width is sufficient to allow the occupants to move comfortably along the corridors in a staggered formation. A reduction in width of 180 mm from that of a BCA DtS compliant exit does not impact on the potential for safe and effective movement of persons any more than the DtS-compliant exit width.

20.2.5 *Movement Time to an Exit*

Based on the hypothetical, BCA DtS compliant design involving a minimum exit width of 1,000 mm, the proposed stairway configuration, involving an 820 mm width will provide an equivalent exit width and, therefore, an equivalent flow of occupants and total evacuation time that does not exceed that of the BCA DtS compliant design.

The time to evacuate from the basement for both the Alternative Solution and the BCA DtS compliant design is considered similar based on the same occupancy figures and the exit width not allowing for side-by-side movement of two persons.

As a result, it is considered that the safety of the occupants during emergency evacuation will be sufficiently facilitated by the proposed Alternative Solution, whereby the evacuation time will be at least equivalent to the BCA DtS compliant design.

20.2.6 *Available Safe Egress Time*

Based on the following qualitative assessment, the available safe egress time from the swimschool is expected to be at least equivalent to that of the BCA DtS compliant design based on fuel loads, which would be identical for both the BCA DtS compliant design and the Alternative Solution, resulting in equivalent fire and smoke development for each design.

20.2.7 *Fire Brigade Intervention*

Assessment of the effects of the proposed number of occupants within the building and the aggregate exit width of the stair has been made, which ascertains that the design does not increase the risk associated with fire fighting activities in comparison to that of the BCA DtS compliant design.

The means of egress carried out above determined that the time for occupants to evacuate from the building will be at least equivalent for the Alternative Solution when compared with a BCA DtS compliant design. Therefore, it is considered that the Alternative Solution will facilitate fire brigade intervention to a degree that is at least equivalent to that of the BCA DtS compliant design.

Consideration has been given to the effect of the exit width on the passage of individual fire fighters. According to data presented by FAMA[137] on dimensions of US fire fighters (male and female) fitted with standard fire-fighting turnout gear (similar dimensions for Australian fire fighters not being available at this point, as advised by Fire and Rescue NSW), the 95th percentile of the studied population did not exceed the following dimensions when fully clothed:

- male fire fighters – a shoulder breadth of 592 mm and a width across arms of 699 mm
- female fire fighters – a shoulder breadth of 554 mm and a width across arms of 650 mm (note that in contrast to the dimensions on the general population for females given previously in this report, shoulder width exceeded hip width for female fire fighters)

As the clear width of the paths of travel within the subject building will be a minimum of 820 mm, the 95th-percentile dimensions of the abovementioned shoulder widths and widths across arms for both males and females will be achieved. Based on this, the design will be capable of facilitating movement for the 95th percentile male fire fighter, with no effect expected on the flow times into and though the exit.

As such, it is considered that the Alternative Solution, involving a variation in the exit width will facilitate fire brigade intervention activities to an extent that is at least equivalent to that of the benchmark, BCA DtS-compliant design.

Note: Fire Brigade intervention has not been relied upon in the assessment carried out above.

20.3 Summary

In relation to the proposed exit width within the swim school, the assessment undertaken above demonstrates a level of safety which is at least equivalent to the BCA DtS-compliant design by way

137 FAMA Technical Committee, Chassis Subcommittee, Firefighter Anthropometric Data White Paper, Fire Apparatus Manufacturer's Association, October, 2007.

of the proposed fire safety strategy for the subject development. This results in the facilitation of occupant evacuation to a degree that is at least equivalent to that of the benchmark, BCA DtS-compliant, case.

It is therefore considered that the proposed design will satisfy the acceptance criteria nominated for this assessment in section 9.

21 ALTERNATIVE SOLUTION 11 – FIRE RESISTANCE LEVEL TO ROOF, SPANDREL SEPARATION AND SMOKE HAZARD MANAGEMENT

21.1 Assessment Criteria

Table 21.1 provides a summary of the criteria for consideration as the basis of this Alternative Solution.

Table 21.1 – Assessment criteria

Consideration	Criterion
Applicable BCA DtS provisions	Clause C1.1 of the BCA which refers to Clause 3.5 of Spec. C1.1 stipulates that the roof of a building need not have an FRL of 120/60/30 if its covering is non-combustible and the building is sprinkler protected throughout. Clause C2.6(b) of the BCA stipulates that the requirements of Clause C2.6(b) for vertical separation do not apply to a building which has a sprinkler system installed throughout. Clause E2.2 of the BCA refers to Table E2.2a which stipulates that, for the subject building, an automatic smoke detection system or sprinkler system is provided throughout to satisfy the smoke hazard management provisions.
Proposed Alternative Solution	The proposed alternative solution is based on: (i) The non-provision of a sprinkler system to the swimschool; (ii) The swimschool being a separate fire compartment from the remainder of the building. (iii) The non-provision of a roof having an FRL of 120/60/30; (iv) The non-provision of separation between vertical openings in external walls; (v) The provision of a sprinkler system throughout the building with the exception of the swim school; and (vi) The provision of a beam type automatic fire detection system to the swimschool.
BCA assessment method	Qualitative assessment based on BCA A0.5b(i) "formulating an Alternative Solution which complies with the Performance Requirements" and A0.9(b)(ii) "such other Verification Methods as the appropriate authority accepts for determining compliance with the Performance Requirements".
Methods of analysis	Based on a direct assessment against the performance requirements, the methods of analysis to be undertaken will be qualitative and quantitative in nature and will comprise: (i) Review of the potential for fire spread from the subject building to the adjoining buildings. (ii) Review and determination for the potential for fire spread from the swimschool to the adjacent areas within the building. (iii) Review and determination of the potential for fire spread between storeys via external openings. (iv) Review of the proposed smoke hazard management system for the building which comprises a combination of an automatic sprinkler system and smoke detection system.

Consideration	Criterion
Acceptance criteria	Absolute acceptance criteria are to be adopted, being as follows: (i) The potential for fire spread from the subject building to the adjoining buildings is mitigated based on the provision of an automatic sprinkler system throughout the building except for the swim school, which is located on Ground Floor. (ii) The potential for fire spread from the swim school to the adjacent areas *within the building is mitigated based on the provision of an automatic* sprinkler system throughout the building except for the swim school, which is located on Ground Floor. (iii) Fire spread between vertical openings is mitigated, based on an automatic sprinkler system provided throughout the building except for the swim school which do not comprise any vertical openings to its external walls. (iv) The combination of an automatic sprinkler system and smoke detection system will not adversely affect the smoke hazard management system.
IFEG sub-systems	The relevant sub-system from the International Fire Engineering Guidelines[138] are considered to be: • Sub-system A – Fire Initiation and Development and Control • Sub-system B – Smoke Development and Spread and Control • Sub-system C – Fire Spread and Impact and Control • Sub-system D – Fire Detection, Warning and Suppression • Sub-system E – Occupant Evacuation and Control • Sub-system F – Fire Services Intervention
Relevant performance requirement	CP1, CP2, EP1.4 and EP2.2.

21.2 Fire Engineering Assessment

21.2.1 *Intent of the DtS Provisions for Roof Fire Resistance Levels*

The stipulation of fire resistance levels by the BCA is matched to each of the nominated occupancy classes, such that those that are considered to contain higher fuel loads, such as retail and industrial/storage use, are given higher FRLs (3-4 hours) and those that are considered to contain lower fuel loads, such as residential, health care and office use, are given lower FRLs (1-2 hours).

The intent can be seen to allow a building to adequately resist the impact of fire to limit the potential for the spread of fire between fire compartments, buildings and classifications having different FRLs, reflecting the Objective of Section C of the BCA, CO1.

In relation to the specific role played by of the roof structure, the fire resistance level stipulated of 120/60/30 reflects an objective to limit the spread of fire via the roof structure, which could result in neighbouring buildings being affected.

This viewpoint is supported by the Guide to the BCA[139], which states that:

> *The roofs of certain types of buildings can be required to have an FRL to limit the spread of fire from the roof to another building, or from another building to the roof*

21.2.2 *Intent of the DtS Provisions for Vertical Separation in External Walls*

Clause C2.6 of the DTS provisions of the BCA require vertically aligned openings to be seperated by vertical spandrels of 900mm height, of which 600mm is required to extend above the finished floor level between the two storeys, or to be separated by horizontal spandrels projecting 1,100mm from the face of the building and extending 450 mm, as illustrated in Figure 21.1 and Figure 21.2 below.

138 Australian Building Codes Board, ABCB, International Fire Engineering Guidelines Edition 2005, Australian Building Codes Board, Australia, 2005.

139 Australian Building Codes Board (ABCB), Guide to the BCA 2014 Class 2 to Class 9 Buildings, ABCB, Canberra, Australia, 2014.

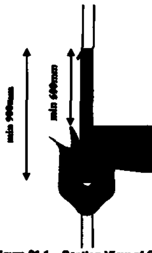


Figure 21.1 – Section View of Compliant spandrel in accordance with the BCA DtS provisions

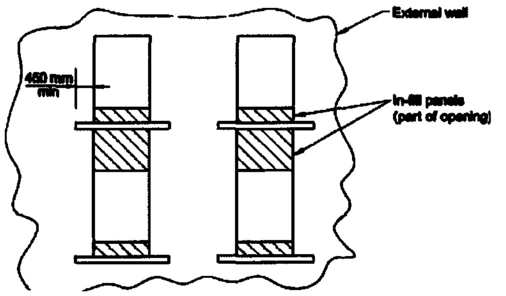


Figure 21.2 – Elevation View of Compliant spandrel in accordance with the BCA DtS provisions

Spandrels are provided in order to prevent fire spread from one floor to another within a building of Type A construction via the external walls. The flames from a fire on a level below may rise up the side of a building e.g. after glazing failure and ignite materials on another floor level via radiant heat transfer or direct flame impingement.

The Guide to the BCA[140] supports this viewpoint stating that:

> *To minimise the risk of fire spreading from one floor to another via openings in external walls in buildings of Type A construction.*

21.2.3 *Intent of the DtS Provisions for Smoke Hazard Management*

The intent of BCA Table E2.2b in relation to smoke hazard management is, having specific regard to the stipulation of some general and specific strategies for smoke hazard management, for minimising

140 Australian Building Codes Board (ABCB), Guide to the BCA 2014 Class 2 to Class 9 Buildings, Australian Building Codes Board, Canberra, Australia, 2014.

smoke risks within a building which can pose a significant hazard to the occupants, as discussed in The Guide to the BCA[141]:

To specify the requirements for minimising the smoke risks.

21.2.4 Assessment on the Spread of Fire

Fire Spread from the Swim School

A detailed assessment has been made of the potential for fire spread between the swim school and the adjacent tenancies. The potential for fire spread will largely be based on the severity of the fire, this being a factor of the low fuel loads (compared to typical class 9b occupancies) commensurate with a swim school and the intensity of an uncontrolled fire.

Fire severity within the building will primarily be influenced by the expected low fuel loads. The classification of the building is assembly related (i.e. typically dining, social activities and educational training), which results in a relatively low fuel load. However, the use of the subject building primarily relates to a swim school, with lobby areas and change rooms having minimal combustibles and fuel load. Fuel loads within the swim school may comprise fixed furniture being the reception desk, chairs and benches, as shown in Figure 21.3. Furnishings typically associated with the majority of class 9b assembly buildings, comprising items such as tables, chairs and kitchen equipment will therefore be limited.

The swim school will be a separate fire compartment from the remainder of the building via FRL 120/120/120 construction. The ability for the 120-minute bounding fire wall to withstand the effects of a fire for a specified period of time will enable the performance of the building to be quantified and the resulting in the ability for the building to provide a fire separation for the period required.

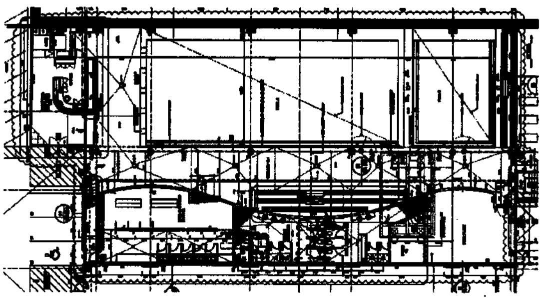


Figure 21.3 – Floor Plan of Swim School

Fire Spread from Sprinkler Protected Area

Fire development within the subject building would be governed by the arrangement of fuels and the ability for either occupants or fire fighters to intervene to control the fire and limit further fire spread.

For the subject development, a non-flashover fire presents as the "most probable" fire scenario for the building, based on the presence of an automatic sprinkler system throughout the building, except for the swim school which is a separate fire compartment and located on Ground Floor, and occupants who may attempt to undertake first-aid fire-fighting during the early stages of the fire growth.

141 Australian Building Codes Board (ABCB), Guide to the BCA 2012 Class 2 to Class 9 Buildings, ABCB, Canberra, Australia, 2012, p. 350.

Fire Spread via Roof

A fully-developed compartment fire is unlikely in a sprinkler protected building. In the unlikely event of a fully developed fire, fire spread via the roof is unlikely to occur, as there are presently no buildings or fire source within close proximity of the subject building, as shown in Figure 21.4. As such, specific, quantitative fire spread calculations will not be performed for the determination of radiant heat flux values within each allotment. This is based on control of the permissible extent of construction on the neighbouring allotment.

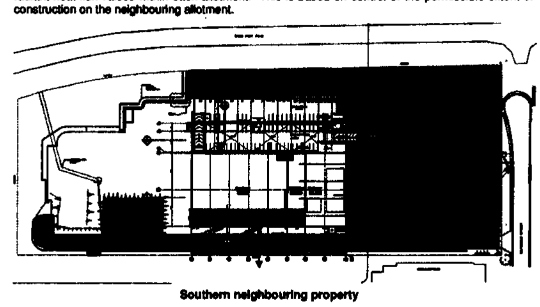


Figure 21.4 – Proximity of Subject Building to Neighbouring Buildings

Fire Spread from Adjoining Property

As previously discussed, there are no nearby building structures located within the adjoining property; therefore, the risk of fire spread from the adjacent property is not applicable in this case.

21.2.5 Vertical Fire Spread via External Openings

Assessment on the potential for fire spread via vertical openings is to be made based on the non-provision of sprinklers to the swim school. The northern and southern façade of the swim school, as shown in

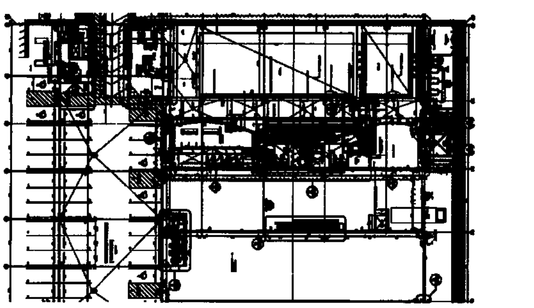


Figure 21.5 and

Figure 21.6, comprises masonry construction.

Fire spread via vertical openings from the swim school to the above tenancies is not expected to occur based on the Level 2 office roofline being setback at least 10 metres from the swim school below for the northern façade. The eastern and western façade comprises bounding walls and the southern façade does not comprises any openings.

As previously discussed, the potential for fire spread will largely be based on the severity of the fire, this being a factor of the low fuel loads (compared to typical class 9b occupancies) commensurate with a swim school.

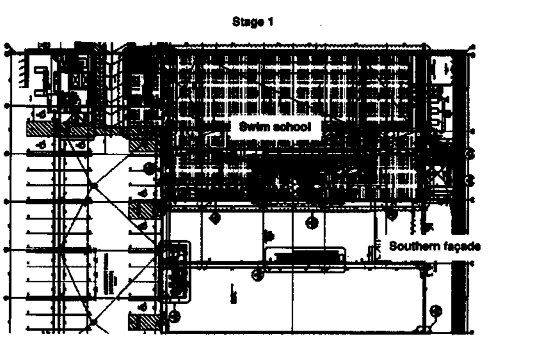


Figure 21.5 – Swim school Ground Floor plan

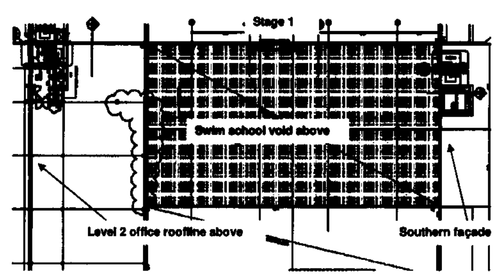


Figure 21.6 – Swim school Level 1 plan

21.2.6 Impact of a Combination of Two Systems to Satisfy the Smoke Hazard Provisions

As detailed above, a number of fire safety measures have been included within the building design to satisfy the smoke hazard requirements, being:

- An automatic sprinkler system throughout the building, except for the swim school;
- An automatic fire detection and alarm system to the Level 2 offices and swim school;
- The low fuel load within the swim school

On the basis of the above, it is considered that the smoke hazard management will not be adversely affected by the combination of two systems detailed above.

The likelihood of fully-developed conditions within the swim school occurring is low, based on the minimal fuel load associated with typical swimming pools, as previously discussed. The swim school layout is shown in Figure 21.3 above, which shows the proposed fixed furnishing. The building is separated via fire compartments (the swim school is separated from the remainder of the building) resulting in the risk of fire and smoke spread being mitigated.

An automatic sprinkler system installed throughout the remainder of the building is expected to mitigate the risk of significant fire development and spread in the event that control is unable to be facilitated by the occupants prior to arrival at the scene by fire-fighting crews.

A sprinkler-controlled fire will have limited impact on fire-resisting elements such as walls, floors or columns, with the likelihood of a fully developed fire occurring being very low during occupied hours, due to the relatively large number of staff members that could undertake either first aid fire-fighting or raise an alarm during the early stages of a fire.

21.2.7 Fire Brigade Intervention

Assessment of the effects on fire brigade intervention of the proposed design is to be made, in order to ascertain that the design does not adversely affect the hazard associated with fire-fighting activities. Based on the fuel loads expected within the swim school, the low risk of fire spread between the subject building and neighbouring buildings via the roof, no vertical openings to the external wall of the swim school which could result in vertical fire spread, the proposed Alternative Solution is not expected to adversely affect fire brigade intervention.

It is also understood that fire brigades are also able to fight a fire externally in the event of a fire spread to the intervening floor above throughout the perimeter of the building.

21.3 SUMMARY

The assessment undertaken above demonstrates that the proposed Alternative Solution is considered to facilitate an acceptable level of fire and life safety in minimising the risk of fire spread between buildings via the roof, fire spread via vertical openings and a combination of two systems to satisfy the smoke hazard requirements of the BCA.

It is therefore considered that the proposed design will satisfy the acceptance criteria nominated for this assessment in section 9.

22 ALTERNATIVE SOLUTION 12 – PROVISION OF JET-FANS WITHIN BASEMENT CARPARK LEVEL

22.1 ASSESSMENT CRITERIA

Table 22.1 provides a summary of the criteria for consideration as the basis of this Alternative Solution.

Table 22.1 – Assessment criteria

Consideration	Criterion
Applicable BCA DtS provisions	Table E2.2a of BCA Clause E2.2a stipulates that a Class 7a building, including a basement, provided with a mechanical ventilation system in accordance with AS 1668.2 must comply with clause 5.5 of AS/NZS 1668.1.
Proposed Alternative Solution	The proposed Alternative Solution is based on: (i) The use of jet-fans in lieu of a conventional exhaust air system in the basement carpark where the jet-fans do not comply with the requirements and recommendations in clause 5.5 of AS/NZS 1668.1. (ii) The provision of an automatic sprinkler system with fast response heads in lieu of a standard sprinkler system. (iii) The provision of manual controls by the fire fan control and indication panel (FFCP) at the fire indicator panel which override the automatic operation of the jet-fans; (iv) An additional detector(s) being located on the downstream side of each jet fan for auto shutdown; and (v) The jet fans located above driveways and access ways.
BCA assessment method	Qualitative and quantitative analysis, based on BCA A0.5(b)(ii) "is shown to be at least equivalent to the Deemed-to-Satisfy Provisions" and A0.9(c) "Comparison with the Deemed-to-Satisfy Provisions".
Methods of analysis	Based on a comparative assessment approach, the methods of analysis to be undertaken will comprise: (i) CFD modelling to predict the local effect of a jet-fan on sprinkler activation times (fast response and conventional sprinklers) during a fire; (ii) comparison of the sprinkler detection time for both the Alternative Solution and the BCA DtS-compliant benchmark design (iii) comparison of the visibility and temperature for both the Alternative Solution and the BCA DtS-compliant benchmark design in relation to the movement of smoke. (iv) Assessment will also involve a qualitative review of smoke spread and building design to mitigate the risk or occupants to reach a place of safety considering the building layout.
Acceptance criteria	A comparative acceptance criterion is to be adopted, whereby: (i) The performance of the sprinkler system with the jet-fans installed is equivalent to that of the BCA DtS compliant design without jet-fans, based on the sprinkler activation time; and (ii) Conditions in the carpark with jet-fans is at least equivalent than that of the BCA DtS compliant design without jet-fans, based on the operation of the sprinklers and shutdown of the jet-fans.
Relevant IFEG sub-systems	The relevant sub-system from the *International Fire Engineering Guidelines*[142] are considered to be: (i) Sub-system A – Fire Initiation and Development and Control (ii) Sub-system B – Smoke Development and Spread and Control (iii) Sub-system C – Fire Spread and Impact and Control (iv) Sub-system D – Fire Detection, Warning and Suppression (v) Sub-system E – Occupant Evacuation and Control (vi) Sub-system F – Fire Services Intervention
Relevant performance requirements	EP1.4 and EP2.2.

142 Australian Building Code Board, 2005, International Fire Engineering Guidelines (IFEG).

22.2 FIRE SAFETY ASSESSMENT

22.2.1 *Intent of the DtS Provisions for Smoke Exhaust*

The Guide to the BCA[143] discusses the requirements to minimise smoke risks for a Class 7a carpark:

Table E2.2a provides smoke hazard management strategies structured to help application to buildings of mixed classification. In the case of a multi-classified building, each classifiable part must comply with the relevant provisions for its classification

A carpark ventilation system is consistent with the treatment of miscellaneous air-handling systems in AS/NZS 1668.1. Accordingly, the electric power and control cabling for a carpark ventilation system need not be fire rated.

Likewise, a concession is granted to allow fans with metal blades suitable for operating at normal temperatures to be used instead of fans required to operate at elevated temperatures as required by Clause 4.8.1 of AS 1668.1.

To make sure that the manual override provision of Clause 5.5.3 of AS/NZS 1668.1 is not subject to the control of any general installation main switches, the power supply arrangement must comply with AS 3000

22.2.2 *Details of the DtS-Compliant Benchmark Design*

A BCA DtS compliant design will be used as the "base case" scenario for comparative assessment of the proposed design. The level of fire safety performance measured for the BCA DtS compliant design will be determined and measured against the performance measured for the Alternative Solution.

The BCA DtS compliant design for the building would comprise the following:

(i) Provision of an automatic sprinkler system with standard response heads provided throughout the carpark in accordance with BCA E1.5 and AS 2118.1-1999.

(ii) Provision of all other fire protection systems stipulated by the BCA DtS provisions, including fire hydrants, fire hose reels, portable extinguishers, emergency lighting, exits signs and exhaust air system for mechanical ventilation purposes.

22.2.3 *Proposed Alternative Solution*

The proposed Alternative Solution is based on:

(i) *The provision of jet-fans to the basement carpark levels.*

(ii) The jet air stream being between two sprinkler heads

(iii) A detector being located within the down flow of the jet fan, which switches the jet fan off.

(iv) Provision of an automatic sprinkler system with fast response heads provided throughout the carpark in accordance with BCA E1.5 and AS 2118.1-1999.

(v) Provision of all other fire protection systems stipulated by the BCA DtS provisions, including fire hydrants, fire hose reels, portable extinguishers, emergency lighting, exits signs and Jetfan system (in lieu of an exhaust system) for mechanical ventilation purposes

Note that both designs considered comprise the same layout and general building design.

22.2.4 *Assessment Approach*

The purpose of an automatic jet-fan system is to move carbon monoxide, a common by-product of motor vehicles, to a designated area where a dedicated exhaust system is used to extract these fumes. There are many reasons for the use of the Jet fans in lieu of individual exhaust points around the ceiling. A few of these reasons are related to economical, restrictions caused by obstructing features (such as beams, columns and the like) and efficiency.

The assessment will comprise the determination of any potential hazards the jetfans could potentially create in the event of a fire. This includes the effects they have on the operation of the sprinkler system in especially located within the air stream from the jetfan nozzle.

143 Australian Building Codes Board (ABCB), BCA 2014 Class 2 to 9 Buildings, Australian Building Codes Board, Canberra, Australia.

Based on the above information a comparative approach has been undertaken to show that both the BCA DtS compliant design and the proposed Alternative Solution feature the same risk profile.

22.2.5 *Comparative Assessment on Sprinkler Activation Time*

The sprinkler activation times for the BCA DtS complaint design and Alternative Solution are summarised below.

Based on a CFD modelling detailed in Appendix D, the sprinkler activation time for both the BCA DtS compliant design and Alternative Solution design has been tabulated in Table 22.2 below. For scenarios 2 and 3, jet-fans continue to run after sprinkler activation. The following scenarios were considered:

Table 22.2 – Sprinkler activation time

No.	Fire scenario	Jetfan (Yes/No)	Sprinkler head	Sprinkler activation time (s)
1a	Fire located in the driveway **(BCA DtS compliant design)**	No	Standard response	230
1b	Fire located in a car parking location. **(BCA DtS compliant design)**	No	Standard response	198
2a	Fire located in the driveway between the jet-fan and closes sprinkler head	Yes	Standard response	205
2b	Fire located away from the jet-fan in a car parking location.	Yes	Standard response	196
3a	Fire located in the driveway between the jet-fan and closes sprinkler head **(Alternative Solution)**	Yes	Fast response	169
3b	Fire located away from the jet-fan in a car parking location **(Alternative Solution)**	Yes	Fast response	149

The impact of the presence of jet-fans on sprinkler activation can be seen when comparing Scenario 2 and Scenario 1, where Scenario 1 represents a BCA DtS compliant design. A fire located in proximity to the jet-fan results in an earlier sprinkler activation time. A fire located away from the jet fan results in a delayed sprinkler activation time, compared to a BCA DtS design. The Alternative Solution, which involves the presence of jet-fans and fast response sprinkler heads, results in the sprinkler activation time for the Alternative Solution being shorter than that associated with the BCA DtS compliant design. Thus, the level of safety and the operation of the jetfan system, by way of the proposed fire safety strategy that forms the basis of the Alternative Solution, is considered to be equivalent to the BCA DtS compliant design.

The following requirements are proposed to mitigate the risk related to the operation of a jet-fan system

- Dedicated detector(s) to each jet fan to activate in the event of a fire located within 2 metres – 3 metres from a jet-fan in the air jet stream location, shown in Figure 22.1.

  N.B. As previously discussed, fan shutdown is not incorporated into the model and is considered as a sensitivity analysis approach. Fan shutdown via the proposed dedicated detectors, which form part of this alternative solution is considered to provide a means of mitigating any adverse effects of the presence of jet-fans on sprinkler activation.

- The jet-fan air stream is to be located in between two sprinkler heads and located at a minimum of 2.5 metres from any jet-fan.

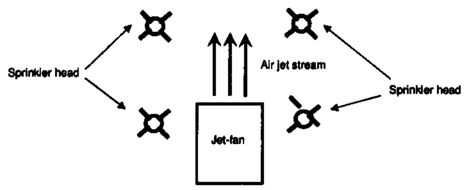


Figure 22.1 - Proposed jet-fan position

- Jet-fans will be monitored and controlled by the main jet-fan controller and at the main fire indicator panel.
- The jet-fans are to be located along the driveways and oriented such that the jet-stream is parallel to the driveways.
- Fire resisting cable recommended for the fire trip to the jet-fan panel from the Fire Indicating Panel (FIP) unless it has a fail-safe switch which switches it off should the connection be severed by a fire.
- Manual operation of the jet-fans from the main controller or fire indication panel is proposed.

22.2.6 *Comparing the Movement Of Smoke In Relation To Visibility*

It is considered that the likely amount of smoke accumulation within the car park during a fire event is similar to that of the BCA DtS-compliant designs.

In order to demonstrate that the conditions are similar as a result of the proposed geometry to result in a similar tenability period for evacuating occupants, CFD modelling has been undertaken, with the details presented within Appendix D.

The modelling results indicate that the standard response sprinkler heads associated with the BCA DtS-compliant designs lead to a faster time of smoke descent, as shown in Figure 22.2 and Figure 22.3 for times of 200 seconds and 400 seconds.

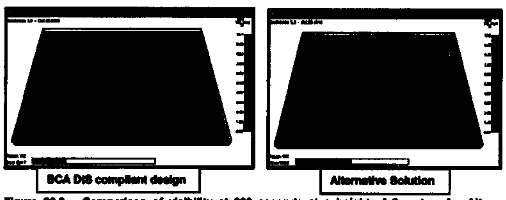


Figure 22.2 – Comparison of visibility at 200 seconds at a height of 2 metres for Alternative Solution and BCA DtS compliant design

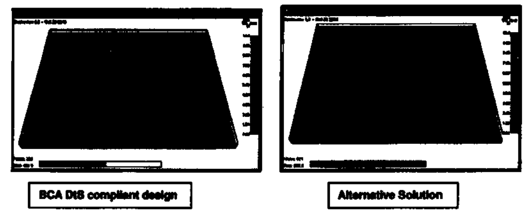


Figure 22.3 – Comparison of visibility at 400 seconds at a height of 2 metres for Alternative Solution and BCA DtS compliant design

Although these results should be treated with caution, due to the approximations associated with achieving a clear, uniform layer height in a compartment with such a low ceiling height which could affect the results, the use of the results for a comparative assessment is considered acceptable for the purposes of demonstrating the significant effects that the different designs have on smoke spread and, as a result of this, the advantages associated with the design of the Alternative Solution.

Impact of Enclosure Conditions and Exit Design on Occupant Evacuation

For consideration of the above results and the proposed egress design against the ability for occupants to safely evacuate as part of the Alternative Solution when compared to the BCA DtS-compliant designs, consideration is given to the following factors:

(i) In the event of a fire, occupants are able to move directly away from the seat of the fire within a short distance, due to the presence of alternative exits within the basement carparking levels; and

(ii) travel distances to a point of choice not exceeding the 20-metre allowance nominated by the BCA DtS provisions. The propensity for occupants to be trapped by the seat of the fire is therefore low (and equivalent to the DtS-compliant design).

22.2.7 *Additional Absolute Assessment*

The potential for fire start and development within proximity to the driveway location where the jet-fans are situated will be limited by the nature of the contents, the fire hazard, severity and fuel load within the carpark levels. The majority of the basement carpark levels are considered an "area of transit" and it is therefore not likely that any storage items would be placed within these areas.

A review of fire statistics in carparks[144] by BHP Melbourne Research Laboratories (MRL) has reported the following:

- There have been no death or serious injuries recorded for fires in carparks in Australia.
- The American Iron and Steel Institute (AISI) survey of US and Canadian carparks has indicated that fire safety risks within carparks are not significant, as there has been no recorded loss of life from a fire in a car in the carpark over a survey period of 60 years. Carparks are generally not a source of death or personal injury.
- The National Fire Protection association analysed fire loss from US and Canadian carparks from 1982 to 1986 and concluded that there is an extremely low fire safety hazard in carparks.
- The referenced AISI report concluded with the following statement: "It is clear from the available fire record that fires in carparks represent little risk to life or of injury, and very low monetary losses, possibly because of a very low frequency of fire starts in this type of building. Accordingly, the requirements for fire protection should not be excessive".

As the carpark levels are of a relatively open-plan design, a fire within the carpark level would be quickly noticed and occupants would evacuate to open space.

144 I.D. Bennetts, I.R., Thomas, K.H., Almand, D.J., Proe and R.R Lewins, "Fire in Carparks", BHP Melbourne Research Laboratories Report Number MRL/PS69/79/006, August 1989.

22.2.8 *Fire Brigade Intervention*

Assessment of the effects on fire brigade intervention of the proposed design is to be made, in order to ascertain that the design does not adversely affect fire-fighting activities.

The above assessment has demonstrated that the design is at least equivalent to a BCA DtS compliant design in relation to sprinkler operation and tenability, based on the operation and configuration of the jet fans and the presence of fast response sprinkler heads. As such, the impact on fire brigade search and rescue activities for the Alternative Solution is considered to be at least equivalent to a BCA DtS compliant design.

22.3 SUMMARY

The assessment undertaken above demonstrates that proposed Alternative Solution relating to the provision of jet-fans to the basement carparking level in lieu of a convention air handling system is at least equivalent to that of the similar BCA DtS compliant benchmark design.

It is therefore considered that the proposed design will satisfy the acceptance criteria given for this assessment within section 9.

23 ANALYSIS AGAINST BCA PERFORMANCE REQUIREMENTS

23.1 METHODOLOGY

This section considers the proposed Alternative Solutions derived in the fire safety engineering analysis and analyse the proposed fire safety design solution against the relevant Performance Requirements in the BCA. The BCA Assessment Methods that were used are Clause A0.9(b) and Clause A0.9(c).

23.2 STRUCTURAL STABILITY

The proposed fire safety strategy was analysed against BCA Performance Requirement CP1. Table 23.1 summarises the discussions of each parameter nominated by this BCA Performance Requirement.

Table 23.1 – BCA Performance Requirement CP1

Parameter for Consideration	Discussion	Parameter Addressed?
CP1 A building must have elements which will, to the degree necessary, maintain structural stability during a fire appropriate to-		
(a) the function or use of the bldg; and	The function or use of the building has been considered in relation to the proposed alternative solution, as discussed in sections 2.3 and 11.2.2.	Yes
(b) the fire load; and	The fire load has been considered in relation to the proposed alternative solution, as discussed in section 11.2.2.	Yes
(c) the potential fire intensity; and	The potential fire intensity has been considered in relation to the proposed alternative solution, as discussed in sections 2.3 and 11.2.2.	Yes
(d) the fire hazard; and	The fire hazard ("the danger in terms of potential harm and degree of exposure arising from the start and spread of fire and the smoke and gases that are thereby generated") has been considered in relation to the proposed alternative solution, as discussed in sections 2.3 and 11.2.2.	Yes
(e) the height of the building; and	The height of the building has been considered in relation to the proposed alternative solution, as discussed in sections 2.3 and 11.2.2.	Yes
(f) its proximity to other property; and	The proximity to other property has been considered in relation to the proposed alternative solution, as discussed in sections 2.3 and 11.2.2.	Yes
(g) any active fire safety systems installed in the building; and	The active fire safety systems installed in the building have been considered in relation to the proposed alternative solution, as discussed in sections 2.3 and 11.2.2.	Yes
(h) the size of any fire compartment; and	The size of any fire compartment has been considered in relation to the proposed alternative solution, as discussed in sections 2.3 and 11.2.2.	Yes
(i) fire brigade intervention; and	Fire brigade intervention has been considered in relation to the proposed alternative solution, as discussed in sections 2.3 and 11.2.2.	Yes
(j) other elements they support; and	The support of other elements has been considered in relation to the proposed alternative solution, as discussed in sections 2.3 and 11.2.2.	Yes
(k) the evacuation time.	The evacuation time has been considered in relation to the proposed alternative solution, as discussed in sections 2.3 and 11.2.2.	Yes

In accordance with acceptable methods outlined during the Fire Engineering Brief process, it is the considered opinion of Exova that the design satisfies the stakeholder-agreed fire safety objectives as they relate to this BCA Performance Requirement, subject to recommendations made in this report.

23.3 FIRE SPREAD

The proposed fire safety strategy was analysed against BCA Performance Requirement CP2. Table 23.2 summarises the discussions of each parameter nominated by this BCA Performance Requirement.

Table 23.2 – BCA Performance Requirement CP2

Parameter for consideration	Discussion	Parameter Addressed?
CP2 (a) A building must have elements which will, to the degree necessary, avoid the spread of fire-		
(i) to exits; and	Refer to comments under (i) to (xi) below.	N/A
(ii) to sole-occupancy units and public corridors; and	N/A	N/A
(iii) between buildings; and	Refer to comments under (i) to (xi) below.	N/A
(iv) in a building,	Refer to comments under (i) to (xi) below.	Yes
CP2 (b) Avoidance of the spread of fire referred to in (a) must be appropriate to-		
(i) the function or use of the building; and	The function or use of the building has been considered in relation to the proposed alternative solution, as discussed in sections 2.3, 11.2.2, 12.2.4, 21.2.4 and 21.2.5.	Yes
(ii) the fire load; and	The fire load has been considered in relation to the proposed alternative solution, as discussed in sections 11.2.2, 12.2.4, 21.2.4 and 21.2.5.	Yes
(iii) the potential fire intensity; and	The potential fire intensity has been considered in relation to the proposed alternative solution, as discussed in sections 11.2.2, 12.2.4, 13.2.2, 21.2.4 and 21.2.5.	Yes
(iv) the fire hazard; and	The fire hazard ("the danger in terms of potential harm and degree of exposure arising from the start and spread of fire and the smoke and gases that are thereby generated") has been considered in relation to the proposed alternative solution, as discussed in sections 11.2.2, 12.2.4, 13.2.2, 21.2.4 and 21.2.5.	Yes
(v) the number of storeys in the building; and	The height of the building has been considered in relation to the proposed alternative solution, as discussed in sections 11.2.2, 12.2.4, 13.2.2, 21.2.4 and 21.2.5.	Yes
(vi) its proximity to other property; and	The proximity to other property has been considered in relation to the proposed alternative solution, as discussed in sections 11.2.2, 12.2.4, 13.2.2, 21.2.4 and 21.2.5.	Yes
(vii) any active fire safety systems installed in the building	The active fire safety systems installed in the building have been considered in relation to the proposed alternative solution, as discussed in sections 11.2.2, 12.2.4, 13.2.2, 21.2.4 and 21.2.5.	Yes
(viii) the size of any fire compartment; and	The size of any fire compartment has been considered in relation to the proposed alternative solution, as discussed in sections 11.2.2, 12.2.4, 13.2.2, 21.2.4 and 21.2.5.	Yes
(ix) fire brigade intervention; and	Fire brigade intervention has been considered in relation to the proposed alternative solution, as discussed in sections 11.2.2, 12.2.4, 13.2.2, 21.2.4 and 21.2.5.	Yes
(x) other elements they support; and	The support of other elements has been considered in relation to the proposed alternative solution, as discussed in sections 11.2.2, 12.2.4, 13.2.2, 21.2.4 and 21.2.5.	Yes
(xi) the evacuation time.	The evacuation time has been considered in relation to the proposed alternative solution, as discussed in sections 11.2.2, 12.2.4, 13.2.2, 21.2.4 and 21.2.5.	Yes

In accordance with acceptable methods outlined during the Fire Engineering Brief process, it is the considered opinion of Exova that the design satisfies the stakeholder-agreed fire safety objectives as they relate to this BCA Performance Requirement, subject to recommendations made in this report.

23.4 NUMBER, DIMENSIONS AND DISTRIBUTION OF EXITS

The proposed fire safety strategy was analysed against BCA Performance Requirement DP4. Table 23.3 summarises the discussions of each parameter nominated by this BCA Performance Requirement.

Table 23.3 – BCA Performance Requirement DP4

Parameter for Consideration	Discussion	Parameter Addressed?
DP4 Exits must be provided from a building to allow occupants to evacuate safely, with their number, location and dimensions being appropriate to-		
(a) the travel distance; and	This travel distance has been considered in relation to the proposed Alternative Solution, as discussed in sections 15.2.4, 16.2.4, 17.2.4, 17.2.5, 18.2.4, 19.2.6 and 20.2.5.	Yes
(b) the number, mobility and other characteristics of occupants; and	The relevant occupant characteristics have been considered in relation to the proposed Alternative Solution, as discussed in sections 15.2.4, 16.2.4, 17.2.4, 17.2.5, 18.2.4, 19.2.6 and 20.2.4.	Yes
(c) the function or use of the building; and	The function or use of the building as a shopping centre has been considered in relation to the proposed Alternative Solution, as discussed in sections 2.3, 15.2.4, 16.2.4, 17.2.4, 17.2.5, 18.2.4, 19.2.6 and 20.2.3.	Yes
(d) the height of the building; and	The height of the building has been considered in relation to the Alternative Solution, as discussed in sections 15.2.4, 16.2.4, 17.2.4, 17.2.5, 18.2.4, 19.2.6 and 20.2.3.	Yes
(e) whether the exit is from above or below ground level.	Whether the exit is from above or below ground level has been considered in relation to the Alternative Solution, as discussed in sections 15.2.4, 16.2.4, 17.2.4, 17.2.5, 18.2.4, 19.2.6 and 20.2.3.	Yes

In accordance with acceptable methods outlined during the Fire Engineering Brief process, it is the considered opinion of Exova that the design satisfies the stakeholder-agreed fire safety objectives as they relate to this BCA Performance Requirement, subject to recommendations made in this report.

23.5 FIRE-ISOLATION OF EXITS

The proposed fire safety strategy was analysed against BCA performance requirement DP5. Table 23.4 summarises the discussions of each parameter nominated by this BCA performance requirement.

Table 23.4 - BCA Performance Requirement DP5

Parameter for consideration	Discussion	Parameter addressed?
DP5: To protect evacuating occupants from a fire in the building exits must be fire isolated, to the degree necessary, appropriate to –		
(a) the number of storeys connected by the exits; and	The number of storeys connected by the exits has been considered in relation to the proposed alternative solution, as discussed in sections 14.2.4 and 14.2.5.	Yes.
(b) the fire safety system installed in the building; and	The fire safety systems have been considered in relation to the proposed alternative solution, as discussed in sections 14.2.4 and 14.2.5.	Yes.
(c) the function or use of the building; and	The function or use of the building has been considered in relation to the proposed Alternative Solution, as discussed in alternative solution, as discussed in sections 2.3, 14.2.4 and 14.2.5.	Yes.

Parameter for consideration	Discussion	Parameter addressed?
(d) the number of storeys passed through by the exits; and	The number of storeys passed through has been considered in relation to the proposed Alternative Solution, as discussed in alternative solution, as discussed in sections 14.2.4 and 14.2.5.	Yes.
(e) fire brigade intervention.	Fire brigade intervention has been considered in relation to the alternative solution, as discussed in sections 2.1.5 and 14.2.6.	Yes.

In accordance with acceptable methods outlined during the Fire Engineering Brief process, it is the considered opinion of Exova that the design satisfies the stakeholder-agreed fire safety objectives as they relate to this BCA Performance Requirement, subject to recommendations made in this report.

23.6 FIRE SUPPRESSION SYSTEM

The proposed fire safety strategy was analysed against BCA Performance Requirement EP1.4. Table 23.5 summarises the discussions of each parameter nominated by this BCA Performance Requirement.

Table 23.5 - BCA Performance Requirement of EP1.4

Parameter for Consideration	Discussion	Parameter Addressed?
EP1.4 An automatic fire suppression system must be installed to the degree necessary to control the development and fire appropriate to-		
(a) the size of the fire compartment	The size of the fire compartment has been considered in relation to the proposed Alternative Solution, as discussed in sections 2.2 and 22.2.3.	Yes
(b) the function or use of the building	The function or use of the building has been considered in relation to the proposed Alternative Solution, as discussed in sections 2.3 and 22.2.3.	Yes
(c) the fire hazard; and	The fire hazard has been considered in relation to the proposed Alternative Solution, as discussed in sections 6 and 22.2.3.	Yes
(d) the height of the building.	The height of the building has been considered in relation to the proposed Alternative Solution, as discussed in sections 2.2 and 22.2.3.	Yes

In accordance with acceptable methods outlined during the Fire Engineering Brief process, it is the considered opinion of Exova that the design satisfies the stakeholder-agreed fire safety objectives as they relate to this BCA Performance Requirement, based on a comparative assessment to demonstrate equivalence with the DtS provisions, subject to recommendations made in this report

23.7 SMOKE HAZARD MANAGEMENT

The proposed fire safety strategy was analysed against BCA performance requirement EP2.2. Table 23.6 summarises the discussions of each parameter nominated by this BCA performance requirement.

Table 23.6 - BCA Performance Requirement EP2.2

Parameter for Consideration	Discussion	Parameter addressed?
EP2.2 (a) In the event of a fire in a building the conditions in any evacuation route must be maintained for the period of time occupants take to evacuate the part of the building so that-		
(i) the temperature will not endanger human life; and	The temperature, level of visibility and level of toxicity has been considered in relation to the proposed alternative solution, as discussed in sections 14.2.5, 15.2.4, 16.2.4, 17.2.4, 21.2.6 and 22.2.6.	Yes.
(ii) the level of visibility will enable the evacuation route to be determined; and		Yes.

Parameter for Consideration	Discussion	Parameter addressed?
(iii) the level of toxicity will not endanger human life.		Yes.
(b) The period of time occupants take to evacuate referred to in (a) must be appropriate to-		
(i) the number, mobility and other characteristics of the occupants; and	The number, mobility and other characteristics of occupants have been considered in relation to the proposed alternative solution, as discussed in sections 14.2.5, 15.2.4, 16.2.4, 17.2.4, 21.2.6 and 22.2.6.	Yes.
(ii) the function or use of the building; and	The function or use of the building as a residential building has been considered in relation to the proposed alternative solution, as discussed in sections 2.3, 14.2.4, 15.2.3, 16.2.3, 17.2.3, 21.2.6 and 22.2.3.	Yes.
(iii) the travel distance and other characteristics of the building; and	The travel distance has been considered in relation to the proposed alternative solution, as discussed in sections 14.2.4, 15.2.3, 16.2.3, 17.2.3, 21.2.6 and 22.2.6.	Yes.
(iv) the fire load; and	The fire (fuel) load has been considered in relation to the proposed alternative solution, as discussed in sections 10.3, 14.2.4, 15.2.4, 16.2.3, 17.2.4, 17.2.5, 21.2.6 and 22.2.6.	Yes.
(v) the potential fire intensity; and	The potential fire intensity in the building has been considered in relation to the proposed alternative solution, as discussed in sections 10.3, 14.2.4, 15.2.4, 16.2.3, 17.2.4, 17.2.5, 21.2.6 and 22.2.6.	Yes.
(vi) the fire hazard; and	The fire hazard ("the danger in terms of potential harm and degree of exposure arising from the start and spread of fire and the smoke and gases that are thereby generated") has been considered in relation to the proposed alternative solution, as discussed in sections 6, 14.2.4, 15.2.4, 16.2.3, 17.2.4, 17.2.5, 21.2.6 and 22.2.6.	Yes.
(vii) any active fire safety systems installed in the building; and	The active fire protection systems have been considered in relation to the proposed alternative solution, as discussed in sections 7.3, 14.2.3, 15.2.3, 16.2.3, 17.2.3, 21.2.6 and 22.2.6.	Yes.
(viii) fire brigade intervention.	Fire brigade intervention has been considered in relation to the proposed alternative solution, as discussed in sections 2.1.5, 14.2.6, 15.2.5, 16.2.5, 17.2.6, 21.2.6 and 22.2.6.	Yes.

In accordance with acceptable methods outlined during the Fire Engineering Brief process, it is the considered opinion of Exova that the design satisfies the stakeholder-agreed fire safety objectives as they relate to this BCA Performance Requirement, subject to recommendations made in this report.

24 CONCLUSION

24.1 General

The proposed alternative solutions described herein have been formulated in consideration of BCA clauses A0.5(b)(i), A0.5(b)(ii) and A0.8 and assessment methods A0.9(b)(ii) and A0.9(c), as agreed by the stakeholders during the FEB process.

It is the considered opinion of Exova Warringtonfire Aust Pty Ltd that the proposed alternative solutions satisfy BCA performance requirements CP1, CP2, DP4, DP5, EP1.4 and EP2.2 subject to the implementation of the fire safety strategy identified below.

24.2 Recommended Fire Safety Design Strategy

A description of the proposed fire safety design strategy for the development is outlined within section 7.1, 7.2 and 7.3 "Fire Safety Design".

24.3 Construction & Commissioning Requirements

A description of the proposed construction, commissioning and certification requirements for the development is outlined within section 7.4 "Standards of Construction, Commissioning, Management and Maintenance".

24.4 Engineering Judgement

Engineering judgement has been used in the fire safety engineering analyses to determine and undertake appropriate methods to assess in qualitative terms the fire safety engineering issues relevant to this project.

24.5 Expert Judgement[146]

Expert judgement has been relied upon to the extent that determination of the BCA Deemed-to-Satisfy Provisions and intent, together with determination of the BCA Performance Requirements and intent, requires expertise in the use, interpretation and application of the BCA in relation to a comparative analysis.

146 As required by the Documentation of Decisions section in the Introduction to the BCA.

25 VALIDITY / DISCLAIMER

This report is prepared for the proposed development at 2 Daydream Street, Warriewood NSW 2102 and should not be applied to other buildings.

This report has formulated and analysed a fire safety design solution against fire safety objectives developed in conjunction with relevant stakeholders and Authorities Having Jurisdiction during the Fire Engineering Brief process. Other issues not specifically addressed in the context of that detailed in the Fire Engineering Brief process have been excluded from the scope of this report.

Any modifications or changes to the building, fire safety management system, or building usage from that described may invalidate the findings of this report. Should such changes occur, a re-assessment should be sought.

Arson has been shown statistically to contribute to fire. This report has addressed the incidence of minor forms of arson as a single ignition source; however, major arson involving accelerants and/or multiple ignition sources are beyond the scope of this analysis and therefore have been excluded from the report.

Attention is drawn to the conditions of use depicted on page 2 of this report.

APPENDIX A EVACUATION CALCULATIONS

A.1. Occupant Egress Assessment Overview

This appendix addresses the evacuation of occupants from the building, given the variation relating to exit travel distances, travel distances to a point of choice and travel distances between alternative exits from each of the subject tenancy spaces.

The total evacuation time for the occupants within each respective part of the building is the summation of the following component times[146]:

(i) Detection (cue) phase (T_c) – detection time or time until people become aware of the fire.

(ii) Pre-movement / response phase (T_{pre}) – time taken for occupants to begin to move towards the exits once an alarm or intrinsic cue has been received.

(iii) Movement phase (T_m) – time for occupants to move to an exit or a safe place (being the point of choice in this case).

(iv) Evacuation phase (RSET) = $T_c + T_r + T_m$

A.2. Detection Time

The detection time, T_c, is the time interval between the ignition of the fire and the time that the occupants become aware of a fire incident within the building.

The detection time is generally given by the time at which the fire alarm is sounded by the automatic fire detection system or the time at which the occupants receive a clear visual or olfactory cue, such as from smoke. Real events usually include the response of occupants being subject to physical cues, such as seeing the fire or smoke, smelling smoke etc. Multiple cues are considered to be consistent with real events.

Basement Carpark Detection Time

With regard to the detection time for the occupants located within the basement carpark, the proposed sprinkler heads will provide an alarm cue in the event of a fire in any part of the building for those not intimate with the fire who are expected to initially receive a cue. The activation of the sprinkler system has been calculated using FireCalc[147], based on a medium t^2 fire for the basement carpark and the following sprinkler head characteristics:

- RTI = 200 $m^{½} s^{½}$ (BCA DtS compliant design)[148] / 50 $m^{½} s^{½}$ (Alternative Solution) [149]
- Activation Temperature = 68 °C
- Radial distance from fire plume = 2.5 m
- Ceiling height within the car park areas = 2.85 metres

146 Australian Building Codes Board, ABCB, International Fire Engineering Guidelines Edition 2005, Australian Building Codes Board, Australia, 2005.
147 CSIRO, FIRECALC, Version 2.3, CSIRO Division of Building Construction and Engineering, 1993.
148 Chartered Institute of Building Services Engineers, "CIBSE Guide E – Fire Engineering", CIBSE Publications Department, Second Edition, 2003.
149 Chartered Institute of Building Services Engineers, "CIBSE Guide E – Fire Engineering", CIBSE Publications Department, Second Edition, 2003

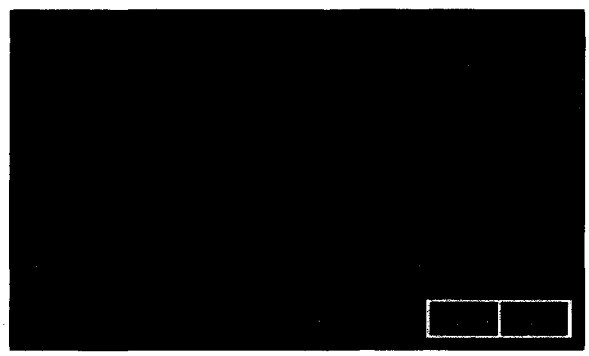


Figure A.1 – Detection time based on the activation of standard-response sprinkler head (BCA DtS compliant design)

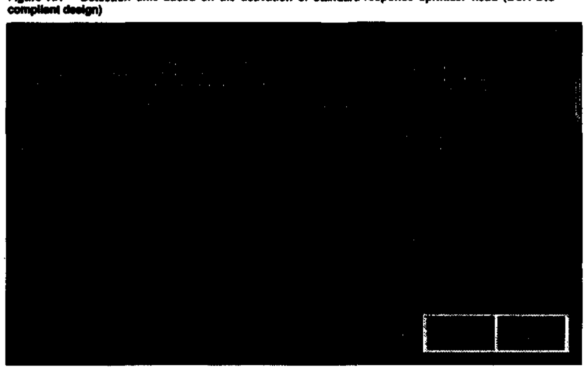


Figure A.2 – Detection time based on the activation of fast-response sprinkler head (Alternative Solution)

As such, the detection time for the alternative solution is expected to be shorter based on the provision of fast-response sprinkler heads, in lieu of standard response sprinkler heads.

G.3 Warehouse Tenancy Detection Time (excludes mezzanine)

With regard to the detection time for the occupants located within the warehouse, the proposed sprinkler heads will provide an alarm cue in the event of a fire in any part of the building for those not intimate with the fire. The activation of the sprinkler system has been calculated using FireCalc[150], based on a medium t^2 fire for the warehouse area and the following sprinkler head characteristics:

- RTI = 200 $m^{1/2} s^{1/2}$
- Activation Temperature = 68°C
- Radial distance from fire plume = 2.5 m

The Firecalc program showing the output data is given below in Figure A.3.

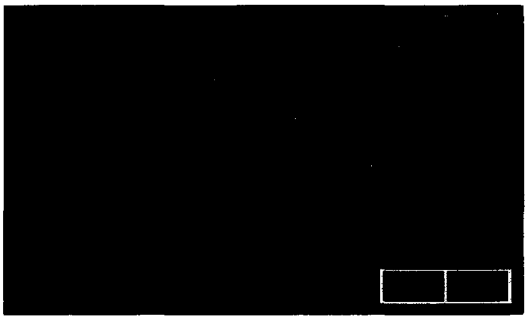


Figure A.3 – Activation time for a fast t^2 fire within Tenancy G.3

The detection time is therefore 298 seconds for the proposed alternative solution in Tenancy G.3.

Level 2 Office Detection Time

As shown in Figure A.6 to Figure A.7, activation of the detection system has been calculated using FireCalc[151] with the following detector characteristics:

- Activation temperature = 13°C above ambient[152 153] *(note that for the purposes of the use of Firecalc for detector response estimation, the actual ambient temperature selected does not affect the outcome of the calculation, subject to a difference of 13°C between ambient and activation temperatures being maintained)*
- Radial distance from fire = 14.4 metres (BCA DtS compliant design – refer to Figure A.4)

  Radial distance from fire = 7.2 metres (Alternative Solution – refer to Figure A.5)
- RTI = 10 $m^{½} s^{½}$
- Medium t^2 growth rate

150 CSIRO, FIRECALC, Version 2.3, CSIRO Division of Building Construction and Engineering, 1993.
151 CSIRO, FIRECALC, Version 2.3, CSIRO Division of Building Construction and Engineering, 1993.
152 Fire Safety Engineering Guidelines (Second Edition), Australian Building Codes Board, November 2001.
153 *Bukowski, R. W. and Averill, J. D., Methods for Predicting Smoke Detector Activation, Proceedings of the Fire Suppression* and Detection Research Application Symposium, Research & Practice, Bridging the Gap, Feb 25-27, 1998, Orlando, FL, NFPRF, Quincy, MA, 1998.

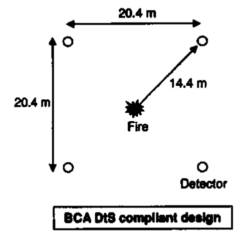


Figure A.4 – Radial distance of detectors to a fire for the BCA DtS compliant design

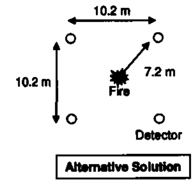


Figure A.5 – Radial distance of detectors to a fire for an Alternative Solution

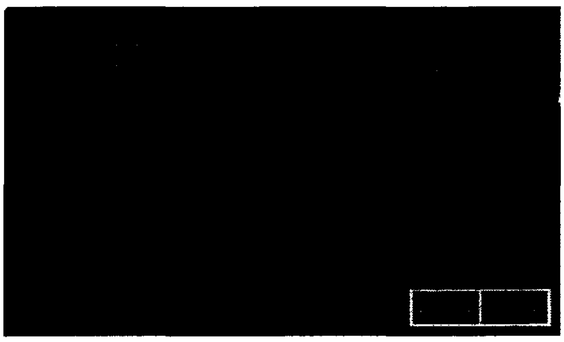


Figure A.6 – Detection time based on activation of smoke detection system (BCA DtS compliant design)

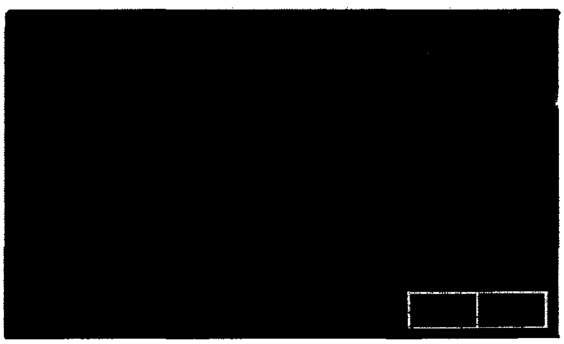


Figure A.7 – Detection time based on activation of smoke detection system (Alternative Solution)

The detection time for the Alternative Solution is shorter, based on the 10.2 metre spacing of the detectors associated with the proposed AS 1670.1-2004 system, which contrasts with the 20.4 metre spacing as stipulated in AS 1668.1-1998.

A.3. Pre-movement time

The pre-movement time, T_{pre}, is the time interval between occupants becoming aware of the fire and commencement of evacuation. One response is to seek more information about the nature of the fire and another is to try to extinguish the fire.

A number of other factors influence the response time to an incident, such as occupant familiarity with the building, interaction between occupants in groups, the perceived threat of the fire and the type of evacuation alarm[154]. In the case that the occupants receive a clear visual cue, such as of smoke, the pre-movement time would be short (60 seconds or less in some cases[155]), as typically encountered in the room of fire origin.

This is consistent with findings from studies in the evacuation of open plan buildings, including the work of Frantzich[156], and would apply to occupants within the floor of fire origin who are located in proximity to the fire.

As the building is to feature an automatic alarm system incorporating a pre-recorded voice message, the best possible scenario with the occupants responding to a voice message is 120 seconds.

For the BCA DtS-compliant design, the benchmark DtS-compliant design is not required to incorporate a voice message. The response time for the BCA DtS design would therefore be based on an automatic alarm not incorporating a voice message. The best possible scenario, with the occupants responding to an alarm bell is 180 seconds.

A.4. Movement time within Tenancy G.3 between Exits

The movement time, T_m, is the time interval between the commencement of evacuation and the completion of evacuation to a specified point. This assessment is concerned with the movement times to reach a point of choice.

The total occupant movement time to an exit or past a specified point is either:

(i) walking time to the exits (usually governs the movement time when the number of occupants is low relative to the width of the exits

(ii) queuing time through the exits (usually governs the movement time when the number of occupants is high relative to the width of the exits and the occupants are well-distributed).

Walking speeds will vary, based on the occupant density in each part of the building and the physical abilities of the occupants. For a person with an average mobility, such as a staff member or visitor, an unobstructed evacuation speed of 1.19 metres/s has been reported[157], whilst for people with disabilities, who may require the assistance of a walking frame, an evacuation speed of 0.57 metres/s has been reported[158]. These unobstructed speeds and flows are considered to be appropriate for occupants travelling through open areas to exit points and stairways, based on an occupant density of less than 0.54 persons/m^2 [159].

In addition to a walking speed of 1.19 m/s, a speed of 0.57 metres/s will also be considered as part of a sensitivity study to account for the walking speed of occupants with disabilities.

The most severe assessment involves consideration of the occupant walking time to a second exit, rather than the queuing time into the exits, as the queuing time will be equivalent for both the proposed and DtS compliant designs due to identical populations and exit widths. As such, the queuing time will not be calculated, which will result in an improved level of performance associated with the DtS compliant benchmark design.

The following equation has been used to determine the walking time:

$$T = d/s$$

154 Sime, J. D., Assessing Occupant Response Time: A Key Issue for Fire Engineering. In R. Barham (ed.) Fire and Emergency Planning: Research and Applications, E & F N Spon, London (48, pp442-449), 1996.
155 Fire Code Reform Centre (FCRC) Fire Safety in Shopping Centres Final Research Report - Project 6, 1998.
156 Frantzich, H., Occupant Behaviour and Response Time – Results from Evacuation Experiments, Conference Proceedings to the 2nd International Symposium on Human Behaviour in Fire. Interscience Communications, 159-165, Boston, MA, 2001.

Ion Experiments, Conference Proceedings to the 2nd International Symposium on Human Behaviour in Fire. Interscience Communications, 159-165, Boston, MA, 2001.

158 Proulx G, Movement of People: The Evacuation Timing, The SFPE Handbook of Fire Protection Engineering, 3rd ed, National Fire Protection Association, US, 2002.
159 Nelson, H.E., & Mowrer, F.W., Emergency Movement, The SFPE Handbook of Fire Protection Engineering, 3rd ed, National Fire Protection Association, US, 2002.

Where:

T = walking time to a point of choice (s)

d = distance from furthest point to a point of choice (m)

s = travel speed in (m/s) i.e. 1.19 m/s and 0.57 m/s

Based on an evacuation speed of 1.19 metres/s, which is considered reasonable to represent the subject Tenancy G.3, the time to travel 110 metres (40 + 70) to a second exit, 92 seconds.

Table A.1 – Movement time between alternative exits

Alternative Solution* (s)	BCA DtS compliant benchmark (s)
92	N/A

* Based on an evacuation speed of 0.57 m/s, movement times for the sensitivity study are approximately 193 s for the alternative solution.

A.5. Movement Time to and Between Exits within Basement Carpark

The movement time, T_m, is the time interval between the commencement of evacuation and the completion of evacuation to a specified point. This assessment is concerned with the movement times to reach a point of choice.

The total occupant movement time to an exit or past a specified point is either:

(iii) walking time to the exits (usually governs the movement time when the number of occupants is low relative to the width of the exits

(iv) queuing time through the exits (usually governs the movement time when the number of occupants is high relative to the width of the exits and the occupants are well-distributed).

Walking speeds will vary, based on the occupant density in each part of the building and the physical abilities of the occupants. For a person with an average mobility, such as a staff member or visitor, an unobstructed evacuation speed of 1.19 metres/s has been reported[160], whilst for people with disabilities, who may require the assistance of a walking frame, an evacuation speed of 0.57 metres/s has been reported[161]. These unobstructed speeds and flows are considered to be appropriate for occupants travelling through open areas to exit points and stairways, based on an occupant density of less than 0.54 persons/m² [162].

In addition to a walking speed of 1.19 m/s, a speed of 0.57 metres/s will also be considered as part of a sensitivity study to account for the walking speed of occupants with disabilities.

The most severe assessment involves consideration of the occupant walking time to a second exit, rather than the queuing time into the exits, as the queuing time will be equivalent for both the proposed and DtS compliant designs due to identical populations and exit widths. As such, the queuing time will not be calculated, which will result in an improved level of performance associated with the DtS compliant benchmark design.

The following equation has been used to determine the walking time:

T = d/s

Where:

T = walking time to a point of choice (s)

d = distance from furthest point to a point of choice (m)

s = travel speed in (m/s) i.e. 1.19 m/s and 0.57 m/s

Based on an evacuation speed of 1.19 metres/s, which is considered reasonable to represent the basement carpark, the time to travel 185 metres (65 + 120) to a second exit, is 155 seconds. For the BCA DtS compliant design, the time to travel 100 metres (40 + 60) is 84 seconds. The movement times to a second exit are summarised in Table A.2 below.

Ion Experiments, Conference Proceedings to the 2nd International Symposium on Human Behaviour in Fire. Interscience Communications, 159-165, Boston, MA, 2001.

161 Proulx G, Movement of People: The Evacuation Timing, The SFPE Handbook of Fire Protection Engineering, 3rd ed, National Fire Protection Association, US, 2002.

162 Nelson, H.E., & Mowrer, F.W., Emergency Movement, The SFPE Handbook of Fire Protection Engineering, 3rd ed, National Fire Protection Association, US, 2002.

Table A.2 – Movement time to reach a point of choice

Alternative Solution* (s)	BCA DtS compliant benchmark (s)
155	84

* Based on an evacuation speed of 0.57 m/s, movement times for the sensitivity study are approximately 324 s for the alternative solution and 147 s for the BCA DtS compliant design.

A.6. Movement Time within Tenancy G.3 Mezzanine to Single Exit

The movement time, T_m, is the time interval between the commencement of evacuation and the completion of evacuation to a specified point. This assessment is concerned with the movement times to reach a single exit.

The total occupant movement time to an exit or past a specified point is either:

(i) walking time to the exits (usually governs the movement time when the number of occupants is low relative to the width of the exits

(ii) queuing time through the exits (usually governs the movement time when the number of occupants is high relative to the width of the exits and the occupants are well-distributed).

Walking speeds will vary, based on the occupant density in each part of the building and the physical abilities of the occupants. For a person with an average mobility, such as a staff member or visitor, an unobstructed evacuation speed of 1.19 metres/s has been reported[163], whilst for people with disabilities, who may require the assistance of a walking frame, an evacuation speed of 0.57 metres/s has been reported[164]. These unobstructed speeds and flows are considered to be appropriate for occupants travelling through open areas to exit points and stairways, based on an occupant density of less than 0.54 persons/m² [165].

In addition to a walking speed of 1.19 m/s, a speed of 0.57 metres/s will also be considered as part of a sensitivity study to account for the walking speed of occupants with disabilities.

The most severe assessment involves consideration of the occupant walking time to a single exit, rather than the queuing time through the point of choice or into the exits, as the queuing time will be equivalent for both the proposed and DtS compliant designs due to identical populations and exit widths. As such, the queuing time will not be calculated, which will result in an improved level of performance associated with the DtS compliant benchmark design.

The following equation has been used to determine the walking time:

T = d/s

Where:

T = walking time to a point of choice (s)

d = distance from furthest point to a point of choice (m)

s = travel speed in (m/s) i.e. 1.19 m/s and 0.57 m/s

Based on an evacuation speed of 1.19 metres/s, which is considered reasonable to represent the subject building, the time to travel 25 metres to an exit is approximately 21 seconds. For the BCA DtS compliant design the time to travel 20 metres to an exit is 17 seconds. The movement times to reach the exit summarised in Table A.2 below.

Table A.3 – Movement time to reach a single exit

Alternative Solution* (s)	BCA DtS compliant benchmark (s)
23	17

* Based on an evacuation speed of 0.57 m/s, movement time for the sensitivity study is approximately 44 s for the alternative solution and 35 s for the BCA DtS compliant design.

Ion Experiments, Conference Proceedings to the 2nd International Symposium on Human Behaviour in Fire. Interscience Communications, 159-165, Boston, MA, 2001.

164 Proulx G, Movement of People: The Evacuation Timing, The SFPE Handbook of Fire Protection Engineering, 3rd ed, National Fire Protection Association, US, 2002.

165 Nelson, H.E., & Mowrer, F.W., Emergency Movement, The SFPE Handbook of Fire Protection Engineering, 3rd ed, National Fire Protection Association, US, 2002.

A.7. Movement Time to a Single Exit within Level 2 Office

The movement time, T_m, is the time interval between the commencement of evacuation and the completion of evacuation to a specified point. This assessment is concerned with the movement times to reach a single exit.

The total occupant movement time to an exit or past a specified point is either:

(i) walking time to the exits (usually governs the movement time when the number of occupants is low relative to the width of the exits

(ii) queuing time through the exits (usually governs the movement time when the number of occupants is high relative to the width of the exits and the occupants are well-distributed).

Walking speeds will vary, based on the occupant density in each part of the building and the physical abilities of the occupants. For a person with an average mobility, such as a staff member or visitor, an unobstructed evacuation speed of 1.19 metres/s has been reported[166], whilst for people with disabilities, who may require the assistance of a walking frame, an evacuation speed of 0.57 metres/s has been reported[167]. These unobstructed speeds and flows are considered to be appropriate for occupants travelling through open areas to exit points and stairways, based on an occupant density of less than 0.54 persons/m² [168].

In addition to a walking speed of 1.19 m/s, a speed of 0.57 metres/s will also be considered as part of a sensitivity study to account for the walking speed of occupants with disabilities.

The most severe assessment involves consideration of the occupant walking time to a single exit, rather than the queuing time through the point of choice or into the exits, as the queuing time will be equivalent for both the proposed and DtS compliant designs due to identical populations and exit widths. As such, the queuing time will not be calculated, which will result in an improved level of performance associated with the DtS compliant benchmark design.

The following equation has been used to determine the walking time:

T = d/s

Where:

T = walking time to a point of choice (s)

d = distance from furthest point to a point of choice (m)

s = travel speed in (m/s) i.e. 1.19 m/s and 0.57 m/s

Based on an evacuation speed of 1.19 metres/s, which is considered reasonable to represent the subject office area, the time to travel 30 metres to an exit is approximately 25 seconds. For a BCA DtS compliant design the time to travel 20 metres to an exit is approximately 17 seconds. The movement times to reach an exit are summarised in Table A.2 below.

Table A.4 – Movement time to reach the single exit

Alternative Solution* (s)	BCA DtS compliant benchmark (s)
25	17

* Based on an evacuation speed of 0.57 m/s, movement times for the sensitivity study is approximately 53 s for the Alternative Solutions and 35 s for the BCA DtS compliant design.

A.8. Evacuation Time

Comparison of the evacuation times between the BCA DtS compliant benchmark design and the proposed alternative solutions are summarised in Table A.5 below.

Ion Experiments, Conference Proceedings to the 2nd International Symposium on Human Behaviour in Fire. Interscience Communications, 159-165, Boston, MA, 2001.

167 Proulx G, Movement of People: The Evacuation Timing, The SFPE Handbook of Fire Protection Engineering, 3rd ed, National Fire Protection Association, US, 2002.

168 Nelson, H.E., & Mowrer, F.W., Emergency Movement, The SFPE Handbook of Fire Protection Engineering, 3rd ed, National Fire Protection Association, US, 2002.

Table A.5 – Evacuation times for the BCA DtS Design and Alternative Solution

Location	Alternative Solution (s)	BCA DtS compliant benchmark (s)
Tenancy G.3	Detection time = 298 Pre-movement time = 120 Movement time = 92 Total = 759 seconds	N/A
Basement Carpark	Detection time = 207 Pre-movement time = 120 Movement time = 155 Total = 482 seconds	Detection time = 294 Pre-movement time = 180 Movement time = 84 Total = 558 seconds
Tenancy G.3 Mezzanine	Detection time = equivalent Pre-movement time = 120 Movement time = 23 54 seconds less than BCA DtS complaint design	Detection time = equivalent Pre-movement time = 180 Movement time = 17 54 seconds more than alternative solution
Level 2 Office	Detection time = 113 Pre-movement time = 120 Movement time = 25 Total = 258 seconds	Detection time = 157 Pre-movement time = 180 Movement time = 17 Total = 354 seconds

APPENDIX B WAREHOUSE TENANCY FIRE MODELLING

B.1. Zone Modelling

The relatively small floor area with and geometrically simple compartment of the warehouse is considered to result in zone modelling being applicable to the assessment. As the subject warehouse could be separated into two separate tenancies, a floor area of approximately 800 m^2 has been considered for the purposes of modelling.

The major limitation of zone modelling techniques is the lack of details within the zone. Variation of temperatures and densities within the zones (e.g. stratification, turbulence) is not modelled. However, with respect to enclosure volume, zone model programs have been extensively validated against data from smaller enclosures. In particular, the application of CFAST to smoke modelling in relatively large volumes has been verified in a number of instances, as reported below:

- By Chow[169] in comparing the smoke filling processes in an atrium of dimensions 30 m x 24 m and 26.3 m high (volume approx. 19,000 m^3) with a 1.3 MW fire and the author stated that the model gave a satisfactory prediction of the experimental results.
- By Duong[170] in comparing the test results for a 36 MW fire with roof vents in an aircraft hanger of approximate dimensions of 54.2 m x 94 m with an arched roof of 15m maximum height (volume approx. 62,000 m^3). The author stated that CFAST tended to over predict the mass *entrainment rate and smoke layer depth and temperature. Hence, the results produced by the* FAST model were more conservative.

Project 6 – Fire Safety in Shopping Centres[171] states that a zone model, such as CFAST, can be used to estimate the smoke layer (hot layer) depth in an enclosure in the event of a fire.

Based on the above discussion, and given that the building layout for the area to be modelled feature a relatively simple geometry, it is considered appropriate to employ zone modelling techniques for the purposes and the depth of this study.

Each compartment is modelled as two zones, a relatively 'hot' upper layer where the combustion effluents would accumulate and a relatively 'cold' lower layer where oxygen supply is obtained for combustion. It is assumed that physical properties such as temperature and density are uniform within a zone. The fire serves as the engine in the model to transfer mass and energy from the lower layer to the upper layer. In general, as the fire develops with time, the upper layer expands, its temperature increases and the interface of the two layers descends. The formation of two layers is in general accordance with what has been observed from room fire tests.

As discussed above, the major limitation of zone modelling techniques is the lack of details within the zone. Variation of temperatures and densities within the zones (e.g. stratification, turbulence) is not modelled. However, for the purposes and the depth of this study, it is considered appropriate to employ zone modelling techniques for the simulation.

The computer based zone fire model CFAST Version 3.1.7[172] has been used to predict the interface upper smoke layer height for the selected fire scenarios and the results used to estimate tenability conditions.

B.2. Basic Model Geometry

The warehouse has been considered in the model based on it being the worse-case scenario. The model inputs are shown in Table 6 below.

169 Chow, W.K., "A Short Note on the Simulation of Atrium Smoke Filling Process Using Fire Zone Models", Journal of Fire Sciences, Vol. 12, 1994, pp. 516-528.
170 Duong, D.Q., "The Accuracy of Computer Fire Models: Some Comparisons with Experimental Data from Australia", Fire Safety Journal, Vol. 16, 1990, pp. 415-431.
171 FCRC, Fire Safety in Shopping Centres, Final Research Report - Project 6, Fire Code Reform Centre Ltd, Sydney, Australia, 1998.
Peacock, Richard D., et al., FAST, the Consolidated Model of Fire Growth and Smoke Transport, NIST Technical Note, 1992, February 1993.

Table 6 – Warehouse geometry for each scenario

Model run	Floor area (m)	Average enclosure height (m)
Alternative solution	20 x 40	10.35
BCA DtS design	20 x 40	2.4

B.3. Smoke Toxicity Assessment

Toxicity is required to be assessed in the event where smoke descends to less than 2.1m above floor level.

An assessment of the smoke concentration is not required to be undertaken, as the smoke layer height does not reach 2.1m throughout the course of the model.

B.4. Zone Modelling Results

The modelling results from Figure 8 and Figure 9 indicate that the lower enclosure heights associated with the BCA DtS-compliant design lead to a more rapid descent of smoke.

Hot layer temperatures are similar for both designs for the initial period of burning that would coincide with the time during which occupants are evacuating from the car park.

Although these results should be treated with caution, due to the approximations associated with achieving a clear, uniform layer height in a compartment with such a low ceiling height and the lack of consideration of external factors, such as wind, which could affect the results, the use of the results for a comparative assessment is considered acceptable for the purposes of demonstrating the significant effects that the different geometries have on smoke spread and, as a result of this, the advantages associated with the geometry of the Alternative Solution.

Table 7 – Warehouse tenancy result

Scenario	Time to onset of untenability	Smoke layer height to reach below 2.1 m
Alternative Solution	Approx. 700 s	Approx. 600 s
BCA DtS compliant design	Approx. 100 s	Approx. 100 s

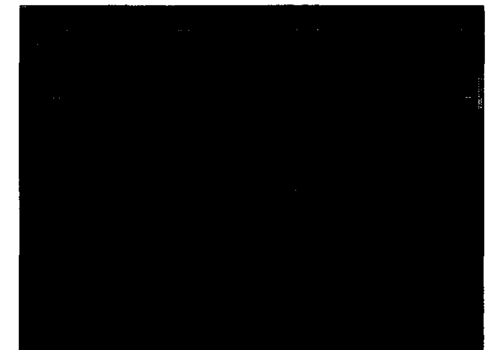


Figure 8 – Alternative Solution result

Figure 9 – BCA DtS design result

B.5. ASET Values

Tenability Criteria

The environment around the evacuating occupants in the Level 1 carpark is deemed to have reached untenable conditions when the following temperatures occur:

1. Air / smoke temperature reaches 183°C (approximately equivalent to 2.5kW/m^2) consistently across the entire fire enclosure at any height.
2. Air / smoke temperature reaches 60°C in the vicinity of the egress paths at a height of 2.1 m or less.

The criteria for tenability are generally derived from those presented in the International Fire Engineering Guidelines173 and the SFPE Handbook[174].

Visibility within floor area

The environment around the evacuating occupants in the warehouse tenancy is deemed to have reached untenable conditions when stagnant smoke is formed below 2.1 m in the vicinity of the egress path which limits the visibility to less than 10 m, which is equivalent to an optical density of 0.1m^{-1} or 1.0 db/m (s).

173 International Fire Engineering Guidelines (IFEG), Australian Building Codes Board, 2005.
174 Purser D, Toxicity Assessment of Combustion Products, The SFPE Handbook of Fire Protection Engineering, 3rd ed, National Fire Protection Association, US, 2002.

APPENDIX C FIRE BRIGADE INTERVENTION MODEL

C.1. General

Fire brigade intervention time has been estimated from the Fire Brigade Intervention Model, developed by Australian Fire Authorities Council for use primarily in performance-based fire safety engineering design.[175]

The FBIM is an event-based methodology, quantifying fire brigade actions from time of notification through to fire control and extinguishment. For this project, the model has been used to predict brigade arrival time on site and the time for commencement of fire-fighting activities. The intervention of the fire brigade may be critical in the event of a major fire or system component failure.

C.2. Location of Fire Services

In the event of an emergency in the building, FRNSW has advised that the closest responding fire stations would be Mona Vale Fire Station and Narrabeen Fire Station, as given in 2.1.5.

C.3. Fire Brigade Intervention Model

The following considerations have been made in the adoption of the FBIM for this building:

(i) The closest fire station at Mona Vale may not be available at the time of the incident. As such, an additional appliance from Narrabeen Fire Station may be required to attend. A signal will therefore be sent automatically to both fire stations from headquarters for fire-ground attendance. This is consistent with FRNSW policy.

(ii) Fire brigade call-out is based on receipt of an automatic fire alarm, as there is a low probability of both the sprinkler system and the fire detection system failing to operate and transmit a signal to FRNSW, based on an estimated reliability for the sprinkler system of 90 per cent [176] [177] and, for the fire detection system, 72 per cent[178] – the risk of both systems failing is approximately 3 per cent.

(iii) The Fire Brigade Intervention Model has been conducted with a safety factor based on the 90th percentile and assumed normal distribution for all activity times with the exception of travel to site. The travel time, which is based a travel speed, is instead based on the average travel speed, this being more consistent with statistics on fire brigade response times for the greater metropolitan area of 9 minutes for at least 90 per cent of incidents.[179]

(iv) The FBIM model is to be used to arrive at a time that indicates the period in which the fire brigade is likely to be arriving at the site, setting-up equipment and the like and carrying out fire-fighting activities at the site.

(v) *Fire brigade access into the building is available from a bounding roadway on the eastern side* of the building.

The main times associated with the fire brigade are summarised in Table 8.

Table 8 – Fire brigade intervention modelling summary

Event	Time (s)
Mona Vale Fire Station arrival	779 (~ 13 min.)
Narrabeen Fire Station arrival	1357 (~ 27 min.)
Application of water	1,376 (~ 22 min.)

175 Australasian Fire Authorities Council, Fire Brigade Intervention Model, Version 2.2, Australia, October 2004.
176 Rohr, K. D., & Hall, J.R., US Experience with Sprinklers and Other Fire Extinguishing Equipment, Fire Analysis and Research Division, National Fire Protection Association (NFPA), Quincy, MA, 2005.
177 England, J.P. & Young, S. A., Fire Risk Management for Buildings with Aged Accommodation, Fire Australia Proceedings, 1998.
178 Bukowski, R. W.; Budnick, E. K.; Schemel, C. F., Estimates of the Operational Reliability of Fire Protection Systems, Fire Protection Strategies for 21st Century Building and Fire Codes Symposium. EXTENDED ABSTRACTS. Proceedings. Society of Fire Protection Engineers and American Institute of Architects. September 17-18, 2002, Baltimore, MD, 111-124, National Institute of Standards and Technology, Gaithersburg, MD and Hughes Associates, Inc., Baltimore, MD
179 NSW Audit Office, NSW Auditor-General's Financial Audit, Volume Six, Sydney, 2003.

The results indicate that for all fire scenarios, evacuation of the warehouse occupants would be completed by the time the fire brigade is able to commence fire-fighting. In this respect, the brigade's primary roles are expected to be predominantly fire control and extinguishment and not initial evacuation. However, if a total evacuation of the building is necessary, they may assist with the orderly evacuation of parts of the building where necessary, commensurate with the fire severity.

C.4. GANTT CHART OF FBIM

In considering the factors for fire brigade response given in sections C.2 and C.3 above, the determination of total fire brigade intervention time has been made below.

From the assessment undertaken, the total time required for fire-fighters to respond, set-up and carry out the necessary activities to commence application of water on the fire is 1,376 seconds (~ 22 minutes) for Mona Vale Fire Station and 1,954 seconds (~ 32 minutes) for Narrabeen Fire Station.

	Ref	Unit Rate		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Figure 10 – Fire Brigade Intervention Model timeline

APPENDIX D CFD MODELLING FOR JETFAN ALTERNATIVE SOLUTION

D.1. GENERAL

Modelling has been undertaken using the computational fluid dynamics (CFD) computer program Fire Dynamics Simulator (FDS), Version 5[180].

FDS has been employed to simulate the flow of heat and smoke generated by a fire within the building. FDS is a field model, based on the approach of the Large Eddy Simulation technique, where low Mach number combustion equations (representing a simplified form of equations describing the transport of mass, momentum and energy by the fire induced flows) are solved numerically in a large number of rectangular cells representing the physical space. This approach is considered suitable to simulate the flow of heat and smoke through a large area such as the subject basement carpark.

The outputs of FDS include parameters such as gas temperature, flow velocities, visibility and species concentrations as functions of space and time. FDS results are presented in colour graphics using the Smokeview[181] computer module.

D.2. MODEL GEOMETRY

With reference to the architectural drawings, the subject basement carparking levels is modelled as a 93-m wide (X-axis), 73 m deep (Y-axis), and 4 m high (Z-axis) compartment. The size of grid cells in the X, Y and Z directions are generally 0.5 m. Low-level openings with a height of 0.25 metre to a single façade has been modelled to allow for an inflow of fresh air from the outside to facilitate combustion.

An internal layout of the FDS model is as shown in Figure 11 below:

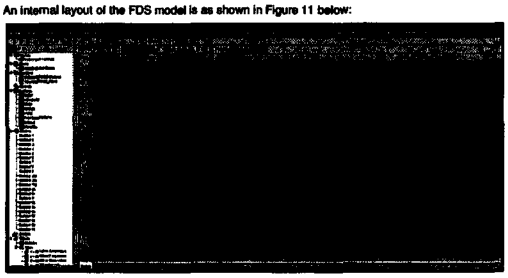


Figure 11 - Internal FDS-model layout of subject basement carparking level

D.3. MODEL INPUTS

A fire has been modelled in the driveway between a sprinkler head and a jet-fan. This is considered to be adequately conservative based on the driveways being an area of transit, with the fuel load being the cars situated within the allocated car parking spots.

Each scenario was run for a period of 600 seconds.

180 McGrattan KB, Hostikka S, Floyd JE, Baum HR & Rehm RG, Fire Dynamics Simulator Version 5, NIST, US, October 2007.
181 Forney G. P. and McGrattan K. B., User's Guide for Smokeview Version 4- A Tool for Visualizing Fire Dynamics Simulation Data, NIST Special Publication 1017, March 2006.

FDS modelling was undertaken for a medium t^2 fire ($Q=(t/k)^2$ and $k=300$) to the floor of the carpark. The peak heat release rate is considered to be 8.5 MW, based on the content of the building mainly comprising cars. This fire growth rate is based on fire tests[182].

D.4. FDS MODELLING

D.4.1. Scenario 1a

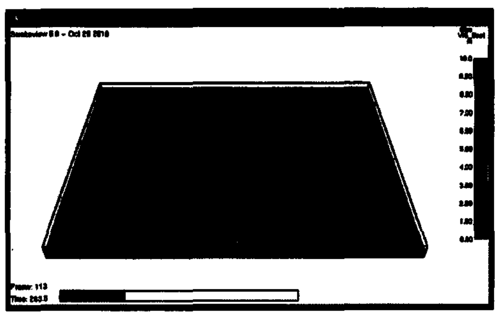


Figure 12 – Scenario 1a visibility at 200 seconds

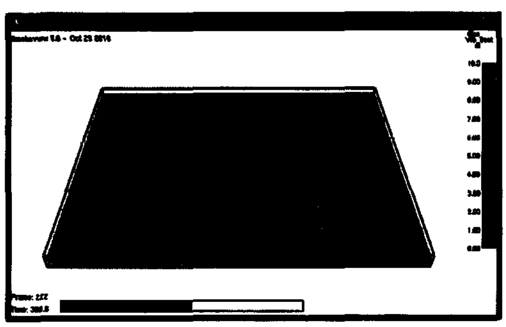


Figure 13 – Scenario 1a visibility at 400 seconds

182 NFPA 92B, "Guide for Smoke Management Systems in Malls, Atria, and Large Areas", 2000 Edition, NFPA.

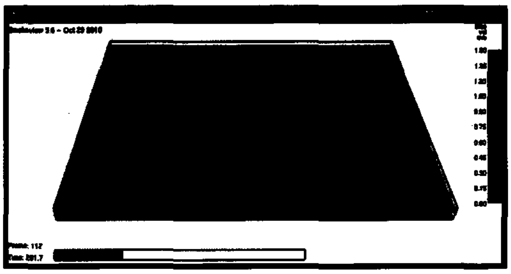


Figure 14 – Scenario 1a velocity at 200 seconds

D.4.2 *Scenario 1b*

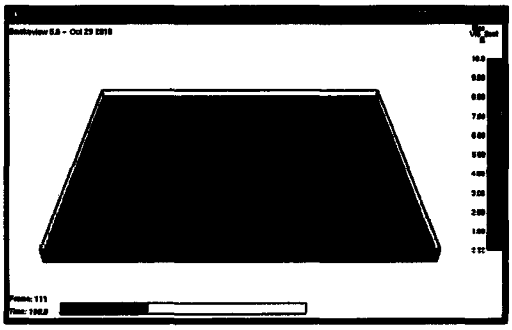


Figure 15 – Scenario 1b visibility at 200 seconds

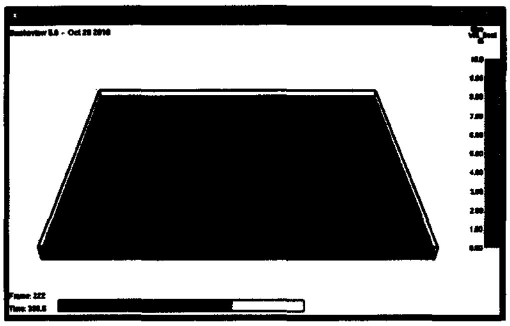


Figure 16 – Scenario 1b visibility at 400 seconds

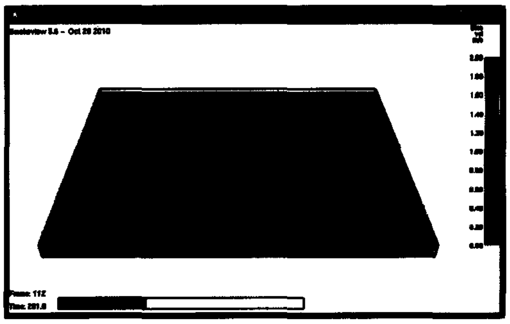


Figure 17 – Scenario 1b velocity at 200 seconds

D.4.3 *Scenario 2a*

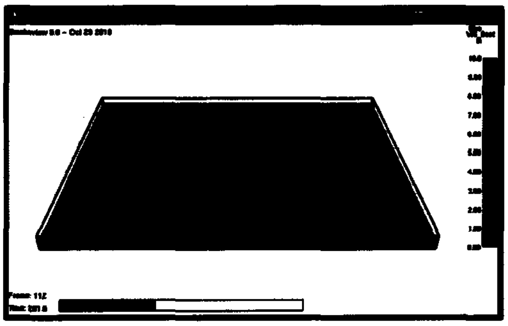


Figure 18 – Scenario 2a visibility at 200 seconds

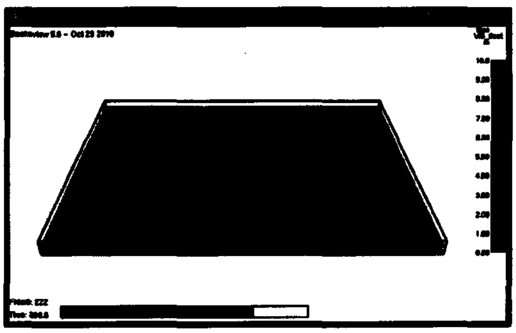


Figure 19 – Scenario 2a velocity at 400 seconds

D.4.4 *Scenario 2b*

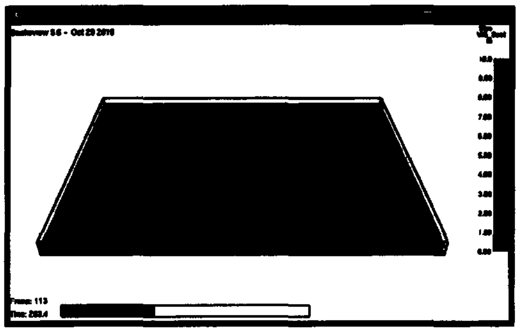


Figure 20 – Scenario 2b visibility at 200 seconds

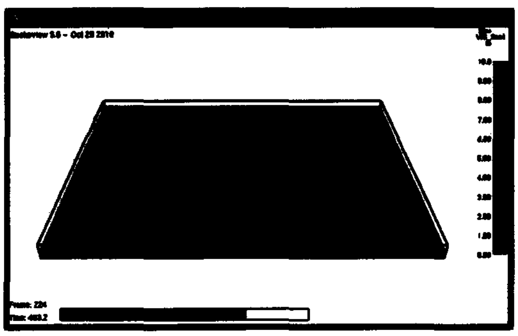


Figure 21 – Scenario 2b velocity at 200 seconds

D.4.5 *Scenario 3a (Alternative Solution)*

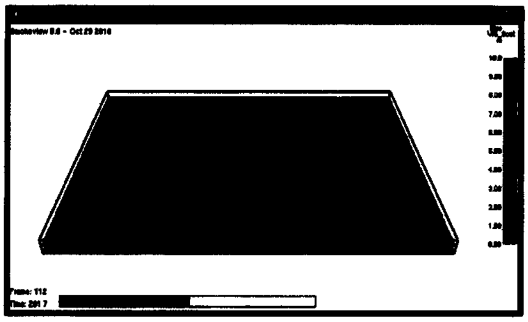


Figure 22 – Scenario 3a visibility at 200 seconds

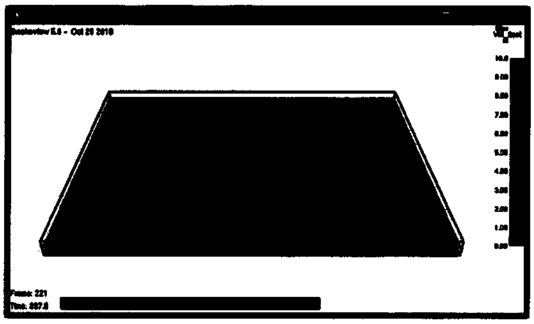


Figure 23 – Scenario 3a visibility at 400 seconds

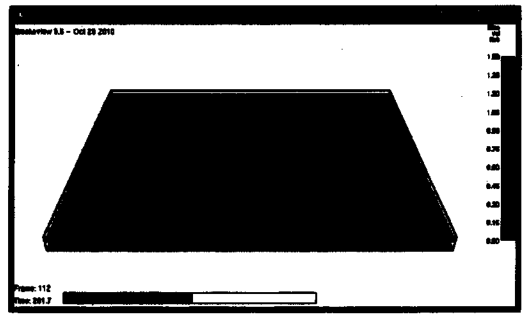


Figure 24 – Scenario 3a velocity at 200 seconds

D.4.6 Scenario 3b (Alternative Solution)

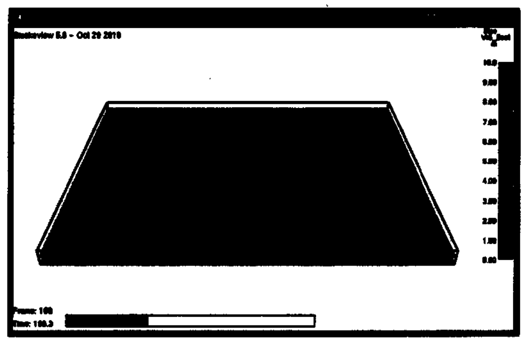


Figure 25 – Scenario 3b visibility at 200 seconds

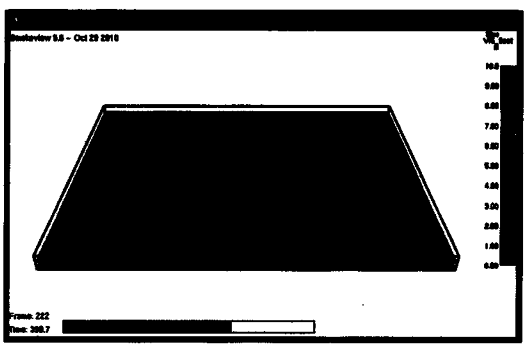


Figure 26 – Scenario 3b visibility at 400 seconds

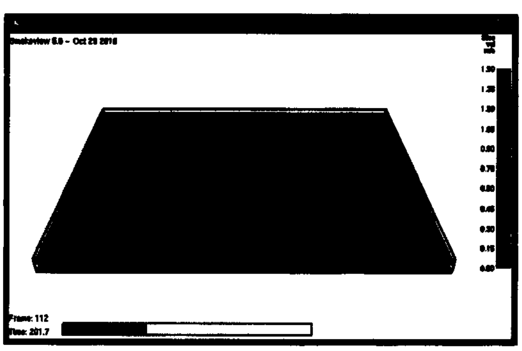


Figure 27 – Scenario 3b velocity at 200 seconds

APPENDIX E BASMENT CARPARK SPRINKLER ACTIVATION SLICE FILES

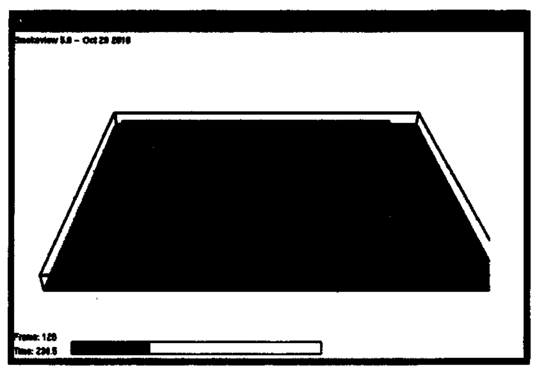


Figure 28 – Driveway fire with Standard sprinkler (without jet-fan) activation time

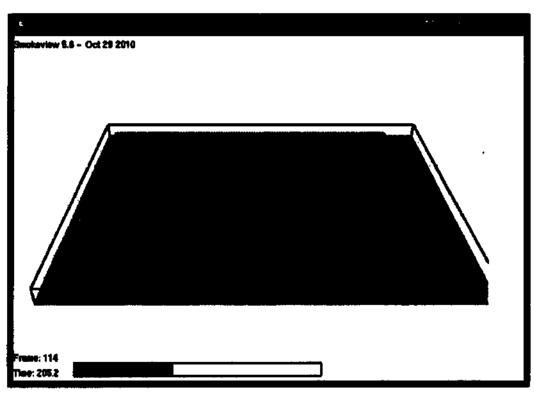


Figure 29 – Driveway fire with Standard sprinkler (with jet-fan) activation time

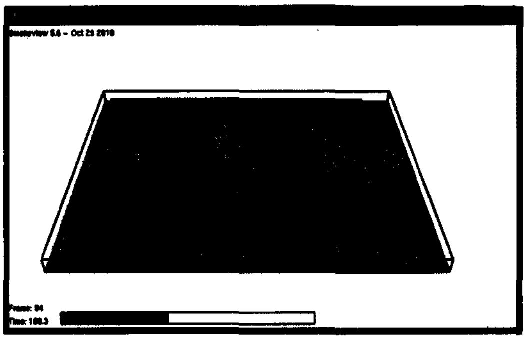


Figure 30 – Driveway fire with fast response sprinkler (with jet-fan) activation time

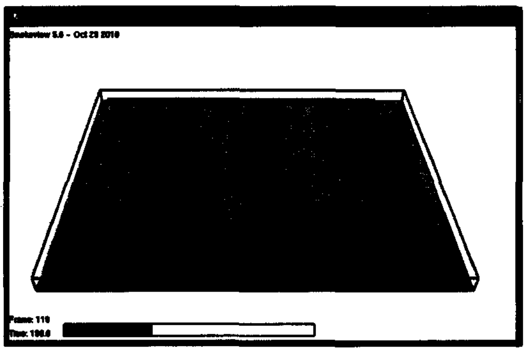


Figure 31 - Parked car fire with Standard sprinkler (no jet-fan) activation time

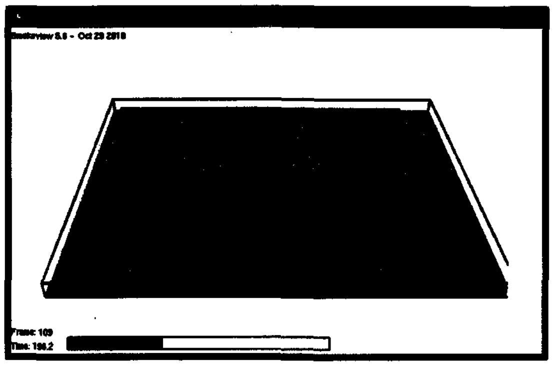


Figure 32 – Parked car fire with standard sprinkler (with jet-fan) activation time

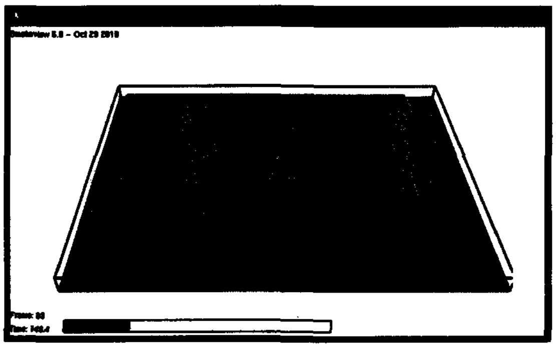
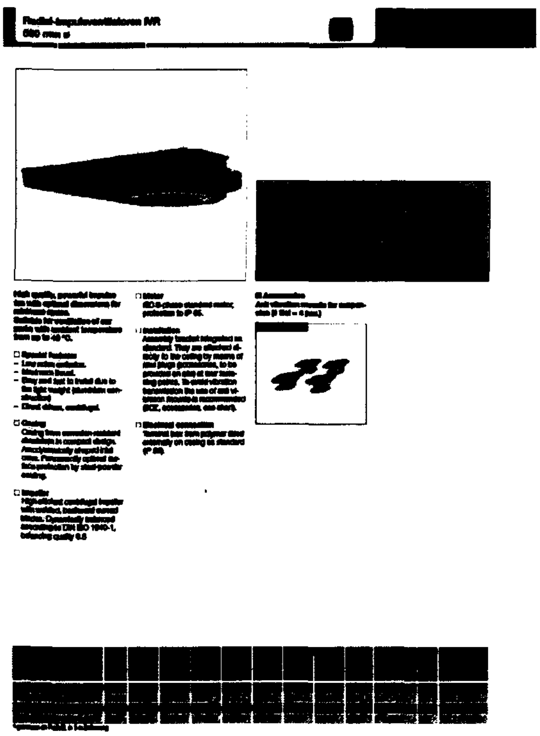
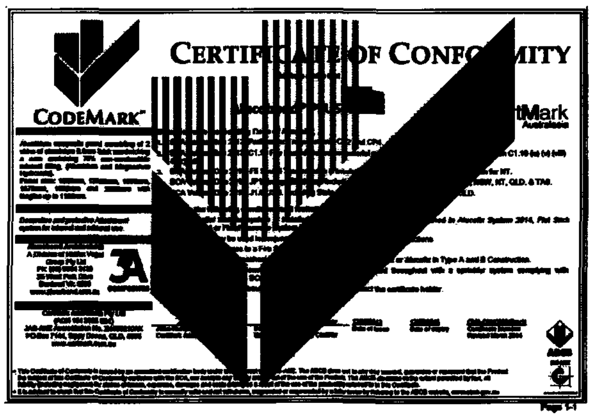


Figure 33 - Parked car fire with fast-response Sprinkler (with jet-fan) activation time

APPENDIX F JET FAN SPECIFICATION



APPENDIX G ALUCOBOND CERTIFICATE OF CONFORMITY


CERTIFICATE OF CONFORMITY

CODEMARK

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APPENDIX H ALUCOBOND TEST REPORT EXCERPT

warringtonfiregent
global safety

TEST REPORT 14576A

Sponsor

3A COMPOSITES GmbH
Alusingenplatz 1
78224 SINGEN
GERMANY

Construction product and trade name

Composite panels "ALUCOBOND® plus"

Nature of the test

Full-scale room test for surface products according to ISO 9705 – 1st edition 1993

Summary of the results

$FIGRA_{RO}$ (W/s)	0,427
THR_{RO} (MJ)	170,46
SMOGRA value (m^2/s^2)	1,385
TSP_{RO} (m^2)	550,1
Time to flash over (s)	No flash over

Ghent, 3 1 NOV. 2010

Ing. F. DUTRIEUE
Project manager

Prof.dr.ir. P. VANDEVELDE
Director

ISO9705-WG-1E

This report contains 15 pages including 7 annexes

This document is the original version of this test report and is written in English.

This report may be used only literally and completely for publications. - For publications of certain texts, in which this report is mentioned, our permission must be obtained in advance.

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warringtonfiregent
global safety

1. DESCRIPTION OF THE TEST METHOD

ISO 9705: 1993 – Full-scale room test for surface products according to ISO 9705.
The standard ISO 9705 prescribes the following procedure:
- 0 – 10 minutes: heat output level of the burner: 100 kW
- 10 – 20 minutes: heat output level of the burner: 300 kW
- 20 minutes: extinction of the burner

2. IDENTIFICATION OF THE PRODUCT

Date of sample arrival	:	2010-07-12
Identification of the samples	:	Not applicable
Sampling done by	:	The sponsor
Sampling date	:	Not communicated
Name of the manufacturer / supplier	:	3A COMPOSITES GmbH Architecture & Display Europe / CT Alusingenplatz 1 78224 SINGEN GERMANY
Trade name	:	ALUCOBOND® plus
Description of the product	:	

This description is based on information given by the sponsor.

The tested product consists of composite panels aluminium substrate outside, lacquered on both sides; mineral filled core inside bonded with polyolefin based medium.

Niky Makroglou

From:	Niky Makroglou
Sent:	Friday, 29 May 2015 10:17 AM
To:	'bfs@fire.nsw.gov.au'
Cc:	Tony Heaslip
Subject:	Notice of Design Change - BFS15/399 (6766) 2 Daydream Street, Warriewood
Attachments:	26664700-RPT01-8.pdf; Request for Report - Initial Fire Safety Report Notice of Design Change Form.docx

Please find attached Notice of Design Change Form and Fire Engineering Report Revision 8.

Kind Regards

Niky Makroglou
Personal Assistant

BLACKETT MAGUIRE+ GOLDSMITH

SYDNEY	WOLLONGONG
Suite C2.01,22-36 Mountain St Ultimo	Suite 1, 100 Railway St, Corrimal
PO Box 167, Broadway NSW 2007	PO Box 90, Corrimal NSW 2518

Ph: 02 9211 7777 **Fax:** 02 9211 7774 Wollongong **Ph:** 02 4285 5696

www.bmplusg.com.au

Niky Makroglou

From: BFS <BFS@fire.nsw.gov.au>
Sent: Friday, 29 May 2015 7:57 PM
To: Niky Makroglou
Subject: RE: Notice of Design Change - BFS15/399 (6766) 2 Daydream Street, Warriewood

Fire & Rescue NSW acknowledge receipt of your email and supporting documentation.

If you have any further queries regarding this matter, please contact the Fire Safety Branch on 9742 7434 quoting your reference number.

Fire Safety Branch
Community Safety Directorate

Fire & Rescue NSW

E bfs@fire.nsw.gov.au | T (02) 9742 7434 | F (02) 9742 7483 | www.fire.nsw.gov.au
Amarina Avenue, Greenacre, NSW 2190 | Locked Bag 12, Greenacre, NSW 2190

Twitter.com/FRNSW | Facebook.com/FRNSW | YouTube.com/FireAndRescueNSW

From: Niky Makroglou [mailto:niky@bmplusg.com.au]
Sent: Friday, 29 May 2015 10:17 AM
To: BFS
Cc: Tony Heaslip
Subject: Notice of Design Change - BFS15/399 (6766) 2 Daydream Street, Warriewood

Please find attached Notice of Design Change Form and Fire Engineering Report Revision 8.

Kind Regards

Niky Makroglou
Personal Assistant

BLACKETT MAGUIRE+ GOLDSMITH

SYDNEY
Suite C2.01,22-36 Mountain St
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PO Box 167, Broadway
NSW 2007

WOLLONGONG
Suite 1, 100 Railway St, Corrimal
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Ph: 02 9211 7777 **Fax:** 02 9211 7774 Wollongong **Ph:** 02 4285 5696

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