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**Attention: Mr Mauricio Vera**

Dear Mr Vera,

**Project:** New High-Quality Classrooms, Package 2 – East Leppington Public School

**Subject:** East Leppington SSD 9476 – Condition B6

In relation to SSD 9476 – East Leppington Public School (Lot 9001, DP1206596), this letter is intended to confirm compliance with Condition B6 - External Walls and Cladding

## External Walls & Cladding

*<u>SSD 9476_Condition B6.</u> Prior to the commencement of construction, the Applicant must provide the Certifier with documented evidence that the products and systems proposed for use or used in the construction of external walls, including finishes and claddings such as synthetic or aluminium composite panels, comply with the requirements of the BCA. The applicant must provide a copy of the documentation given to the Certifier to the Planning Secretary within seven days after the Certifier accepts it.*

This project has been designed with reference to National Construction Code (NCC) 2016 Volume 1 Amendment 1 (aka, the Building Code of Australia (BCA) 2016 Volume 1 Amendment 1). There are five blocks (A, B, C, D & E) on site. Blocks A, B, C & D are connected via a roof, and thus are considered a single building (Type A). Block E is a standalone building (Type C). All buildings are considered Class 9b (School).

In line with NCC 2016, Amendment 1, the project has developed Performance solutions outlined with a Fire Engineering Report prepared for this project by MCD Fire Engineering. This document is referenced within the appendices to this letter and titled "S19033.EF_FER 1.1_East Leppington Public School_200619_LW"

With regards to NCC 2016 Building Code of Australia – Volume One Amendment 1, C1.9 the external walls have been designed with consultation with the Fire Engineer to ensure compliance with codes and consideration for "Safety in Design" for schools.

The following items are considered part of the External Wall "System" currently documented:

1) Metal sub-frame (Non-Combustible)
2) Sarking – Bradford Proctor Wrap (Performance Solution - Refer to Fire Engineering Report) **
3) Timber Noggings (Performance Solution - Refer to Fire Engineering Report) **
4) Cladding - Compressed Fibre Cement Sheeting (Non-Combustible – Group 1)
    a) CSR – Cemintel – Barestone
    b) CSR – Cemintel - Surround

Excluding items above marked with ** which refers to a performance solution for the use of these products as allowed under BCA 2016 Amd. 1, these items are considered "non-combustible as per C1.9 (e). Relevent attachments provided by the material suppliers has been included within the appendices of this letter. This includes relevant test certificates and confirmation of products compliance where required.

NCC 2016 Building Code of Australia – Volume One Amendment 1, C1.14 Ancillary elements, requires for ancillary elements to be non-combustible. The Project currently has document sunshade structures which protrude from the façade line and fixed directly to the sub-frame. These elements have been specified as pre-finished aluminium louvres This is a louvreclad product as part of the Caprice series. This product is non-combustible and non-flammable.

Other cladding materials include:

1) Brick; &
2) Glazed facades

These systems are not flammable

Kind regards,

Paul Nelson
**Design Manager**
On behalf of the authorised person
**Hansen Yuncken Pty Ltd**
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# Appendix Contents

**Appendix 1** – Fire Engineering Report v1.1 – East Leppington Public School
**Appendix 2** – CSR Cemintel – Barstone
- CodeMark

**Appendix 3 –** Bradford ProctorWrap Sarking
- AWTA Product Testing

**Appendix 1** – Fire Engineering Report v1.1 – East Leppington Public School

# Fire Engineering Report

# East Leppington Public School

# Commissioners Drive

# Denham Court NSW 2565

Revision: FER 1.1 | Date: 19 June 2020 |Ref: S19033.EL



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Prepared for: Hansen Yuncken Pty Ltd

# Document Control

| Document Control and Verification | | | | | |
|---|---|---|---|---|---|
| **Revision** | **Date** | | **Prepared by** | **Reviewed By** | **Approved By** |
| **FER 1.0** | 29/05/2020 | ***Name:*** | **Lei Wang**<br>C10: BPB3165 | **Mark McDaid**<br>C10: BPB2165 | **Mark McDaid**<br>C10: BPB2165 |
| | | ***Signature:*** | | | |
| | | ***Comment:*** | Issue 1.0 - Draft for comment | | |
| **FER 1.1** | 19/06/2020 | ***Name:*** | **Lei Wang**<br>C10: BPB3165 | **Mark McDaid**<br>C10: BPB2165 | **Mark McDaid**<br>C10: BPB2165 |
| | | ***Signature:*** | | | |
| | | ***Comment:*** | Issue 1.1 – Final issue incorporating comments received from stakeholders including:<br>▪ Reference to applicable BCA 2016 version 2016 Amendment 1 and associated clauses.<br>▪ Update on BCA Classification being Class 9b (School) only.<br>▪ Recognition of Block A being conventional construction and consequent updates on assessment/calculations to the performance solutions (e.g., spandrel issue, construction for floor/ceiling system etc) and associated fire safety requirements. | | |

# Executive Summary

MCD Fire Engineering Pty Ltd has been instructed to carry out a fire engineering assessment for the proposed development known as East Leppington Public School, located at Commissioners Drive, Denham Court NSW 2565.

The Fire Engineering Report (FER) is to address the identified non-compliances with the Deemed-to-satisfy Provisions of the National Construction Code (NCC) 2016 Volume 1 Amendment 1 (aka, the Building Code of Australia (BCA) 2016 Volume 1 Amendment 1) as identified by the BCA/PCA consultant with respect to the subject development and to present a proposed solution for each, to ensure compliance with the relevant BCA Performance Requirements.

The following deviations from the Deemed-to-Satisfy (DtS) Provisions have been identified by the Principal Certifying Authority (PCA) with respect to matters being assessed in this report:

**Table 1: Summary of Performance Solution**

| No | Description of non-compliance | DtS Clause | Performance Requirement (A0.7) | IFEG Sub-systems | Method of meeting Performance Requirements (A0.2) | Assessment Method (A0.5) |
|---|---|---|---|---|---|---|
| 1 | To review and permit a reduction in spandrel/balcony separation between vertically aligned openings for building of Type A construction (Blocks A-D). | C2.6 | CP2 | A and C | A0.2(a) Refer Table 3 | A0.5(b)(ii) Refer Table 3 |
| 2 | To permit the reduction in general FRLs;<br>▪ from the required FRL of 120 minutes down to 60 minutes for building of Type A construction, i.e., main School Buildings (Blocks A-D);<br>▪ from the required FRL of 90 minutes down to 60 minutes for building of Type C construction, i.e., Hall Building (Block E). | Spec C1.1, Table 3, Table 5 | CP1 and CP2 | A and C | A0.2(a) Refer Table 3 | A0.5(b)(ii) Refer Table 3 |
| 3 | To permit the reduction of FRLs to the floors for buildings of Type A construction (Blocks A-D), from 120/120/120 to a ceiling having a Resistance to Incipient Spread of Fire (RISF) of 60 minutes. | Spec C1.1, Clause 3.1 Table 3 | CP1 and CP2 | A and C | A0.2(a) Refer Table 3 | A0.5(b)(ii) Refer Table 3 |
| 4 | To permit the reduction of FRLs to the floors for buildings of Type A construction (Blocks B, C & D), from 120/120/120 to a ceiling having a Resistance to Incipient Spread of Fire (RISF) of 60 minutes. | Spec C1.1, Clause 3.1 Table 3 | CP2, CP4 | A, C | A0.2(a) Refer Table 3 | A0.5(b)(ii) Refer Table 3 |
| 5 | To permit the use of plywood timber noggings/reinforcement (for handrails/grabrails/wall mounted wet areas systems such as WHBs etc) in cavities of fire rated walls (internal or external) and non-fire-rated external walls the building of Type A construction (Blocks A-D). | C1.9, Spec C1.1, Clause 3.1(d) | CP2, CP4 | A, C & F | A0.2(a) Refer Table 3 | A0.5(b)(ii) Refer Table 3 |

| No | Description of non-compliance | DtS Clause | Performance Requirement (A0.7) | IFEG Sub-systems | Method of meeting Performance Requirements (A0.2) | Assessment Method (A0.5) |
|---|---|---|---|---|---|---|
| **6** | The residual pressure of internal fire hydrants is to be designed in accordance with AS 2419.1-2017 instead of AS 2419.1-2005, i.e., 250 kPa instead of 700 kPa by viewing them as "unassisted attack fire hydrant". | E1.3, AS 2419.1 | EP1.3 | F | A0.2(a) Refer Table 3 | A0.5(b)(ii) Refer Table 3 |
| **7** | To permit the location of the fire hydrant booster to not technically be within sight of each building entry on the site, and not adjacent to the vehicular entrance. | E1.3, AS 2419.1 | EP1.3 | F | A0.2(a) Refer Table 3 | A0.5(b)(ii) Refer Table 3 |
| **8** | To permit the omission of Fire Hose Reels serving parts of the buildings that are not forming part of the main classroom areas of the building (i.e. admin, BOH, etc). | E1.4 | EP1.1 | C and D | A0.2(a) Refer Table 3 | A0.5(b)(ii) Refer Table 3 |

It is outlined herein that, subject to the proposed fire safety measures being incorporated into the design as detailed in Table 2 as part of the fire safety design, and in conjunction with fire safety measures as listed in base building FER, the assessments undertaken in this report demonstrate that the above deviations from the Deemed-to-Satisfy (DtS) Provisions meet the relevant Performance Requirements of the BCA. All other aspects of the proposed works are understood to be in accordance with the BCA DtS Provisions and/or the standards not less than that in force at the time of its original approval, where deemed relevant by the PCA.

### Table 2: Required Fire Safety Features

| Fire Safety Measure | Description |
|---|---|
| **Construction Requirements** | The building having a rise in storey of 3 (**Main School Buildings, Blocks A-D**) is to have a **Type A construction** and the building having a rise in storey of 1 (**Multipurpose Hall, Block E**) is to have a **Type C construction.**<br><br>All building elements are required to have a fire resistance level (FRL) as listed in Table 3 or Table 5, respectively, of Specification C1.1 of BCA as appropriate, except where addressed in the proposed Fire Engineering Report as a Performance Solution as part of the Crown Certificate.<br><br>All penetrations in fire rated construction shall be fire stopped in accordance with the BCA DtS requirements, except where addressed in this Report as a Performance Solution.<br><br>It is noted that Blocks A & E are to be of conventional construction with concrete slab etc., and Blocks B, C & D are to be of modular construction with lightweight floor/ceiling system. |
| **Spandrel separation for building of Type A construction (Blocks A-D)** | **For Blocks B, C & D being of modular construction with lightweight floor/ceiling system**<br><br>The FRL of the spandrel is permitted to be **-/60/60** (non-loadbearing) and fire rated from outside only instead of 60/60/60 and rated on both sides.<br><br>The part of vertical spandrel above the slab/floor level may reduce from 0.6 m to 0.0 m, and the total height of vertical spandrel of 0.9 m may reduce down to **0.58 m**, subject to the following additional requirement/conditions:<br><br>▪ The 580 mm high spandrel shall be achieved by 2 layers of 13 mm Fyrchek (or equal approved fire-grade plasterboard) which provides an FRL of -/60/60 when tested from the inside. |

| Fire Safety Measure | Description |
|---|---|
| | ▪ The above-mentioned 580 mm high spandrel achieved by 2 layers of 13 mm Fyrchek (or equal approved fire-grade plasterboard) is measured from the level of fire rated (RISF) ceiling to level of 24 mm CFC Flooring.<br>▪ Immediately above this 580 mm high spandrel by 2 layers of 13 mm Fyrchek, and to a minimum height of **1000 mm** above the internal finished floor level, the external wall/façade (above the fire-grade spandrel portion) shall be constructed with:<br>▪ 6 mm fixed shut toughened glazing in metal framing (aluminium permitted); **OR**<br>▪ Where no glazing is proposed, a non-combustible external wall lining of at least 13 mm thickness (e.g. CFC Sheeting, plasterboarding (external grade), or combination of both provided total thickness is at least 13 mm. This 13 mm of wall lining shall be placed externally of the wall, not internally and behind the insulation/sarking.<br>▪ Where 6 mm fixed shut toughened glazing is adopted for the above, the following detailed requirements for windows with toughened glazing are:<br>▪ The window shall be fitted with 6 mm thick toughened safety glass, and fixed shut.<br>▪ Window frames and hardware shall be made of metal (aluminium allowed).<br>▪ Seals to stiles, head and sills or thresholds shall be manufactured from silicone (having a flammability index no greater than 5 according to AS 1530.2).<br>▪ A fixed tag shall be placed on the inside of the window frame stating "**Window made of Metal Framing and Toughened Glazing. Refer to Construction Certificate when replacing the window**".<br>▪ The tag shall comply with the requirements in Table 17.<br>▪ The gap between the RISF ceiling/FR plasterboard spandrel and the external 13 mm sheeting shall be fire stopped/packed with non-combustible materials.<br>▪ Example of the construction build up to satisfy the above glazing / non-combustible external lining is illustrated in Figure 1. *Note: the current section details show only a 350 mm of FC sheeting or toughened glass, this needs to be extended to at least 1000 mm as above requirement.*<br>**For Block A being of modular construction with lightweight floor/ceiling system**<br>The part of vertical spandrel above the slab may reduce from 0.6 m to 0.0 m, and the total height of vertical spandrel of 0.9 m may reduce down to **0.45 m (i.e. edge beam)**, subject to the following additional requirement/conditions:<br>▪ Immediately above this 450 mm high spandrel (i.e. edge beam), and to a minimum height of **1000 mm** above the edge beam, the external wall/façade shall be constructed with:<br>▪ 6 mm fixed shut toughened glazing in metal framing (aluminium permitted); **OR**<br>▪ Where no glazing is proposed, a non-combustible external wall lining of at least 13 mm thickness (e.g. CFC Sheeting, plasterboarding (external grade), or combination of both provided total thickness is at least 13 mm. This 13 mm of wall lining shall be placed externally of the wall, not internally and behind the insulation/sarking; **OR**<br>▪ 110 mm thick brickwork.<br>▪ Where 6 mm fixed shut toughened glazing is adopted for the above, the following detailed requirements for windows with toughened glazing are:<br>▪ The window shall be fitted with 6 mm thick toughened safety glass, and fixed shut.<br>▪ Window frames and hardware shall be made of metal (aluminium allowed).<br>▪ Seals to stiles, head and sills or thresholds shall be manufactured from silicone (having a flammability index no greater than 5 according to AS 1530.2). |

| Fire Safety Measure | Description |
|---|---|
| | ▪ A fixed tag shall be placed on the inside of the window frame stating "**Window made of Metal Framing and Toughened Glazing. Refer to Construction Certificate when replacing the window**".<br>▪ The tag shall comply with the requirements in Table 17.<br><br>▪ Example of the construction build up to satisfy the above glazing / non-combustible external lining are illustrated in Figure 12.<br>**<u>Additional notes</u>**<br>*Spandrel Note:*<br>▪ *Where balconies are constructed of concrete along the long sides of each Homebase and achieves the following requirements as per BCA C2.6, then vertical spandrels are not required:*<br>▪ have *an FRL of 60/60/60; and*<br>▪ *are at* least *1100 mm deep and extend at least 450 mm past each opening located above/below that balcony; and*<br>▪ *the gaps between those balconies and the building are fire stopped/rated along the line of each floor to form a continuous fire separated between floors that extend through to the balcony.*<br><br>*General Notes:*<br><br>▪ *CSR have also confirmed (See Appendix E) that the replacement of CSR Gyprock Fyrchek or Fyrchek MR with the EC08 range of linings with an equivalent thickness is supported by dedicated Test Reports that support their use in lieu of the CSR Gyprock Fyrchek or Fyrchek MR.* |
| Reduction of FRLs (general) | As permitted in this FER, the general FRLs throughout all Blocks (A - E) can be reduced from 120 minutes to **60 minutes**.<br>▪ This includes all fire rated elements throughout the building, including walls, floor/ceiling, columns, beams etc.<br>▪ Refer to Figure 3 for mark-up on general fire rating requirements with consideration of performance solutions. |
| Floor/ceiling system for building of Type A construction (Blocks B, C & D) | **<u>For Blocks B, C & D being of modular construction with lightweight floor/ceiling system</u>**<br><br>The requirement for a floor having an FRL of 120/120/120 for Type A construction building (i.e., Blocks B, C & D) can be reduced to a ceiling below floor on each level (except for ceiling to top level which is permitted to not have an FRL provided the roof covering is a non-combustible roof covering) having a Resistance to Incipient Spread of Fire (RISF) of 60 minutes.<br>▪ The floors between levels in Type A construction (Blocks B, C & D) can be of lightweight construction with the floor joists instead of a concrete slab.<br>▪ The floor structure shall be made of non-combustible materials, i.e., steel joists/beams/trusses.<br>▪ Under the floor joists, a ceiling having Resistance of Incipient Spread of Fire (RISF) for 60 minutes shall be installed.<br>▪ The ceilings shall comprise of a CSR ceiling system achieving a Resistance to Incipient Spread of Fire (RISF) of 60 minutes (or an equivalent system such as Boral, Knauf, etc having the same RISF) that is appropriate for the design of floor/ceiling system.<br>▪ Any downlights, services, etc. must not reduce this fire rating (RISF 60 min) and comply with tested specifications for the service in question (generally, this tested system would be attributed to the FRL of the ceiling system rather than the RISF rating, so a minimum |

| Fire Safety Measure | Description |
|---|---|
| | FRL of the ceiling from below is required to be 60/60/60, noting that a ceiling having a RISF of 60 minutes will generally have at least (or higher) FRL of 60/60/60).<br>▪ Floor covering shall comprise of 24 mm thick CFC flooring, 19 mm Thermifloor flooring and carpet where applicable.<br>▪ The floor lining or floor covering shall have fire hazard properties complying with BCA Spec C1.10 Clause 3.<br>▪ Refer to Figure 1 and Figure 3 for the ceiling/floor arrangement.<br>*Notes:*<br>*(1) The current section details show 2 layers of 13 mm Fyrchek; The applicable Tested System (e.g. CSR Systems 6132, 6134, 6190, 6193. 6221, 66222, 6241, 6242 which generally require 1 x 13 mm and 1 x 16 mm or 2x 16 mm fire grade plasterboard linings) shall demonstrate compliance with the required RISF 60 min as per above requirement.*<br>(1) *CSR have also confirmed (See Appendix E) that the replacement of CSR Gyprock Fyrchek or Fyrchek MR with the EC08 range of linings with an equivalent thickness is supported by dedicated Test Reports that support their use in lieu of the CSR Gyprock Fyrchek or Fyrchek MR.* |
| **Sarking material inside the external walls for building of Type A construction (Blocks A-D)** | Combustible sarking material (Bradford Enviroseal ProctorWrap RW) having a thickness of not more than 1 mm and a Flammability Index of ≤5 (noting that the applicable NCC is 2016 Amd 1 and not NCC 2019 which provides a concession for such sarking-type materials) can be used inside the external walls.<br>▪ This solution applies to Type A construction building (i.e., Blocks A-D) only.<br>▪ Building of Type C construction (i.e., Block E) is not subject to the requirement of non-combustible materials in or on external walls. |
| **Plywood used in fire-rated walls for building of Type A construction (Blocks A-D)** | Plywood can be used as noggings/reinforcement (for handrails/grabrails/wall mounted wet areas systems such as WHBs etc) in cavities of fire rated walls (internal or external) and non-fire-rated external walls, with the following conditions:<br>▪ The plywood used as wall reinforcing / strengthening element for handrails/grabrails/wall mounted wet areas systems in cavities of fire rated walls (internal or external) and non-fire-rated external walls shall have a finished thickness of not less than 12 mm and have an average density of not less than 600 kg/m$^3$ at a moisture content of 12%; and shall not be joined by means of glue unless it has been laminated and glued with resorcinol formaldehyde or resorcinol phenol formaldehyde glue.<br>▪ The application of the plywood noggin is not for the entire wall (i.e., with one layer timber inside the wall), but only locally between studs (typically 600 mm) where deemed necessary, e.g., behind grab rails and fixings.<br>▪ The maximum height of the plywood noggin is 600 mm. Refer to an illustration in Figure 2. Where a wall is required to be provided with multiple portions of plywood noggings, they shall be separated by a vertical distance of at least 300 mm.<br>▪ This solution applies to Type A construction building (i.e., Blocks A-D) only.<br>▪ Building of Type C construction (i.e., Block E) is not subject to the requirement of non-combustible materials in fire-rated walls (internal or external) and non-fire-rated external walls. |
| **Smoke hazard management** | The buildings do not prescribe require an automatic fire detection and alarms system, but smoke detection system is required to initiate automatic shutdown for any air-handling system (other than non-ducted aircon) in accordance with AS 1670.1 Section 7 (Smoke Control Systems). |
| **Fire hydrant system** | A fire hydrant system shall be provided in accordance with BCA Clause E1.3 and AS 2419.1-2005, with the following exception/requirements: |

| Fire Safety Measure | Description |
| --- | --- |
| | **Location of fire hydrant booster**<br><br>The hydrant booster can be located not within sight of each building entry and not adjacent to the vehicular entrance, as shown in Figure 41.<br>▪ A fadeproof and weatherproof Fire Hydrant Block Plan shall be provided in accordance with the AS 2419.1-2005 requirements and placed at the fire hydrant booster. Refer to AS 2419.1-2005 Clause 7.11 for detailed requirements for block plans.<br>▪ The block plan shall be orientated to reflect the actual layout of the site from the location of the block plan being viewed.<br>▪ The block plan shall each building location include the surrounding street access routes. Alternatively, a separate site plan can be provided next to fire hydrant block plan, which shows the location of all site entrances and the location of each building.<br>▪ A signage shall be provided next to the vehicular entrance off Elkhorn Street, stating "**FIRE HYDRANT BOOSTER ON COMMISSIONERS DRIVE**", with arrow pointing to the direction of Commissioners Drive.<br>▪ A signage shall be provided next to the secondary pedestrian entrance off Elkhorn Street, stating "**FIRE HYDRANT BOOSTER ON COMMISSIONERS DRIVE**", with arrow pointing to the direction of Commissioners Drive.<br>▪ A signage shall be provided next to the secondary pedestrian entrance off Willowdale Drive, stating "**FIRE HYDRANT BOOSTER ON COMMISSIONERS DRIVE**", with arrow pointing to the direction of Commissioners Drive.<br>▪ The above-mentioned signs shall comprise of capital letters not less than 50 mm high in a colour contrasting with the background.<br>▪ The above-mentioned signs shall be weather/fade proof and mechanically fixed on a wall/fence or a standalone post. The signage be listed as an Essential Fire Safety Measure, to be included on the Fire Safety Schedule.<br>▪ The fire hydrant booster assembly connections and all fire hydrant valves must be fitted with Storz aluminium alloy delivery couplings manufactured and installed in accordance with clauses 7.1 and 8.5.11.1 of AS 2419.1-2005. Blank caps must be fitted to the couplings via a screw thread. Refer to guide sheet no. 4 'Fire brigade hose couplings' prepared by Fire and Rescue NSW for more information. This document is available at www.fire.nsw.gov.au.<br><br>**Residual Pressure for internal fire hydrants**<br><br>▪ The internal fire hydrants located at the verandas/balconies near external stairs can be considered internal unassisted attack fire hydrants, with the residual pressure of more than 250 kPa but less than 700 kPa.<br>▪ The hydrant block plan shall highlight that there are no on-site fire hydrant pumps and the relevant internal fire hydrants located at verandas near external stairs being internal unassisted attack fire hydrants, with the residual pressure of more than 250 kPa but less than 700 kPa. It shall state words to the effect:<br>**NO ON-SITE FIRE HYDRANT PUMPS**<br>**ALL HYDRANTS ARE UNASSISTED ATTACK FIRE HYDRANTS**<br>**WITH RESIDUAL PRESSURE: XXX KPA**<br>**USE HYDRANT BOOSTER TO BOOST PRESSURE**<br>The above shall be either on the hydrant block plan or a separate sign next to the block plan that is clearly visible on approach to the hydrant block plan. When setting as separate sign, it shall be of a non-combustible material written in capital letters not less than 25 mm high in a colour contrasting with the background and must be |

| Fire Safety Measure | Description |
|---|---|
| | mechanically fixed to the walls/poles. When exposed in outside at the hydrant booster, the sign shall be weather proof and fade proof. |
| **Fire hose reels (nil)** | Fire hose reels are prescriptively not required to "*classrooms and associated corridors*" in accordance with BCA Clause E1.4 and AS 2441-2005.<br>For building parts not considered as classrooms or associated corridors, fire hose reels are to be omitted.<br>▪ Additional fire extinguishers shall be provided such that all areas within the building parts not considered as classrooms or associated corridors, are with 10 m of a fire extinguisher.<br>▪ Each fire extinguisher shall be a multi-purpose Type ABE 2.5 kg extinguisher.. |
| **Portable fire extinguishers** | Portable fire extinguishers shall be provided in accordance with BCA Clause E1.6 and AS 2444.<br>▪ Refer to above regarding the requirements for additional portable fire extinguishers for areas where fire hose reels are omitted, i.e., additional fire extinguishers shall be provided such that all areas within the building parts not considered as classrooms or associated corridors, are with 10 m of a fire extinguisher. |
| **Emergency lighting and exit signs** | Emergency lighting and exit signage shall be provided in accordance with BCA Clause E4.2 and E4.5 respectively, and AS 2293.1. |
| **Management in use** | An emergency management and evacuation plan shall be developed and implemented prior to Occupation Certificate. The plan should satisfy the requirements of AS 3745. |
| **Maintenance** | A maintenance program shall be developed with all essential safety measures (active, passive and management) maintained in accordance with AS 1851 and AS 2293.2, and is to incorporate system interface testing, where relevant. |

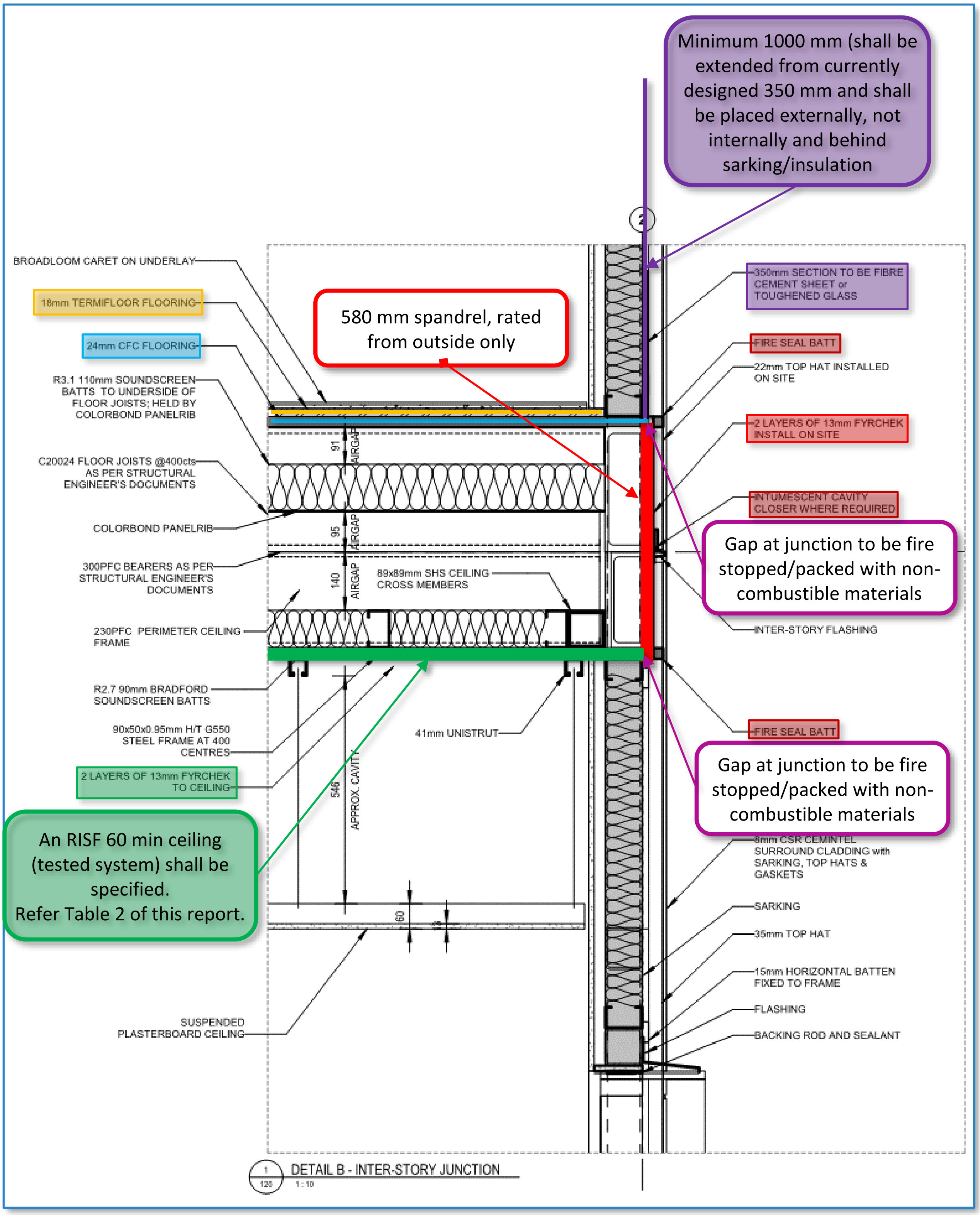



**Figure 1: Section showing fire rated (RISF) ceiling, flooring materials and spandrel arrangement (For Blocks B, C & D being of modular construction with lightweight floor/ceiling system)**

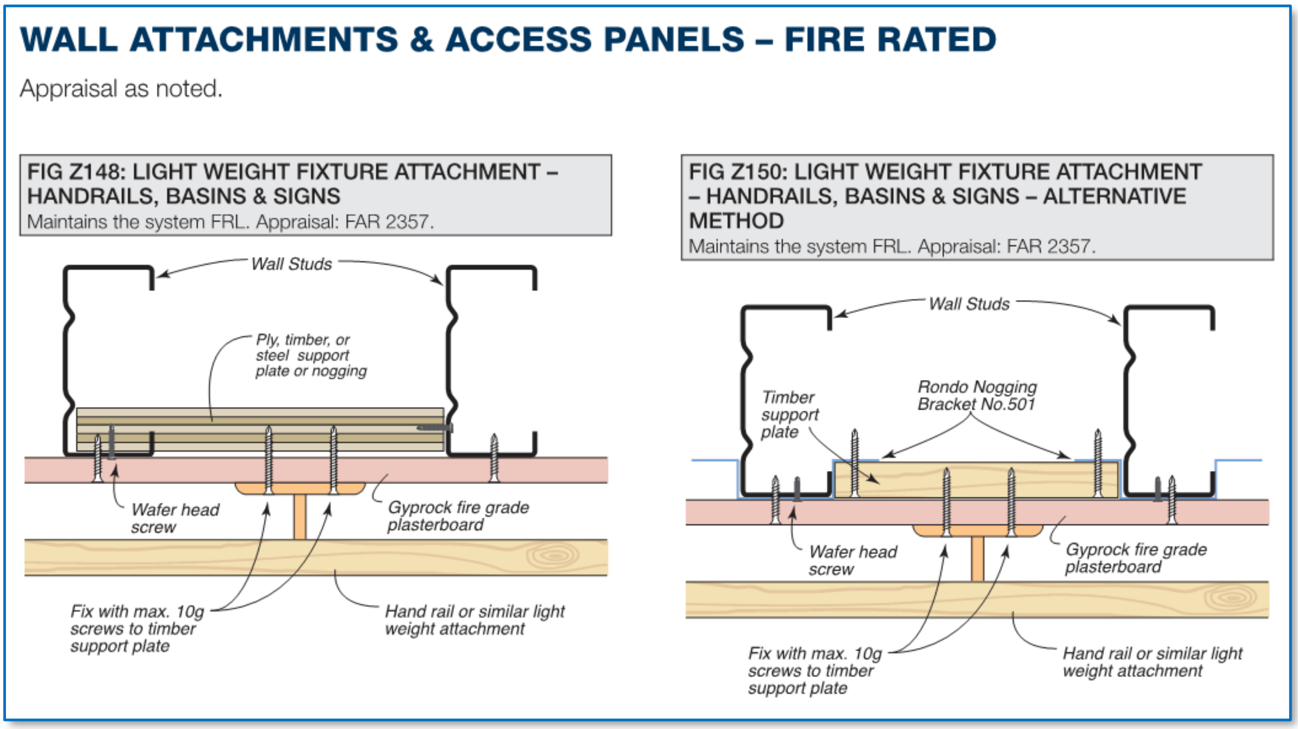



**Figure 2: Use of timber nogging/support plate in fire rated plasterboard walls (excerpt from CSR Redbook)**

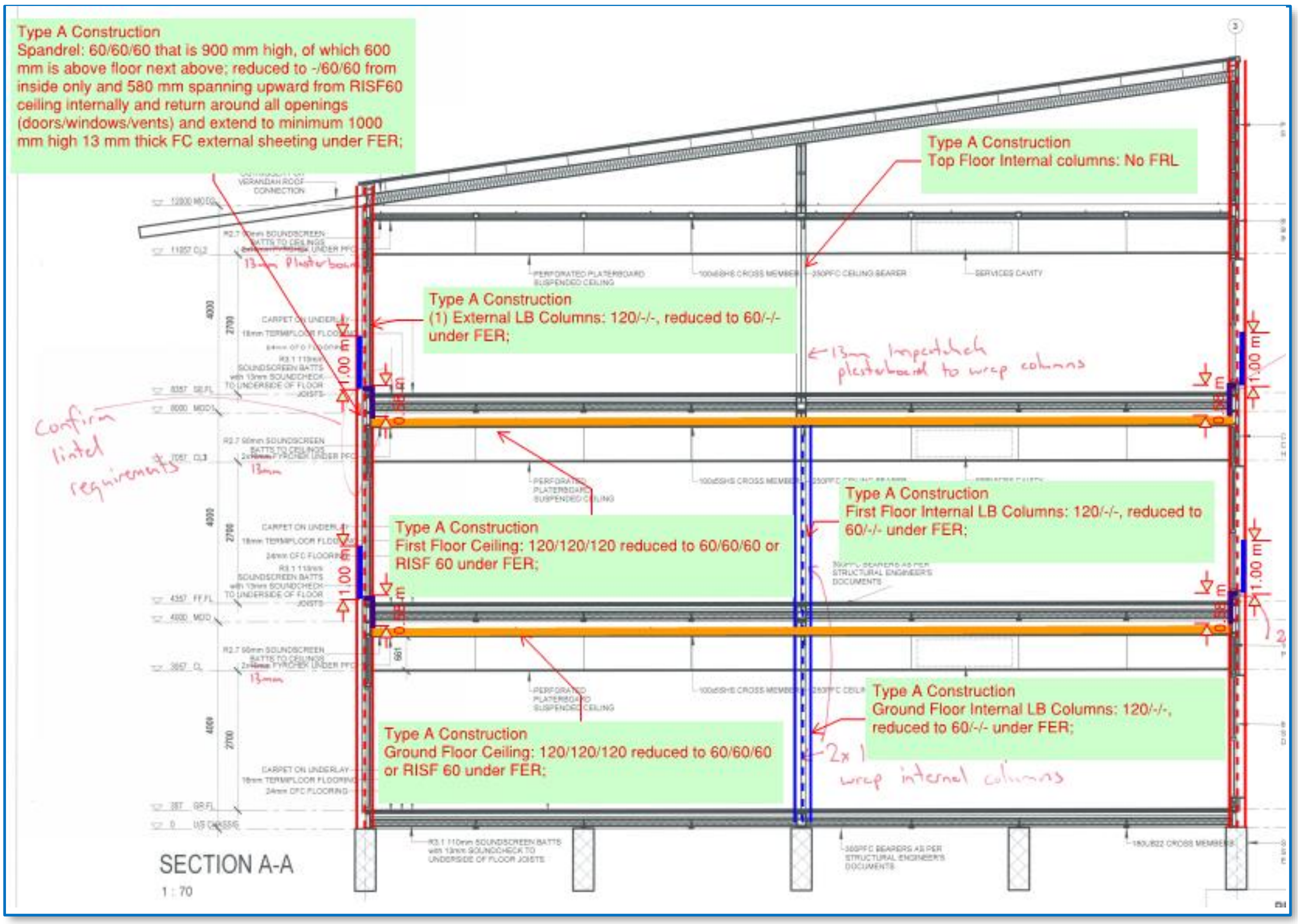



**Figure 3: Section with mark-up on general fire rating requirements with consideration of performance solutions**

# Contents

# 1 Introduction

## 1.1 Objective

MCD Fire Engineering Pty Ltd has been instructed to carry out a fire engineering assessment for the proposed development known as East Leppington Public School, located at Commissioners Drive, Denham Court NSW 2565.

## 1.2 Report Applicability

This report addresses only the identified non-compliances forming part of this Performance Solution having regard to the scope of the proposed works to which the certification applies. All other aspects of the design with regard to fire and life safety are assumed to meet the standards in force at the time of its original approval.

This report is for the use of Hansen Yuncken Pty Ltd and the design team appointed to this project. It should not be used in full or in part to support any other scheme and MCD Fire Engineering will not accept any responsibility for matters arising as a result of its misuse. Changes in the design of the building may invalidate the proposals of this scheme, and therefore the report will need to be updated if the scheme changes. The findings and opinions expressed within this report are based on the conditions encountered and / or the information reasonably available at the date of issue of this document, and shall be applicable only to the circumstances envisaged herein.

## 1.3 Applicable Legislation

The primary legislation applicable to the development is the National Construction Code (NCC), Volume One aka as the BCA 2016 (Amendment 1): Building Code of Australia. The BCA provides a set of prescriptive requirements, *Deemed-to-Satisfy* (DtS) Provisions that if meet, are deemed an acceptable level of safety and achieve compliance with the Performance Requirements of the BCA. Deviations from the BCA DtS Provisions must be shown and be addressed as a Performance Solutions to demonstrate they comply with the BCA Performance Requirements.

The assessment of an Performance Solution can be undertaken using a variety of methods. These are defined in BCA Clause A0.5. One or more, or a combination of these methods are adopted to determine whether the proposed Performance Solution complies with the BCA Performance Requirements. The relevant BCA Performance Requirements are determined in accordance with BCA Clause A0.7. Compliance with BCA Performance Requirements is undertaken in accordance with BCA Clause A0.2. BCA Clause A0.2 and A0.5 are presented below in Table 3.

**Table 3: Methods of Meeting the Performance Requirements and Assessment Method for Performance Solutions**

| BCA Clause A0.2 | BCA Clause A0.5 |
|---|---|
| The Performance Requirements can only be satisfied by a—<br>(a) Performance Solution; or<br>(b) Deemed-to-Satisfy Solution; or<br>(c) a combination of (a) and (b) | The following Assessment Methods, or any combination of them, can be used to determine that a Performance Solution or a Deemed-to-Satisfy Solution complies with the Performance Requirements, as appropriate:<br>(a) Evidence to support that the use of a material or product, form of construction or design meets a Performance Requirement or a Deemed-to-Satisfy Provision as described in A2.2 of the BCA.<br>(b) Verification methods such as—<br>(i) the Verification Methods in the NCC; or<br>(ii) such other Verification Methods as the appropriate authority accepts for determining compliance with the Performance Requirements<br>(c) Expert Judgement<br>(d) Comparison with the Deemed-to-Satisfy Provisions |

The following New South Wales Legislation is applicable:

- NSW Environmental Planning and Assessment Act, 1979 and subsequent amendments

- NSW Environmental Planning and Assessment Regulation, 2000 and subsequent amendments

This document has been prepared by MCD Fire Engineering to support the application for a Construction Certificate (CC) under Crown Development in meeting the legislative requirements of the NSW Environmental Planning and Assessment Regulations 2000.

### 1.4 Fire Engineering Process

In accordance with the International Fire Engineering Guidelines (IFEG), a fire engineer should prepare a Fire Engineering Brief (FEB) that is subject to the Performance Solutions to the BCA for the project. The FEB should include the objectives, proposed trial designs, methods of analysis and acceptance criteria for any proposed Performance Solutions for the project. Depending on the complexity of the project, this process may be documented in an individual document, or in the case of more simple or well established industry Performance Solutions, combined in the Fire Engineering Report. This is the case for the proposed design solution in that only one non-compliance arises to which the certification relates.

The Fire Engineering Report (FER) contains all the relevant design calculations, assessments, findings, justifications and conclusions to demonstrate that the proposed Performance Solution complies with the relevant BCA Performance Requirements. On completion, submission to the PCA for their assessment and approval of compliance to the BCA Performance Requirements is finalised.

The FEB process has identified Category 2 Fire Safety Provisions (as defined by the EP&A Regulation 2000). However, the compartment areas for the building are within the limits set in Clause 144 the Regulation and so a referral to the fire brigade is not required. It is noted however, that a voluntary FEBQ submission is to be provided to FRNSW and comments received through that process will be incorporated into the Final FER.

### 1.5 Scope and Objectives

The objective of the Fire Engineering process is to recognise variations from the DtS Provisions and to present a way forward for resolution of each, and to demonstrate compliance with the relevant BCA Performance Requirements. All design solutions are subject to formal approval by the relevant regulatory authorities.

In order to provide a robust fire engineering design that meets the BCA Performance Requirements, it is important that all stakeholders agree to the fire engineering design principles before the analysis is carried out and the design is finalised. Key features of this report are to be reviewed and agreed to by the stakeholders, including the assumptions, design fires, occupant characteristics, proposed fire and egress modelling scenarios (where applicable), methods of analysis and the proposed overall design philosophy.

### 1.6 Key Stakeholders and Documentation

The key stakeholders in the design of this development are listed in Table 4.

**Table 4: Relevant Stakeholders**

| Name | Organisation | Role |
|---|---|---|
| - | Department of Education, NSW | Owner |
| - | TSA | Client Representative |
| Marco Beretta | Hansen Yuncken | Project Management |
| Sam Rigoli | Perumal Pedavoli Architects | Architect |
| Josh Chaplin | MBS | Builder/Developer |
| Brett Clabburn | Group DLA | Principal Certifying Authority |
| Mark McDaid, Lei Wang | MCD Fire Engineering Pty Ltd | Fire Engineering |
| TBA | Fire + Rescue NSW | Voluntary Referral/Advice Agency |

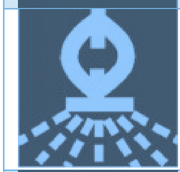
The relevant documents and drawings assessed as part of this report are listed in Table 5. Refer to Appendix G for a full set of relevant drawings.

**Table 5: Relevant documentation**

| Ref | Name | Organisation | Date | Revision |
|---|---|---|---|---|
| 190178 | BCA Compliance Review Report | Group DLA | 28.02.2020 | R6 |
| 00_S002 | Site Plan | Perumal Pedavoli Architects | 23.03.2020 | J |
| 00_S011 | Composite Plan – Level 00 Block A & B | Perumal Pedavoli Architects | 23.03.2020 | M |
| 00_S012 | Composite Plan – Level 00 Block E | Perumal Pedavoli Architects | 23.03.2020 | J |
| 00_S013 | Composite Plan – Level 01 Block A & B, Level 00 Block C & D | Perumal Pedavoli Architects | 23.03.2020 | M |
| 00_S014 | Composite Plan – Level 02 Block A & B, Level 01 Block C & D | Perumal Pedavoli Architects | 23.03.2020 | M |
| 00_S015 | Composite Plan – Level 02 Block C | Perumal Pedavoli Architects | 23.03.2020 | M |
| 00_S021 | Composite Plan – Roof Part 1 | Perumal Pedavoli Architects | 23.03.2020 | K |
| 00_S022 | Composite Plan – Roof Part 2 | Perumal Pedavoli Architects | 23.03.2020 | I |
| 00_S101 | Overall Elevations – Sheet 01 | Perumal Pedavoli Architects | 23.03.2020 | K |
| 00_S102 | Overall Elevations – Sheet 02 | Perumal Pedavoli Architects | 23.03.2020 | G |
| 00_S201 | Overall Sections – Sheet 01 | Perumal Pedavoli Architects | 23.03.2020 | I |
| 00_S202 | Overall Sections – Sheet 02 | Perumal Pedavoli Architects | 23.03.2020 | I |

## 1.7 Fire Safety Sub-Systems

**Table 6: Fire Safety Sub-Systems [IFEG]**

| Symbol | Name | Description |
|---|---|---|
|  | **Sub-system A:** Fire Initiation & Development & Control | Sub-system A (SS-A) is used to define design fires in the enclosure of fire origin as well as enclosures to which the fire has subsequently spread and how fire initiation and development might be controlled. |
|  | **Sub-system B:** Smoke Development & Spread & Control | Sub-system B (SS-B) is used to analyse the development of smoke, its spread within the building, the properties of the smoke at locations of interest and how the development and spread might be controlled. |
|  | **Sub-system C:** Fire Spread & Impact & Control | Sub-system C (SS-C) is used to analyse the spread of fire beyond an enclosure, the impact a fire might have on the structure and how the spread and impact might be controlled. |
|  | **Sub-system D:** Fire Detection, Warning & Suppression | Sub-system D (SS-D) is used to analyse detection, warning and suppression for fires. This process enables estimates to be made of the effectiveness of suppression. |
|  | **Sub-system E:** Occupant Evacuation & Control | Sub-system E (SS-E) is used to analyse the evacuation of the occupants of a building. This process enables estimates to be made of the times required for occupants to reach a place of safety. |

| Symbol | Name | Description |
|---|---|---|
|  | **Sub-system F:**<br>Fire Services Intervention | Sub-system F (SS-F) is used to analyse the effects of the intervention activities of fire services on a fire including the effectiveness of suppression activities. |

## 2 Principal Building and Occupant Characteristics

### 2.1 Principal Building Characteristics

#### 2.1.1 Occupancy

There are five blocks (A, B, C, D & E) on site. Blocks A, B, C & D are physically connected by the roof and therefore are considered a united building. Block E is a standalone building. Both buildings consist of Class 9b (School).

#### 2.1.2 Location

The subject building is located at Commissioners Drive, Denham Court NSW 2565. The Fire Service can access the school from Commissioners Drive, Elkhorn Street and Willowdale Drive as shown in Figure 4.

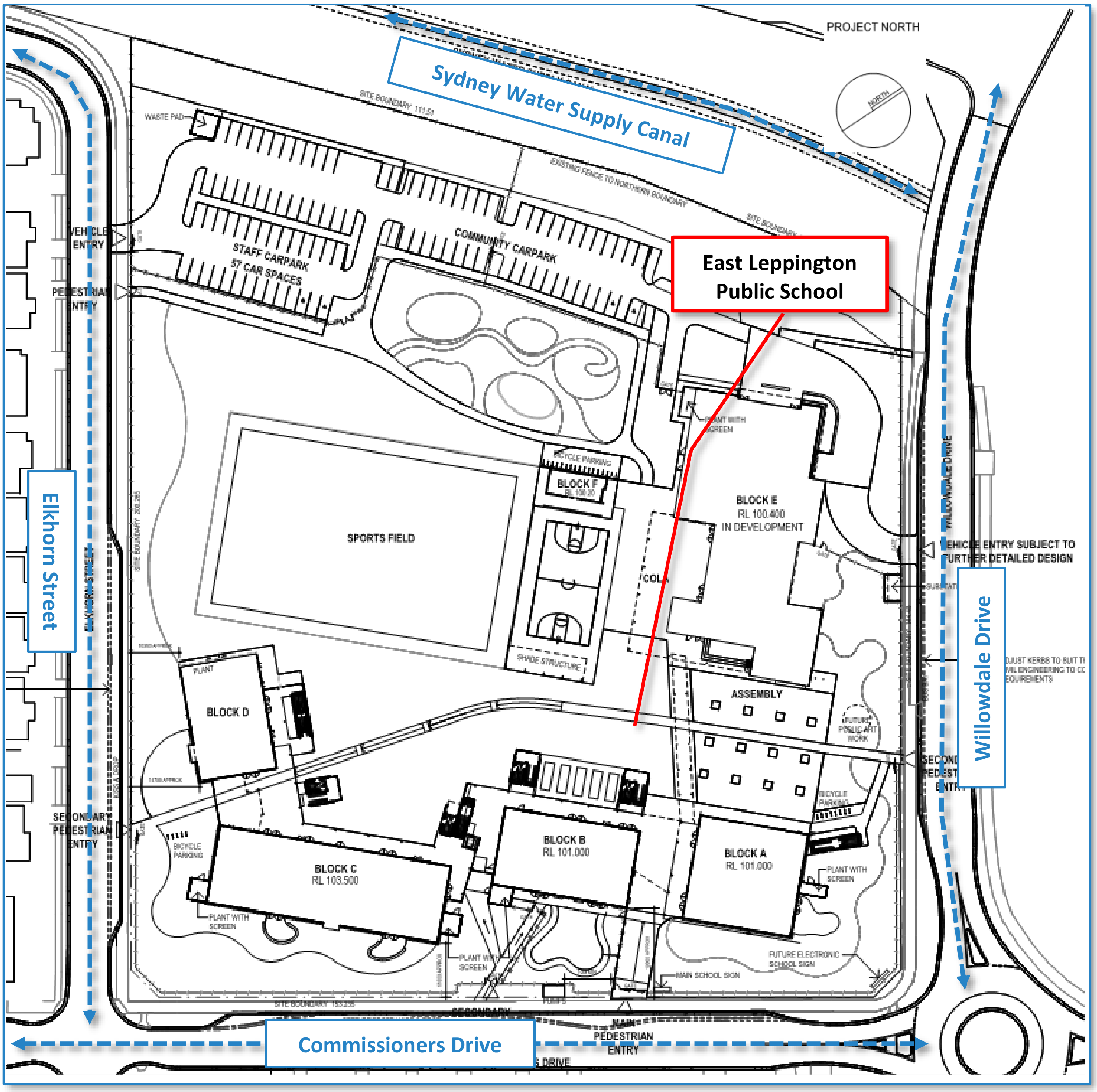



Figure 4: Map showing brigade access (©2020 Google)

The closest Fire & Rescue NSW stations have been listed in Table 7.

**Table 7: Responding fire services**

| Station Location | Resources | Road Distance (Google Maps – ©2020 Google) |
|---|---|---|
| **ST ANDREWS FIRE STATION**<br>Cnr Campbeltown RD & Ben Lomond Rd<br>ST Andrews NSW 2566 | 1 x Class 3 Pumper<br>1 x Bronto F37 Ladder Platform | 10.9 km |
| **INGLEBURN FIRE STATION**<br>41 Carlisle Street<br>Ingleburn NSW 2565 | 1 x Class 2 Pumper | 11.0 km |

### 2.1.3 Size and shape

As shown in Figure 5, the school comprise of five blocks:

- Block A – Admin/library building with 3 storeys
- Block B – Classroom building with 3 storeys
- Block C – Classroom building with 3 storeys
- Block D – Classroom building with 2 storeys
- Block E – Multipurpose Hall with 1 storey

Blocks A-D are connected by open walkways and therefore considered a united building. Block E is a standalone building.

Refer to Appendix G for relevant drawings.

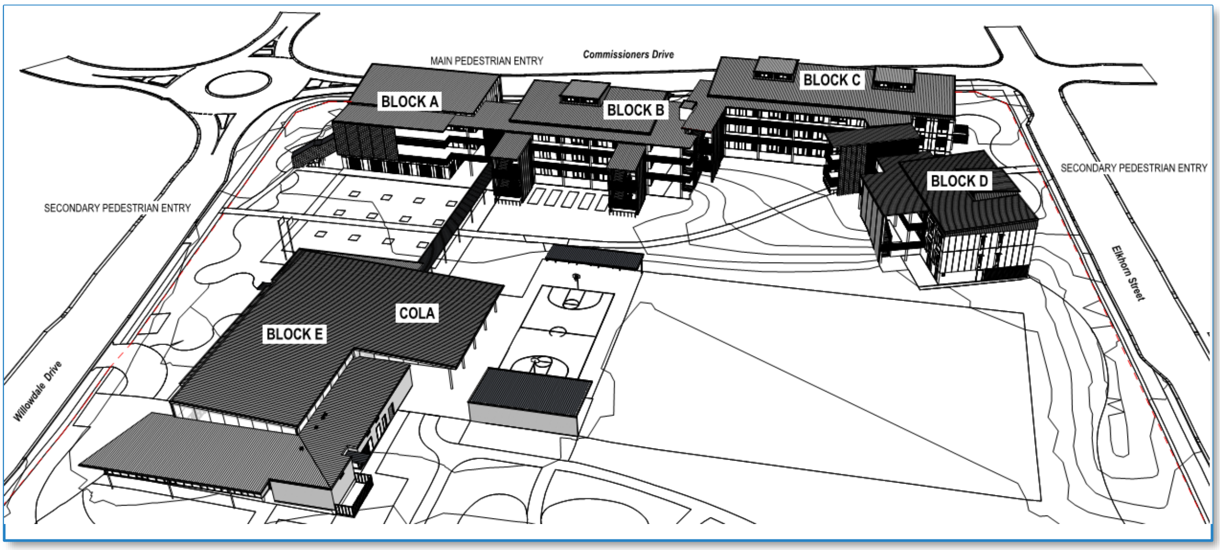



**Figure 5: 3D Site view showing five blocks**

## 2.2 Occupant Characteristics

Building occupants can generally be classified into separate distinctive groups: staff, students and visitors. All occupants are assumed to be representative of the general population with no specific or unusual distributions in respect to gender, age and physical or mental attributes. A detailed description is contained in Table 8 below:

**Table 8: Occupancy Characteristics**

| Characteristic | Description |
|---|---|
| Familiarity | Staff: Staff are expected to be familiar with the layout of the building and the location of exits.<br>Students: Students are expected to be familiar with the layout of the building and the location of exits.<br>Visitors: Visitors will generally be aware of the route they entered the building and are more likely to evacuate the building via this route even if other exits are closer.<br>Most occupants, however, are expected to be mostly transient and it cannot be guaranteed that all occupants would be familiar with the building, its layout and the exit points. However due to the simple layout of the building they are expected to be able to make their way to exits, or be guided by their staff. |
| Awareness | Staff: Staff are expected to be alert and sober.<br>Students are expected to be awake and alert to a potential emergency event such as a fire in the building.<br>Visitors: Visitors may be under the influence of alcohol or other mild narcotics at some times. |
| Mobility | Staff: Any hearing, visual or mobility impaired staff are assumed to be able to self-evacuate or be assisted by other staff members.<br>Students: Students are considered to be representative of the general population with some members having hearing, visual or mobility impairment and assumed to be assisted by staff.<br>Visitors: Visitors are considered to be representative of the general population including a limited proportion of mobility impaired occupants. These occupants may require crutches, a wheelchair or similar to evacuate on their own or need assistance from other occupants and / or staff. |
| Training | Staff: Some staff are expected to have received some form of emergency / first aid training but for the purposes of the assessment, all occupants are assumed to be untrained.<br>Students: Students are expected to have received some form of emergency but for the purposes of the assessment, all occupants are assumed to be untrained.<br>Visitors: Visitors are expected to have no form of emergency / first aid training and for the purposes of the report, are assumed to be untrained. |
| Age | Staff: Staff are considered to be representative of the general population with no specific or unusual distributions in respect to gender or age.<br>Students: Students are considered to be representative of the general population with a school age distribution but no specific or unusual distributions in respect to gender. |
| Culture / language | Staff: Staff are considered to be representative of the general population with some members having hearing, visual or mobility impairment and assumed to be assisted by staff.<br>Students: Students are considered to be representative of the general population with some members having varying cultural backgrounds and languages.<br>Visitors: Visitors are considered to be representative of the general population with some members having varying cultural backgrounds and languages.<br>Although occupants may have English as their second language, they are expected to understand signs or verbal instructions in English to the degree necessary to not adversely impact upon evacuation. |
| Occupancy Loading | Occupancy levels and distribution throughout the building is assumed to be in accordance with the occupancy loadings of Table D1.13 of the BCA for the respective area usage. |

# 3 Building Fire Safety

## 3.1 BCA Reference Characteristics

The information listed in Table 9 has been based on BCA Assessment Report.

### Table 9: Basic Building Information

| BCA Clause | | Description or Requirement |
|---|---|---|
| A1.1 | Effective Height | Less than 25 m |
| A3.2 | Occupancy Classification | BCA Class 9b (School) |
| C1.1 | Minimum Type of Construction | **Type A** for Main School Buildings (Block A, B, C, D)<br>**Type C** for Multipurpose Hall (Block E) |
| C1.2 | Rise in Storeys | 3 for Main School Buildings (Block A, B, C, D, being a united building)<br>1 for Multipurpose Hall (Block E) |
| C2.2 | Fire Compartment Floor Area and Volume | Main School Buildings: BCA Class 9b < 8,000 $m^2$, 48,000 $m^3$<br>Multipurpose Hall (Block E): BCA Class 9b < 3,000 $m^2$, 18,000 $m^3$ |

## 3.2 Summary of the Performance Solution

Table 10 lists variations to the BCA DtS Provisions that have been identified by the PCA and are addressed in this report:

### Table 10: Summary of Performance Solution

| No | Description of non-compliance | DtS Clause | Performance Requirement (A0.7) | IFEG Sub-systems | Method of meeting Performance Requirements (A0.2) | Assessment Method (A0.5) |
|---|---|---|---|---|---|---|
| **1** | To review and permit a reduction in spandrel/balcony separation between vertically aligned openings for building of Type A construction (Blocks A-D). | C2.6 | CP2 | A and C | A0.2(a) Refer Table 3 | A0.5(b)(ii) Refer Table 3 |
| **2** | To permit the reduction in general FRLs;<br>▪ from the required FRL of 120 minutes down to 60 minutes for building of Type A construction, i.e., main School Buildings (Blocks A-D);<br>▪ from the required FRL of 90 minutes down to 60 minutes for building of Type C construction, i.e., Hall Building (Block E). | Spec C1.1, Table 3, Table 5 | CP1 and CP2 | A and C | A0.2(a) Refer Table 3 | A0.5(b)(ii) Refer Table 3 |
| **3** | To permit the reduction of FRLs to the floors for buildings of Type A construction (Blocks A-D), from 120/120/120 to a ceiling having a Resistance to Incipient Spread of Fire (RISF) of 60 minutes. | Spec C1.1, Clause 3.1 Table 3 | CP1 and CP2 | A and C | A0.2(a) Refer Table 3 | A0.5(b)(ii) Refer Table 3 |
| **4** | To permit the reduction of FRLs to the floors for buildings of Type A construction (Blocks B, C & D), from | Spec C1.1, Clause 3.1 Table 3 | CP2, CP4 | A, C | A0.2(a) Refer Table 3 | A0.5(b)(ii) Refer Table 3 |

| No | Description of non-compliance | DtS Clause | Performance Requirement (A0.7) | IFEG Sub-systems | Method of meeting Performance Requirements (A0.2) | Assessment Method (A0.5) |
|---|---|---|---|---|---|---|
| | 120/120/120 to a ceiling having a Resistance to Incipient Spread of Fire (RISF) of 60 minutes. | | | | | |
| **5** | To permit the use of plywood timber noggings/reinforcement (for handrails/grabrails/wall mounted wet areas systems such as WHBs etc) in cavities of fire rated walls (internal or external) and non-fire-rated external walls the building of Type A construction (Blocks A-D). | C1.9, Spec C1.1, Clause 3.1(d) | CP2, CP4 | A, C & F | A0.2(a) Refer Table 3 | A0.5(b)(ii) Refer Table 3 |
| **6** | The residual pressure of internal fire hydrants is to be designed in accordance with AS 2419.1-2017 instead of AS 2419.1-2005, i.e., 250 kPa instead of 700 kPa by viewing them as “unassisted attack fire hydrant”. | E1.3, AS 2419.1 | EP1.3 | F | A0.2(a) Refer Table 3 | A0.5(b)(ii) Refer Table 3 |
| **7** | To permit the location of the fire hydrant booster to not technically be within sight of each building entry on the site, and not adjacent to the vehicular entrance. | E1.3, AS 2419.1 | EP1.3 | F | A0.2(a) Refer Table 3 | A0.5(b)(ii) Refer Table 3 |
| **8** | To permit the omission of Fire Hose Reels serving parts of the buildings that are not forming part of the main classroom areas of the building (i.e. admin, BOH, etc). | E1.4 | EP1.1 | C and D | A0.2(a) Refer Table 3 | A0.5(b)(ii) Refer Table 3 |

### 3.2.1 Exit arrangements

The exit / egress locations for the subject building are shown in Figure 6 - Figure 10. Refer to Appendix G for relevant drawings.

*Note: the “exit signs” used in the following figures are illustrative only and not the confirmed exit / directional exit sign posting locations (to be confirmed by electrical engineer).*


**Figure 6: Exit provisions on Level 00 Block A & B**

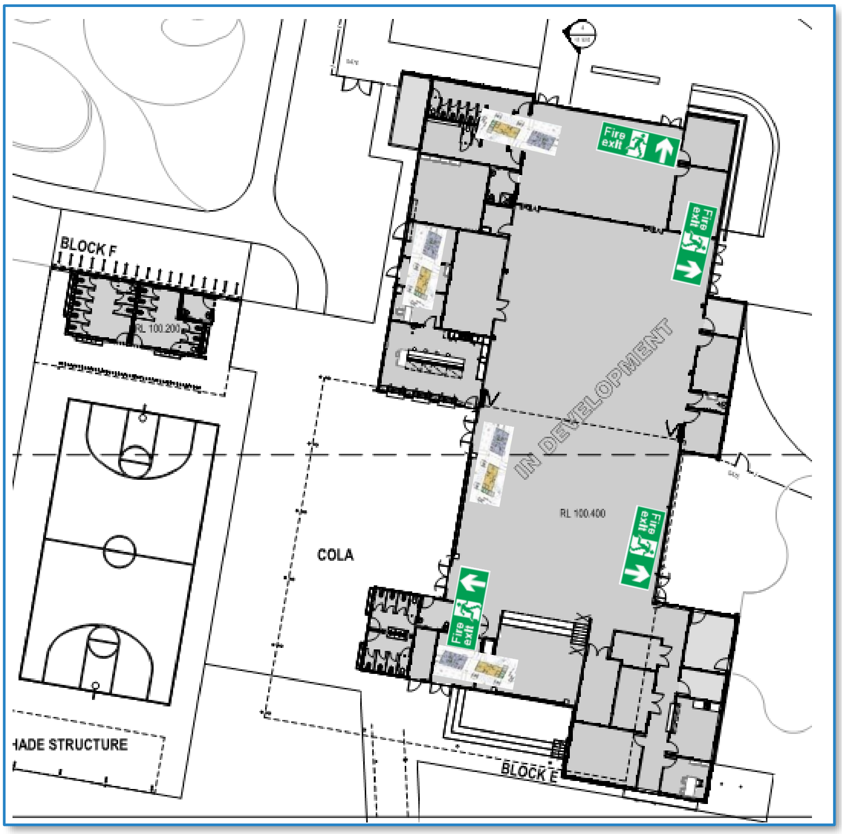



**Figure 7: Exit provisions on Level 00 Block E**

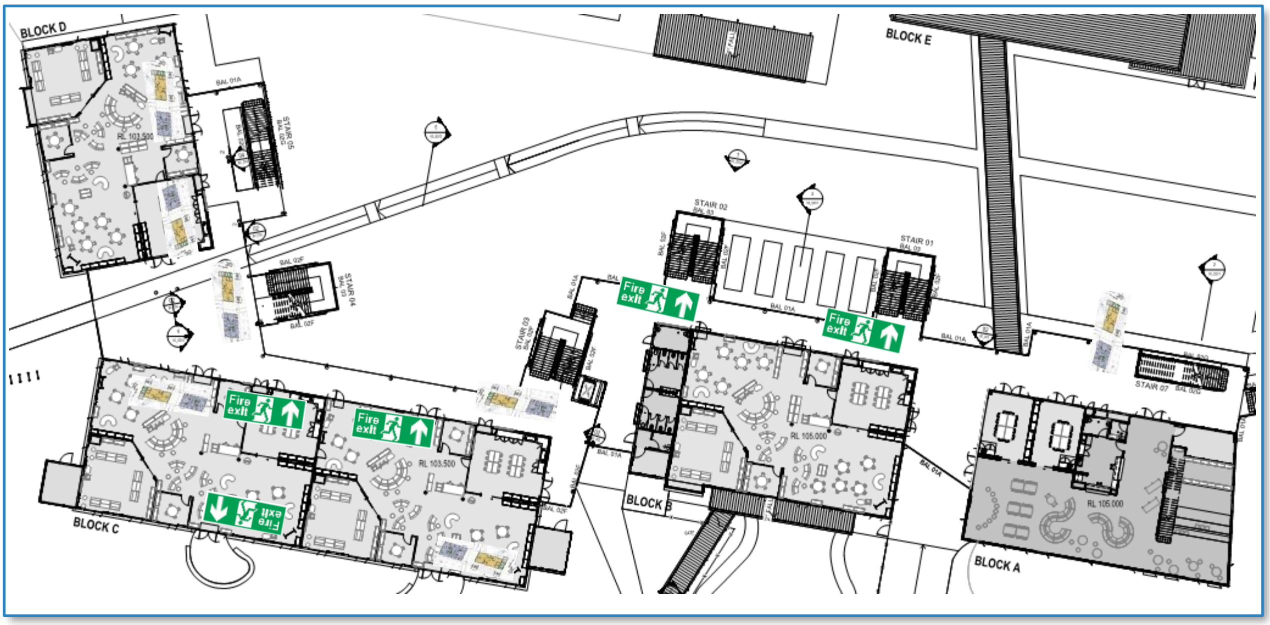



Figure 8: Exit provisions on Level 01 Block A & B, Level 00 Block C & D

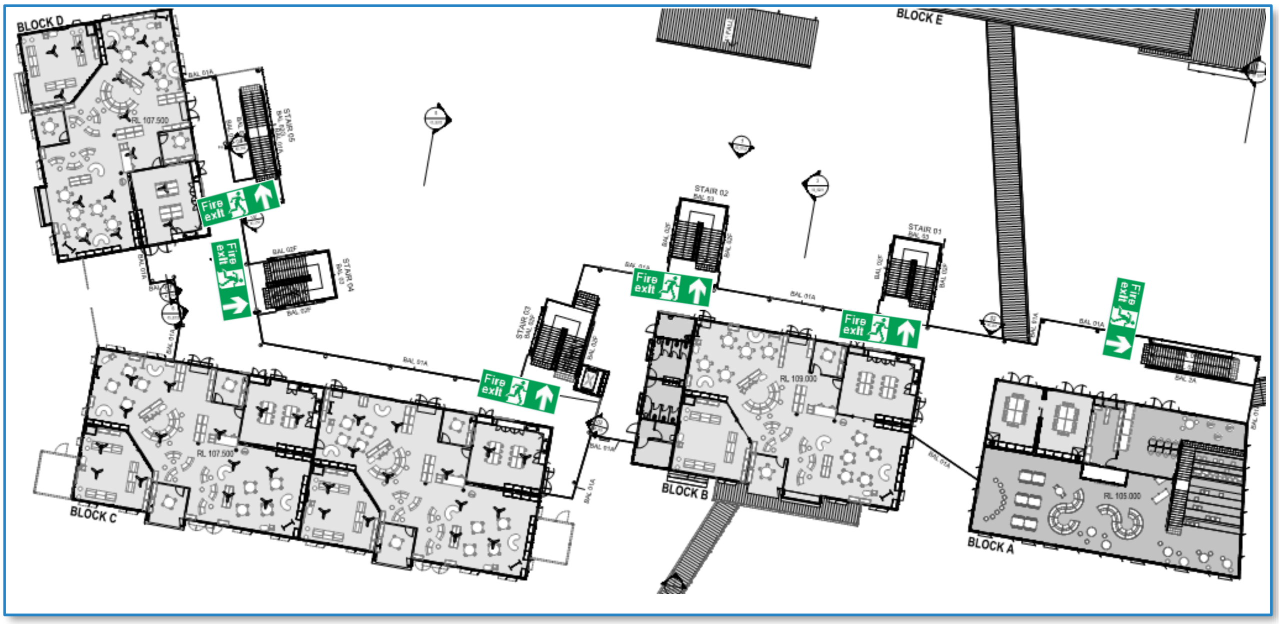



Figure 9: Exit provisions on Level 02 Block A & B, Level 01 Block C & D


Figure 10: Exit provisions on Level 02 Block C

### 3.2.2 Required fire safety features

The design includes the fire safety features listed in Table 2 earlier. These fire safety measures should be read in conjunction with the BCA Report /CC Checklist.

### 3.2.3 Fire Resistance

The building having a rise in storey of 3 (Main School Buildings, i.e., Blocks A-D) is to have a Type A construction and the building having a rise in storey of 1 (Multipurpose Hall, i.e., Block E) is to have a Type C construction. All building elements are required to have a fire resistance level (FRL) as listed in Table 5 or Table 3, respectively, of Specification C1.1 of BCA as appropriate.

All penetrations in fire rated construction shall be fire stopped in accordance with the BCA DtS requirements, except where addressed in this Report as an Alternative Solution.

It is noted that Blocks A & E are to be of conventional construction with concrete slab etc., and Blocks B, C & D are to be of modular construction with lightweight floor/ceiling system.

# 4 Performance Solution

## 4.1 Solution 1: Vertically Aligned Openings in External Walls for building of Type A construction (Blocks A-D)

### 4.1.1 Introduction

Table 11 provides a summary of this Solution, the relevant BCA DtS Provisions which are affected, and the relevant BCA Performance Requirements and IFEG sub-systems.

**Table 11: Summary of Solution**

| No | Description of non-compliance | DtS Clause | Performance Requirement (A0.7) | IFEG Sub-systems | Method of meeting Performance Requirements (A0.2) | Assessment Method (A0.5) |
|---|---|---|---|---|---|---|
| 1 | To review and permit a reduction in spandrel/balcony separation between vertically aligned openings for building of Type A construction (Blocks A-D). | C2.6 | CP2 | A and C | A0.2(a) Refer Table 3 | A0.5(b)(ii) Refer Table 3 |

It is proposed to have a performance-based spandrel separation for building of Type A construction (Blocks A-D).

Blocks A & E are to be of conventional construction with concrete slab etc., and Blocks B, C & D are to be of modular construction with lightweight floor/ceiling system.

This performance solution applies to Type A construction building (i.e., Blocks A-D) only. Building of Type C construction (i.e., Block E) is not subject to the requirement for spandrels.

**For Blocks B, C & D being of modular construction with lightweight floor/ceiling system**, the following DtS departures are to be addressed via this performance solution:

- The FRL of the spandrel is permitted to be **-/60/60** (non-loadbearing) and fire rated from outside only instead of 60/60/60.
- The part of vertical spandrel above the floor may reduce from 0.6 m to 0.0 m, and the total height of vertical spandrel of 0.9 m may reduce down to **0.58 m**.

Note the above reduction is subject to additional requirements as detailed in this Solution and Table 2 of Executive Summary, one notably being:

- Immediately above this 580 mm high spandrel by 2 layers of 13 mm Fyrchek, and to a minimum height of **1000 mm** above the internal finished floor level, the external wall/façade (above the fire-grade spandrel portion) shall be constructed with:
  - 6 mm fixed shut toughened glazing in metal framing (aluminium permitted); **OR**
  - Where no glazing is proposed, a non-combustible external wall lining of at least 13 mm thickness (e.g. CFC Sheeting, plasterboarding (external grade), or combination of both provided total thickness is at least 13 mm. This 13 mm of wall lining shall be placed externally of the wall, not internally and behind the insulation/sarking.

Example of the construction build up to satisfy the above glazing / non-combustible external lining is illustrated in Figure 11.

**For Block A being of conventional construction with concrete slab and set down**, the following DtS departures are to be addressed via this performance solution:

- The part of vertical spandrel above the slab may reduce from 0.6 m to 0.0 m, and the total height of vertical spandrel of 0.9 m may reduce down to **0.45 m (i.e. edge beam)**.

Note the above reduction is subject to additional requirements as detailed in this Solution and Table 2 of Executive Summary, one notably being:

- Immediately above this 450 mm high spandrel (i.e. edge beam), and to a minimum height of **1000 mm** above the edge beam, the external wall/façade shall be constructed with:
  - 6 mm fixed shut toughened glazing in metal framing (aluminium permitted); **OR**
  - Where no glazing is proposed, a non-combustible external wall lining of at least 13 mm thickness (e.g. CFC Sheeting, plasterboarding (external grade), or combination of both provided total thickness is at least 13 mm. This 13 mm of wall lining shall be placed externally of the wall, not internally and behind the insulation/sarking; **OR**
  - 110 mm thick brickwork.

Example of the construction build up to satisfy the above glazing / non-combustible external lining are illustrated in Figure 12.

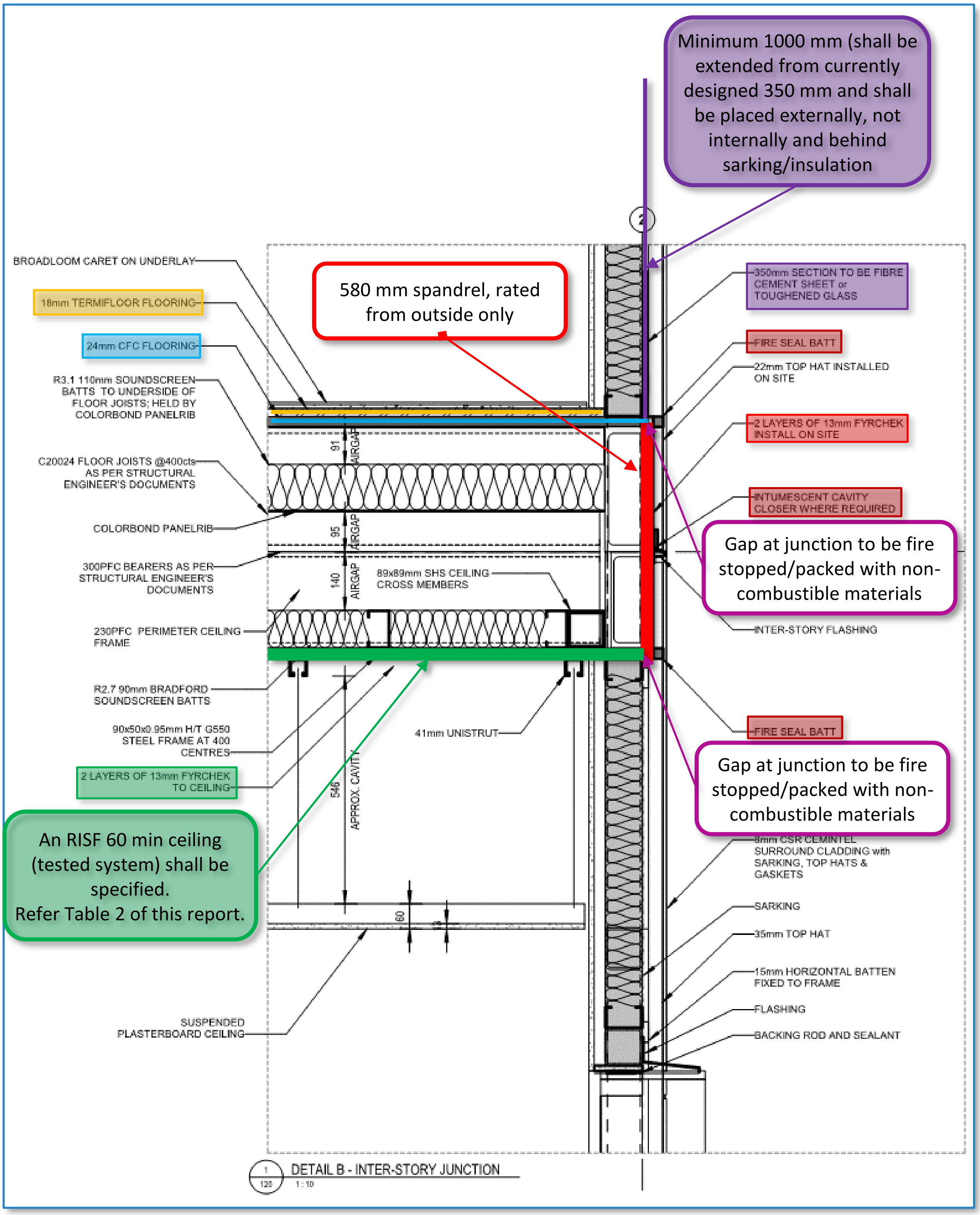



**Figure 11: Section showing fire rated (RISF) ceiling, flooring materials and spandrel arrangement (For Blocks B, C & D being of modular construction with lightweight floor/ceiling system)**

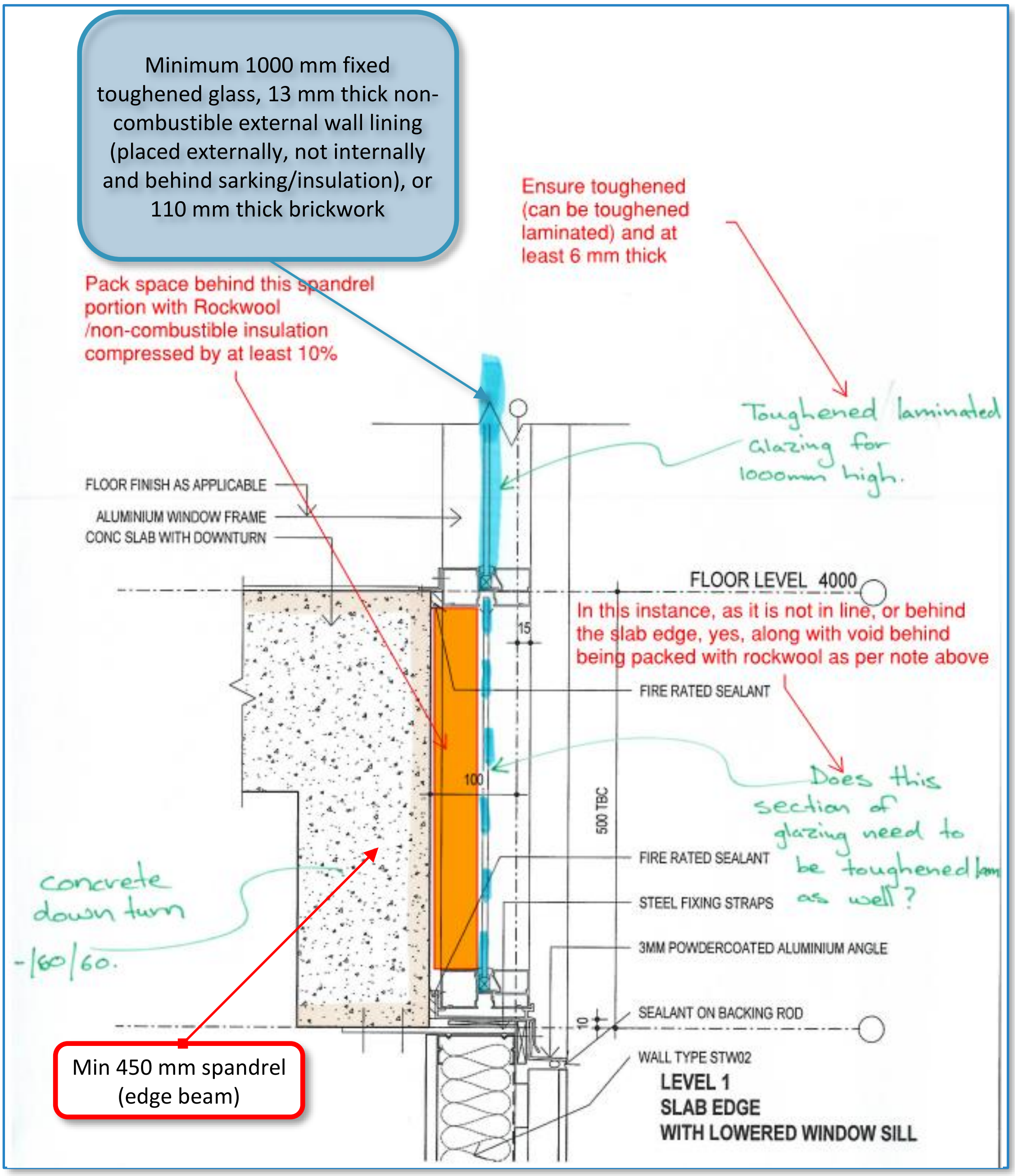



**Figure 12: Example of proposed spandrel separation (For Block A being of conventional construction with concrete slab and set down)**

### 4.1.2 Intent of the BCA

#### *4.1.2.1 BCA Clause C2.6*

BCA Clause C2.6 outlines the DtS requirements for vertical separation of openings in external walls and states that:

> (a) If in a building of Type A construction, any part of a window or other opening in an external wall is above another opening in the storey next below and its vertical projection falls no further than 450 mm outside the lower opening (measured horizontally), the openings must be separated by—
>
> (i) a spandrel which—
>
> (A) is not less than 900 mm in height: and

(B) extends not less than 600 mm above the upper surface of the intervening floor: and

(C) is of non-combustible material having an FRL of not less than 60/60/60: or

(ii) part of a curtain wall or panel wall that complies with (i); or

(iii) construction that complies with (i) behind a curtain wall or panel wall and has any gaps packed with a non-combustible material that will withstand thermal expansion and structural movement of the walling without the loss of seal against fire and smoke; or

(iv) a slab or other horizontal construction that—

(A) projects outwards from the external face of the wall not less than 1100 mm; and

(B) extends along the wall not less than 450 mm beyond the openings concerned; and

(C) is non-combustible and has an FRL of not less than 60/60/60.

BCA Guide outlines that the intent of BCA Clause C2.6 is to minimise the risk of fire spreading from one floor to another via openings in external walls in buildings of Type A construction. The vertical separation of openings can be achieved by the following method as illustrated in the BCA Guide:

> (1) A non-combustible spandrel or other non-combustible vertical construction having an overall height of 900 mm or more, extending at least 600 mm or more above the upper surface of the intervening floor, and having an FRL of 60/60/60 as shown in Figure C2.6(1).

BCA Figure C2.6 (1) below: Section showing separation of external wall openings in a curtain wall.

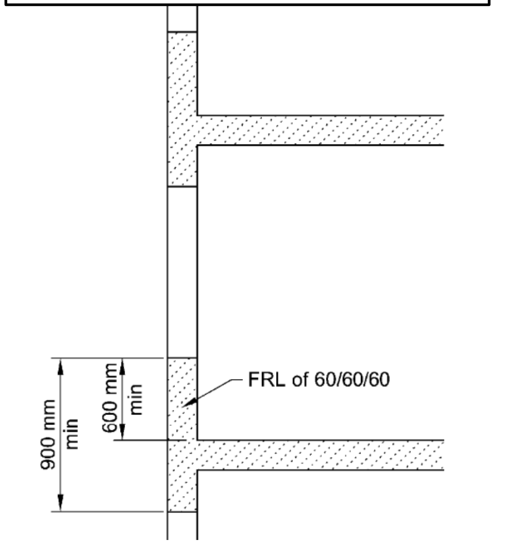



**Figure 13: BCA Guide illustration of an acceptable method of protection for BCA Clause C2.6**

The BCA Guide outlines that whilst it could be argued that the spandrel or vertical projection should have the same FRL as the floor separating the affected storeys, this has not been found to be necessary.

#### *4.1.2.2 BCA Performance Requirement CP2*

BCA Performance Requirement CP2 is described in Appendix A of this report.

### 4.1.3 Approach and assessment method

The approach for the spandrels is to be quantitative and abosulte using the assessment methods as shown in Table 3 and Table 11.

### 4.1.4 Trial Fire Safety Design

The fire safety measures listed in Table 2 forms the holistic fire safety design for the building.

**For Blocks B, C & D being of modular construction with lightweight floor/ceiling system**

The FRL of the spandrel is permitted to be **-/60/60** (non-loadbearing) and fire rated from outside only instead of 60/60/60.

The part of vertical spandrel above the slab/floor level may reduce from 0.6 m to 0.0 m, and the total height of vertical spandrel of 0.9 m may reduce down to **0.58 m**, subject to the following additional requirement/conditions:

- The 580 mm high spandrel shall be achieved by 2 layers of 13 mm Fyrchek (or equal approved fire-grade plasterboard) which provides an FRL of -/60/60 when tested from the inside.
- The above-mentioned 580 mm high spandrel achieved by 2 layers of 13 mm Fyrchek (or equal approved fire-grade plasterboard) is measured from the level of fire rated (RISF) ceiling to level of 24 mm CFC Flooring.
- Immediately above this 580 mm high spandrel by 2 layers of 13 mm Fyrchek, and to a minimum height of **1000 mm** above the internal finished floor level, the external wall/façade (above the fire-grade spandrel portion) shall be constructed with:
  - 6 mm fixed shut toughened glazing in metal framing (aluminium permitted); **OR**
  - Where no glazing is proposed, a non-combustible external wall lining of at least 13 mm thickness (e.g. CFC Sheeting, plasterboarding (external grade), or combination of both provided total thickness is at least 13 mm. This 13 mm of wall lining shall be placed externally of the wall, not internally and behind the insulation/sarking.

- Where 6 mm fixed shut toughened glazing is adopted for the above, the following detailed requirements for windows with toughened glazing are:
  - The window shall be fitted with 6 mm thick toughened safety glass, and fixed shut.
  - Window frames and hardware shall be made of metal (aluminium allowed).
  - Seals to stiles, head and sills or thresholds shall be manufactured from silicone (having a flammability index no greater than 5 according to AS 1530.2).
  - A fixed tag shall be placed on the inside of the window frame stating "**Window made of Metal Framing and Toughened Glazing. Refer to Construction Certificate when replacing the window**".
  - The tag shall comply with the requirements in Table 17.

- The gap between the RISF ceiling/FR plasterboard spandrel and the external 13 mm sheeting shall be fire stopped/packed with non-combustible materials.
- Example of the construction build up to satisfy the above glazing / non-combustible external lining is illustrated in Figure 11. *Note: the current section details show only a 350 mm of FC sheeting or toughened glass, this needs to be extended to at least 1000 mm as above requirement.*

**For Block A being of modular construction with lightweight floor/ceiling system**

The part of vertical spandrel above the slab may reduce from 0.6 m to 0.0 m, and the total height of vertical spandrel of 0.9 m may reduce down to **0.45 m (i.e. edge beam)**, subject to the following additional requirement/conditions:

- Immediately above this 450 mm high spandrel (i.e. edge beam), and to a minimum height of **1000 mm** above the edge beam, the external wall/façade shall be constructed with:
  - 6 mm fixed shut toughened glazing in metal framing (aluminium permitted); **OR**
  - Where no glazing is proposed, a non-combustible external wall lining of at least 13 mm thickness (e.g. CFC Sheeting, plasterboarding (external grade), or combination of both provided total thickness is at least 13 mm. This 13 mm of wall lining shall be placed externally of the wall, not internally and behind the insulation/sarking; **OR**
  - 110 mm thick brickwork.

- Where 6 mm fixed shut toughened glazing is adopted for the above, the following detailed requirements for windows with toughened glazing are:
  - The window shall be fitted with 6 mm thick toughened safety glass, and fixed shut.
  - Window frames and hardware shall be made of metal (aluminium allowed).

- Seals to stiles, head and sills or thresholds shall be manufactured from silicone (having a flammability index no greater than 5 according to AS 1530.2).
    - A fixed tag shall be placed on the inside of the window frame stating "**Window made of Metal Framing and Toughened Glazing. Refer to Construction Certificate when replacing the window**".
    - The tag shall comply with the requirements in Table 17.

- Example of the construction build up to satisfy the above glazing / non-combustible external lining are illustrated in Figure 12.

**Additional notes**

- *Spandrel Note: Where balconies are constructed of concrete along the long sides of each Homebase and achieves the following requirements as per BCA C2.6, then vertical spandrels are not required:*
    - *have an FRL of 60/60/60; and*
    - *are at least 1100 mm deep and extend at least 450 mm past each opening located above/below that balcony; and*
    - *the gaps between those balconies and the building are fire stopped/rated along the line of each floor to form a continuous fire separated between floors that extend through to the balcony.*
- *General Notes:*
    - *CSR have also confirmed (See Appendix E) that the replacement of CSR Gyprock Fyrchek or Fyrchek MR with the EC08 range of linings with an equivalent thickness is supported by dedicated Test Reports that support their use in lieu of the CSR Gyprock Fyrchek or Fyrchek MR.*

### 4.1.5 Acceptance criteria

The acceptance criterion is that the heat radiation received at the openings above the spandrel does not cause an ignition. As per Table A3 of AS 1530.4, ignition is assumed to occur at 25 kW/m$^2$ for unpiloted ignition and 13 kW/m$^2$ for piloted ignition (which correspond to the normal ignition range of materials), which will be used for receiving radiant heat flux to the unprotected openings.

TABLE A3

TYPICAL RADIANT HEAT INTENSITIES FOR VARIOUS PHENOMENA

| Phenomena | kW/m$^2$ |
|---|---|
| **Maximum for indefinite exposure for humans** | |
| Pain after 10 s to 20 s | 4 |
| Pain after 3 s | 10 |
| Piloted ignition of cotton fabric after a long time | 13 |
| Piloted ignition of timber after a long time | 13 |
| Non-piloted ignition of cotton fabric after a long time | 25 |
| Non-piloted ignition of timber after a long time | 25 |
| Non-piloted ignition of gaberdine fabric after a long time | 27 |
| Non-piloted ignition of black drill fabric after a long time | 38 |
| Non-piloted ignition of cotton fabric after 5 s | 42 |
| Non-piloted ignition of timber in 20 s | 45 |
| Non-piloted ignition of timber in 10 s | 55 |

Figure 14: Typical Radiant Heat Intensities for Various Phenomena (AS 1530.4)

### 4.1.6 Method of analysis

For the DtS departures of one way fire rating, portion of spandrel above floor, a qualitative assessment is undertaken with the consideration of the specific spandrel configuration and other proposed requirements.

For the insufficient spandrel height, a quantitative analysis based on the equations to determine the flame projection from an opening as per Eurocode 1: 2002, Part 1-2: Annex B 'Thermal actions for external members' is conducted. From the flame projection predictions the amount of heat radiated back onto the window above is determined. This is then be compared against the ignition criteria for possible fire spread. The calculation methodology is presented in Appendix B.

Further, a qualitative comparative analysis will be carried out in areas of the building that whilst within an overall building having a RIS of 3 (thus attracting the Type A construction requirements (spandrels)), some part (i.e., Block D) only contains two levels and the risk of fire spread comparable to an equivalent 2-storey (Type B construction) school building.

### 4.1.7 Hazards

There is an increased risk of external vertical fire spread along the height of the building with the non-compliant spandrel configuration in the subject building. The external vertical fire spread may start a fire in the storey above the storey where the fire originated and the same may occur on subsequent upper storeys.

### 4.1.8 Analysis

#### *4.1.8.1 Relevance of spandrel fire rating from the inside*

BCA Guide outlines that the intent of BCA Clause C2.6 is to minimise the risk of fire spreading from one floor to another via openings in external walls in buildings of Type A construction. It is therefore considered that the main purpose for the spandrel is to separate the fire externally from spreading upwards. The hazard for the building elements is then a direct fire impingement on the external side. With the fire rating from the outside, the spandrel is deemed to work as an effective method of separating fire from spreading in the same manner as in a BCA DtS design.

Although there is a lack of fire rating from the inside, the risk of fire breaking out the spandrel on the fire floor and then spreading upwards is not increased. This is due to the design of the spandrel being located above the RISF ceiling, as shown in Figure 13. With the RISF ceiling in place, the fire is expected to be contained below the ceiling, the internal side of spandrel is not subject to the direct impact of fire/flame.

Overall, given the configuration of the spandrel in the performance solution, and in combination of the proposed RISF ceiling, it is considered the spandrel with fire rating from outside only is appropriate and acceptable.

#### *4.1.8.2 Discussion of FRL testing method*

The FRL required in the BCA is tested in accordance with AS 1530.4 which stipulate for instances that one-way fire rating may be accepted:

> *3.5.1 Fire resistance from either direction*
>
> *Where an element is required to resist fire from either direction, specimens shall be tested from each direction, except that where the testing laboratory considers that one particular direction will give a lower fire resistance, the first test shall be conducted in that direction and the testing authority may, at its discretion, waive the second test.*
>
> *3.5.2 Fire resistance from one direction*
>
> *Where an element is to resist fire in one direction only, the test specimen shall be tested in that direction.*

The above clauses indicate that it is acknowledged in some scenarios (although not specified), only one-way fire rating shall be considered, which in the case of this Performance Solution is considered justified. The spandrels with the analysis in the above section are believed to fall in this category.

#### *4.1.8.3 Portion of spandrel above or below the "floor"*

A typical vertical spandrel involves at 600 mm fire rated element above the floor level of the upper level (i.e., 600 mm spandrel being part of the upper level) and at least 300 mm including floor slab and any spandrel from the lower level, as shown in Figure 13.

For Blocks B, C & D being of modular construction with lightweight floor/ceiling system, the subject design involves a 580 mm fire rated spandrel below the floor (i.e., fully within the lower level) and a minimum of 1000 mm of fixed shut toughened glazing or 13 mm thick CFC Sheeting / plasterboarding above the 580 mm spandrel, as shown in Figure 11.

It is noted although the spandrel is fully below the floor (i.e., fully within the lower level) instead of at least 600 mm above the floor, it is above the line of an RISF ceiling, which is the proposed horizontal fire separation between levels. If deeming the RISF ceiling the actual floor level (arguably more accurate since the concept of floor separation in the context of spandrel requirement for fire separation between levels), the potion of the spandrel is comparable to the design where the majority of the spandrel is located above the floor slab.

#### *4.1.8.4 Calculations on heat radiation received at openings above*

A quantitative analysis based on Margaret Law's 'Fire Safety of Bare External Structural Steel' is carried out. This assessment conservatively assumes that each floor is a compartment floor and that all the fire and energy spread through the window of the lower fire compartment to the windows directly overhead. The dimensions of the burning compartment were measured in the referenced drawings. The fire is assumed to be ventilation controlled which is expected to be a rare worst case scenario considering the size of the window.

Each block is assessed individually with a representative window from each of the façade. A full calculation process for W3 of Block A as an example is shown in Appendix B.

**For Blocks B, C & D being of modular construction with lightweight floor/ceiling system:**

- 0.58 m vertical spandrel.
- Immediately above this 580 mm high spandrel, a minimum height of 1000 mm of 6 mm fixed shut toughened glazing or non-combustible external wall lining of at least 13 mm thickness (e.g. CFC Sheeting, plasterboarding (external grade).

**For Block A being of conventional construction with concrete slab and set down**

- 0.45 m vertical spandrel (i.e. edge beam).
- Immediately above this 450 mm high spandrel (i.e. edge beam), a minimum height of 1000 mm of 6 mm fixed shut toughened glazing or non-combustible external wall lining of at least 13 mm thickness (e.g. CFC Sheeting, plasterboarding (external grade), or 110 mm thick brickwork.

The calculation results for Blocks A-D (building of Type A construction) are shown in Table 12 - Table 15.

**Table 12: Summary of calculation results – Block A (conventional construction with concrete slab and set down)**

| Openings | Maximum Radiation received on openings above DtS spandrel (kW/m²) | Maximum Radiation received on openings Performance Solution spandrel (kW/m²) | Maximum Radiation received on level above after attenuation in Performance Solution (kW/m²) |
|---|---|---|---|
| W1 | 28.5 | 31.3 | 18.8 |
| W2 | 28.5 | 31.3 | 18.8 |
| W3 | 36.3 | 39.8 | 23.9 |
| W4 | 28.5 | 31.3 | 18.8 |

**Table 13: Summary of calculation results – Block B (modular construction with lightweight floor/ceiling system)**

| Openings | Maximum Radiation received on openings above DtS spandrel (kW/m²) | Maximum Radiation received on openings Performance Solution spandrel (kW/m²) | Maximum Radiation received on level above after attenuation in Performance Solution (kW/m²) |
|---|---|---|---|
| W1 | 29.2 | 32.9 | 19.7 |
| W2 | 28.1 | 31.7 | 19.0 |
| W3 | 28.1 | 31.7 | 19.0 |
| W4 | 24.1 | 27.2 | 16.3 |

### Table 14: Summary of calculation results – Block C (modular construction with lightweight floor/ceiling system)

| Openings | Maximum Radiation received on openings above DtS spandrel (kW/m²) | Maximum Radiation received on openings Performance Solution spandrel (kW/m²) | Maximum Radiation received on level above after attenuation in Performance Solution (kW/m²) |
|---|---|---|---|
| W1 | 30.1 | 33.9 | 20.3 |
| W2 | 27.3 | 30.8 | 18.5 |
| W3 | 24.0 | 27.1 | 16.3 |
| W4 | 29.6 | 33.3 | 20.0 |

### Table 15: Summary of calculation results – Block D (modular construction with lightweight floor/ceiling system)

| Openings | Maximum Radiation received on openings above DtS spandrel (kW/m²) | Maximum Radiation received on openings Performance Solution spandrel (kW/m²) | Maximum Radiation received on level above after attenuation in Performance Solution (kW/m²) |
|---|---|---|---|
| W1 | 26.0 | 29.5 | 17.7 |
| W2 | 27.3 | 30.9 | 18.5 |
| W3 | 22.3 | 25.3 | 15.2 |
| W4 | 27.7 | 31.4 | 18.8 |

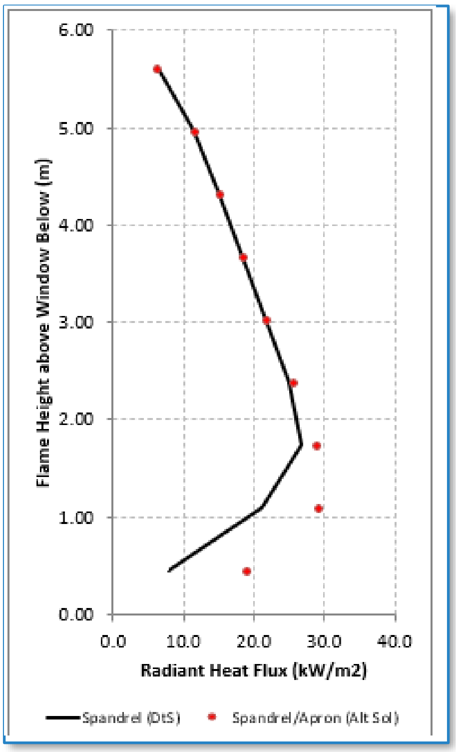


Figure 15: Results of heat radiation received above opening at centre of flame – worst case scenario (W3) in Block A

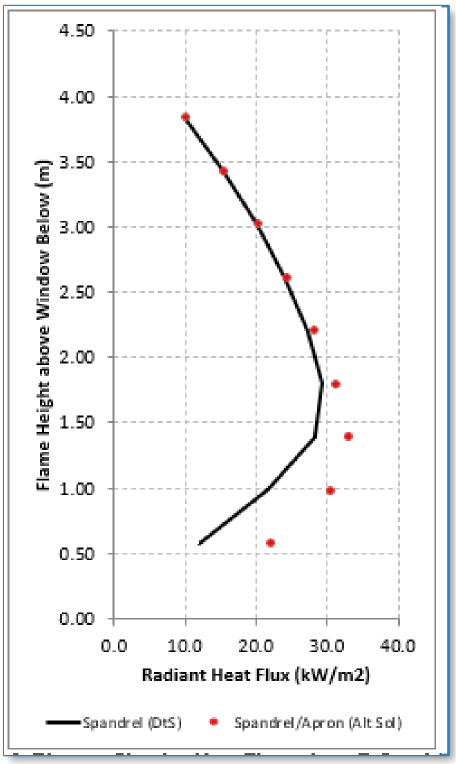



Figure 16: Results of heat radiation received above opening at centre of flame – worst case scenario (W1) in Block B

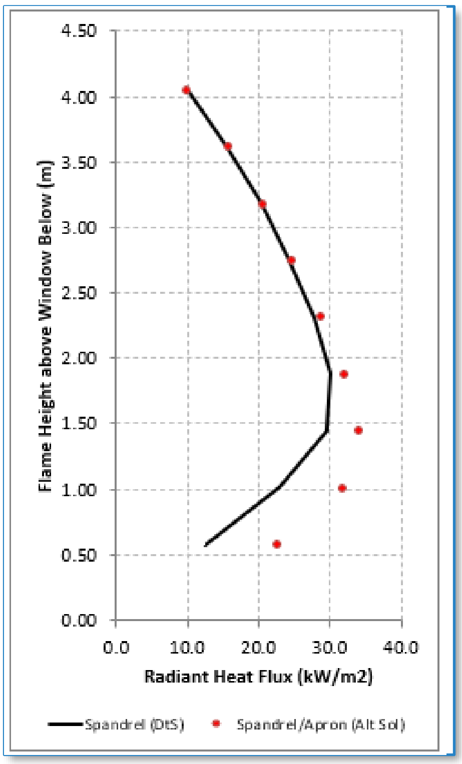


Figure 17: Results of heat radiation received above opening at centre of flame – worst case scenario (W1) in Block C

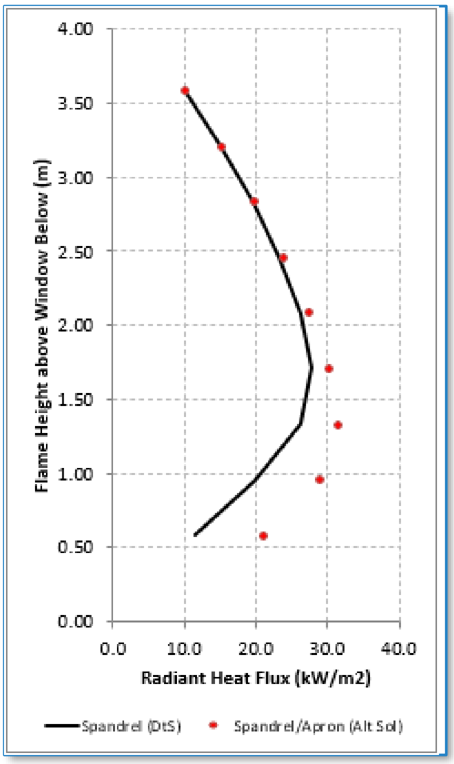



Figure 18: Results of heat radiation received above opening at centre of flame – worst case scenario (W4) in Block D

The results show that the maximum radiant heat flux received at the opening above by the external flame in the performance solution with 580 mm spandrel is up to **39.8 kW/m²** (W3 of Block A being the worst case scenario). In contrast, the maximum radiant heat flux received at the opening above by the external flame in a DtS design with 900 mm spandrel is lower but with only a slight reduction, i.e., **36.3 kW/m²**.

The results from ***both the designs exceed the ignition criteria***, which indicates the DtS design is not necessarily safe / sufficient to avoid vertical fire spread

To mitigate this, additional requirement is proposed in the performance solution with at least 1000 mm of 6 mm toughened glass or at least 13 mm thickness (e.g. CFC Sheeting, plasterboarding (external grade) above the 580 mm spandrel. The proposed toughened glass or CFC Sheeting / plasterboarding, whilst not rated, would withstand the flame and provide attenuation of the radiation such that the received heat radiation inside the room after the attenuation is lower than the ignition criteria, and therefore the fire spread is not expected to occur.

#### *4.1.8.5 Attenuation of Toughened Glass*

As part of the performance solution requirement, it is required that immediately above the 580 mm high spandrel, a minimum height of 1000 mm of 6 mm fixed shut toughened glazing or non-combustible external wall lining of at least 13 mm thickness (e.g. CFC Sheeting, plasterboarding (external grade). This section provides further details on the attenuation effects of the toughened glazing.

AS 3959 prescribes the type of construction for windows to withstand a bushfire attack level of 40 (BAL 40). Sub-section 8.1 of AS 3959 prescribes that "*BAL40 is primarily concerned with protection from ember attack, increased likelihood of flame contact and radiant heat greater than 29 kW/m² and up to and including 40 kW/m².*" Therefore, window construction to BAL40 is designed to withstand an incident heat flux of up to 40 kW/m². Toughened glass proposed for this type of glass has been tested by Bowditch up to a radiant heat exposure of 40 kW/m² without fracture.

Through the Bushfire CRC, the CSIRO Bushfire Research Laboratory at Highett, Victoria, carried out an experimental project in which glazing was subjected to simulated bushfire. The experiments were led by P. A. Bowditch et al. The intent of the project work was to investigate the common design parameters found in conventional building systems and determine their influence on performance under bushfire exposure conditions. The key variables are:

- Glass type
- Glass treatment
- Glass thickness
- Frame material
- Frame design
- Multi-glazed elements

The test apparatus developed for this research was constructed at the CSIRO Bushfire Research Laboratory to simulate the exposure of specimens to bushfire conditions. The gas-fired radiant panel array is 1500 × 1500 mm and can expose materials at radiation levels up to 60 kW/m². Figure 19 shows the test apparatus with the radiant panel in the background.

**Figure 19: Test apparatus used in Bushfire CRC tests**

The characteristics of a radiation versus time exposure recorded were:

- Peak radiation exposure.
- Rate at which peak exposure was attained.
- Maximum time of peak and overall specimen exposure.

Radiation was measured using water-cooled Schmidt Boelter radiometers with a sensing range of 0–100 kW/m². Radiometers were placed above and below each test specimen, facing the radiant panel. The feedback from the radiometers was used to determine the location of each specimen in relation to the radiant panel to give the desired radiation loading on the specimen during a test.

Figure 20 shows the location of thermocouples and radiometers used on and around the test specimens.

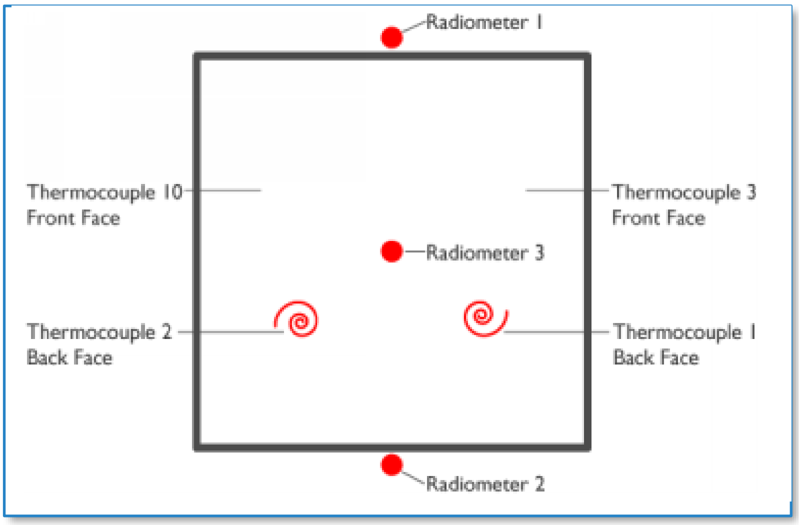



**Figure 20: Thermocouple and radiometer locations on test specimen**

A radiometer was also placed 25 mm behind the glass in the centre of the specimen facing the radiant panel. This measured the radiation passing through the specimen and gave an indication of the attenuation of radiation incident on the glass.

In the report "*Window and Glazing Exposure to Laboratory-Simulated Bushfires*", the peak front and back face temperatures of toughened glass was reported, as shown in Figure 21.

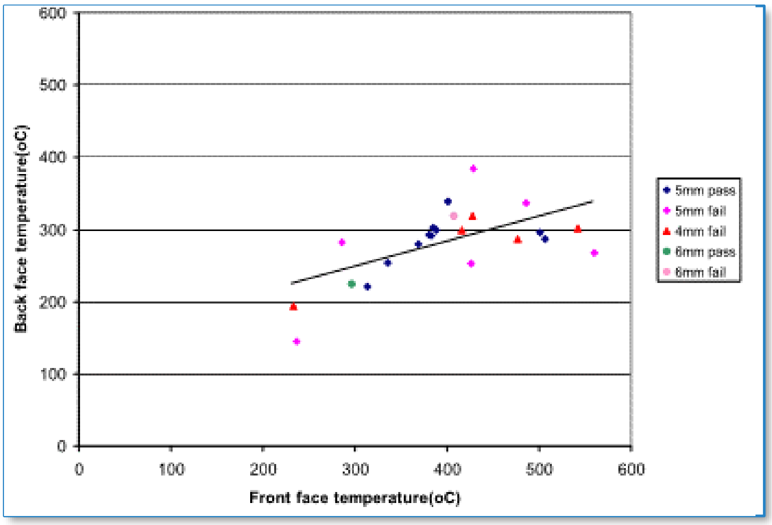



**Figure 21: Peak front and back face temperatures of toughened glass**

Work by Bowditch identified that window construction similar to BAL40 glazing is able to withstand an incident heat flux of 40 kW/m$^2$ without fracture, and toughened glass provides a substantial reduction to the amount of radiant heat flux transmitted through the glazing.

A snapshot of the complied test data is shown in Figure 22 where the highlighted row shows the attenuation rate for the 6 mm toughened glass is:

(Peak_Rad – Peak_Back face)/ Peak_Rad = (51-16)/51 = 68.6%

Tests for other thickness are summarised with a regression analysis shown in Table 16.

| Specimen no. | Glass | Thickness (mm) | Glass treatment | Frame type | Window seal | Sash (fixed/open) | Test profile | Radiation (kW/m²) Peak at failure | Peak Rad 1 | Peak Rad 2 | Temperature (°C) Peak back face | Peak front face | Peak back face | Time to flaming (s) | Failure mode | Glass failure 1st crack (s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5TFA40S | Toughened | 5 | No | Alum A | Rubber | No | F | 1C | 63 | 47 | 23 | 442 | 412 | No | No | 800R |
| Trend 1 | Toughened | 5 | No | Alum E | Rubber | Open | E | No | 37 | 43 | 16 | 339 | 309 | No | No | No |
| Trend 2 | Toughened | 5 | No | Alum F | Rubber | Open | E | No | 38 | 40 | 10 | 191 | 147 | No | No | No |
| Trend 8 | Toughened | 5 | No | Alum E | Rubber | Open | E | 1C | 43 | 44 | 20 | 422 | 246 | 156 | No | 2.5 hour post-test |
| Trend 9 | Toughened | 5 | No | Alum H | Rubber | Open | E | 1C | 40 | 39 | 12 | 365 | 240 | 230 | No | 4 min post-test |
| Trend 10 | Toughened | 5 | No | Alum G | Rubber | Open | E | No | 41 | 40 | 11 | 365 | 265 | 165 | No | No |
| Trend 12 | Toughened | 5 | No | Alum E | Silicone | Open | F | 40 | 45 | 25 | 22 | 403 | 264 | 734 | 742 s internal flaming | No |
| Trend 13 | Toughened | 5 | No | Alum E | Silicone | Open | E | 40 | 39 | 24 | 17 | 328 | 317 | 240 | No | No |
| Trend 14 | Toughened | 5 | No | Alum E | Silicone | Open | E | No | 39 | 24 | 19 | 193 | 272 | No | No | No |
| Trend 15 | Toughened | 5 | No | Alum E | Silicone | Open | F | No | 41 | 24 | 22 | 351 | 409 | No | No | No |
| Trend 16 | Toughened | 5 | No | Alum F | Silicone | Open | F | No | 38 | 24 | 17 | 351 | 318 | 735 | No | No |
| Trend 17 | Toughened | 5 | No | Alum E | Silicone | Open | F | No | 46 | 26 | 18 | 473 | 428 | 692 | 817 s internal flaming | No |
| Trend 18 | Toughened | 5 | No | Alum E | Silicone | Open | F | No | 46 | 25 | 19 | 438 | 361 | 625 | No | No |
| Trend 19 | Toughened | 5 | No | Alum E | Silicone | Open | F | No | 46 | 27 | 19 | 415 | 313 | No | No | No |
| Trend 20 | Toughened | 5 | No | Alum F | Silicone | Open | F | 40 | 46 | 25 | 20 | 430 | 386 | 904 | 913 s internal flaming | No |
| Trend 21 | Toughened | 5 | No | Alum F | Silicone | Open | F | 40 | 46 | 24 | 19 | 420 | 380 | 683 | 683 s internal flaming | No |
| Trend 22 | Toughened | 5 | No | Alum F | Silicone | Open | F | No | 50 | 24 | 21 | 443 | 398 | No | No | No |
| Trend 23 | Toughened | 5 | No | Alum F | Silicone | Open | F | No | 44 | 23 | 19 | 390 | 373 | No | No | No |
| Trend 24 | Toughened | 5 | B | Alum F | Silicone | Open | E | No | 67 | 40 | 18 | 509 | 370 | 314 | No | No |
| Trend 25 | Toughened | 5 | No | Alum F | Silicone | Open | F | 60 | 64 | 38 | 42 | 368 | 272 | No | Shatter | 576 shatter |
| 6TFA40F | Toughened | 6 | No | Alum A | Rubber | No | E | No | 51 | 40 | 16 | 394 | 340 | No | No | No |
| Trend 11 | An/toughened | 15.38 | No | Alum G | Rubber | Open | E | 22 | 22 | 20 | 1 | 95 | 32 | 150 | Crack | 65 |
| Trend 7 | An/toughened | 15.38 | No | Alum G | Rubber | Open | F | 11 | 9 | 11 | 1 | 163 | 74 | | Crack | 621 |
| Trend 4 | An/toughened | 15.38 | No | Alum G | Rubber | Open | E | 40 | 38 | 39 | 1 | 253 | 51 | No | Crack | 115 |
| L5B30ALW30 | Laminated | 5.38 | No | Alum A | No | No | B | 19 | 23 | 16 | 6 | 81 | 59 | No | Crack | 82 |

### Figure 22: Test results for aluminium framed glass

### Table 16: Attenuation of Toughened Glass [Bowditch]

| Glass | Framing | Thickness (mm) | Radiation Attenuation Min | Max | Average |
|---|---|---|---|---|---|
| **Toughened** | Aluminium | 3 | 38.4% | 64% | 51.4% |
| **Toughened** | Aluminium | 4 | 40% | 76.7% | 57.5% |
| **Toughened** | Aluminium | 5 | 34.3% | 73.9% | 59.8% |
| **Toughened** | Aluminium | 6 | 68.6%<br>(only 1 test conducted) | 68.6%<br>(only 1 test conducted) | 68.6%<br>(only 1 test conducted) |

The inclusion of toughened glass to the identified openings requiring protection shall contribute to reducing the radiant heat flux received from a fire in level below. The use of toughened glass at various thickness prescribed shall attenuate the radiation received at the openings to be less than 25 kW/m$^2$ for which unpiloted ignition occurs.

The average attenuation rage from 3 mm to 6 mm toughened glass follows the trend from 51.4% to 68.6%. It is acknowledged only 1 test was conducted for the 6 mm toughened glass however the overall results provides consistency. Overall it is considered reasonable to apply an attenuation rate of 40% for the proposed 6 mm toughened glass.

For the worst case of up to 39.8 kW/m$^2$ (W3 of Block A), the received heat radiation inside the room on the level above after attenuation is **reduced** from 39.8 kW/m$^2$ **to 23.9 kW/m$^2$**, which is lower than the unpiloted ignition criteria (25 kW/m$^2$).

The construction requirements for windows with toughened glazing are:

- The window shall be fitted with 6 mm thick toughened safety glass, and fixed shut.
- Window frames and hardware shall be made of metal (aluminium allowed).

- Seals to stiles, head and sills or thresholds shall be manufactured from silicone (having a flammability index no greater than 5 according to AS 1530.2).
- A fixed tag shall be placed on the inside of the window frame stating “Window made of Metal Framing and Toughened Glazing. Refer to Construction Certificate when replacing the window”.
- The tag shall comply with the requirements in Table 17.

**Table 17: Tag requirements (similar to those required for fire doors in AS 1905.1)**

| Tag requirement | Description |
|---|---|
| Dimensions | The dimensions of the metal tag for marking shall be not less than 50 mm × 10 mm. |
| Method of marking | The required information shall be etched, embossed or stamped on the metal tags so that it is recessed or projected not less than 0.25 mm below or above the surface of the tag. Alphabetic or numeric characters shall be not less than 1.5 mm high. |
| Location | The tag shall be located on the window frame so as to be readily visible when viewed from the inside of the room with the window in either the open or closed position. |
| Method of Fixing | The tag shall be firmly fixed to minimize the possibility of detachment during the service life of the window. |

Where it is proposed to use 13 mm thickness (e.g. CFC Sheeting, plasterboarding (external grade) instead of the 6 mm toughed glass, it is expected that the attenuation effect is at least equivalent. Based on above, the risk of vertical fire spread is considered mitigated in the performance solution.

#### *4.1.8.6 Discussion on Block A with 2 storeys*

Whilst Blocks A-D forms one united building, Block D has only two storeys, it is only being triggered as Type A by virtue of the horizontal connections to other blocks. Therefore it is considered the risk of fire spread between levels for Block D is similar to that of a standalone building, which is of Type B construction and does not require spandrel protection.

Notwithstanding this, the design of the subject spandrels is the same (design, materials, construction) as in Block D, which is also been quantitatively justified in the above section.

### 4.1.9 Conclusion

This analysis demonstrates that the proposed fire safety measures forming part of this Performance Solution manage the deviations from the relevant BCA DtS provisions and demonstrate that the relevant BCA Performance Requirement CP2 is met.

## 4.2 Solution 2: Reduction of general FRLs from 120/90 minutes to 60 minutes

### 4.2.1 Introduction

Table 18 provides a summary of this Solution, the relevant BCA DtS Provisions which are affected, and the relevant BCA Performance Requirements and IFEG sub-systems.

**Table 18: Summary of Solution**

| No | Description of non-compliance | DtS Clause | Performance Requirement (A0.7) | IFEG Sub-systems | Method of meeting Performance Requirements (A0.2) | Assessment Method (A0.5) |
|---|---|---|---|---|---|---|
| 2 | To permit the reduction in general FRLs;<br>▪ from the required FRL of 120 minutes down to 60 minutes for building of Type A construction, i.e., main School Buildings (Blocks A-D);<br>▪ from the required FRL of 90 minutes down to 60 minutes for building of Type C construction, i.e., Hall Building (Block E). | Spec C1.1, Table 3, Table 5 | CP1 and CP2 | A and C | A0.2(a) Refer Table 3 | A0.5(b)(ii) Refer Table 3 |

As a Class 9b school building with a rise in storey of 2, the building is required to be of Type B construction, which stipulates a general FRL requirement of 120 minutes.

There are five blocks (A, B, C, D & E) on site. Blocks A, B, C & D are physically connected by the roof and therefore are considered a united building. Block E is a standalone building. Both buildings consists of Class 9b (School).

The united building having a rise in storey of 3 (Main School Buildings, i.e., Blocks A-D) are to have a Type A construction and the required general FRLs is 120 minutes for a Class 9b building.

The building having a rise in storey of 1 (Multipurpose Hall, i.e., Block E) is to have a Type C construction and the required general FRLs is 90 minutes for a Class 9b building.

It is proposed to reduce the general FRLs from 120/90 minutes to 60 minutes throughout all building areas.

### 4.2.2 Intent of the BCA

#### *4.2.2.1 Specification C1.1 Clause 3.1*

It is noted that Clause 3.1 of BCA Specification C1.1 requires that fire rated elements in Class 9b buildings are generally required to achieve an FRL of 120/120/120. BCA Specification C1.1, Table 3 (Type A Construction) is shown in Figure 23 and sets out the FRL requirements for Type A constructions for Class 9b buildings.

**Table 3 TYPE A CONSTRUCTION: FRL OF BUILDING ELEMENTS**

| Building element | Class of building — FRL: (in minutes) *Structural adequacy/Integrity/Insulation* | | | |
|---|---|---|---|---|
| | 2, 3 or 4 part | 5, 7a or 9 | 6 | 7b or 8 |
| **EXTERNAL WALL** (including any column and other building element incorporated therein) or other external building element, where the distance from any *fire-source feature* to which it is exposed is— | | | | |
| For *loadbearing* parts— | | | | |
| less than 1.5 m | 90/ 90/ 90 | 120/120/120 | 180/180/180 | 240/240/240 |
| 1.5 to less than 3 m | 90/ 60/ 60 | 120/ 90/ 90 | 180/180/120 | 240/240/180 |
| 3 m or more | 90/ 60/ 30 | 120/ 60/ 30 | 180/120/ 90 | 240/180/ 90 |
| For non-*loadbearing* parts— | | | | |
| less than 1.5 m | –/ 90/ 90 | –/120/120 | –/180/180 | –/240/240 |
| 1.5 to less than 3 m | –/ 60/ 60 | –/ 90/ 90 | –/180/120 | –/240/180 |
| 3 m or more | –/–/– | –/–/– | –/–/– | –/–/– |
| **EXTERNAL COLUMN** not incorporated in an *external wall*— | | | | |
| For *loadbearing* columns— | 90/–/– | 120/–/– | 180/–/– | 240/–/– |
| For non-*loadbearing* columns— | –/–/– | –/–/– | –/–/– | –/–/– |
| **COMMON WALLS and FIRE WALLS**— | 90/ 90/ 90 | 120/120/120 | 180/180/180 | 240/240/240 |
| **INTERNAL WALLS**— | | | | |
| *Fire-resisting* lift and stair *shafts*— | | | | |
| *Loadbearing* | 90/ 90/ 90 | 120/120/120 | 180/120/120 | 240/120/120 |
| Non-*loadbearing* | –/ 90/ 90 | –/120/120 | –/120/120 | –/120/120 |
| Bounding *public corridors*, public lobbies and the like— | | | | |
| *Loadbearing* | 90/ 90/ 90 | 120/–/– | 180/–/– | 240/–/– |
| Non-*loadbearing* | –/ 60/ 60 | –/–/– | –/–/– | –/–/– |
| Between or bounding *sole-occupancy units*— | | | | |
| *Loadbearing* | 90/ 90/ 90 | 120/–/– | 180/–/– | 240/–/– |
| Non-*loadbearing* | –/ 60/ 60 | –/–/– | –/–/– | –/–/– |
| Ventilating, pipe, garbage, and like *shafts* not used for the discharge of hot products of combustion— | | | | |
| *Loadbearing* | 90/ 90/ 90 | 120/ 90/ 90 | 180/120/120 | 240/120/120 |
| Non-*loadbearing* | –/ 90/ 90 | –/ 90/ 90 | –/120/120 | –/120/120 |
| **OTHER LOADBEARING INTERNAL WALLS, INTERNAL BEAMS, TRUSSES and COLUMNS**— | 90/–/– | 120/–/– | 180/–/– | 240/–/– |
| **FLOORS** | 90/ 90/ 90 | 120/120/120 | 180/180/180 | 240/240/240 |
| **ROOFS** | 90/ 60/ 30 | 120/ 60/ 30 | 180/ 60/ 30 | 240/ 90/ 60 |

**Figure 23: Table 3 - Type A construction: FRL of building elements**

#### *4.2.2.2 Specification C1.1 Clause 5.1*

It is noted that Clause 5.1 of BCA Specification C1.1 requires that fire rated elements in Class 9b buildings are generally required to achieve an FRL of 90/90/90. BCA Specification C1.1, Table 5 (Type C Construction) is shown in Figure 24 and sets out the FRL requirements for Type C constructions for Class 9b buildings.

**Note: As shown in Figure 24, the requirements for 90 mins FRL for a Type C construction building (i.e., Block E) only apply to external walls and external columns that are closer than 1.5 m to the a fire-source feature. It is understood all external walls and external columns of the Type C construction building (i.e., Block E) are located more than 1.5 m to a fire-source feature. Therefore the subject Type C construction building (i.e., Block E) may inherently only required for so a 60 min FRLs. The following analysis for Type C construction building (i.e., Block E) provides further robustness and conservatism.**

Table 5 TYPE C CONSTRUCTION: FRL OF BUILDING ELEMENTS

| Building element | Class of building—FRL: (in minutes) Structural adequacy/Integrity/Insulation | | | |
|---|---|---|---|---|
| | 2, 3 or 4 part | 5, 7a or 9 | 6 | 7b or 8 |
| **EXTERNAL WALL** (including any column and other building element incorporated therein) or other external building element, where the distance from any *fire-source feature* to which it is exposed is— | | | | |
| Less than 1.5 m | 90/ 90/ 90 | 90/ 90/ 90 | 90/ 90/ 90 | 90/ 90/ 90 |
| 1.5 to less than 3 m | –/–/– | 60/ 60/ 60 | 60/ 60/ 60 | 60/ 60/ 60 |
| 3 m or more | –/–/– | –/–/– | –/–/– | –/–/– |
| **EXTERNAL COLUMN** not incorporated in an *external wall*, where the distance from any *fire-source feature* to which it is exposed is— | | | | |
| Less than 1.5 m | 90/–/– | 90/–/– | 90/–/– | 90/–/– |
| 1.5 to less than 3 m | –/–/– | 60/–/– | 60/–/– | 60/–/– |
| 3 m or more | –/–/– | –/–/– | –/–/– | –/–/– |
| **COMMON WALLS and FIRE WALLS—** | 90/ 90/ 90 | 90/ 90/ 90 | 90/ 90/ 90 | 90/ 90/ 90 |
| **INTERNAL WALLS-** | | | | |
| Bounding *public corridors*, public lobbies and the like— | 60/ 60/ 60 | –/–/– | –/–/– | –/–/– |
| Between or bounding *sole-occupancy units*— | 60/ 60/ 60 | –/–/– | –/–/– | –/–/– |
| Bounding a stair if *required* to be rated— | 60/ 60/ 60 | 60/ 60/ 60 | 60/ 60/ 60 | 60/ 60/ 60 |
| **ROOFS** | –/–/– | –/–/– | –/–/– | –/–/– |

Figure 24: Table 5 - Type C construction: FRL of building elements

#### *4.2.2.3 BCA Performance Requirements CP1 and CP2*

BCA Performance Requirements CP1 and CP2 are described in Appendix A of this Report.

### 4.2.3 Approach and assessment method

The approach is quantitative, deterministic and absolute using the assessment methods as shown in Table 3 and Table 18.

### 4.2.4 Trial Fire Safety Design

The fire safety measures listed in Table 2 form the holistic fire safety design for the building.

### 4.2.5 Acceptance criteria

The acceptance criterion for this particular non-compliance is that the building elements will survive the complete burnout of a fire, while maintaining structural adequacy, integrity and insulation for this period.

### 4.2.6 Hazards

The primary risk with reducing Fire Resistance Levels (FRLs) is that the risk for fire spread within the building, collapse or partial collapse before occupants have evacuated or during fire brigade intervention could increase.

### 4.2.7 Method of analysis

#### *4.2.7.1 Time equivalence calculations*

The analysis will be using calculations to evaluate the time-equivalence period. The time-equivalence approach gives the equivalent structural fire severity for exposure to the standard fire curve for a given enclosure based on fuel load, ventilation conditions and lining materials. The time equivalence calculations will be based on three calculation methods:

- Eurocode formula from [EN 1991-1-2]
- [CIB] Formula
- [Law] Formula

The time equivalence formula are defined as the time of exposure to the standard fire resistance test that would result in the same thermal impact as a complete burnout of the compartment in a real fire. Assemblies provided with a fire resistance equal to, or greater than, the equivalent structural fire severity, are generally expected (based on testing) to be able to withstand a complete burnout of the compartment.

For our analysis, input data will be taken from IFEG which compiles different groups of data and the geometrical data from the design drawings. Sensitivity and uncertainty studies will be performed on the opening factors to provide a level of robustness to the design.

Two groups of data from IFEG are presented:

- Table 3.4.1a: Warrington-BCC document ‘Fire resistant barriers and structures’ [England, Young & Hui]
- Table 3.4.1b: CIB W14 Workshop [CIB, 1983]

**Table 3.4.1a:**

This table gives a very detailed breakdown of fire load density on various occupancies. For storage areas, the height of storage is also considered when calculating fire load density. For consideration on variation of the data when choosing them, suggested coefficients of variation and different fractile values are given:

- For well-defined occupancies that are rather similar or with very limited differences in furniture and stored goods, for example, dwellings, hotels, hospitals, offices and schools, the following estimates may suffice:
  - Coefficient of variation = 30%–50% of the given average value
  - **90% fractile value** = (1.35–1.65) x average value
  - **80% fractile value** = (1.25–1.5) x average value
  - Isolated peak values = 2 x average value
- For occupancies that are rather dissimilar or with larger differences in furnishings and stored goods, for example, shopping centres, department stores and industrial occupancies, the following estimates are tentatively suggested:
  - Coefficient of variation = 50%–80% of given average value
  - **90% fractile value** = (1.65–2.0) x average value
  - **80% fractile value** = (1.45–1.75) x average value
  - Isolated peak values = 2.5 x average value

**Table 3.4.1b:**

This table gives data of fire load density for more generalised occupancies as per Table 3.4.1a of the IFEG. In addition to the mean value, the 80%, 90% and 95% fractiles are also given.

It is important to note that for use of data in this table, it is stated in IFEG that:

*“The CIB compilation emphasises that, for design purposes, fire load density cannot prudently be chosen at the mean level—this would provide a negative safety factor for all values greater than the mean. At least the 95% fractile should be selected, although in some cases even higher values will be appropriate.”*

Table 3.4.1b. Fire load density in different occupancies

| Densities in mega-joules per square metre | | | | |
|---|---|---|---|---|
| **Occupancy** | *Mean* (MJ/m²) | *Percent fractile ** | | |
| | | 80 | 90 | 95 |
| Dwelling | 780 | 870 | 920 | 970 |
| Hospital | 230 | 350 | 440 | 520 |
| Hospital storage | 2000 | 3000 | 3700 | 4400 |
| Hotel bedroom | 310 | 400 | 460 | 510 |
| Offices | 420 | 570 | 670 | 760 |
| Shops | 600 | 900 | 1100 | 1300 |
| Manufacturing | 300 | 470 | 590 | 720 |
| Manufacturing and Storage⁺ <150kg $m^{-2}$ | 1180 | 1800 | 2240 | 2690 |
| Libraries | 1500 | 2250 | 2550 | --- |
| Schools | 285 | 360 | 410 | 450 |

**Figure 25: Fire load densities from CIB 1983 (excerpt from Table 3.4.1b of IFEG)**

The subject building for the assessment is Class 9b school use. The FLED can be extracted from Table 3.4.1b of IFEG which provides a series of relevant occupancies as shown in Table 19.

**Table 19: Fire load energy densities (FLEDs) for relevant occupancies (Source: Table 3.4.1b of IFEG)**

| Occupancy | Fire load density, $q_{f,k}$ | | |
|---|---|---|---|
| | Fractile (MJ/m²) [b] | | |
| | Mean (MJ/m²) | 80th [a] | 95th |
| Schools | 285 | 360 | 450 |

*a) The 80th fractile is the value that is not exceeded in 80 % of the rooms or occupancy of the survey data. Typically this value is used in design and is consistent with values from IFEG.*
*b) Storage of combustible materials at less than 150 kg/m².*

The approach conservatively ignores any beneficial effect of fire suppression by occupants or the fire brigade. In reality, if occupants fail to extinguish a fire, fire brigade response to the building is likely and would have a substantial beneficial effect however, this has been conservatively ignored.

#### *4.2.7.2 Ventilation to compartments and Limitations*

Referenced data such as [FEDG, 7974, etc] outline that temperature more than 200 °C is likely to cause breakage of the glazing. Laminated / toughened glazing can withstand even higher temperatures (typically in the region of 350-400 °C, or more).

If the temperatures are less than this, then there would be no structural impact that requires consideration in relation to this solution. If the temperatures are higher than 200 °C, glass is likely to break. The extent of that breakage is dependent on the type and construction of glazing.

The analysis carried out calculations is based on the temperatures being high enough to break all glazing (i.e. greater than 200 °C) however, as recommended in the Eurocode, a sensitivity analysis on less glass breaking has been carried out, with only 50% of the glass breaking (which is in line with FEDG and recommendations of FRNSW).

As such, the time equivalence calculations, much like other fire severity assessments are in essence, a sensitivity analysis, then the reduction % of glass breakage is effectively a sensitivity on a sensitivity.

### 4.2.8 Analysis

There are five Blocks A, B, C, D & E. In order to provide a robust result, each Block is assessed based on the dimension and openings. The assessment takes the level with maximum floor area as the worst case scenario.

The time equivalence calculations were carried out based on the floor area and its opening areas and height of the spaces based on the referenced architectural drawings. The fire load is based on the mean value and 80$^{th}$ as well as the 95$^{th}$ percentile value.

A summary of the input data and results for the time-equivalence method for each block is provided in the following sections. One example of the detailed calculations (Block A – Level 01) is shown in Appendix B.

#### *4.2.8.1 Block A – Level 01*

Results from the time-equivalence calculations given in Table 20 indicate that based on the typical fuel loads and ventilation conditions, the minimum Fire Resistance Levels (FRLs) necessary to withstand a full burn out of Block A – Level 01 is less than 60 minutes.

**Table 20: Input data and results for time equivalence calculations: Block A – Level 01**

| Description of Inputs | Parameters/Outputs | | |
|---|---|---|---|
| Area of interest | Block A – Level 01 | | |
| Occupancy Type | School | | |
| Mean FLED (MJ/m$^2$) | 285 | | |
| 80$^{th}$ percentile FLED (MJ/m$^2$) | 360 | | |
| 95$^{th}$ percentile FLED (MJ/m$^2$) | 450 | | |
| Floor area (m$^2$) | 484 | | |
| Average ceiling height (m) | 2.7 | | |
| Vertical opening area (m$^2$) | 66.93 | | |
| Horizontal opening area (m$_2$) | 0 | | |
| **Results** | | | |
| **Time equivalence method** | **Eurocode** | **CIB W14** | **Law Method** |
| **Time equivalent (min) - (Mean FLED)** | 27 | 27 | 21 |
| **Time equivalent (min) - (80$^{th}$ percentile FLED)** | 33 | 34 | 26 |
| **Time equivalent (min) - (95$^{th}$ percentile FLED)** | 42 | 42 | 33 |

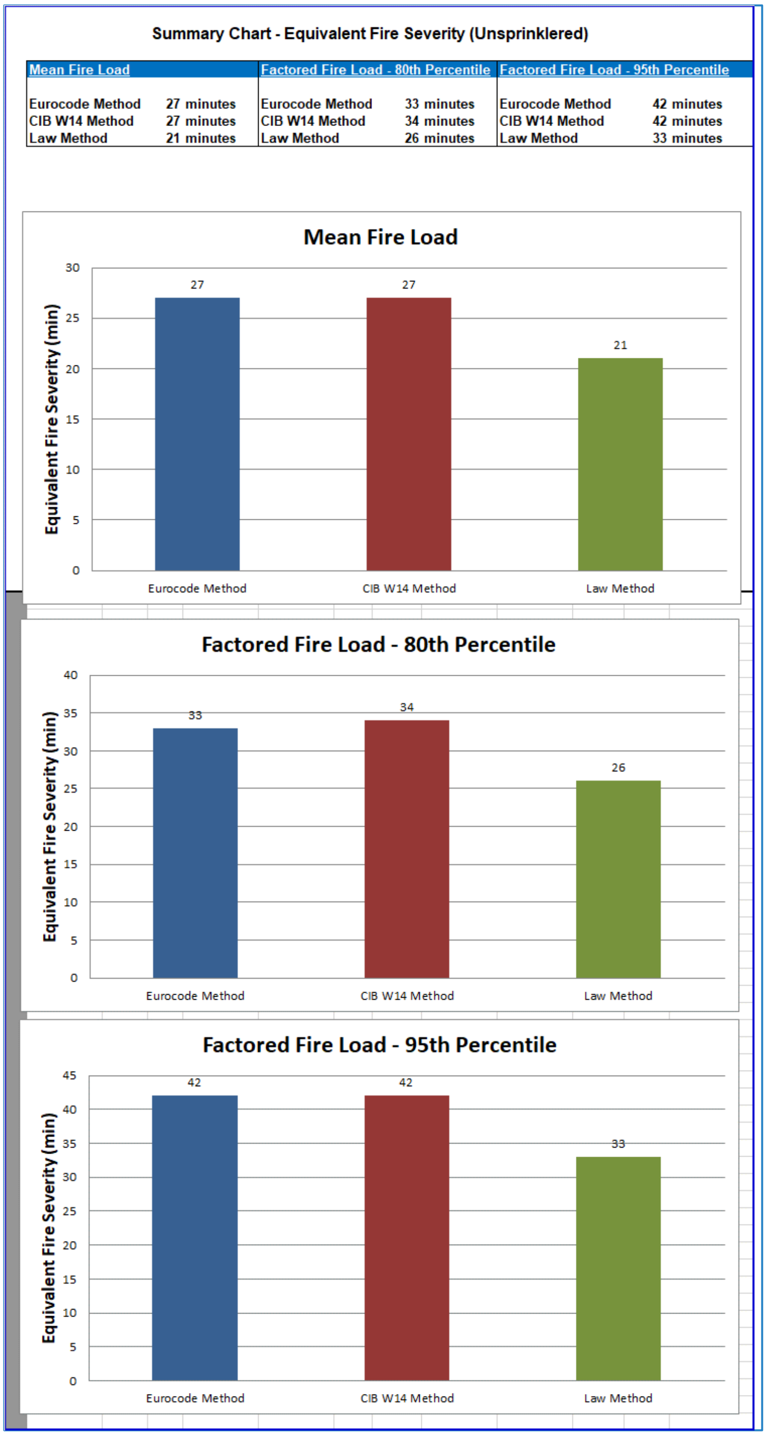



**Figure 26: Fire Severity Assessment Results Summary: Block A – Level 01**

#### *4.2.8.2 Block B – Level 01*

Results from the time-equivalence calculations given in Table 21 indicate that based on the typical fuel loads and ventilation conditions, the minimum Fire Resistance Levels (FRLs) necessary to withstand a full burn out of Block B – Level 01 is less than 60 minutes.

**Table 21: Input data and results for time equivalence calculations: Block B – Level 01**

| Description of Inputs | Parameters/Outputs | | |
|---|---|---|---|
| Area of interest | Block B – Level 01 | | |
| Occupancy Type | School | | |
| Mean FLED (MJ/m$^2$) | 285 | | |
| 80$^{th}$ percentile FLED (MJ/m$^2$) | 360 | | |
| 95$^{th}$ percentile FLED (MJ/m$^2$) | 450 | | |
| Floor area (m$^2$) | 491 | | |
| Average ceiling height (m) | 2.7 | | |
| Vertical opening area (m$^2$) | 92.37 | | |
| Horizontal opening area (m$_2$) | 0 | | |
| Results | | | |
| **Time equivalence method** | **Eurocode** | **CIB W14** | **Law Method** |
| **Time equivalent (min) - (Mean FLED)** | 21 | 23 | 18 |
| **Time equivalent (min) - (80$^{th}$ percentile FLED)** | 26 | 29 | 23 |
| **Time equivalent (min) - (95$^{th}$ percentile FLED)** | 32 | 36 | 29 |

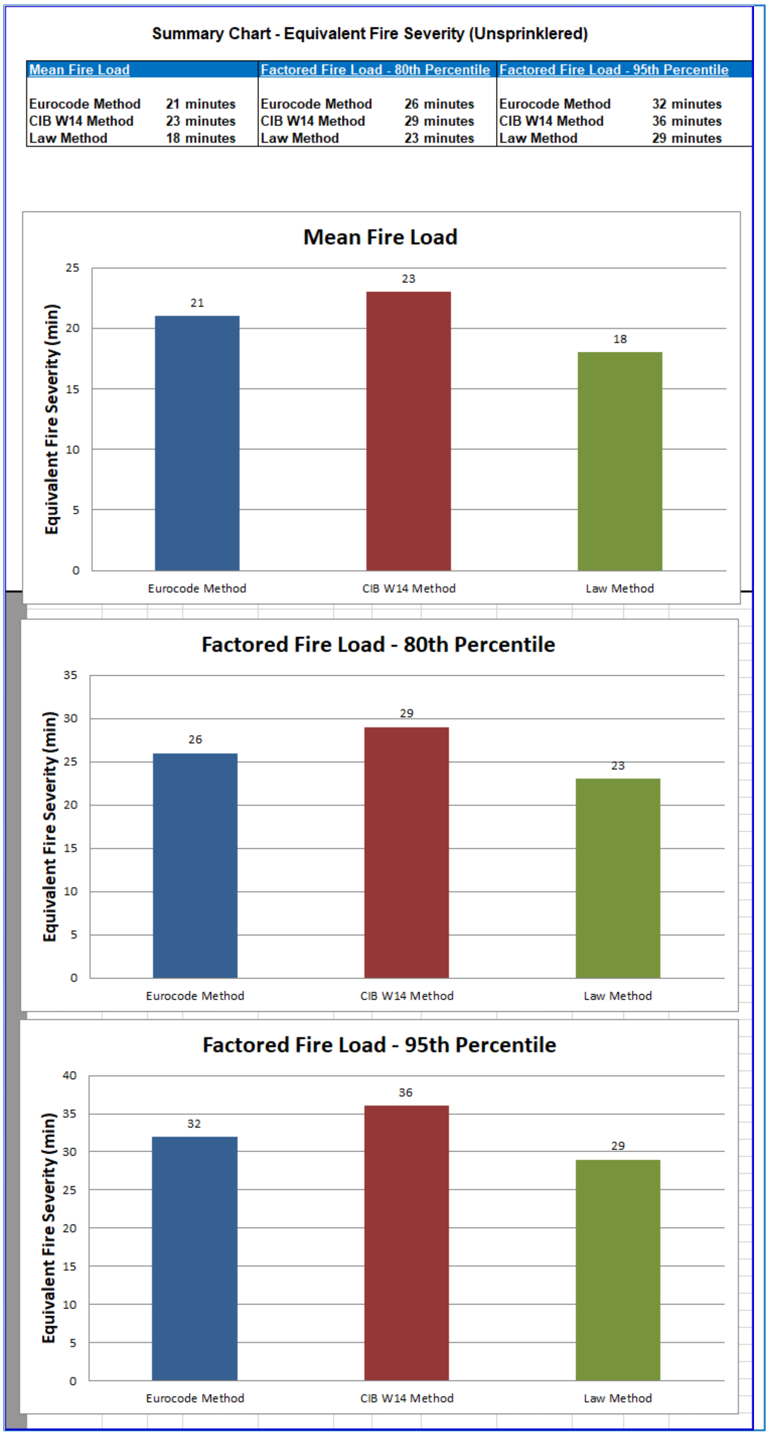



**Figure 27: Fire Severity Assessment Results Summary: Block B – Level 01**

#### *4.2.8.3 Block C – Level 01*

Results from the time-equivalence calculations given in Table 22 indicate that based on the typical fuel loads and ventilation conditions, the minimum Fire Resistance Levels (FRLs) necessary to withstand a full burn out of Block C – Level 01 is less than 60 minutes.

**Table 22: Input data and results for time equivalence calculations: Block C – Level 01**

| Description of Inputs | Parameters/Outputs | | |
|---|---|---|---|
| Area of interest | Block C – Level 01 | | |
| Occupancy Type | School | | |
| Mean FLED (MJ/m$^2$) | 285 | | |
| 80th percentile FLED (MJ/m$^2$) | 360 | | |
| 95th percentile FLED (MJ/m$^2$) | 450 | | |
| Floor area (m$^2$) | 855 | | |
| Average ceiling height (m) | 2.7 | | |
| Vertical opening area (m$^2$) | 153.13 | | |
| Horizontal opening area (m$_2$) | 0 | | |
| **Results** | | | |
| **Time equivalence method** | **Eurocode** | **CIB W14** | **Law Method** |
| **Time equivalent (min) - (Mean FLED)** | 21 | 24 | 19 |
| **Time equivalent (min) - (80th percentile FLED)** | 27 | 30 | 24 |
| **Time equivalent (min) - (95th percentile FLED)** | 34 | 38 | 30 |

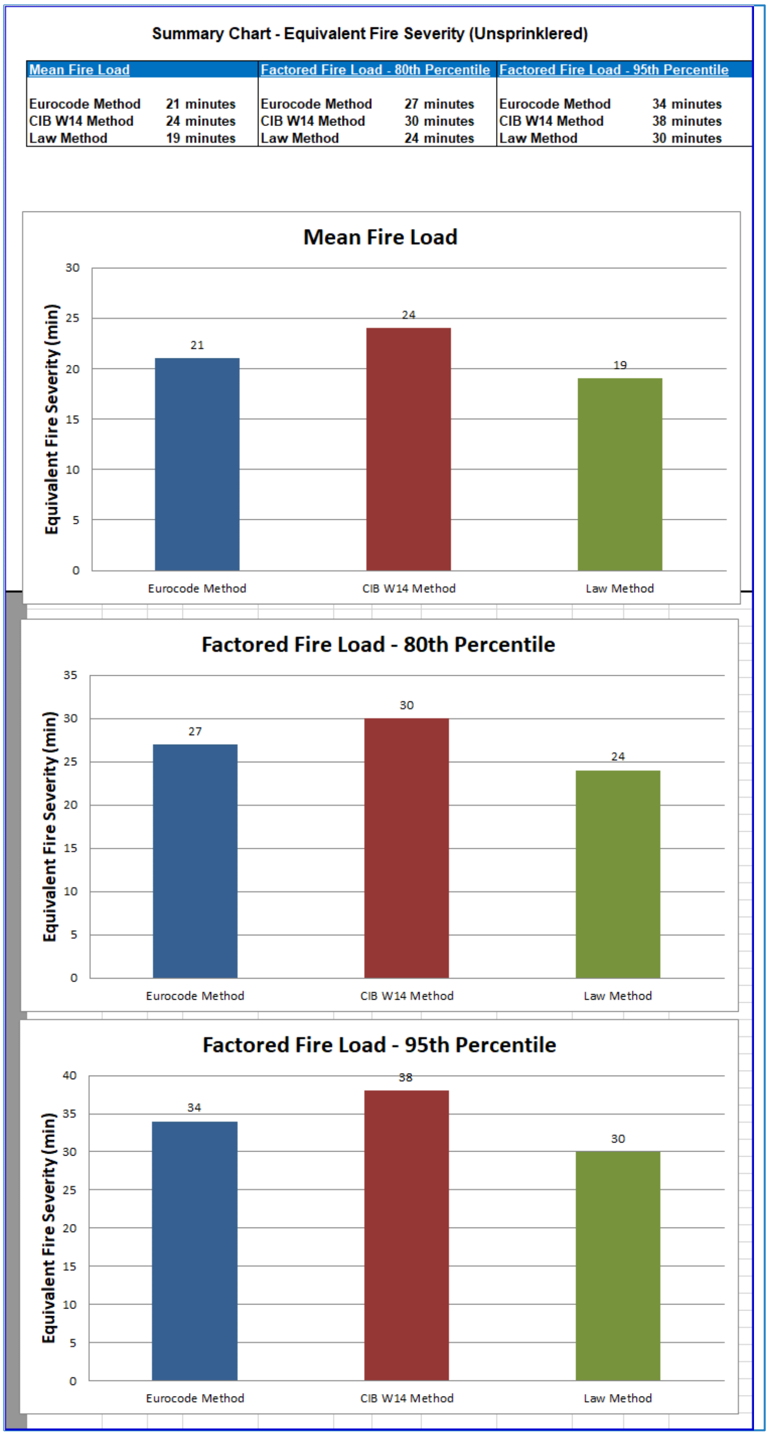



**Figure 28: Fire Severity Assessment Results Summary: Block C – Level 01**

#### *4.2.8.4 Block D – Level 01*

Results from the time-equivalence calculations given in Table 23 indicate that based on the typical fuel loads and ventilation conditions, the minimum Fire Resistance Levels (FRLs) necessary to withstand a full burn out of Block D – Level 01 is less than 60 minutes.

**Table 23: Input data and results for time equivalence calculations: Block D – Level 01**

| Description of Inputs | Parameters/Outputs | | |
|---|---|---|---|
| Area of interest | Block D – Level 01 | | |
| Occupancy Type | School | | |
| Mean FLED ($MJ/m^2$) | 285 | | |
| 80th percentile FLED ($MJ/m^2$) | 360 | | |
| 95th percentile FLED ($MJ/m^2$) | 450 | | |
| Floor area ($m^2$) | 421 | | |
| Average ceiling height (m) | 2.7 | | |
| Vertical opening area ($m^2$) | 83.08 | | |
| Horizontal opening area ($m_2$) | 0 | | |
| **Results** | | | |
| **Time equivalence method** | **Eurocode** | **CIB W14** | **Law Method** |
| **Time equivalent (min) - (Mean FLED)** | 20 | 22 | 18 |
| **Time equivalent (min) - (80th percentile FLED)** | 25 | 28 | 22 |
| **Time equivalent (min) - (95th percentile FLED)** | 31 | 35 | 28 |

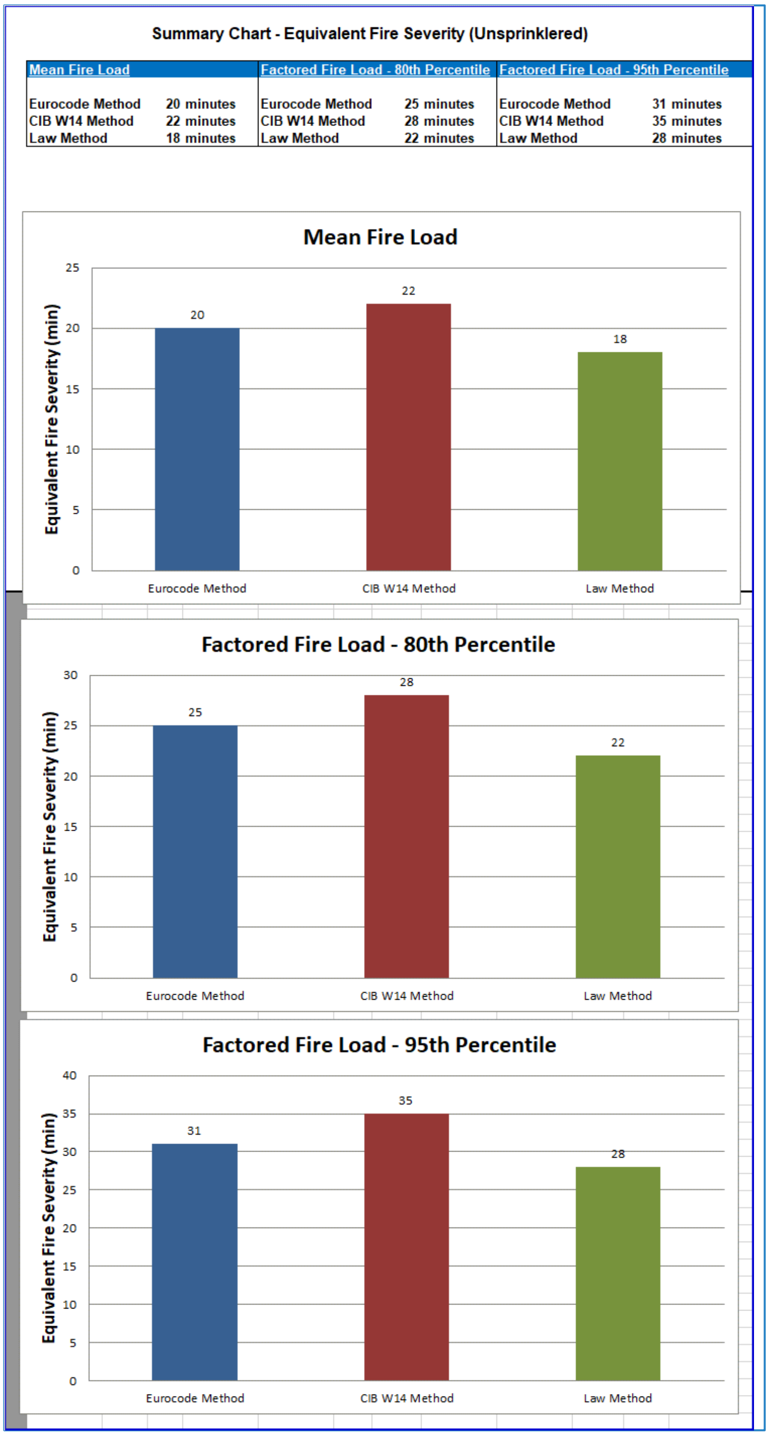



**Figure 29: Fire Severity Assessment Results Summary: Block D – Level 01**

#### *4.2.8.5 Block E – Level 00*

Results from the time-equivalence calculations given in Table 24 indicate that based on the typical fuel loads and ventilation conditions, the minimum Fire Resistance Levels (FRLs) necessary to withstand a full burn out of Block E – Level 00 is less than 60 minutes.

**Note: As shown in Figure 24, the requirements for 90 mins FRL for a Type C construction building (i.e., Block E) only apply to external walls and external columns that are closer than 1.5 m to the a fire-source feature. It is understood all external walls and external columns of the Type C construction building (i.e., Block E) are located more than 1.5**

**m to a fire-source feature. Therefore the subject Type C construction building (i.e., Block E) may inherently only required for so a 60 min FRLs. The analysis for Type C construction building (i.e., Block E) provides further robustness and conservatism.**

**Table 24: Input data and results for time equivalence calculations: Block E – Level 00**

| Description of Inputs | Parameters/Outputs | | |
|---|---|---|---|
| Area of interest | Block E – Level 00 | | |
| Occupancy Type | School | | |
| Mean FLED (MJ/m$^2$) | 285 | | |
| 80$^{th}$ percentile FLED (MJ/m$^2$) | 360 | | |
| 95$^{th}$ percentile FLED (MJ/m$^2$) | 450 | | |
| Floor area (m$^2$) | 1478 | | |
| Average ceiling height (m) | 2.7 | | |
| Vertical opening area (m$^2$) | 267.2 | | |
| Horizontal opening area (m$_2$) | 0 | | |
| Results | | | |
| **Time equivalence method** | **Eurocode** | **CIB W14** | **Law Method** |
| **Time equivalent (min) - (Mean FLED)** | 22 | 22 | 20 |
| **Time equivalent (min) - (80$^{th}$ percentile FLED)** | 27 | 28 | 25 |
| **Time equivalent (min) - (95$^{th}$ percentile FLED)** | 34 | 35 | 31 |

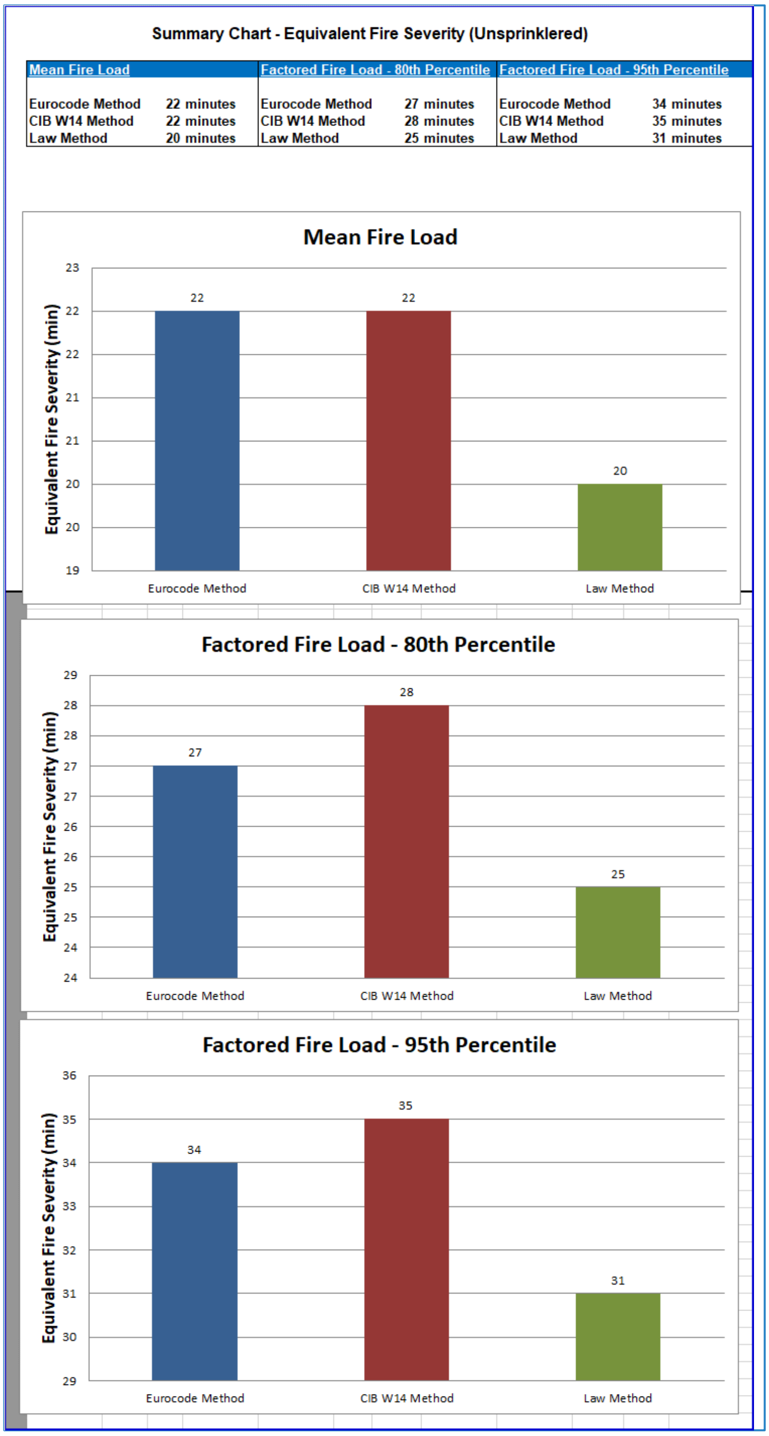



**Figure 30: Fire Severity Assessment Results Summary: Block E – Level 00**

#### *4.2.8.6 Sensitivity Analysis*

The Eurocode recommends also doing a sensitivity study using opening percentages to account for not all openings failing/falling out. The experimental results that this code is based on showed that the real opening percentage was generally within this range. The results of the analysis using the mean fuel load and 80th percentile fuel load is given in Table 25 - Table 29. It is shown the results for the sensitivity assessment are still within the limit for reduced FRL, i.e., 60 minutes.

It is further noted that the sensitivity study of limiting the area of window breakage whilst using the 80th percentile FLED is ultra-sensitive, considering the higher fire load leads to more glass breakage.

It is conservative to assume only 50% of window breakage in all cases as the fire can only grow to a certain size as it becomes ventilation controlled as specified in Section 4.5 of the 'Fire Engineering Design Guide'.

Temperatures above 200 °C are likely to cause significant glass breakage. For fire to grow from this stage to reach flashover, this will require oxygen and hence a significant amount of window breakage.

The above quantitative assessment clearly shows that the Fire Severity assessment as carried out in line with the IFEG satisfies the performance requirements of the BCA.

**Table 25: Time-equivalence results for the different opening percentages – sensitivity case for Block A – Level 01**

| Description | Equivalent Fire Duration (min) | | |
|---|---|---|---|
| Area of interest | Block A – Level 01 | | |
| **Time equivalence method** | **Eurocode** | **CIB W14** | **Law Method** |
| Mean fuel load – 50 % vertical opening | 43 | 38 | 30 |
| 80th percentile fuel load – 50 % vertical opening | **54** | **48** | **37** |

**Table 26: Time-equivalence results for the different opening percentages – sensitivity case for Block B – Level 01**

| Description | Equivalent Fire Duration (min) | | |
|---|---|---|---|
| Area of interest | Block B – Level 01 | | |
| **Time equivalence method** | **Eurocode** | **CIB W14** | **Law Method** |
| Mean fuel load – 50 % vertical opening | 36 | 41 | 26 |
| 80th percentile fuel load – 50 % vertical opening | **45** | **51** | **32** |

**Table 27: Time-equivalence results for the different opening percentages – sensitivity case for Block C – Level 01**

| Description | Equivalent Fire Duration (min) | | |
|---|---|---|---|
| Area of interest | Block C – Level 01 | | |
| **Time equivalence method** | **Eurocode** | **CIB W14** | **Law Method** |
| Mean fuel load – 50 % vertical opening | 37 | 43 | 27 |
| 80th percentile fuel load – 50 % vertical opening | **47** | **53** | **34** |

**Table 28: Time-equivalence results for the different opening percentages – sensitivity case for Block D – Level 01**

| Description | Equivalent Fire Duration (min) | | |
|---|---|---|---|
| Area of interest | Block D – Level 01 | | |
| **Time equivalence method** | **Eurocode** | **CIB W14** | **Law Method** |
| Mean fuel load – 50 % vertical opening | 34 | 31 | 25 |
| 80th percentile fuel load – 50 % vertical opening | **43** | **40** | **31** |

**Table 29: Time-equivalence results for the different opening percentages – sensitivity case for Block E – Level 00**

| Description | Equivalent Fire Duration (min) | | |
|---|---|---|---|
| Area of interest | Block E – Level 00 | | |
| **Time equivalence method** | **Eurocode** | **CIB W14** | **Law Method** |
| Mean fuel load – 50 % vertical opening | 37 | 32 | 27 |
| 80th percentile fuel load – 50 % vertical opening | **47** | **40** | **35** |

#### 4.2.9 Conclusion

This analysis demonstrates that the proposed fire safety measures forming part of this performance solution manage the deviations from the relevant BCA DtS provisions and demonstrate that the relevant BCA Performance Requirements CP1 and CP2 are met.

## 4.3 Solution 3: Type A construction (Blocks B, C & D) to have RISF ceiling for 60 minutes

### 4.3.1 Introduction

Table 30 provides a summary of this Solution, the relevant BCA DtS Provisions which are affected, and the relevant BCA Performance Requirements and IFEG sub-systems.

**Table 30: Summary of Solution**

| No | Description of non-compliance | DtS Clause | Performance Requirement (A0.7) | IFEG Sub-systems | Method of meeting Performance Requirements (A0.2) | Assessment Method (A0.5) |
|---|---|---|---|---|---|---|
| **3** | To permit the reduction of FRLs to the floors for buildings of Type A construction (Blocks B, C & D), from 120/120/120 to a ceiling having a Resistance to Incipient Spread of Fire (RISF) of 60 minutes. | Spec C1.1, Clause 3.1 Table 3 | CP1 and CP2 | A and C | A0.2(a) Refer Table 3 | A0.5(b)(ii) Refer Table 3 |

Blocks A & E are to be of conventional construction with concrete slab etc., and Blocks B, C & D are to be of modular construction with lightweight floor/ceiling system.

**For Blocks B, C & D being of modular construction with lightweight floor/ceiling system,** due to the proposed modular construction, it is not practical to have a concrete floor slab to the buildings. It is proposed to reduce the FRLs to the floors for buildings of Type A construction (Blocks B, C & D), from 120/120/120 to a ceiling having a Resistance to Incipient Spread of Fire (RISF) of 60 minutes. A lightweight floor/ceiling system will be provided as shown in Figure 31.

The following DtS departures are identified:

- A reduction of FRL from 120 minutes to 60 minutes (RISF). This is addressed in previous Solution No. 2 which permits the reduction of general FRLs from 120 minutes to 60 minutes throughout all buildings.

- The proposed a lightweight floor/ceiling system with a RISF ceiling for 60 minutes provides one way fire rating (from underside) only.

This performance solution applies to Blocks B, C & D only being of modular construction with lightweight floor/ceiling system. Block A is of conventional construction with concrete slab and therefore is a DtS design. Building of Type C construction (i.e., Block E) is not subject to the requirement.

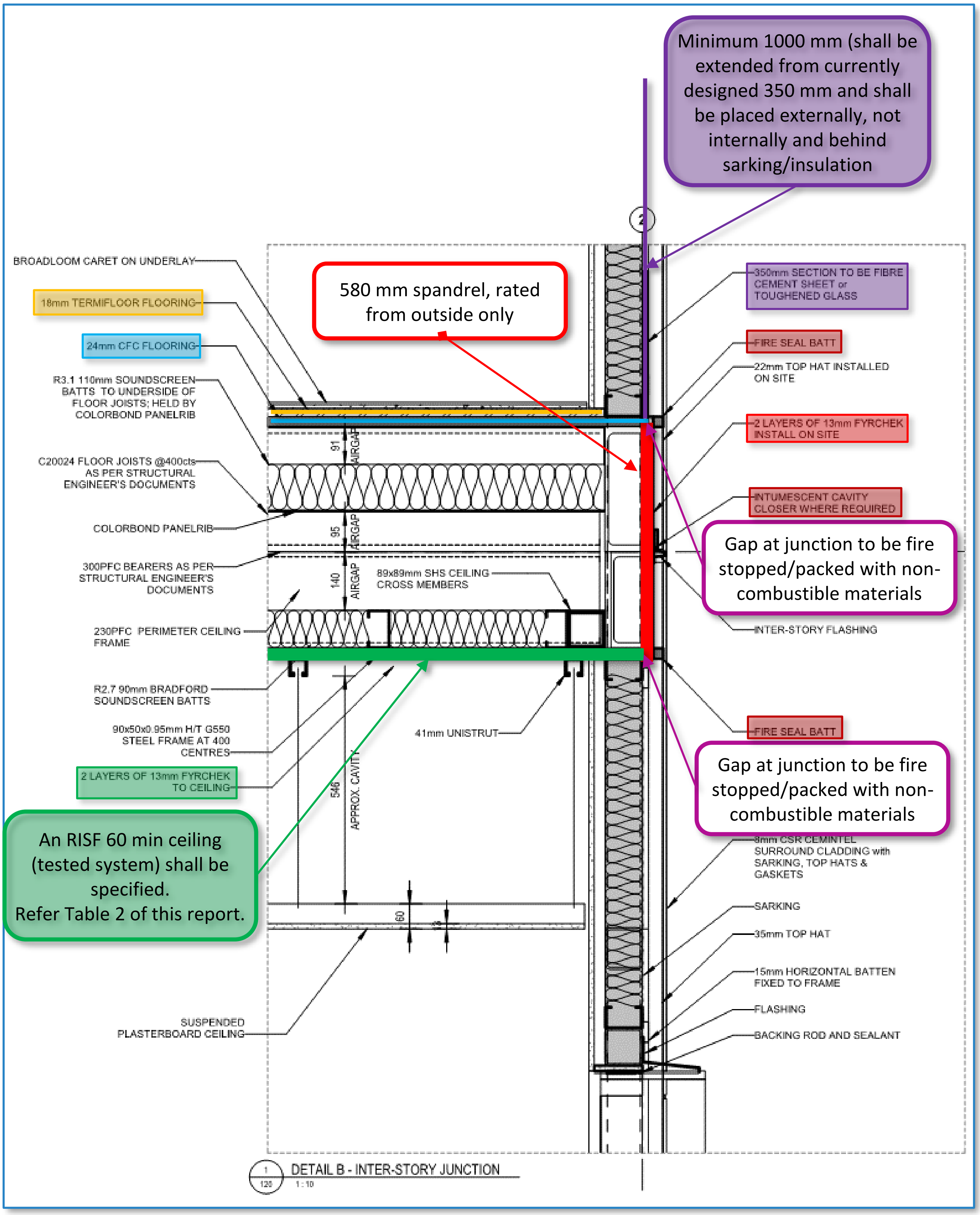



**Figure 31: Section showing fire rated (RISF) ceiling, flooring materials and spandrel arrangement (For Blocks B, C & D being of modular construction with lightweight floor/ceiling system)**

## 4.3.2 Intent of the BCA

### *4.3.2.1 Specification C1.1 Clause 3.1*

It is noted that Clause 3.1 of BCA Specification C1.1 requires that fire rated elements in Class 9b buildings are generally required to achieve an FRL of 120/120/120. BCA Specification C1.1, Table 3 (Type A Construction) is shown in Figure 32 and sets out the FRL requirements for Type A constructions for Class 9b buildings.

**Table 3 TYPE A CONSTRUCTION: FRL OF BUILDING ELEMENTS**

| **Building element** | **Class of building — FRL: (in minutes)** *Structural adequacy/Integrity/Insulation* | | | |
|---|---|---|---|---|
| | **2, 3 or 4 part** | **5, 7a or 9** | **6** | **7b or 8** |
| **EXTERNAL WALL** (including any column and other building element incorporated therein) or other external building element, where the distance from any *fire-source feature* to which it is exposed is— | | | | |
| For *loadbearing* parts— | | | | |
| less than 1.5 m | 90/ 90/ 90 | 120/120/120 | 180/180/180 | 240/240/240 |
| 1.5 to less than 3 m | 90/ 60/ 60 | 120/ 90/ 90 | 180/180/120 | 240/240/180 |
| 3 m or more | 90/ 60/ 30 | 120/ 60/ 30 | 180/120/ 90 | 240/180/ 90 |
| For non-*loadbearing* parts— | | | | |
| less than 1.5 m | –/ 90/ 90 | –/120/120 | –/180/180 | –/240/240 |
| 1.5 to less than 3 m | –/ 60/ 60 | –/ 90/ 90 | –/180/120 | –/240/180 |
| 3 m or more | –/–/– | –/–/– | –/–/– | –/–/– |
| **EXTERNAL COLUMN** not incorporated in an *external wall*— | | | | |
| For *loadbearing* columns— | 90/–/– | 120/–/– | 180/–/– | 240/–/– |
| For non-*loadbearing* columns— | –/–/– | –/–/– | –/–/– | –/–/– |
| **COMMON WALLS and FIRE WALLS**— | 90/ 90/ 90 | 120/120/120 | 180/180/180 | 240/240/240 |
| **INTERNAL WALLS**— | | | | |
| *Fire-resisting* lift and stair *shafts*— | | | | |
| *Loadbearing* | 90/ 90/ 90 | 120/120/120 | 180/120/120 | 240/120/120 |
| Non-*loadbearing* | –/ 90/ 90 | –/120/120 | –/120/120 | –/120/120 |
| Bounding *public corridors*, public lobbies and the like— | | | | |
| *Loadbearing* | 90/ 90/ 90 | 120/–/– | 180/–/– | 240/–/– |
| Non-*loadbearing* | –/ 60/ 60 | –/–/– | –/–/– | –/–/– |
| Between or bounding *sole-occupancy units*— | | | | |
| *Loadbearing* | 90/ 90/ 90 | 120/–/– | 180/–/– | 240/–/– |
| Non-*loadbearing* | –/ 60/ 60 | –/–/– | –/–/– | –/–/– |
| Ventilating, pipe, garbage, and like *shafts* not used for the discharge of hot products of combustion— | | | | |
| *Loadbearing* | 90/ 90/ 90 | 120/ 90/ 90 | 180/120/120 | 240/120/120 |
| Non-*loadbearing* | –/ 90/ 90 | –/ 90/ 90 | –/120/120 | –/120/120 |
| **OTHER LOADBEARING INTERNAL WALLS, INTERNAL BEAMS, TRUSSES and COLUMNS**— | 90/–/– | 120/–/– | 180/–/– | 240/–/– |
| **FLOORS** | 90/ 90/ 90 | 120/120/120 | 180/180/180 | 240/240/240 |
| **ROOFS** | 90/ 60/ 30 | 120/ 60/ 30 | 180/ 60/ 30 | 240/ 90/ 60 |

**Figure 32: Table 3 - Type A construction: FRL of building elements**

The BCA Guide states that the intent with Clause 3.1 is

> To specify the fire-resistance level (FRL) and other requirements for building elements in Type A construction.

### *4.3.2.2 BCA Performance Requirements CP1 and CP2*

BCA Performance Requirements CP1 and CP2 are described in Appendix A of this report.

These BCA performance requirements outline that a building must have elements which will, in the case of CP1, to the degree necessary, maintain structural stability during a fire and for CP2, that, to the degree necessary, avoid the spread of fire to exits, SOUs, public corridors, between buildings and in a building.

The Guide to the BCA outlines that the following with respect to the term:

> to the degree necessary" is used to "show that provisions can differ according to various elements which appropriate authorities may take into consideration when assessing building applications.

The Guide further expands and elaborates the intention of this phrase by stating that:

> this expression provides flexibility by allowing appropriate authorities to determine the degree of compliance necessary in a particular case. For example, an appropriate authority might judge that an item need not be installed, or a particular level of performance be achieved" and that:
>
> … the BCA recognises that different building elements require differing degrees of structural stability during a fire…Any decision made in this context can extend to not requiring an item to be installed or a particular level of performance to be achieved, if that is the appropriate action to be taken

If a Performance Solution is used, it may be appropriate to assess it using CP1 and CP2 for guidance purposes. However, it is stressed that compliance with CP1 and CP2 is not compulsory if alternative means can be found to satisfy the appropriate authority that the Performance Requirements will be achieved.

### 4.3.3 Approach and assessment methodology

The approach is qualitative, comparative and absolute using the assessment methods as shown in Table 3 and Table 30.

### 4.3.4 Trial Fire Safety Design

The fire safety measures listed in Table 2 form the holistic fire safety design for the building. Specific measures to this solution include the follow:

**For Blocks B, C & D being of modular construction with lightweight floor/ceiling system**

- The floors between levels in Type A construction (Blocks B, C & D) can be of lightweight construction with the floor joists instead of a concrete slab.
- The floor structure shall be made of non-combustible materials, i.e., steel joists/beams/trusses.
- Under the floor joists, a ceiling having Resistance of Incipient Spread of Fire (RISF) for 60 minutes shall be installed, as shown in Figure 31.
- The ceilings shall comprise of a CSR ceiling system achieving a Resistance to Incipient Spread of Fire (RISF) of 60 minutes (or an equivalent system such as Boral, Knauf, etc having the same RISF) that is appropriate for the design of floor/ceiling system.
- Any downlights, services, etc. must not reduce this fire rating (RISF 60 min) and comply with tested specifications for the service in question (generally, this tested system would be attributed to the FRL of the ceiling system rather than the RISF rating, so a minimum FRL of the ceiling from below is required to be 60/60/60, noting that a ceiling having a RISF of 60 minutes will generally have at least (or higher) FRL of 60/60/60).
- Floor covering shall comprise of 24 mm thick CFC flooring, 19 mm Thermifloor flooring and carpet where applicable.
- The floor lining or floor covering shall have fire hazard properties complying with BCA Spec C1.10 Clause 3.

*Notes:*

- *The current section details show 2 layers of 13 mm Fyrchek; The applicable Tested System (e.g. CSR Systems 6132, 6134, 6190, 6193. 6221, 66222, 6241, 6242 which generally require 1 x 13 mm and 1 x 16 mm or 2x 16 mm fire grade plasterboard linings) shall demonstrate compliance with the required RISF 60 min as per above requirement.*
- *CSR have also confirmed (See Appendix E) that the replacement of CSR Gyprock Fyrchek or Fyrchek MR with the EC08 range of linings with an equivalent thickness is supported by dedicated Test Reports that support their use in lieu of the CSR Gyprock Fyrchek or Fyrchek MR.*

### 4.3.5 Acceptance criteria

The acceptance criterion for this particular non-compliance is that the proposed fire safety measures employed will maintain adequate structural protection by the RISF ceiling and thus the required FRL during a fire.

### 4.3.6 Hazards

The key hazard associated with one-way fire rating to a floor (RISF instead of FRL) is that a fire above the floor level can potentially spread downwards and breach the fire separation.

### 4.3.7 Method of analysis

The proposed design will be evaluated in a qualitative and comparative analysis discussing risk to fire spread and structural stability as well as the fire brigade undertaking an attack.

Discussion is also made on the difference and RISF ceiling and 2-way fire rated floors and the actual fire risk at the subject floor area.

### 4.3.8 Analysis

#### *4.3.8.1 Comparison between RISF and two-way fire rated floor/ceiling system*

The highest risk to the floor is from a fire from the level below, due to the buoyant nature of fire/smoke. With the ceiling having a RISF of 60 minutes, the level of protection afforded to the ceiling is commensurate with the DtS Provisions.

The BCA defines the resistance to the incipient spread of fire (RISF), as follows:

> "in relation to a ceiling membrane, means the ability of the membrane to insulate the space between the ceiling and roof, or ceiling and floor above, so as to limit the temperature rise of materials in this space to a level which will not permit the rapid and general spread of fire throughout the space."

The BCA guide explains that the resistance to the incipient spread of fire:

> "Refers to the ability of a ceiling to prevent the spread of fire and thermally insulate the space between the ceiling and the roof, or floor above. "Resistance to the incipient spread of fire" is superior to "fire-resistance" because it requires a higher standard of heat insulation. Refer to AS 1530.4"

AS 1530.4 defines a the RISF as:

> "The ability of the membrane to insulate the space between the ceiling and roof, or ceiling and floor above, so as to limit the temperature rise of materials in this space to a level that will not permit the rapid and general spread of fire throughout the space to adjoining fire compartments."

AS 1530.4 outlines that where horizontal separating elements are proposed and a ceiling is used as a RSIF, then this ceiling prevents the spread of fire from one compartment to another through a floor-ceiling cavity and is only applicable in those configurations where the ceiling is the primary separating element. Thus, the ceiling system having the RISF alone is considered to protect the joists in the cavity as well as other elements in the cavity in terms of fire spread.

With the highest temperatures in compartment fires are recorded at ceiling level, a ceiling having a RISF of 60 minutes inherently offer protection to the building elements within the void space between the ceiling and floor (i.e. the joists/beams in question that support the floor). The proposed 60 minutes RISF ceiling would offer an effective FRL from below and further enhance the protection to the joists within the ceiling cavity, noting that required FRL to the floor has been assessed and permitted to be reduced from 120 minutes to 60 minutes.

Furthermore, AS 1530.4 outlines that under the test procedures for RSIF, the standard testing of an element / membrane (such as a ceiling) applies with the additional measurement for the RSIF to achieve a minimum of 60 minutes, i.e. the ceiling would not only achieve the FRL of 60 minutes (and more), it would also satisfy the ability to **insulate the space in the void above**. this is considered a much higher performance that an FRL and therefore offers further fire safety to the joists in the void space.

#### *4.3.8.2 Effect of flooring on downward fire spread*

BRANZ [SR 117] carried out a research project to investigate the behaviour of light timber framed floors when exposed to a fire from above. The report investigated the possibility that fire can spread downwards into a lower fire compartment through a timber floor by requiring non-combustible floor overlays to be used where the fire resistance rating is required to be 60 minutes or more. The subsequent revised New Zealand Building Code (NZBC) Acceptable Solution C/AS1 (2001) modified the requirements relating to wood and wood products in floors, stating that in any fire compartment which has another fire compartment below, the flooring may be of wood products provided the product used is no less than 20 mm thick. The studies found that the fire-resistance of a floor is quite different depending on the direction of fire exposure. The current NZBC maintained this requirement and sets out that wood flooring on a floor that separates two fire cells (fire compartments), be at least 20 mm thick.

To determine the effects on the timber flooring (joists and floorboard covering) themselves, the failure components were broken into two stages; one for the floor boards themselves and one for the failure of the joists after that (i.e. floor collapse).

The first stage required the fire to burn through the floor boards, thus enabling the fire to attack the joists directly. The reports noted, with regards to fuel load sitting on the flooring such as furniture, that it was assumed by this time that any large objects resting on the floor would either have been consumed by the fire before the particleboard failed or would be of sufficient dimensions to straddle the framework of joists and thereby be prevented from penetrating the ceiling lining sufficiently to fall into the lower fire compartment.

The second stage of failure is the collapse of the floor as a whole. At this stage the joists have been eroded by the fire to the point where they are unable to support themselves, let alone any objects being supported by them.

A number of tests were carried out and after some initial tests, the fire cribs (fuel used to generate the heat) collapsed on top of the flooring due to the consumption of the wood as would be the case in a real fire. However, the experiments were then modified by building a fire resistance structure that aimed to keep as much of the crib standing as possible to increase the level of downward radiation and charring to the floor board. Observations from the tests showed that when the structure of a crib failed due to the degree of its consumption by fire, the collapsed material protected the floor very effectively. At the conclusion of the research, it found that 20 mm fibreboard flooring provided approximately 30 minutes protection to the timber floor joist, with the timber floor joist failing in various times after that depending on whether the ceiling was lined or not. Without a ceiling below the floor joists, the resulting fallen fire load to the floor below began to attack the floor joists quickening the failure of the floor system, whilst with a ceiling in place, the fuel fell into the voids between the cavities and as such was “split up” and slowed down the attack on the floor joists. With the floor joists in the experiment timber only and fully exposed, there is no direct comparable evidence to be drawn on this building solution with regard to the steel joists. Only the effects of downward fire spread through the floor board is what the important factor is considered here.

**Unlike the BRANZ study and experiments**, the proposed design has **steel** joists/beams/trusses, then on the top, a layer comprising of 24 mm thick CFC flooring + 19 mm Thermifloor flooring to protect the downward heat exposure to the top of the joists itself. The proposed Performance Solution is considered superior to the set-up used in the BRANZ study and experiments, therefore providing further robustness.

### 4.3.9 Conclusion

This analysis demonstrates that the proposed fire safety measures forming part of this performance solution manage the deviations from the relevant BCA DtS provisions and demonstrate that the relevant BCA Performance Requirements CP1 and CP2 are met.

## 4.4 Solution 4: Sarking material inside the external walls for building of Type A construction (Blocks A-D)

### 4.4.1 Introduction

Table 31 provides a summary of this Solution, the relevant BCA DtS Provisions which are affected, and the relevant BCA Performance Requirements and IFEG sub-systems.

**Table 31: Summary of Solution**

| No | Description of non-compliance | DtS Clause | Performance Requirement (A0.7) | IFEG Sub-systems | Method of meeting Performance Requirements (A0.2) | Assessment Method (A0.5) |
|---|---|---|---|---|---|---|
| 4 | To permit the use of combustible sarking material (Bradford Enviroseal ProctorWrap RW) inside the external walls of the building of Type A construction (Blocks A-D). | C1.9 | CP2, CP4 | A, C | A0.2(a) Refer Table 3 | A0.5(b)(ii) Refer Table 3 |

A sarking material, Bradford Enviroseal ProctorWrap RW is proposed to be installed in the external wall of the building. As technically considered as part of the external wall which is required to be non-combustible, the use of Enviroseal ProctorWrap RW does not comply with the BCA 2016 (Amendment 1) Clause C1.9.

According to the datasheet, the Bradford Enviroseal ProctorWrap RW has a thickness of not greater than 1 mm and has a Flammability Index not greater than 5.

An installation detail of Enviroseal ProctorWrap RW is shown in Figure 33.

This performance solution applies to Type A construction building (i.e., Blocks A-D) only.

Building of Type C construction (i.e., Block E) is not subject to the requirement of non-combustible materials in or on external walls.

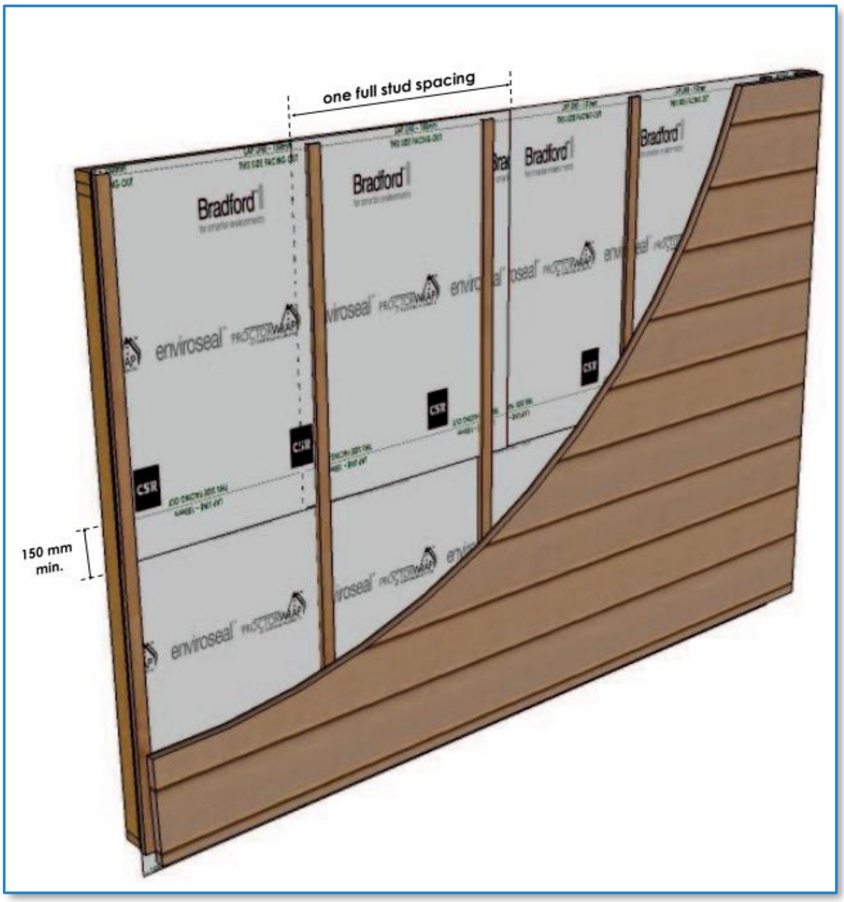



**Figure 33: Enviroseal ProctorWrap RW installation details (excerpt from product Installation Guide)**

### 4.4.2 Intent of the BCA

#### *4.4.2.1 BCA 2016 (Amdt 1) Clause C1.9*

BCA 2016 (Amdt 1) Clause C1.9 deals with non-combustible building elements and states:

> (a) *In a building required to be of **Type A or B construction**, the following building elements and their components must be non-combustible:*
>
> > (i) ***External walls and common walls, including all components incorporated in them including the façade covering, framing and insulation.***

As per the BCA Guide the intent of Clause C1.9 is to specify the non-combustibility for building elements and to permit the use of certain materials that are known to provide acceptable levels of fire safety where an element is required to be non-combustible.

#### *4.4.2.2 BCA Performance Requirements CP2 and CP4*

BCA Performance Requirements CP2 and CP4 are described in Appendix A of this report.

### 4.4.3 Approach and assessment method

The approach is to be qualitative, comparative and absolute using the assessment methods as shown in Table 3 and Table 31.

### 4.4.4 Trial Fire Safety Design

The fire safety measures listed in Table 2 forms the holistic fire safety design for the building.

#### 4.4.5 Acceptance criteria

The acceptance criterion for the Performance Solution is that use of combustible sarking materials in the Performance Space compartment does not warrant an increase of risk fire spread or life safety.

#### 4.4.6 Method of analysis

A qualitative and comparative assessment will be carried out to compare the risk of fire spread due to the use of sarking within the external wall.

The assessment will assess the fire hazard properties of the sarking material and then discuss and compare different clauses in BCA in terms of concession given to other materials.

Reference will also be to the industry's opinions and latest NCC 2019 that permits combustible sarking with flammability < 5 to AS 1530.2 provided it is not thicker than 1 mm.

#### 4.4.7 Hazards

The hazard specific to this Solution is that as the sarking material is deemed combustible, there is increased risk of fire spread and the increased fuel load to the building.

#### 4.4.8 Analysis

##### *4.4.8.1 Fire hazard properties*

It is acknowledged that due to the use in the external wall, the governing clause in BCA is Specification C1.1, Clause 3.1(b) (or C1.9 in BCA 2016 Amendment 1), instead of the requirement for fire hazard properties as stipulated in BCA C1.10 and Spec C1.10. However, from a performance-based fire engineering perspective, it is important to investigate the actual fire hazard properties of this material.

BCA Spec C1.10 requires that sarking-type material shall comply with the requirement of Clause 7 of Spec C1.10, which states that "Materials and assemblies in a Class 2 to 9 building not included in Clauses 3, 4, 5 or 6 must not exceed the indices set out in Table 4." Note there is a NSW variation for Table 4 however the requirement for sarking-type materials remains unchanged. Figure 34 shows an excerpt of Table 4 of Clause 7 of Spec C1.10.

**Table 4 OTHER MATERIALS**

| Material or assembly location | Flammability Index | Spread-of-Flame Index | Smoke-Developed Index |
|---|---|---|---|
| Fire control rooms subject to **Specification E1.8** and fire-isolated *exits*, other than a *sarking-type material* used in a ceiling or used as an attachment or part of an attachment to a building element. Note 1 | — | 0 | 2 |
| Class 9b buildings used as a theatre, public hall or the like: | | | |
| (a) Any part of fixed seating in the audience area or auditorium. | — | 0 | 5 |
| (b) A proscenium curtain *required* by **Specification H1.3**. | — | 0 | 3 |
| Escalators, moving walkways or non-*required* non-*fire-isolated stairways* or pedestrian ramps subject to **Specification D1.12**. | — | 0 | 5 |
| *Sarking-type material*: | | | |
| (a) In a fire control room subject to **Specification E1.8** or a fire-isolated *exit* or fire control room used in the form of an exposed wall or ceiling. | 0 | — | — |
| (b) In other locations. Note 2 | 5 | — | — |
| Other materials or locations and insulation materials other than *sarking-type materials*. Notes 2 and 3 | — | 9 | 8 if the *Spread-of-Flame Index* is more than 5 |

**Notes:**

1. In a fire control room or *fire-isolated stairway*, a material used as an attachment or part of an attachment to a building element must, if *combustible*, be attached directly to a *non-combustible* substrate and not exceed 1 mm finished thickness.
2. A material, other than one located within a fire-isolated *exit* or fire control room, may be covered on all faces by concrete or masonry not less than 50 mm thick, as an alternative to meeting the specified indices.
3. In the case of a composite member or assembly, the member or assembly must be constructed so that when assembled as proposed in a building—
   (a) any material which does not comply with this Table is protected on all sides and edges from exposure to the air; and
   (b) the member or assembly, when tested in accordance with **Specification A2.4**, has a *Spread-of-Flame Index* and a *Smoke-Developed Index* not exceeding those prescribed in this Table; and
   (c) the member or assembly retains the protection in position so that it prevents ignition of the material and continues to screen it from access to free air for a period of not less than 10 minutes.

**Figure 34: Fire hazard properties for "Other Materials" (excerpt from Table 4 of Clause 7 of Spec C1.10)**

As shown in Figure 34, Table 4 of Clause 7 of Spec C1.10 requires a sarking-type material to have a **flammability index no more than 5**, when tested against AS 1530.2.

The subject sarking material Enviroseal ProctorWrap RW has been tested by Australian Wool Testing Authority (AWTA) against AS 1530.2 (Test Number 16-001226) and the test report shows a **Flammability Index of 2**.

A copy of the Test Report is shown in Appendix B.

The test results show that Enviroseal ProctorWrap RW is suitable for internal use except for fire control room or fire-isolated exit (for which neither is applicable in subject design).

Whilst being treated as part of external wall, the Enviroseal ProctorWrap RW sarking membrane is entire inside the wall itself and the risk of exposure is significantly lower than other combustibles on the surface of the external walls, e.g., cladding. There is no combustible cladding proposed to the subject building. The likelihood of a fire scenario of the Enviroseal ProctorWrap RW sarking membrane being ignited and causing fire spread is extremely, when considering the high performance of the fire hazard properties as assessed above.

#### 4.4.8.2 BCA 2016 Concessions

Most sarking materials, including the Enviroseal ProctorWrap RW used in the subject building, are combustible. Prior to the Grenfell disaster, there were no DtS non-combustible (AS1530.4 tested) sarking materials in general use in the Australian building industry. Only since then, have manufacturer's ventured into the application and use of non-combustible sarking materials. It is noted due to its use and unexposed location in the building the fire hazard of sarking material is low.

BCA Spec C1.1 Clause 3.1(c) permits the penetration of sarking-type material through internal wall required to have an FRL while generally other combustible building elements are prohibited:

> *In a building required to be of Type A construction—*
> *(c) any internal wall required to have an FRL with respect to integrity and insulation must extend to—*
> *(i) …*
> *(ii) …*
> *(iii) if under Clause 3.5 the roof is not required to comply with Table 3, the underside of the non-combustible roof covering and,* ***except for*** *roof battens with dimensions of 75 mm x 50 mm or less* ***or sarking-type material, must not be crossed by timber or other combustible building elements***

BCA Spec C1.1 Clause 4.1(d) and Clause 5.1(d) have the same concession for Type B and Type C construction, respectively.

Separate to sarking type materials and non-combustibility requirements, BCA Clause and Spec C1.10 set out the general requirements for the fire hazard properties for intern wall and ceiling linings. Table 1 of Spec C1.10 stipulates the fire hazard property requirements and the sarking-type materials is differentiated from floor/wall/ceiling linings with the sarking-type materials subject to Clause 7 which is less strict those Clause 3 or 4. In Table 4 under Clause 7, the sarking-type material is only subject to a requirement of flammability index of not greater than 5 and not subject to two other indexes (spread-of-flame index and smoke-developed index). It is noted that the subject sarking material Enviroseal ProctorWrap RW achieves this requirement for a flammability index of 2.

We understand that all the internal wall and ceiling linings are to comply with the DtS provisions of BCA Spec C1.10.

In the South Australia NCC/BCA variation for construction requirement for different BAL (Bushfire Attack Level), a sarking-type material with a flammability index of not more than 5 is permitted to be used for the external walls up to BAL-FZ.

In BCA Volume 2 Clause 3.7.1.9, the use of sarking-type material with a flammability index of not more than 5 is deemed compliant in terms of fire hazard properties of materials in a Class 1 building.

#### 4.4.8.3 BCA 2019 Concession

Note the building/project is subject to BCA 2016 Amendment. For comparative reference, the BCA 2019, effective since 1 May 2019, stipulates a concession for sarking material as one of the exempt materials under C1.9(e).

> *(e) The following material may be used wherever a non-combustible material is required:*
> *(i) …*
> *(ii) …*
> *(iii) …*
> *(iv) …*
> *(v) …*
> ***(vi) Sarking-type materials that do not exceed 1 mm in thickness and have a Flammability Index not greater than 5.***
> *(vii) …*

The above concession is in line with other current concessions in BCA. The subject sarking material Bradford Enviroseal ProctorWrap RW achieves this requirement for a flammability index of 2 (less than 5) and a not greater than 1 mm. **Therefore the use of this product would be a compliant design if the project was subject to BCA 2019.**

#### *4.4.8.4 Industry opinions*

It is noted with recent fire incidents worldwide involving fire spreading externally via cladding materials, the interpretation of BCA requirements has become more conservative, e.g., both Victorian Building Authority (VBA) "Industry Alert" and CSIRO "Fire safety guideline for external walls" have interpreted that "if the cladding/lining/other item is removed and the remaining structure no longer functions suitably as an external wall (for example, the remaining structure has no fire resistance level, is unable to prevent the penetration of water, is unable to resist wind loads, or in certain applications cannot meet acoustic requirements), then it is considered an integral part of the external wall, and BCA Specification C1.1, Sections 3.1(b) &4.1 (b) applies".

As the sarking serves function of water-proofing, it is deemed part of external wall based on the above interpretations.

However, sarking materials complying with fire hazard properties requirements without referring to the "non-combustibility" requirements have been widely accepted in the past and acknowledged by CSIRO:

"*CSIRO acknowledges that there is variance in the interpretation of BCA Deemed to Satisfy provisions for insulation and sarking for external walls that is currently applied in the building industry. For example, it is common for parts of the building industry to simply interpret that BCA Specification C1.10 clause 7 which specifies AS/NZS 1530.3 test requirements is the applicable requirement for insulation in external walls for Type A and Type B construction and AS 1530.2 for sarking.*";

and by Australian Institute of Building Surveyors (AIBS):

*"External walls typically contain many combustible components, including insulation, plumbing pipework, wiring, sarking, timber strengthening elements to fix handrails and grabrails, silicones, the list goes on. A literal application of the VBA Alert will disallow construction of external walls as they have always been constructed and as they must, practically, continue to be constructed. There is now certainly a need to review the BCA DTS provisions in this regard. For example, all available sarking products, which are a necessary part of external wall construction, are to our knowledge "combustible.".*

### 4.4.9 Conclusion

This analysis demonstrates that the proposed fire safety measures forming part of this Performance Solution manage the deviations from the relevant BCA DtS provisions and demonstrate that the relevant BCA Performance Requirements CP2 and CP4 are met.

## 4.5 Solution 5: Plywood strengthening elements used in fire-rated walls (internal or external) and non-fire-rated external walls the building of Type A construction (Blocks A-D).

### 4.5.1 Introduction

Table 32 provides a summary of this Solution, the relevant BCA DtS Provisions which are affected, and the relevant BCA Performance Requirements and IFEG sub-systems.

**Table 32: Summary of Solution**

| No | Description of non-compliance | DtS Clause | Performance Requirement (A0.7) | IFEG Sub-systems | Method of meeting Performance Requirements (A0.2) | Assessment Method (A0.5) |
|---|---|---|---|---|---|---|
| 5 | To permit the use of plywood timber noggings/reinforcement (for handrails/grabrails/wall mounted wet areas systems such as WHBs etc) in cavities of fire rated walls (internal or external) and non-fire-rated external walls the building of Type A construction (Blocks A-D). | C1.9, Spec C1.1, Clause 3.1(d) | CP2, CP4 | A, C & F | A0.2(a) Refer Table 3 | A0.5(b)(ii) Refer Table 3 |

It is proposed that 12 mm thick plywood is used as wall reinforcing / strengthening element for handrails/ grabrails/ wall mounted wet areas systems in cavities of fire rated walls (internal or external) and non-fire-rated external walls.

Note that this solution covers both walls required to have an FRL and those not required to have an FRL but still be non-combustible, e.g. external walls not fire rated.

This performance solution applies to Type A construction building (i.e., Blocks A-D) only.

Building of Type C construction (i.e., Block E) is not subject to the requirement of non-combustible materials in fire-rated walls (internal or external) and non-fire-rated external walls.

### 4.5.2 Intent of the BCA

#### *4.5.2.1 BCA 2016 (Amdt 1) Clause C1.9*

BCA 2016 (Amdt 1) Clause C1.9 deals with non-combustible building elements and states:

> (a) *In a building required to be of **Type A or B construction**, the following building elements and their components must be non-combustible:*
>
> > (i) ***External walls and common walls, including all components incorporated in them including the façade covering, framing and insulation.***

As per the BCA Guide the intent of Clause C1.9 is to specify the non-combustibility for building elements and to permit the use of certain materials that are known to provide acceptable levels of fire safety where an element is required to be non-combustible.

#### *4.5.2.2 BCA (2016 Amendment 1) Spec C1.1 Clause 3.1(d)*

BCA Spec C1.1 Clause 3.1 states:

> In a building required to be Type A construction-
> (d) a loadbearing internal wall and a loadbearing fire wall (including those that are part of a loadbearing shaft) must be constructed from—

(i) concrete; or
(ii) masonry; or
(iii) fire-protected timber, provided that…

#### *4.5.2.3 BCA Performance Requirements CP2 and CP4*

BCA Performance Requirements CP2 and CP4 are described in Appendix A of this report.

### 4.5.3 Approach and assessment method

The approach is to be qualitative and absolute using the assessment methods as shown in Table 3 and Table 32.

### 4.5.4 Trial Fire Safety Design

The fire safety measures listed in Table 2 forms the holistic fire safety design for the building. The specific fire safety measures for the building to the consideration of this deviation include the following:

- The plywood used as wall reinforcing / strengthening element for handrails/grabrails/wall mounted wet areas systems in cavities of fire rated walls (internal or external) and non-fire-rated external walls shall have a finished thickness of not less than 12 mm and have an average density of not less than 600 kg/$m^3$ at a moisture content of 12%; and shall not be joined by means of glue unless it has been laminated and glued with resorcinol formaldehyde or resorcinol phenol formaldehyde glue.
- The application of the plywood noggin is not for the entire wall (i.e., with one layer timber inside the wall), but only locally between studs (typically 600 mm) where deemed necessary, e.g., behind grab rails and fixings. The maximum height of the plywood noggin is 600 mm. Refer to an illustration in Figure 2.
- Where a wall is required to be provided with multiple portions of plywood noggings, they shall be separated by a vertical distance of at least 300 mm.

### 4.5.5 Acceptance criteria

The acceptance criterion for the Performance Solution is that use of timer elements in the buildings does not warrant an increase of risk on structural adequacy of internal fire-rated walls, fire spread or life safety.

### 4.5.6 Method of analysis

A qualitative and absolute assessment will be carried out to assess the risk of impairment of the internal wall FRL, the safe evacuation of the building and fire spread with the consideration the actual arrangement (location) of plywood and the hazard properties of the plywood.

### 4.5.7 Hazards

The hazard specific to this Solution is that if the inclusion of plywood (combustible) within fire rated internal walls may impair the FRL of the internal wall to which it is attached or increase the fuel load and cause greater risk of fire spread.

### 4.5.8 Analysis

#### *4.5.8.1 Intent of the BCA Performance Requirements*

BCA Performance Requirement CP2 uses the term “to the degree necessary”. The BCA Guide states that the phrase “to the degree necessary” is used to “show that provisions can differ according to various elements which appropriate authorities may take into consideration when assessing building applications”.

The Guide to the BCA outlines that the following with respect to the term:

> “to the degree necessary” is used to “show that provisions can differ according to various elements which appropriate authorities may take into consideration when assessing building applications”.

The Guide further expands and elaborates the intention of this phrase by stating that:

“this expression provides flexibility by allowing appropriate authorities to determine the degree of compliance necessary in a particular case. For example, an appropriate authority might judge that an item need not be installed, or a particular level of performance be achieved” and that:
“… the BCA recognises that different building elements require differing degrees of structural stability during a fire…Any decision made in this context can extend to not requiring an item to be installed or a particular level of performance to be achieved, if that is the appropriate action to be taken”.

If a Performance Solution is used, it may be appropriate to assess it using Performance Requirements CP2 for guidance purposes. The BCA Guide sets out that the intent of BCA Performance Requirements CP2 is to set structural stability requirements for building elements during fire and avoid spread of fire between fire compartments and buildings. However, it is stressed that compliance with CP2 is not compulsory if alternative means can be found to satisfy the appropriate authority that the Performance Requirements will be achieved.

#### *4.5.8.2 Risk of fire spread risk and increased fuel load*

The timber elements (plywood backing to grabrails in bathroom) are not expected to impair the FRL of the wall, and in fact form part of similar timber framed tested systems with the same FRL. The encapsulated plywood between the fire rated plasterboard presents much in the same way timber/steel fire rated walls. The plywood is understood located behind the fire-rated plasterboard which provides the fire rating to the lightweight wall, thus it is the fire grade plasterboard that offers the protection to the internal materials of the wall itself. The plywood, although being combustible, is also not expected to increase the fuel load as its size/weight is not considered significant in the entire content of the fire rated wall system itself. For the plywood to ignite, the fire-grade plasterboarding itself would need to fail before that plywood becomes ignited. This scenario is generally not considered in the occupant’s evacuation phase and early fire intervention phase.

Comparison can also be drawn with a BCA DtS design, with reference to Clause 3.10 of spec C1.1 regarding the concessions for low residential buildings that are permitted to have timber framed throughout. Whilst the concession is not applicable to the subject performance solution as it is not a Class 2 or 3 building, the content of the combustible elements (timber) is much more in the BCA DtS design (3 full stories) when compared to the subject performance solution where the use of plywood is limited and encapsulated inside the wall cavity.

#### *4.5.8.3 Fire hazard properties*

V/VM2 (Verification Method: Framework for Fire Safety Design for New Zealand Building Code Clauses C1-C6 protection from Fire) provides a means of compliance with the New Zealand fire code. In the Appendix B (Critical Radiant Flux values for some flooring materials), it states that

> *“B1.0 For the purposes of compliance with Clause C3.4(b) of the Building Code the following critical radiant flux values may be assigned as shown in Table B1 for the given flooring material without further evidence of testing to ISO 9239-1:2010.”*

The Table B1 in the Appendix B following the above gives the suggested values for certain materials without testing, including wood products, plywood or solid timber that are at least 12 mm thick with a minimum density of 400 kg/m$^3$, as shown in Figure 35. The suggested critical radiant flux for above mentioned timber products is 2.2 kW/m$^2$.

| Table B1 | Specified performances for some flooring materials |
|---|---|
| Flooring material | Critical Radiant Flux (CRF) |
| Concrete[2], brick, ceramic or porcelain tile | 4.5 kW/M$^2$ |
| Wood Products, Plywood or Solid Timber [1,2]<br>≥ 12 mm thick; and<br>≥ 400 kg/m$^3$ | 2.2 kW/M$^2$ |

Note

1. Some timber species and thicknesses and with/without applied coatings when tested may achieve a higher CRF. When a greater CRF is required to meet Clause C3.4 (b) than given in this table, supporting test data to ISO 9239-1:2010 for the product is required.
2. May include waterborne or solvent borne applied surface coatings not more than 0.4 mm thick and not more than 100 g/m $^2$.

**Figure 35: Table B1 of C/VM2 - Specified performances for some flooring materials**

As stated above, the plywood backing for the grabrails in bathroom has a thickness of 12 mm, therefore is expected to have a radiant flux of at least 2.2 kW/m$^2$.

The above assumptions and statement from C/VM2 are supported by fire tests undertaken by Warrington Fire Research (Report No. SFR 411117.2). The tests were undertaken in accordance with AS/NZS 3837 and AS ISO 9293.1, the latter of which is the referenced standard for testing critical radiant flux in the BCA. The types (of floor covering tested) include solid timber (no substrate), solid timber (with substrate) and plywood. The timber species cover wide range including ash, gum, pine, stringy bark, blackbutt, brownbarret, messmate, beech, blackwood, box, ironbark, jarrah, karri, mahogany, merbau, tallowwood, turpentine, wattle etc. The thickness of the floor covering varies from 12 mm to 19 mm. A summary of the results of this research is presented in Figure 36.

The results show that all the species have a critical radiant flux at least 2.2 kW/m$^2$, meeting the minimum requirement of the subject performance solution.

***Table 7 – Critical Radiant Heat Flux for Floor Coverings***

| Flooring Construction | Minimum Thickness | Applicable Species | Performance | |
|---|---|---|---|---|
| | | | Critical Radiant Heat Flux | Smoke Development Rate |
| Solid Timber (Substrates in Table 6) | 12mm | Table 3 and Table 4 | Between 2.2 (kW/m$^2$) and 4.5 (kW/m$^2$) | Less than 750 (%-min) |
| Solid Timber (No Substrate) | 12mm | Table 2 | Between 2.2 (kW/m$^2$) and 4.5 (kW/m$^2$) | |
| | 19mm | Table 3 and Table 4 | Between 2.2 (kW/m$^2$) and 4.5 (kW/m$^2$) | |
| | 19mm | Table 4 | More than 4.5 (kW/m$^2$) | |
| Plywood (No Substrate) | 15mm or 17mm | Table 5 | Between 2.2 (kW/m$^2$) and 4.5 (kW/m$^2$) | |

**Figure 36: Table 7 of Warrington Fire Research (Report No. SFR 411117.2) – Critical radiant heat flux for floor coverings**

Further data on the fire hazard properties of plywood published by Engineered Wood Products Association Of Australasia (EWPAA) (http://www.pngfp.com/timber-products/plywood2.pdf) indicate that the plywood generally perform well for all the three categories under BCA Spec C1.10:

- Floor material and coverings – measured by critical radiant flux
- Wall and ceiling linings – measured by group number
- Other materials – measured by spread of flame index and smoke development index

An abstract of the reported data is shown in Figure 37.

**Floor Material And Coverings**

| Species | Thickness | CRF | Smoke Development Rate |
|---|---|---|---|
| Pine, Hoop – Araucaria cunninghamii | 15mm or greater | Between 2.2 and 4.5 | Less than 750 percent-minutes |
| Pine, Radiata – Pinus Radiata | 17mm or greater | | |
| Pine, Slash – Pinus Elliottii | 17mm or greater | | |

**Wall and Ceiling Linings**

| Plywood Species | Minimum Thickness (mm) | Group No. | Average Specific Extinction Area ($m^2/kg$) |
|---|---|---|---|
| Pine, Radiata – Pinus Radiata | 6mm or greater | 3 | < 250 |
| Lauan – Shorea agsaboensis | 6mm or greater | 3 | < 250 |
| Pine, Hoop | 6mm or greater | 3 | 82.4 |
| Pine, Slash | 6mm or greater | 3 | 96.0 |

**Other Materials**

| Face Veneer Common Name | Botanical Name | Spread of Flame Index (0-10) | Smoke Developed Index (0-10) |
|---|---|---|---|
| Klinkii pine | Aurancaria hunsteinii | 8 | 4 |
| Radiata Pine | Pinus radiata | 8 | 2 |
| Radiata Pine (scorched and brushed surface) | Pinus radiata | 7 | 2 |

Figure 37: Performance of plywood on fire hazard properties (excerpt from EWPAA publication)

#### *4.5.8.4 Summary*

Overall, with the all considerations in different aspect, it is considered that plywood used as wall reinforcing / strengthening element for handrails/grabrails/wall mounted wet areas systems in cavities of fire rated walls (internal or external) and non-fire-rated external walls does not have a significant increase of risk of impairment of the internal wall FRL, the safe evacuation of the building and fire spread.

### 4.5.9 Conclusion

This analysis demonstrates that the proposed fire safety measures forming part of this performance solution manage the deviations from the relevant BCA DtS provisions and demonstrate that the relevant BCA Performance Requirements CP2 and CP4 are met.

## 4.6 Solution 6: Internal fire hydrant design requirement in accordance with AS 2419.1-2017 instead of AS 2419.1-2005

### 4.6.1 Introduction

Table 33 provides a summary of this Solution, the relevant BCA DtS Provisions which are affected, and the relevant BCA Performance Requirements and IFEG sub-systems.

**Table 33: Summary of Solution**

| No | Description of non-compliance | DtS Clause | Performance Requirement (A0.7) | IFEG Sub-systems | Method of meeting Performance Requirements (A0.2) | Assessment Method (A0.5) |
|---|---|---|---|---|---|---|
| 6 | The residual pressure of internal fire hydrants is to be designed in accordance with AS 2419.1-2017 instead of AS 2419.1-2005, i.e., 250 kPa instead of 700 kPa by viewing them as "unassisted attack fire hydrant". | E1.3, AS 2419.1 | EP1.3 | F | A0.2(a) Refer Table 3 | A0.5(b)(ii) Refer Table 3 |

Figure 38 shows the fire hydrant location at verandas near external stairs on Level 02 Block A & B, Level 01 Block C & D as an example.

Technically they are considered internal fire hydrants, however they will not meet the design requirement for internal fire hydrant as per AS 2419.1-2005, i.e., having a minimum required residual pressure of at least 700 kPa.

It is proposed to not have on-site fire hydrant pumps, i.e., the residual pressure of internal fire hydrants is to be designed in accordance with AS 2419.1-2017 instead of AS 2419.1-2005, i.e., 250 kPa instead of 700 kPa by viewing them as "unassisted attack fire hydrant". The pressure can be boosted via the fire hydrant booster if needed

This is a DtS departure to the requirement of residual pressure as per AS 2419.1-2005 for being considered as attack hydrants, i.e., 700 KPA at a flow rate of 10 L/s.

It is ambiguous in AS 2419.1-2005 that if an internal fire hydrant can be considered as "*unassisted attack fire hydrant*" and then applied for the requirement of residual pressure of at least 250 kPa:

**TABLE 2.2**

**MINIMUM FIRE HYDRANT OUTLET FLOW RATES AND PRESSURES**

| Fire hydrant type | Minimum required flow rate (L/s) | Minimum required residual pressure (kPa) | |
|---|---|---|---|
| | | NSW | All other states and territories |
| Feed fire hydrant, unassisted | 10 | 150 | 200 |
| Attack fire hydrant, unassisted | 10 | 250 | 350 |
| Internal and external fire hydrants when boosted by a fire brigade pumping appliance | 10 | 700 | 700 |

By contrast, in AS 2419.1-2017, it is clarified that the attack fire hydrants can include both external and internal hydrants, and the required design requirement for "*unassisted attack fire hydrant*" is residual pressure of at least 250 kPa:

**TABLE 2.2.3.1(B)**

**ATTACK FIRE HYDRANT PERFORMANCE—
MINIMUM UNASSISTED OUTLET PRESSURE AND FLOW RATE**

| Attack fire hydrant 'unassisted' | Minimum required flow rate | Minimum required residual pressure kPa | |
|---|---|---|---|
| | L/s | NSW | Other States and Territories |
| External fire hydrant | 10 | 250 | 350 |
| Internal fire hydrant | 10 | 250 | 350 |

It is proposed to adopt AS 2419.1-2017 for the design requirements of the hydrant located at verandas near external stairs.

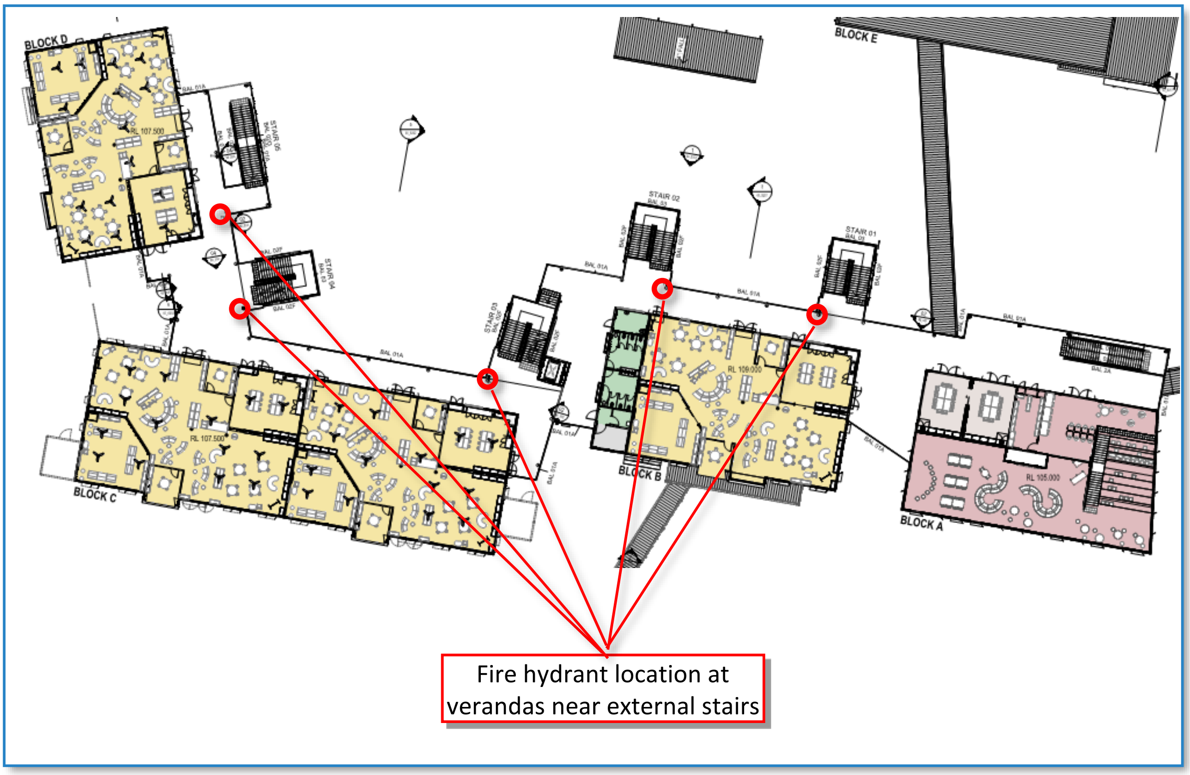



**Figure 38: Fire hydrant location at verandas near external stairs on Level 02 Block A & B, Level 01 Block C & D**

### 4.6.2 Intent of the BCA

#### *4.6.2.1 BCA Clause E1.3*

BCA Clause E1.3 states:

(a) A fire hydrant system must be provided to serve a building—

(i) having a total floor area greater than 500 m$^2$; and
(ii) where a fire brigade is available to attend a building fire.
(b) The fire hydrant system—
(i) must be installed in accordance with AS 2419.1; ….

The BCA Guide outlines that the intent of BCA Clause E1.3 is to require the installation of suitable fire hydrant systems to facilitate the fire brigade's firefighting operations.

BCA Clause E1.3(b) states that the fire hydrant system must be installed in accordance with AS 2419.1-2005. The relevant Clauses of AS 2419.1-2005 for this Performance Solution are shown in the Analysis section.

#### *4.6.2.2 BCA Performance Requirement EP1.3*

BCA Performance Requirement EP1.3 is described in Appendix A of this report.

### 4.6.3 Approach and assessment method

The approach is qualitative and comparative using the assessment methods as shown in Table 3 and Table 33.

### 4.6.4 Trial Fire Safety Design

The specific fire safety measures for the building to the consideration of this deviation include the following:

- The internal fire hydrants located at the verandas/balconies near external stairs can be considered internal unassisted attack fire hydrants, with the residual pressure of more than 250 kPa but less than 700 kPa.
- The hydrant block plan at the fire hydrant booster shall highlight that there are no on-site fire hydrant pumps and the relevant internal fire hydrants located at verandas near external stairs (shown in Figure 38 as an example for tentative internal fire hydrant locations) being internal unassisted attack fire hydrants, with the residual pressure of more than 250 kPa but less than 700 kPa. It shall state words to the effect:

  **NO ON-SITE FIRE HYDRANT PUMPS**
  **ALL HYDRANTS ARE UNASSISTED ATTACK FIRE HYDRANTS**
  **WITH RESIDUAL PRESSURE: XXX KPA**
  **USE HYDRANT BOOSTER TO BOOST PRESSURE**

  The above shall be either on the hydrant block plan or a separate sign next to the block plan that is clearly visible on approach to the hydrant block plan. When setting as separate sign, it shall be of a non-combustible material written in capital letters not less than 25 mm high in a colour contrasting with the background and must be mechanically fixed to the walls/poles. When exposed in outside at the hydrant booster, the sign shall be weather proof and fade proof.

### 4.6.5 Acceptance criteria

The acceptance criterion is that the subject building is at least equivalent to the DtS Provisions in terms of life safety and fire brigade operations with regards to the fire hydrant design.

### 4.6.6 Hazards

The hazard specific to this performance solution is that there might be reduced performance of firefighting when adopting the standard AS 2419.1-2017 for the subject fire hydrants.

### 4.6.7 Method of analysis

The analysis is qualitative and comparative with the discussion of AS 2419.1-2017 and comparison of the subject fire hydrants to external fire hydrants.

#### 4.6.8 Analysis

##### *4.6.8.1 Ambiguity in AS 2419.1-2005*

AS 2419.1-2005 Clause 2.3.2 stipulates the requirements of operating pressures for fire hydrants and states that

> *With the required number of fire hydrants simultaneously flowing at appropriate flow rate, a water supply to a fire hydrant system shall be capable of maintaining a residual pressure at each of the flowing fire hydrants. The flow rate and residual pressure shall be as given in Table 2.2.*
>
> *Where attack hydrants are required and they cannot achieve the performance as set out in Table 2.2, at the required number of most hydraulically disadvantaged hydrant(s) then the flow rate and residual pressure shall be as given in Table 2.3.*

The excerpt of Table 2.2 & 2.3 of AS 2419.1-2005 are shown in Figure 39.

**TABLE 2.2**

**MINIMUM FIRE HYDRANT OUTLET FLOW RATES AND PRESSURES**

| Fire hydrant type | Minimum required flow rate (L/s) | Minimum required residual pressure (kPa) | |
|---|---|---|---|
| | | NSW | All other states and territories |
| Feed fire hydrant, unassisted | 10 | 150 | 200 |
| Attack fire hydrant, unassisted | 10 | 250 | 350 |
| Internal and external fire hydrants when boosted by a fire brigade pumping appliance | 10 | 700 | 700 |

NOTES:

1 'Unassisted' specifies the system performance characteristics achieved by a water agency's system or other elevated reservoir, before a fire brigade pumping appliance is connected to the system. On-site pumps must not be used to achieve this performance. If pumps are required, then fire hydrants will need to have attack fire hydrant performance and be located in accordance with Clause 3.2.2.2(c).

2 In a system that incorporates a fire brigade booster assembly, external above-ground fire hydrants, accessible by a fire brigade pumping appliance, if located as attack fire hydrants, need only have feed fire hydrant unassisted performance (see Clause 3.2.2.2(d)).

**TABLE 2.3**

**FIRE HYDRANT OUTLET FLOW RATES AND PRESSURES**

| Fire hydrant type | Minimum required flow rate (L/s) | Minimum required residual pressure (kPa) |
|---|---|---|
| Attack fire hydrant performance achieved without the use of a fire brigade pumping appliance | 5 | 700 |
| Internal and external fire hydrants when boosted by a fire brigade pumping appliance | 10 | 700 |

NOTE: Where the supply from a water agency's reticulated water system does not meet the requirements of this Standard and tanks and pumps are installed, the performance requirements for feed fire hydrants at a booster assembly fed by that water supply may be waived.

**Figure 39: Excerpt of Table 2.2 & 2.3 of AS 2419.1-2005**

The above indicates that it is possible to have system design as per Table 2.2 as long as the performances for attack hydrants are achieved. Further commentary in Clause C2.3.2 explains this:

> *C2.3.2 Minimum residual pressures depending on the way the fire hydrant is being used are given in Table 2.2. This assumes a fire hydrant system that utilizes supply pressure and flows without the assistance of on-site pumps.*

*Where the water agency supply performance dictates the necessity to install on-site facilities, e.g., tanks, pumps or other systems (excluding reliance on fire brigade pumping appliance) the minimum residual pressures needs to be increased to 700 kPa, as required by Table 2.3. Firefighting nozzles or tips need high pressures to break up the water into fine 'fog' droplets.*

However it does not clearly state if any internal fire hydrant can be viewed as "*unassisted attack fire hydrant*" and then applied for the requirement of residual pressure of at least 250 kPa. In practice, it has been generally assumed that any internal fire hydrant would require a residual pressure of 700 kPa and to achieve that, on-site fire hydrant pumps are required.

#### 4.6.8.2 Clarity in AS 2419.1-2017

In AS 2419.1-2005 it is clarified in the general requirement of Clause 2.2.3.1 as follows:

*The number of fire hydrant(s) required to flow simultaneously in accordance with Clause 2.2.2 shall provide the **minimum residual unassisted pressure and flow rates as detailed in Table 2.2.3.1(A) and Table 2.2.3.1(B)**, where applicable, or Clause 2.2.6 for not less than 4 h.*
*Where the unassisted pressures or flows detailed in Table 2.2.3.1(A) and Table 2.2.3.1(B) or Clause 2.2.6 are not met by the primary water supply, a fixed on-site pump and/or tank shall be provided in accordance with the requirements of Clause 2.2.4, 2.2.5 or 2.2.6, as applicable.*

The excerpt of Table 2.2.3.1(A) & 2.2.3.1(B) of AS 2419.1-2017 are shown in Figure 40. It is clearly seen that if adopting AS 2419.1-2017, those subject fire hydrants, whilst being internal fire hydrants, can be considered "*unassisted attack fire hydrant*" and then applied for the requirement of residual pressure of at least 250 kPa, and therefore on-site fire hydrant pumps are not required.

TABLE 2.2.3.1(A)

FEED FIRE HYDRANT PERFORMANCE—
MINIMUM UNASSISTED OUTLET PRESSURE AND FLOW RATE

| Fire hydrant type 'unassisted' | Minimum required flow rate | Minimum required residual pressure kPa | |
|---|---|---|---|
| | L/s | NSW | Other States and Territories |
| External fire hydrant, located not more than 20 m from a hardstand area | 10 | 150 | 200 |

NOTES:

1 Minimum required flow = 10 L/s × number of hydrant outlets required to flow.

2 The differing minimum required residual pressures detailed in this Table can be attributed to the differing size fire hoses used by fire brigades across Australia; in NSW 70 mm fire hose is used while in other States and Territories 65 mm fire hose is used.

TABLE 2.2.3.1(B)

ATTACK FIRE HYDRANT PERFORMANCE—
MINIMUM UNASSISTED OUTLET PRESSURE AND FLOW RATE

| Attack fire hydrant 'unassisted' | Minimum required flow rate | Minimum required residual pressure kPa | |
|---|---|---|---|
| | L/s | NSW | Other States and Territories |
| External fire hydrant | 10 | 250 | 350 |
| Internal fire hydrant | 10 | 250 | 350 |

NOTE: Minimum required flow = 10 L/s × number of hydrant outlets required to flow simultaneously.

**Figure 40: Excerpt of Table 2.2.3.1(A) & 2.2.3.1(B) of AS 2419.1-2017**

#### 4.6.8.3 Comparison to external fire hydrants

It is acknowledged in both versions of the standards, the subject fire hydrants are considered internal fire hydrants instead of external fire hydrants. However, it should also be noted that the fire hydrants are located at verandas near external stairs (shown in Figure 38 as an example for tentative internal fire hydrant locations). There is ample openness and ventilation at these areas and the operations on these hydrants are not expected to significantly affected by an internal fire.

#### *4.6.8.4 Redundancy of using hydrant booster*

The above assessment only focuses on the requirement of residual pressure of the hydrants when being "unassisted". In reality, it is understood that the attending fire brigade would use the on-site fire hydrant booster to boost the pressure up to at least 700 kPa for the internal fire hydrants, regardless if there was on-site hydrant pumps.

Compared to on-site hydrant pumps, the fire brigade would generally prefer the use of hydrant booster to achieve the required pressure as pumps from the fire appliances are generally considered more reliable than the on-site hydrant pumps.

The attending fire brigade will need to be notified/warned that there are no on-site fire hydrant pumps and instead the hydrant booster shall be used. Therefore the following requirements are proposed:

- The hydrant block plan at the fire hydrant booster shall highlight that there are no on-site fire hydrant pumps and the relevant internal fire hydrants located at verandas near external stairs (shown in Figure 38 as an example for tentative internal fire hydrant locations) being internal unassisted attack fire hydrants, with the residual pressure of more than 250 kPa but less than 700 kPa. It shall state words to the effect:

  **NO ON-SITE FIRE HYDRANT PUMPS**
  **ALL HYDRANTS ARE UNASSISTED ATTACK FIRE HYDRANTS**
  **WITH RESIDUAL PRESSURE: XXX KPA**
  **USE HYDRANT BOOSTER TO BOOST PRESSURE**

  The above shall be either on the hydrant block plan or a separate sign next to the block plan that is clearly visible on approach to the hydrant block plan. When setting as separate sign, it shall be of a non-combustible material written in capital letters not less than 25 mm high in a colour contrasting with the background and must be mechanically fixed to the walls/poles. When exposed in outside at the hydrant booster, the sign shall be weather proof and fade proof.

#### *4.6.8.5 Adoption of AS 2419.1-2017 as a Performance Solution*

AS 2419.1-2017 is not referenced in the BCA/NCC (either 2016 or 2019), however it is commonly acceptable to adopt part or whole of the new AS 2419.1-2017 via a Performance solution.

In an update (No. 4) from the ABCB for "*Documents considered as part of a Performance Solution*", it states that ABCB agrees, that in the interim when the new standards (e.g., AS 2419.1-2017) are not referenced in the BCA/NCC, "*these documents may be considered for use as part of a Performance Solution*."

ABCB has also established an initiative to promote revised or amended documents (such as AS 2419.1-2017) which are not referenced in the NCC that may be suitable for use as part of a Performance Solution.

The following FRNSW position statement is also noted:

> *FRNSW endorse the use of Australian Standard AS 2419.1-2017 in the design and installation of fire hydrant systems in new premises. If AS 2419.1-2017 is adopted in its entirety to meet performance requirement EP1.3 of the National Construction Code, instead of the referenced AS 2419.1-2005 version, FRNSW will be likely to support an exemption under clause 188 of the Environmental Planning and Assessment Regulation 2000 (EP&A Reg.) or an alternative solution with regards to the fire hydrant system.*

### 4.6.9 Conclusion

This analysis demonstrates that the proposed fire safety measures forming part of this performance solution manage the deviations from the relevant BCA DtS provisions and demonstrate that the relevant BCA Performance Requirement EP1.3 met.

## 4.7 Solution 7: Fire hydrant booster not within sight of each building entry

### 4.7.1 Introduction

Table 34 provides a summary of the Solutions, the relevant BCA DtS Provisions, which are affected, and the relevant BCA Performance Requirements and IFEG sub-systems.

**Table 34: Summary of Solution**

| No | Description of non-compliance | DtS Clause | Performance Requirement (A0.7) | IFEG Sub-systems | Method of meeting Performance Requirements (A0.2) | Assessment Method (A0.5) |
|---|---|---|---|---|---|---|
| **7** | To permit the location of the fire hydrant booster to not technically be within sight of each building entry on the site, and not adjacent to the vehicular entrance. | E1.3, AS 2419.1 | EP1.3 | F | A0.2(a) Refer Table 3 | A0.5(b)(ii) Refer Table 3 |

The location of the fire hydrant booster is next to the main pedestrian entrance to the school site off Commissioners Drive, as shown in Figure 41.

Whilst the hydrant booster is located adjacent to the main pedestrian entrance to the school site, it is technically not within sight of each building entrance on the site, as there are four other pedestrian entrances, one being adjacent to the main pedestrian entrance off Commissioners Drive, two off Elkhorn Street, and the other off Willowdale Drive.

Another technical DtS departure is that the fire hydrant booster is not adjacent to the vehicular entrance to the on grade staff carpark. There are two vehicular entrances, one being off Elkhorn Street and the other one being off Willowdale Drive.

The distance between the fire hydrant booster and the main pedestrian entrance is approximately 10 m.

It is noted that as building is not prescriptively required for a fire detection and alarm system, there is no FIP or nominated fire control centre.

The substation is located next to the vehicular entrance, more than 10 m from the hydrant booster.

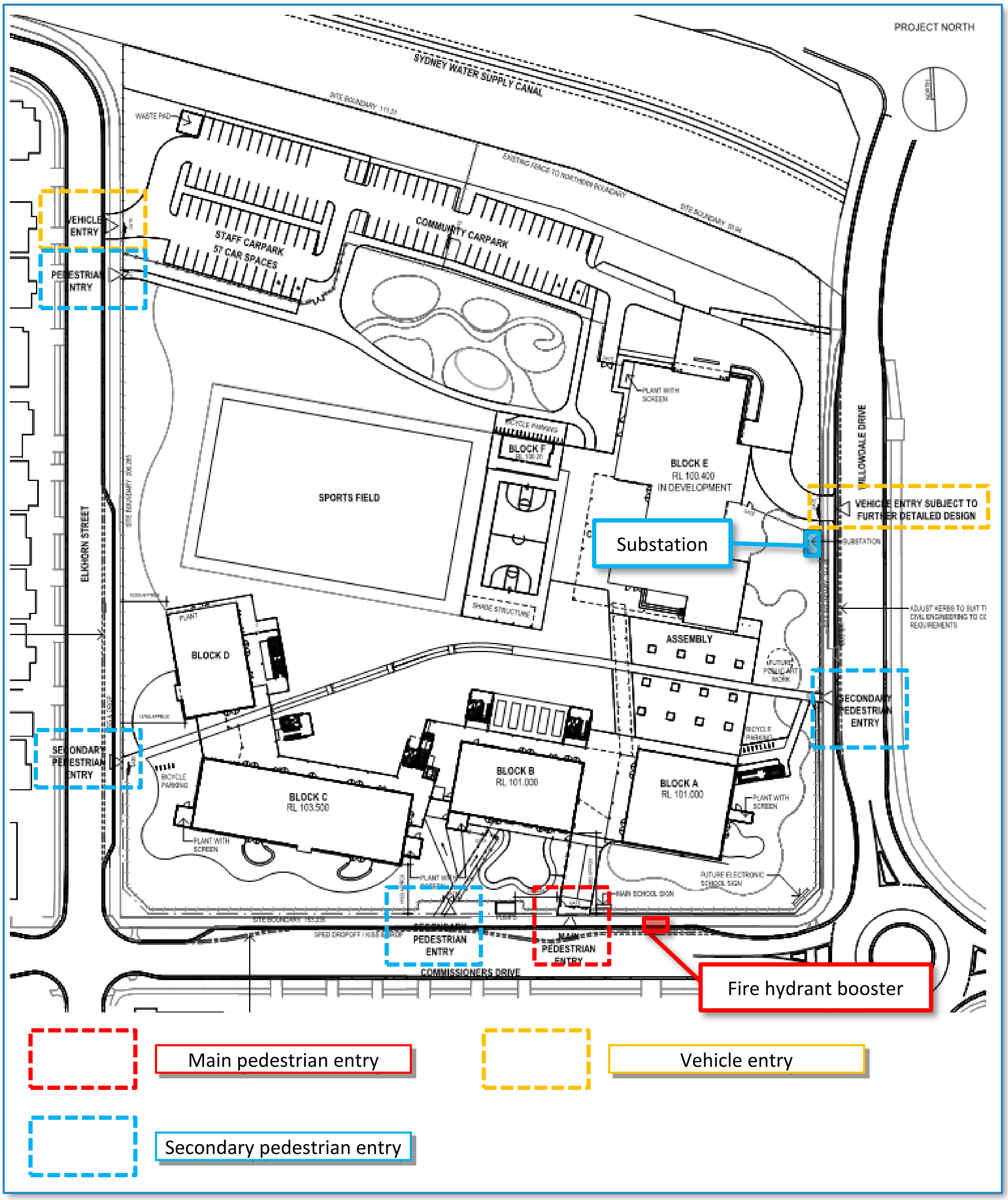



**Figure 41: Fire hydrant booster and building locations**

### 4.7.2 Intent of the BCA

#### *4.7.2.1 BCA Clause E1.3*

BCA Clause E1.3 states:

(a) A fire hydrant system must be provided to serve a building—

**(i) having a total floor area greater than 500 m²; and**

**(ii) where a fire brigade is available to attend a building fire.**

(b) The fire hydrant system—

**(i) must be installed in accordance with AS 2419.1; and**

(ii) where internal fire hydrants are provided, they must serve only the storey on which they are located except that a sole-occupancy unit—

(A) in a Class 2 or 3 building or Class 4 part may be served by a single fire hydrant located at the level of egress from that sole-occupancy unit; or

(B) of not more than 2 storeys in a Class 5, 6, 7, 8 or 9 building may be served by a single fire hydrant located at the level of egress from that sole-occupancy unit provided the fire hydrant can provide coverage to the whole of the sole-occupancy unit.

As per the BCA Guide the intent of Clause E1.3 is to require the installation of suitable fire hydrant systems to facilitate the fire brigade's firefighting operations. BCA DtS Clause E1.3 stipulates that a Fire Hydrant system must be installed in accordance with AS 2419.1 which requires that the hydrant booster be located within 20 m and within sight of the main entry to the building and sited on a hard standing.

The intent of the provision of hydrant boosters is to provide the attending fire brigade with a means to facilitate fire-fighting operations.

As per EP1.3, fire hydrant boosters must be installed to the degree necessary for the fire brigade to safely undertake operational fire-fighting activities in their attack on a fire.

#### *4.7.2.2 AS 2419.1 Clause 7.3*

AS 2419.1 Clause 7.3 states that:

Fire brigade booster assemblies shall be located so that they meet the following requirements:

(a) They are readily accessible to firefighters.

(b) They are operable by fire brigade pumping appliances located within 8 m.

(c) If within, or affixed to, the external wall of the building, the booster shall be—

(i) within sight of the main entrance to the building; and

(ii) separated from the building by a construction with a fire resistance rating of not less than FRL 90/90/90 for a distance of not less than 2 m each side of and 3 m above the upper hose connections in the booster assembly

**(d) If remote from the building, the booster shall be—**

**(i) at the boundary of the site and be within sight of the main entrance of the building;**

**(ii) adjacent to the principal vehicular access to the site; and**

(iii) located not less than 10 m from the external wall of any building served

(e) The booster enclosure shall only contain firefighting pipework and equipment.

#### *4.7.2.3 BCA Performance Requirement EP1.3*

Performance criteria EP1.3 of the BCA is described in Appendix A of this report.

### 4.7.3 Approach and assessment method

The approach is qualitative and comparative using the assessment methods as shown in Table 3 and Table 34.

### 4.7.4 Trial Fire Safety Design

The fire safety measures listed in Table 2 form the holistic fire safety design for the building. Fire safety measures specific to this solution are as follows:

- A fadeproof and weatherproof Fire Hydrant Block Plan shall be provided in accordance with the AS 2419.1-2005 requirements and placed at the fire hydrant booster. Refer to AS 2419.1-2005 Clause 7.11 for detailed requirements for block plans.

- The block plan shall be orientated to reflect the actual layout of the site from the location of the block plan being viewed.
- The block plan shall each building location include the surrounding street access routes. Alternatively, a separate site plan can be provided next to fire hydrant block plan, which shows the location of all site entrances and the location of each building.
- A signage shall be provided next to the vehicular entrance off Elkhorn Street, stating "**FIRE HYDRANT BOOSTER ON COMMISSIONERS DRIVE**", with arrow pointing to the direction of Commissioners Drive. The sign shall comprise of capital letters not less than 50 mm high in a colour contrasting with the background. The sign shall be weather/fade proof and mechanically fixed on a wall/fence or a standalone post. The signage be listed as an Essential Fire Safety Measure, to be included on the Fire Safety Schedule.
- A signage shall be provided next to the secondary pedestrian entrance off Elkhorn Street, stating "**FIRE HYDRANT BOOSTER ON COMMISSIONERS DRIVE**", with arrow pointing to the direction of Commissioners Drive. The sign shall comprise of capital letters not less than 50 mm high in a colour contrasting with the background. The sign shall be weather/fade proof and mechanically fixed on a wall/fence or a standalone post. The signage be listed as an Essential Fire Safety Measure, to be included on the Fire Safety Schedule.
- A signage shall be provided next to the secondary pedestrian entrance off Willowdale Drive, stating "**FIRE HYDRANT BOOSTER ON COMMISSIONERS DRIVE**", with arrow pointing to the direction of Commissioners Drive. The sign shall comprise of capital letters not less than 50 mm high in a colour contrasting with the background. The sign shall be weather/fade proof and mechanically fixed on a wall/fence or a standalone post. The signage be listed as an Essential Fire Safety Measure, to be included on the Fire Safety Schedule.
- The fire hydrant booster assembly connections and all fire hydrant valves must be fitted with Storz aluminium alloy delivery couplings manufactured and installed in accordance with clauses 7.1 and 8.5.11.1 of AS 2419.1-2005. Blank caps must be fitted to the couplings via a screw thread. Refer to guide sheet no. 4 'Fire brigade hose couplings' prepared by Fire and Rescue NSW for more information. This document is available at www.fire.nsw.gov.au.

### 4.7.5 Method of analysis

The performance solution is assessed by identifying the hazards posed to attending firefighters in a fire emergency with respect to the location of the hydrant booster. Discussion is made on the mitigating measures for the potential delay or difficulty of fire brigade operations.

### 4.7.6 Acceptance criteria

The acceptance criterion is that location of the hydrant booster is appropriate to the attending fire brigade in a fire emergency and the delay of fire brigade interventions is minimal with the proposed mitigating measures.

### 4.7.7 Hazards

The main hazards presented by sites containing multiple buildings having multiple entries on various locations and frontages of each building over a school campus ground arises where the fire and rescue service arrive and are presented with delays in locating the correct hydrant booster for the building in which the fire is situated.

### 4.7.8 Analysis

#### *4.7.8.1 Booster not within sight of main entrance*

It is understood that the requirements of having hydrant booster within sight of the main entrance of the building ensures that the booster is easily identified by brigade personnel (i.e. a familiar and obvious location) and is practical for the staging and intervention actions of brigade personnel. By locating the booster within sight of the main entrance the booster is easily identified by brigade personnel, as the main entrance is expected to be amongst the first points of call from where brigade personnel will begin their intervention.

It is however noted that the subject school site, whilst having multiple buildings, is registered with the address at Commissioners Drive as shown in Figure 41, therefore it is expected that the attending firefighters would first arrive on

Commissioners Drive and they should be able to see the fire hydrant booster, which is located ~10 m from the main school entrance.

As the school is also bounded by other public roads, it is possible that the fire brigade may first arrive on other roads. To provide the ease to identifying the location of fire hydrant booster in this event, the following signage are provided:

- A signage shall be provided next to the secondary pedestrian entrance off Elkhorn Street, stating "**FIRE HYDRANT BOOSTER ON COMMISSIONERS DRIVE**", with arrow pointing to the direction of Commissioners Drive. The sign shall comprise of capital letters not less than 50 mm high in a colour contrasting with the background. The sign shall be weather/fade proof and mechanically fixed on a wall/fence or a standalone post. The signage be listed as an Essential Fire Safety Measure, to be included on the Fire Safety Schedule.
- A signage shall be provided next to the secondary pedestrian entrance off Willowdale Drive, stating "**FIRE HYDRANT BOOSTER ON COMMISSIONERS DRIVE**", with arrow pointing to the direction of Commissioners Drive. The sign shall comprise of capital letters not less than 50 mm high in a colour contrasting with the background. The sign shall be weather/fade proof and mechanically fixed on a wall/fence or a standalone post. The signage be listed as an Essential Fire Safety Measure, to be included on the Fire Safety Schedule.

It is also noted that the requirement of fire hydrant booster being within sight of entrances of all building is omitted under the concession in AS 2419.1-2007 Clause 7.3.4, i.e., this design of booster location would be compliant under AS 2419.1-2007.

#### *4.7.8.2 Booster not adjacent to vehicular entrance*

There is only an on grade carpark. Although the carpark entrance is not adjacent to fire hydrant booster, it is not expected to have any significant impact to cause a delay for the attending firefighters to identify the location of fire hydrant booster.

If the fire bridge fire arrive site on Elkhorn Street, next to the vehicular entrance, they will be prompted with sign:

- A signage shall be provided next to the vehicular entrance off Elkhorn Street, stating "**FIRE HYDRANT BOOSTER ON COMMISSIONERS DRIVE**", with arrow pointing to the direction of Commissioners Drive. The sign shall comprise of capital letters not less than 50 mm high in a colour contrasting with the background. The sign shall be weather/fade proof and mechanically fixed on a wall/fence or a standalone post. The signage be listed as an Essential Fire Safety Measure, to be included on the Fire Safety Schedule.

If the fire bridge fire arrive site on Elkhorn Street, next to the vehicular entrance, they will be prompted with sign at the pedestrian entrance not far from the secondary pedestrian entrance off Willowdale Drive:

- A signage shall be provided next to the secondary pedestrian entrance off Willowdale Drive, stating "**FIRE HYDRANT BOOSTER ON COMMISSIONERS DRIVE**", with arrow pointing to the direction of Commissioners Drive. The sign shall comprise of capital letters not less than 50 mm high in a colour contrasting with the background. The sign shall be weather/fade proof and mechanically fixed on a wall/fence or a standalone post. The signage be listed as an Essential Fire Safety Measure, to be included on the Fire Safety Schedule.

With the above signs, it is deemed that the risk of delaying the operations of firefighters is minimal.

It is also noted that where one booster serving multiple buildings on the same site, the requirement of fire hydrant booster being adjacent to vehicular entrance is omitted under the concession in AS 2419.1-2007 Clause 7.3.4, i.e., this design of booster location would be compliant under AS 2419.1-2007.

### 4.7.9 Conclusion

This analysis demonstrates that the proposed fire safety measures forming part of this performance solution manage the deviations from the relevant BCA DtS provisions and demonstrate that the relevant BCA Performance Requirement EP1.3 met.

## 4.8 Solution 8: Omission of fire hose reels to non-classroom areas

### 4.8.1 Introduction

Table 35 provides a summary of this Solution, the relevant BCA DtS Provisions which are affected, and the relevant BCA Performance Requirements and IFEG sub-systems.

**Table 35: Summary of Solution**

| No | Description of non-compliance | DtS Clause | Performance Requirement (A0.7) | IFEG Sub-systems | Method of meeting Performance Requirements (A0.2) | Assessment Method (A0.5) |
|---|---|---|---|---|---|---|
| 8 | To permit the omission of Fire Hose Reels serving parts of the buildings that are not forming part of the main classroom areas of the building (i.e. admin, BOH, etc). | E1.4 | EP1.1 | C and D | A0.2(a) Refer Table 3 | A0.5(b)(ii) Refer Table 3 |

BCA E1.4 permits the omission of fire hose reels in classrooms and associated corridors in a primary or secondary school. It is proposed in this performance solution that fire hose reels are also omitted in building parts where they are not forming part of the main classroom areas of the building (i.e. admin, BOH, etc) and supplemented with portable fire extinguishers.

### 4.8.2 Intent of the BCA

#### *4.8.2.1 BCA Clause E1.4*

BCA Clause E1.4 sets out the requirements for when fire hose reels are required to a building and states:

(a) E1.4 does not apply to—
- (i) a Class 9c aged care building; or
- (ii) **classrooms and associated corridors in a primary or secondary school**.

(b) A fire hose reel system must be provided—
- (i) to serve the whole building where one or more internal fire hydrants are installed; or
- (ii) where internal fire hydrants are not installed, to serve any fire compartment with a floor area greater than 500 m$^2$, and for the purposes of this clause, a sole occupancy unit in a Class 2 or 3 building or Class 4 part is considered to be a fire compartment.

According to the BCA Guide, the intent with E1.4 is *"To require the installation of suitable fire hose reel systems to enable, where appropriate, a building's occupants to undertake initial attack on a fire".*

The BCA Guide also states *"The concession not requiring the installation of fire hose reels in classrooms, etc is based on normal school use when teachers or school staff could be expected to be in control of students for the purpose of evacuation. Fire hose reels are required in other areas of the school such as halls, gymnasiums, etc where activities take place outside normal school hours and with outside organisations that are not under the control of teachers or school staff."*

#### *4.8.2.2 BCA Performance Requirement EP1.1*

BCA Performance Requirement EP1.1 is described in Appendix A of this report.

### 4.8.3 Approach and assessment method

The approach is to be qualitative and comparative using the assessment methods as shown in Table 3 and Table 35.

#### 4.8.4 Trial Fire Safety Design

The fire safety measures listed in Table 2 forms the holistic fire safety design for the building. The specific fire safety measures for the building to the consideration of this deviation include the following:

- Additional fire extinguishers shall be provided such that all areas within the building parts not considered as classrooms or associated corridors, are with 10 m of a fire extinguisher.
- Each fire extinguisher shall be a multi-purpose Type ABE 2.5 kg extinguisher.

#### 4.8.5 Acceptance criteria

To determine whether the Performance Solution is considered to meet the BCA Performance Requirements, it is demonstrated that sufficient provision has been made for first aid firefighting and that the omission of hose reels in the Office/Admin areas and parts of the school that are not considered to be classrooms or associated corridors of the school, meets the intent of the BCA.

#### 4.8.6 Method of analysis

A qualitative and absolute assessment will be demonstrated that hose reels are unlikely to be used effectively in the event of a fire and it may not be safe for occupants to do so as the use of hose reels could increase the likelihood of injury due to occupants fighting the fire instead of evacuating.

#### 4.8.7 Hazards

The risk of omission to fire hose reels is occupants may not be able to operate initial first-aid firefighting at the early stage of fire. However this is mitigated by the replacement of portable fire extinguishers.

#### 4.8.8 Analysis

##### *4.8.8.1 Hazards associated with fire hose reel use*

[CIBSE Guide E] outlines that when specifying hose reels, consideration shall be given to:

- The objective of providing hose reels (noting that additional fire extinguishers are proposed to be provided);
- The maximum size of fire expected to be attacked;
- The persons likely to use the equipment;
- The difficulty, and physical strength required, in pulling out the hose along a potentially tortuous route (and potentially across multiple smoke and fire boundaries such as doors and across public lift lobby / corridors given access to exits from all other areas).

[CIBSE Guide E] expands by outlining that:

> Some fire and rescue authorities have taken the view that portable fire extinguishers are a more appropriate and safer option than hose reels. As mentioned above, it is important to carry out an assessment of the physical capability of staff before deciding on the type of fire extinguishing equipment to be provided. If occupiers decide to fight a fire, the dangers inherent in so doing are not altered by the choice of firefighting equipment.

The BCA Guide outlines that intent of the hose reels is to provide a means of first aid firefighting, where it is appropriate for occupants to do so. As a school building, it is understood that the priority for the occupants to evacuate out of the building, instead of fighting the fire. As the operation of fire hose reels involves unlatching the fire hose reels and dragging it to fire origin which could present additional hazard of tripping, and blocking/delaying the egress , the use of fire hose reels could therefore increase the likelihood of injury or death in case of a fire due to the occupants fighting the fire (when they have not been suitably trained to do so) instead of evacuating.

As such, the occupants focusing their efforts on evacuating the occupants and visitors before undertaking any attempt to extinguish the fire provides a safer outcome. The safety to occupants in the proposed design incorporating only includes portable fire extinguishers is expected to be at least equivalent to that of a DtS compliant building which includes fire hose reels.

#### 4.8.8.2 *Proposal of extinguishers in lieu of fire hose reels*

To compensate for the omission of the fire hose reels from areas not considered to be "*in classrooms and associated corridors*", hand held portable fire extinguishers are proposed such that all areas are within 10 m of an extinguisher. Portable fire extinguishers are more appropriate for the initial attack on a fire as they have a limited capacity of approximately 30-60 s of continuous use, at which point occupants have more time to evacuate than using hose reels if they have not been able to extinguish a fire. As a result, it is less likely for a person to continue attempting to fight a fire, which may become too large and then overwhelms them. Portable fire extinguishers also have less likelihood of preventing fire doors from closing properly or create trip hazards to the same extent as a fire hose reel unwound across a public corridor or fire/smoke doors.

Fire extinguishers complying with the Australian Standard are marked with a classification and rating, which provides a description of the fires suitable for attack by the respective extinguisher type, as determined in accordance with [AS 2444] and shown in Table 36 below.

**Table 36: Categories of Fire Extinguishers**

| Fire Extinguisher Type | Description |
|---|---|
| Class A | Fires involving carbonaceous solids (i.e. Combustible materials, such as wood, cloth, paper, rubber and many plastics). |
| Class B | Fires in flammable and combustible liquids, greases, and oils. |
| Class C | Fires in combustible gases. |
| Class D | Fires in combustible metals. |
| Class E | Fires which involve energised electrical equipment. |
| Class F | Fires for cooking oils and fats. |

As water extinguisher or fire hose reels are only appropriate for Class A fires, portable multi-purpose extinguisher such as those proposed in the design, can be used for Class A, B, C, D and E fires, i.e. portable extinguishers being more versatile than fire hose reels.

Fire hose reels are also quite heavy (particularly when charged with water) and require an amount of strength which many occupants may not possess, particularly elderly, young, or unwell occupants. The proposed design includes multi-purpose Type ABE 2.5 kg extinguishers which are lighter and easier to move and wield and therefore are more useful to a wider number of the building's occupants.

### 4.8.9 Conclusion

This analysis demonstrates that the proposed fire safety measures forming part of this performance solution manage the deviations from the relevant BCA DtS provisions and demonstrate that the relevant BCA Performance Requirement EP1.1 is met.

# 5 Key Assumptions and Limitations

- This report is consistent with the fire safety provisions, objectives and limitations of the Building Code of Australia (BCA):

    - All new works associated with the development comply with the current DtS provisions of the BCA except for the specific Performance Solutions described within Section 4 of this report.
    - This report excludes the assessment and design against fires that include incendiary ones involving accelerants, explosives, multiple ignition sources, or acts of terrorism.
    - The concepts outlined in this report assume a complete and operational building, and do not address protection of the building during construction, renovation or demolition.
    - All of the fire safety systems are assumed to be designed, installed and operate in accordance with the appropriate Australian standards, other design codes, legislation and regulations relevant to the project unless specifically stated otherwise. All essential services equipment will be maintained, to the operational capacity to which they were designed, installed, commissioned and certified, in accordance with the manufacturer's instructions. As such, all essential services equipment and management plans, etc discussed within this report are assumed to function correctly during a fire situation.
    - Access and Egress provisions for persons with disabilities including compliance with the Disability Discrimination Act (DDA) are considered to the same degree as the BCA.
    - Unless stated otherwise, protection of property (other than within the subject property), business continuity, interruption or losses, environmental impacts, personal or moral obligations of the owner/occupier, reputation, amenity or non-fire related matters in the building such as health, security, energy efficiency, and occupational health & safety or the costs associated with any fire damages are specifically excluded from this analysis.

- This report is not a compliance or conformance audit for any fire safety system. For example, operational checks of fire safety equipment, verification of construction techniques, fire resistance levels or the witnessing of fire drills or exercises are specifically excluded from the scope of this report.
- The assessment, recommendations, findings and conclusions in this report are based on the relevant information provided by stakeholders as listed in Section 1.6. MCD Fire Engineering has relied on the listed stakeholders to verify the accuracy and/or completeness of that information.
- The findings and outcomes of this report apply only to the subject building / works and must not be utilised for any other purpose. Any modifications, extensions, change of use, etc. to the building, fire safety measures or essential services equipment, from that described in this report may invalidate the findings, necessitating a re-assessment.

# Appendix A BCA Performance Requirements

## A.1 BCA Performance Requirements CP1 and CP2

BCA Performance Requirement CP1 stipulates;

> 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 building; and
> (b) the fire load; and
> (c) the potential fire intensity; and
> (d) the fire hazard; and
> (e) the height of the building; and
> (f) its proximity to other property; and
> (g) any active fire safety systems installed in the building; and
> (h) the size of any fire compartment; and
> (i) fire brigade intervention; and
> (j) other elements they support; and
> (k) the evacuation time.

BCA Performance Requirement CP2 stipulates;

> (a) A building must have elements which will, to the degree necessary, avoid the spread of fire—
> (i) to exits; and
> (ii) to sole-occupancy units and public corridors; and
> (iii) between buildings; and
> (iv) in a building.
> (b) Avoidance of the spread of fire referred to in (a) must be appropriate to—
> (i) the function or use of the building; and
> (ii) the fire load; and
> (iii) the potential fire intensity; and
> (iv) the fire hazard; and
> (v) the number of storeys in the building; and
> (vi) its proximity to other property; and
> (vii) any active fire safety systems installed in the building; and
> (viii) the size of any fire compartment; and
> (ix) fire brigade intervention; and
> (x) other elements they support; and
> (xi) the evacuation time."

The BCA Guide sets out that the intent of BCA Performance Requirements CP1 and CP2 is to set structural stability requirements for building elements during fire and avoid spread of fire between fire compartments and buildings. CP1 and CP2 do not reference a fire-resistance level (FRL). FRLs are only included as part of the Deemed-to-Satisfy Provisions. The BCA Guide also states that it may be determined by a building proponent using an Performance Solution that applying FRLs to building element is not necessary because other methods, such as the use of active systems, can satisfy the Performance Requirements.

## A.2 BCA Performance Requirement CP4

BCA Performance Requirement CP4 stipulates;

> To maintain tenable conditions during occupant evacuation, a material and an assembly must, to the degree necessary, resist the spread of fire and limit the generation of smoke and heat, and any toxic gases likely to be produced, appropriate to—

> (a) the evacuation time; and
> (b) the number, mobility and other characteristics of occupants; and
> (c) the function or use of the building; and
> (d) any active fire safety systems installed in the building.

As per the BCA Guide, Performance Requirement CP4 deals with the fire hazard properties of materials used in the construction of a building which include such matters as their smoke, toxic gas and heat generation capacities.

The BCA Performance Requirement CP4 uses the term "to the degree necessary". This word usage is designed to provide flexibility in the way this provision is implemented. It means that the BCA recognises that different materials and assemblies must resist the spread of fire to limit the generation of smoke, heat and toxic gases to differing degrees, depending on the circumstances of their use. The expression is intended to allow the appropriate authority to determine the degree of compliance necessary in each particular case after consideration of the building scenario.

Any decision made in this context can extend to not requiring an item to be installed or particular level of performance to be achieved, if that is the appropriate action to be taken.

The materials used in the building must be appropriate to avoid the spread of fire and the generation of smoke, heat and toxic gases after consideration of the matters listed in CP4. The reason for each of these matters is as follows:

- If the occupants can evacuate in a short time, then the smoke, heat and toxic gases generated prior to the completion of the evacuation will be less likely to have an impact on the safety of the occupants than if a longer evacuation time is required.
- The number, mobility and other characteristics of the occupants influence the time taken for the evacuation of the building. If the number of occupants is large, or they are not mobile, such as patients in a hospital or residents of an elderly people's home, the evacuation time could be long. Such an evacuation time may allow the fire to develop and generate greater amounts of smoke, heat and toxic gases that will endanger the safety of the occupants trying to evacuate.
- The function or use of the building has an impact on the types of materials and linings that are part of the building's fire load. This directly influences the rate of spread of any fire in the building.
- Any active fire safety system installed in the building, such as a sprinkler system, may limit the spread of fire and allow additional time for the evacuation of the occupants.

The BCA Guide explains that where a Performance Solution to the DtS provisions in Section C is being used, it may be appropriate to assess it using the Section C DtS provisions for guidance purposes.

It is stressed, however, that compliance with the Deemed-to-Satisfy Provisions is not compulsory if alternative means can be found to satisfy the appropriate authority that the Performance Requirements will be achieved. The building proponent should refer to A0.5 for guidance on acceptable assessment methods for determining compliance with the Performance Requirements.

### A.3 BCA Performance Requirement EP1.1

BCA Performance Requirement EP1.1 stipulates that;

> A fire hose reel system must be installed to the degree necessary to allow occupants to safely undertake initial attack on a fire appropriate to—
> (a) the size of the fire compartment; and
> (b) the function or use of the building; and
> (c) any other fire safety systems installed in the building; and
> (d) the fire hazard.

The BCA Guide states that "Fire hose reels in buildings allow occupants to fight a fire. The fire may be in its infancy and early control or extinguishment may reduce the hazard, allow more time for evacuation and prevent structural damage."

It is further noted that the Functional Statement Requirement EF1.1 of the BCA states that: “A building is to be provided with fire-fighting equipment to safeguard against fire spread so as to allow occupants time to evacuate safely without being overcome by the effects of fire; and so that occupants may undertake initial attack on a fire”.

### A.4 BCA Performance Requirement EP1.3

Performance criteria EP1.3 of the BCA stipulates;

> A fire hydrant system must be provided to the degree necessary to facilitate the needs of the fire brigade appropriate to—
> (a) fire-fighting operations; and
> (b) the floor area of the building; and
> (c) the fire hazard.

The BCA Guide states the intent of BCA Performance Requirement EP1.3 is the installing a fire hydrant system is to provide adequate water, under sufficient pressure and flow, to allow the fire brigade to fight fires. The use of the expression “to the degree necessary” in EP1.3 indicates that the BCA recognises that not all buildings need fire hydrants. Any decision made in this context can extend to not requiring an item to be installed or a particular level of performance to be achieved, if that is the appropriate action to be taken.

If an Performance Solution is used, it may be appropriate to assess it using E1.3 for guidance purposes. However it is stressed that compliance with E1.3 is not compulsory if alternative means can be found to satisfy the appropriate authority that the Performance Requirements will be achieved.

# Appendix B Flame and Radiation Assessment – Spandrels

## B.1 Methodology

The calculation principles for the spandrel/balconies is described below:

$$\dot{q}_r'' = F_{1-2}\varepsilon_f \sigma T_{emitter}^4 \qquad \textbf{Equation 1}$$

| | |
|---|---|
| $\dot{q}_r''$ | *is the radiant heat flux received by the receiver [kW/m²]* |
| $F_{1-2}$ | *is the configuration factor* |
| $\varepsilon_f$ | *is the emissivity of emitter to be calculated using the relationship $\varepsilon_f = 1 - e^{-ad_f}$ for emissivity of flame. Where 'a' is the absorption coefficient taken as 1.13 for furniture type materials [Drysdale, 1992]* <br> *Note that the emissivity of flames given in Eurocode 1 as $\varepsilon_f = 1 - e^{-0.3d_f}$ is not appropriate in this instance as the as the absorption coefficient given is for external structural steel [Carlsson, 1999].* |
| $d_f$ | *is the flame thickness [m] taken as $^2/_3\, h_{eq}$. Where $h_{eq}$ is the weighted average of window heights on all relevant walls.* |
| $\sigma$ | *is the Stefan Boltzmann constant [= 5.67x10-8 W/m²/K⁴]* |
| $T_{emitter}^4$ | *is the absolute temperature of the emitter [K] to be calculated as per Eurocode 1 for the external flame.* |

The flame temperature along the axis of the flame $T_z$ is given by:

$$T_z = (T_w - T_0)\left[1 - 0.4725\left(\frac{L_x w_t}{Q}\right)\right] + T_0 \qquad \textbf{Equation 2}$$

*Where:*

$$\frac{L_x w_t}{Q} < 1$$

*And*:

| | |
|---|---|
| $T_z$ | *is the flame temperature along the flame axis [K]* |
| $T_w$ | *is the flame temperature at window [K]* |
| $T_0$ | *is the initial temperature (= 293 [K])* |
| $L_x$ | *is the axis length from the window to the point where the calculation is made [m]* |
| $w_t$ | *is the sum of window widths on all walls ($w_t = \sum w_i$) [m]* |
| $w_i$ | *is the width of window "i" [m]* |
| $Q$ | *is the burning rate [MW]* |

The flame temperature at the window $T_w$ is given by:

$$T_w = \frac{520}{\left[1 - 0.4725\left(\frac{L_f w_t}{Q}\right)\right]} + T_0 \qquad \textbf{Equation 3}$$

*Where:*

$$\frac{L_f w_t}{Q} < 1 \qquad \textbf{Equation 4}$$

*And:*

| | |
|---|---|
| $L_f$ | *is the flame length along axis [m]* |

*The burning rate $Q$ is given by:*

$$Q = min\left[\frac{(A_f q_{f,d})}{\tau_f}; 3.15\left(1-e^{-0.036/O}\right)A_v\left(\frac{h_{eq}}{D/W}\right)^{1/2}\right]$$ **Equation 5**

*Where:*

| | |
|---|---|
| $A_f$ | *is the floor area of the fire compartment [m²]* |
| $q_{f,d}$ | *is the design fire load density related to the floor area $A_f$ [MJ/m²]* |
| $\tau_f$ | *is free burning fire duration (assumed to be 1200 [s] in Eurocode 1)* |
| $O$ | *is the opening factor of the fire compartment [m$^{1/2}$] given by:* |

$$O = A_v \frac{\sqrt{h_{eq}}}{A_t}$$ **Equation 6**

$h_{eq}$ *is the weighted average of window heights on all walls [m] given by:*

$$h_{eq} = \frac{\sum_i (A_{v,i} h_i)}{A_v}$$ **Equation 7**

| | |
|---|---|
| $D$ | *is depth of the fire compartment [m]* |
| $W$ | *is the width of wall containing window(s) (W1) [m]* |
| $A_v$ | *is the total area of vertical openings on all walls [m²] given by:* |

$$A_v \sum_i (A_{v,i})$$ **Equation 8**

*The flame length $L_L$ along its axis is then given by:*

*When $L_L$ > 0,*

$$L_f = L_L + \frac{h_{eq}}{2}$$ **Equation 9**

(if a wall exists above the opening, or if $h_{eq} \leq 1.25 w_t$)

$$L_f = \left({L_L}^2 + \left(L_H - \frac{h_{eq}}{3}\right)^2\right)^{1/2} + \frac{h_{eq}}{2}$$ **Equation 10**

(when no wall exists or if $h_{eq} > 1.25 w_t$)

*Where:*

| | |
|---|---|
| $L_L$ | *is the flame height (from the upper part of the window) [m]* |
| $L_H$ | *is the horizontal projection of the flame (from the façade) [m]* |

*The horizontal projection of the flame $L_H$ is then given by:*

*if wall exists above the opening:*

$$L_H = \frac{h_{eq}}{3}$$ **Equation 11**

(if $h_{eq} \leq 1.25 w_t$)

$$L_H = 0.3h_{eq}\left(\frac{h_{eq}}{w_t}\right)^{0.54}$$

(if $h_{eq} > 1.25w_t$) and the distance to any other widows $> w_t$ **Equation 12**

$$L_H = 0.454h_{eq}\left(\frac{h_{eq}}{2w_t}\right)^{0.54}$$

(in other cases) **Equation 13**

*when no wall exists:*

$$L_H = 0.6h_{eq}\left(\frac{L_L}{h_{eq}}\right)^{1/3}$$ **Equation 14**

$$L_L = max\left[0;\left(2.37\left(\frac{Q}{A_v\rho_g\left(h_{eq}g\right)^{1/2}}\right)^{2/3} - 1\right)\right]$$ **Equation 15**

*Where:*

$\rho_g$ *is the internal gas density ( = 0.45 [kg/m3])*
$g$ *is the gravitational acceleration( = 9.81 [m/s2])*

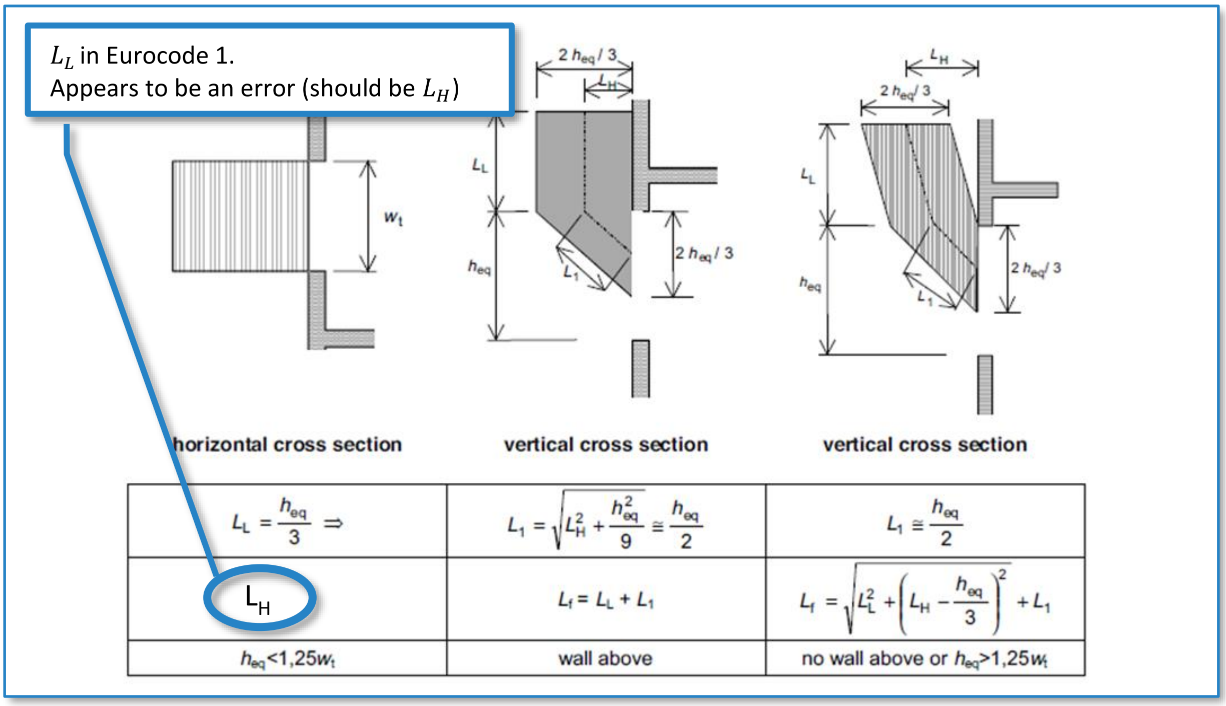



*Figure 42: Flame Dimensions, No through Draught (Eurocode 1)*

*In accordance with Clause B.2 Annex B of Eurocode 1, when there is more than one window in the fire compartment, the weighted average height of windows ($h_{eq}$), the total area of vertical openings ($A_v$) and the sum of window widths ($w_t = \sum w_i$) are used.*

Where the affected walls of each SOU have more than one window, in accordance with Clause B.2, the ratio $\frac{D}{W}$ has to be obtained using the following equation,

$$\frac{D}{W} = \frac{w_2}{w_1}\frac{A_{v1}}{A_v}$$ **Equation 16**

Where:

| | |
|---|---|
| $A_{v1}$ | *is the sum of window areas on wall 1 [m²]* |
| $w_1$ | *is the width of the wall 1, assumed to contain the greatest window area [m]* |
| $w_2$ | *is the width of the wall perpendicular to wall 1 in the fire compartment [m]* |

As per Clause B.2 of Annex B, all parts of an external wall that do not have the fire resistance required for the stability of the building should be classified as windows area. The total area of windows in an external wall is;

The total area, if less than 50% of the area of the relevant external wall of the compartment;

Firstly the total area and secondly 50% of the area of the relevant wall of the compartment, if the area is more than 50%.

As there are no openings on the opposite sides of the fire *compartment* where the affected windows are located, the calculations will be done with no forced draught conditions. Also, since this is a comparative analysis, rather than absolute, the results would be the same for both assessments.

It should be noted that although the Eurocode 1 method to *calculate* the external flame projection applies to flame projections perpendicular to the plane of the openings, this method will be applied to the comparative analysis of flame projections parallel to the plane of the openings.

## B.2 Results for Block A (W3)

| *Compartment Dimensions* | | | | |
|---|---|---|---|---|
| Width | B | = | 21.0 | m |
| Length | L | = | 32 | m |
| Height | H | = | 2.7 | m |
| Floor area | $A_f$ | = | 671.0 | m^2 |
| Total area of compartment | $A_t$ | = | 1628.0 | m^2 |
| Ambient Temperature | $T_0$ | = | 20.0 | °C |

***Opening Dimensions***

| Wall | ID | Width (m) | Height (m) | Multiple | Area ($m^2$) |
|---|---|---|---|---|---|
| SE | W1 | 1.2 | 2.7 | 8 | 25.92 |
| SW | W2 | 1.2 | 2.7 | 7 | 22.68 |
| NW | W3 | 1.8 | 2.7 | 7 | 34.02 |
| SW | W4 | 1.2 | 1.5 | 6 | 10.8 |
| | | | | | 0 |
| | | | | | 0 |

| | | | | |
|---|---|---|---|---|
| Aggregate height of windows | $h_{eq}$ | = | 2.56 | m |
| Total window width | $w_t$ | = | 37.80 | m |

Note: Total window area ≠ $h_{eq}$ x $w_t$

| Wall | Opening Area ($m^2$) | Wall Width (m) | Wall Area ($m^2$) | % of Wall Area |
|---|---|---|---|---|
| SE | 25.92 | 32 | 86.4 | 30.0% |
| SW | 33.48 | 21 | 56.61563 | 59.1% |
| NW | 34.02 | 32 | 86.4 | 39.4% |
| SW | 33.48 | 21 | 56.61563 | 59.1% |
| | | | | |
| | | | | |

| | | | | |
|---|---|---|---|---|
| Wall width greatest window area, $W_1$ | | = | NW | |
| Total window areas at wall NW | ,$A_{v1}$ | = | 34.02 | $m^2$ |
| Total Area of windows(s) | $A_v$ | = | 93.42 | $m^2$ |
| Width of wall NW | $W_1$ | = | 32 | m |
| Compartment wall width 90° to $W_1$, $W_2$ | | = | 20.96875 | m |

| | | | |
|---|---|---|---|
| Distance to any window > 146.40 m | = | NO | |

$$\frac{D}{W} = \frac{W_2}{W_1}\frac{A_{v1}}{A_v}$$

| | | | |
|---|---|---|---|
| Ratio of D/W | = | 0.245 | |

### *Fuel Characterics*

| | | | |
|---|---|---|---|
| Type of fuel | = | Furniture | |
| Absorption coefficient, a | = | 1.13 | |

### Opening Factor

$$O = A_v \frac{\sqrt{h_{eq}}}{A_t}$$

| | | | |
|---|---|---|---|
| Opening factor, O | = | 0.090 | |

### *Fire Load*

From Table 3.4.1a of IFEG

| | | | |
|---|---|---|---|
| Type of Occupancy | = | School | |
| Mean fire load | = | 285 | MJ/m$^2$ |
| Factor | = | 1.263158 | |
| Factored fire load | = | 360 | MJ/m$^2$ |
| Apply 61% FLED for sprinklers | | NO | |
| Design fire load $q_{f,d}$ | = | 360 | MJ/m$^2$ |

### *Rate of Burning or Rate of Heat Release*

$$Q = \min\left[\left(\frac{A_f . q_{f,d}}{\tau_F}\right); 3.15\left(1 - e^{-0.036/O}\right) A_v \left(\frac{h_{eq}}{D/W}\right)^{1/2}\right]$$

| | | | |
|---|---|---|---|
| Free burning duration of fire, $\tau_F$ | = | 1200 | s |
| Rate of burning (fuel controlled) | = | 201.3 | MW |
| Rate of burning (ventilation controlled) | = | 307.3 | MW |
| Rate of burning , Q | = | 201.3 | MW |

## *Temperature of fire compartment*

$$T_f = 6000\left(1 - e^{-0.1/O}\right)O^{1/2}\left(1 - e^{-0.00286\Omega}\right) + T_0$$

$$\Omega = \frac{A_f . q_{f,d}}{\left(A_v . A_t\right)^{1/2}}$$

| | | | |
|---|---|---|---|
| $\Omega$ | = | 619.4 | |
| Temperature of compartment, $T_f$ = | | 1021 | °C |

## *Flame Height*

$$L_L = \max\left(0; h_{eq}\left(2.37\left(\frac{Q}{A_v \rho_g \left(h_{eq} g\right)^{1/2}}\right)^{2/3} - 1\right)\right)$$

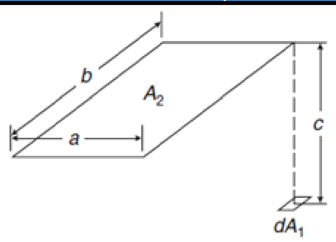
| | | | |
|---|---|---|---|
| Internal gas density, $\rho_g$ | = | 0.27 | $kg/m^3$ |
| Gravitational acceleration, g | = | 9.81 | $m/s^2$ |
| Flame height above opening, $L_L$ = | | 5.66 | m |

## *Emmtting Radiation Calculation*

$$\dot{q}''_e = \varepsilon \sigma T^4_{emitter}$$

| | | | | |
|---|---|---|---|---|
| Flame thickness | $d_f$ | = | 1.71 | m |
| Emissivity, | $\varepsilon_f$ | = | 0.85 | |
| Stefan-Boltzmann constant | $\sigma$ | = | 5.67E-11 | $kW/m^2/K^4$ |

## *Configuration Factor Calculation*




$X = a/c \qquad Y = b/c$

$$F_{d1-2} = \frac{1}{2\pi}\left[\frac{X}{\sqrt{1+X^2}}\tan^{-1}\left(\frac{Y}{\sqrt{1+X^2}}\right) + \frac{Y}{\sqrt{1+Y^2}}\tan^{-1}\left(\frac{X}{\sqrt{1+Y^2}}\right)\right]$$

**_Receiving Radiation Calculation_**

$$\dot{q}_r'' = F_{d1-2,4}\,\dot{q}_e''$$

Select window below spandrel for analysis = W3

**Receiving Heat Flux for Spandrel Construction**

Wall above the window = YES

**_Horizontal Projection of Flame_**

$$L_H = \frac{h_{eq}}{3}$$

Applies

$$L_H = 0.3h_{eq}\left(\frac{h_{eq}}{w}\right)^{0.54}$$

N/A

$$L_H = 0.454h_{eq}\left(\frac{h_{eq}}{2w_t}\right)^{0.54}$$

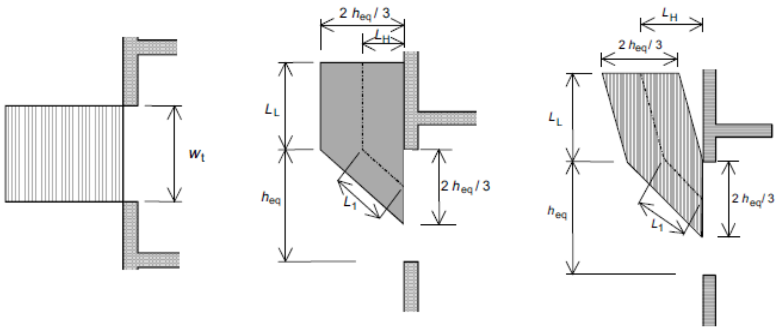
N/A

$$L_H = 0.6h_{eq}\left(\frac{L_L}{h_{eq}}\right)^{1/3}$$

N/A

Horizontal projection of flame, $L_H$ = 0.854 m

**_Flame Length along Axis_**




horizontal cross section | vertical cross section | vertical cross section

| | Applies | N/A |
|---|---|---|
| Flame height above opening, $L_L$ = | | 5.66 m |
| Flame length to the top of windows, $L_1$ = | | 1.28 m |
| Flame length along axis, $L_f$ = | | 6.94 m |

## Flame Temperature at window

$$T_w = \frac{520}{\left[1 - 0.4725\left(\frac{L_f.w_t}{Q}\right)\right]} + T_0$$

with $L_f.w_t/Q < 1$

Flame temperature at window, $T_w$ = 1006 °C

## Temperature Distribution along Flame Axis

$$T_z = (T_w - T_0)\left(1 - \frac{0.4725 L_x.w_t}{Q}\right) + T_0$$

with $L_f.w_t/Q < 1$

Temperature at window, $T_z$

| | | |
|---|---|---|
| Axis length, $L_x$ = | 0 | m |
| Flame temperature, $T_z$ = | 1006 | °C |

Temperature at top of window, $T_z$

| | | |
|---|---|---|
| Axis length, $L_x$ = | 1.281 | m |
| Flame temperature, $T_z$ = | 894 | °C |

| | | | | |
|---|---|---|---|---|
| Height of spandrel | | = | 0.9 | m |
| Distance from spandrel edge to glass | | = | 0 | m |
| Height of flame radiating on floor above | | = | 4.76 | m |
| Flame length at sill, $L_x$ | | = | 2.18 | m |
| Flame temperature at sill | $T_z$ | = | 859 | °C |
| Average flame temperature | $T_{emitter}$ | = | 700 | °C |
| Radiant heat flux emitted, | $\dot{q}''_e$ | = | 43.4 | kW/m$^2$ |
| 1/2 flame height, | a | = | 2.38 | m |
| 1/2 flame width, | b | = | 0.90 | m |
| Distance from flame to glass, | c | = | 0.85 | m |
| | X | = | 2.79 | |
| | Y | = | 1.05 | |
| Configuration factor for 1/4 plane element, | $F_{d1-2}$ | | 0.18 | |
| Configuration factor for 1 plane element, | $F_{d1-2}$ | | 0.71 | |
| Radiant heat flux emitted, | $\dot{q}''_r$ | = | **36.3** | kW/m$^2$ |

## *Temperature distribution along flame axis*

$$T_z = (T_w - T_0)\left(1 - \frac{0.4725 L_x . w_t}{Q}\right) + T_0$$

with $L_f.w_t/Q < 1$

Temperature at window, Tz

| | | |
|---|---|---|
| Axis Length, $L_x$ = | 0 | m |
| Flame temperature, $T_z$ = | 1006 | °C |

Temperature at top of window, Tz

| | | |
|---|---|---|
| Axis Length, $L_x$ = | 1.281 | m |
| Flame temperature, $T_z$ = | 894 | °C |

| | | | | |
|---|---|---|---|---|
| Length of apron, $W_a$ | | = | 0 | m |
| Apron thickness | | = | 0 | m |
| Height of spandrel | | = | 0.45 | m |
| Distance from wall edge to glass | | = | 0 | m |
| Height of flame radiating on floor above | | = | 5.21 | m |
| Flame length at sill, $L_x$ | | = | 1.73 | m |
| Flame temperature at sill | $T_z$ | = | 890 | °C |
| Average flame temperature | $T_{emitter}$ | = | 715 | °C |
| Radiant heat flux emitted, | $\dot{q}''_e$ | = | 46.1 | kW/m$^2$ |
| 1/2 flame height, | a | = | 2.61 | m |
| 1/2 flame width, | b | = | 0.90 | m |
| Distance from flame to glass, | c | = | 0.85 | m |
| | X | = | 3.05 | |
| | Y | = | 1.05 | |
| Configuration factor for 1/4 plane element, | | $F_{d1-2}$ | 0.18 | |
| Configuration factor for 1 plane element, | | $F_{d1-2}$ | 0.71 | |
| Radiant heat flux emitted, | $\dot{q}''_r$ | = | **39.8** | kW/m$^2$ |

***References***

1. Drysdale, D., *An Introduction to Fire Dynamics (Reprinted)*, John Wiley and Sons, Great Britain, 1992.

2. BSI, *BS EN 1991-1-2:2002: EC1: Actions on on structures - Part 1-2: General actions - Actions on structures exposed to fire*, 2009.

3. Tien, C. L., Lee, K. Y., Stretton, A. J., *Radiation Heat Transfer*, Section 1/Chapter 4, SFPE Handbook of Fire Protection Engineering (4th Ed), 2008.

4. ABCB, *International Fire Engineering Guidelines*, 2005 Edition, Australian Building Codes Board, Canberra, 2005.

***Assumptions***

1. The model assumes that the air flow is driven by burning of the fire and room dimensions without any external air supply (wind).

# Appendix C Fire Severity Calculations

## C.1 Eurocode Calculation Results: Block A – Level 01

| | | | | |
|---|---|---|---|---|
| MCD FIRE ENGINEERING | Project: | | | |
| | Title: | Eurocode Time Equivalence Method (EC1, 2002) | | |
| | | | Date: | |
| | | | Page: | 1 |

| Ref | Calculations | Comments |
|---|---|---|
| | | Version 1.0 |

Ref 1

***Time Equivalent Formula based on EC1 (2002)***

$$t_e = e_f k_b w_f$$

Where:

$$w = \left(\frac{6.0}{H}\right)^{0.3} \cdot \left[0.62 + \frac{90(0.4-\alpha_v)^4}{1+(b_v \alpha_h)}\right] > 0.5$$

***Fire cell dimensions***

| | | |
|---|---|---|
| Width, $l_1$ = | 16.69 | m |
| Length, $l_2$ = | 29.00 | m |
| Ceiling height, H = | 2.7 | m |
| Wall area of fire cell, $A_w$ | 1214.7 | $m^2$ |
| Floor area of fire cell, $A_f$ = | 484.0 | $m^2$ |

***Vertical openings***

| ID | Width | Height | Multiple |
|---|---|---|---|
| SE | 1.2 | 2.7 | 6 |
| SW | 7.1 | 2.7 | 1 |
| NW | 8 | 2.7 | 1 |
| SW | 1.2 | 1.4 | 4 |
| | | | |

| | | |
|---|---|---|
| Area of vertical openings, $A_v$ = | 66.93 | $m^2$ |
| % of vertical openings, $A_v/A_w$ = | 5.51% | |

***Horizontal openings***

| ID | Width | Length | Multiple |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

| | | |
|---|---|---|
| Area of horizontal openings, $A_h$ = | 0 | $m^2$ |
| % of horizontal openings, $A_h/A_f$ = | 0.00% | |

| Project: | | | | |
|---|---|---|---|---|
| Title: | Eurocode Time Equivalence Method (EC1, 2002) | | | |
| | | Date: | | |
| | | Page: | 2 | |

| Ref | Calculations | | | | Comments |
|---|---|---|---|---|---|
| | ***Fire Load*** | | | | Version 1.0 |
| Ref 2 | From Table 3.4.1a of IFEG | | | | |
| | Type of occupancy = | School | | | |
| | Mean fire load = | 285 | $MJ/m^2$ | | |
| | Factor for 80th percentile FLED = | 1.263158 | | | |
| | 80th percentile FLED, $e_f$ = | 360 | $MJ/m^2$ | | |
| | Factor for 95th percentile FLED = | 1.578947 | | | |
| Ref 1 | 95th percentile FLED fire load, $e_f$ = | 450 | $MJ/m^2$ | | Table E.2 (Annex E) of Ref. 1 |
| | Apply 61% FLED if sprinklers provided ? | No | | | |
| | Dimensionless parameter, $\alpha_v$ = | 0.14 | | $(A_v/A_f)$ | Ok |
| | Dimensionless parameter, $\alpha_h$ = | 0.00 | | $(A_h/A_f)$ | Ok |
| | Dimensionless parameter, $b_v$ = | 29.55 | | | Ok |
| | Ventilation factor, $w_f$ = | 1.3 | | | Ok |

| Ref | Properties | Walls | 246.7241 | 20.3% | Floors | 484.0 | 39.8% | Ceiling | 484.0 | 39.8% |
|---|---|---|---|---|---|---|---|---|---|---|
| Ref 3 | ***Properties of lining material*** | | | | | | | | | |
| | Type of material | Gypsum plaster | | | Unknown | | | Gypsum plaster | | |
| | Thermal conductivity, $\lambda$ = | | 0.48 | W/m/K | | 0.2 | W/m/K | | 0.48 | W/m/K |
| | Density, $\rho$ = | | 1440 | $kg/m^3$ | | 800 | $kg/m^3$ | | 1440 | $kg/m^3$ |
| | Specific heat capacity, $c_p$ = | | 840 | J/kgK | | 1200 | J/kgK | | 840 | J/kgK |
| | Thermal inertia = | | 762 | $J/s^{1/2}m^2K$ | | 438 | $J/s^{1/2}m^2K$ | | 762 | $J/s^{1/2}m^2K$ |
| | Conversion factor, $k_b$ = | | 0.055 | | | 0.09 | | | 0.055 | |

Conversion factor from Table F.2 in Ref 1

**Table 1: Recommended values for $k_b$ (BS EN 1991-1-2:2002)**

| $\sqrt{\lambda \rho c_p}$ | $k_b$ |
|---|---|
| $J/s^{1/2}m^2K$ | $min/MJ/m^2$ |
| ≤ 720 | 0.09 |
| 720 to 2500 | 0.055 |
| ≥ 2500 | 0.04 |

| Calculations | | | Comments |
|---|---|---|---|
| Conversion factor, $k_b$ = | 0.07 | | |
| $t_e$ rounded to nearest | 1 | min | |
| Design fire load (mean) = | 285 | $MJ/m^2$ | |
| Equivalent time of fire exposure to the standard test, $t_e$ = | **27** | min | Mean fire load |
| Design fire load (80th percentile) = | 360.0 | $MJ/m^2$ | |
| Equivalent time of fire exposure to the standard test, $t_e$ = | **33** | min | 80th Percentile |
| Design fire load (95th percentile) = | 450.0 | $MJ/m^2$ | |
| Equivalent time of fire exposure to the standard test, $t_e$ = | **42** | min | 95th Percentile |

## C.2 CIB W14 Calculation Results: Block A – Level 01

| MCD FIRE ENGINEERING | Project: | | | |
|---|---|---|---|---|
| | Title: | CIB W14 Time Equivalence Method | | |
| | | | Date: | |
| | | | Page: | 1 |

| Ref | Calculations | Comments |
|---|---|---|
| | | Version 1.0 |
| Ref 1 | ***Time Equivalent Formula based on CIB W14*** | |

$$t_e = k_c\, w\, e_f$$

Where:

$$w = \frac{A_f}{\sqrt{A_v A_t \sqrt{H_v}}}$$

***Fire cell dimensions***

| | | |
|---|---|---|
| Width, $l_1$ = | 16.69 | m |
| Length, $l_2$ = | 29.00 | m |
| Ceiling height, H = | 2.7 | m |
| Wall area of fire cell, $A_w$ | 1214.7 | $m^2$ |
| Floor area of fire cell, $A_f$ = | 484.0 | $m^2$ |

***Vertical openings***

| ID | Width | Height | Multiple |
|---|---|---|---|
| SE | 1.2 | 2.7 | 6 |
| SW | 7.1 | 2.7 | 1 |
| NW | 8 | 2.7 | 1 |
| SW | 1.2 | 1.4 | 4 |
| 0 | 0 | 0 | 0 |

No horizontal openings are allowed for CIW W14 method.

| | | |
|---|---|---|
| Area of vertical openings, $A_v$ = | 66.93 | $m^2$ |
| % of vertical openings, $A_v/A_w$ = | 5.51% | |
| Weighted height of windows, $H_v$= | 2.6 | m |

| | | | |
|---|---|---|---|
| | Project: | | |
| | Title: | CIB W14 Time Equivalence Method | |
| | | | Date: |
| | | | Page: 2 |

| Ref | Calculations | | | Comments |
|---|---|---|---|---|
| | | | | Version 1.0 |
| Ref 2 | ***Fire Load*** | | | |
| | From Table 3.4.1a of IFEG | | | |
| | Type of occupancy = | School | | |
| | Mean fire load = | 285 | $MJ/m^2$ | |
| | Factor for 80th percentile FLED = | 1.263158 | | |
| | 80th percentile FLED, $e_f$ = | 360 | $MJ/m^2$ | |
| Ref 4 | Factor for 95th percentile FLED = | 1.578947 | | Table E.2 (Annex E) c |
| | 95th percentile FLED fire load, $e_f$ = | 450 | $MJ/m^2$ | |
| Ref 1 | Apply 61% FLED if sprinklers provided ? | No | | |
| | Ventilation factor, $w_f$ = | 1.3 | | |
| | ***Properties of lining material*** | | | |
| | Type of material | Gypsum plaster | | |
| | Thermal conductivity, $\lambda$ = | 0.48 | W/m/K | |
| | Density, $\rho$ = | 1440 | $kg/m^3$ | |
| Ref 3 | Specific heat capacity, $c_p$ = | 840 | J/kgK | |
| | Thermal inertia = | 762 | $J/s^{1/2}m^2K$ | |
| | Conversion factor from Table A2.2 in Ref 1 | | | |

**Table 1: Recommended values for $k_c$ (CIB W14)**

| $\sqrt{\lambda \rho c_p}$ | $k_b$ |
|---|---|
| $J/s^{1/2}m^2K$ | $min/MJ/m^{2.25}$ |
| ≤ 720 | 0.09 |
| 720 to 2500 | 0.07 |
| ≥ 2500 | 0.05 |

| | | | | |
|---|---|---|---|---|
| | Conversion factor, $k_b$ = | 0.07 | | |
| | $t_e$ rounded to nearest | 1 | min | |
| | Design fire load = | 285 | $MJ/m^2$ | Mean fire load |
| | Equivalent time of fire exposure to the standard test, $t_e$ = | **27** | min | |
| | Design fire load = | 360.0 | $MJ/m^2$ | 80th Percentile |
| | Equivalent time of fire exposure to the standard test, $t_e$ = | **34** | min | |
| | Design fire load = | 450.0 | $MJ/m^2$ | 95th Percentile |
| | Equivalent time of fire exposure to the standard test, $t_e$ = | **42** | min | |

## C.3 Law Method Calculation Results: Block A – Level 01

| | Project: | | | |
|---|---|---|---|---|
| | Title: | Law Time Equivalence Method | | |
| | | | Date: | |
| | | | Page: | 1 |

| Ref | Calculations | Comments |
|---|---|---|
| | | Version 1.0 |
| Ref 1 | ***Time Equivalent Formula based Law's Method*** | |
| | $$t_e = \frac{KA_f\ e_f}{\Delta H_c\ \sqrt{A_v\ (A_t - A_v)}}$$ | Formula from original Law's document. NOT from Buchanan's book. |

***Fire cell dimensions***

| | | |
|---|---|---|
| Width, $l_1$ = | 16.69 | m |
| Length, $l_2$ = | 29.00 | m |
| Ceiling height, H = | 2.7 | m |
| Wall area of fire cell, $A_w$ | 1214.7 | $m^2$ |
| Floor area of fire cell, $A_f$ = | 484.0 | $m^2$ |

***Vertical openings***

No horizontal openings are allowed for CIW W14 method.

| ID | Width | Height | Multiple |
|---|---|---|---|
| SE | 1.2 | 2.7 | 6 |
| SW | 7.1 | 2.7 | 1 |
| NW | 8 | 2.7 | 1 |
| SW | 1.2 | 1.4 | 4 |
| 0 | 0 | 0 | 0 |

| | | |
|---|---|---|
| Area of vertical openings, $A_v$ = | 66.93 | $m^2$ |
| % of vertical openings, $A_v/A_w$ = | 5.51% | |

| | | | | |
|---|---|---|---|---|
| Project: | | | | |
| Title: | Law Time Equivalence Method | | | |
| | | Date: | | |
| | | Page: | 2 | |

| Ref | Calculations | | | Comments |
|---|---|---|---|---|
| | ***Fire Load*** | | | Version 1.0 |
| Ref 2 | From Table 3.4.1a of IFEG | | | |
| | Type of occupancy = | School | | |
| | Mean fire load = | 285 | MJ/m$^2$ | |
| | Factor for 80th percentile FLED = | 1.263158 | | |
| | 80th percentile FLED, $e_f$ = | 360 | MJ/m$^2$ | |
| | Factor for 95th percentile FLED = | 1.578947 | | |
| Ref 4 | Factored fire load, $e_f$ = | 450 | MJ/m$^2$ | Table E.2 (Annex E) c |
| Ref 1 | Apply 61% FLED if sprinklers provided ? | No | | |
| Ref 1 | Ventilation factor, $w_f$ = | 1.7 | | ** See Ref 1* |
| Ref 3 | Empirical coefficient*, K | 0.95 | min·m$^2$/kg | for detials. |
| | ***Properties of lining material*** | | | |
| | Type of material | Gypsum plaster | | |
| | Thermal conductivity, $\lambda$ = | 0.48 | W/m/K | |
| | Density, $\rho$ = | 1440 | kg/m$^3$ | |
| | Specific heat capacity, $c_p$ = | 840 | J/kgK | |
| | Thermal inertia = | 762 | J/s$^{1/2}$m$^2$K | |
| | Heat of combution from Table E.3 of BS EN 1991-1-2:2002 | | | |

**Table 1: Recommended values for Heat of Combusion (BS EN 1991-1-2:2002)**

| Materials* | $k_b$ min/MJ/m$^2$ |
|---|---|
| Wood | 17.5 |
| Other cellulosic materials | 20 |
| Carbon | 30 |
| Chemicals | 30-50 |
| Plastic | 20-35 |
| Leather | 20 |
| Rubber tyre | 30 |

** See Table 3-4.14* from SFPE Handbook (3rd Edition) for more data.

| | | | |
|---|---|---|---|
| Heat of combustion, delta Hc = | 23.0 | MJ/kg | |
| $t_e$ rounded to nearest | 1 | min | |
| Design fire load = | 285 | MJ/m$^2$ | Mean fire load |
| Equivalent time of fire exposure to the standard test, $t_e$ = | **21** | min | |
| Design fire load = | 360.0 | MJ/m$^2$ | 80th Percentile |
| Equivalent time of fire exposure to the standard test, $t_e$ = | **26** | min | |
| Design fire load = | 450.0 | MJ/m$^2$ | 95th Percentile |
| Equivalent time of fire exposure to the standard test, $t_e$ = | **33** | min | |

# Appendix D AWTA Test Report (AS 1530.2) for ProctorWarp Residential Wall (RW)

# AWTA PRODUCT TESTING

Australian Wool Testing Authority Ltd - trading as AWTA Product Testing
A.B.N 43 006 014 106
**1st Floor, 191 Racecourse Road, Flemington, Victoria 3031**
**P.O Box 240, North Melbourne, Victoria 3051**
**Phone (03) 9371 2400 Fax (03) 9371 2499**

# TEST REPORT

**Client :** Dynamic Composite Technologies Pty Ltd
Unit 8, 171-175 Newton Road
Wetherill Park NSW 2164

**Test Number** : 16-001226
**Issue Date** : 22/03/2016
**Print Date** : 23/03/2016

**Sample Description**

Clients Ref : "ProctorWarp Residential Wall (RW)"
Tear resistant 3 Ply spun bonded polyolefin membrane
Colour : Grey
End Use : Wall Wrap
Nominal Composition : Spunbond, Film, Spunbond Polyolefin Membrane
Nominal Mass per Unit Area/Density : 95g/m2
Nominal Thickness : 0.4mm

**AS 1530.2-1993**

**Methods for Fire Tests on Buildng Materials, Components and Structures.**
**Part 2: Test for Flammability of Materials**

| | | | |
|---|---|---|---|
| Date Tested | | 22/03/2016 | |
| Flammability Index | | 2 | |
| | Length | Width | |
| Spread Factor | 0 | 1 | |
| Heat Factor | 1 | 1 | |
| Maximum height (d) | | | |
| Mean | 3.2 | 3.4 | |
| Coefficient of Variation | 24.7 | 24.2 | % |
| Heat (a) | | | |
| Mean | 3.6 | 3.6 | °C.min |
| Coefficient of Variation | 23.6 | 26.4 | % |
| Number of Specimens Tested | 9 | 9 | |

Observation: Visible smoke and melting of specimens

53070 10861





NATA

Accredited for compliance with ISO/IEC 17025
- Chemical Testing : Accreditation No. 983
- Mechanical Testing : Accreditation No. 985
- Performance & Approvals Testing : Accreditation No. 1356

AWTA LIMITED



APPROVED SIGNATORY

MICHAEL A. JACKSON B.Sc.(Hons)
MANAGING DIRECTOR

0204/11/06

Australian Wool Testing Authority Ltd - trading as AWTA Product Testing
A.B.N 43 006 014 106
**1st Floor, 191 Racecourse Road, Flemington, Victoria 3031**
**P.O Box 240, North Melbourne, Victoria 3051**
**Phone (03) 9371 2400 Fax (03) 9371 2499**

# TEST REPORT

**Client :** Dynamic Composite Technologies Pty Ltd
Unit 8, 171-175 Newton Road
Wetherill Park NSW 2164

**Test Number** : 16-001226
**Issue Date** : 22/03/2016
**Print Date** : 23/03/2016

These test results relate only to the behaviour of the test specimens of the material under the particular conditions of the test, and they are not intended to be the sole criterion for assessing the potential fire hazard of the material in use.





Accredited for compliance with ISO/IEC 17025
- Chemical Testing : Accreditation No. 983
- Mechanical Testing : Accreditation No. 985
- Performance & Approvals Testing : Accreditation No. 1356



APPROVED SIGNATORY

MICHAEL A. JACKSON B.Sc.(Hons)
MANAGING DIRECTOR

0204/11/06

# Appendix E CSR Letter regarding EC08 Linings in lieu of Fyrchek Linings

CSR Lightweight Systems

Locked Bag 26, Wetherill Park, NSW 2164 Australia
T 1800 621 117
www.csr.com.au
ABN 55 008 631 356

DESIGNLINK

24th April 2020

Hi Jake

Just a short email to confirm our recent telephone conversation that your customer MBS is most welcome to use the below nominated CSR Gyprock fire rated linings of equivalent thickness in lieu of CSR Gyprock Fyrchek or FyrchekMR.

Our EC08 range of linings are also supported by their own dedicated fire reports that support their use in lieu of Fyrchek and FyrchekMR as listed below.

- Gyprock Impactchek
- Gyprock EC08 Impact EWFA 24040
- Gyprock EC08 Impact MR EWFA 24040
- Gyprock EC08 Complete EWFA 27358

In consideration of the above, the substitution and use of the nominated alternative linings will not adversely affect our Red Book quoted system FRL's.

Please however ensure that a moisture resistant fire lining solution is selected for external or high humidity applications and that external applications are suitably clad or flashed over to achieve protection from the weather.

Please also find below an excerpt from our Exova Warringtonfire report that formally supports the substitution of CSR Fyrchek fire linings with CSR EC08 Impact and Impact MR.

## 5 FORMAL ASSESSMENT SUMMARY

Based on the discussion presented in this report, it is the opinion of this testing authority that if the tested prototype described in Section 2 had been modified within the scope of Section 3, the fire resistance performance of various walls and ceiling systems otherwise tested or assessed would not be detrimentally affected by replacing CSR Fyrchek with CSR EC08 Impact and EC08 ImpactMR Plasterboard if tested in accordance with the test method referenced in Section 4 and subject to the requirements of Section 7.

Exova Warringtonfire



Kind Regards

Rex Farr
CSR DesignLINK
Technical Officer

CSR

# Appendix F References

Abbreviation in square brackets is how item is referred to throughout this report.

## F.1 Australian Legislation and Referenced Documents

| | |
|---|---|
| [BCA] | National Construction Code Series Volume 1: Class 2 to 9 buildings – Building Code of Australia 2016 (Amendment 1), Australian Building Codes Board. National Construction Code Series Volume 1 Appendices: Variations and Additions – Building Code of Australia 2016 (Amendment 1) Australian Building Codes Board. |
| [EP&A Act] | NSW Environmental Planning and Assessment Act 1979. |
| [EP&A Regs] | NSW Environmental Planning and Assessment Regulation 2000 and subsequent amendments. |

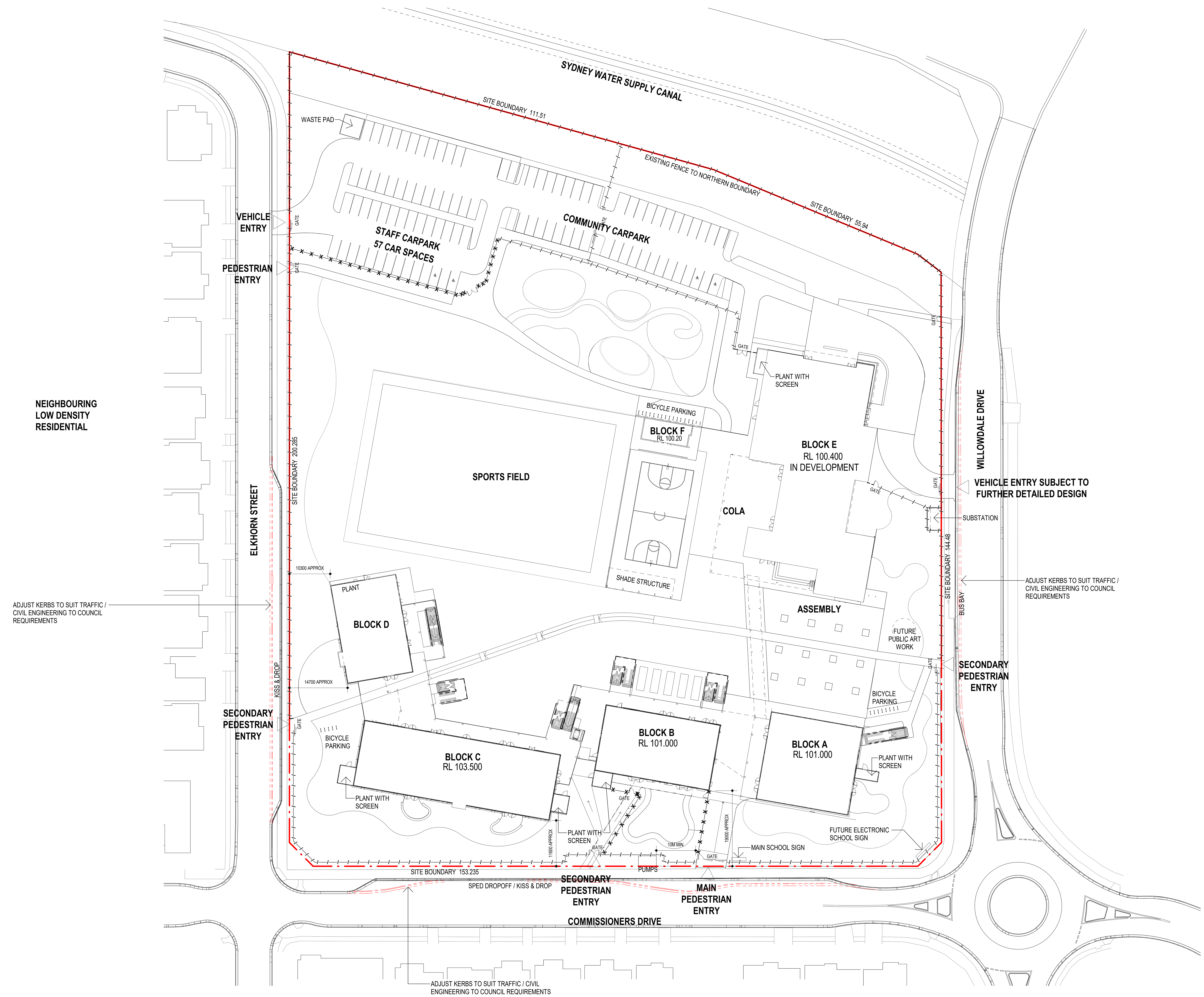
## F.2 Texts and Guidance Documents

| | |
|---|---|
| [BCA Guide] | Guide to the Building Code of Australia, Australian Building Codes Board, 2016 (Amendment 1). |
| [IFEG] | International Fire Engineering Guidelines, Australian Building Code Board, 2005. |

## F.3 Australian Standards

| | |
|---|---|
| [AS 1668.1] | AS 1668 Part 1, 2015, Amdt 1, The use of mechanical ventilation and air-conditioning in buildings – Fire and smoke control in multi-compartment buildings. |
| [AS 1670.1] | AS 1670 Part 1, 2015, Fire detection, warning, control and intercom systems — System design, installation and commissioning — Fire. |
| [AS 1670.4] | AS 1670 Part 4, 2015, Fire detection warning, control and intercom systems – Sound systems and intercom systems for emergency purposes. |
| [AS 1851] | AS 1851, 2012, Routine Service of Fire Protection Systems and Equipment. |
| [AS/ANS 2293.1] | AS/ANS 2293 Part 1, 2005, Emergency escape lighting and exit signs for buildings – System design, installation and operation. |
| [AS 2293.2] | AS 2293 Part 2, 2005, Emergency escape lighting and exit signs for buildings – Inspection and maintenance. |
| [AS 2419.1] | AS 2419 Part 1, 2005, Fire hydrant installations – System design, installation and commissioning. |
| [AS 2441] | AS 2441, 2005, Installation of fire hose reels, Amdt 1. |
| [AS 2444] | AS 2444, 2001, Portable fire extinguishers and fire blankets — Selection and location. |

# Appendix G Referenced Drawings

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| | MN/HS | | AMENDMENTS TO SUIT EFSG COMMENTS |
| E | MN/HS | 20.11.19 | RE-ISSUE FOR SCHEMATIC EFSG REVIEW |
| F | RO | 29.11.19 | ISSUE FOR INFORMATION |
| G | HS | 04.12.19 | ISSUE FOR 75% DESIGN DOCUMENTATION |
| H | RO | 21.01.20 | ISSUE FOR CO-ORDINATION |
| I | RO | 30.01.20 | ISSUE FOR DETAILED DESIGN |
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NEW HIGH QUALITY CLASSROOMS PACKAGE 2

DRAWING NAME

## OVERALL SITE PLAN

PROJECT NORTH

NORTH

0 5000 10000 15000 20000 25000 50000

SCALE 1 : 500 @ A1

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|---|---|---|---|
| PPA | KLC | SR | 23 MARCH 2020 |

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|---|---|---|---|---|---|
| NHQC2 | LP | AR | DWG | 00_S002 | J |


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| | JK | 20.11.19 | STAIRS AMENDED |
| | MN/HS | | AMENDMENTS TO SUIT EFSG COMMENTS |
| H | MN/HS | 20.11.19 | RE-ISSUE FOR SCHEMATIC EFSG REVIEW |
| I | RO | 29.11.19 | ISSUE FOR INFORMATION |
| J | HS | 04.12.19 | ISSUE FOR 75% DESIGN DOCUMENTATION |
| K | RO | 21.01.20 | ISSUE FOR CO-ORDINATION |
| L | RO | 30.01.20 | ISSUE FOR DETAILED DESIGN |
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PROJECT NORTH

NORTH

0 2000 4000 6000 8000 10000 20000

SCALE 1 : 200 @ A1

| DRAWN | CHECKED | VERIFIED | DATE |
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| NHQC2 | LP | AR | DWG | 00_S011 | M |


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| | MN/HS | | AMENDMENTS TO SUIT EFSG COMMENTS |
| E | MN/HS | 20.11.19 | RE-ISSUE FOR SCHEMATIC EFSG REVIEW |
| F | RO | 29.11.19 | ISSUE FOR INFORMATION |
| G | HS | 04.12.19 | ISSUE FOR 75% DESIGN DOCUMENTATION |
| H | RO | 21.01.20 | ISSUE FOR CO-ORDINATION |
| I | RO | 30.01.20 | ISSUE FOR DETAILED DESIGN |
| J | PPA | 23.03.20 | REISSUE FOR DETAIL DESIGN |

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## COMPOSITE FLOOR PLAN - LEVEL 00 BLOCK E

PROJECT NORTH

NORTH

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| NHQC2 | LP | AR | DWG | 00_S012 | J |

NHQC2 - LP - AR - DWG - 00_S012


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| | MN/HS | | AMENDMENTS TO SUIT EFSG COMMENTS |
| H | MN/HS | 20.11.19 | RE-ISSUE FOR SCHEMATIC EFSG REVIEW |
| I | RO | 29.11.19 | ISSUE FOR INFORMATION |
| J | HS | 04.12.19 | ISSUE FOR 75% DESIGN DOCUMENTATION |
| K | RO | 21.01.20 | ISSUE FOR CO-ORDINATION |
| L | RO | 30.01.20 | ISSUE FOR DETAILED DESIGN |
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## COMPOSITE FLOOR PLAN - LEVEL 01 BLK A&B, LEVEL 00 BLK C&D

PROJECT NORTH

NORTH

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SCALE 1 : 200 @ A1

| DRAWN | CHECKED | VERIFIED | DATE |
|---|---|---|---|
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| | JK | 20.11.19 | STAIRS AMENDED |
| | MN/HS | | AMENDMENTS TO SUIT EFSG COMMENTS |
| H | MN/HS | 20.11.19 | RE-ISSUE FOR SCHEMATIC EFSG REVIEW |
| I | RO | 29.11.19 | ISSUE FOR INFORMATION |
| J | HS | 04.12.19 | ISSUE FOR 75% DESIGN DOCUMENTATION |
| K | RO | 21.01.20 | ISSUE FOR CO-ORDINATION |
| L | RO | 30.01.20 | ISSUE FOR DETAILED DESIGN |
| M | PPA | 23.03.20 | REISSUE FOR DETAIL DESIGN |

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DRAWING NAME

## COMPOSITE FLOOR PLAN - LEVEL 02 BLK A&B, LEVEL 01 BLK C&D

PROJECT NORTH

NORTH

0 2000 4000 6000 8000 10000 20000
SCALE 1 : 200 @ A1

| DRAWN | CHECKED | VERIFIED | DATE |
|---|---|---|---|
| PPA | KLC | SR | 23 MARCH 2020 |

DRAWING NUMBER

PROJECT CODE SCH. REF. DISC. TYPE SERIES#

NHQC2 - LP - AR - DWG - 00_S014

REVISION

M


23/03/2020 9:47:15 AM

DETAIL DESIGN

AMMENDMENTS

| REV | BY | DATE | DESCRIPTION |
|---|---|---|---|
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| | JK | 20.11.19 | ROOF & STAIRS AMENDED |
| | MN/HS | | AMENDMENTS TO SUIT EFSG COMMENTS |
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| J | HS | 04.12.19 | ISSUE FOR 75% DESIGN DOCUMENTATION |
| K | RO | 21.01.20 | ISSUE FOR CO-ORDINATION |
| L | RO | 30.01.20 | ISSUE FOR DETAILED DESIGN |
| M | PPA | 23.03.20 | REISSUE FOR DETAIL DESIGN |

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DRAWING NAME
COMPOSITE FLOOR PLAN - LEVEL 02 BLOCK C

PROJECT NORTH

0 2000 4000 6000 8000 10000 20000
SCALE 1 : 200 @ A1

| DRAWN | CHECKED | VERIFIED | DATE |
|---|---|---|---|
| PPA | KLC | SR | 23 MARCH 2020 |

DRAWING NUMBER

| PROJECT CODE | SCH. REF. | DISC. | TYPE | SERIES# | REVISION |
|---|---|---|---|---|---|
| NHQC2 | LP | AR | DWG | 00_S015 | M |

HANSENYUNCKEN

# **Appendix 2** – CSR Cemintel – Barstone - CodeMark & Surround CodeMark

# Certificate of Conformity

**Certification Body:**

SAI GLOBAL

SAI Global Certification Services Pty Limited

(ACN 108 716 669) Trading as "SAI Global"

JAS-ANZ Accreditation No. Z1440295AS

Address: 680 George St, Sydney, NSW 2000

Website: www.saiglobal.com

**Certificate Holder:**

CSR Building Products Limited
(Trading as CSR Cemintel)
Triniti 3, 39 Delhi Road,
North Ryde, NSW, 2113, Australia
Phone: 1800 633 826
Website: https://www.csr.com.au/About-Us/Contact-Us

**Certificate number: CM20198**

THIS TO CERTIFY THAT

## CEMINTEL® BARESTONE Walling System

**Type and/or use of product:**

CEMINTEL® Barestone is an external walling system for residential and commercial buildings. Suitable for use on all building classes where metal top hats can be fixed either to steel stud framing, timber stud framing, or to masonry and concrete substrates.

For Class 2 to Class 9 buildings, CEMINTEL® Barestone walling system is suitable for only Type C Fire-Resisting Construction when fixed to timber stud framing.

CEMINTEL® Barestone panels are also used as internal wall lining.

**Description of product:**

CEMINTEL® Barestone panels are prefinished, square edged, compressed fibre cement panels trimmed and sealed in a standard 1200mm x 2400mm x 9mm or 1200mm x 3000mm x 9mm size. The panels are available in a range of colours featuring a sanded textured finish.

The wall system components & accessories are detailed in the Cemintel Design and Installation Guide – Barestone Series – External Installation dated 03/2020 and for internal applications Internal Design and Installation Guide dated 03/2020.

COMPLIES WITH THE FOLLOWING BCA PROVISIONS AND STATE OR TERRITORY VARIATION(S) **BCA 2019**

| | Volume One | | Volume Two | |
|---|---|---|---|---|
| **Performance Requirement(s)** | **BP1.1(a) limited to (b)(i)(ii) & (iii)** | **Structural reliability** | **P2.1.1(a) limited to (b)(i), (ii), & (iii)** | **Structural stability and resistance** |
| | **FP1.4** | **Weatherproofing** | **P2.2.2** | **Weatherproofing** |
| **Deemed-to-Satisfy Provision(s):** | **C1.1(b) & Spec C1.1 Clause 3** | **Fire Resistance –** Type A Fire-Resisting Construction (120/120/120, or -/180/180 when used in a system with Fyrchek MR | **3.7.1.1(d)** | **General concession — non-combustible materials** |
| | | | **3.7.2.4(b)(i)** | **Fire separation of external walls – Construction of external walls (FRL 60/60/60)** |

SAI Global Certification Services

Heather Mahon
Global Head of Technical Services
SAI Global Assurance

Quintin Kleyn – Unrestricted Building Certifier

**Date of issue: 17 March 2020**

**Date of expiry: 16 March 2023**

| | | | | |
|---|---|---|---|---|
| | | plasterboard, refer to the Design and Installation Guide) | **3.10.5.0(c)** | **Construction in bushfire prone areas** |
| | **C1.9(e)(iv)** | **General concession — Materials deemed to be non-combustible** | | |
| | **C1.10(a)(ii) & Spec C1.10 Clause 4** | **Fire hazard properties – Wall and ceiling linings** | | |
| | **G5.1 & G5.2** | **Construction in bushfire prone areas – (**up to and including BAL 40) | | |
| **State or territory variation(s):** | **NSW G5.2** | **Construction in Bushfire Prone Areas –** Protection. | **NSW 3.10.5.0** | **Construction in bushfire prone areas** |
| | **QLD G5.1** | **Construction in Bushfire Prone Areas –** Construction Requirements | **QLD 3.10.5.0** | **Construction in bushfire prone areas** |

**SUBJECT TO THE FOLLOWING LIMITATIONS AND CONDITIONS AND THE PRODUCT TECHNICAL DATA IN APPENDIX A AND EVALUATION STATEMENTS IN APPENDIX B**

**Limitations and conditions:**

1. Barestone Walling System with Fyrchek MR Plasterboard can be used where the required Fire Resistance Levels (FRLs) does not exceed 120/120/120, or -/180/180 as specified in the NCC 2019 BCA Volume One specification C1.1. The installation must be in accordance with the relevant details contained within the System Engineering section of Cemintel Design and Installation Guide – Barestone Series – External Installation dated 03/2020 for system No. CSR5874 (FRL 120/120/120) and system No. CSR5349 (120/120/120, or -/180/180)
2. For Class 2 to Class 9 buildings, CEMINTEL® Barestone walling system is suitable for only Type C Fire-Resisting Construction when fixed to timber stud framing.
3. For type C Fire-Resisting Construction, Barestone Walling System has not been assessed against the requirements of Specification C1.1 Clause 5.1(c) of a fire wall or an internal wall bounding a sole-occupancy unit or separating adjoining units.
4. Barestone Walling System achieves a Group Number 1 and Smoke Growth Rate Index ($SMOGRA_{RC}$ 0.2 $m^2s^2$x1000) as determined in accordance with AS 5637.1:2015
5. The following were the only wall wraps assessed against the requirements of C1.9(e)(vi) for sarking-type material:
    a) Bradford Thermoseal™ Wall Wrap
    b) Enviroseal ProctorWrap Commercial Wall (CW)
    c) Enviroseal ProctorWrap Residential Wall (RW)

**Building classification/s:**

Volume 1 – Class 2 to Class 9 buildings

Volume 2 – Class 1 and Class 10(a) buildings

6. The following were the only insulations assessed against the requirements of C1.9(a) for non-combustible building elements:
    a) 75 Gold Batts R1.5 at 8.76kg/$m^3$ density
    b) 75 Gold Batts R2.0 at 6.3kg/$m^3$ density
    c) 90 Gold Batts R2.0 at 10.5kg/$m^3$ density
    d) 90 Gold Batts R2.5 at 21.2kg/$m^3$ density
    e) 75 Acoustigard R1.7 at 11.0kg/$m^3$ density
    f) 90 Acoustigard R2.2 at 14.0kg/$m^3$ density
    g) 90 Acoustigard R2.5 at 20.0kg/$m^3$ density
7. Barestone Walling System shall be used for its intended purpose. For further information on limited applications of the product, refer to Cemintel Design and Installation Guide – Barestone Series as relevant:
    a) External Installation dated 03/2020
    b) Internal Installation dated 03/2020
8. Barestone Walling System has been tested for weatherproofing requirements and achieved serviceability limit state wind pressures up to ±2.5kPa water penetration for the cavity system using Cemintel rigid air barrier (typically 6mm thick fibre cement sheet). Construction details and fixing must follow the relevant details contained within the System Engineering section of Cemintel Design and Installation Guide – Barestone Series – External Installation dated 03/2020.
9. Barestone Walling System has been evaluated for use in all Australian wind zones up to and including N6 and Cyclonic C4 in accordance with AS 4055 and for ultimate wind pressures up to 7.0 kPa under AS 1170.2 including cyclonic zones when fixed to steel framing with Cemintel Rigid Air Barrier.
10. The Barestone Walling System is not certified for either energy efficiency or acoustic performance.
11. Site environmental factors such as wind and corrosivity zones need to be considered to determine its suitability for a particular environment.
12. Barestone Walling System is suitable for use on buildings constructed in accordance with AS 3959:2018 that are have a Bushfire Fire Attack Level up to and including BAL 40
13. All flashing including inter-storey junction must be metal flashing.

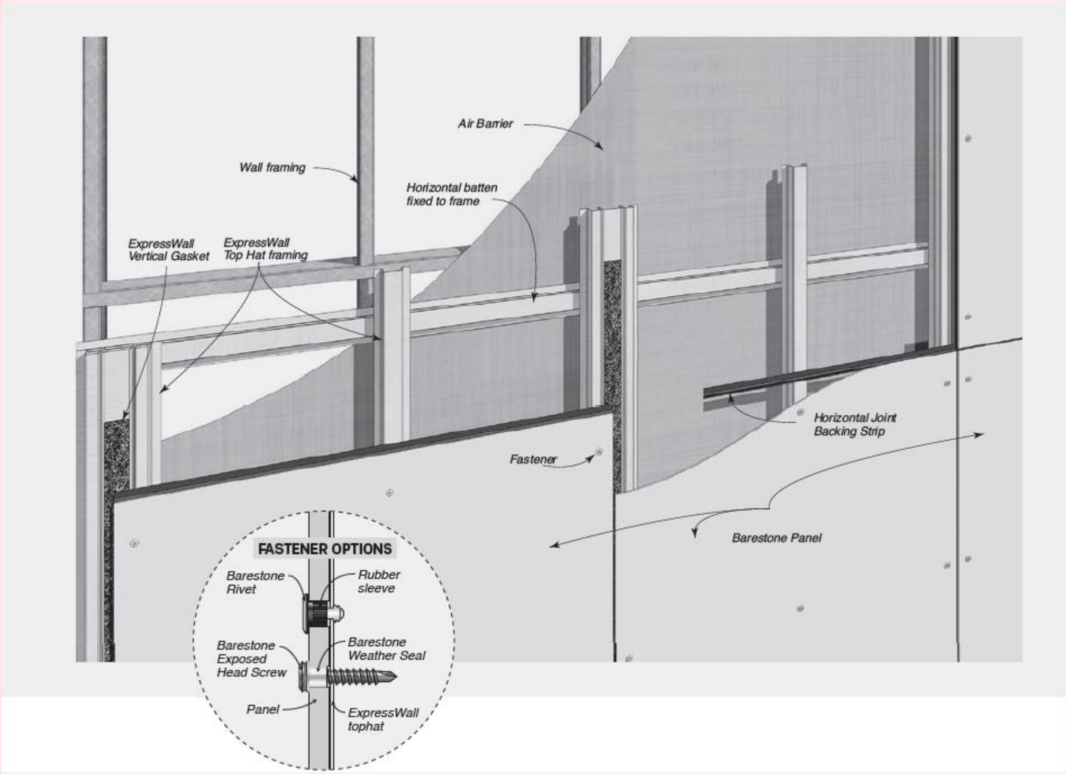
## APPENDIX A – PRODUCT TECHNICAL DATA

**A1 Type and intended use of product**

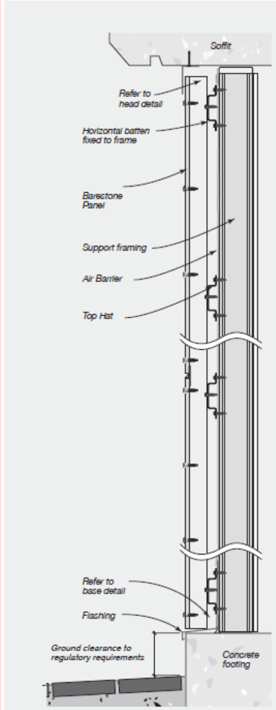
Refer to Page 1 of this certificate.

**A2 Description of product**

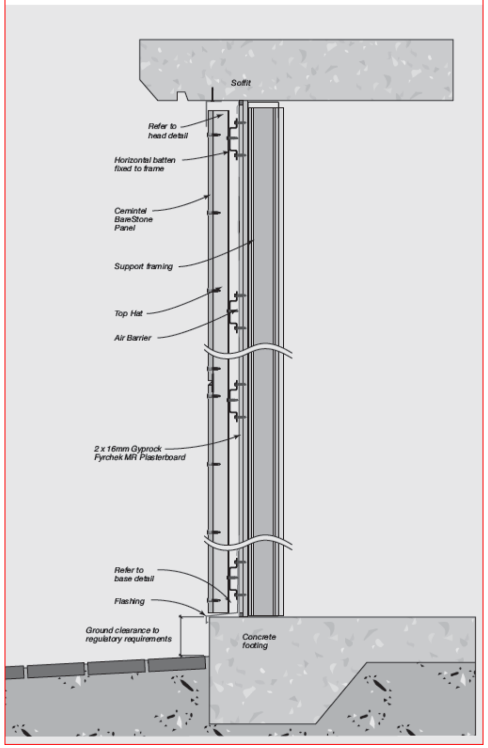
Refer to Page 1 of this certificate and the below diagrams.




Typical Barestone System Cross Section for Steel Framing




Typical Barestone External Fire Rated Installation.
Pressure Equalised Ventilated Cavity System



**A3 Product specification**

Below are some physical properties of fibre cement and system specifications

**Product Specifications**

| Property | Specification | Manufacturing Tolerance | Relevant Standard |
|---|---|---|---|
| Panel Width | 1200mm | + 0 / - 2.0mm | AS 2908.2 |
| Panel Length | 2400 and 3000mm | + 0 / - 2.0mm | AS 2908.2 |
| Panel Thickness | 9mm | + 0.45 / - 0mm | AS 2908.2 |
| Panel Weight (EMC) | 17.8kg/m² | | AS 2908.2 |

**System Solutions**

| | | |
|---|---|---|
| Fire Resistance Level (FRL) | Up to 120/120/120, -/180/180 when used in a system with Gyprock fire grade plasterboard | Refer to System Engineering section or the "The Red Book™ |
| Bushfire Construction | BAL 40 (Construction for Bushfire Attack Level 40 for an external wall) | AS 3959 – 8 |
| Weatherproofing | Suitable for a serviceability wind pressure of +2.50 kPa when installed as a pressure equalised system. | AS 4284 |
| Wind actions (including Cyclonic) | Suitable for ultimate wind loads up to 7.0 kPa with Cemintel Rigid Air Barrier, including cyclonic conditions, and up to 2.5 kPa with Enviroseal ProctorWrap CW-IT | AS 4040.3 |

**A4 Manufacturer and manufacturing plant(s)**

**A5 Installation requirements**

Refer to Page 3 of this certificate and the following:

1. Cemintel Design and Installation Guide – Barestone Series – External Installation dated 03/2020
2. Cemintel Design and Installation Guide – Barestone Series – Internal Installation dated 03/2020

**A6 Other relevant technical data**

- Technical Datasheets for Bradford Thermoseal™ Wall Wrap, Enviroseal ProctorWrap (CW) Wall Wrap, and Enviroseal ProctorWrap (RW) Wall Wrap with nominal thickness <1.0mm for all three products.
- Technical Datasheet for Bradford Acoustigard partition rolls

## APPENDIX B – EVALUATION STATEMENTS

**B1 Evaluation methods**

The system has been assessed as complying with the identified Performance Requirements of the NCC 2019 BCA Volumes 1 and 2. This involved a review of product specifications, test reports, installation manuals, and associated documentation.

1. **Structural assessment:**
   - Volumes 1 & 2 – A2.2(2) / A5.2(1)(d) & (e) – A report issued by an Accredited testing Laboratory – Cyclone Testing Station, James Cook University (NATA accreditation No. 14937) and a report from a professional engineer

2. **Weatherproofing assessment:**
   - Volumes 1 & 2 – A2.2(2) / A5.2(1)(d) & (e) – A report issued by an Accredited testing Laboratory – Ian Bennie and Associates (NATA accreditation No. 2371) and a report from an appropriately qualified person

3. **Fire Resistance assessment:**
   - Volumes 1 & 2 – A2.3(2) / A5.2(1)(d) – An assessment report issued by an Accredited testing Laboratory – BRANZ Ltd (IANZ accreditation No. 37)

4. **Non-Combustibility (General Concessions):**

   **A. Sarking-type material**
   - Volumes 1 & 2 – A2.3(2) / A5.2(1)(d) – A report issued by an Accredited testing Laboratory – Insulation Research Laboratory (NATA accreditation No. 993)
   - Volumes 1 & 2 – A2.3(2) / A5.2(1)(d) – A report issued by an Accredited testing Laboratory – AWTA Product Testing (NATA accreditation No. 1356)

   **B. Insulation material**
   - Volumes 1 & 2 – A2.3(2) / A5.2(1)(e) – An assessment report from an appropriately qualified person – CSIRO
   - Volumes 1 & 2 – A2.2(2) / A5.2(1)(d) – A report issued by an Accredited testing Laboratory – Insulation Research Laboratory (NATA accreditation No. 993)

5. **Fire Hazard Properties assessment:**
   - Volume 1 – A2.3(2) / A5.2(1)(e) – An assessment report from an appropriately qualified person – Warrington Australia Pty Ltd
   - Volume 1 – A2.3(2) / A5.2(1)(d) – A report issued by an Accredited testing Laboratory – Insulation Research Laboratory (NATA accreditation No. 993)
   - Volume 1 – A2.3(2) / A5.2(1)(d) – A report issued by an Accredited testing Laboratory – AWTA Product Testing (NATA accreditation No. 1356)

6. **Resistance to Bushfire Attack assessment:**
   - Volumes 1 & 2 – A2.3(2) / A5.2(1)(f) – Another form of documentary evidence (assessment against specifications in referenced document – AS 3959:2018)

**B2 Reports**

| Evaluation methods | Related Supporting Evidence as listed below |
|---|---|
| Structural Assessment | Numbers 1, 2, 3, 4, & 5 |
| Weatherproofing Assessment | Numbers 6 & 7 |
| Fire Resistance assessment | Numbers 8 & 9 |
| Non-Combustibility (General Concession) | Numbers 10, 11, 12, 13, & 14 |
| Fire Hazard Properties assessment | Numbers 10, 11, 12, & 15 |
| Resistance to Bushfire Construction assessment | Number 16 |

**Structure**

1. **Test Report from a NATA accredited testing laboratory (Accreditation No: 14937) for Connection Testing Cyclic Simulated Wind Load Strength Testing and Assessment of the Cyclic Wind Load Capacity of CSR Cemintel Creative Façade System from James Cook University, Report No. TS1055 Revision A (dated: 26 April 2017)**
   *This document contains the test results of a Cemintel Creative Façade (8mm & 9mm nominal thickness) sample for resistance to simulated cyclic wind load, carried out in accordance with AS 4040.3.*
2. **Test Report from a NATA accredited testing laboratory (Accreditation No: 14937) for Assessment of the Cyclonic Wind Load Capacity of CSR ExpressWall Façade System from James Cook University, Report No. TS584 (dated 4 August 2003)**
   *This document contains the test results of a Cemintel Creative Façade (9mm nominal thickness) sample for resistance to simulated cyclic wind load, carried out in accordance with AS 4040.3. Reappraisal Test Report Summary from a NATA accredited testing laboratory (Accreditation No: 14937) for Assessment of the Cyclonic Wind Load Capacity of CSR Express Wall Façade System from James Cook University, Report No. TS584 (dated 31 December 2016). This document contains the re appraisal test results of a CSR ExpressWall Façade (9mm nominal thickness) sample for resistance to simulated cyclic wind load, carried out in accordance with AS 4040.3.*
3. **Certification of CSR ExpressWall Façade System by David Beneke Consulting, Report 2013-28-LO-1001 Revision 9 (dated 28 June 2019)**
   *This document certifies the maximum top hat spans and spacings of ExpressWall façade system (with either ExpressWall panels or Barestone pre-coated panels) in accordance with normal engineering practice and principals, test methods and the relevant Australian Standards.*
4. **Durability opinion of CSR ExpressWall Metal Components from Branz, Report No. DZ0073 (dated 20 September 2004)**
   *This document contains the opinion of the likely resistance of the ExpressWall system components in relation to durability and Category 4 (Severe Marine) or less, for a minimum service life of 15 years.*

5. **Test Report for Simulated Wind Load Component Testing of Screws used in CSR ExpressWall Façade System from James Cook University, Report No. TS923 (dated 9 October 2013)**
   *This report provides an assessment for the capacity of the screw connections used in the CSR ExpressWall Façade system by undertaking cyclic pull-out load testing on the exposed head screw connections between the fibre cement cladding and the supporting battens.*

**Weatherproofing**

6. **Test Report for Air Infiltration, Water Penetration and Structural ULS of Cemintel Creative Façade System, Report No. 2016-108-S1 (dated 24 February 2017 amended 28 March 2017)**
   *This document contains the test results of the Cemintel Creative Façade System for Water Penetration, carried out in accordance with AS 4284:2008.*
7. **Report from AECOM consultancy advice pertaining to the Cemintel Creative Facade System (for various rain screen materials including Barestone) (dated 07 June 2019).**
   *This advice confirms the compliance of this product with AS 4284:2008, based on the test results of Report No. 2016-108-S1, by Ian Bennie and Associates.*

**Fire Resistance**

8. **Test Report for Fire Resistance of CSR Steel Framed Wall Systems from Branz, Report No. FAR 2357 Issue 12 (dated: 06 July 2017)**
   *This document contains the test results of the CSR steel framed system for resistance to fire, carried out in accordance with AS 1530.4:2014.*
9. **Test Report for Fire Resistance of CSR Timber Framed Walls from Branz, Report No. FAR 2303 Issue 3 (dated: 24 December 2015)**
   *This document contains the test results of the CSR timber framed system for resistance to fire, carried out in accordance with AS 1530.4:1997.*

**Non-Combustibility (General Concession)**

A. **Sarking-type material**

10. **Test Report for Flammability Index of Bradford Thermoseal™ Wall Wrap from Insulation Research Laboratory, Report No. NR-17201 (dated: 1 May 2017)**
    *The report provides the results to testing to AS1530.2:1993 and returns a result of Flammability index 1 for the Bradford Thermoseal wall wrap.*
11. **Test Report for Flammability Index of Enviroseal ProctorWrap (CW) Wall Wrap from AWTA, test No. 16-006359 (dated: 12 December 2016)**
    *The report provides the results to testing of Proctorwrap commercial wall (CW) for AS1530.2:1993 and returns a result of flammability index of 1.*
12. **Test Report for Flammability Index of Enviroseal ProctorWrap (RW) Wall Wrap from AWTA, test No. 17-000553 (dated: 17 February 2017)**
    *The report provides the results to testing of Proctorwrap residential wall (RW) for AS1530.2:1993 and returns a result of flammability index of 1.*

**B. Insulation**

13. **Assessment Report for combustibility of Bradford Glasswool insulation batts from CSIRO, Report No. FCO-2812a (dated: 19 November 2015)**
    *This document provides an assessment of Bradford Glasswool insulation batts and were not deemed combustible when tested to the requirements of AS 1530.1:1994.*
14. **Test Report for combustibility of Bradford Acoustigard from Insulation Research Laboratory, Report No. NR-17002 (dated: 22 March 2017)**
    *This report contains the results of Bradford Acoustigard insulation batts carried out in accordance with AS 1530.1:1994 and were not deemed combustible.*

**Fire Hazard Properties**

10. **Test Report for Flammability Index of Bradford Thermoseal™ Wall Wrap from Insulation Research Laboratory, Report No. NR-17201 (dated: 1 May 2017)**
    *The report provides the results to testing to AS1530.2:1993 and returns a result of Flammability index 1 for the Bradford Thermoseal wall wrap.*
11. **Test Report for Flammability Index of Enviroseal ProctorWrap (CW) Wall Wrap from AWTA, test No. 16-006359 (dated: 12 December 2016)**
    *The report provides the results to testing of Proctorwrap commercial wall (CW) for AS1530.2:1993 and returns a result of flammability index of 1.*
12. **Test Report for Flammability Index of Enviroseal ProctorWrap (RW) Wall Wrap from AWTA, test No. 17-000553 (dated: 17 February 2017)**
    *The report provides the results to testing of Proctorwrap residential wall (RW) for AS1530.2:1993 and returns a result of flammability index of 1.*
15. **Assessment Report for Group Number and Smoke Growth Rate Index (SMOGRARC) from Exova Warrington, Report No. 45759 Revision 10.1 (dated 15 November 2019)**
    *This report shows the assessment undertaken to determine the likely fire hazard properties of the CSR wall and ceiling lining products if tested in accordance with AS ISO 9705:2003 (R2016) and AS5637.1:2015*

**Resistance to Bushfire Attack**

16. **Cemintel® Construction Guide for Bushire Areas (dated October 2019)**
    *This guide provides information on Cemintel® wall cladding products and systems to meet the requirements of each BAL when assessed against specifications in AS 3959:2018*

# Certificate of Conformity

CodeMark Australia

**Certification Body:**

SAI GLOBAL

SAI Global Certification Services Pty Limited

(ACN 108 716 669) Trading as "SAI Global"

JAS-ANZ Accreditation No. Z1440295AS

Address: 680 George St, Sydney, NSW 2000

Website: www.saiglobal.com

**Certificate Holder:**

CSR Building Products Limited
(Trading as CSR Cemintel)
Triniti 3, 39 Delhi Road,
North Ryde, NSW, 2113, Australia
Phone: 1800 633 826
Website:
https://www.csr.com.au/About-Us/Contact-Us

**Certificate number: CM20199 Rev 1**

THIS TO CERTIFY THAT

## CEMINTEL® SURROUND Walling System

**Type and/or use of product:**

CEMINTEL® Surround is an external walling system for residential and commercial buildings. Suitable for use on all building classes where metal top hats can be fixed either to steel stud framing, timber stud framing, or to masonry and concrete substrates.

For Class 2 to Class 9 buildings, CEMINTEL® Surround walling system is suitable for only Type C Fire-Resisting Construction when fixed to timber stud framing.

CEMINTEL® Surround panels are also used as internal wall lining.

**Description of product:**

CEMINTEL® Surround panels are prefinished, fibre cement panels trimmed and sealed in a standard 1200mm x 3000mm x 8mm size. The panels are colour bodied and available in a range of colours and textures featuring a matte finish.

The wall system components & accessories are detailed in the Cemintel Design and Installation Guide – Surround Series – External Installation dated 03/2020 and for internal applications Design and Installation Guide – Internal Installation dated 03/2020.

COMPLIES WITH THE FOLLOWING BCA PROVISIONS AND STATE OR TERRITORY VARIATION(S) **BCA 2019**

| | Volume One | | Volume Two | |
|---|---|---|---|---|
| **Performance Requirement(s)** | **BP1.1(a) limited to (b)(i)(ii) & (iii)** | **Structural reliability** | **P2.1.1(a) limited to (b)(i), (ii), & (iii)** | **Structural stability and resistance** |
| | **FP1.4** | **Weatherproofing** | **P2.2.2** | **Weatherproofing** |
| **Deemed-to-Satisfy Provision(s):** | **C1.1(b) & Spec C1.1 Clause 3** | **Fire Resistance –** Type A Fire-Resisting Construction (120/120/120, or -/180/180 when used in a system with Fyrchek MR | **3.7.1.1(d)**<br>**3.7.2.4(b)(i)** | **General concession — non-combustible materials**<br>**Fire separation of external walls – Construction of external walls (FRL 60/60/60)** |

SAI Global Certification Services

Heather Mahon
Global Head of Technical Services
SAI Global Assurance

Quintin Kleyn – Unrestricted Building Certifier

**Date of issue: 17 March 2020**

**Date of expiry: 27 February 2023**

ABCB  JAS-ANZ

| | | | | |
|---|---|---|---|---|
| | | plasterboard, refer to the Design and Installation Guide) | **3.10.5.0(c)** | **Construction in bushfire prone areas** |
| | **C1.9(e)(iv)** | **General concession — Materials deemed to be non-combustible** | | |
| | **C1.10(a)(ii) & Spec C1.10 Clause 4** | **Fire hazard properties – Wall and ceiling linings** | | |
| | **G5.1 & G5.2** | **Construction in bushfire prone areas – (**up to and including BAL 29) | | |
| **State or territory variation(s):** | **NSW G5.2** | **Construction in Bushfire Prone Areas –** Protection. | **NSW 3.10.5.0** | **Construction in bushfire prone areas** |
| | **QLD G5.1** | **Construction in Bushfire Prone Areas –** Construction Requirements | **QLD 3.10.5.0** | **Construction in bushfire prone areas** |

**SUBJECT TO THE FOLLOWING LIMITATIONS AND CONDITIONS AND THE PRODUCT TECHNICAL DATA IN APPENDIX A AND EVALUATION STATEMENTS IN APPENDIX B**

**Limitations and conditions:**

1. Surround Walling System with Fyrchek MR Plasterboard can be used where the required Fire Resistance Levels (FRLs) does not exceed 120/120/120, or -/180/180 as specified in the NCC 2019 BCA Volume One specification C1.1. The installation must be in accordance with the relevant details contained within the System Engineering section of Cemintel Design and Installation Guide – Surround Series – External Installation dated 03/2020 for system No. CSR5874 (FRL 120/120/120) and system No. CSR5349 (120/120/120, or -/180/180)
2. For Class 2 to Class 9 buildings, CEMINTEL® Surround walling system is suitable for only Type C Fire-Resisting Construction when fixed to timber stud framing.
3. For type C Fire-Resisting Construction, Surround Walling System has not been assessed against the requirements of Specification C1.1 Clause 5.1(c) of a fire wall or an internal wall bounding a sole-occupancy unit or separating adjoining units.
4. Surround Walling System achieves a Group Number 1 and Smoke Growth Rate Index ($SMOGRA_{RC}$ 0.2 $m^2s^2$x1000) as determined in accordance with AS 5637.1:2015
5. The following were the only wall wraps assessed against the requirements of C1.9(e)(vi) for sarking-type material:
   a) Bradford Thermoseal™ Wall Wrap
   b) Enviroseal ProctorWrap Commercial Wall (CW)
   c) Enviroseal ProctorWrap Residential Wall (RW)

**Building classification/s:**

Volume 1 – Class 2 to Class 9 buildings

Volume 2 – Class 1 and Class 10(a) buildings

6. The following were the only insulations assessed against the requirements of C1.9(a) for non-combustible building elements:
    a) 75 Gold Batts R1.5 at 8.76kg/m$^3$ density
    b) 75 Gold Batts R2.0 at 6.3kg/m$^3$ density
    c) 90 Gold Batts R2.0 at 10.5kg/m$^3$ density
    d) 90 Gold Batts R2.5 at 21.2kg/m$^3$ density
    e) 75 Acoustigard R1.7 at 11.0kg/m$^3$ density
    f) 90 Acoustigard R2.2 at 14.0kg/m$^3$ density
    g) 90 Acoustigard R2.5 at 20.0kg/m$^3$ density
7. Surround Walling System shall be used for its intended purpose. For further information on limited applications of the product, refer to Cemintel Design and Installation Guide – Surround Series as relevant:
    a) External Installation dated 03/2020
    b) Internal Installation dated 03/2020
8. Surround Walling System has been tested for weatherproofing requirements and achieved serviceability limit state wind pressures up to ±2.5kPa water penetration for the cavity system using Cemintel rigid air barrier (typically 6mm thick fibre cement sheet). Construction details and fixing must follow the relevant details contained within the System Engineering section of Cemintel Design and Installation Guide – Surround Series – External Installation dated 03/2020.
9. Surround Walling System has been evaluated for use in all Australian wind zones up to and including N6 and Cyclonic C4 in accordance with AS 4055 and for ultimate wind pressures up to 7.0 kPa under AS 1170.2 including cyclonic zones when fixed to steel framing with Cemintel Rigid Air Barrier.
10. The Surround Walling System is not certified for either energy efficiency or acoustic performance.
11. Site environmental factors such as wind and corrosivity zones need to be considered to determine its suitability for a particular environment.
12. Surround Walling System is suitable for use on buildings constructed in accordance with AS 3959:2018 that are have a Bushfire Fire Attack Level up to and including BAL 29
13. All flashing including inter-storey junction must be metal flashing.

# Certificate of Conformity

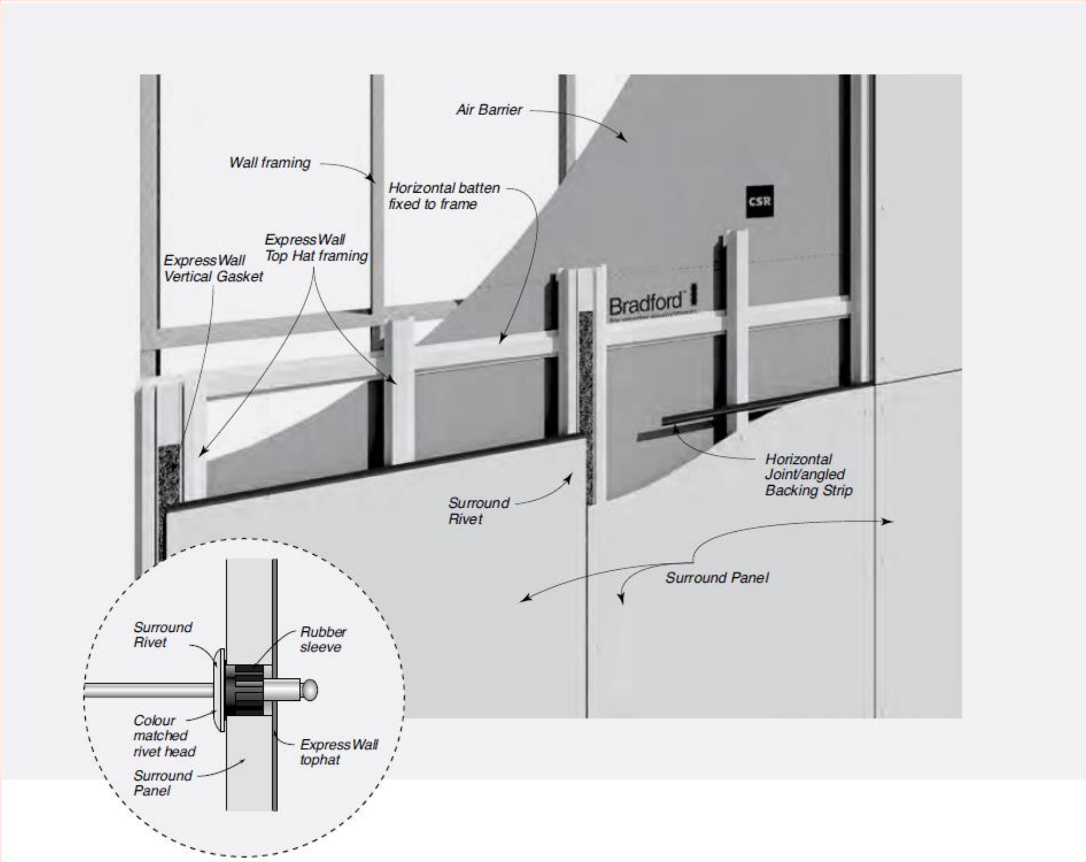
## APPENDIX A – PRODUCT TECHNICAL DATA

**A1 Type and intended use of product**

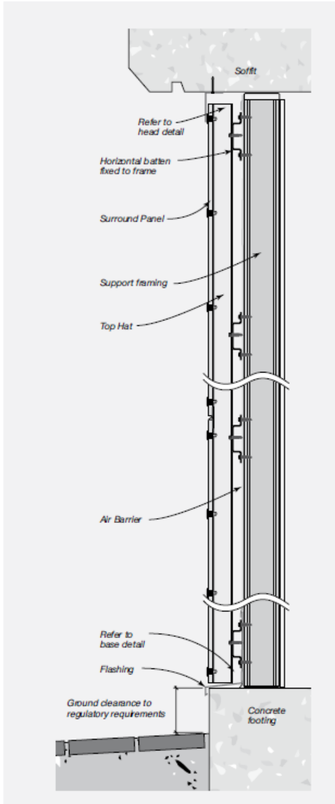
Refer to Page 1 of this certificate.

**A2 Description of product**

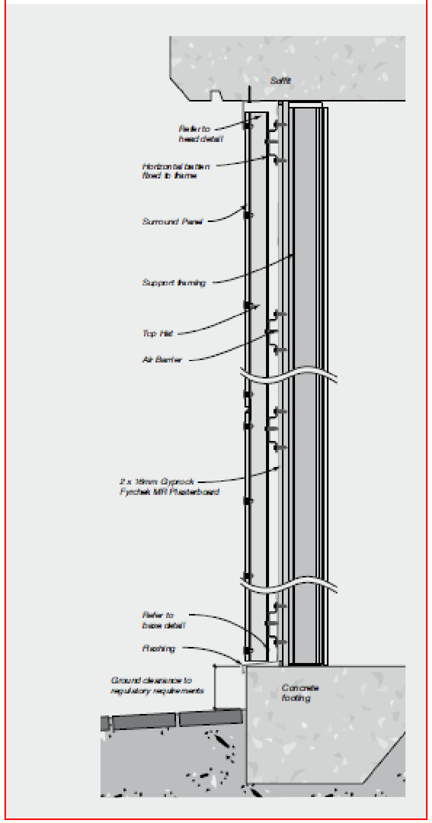
Refer to Page 1 of this certificate and the below diagrams.




Typical Surround System Cross Section for Steel Framing




Typical Surround External Fire Rated Installation.
- Pressure Equalised Ventilated Cavity System



## A3 Product specification

Below are some physical properties of fibre cement and system specifications

**Product Specifications/System Solutions**

| Dimensional/Geometrical Characteristic | Specification (trimmed panel) | Manufacturing Tolerance | Relevant Standard |
|---|---|---|---|
| Panel Width | 1200mm | + / - 1.5mm | EN 12467 |
| Panel Length | 3000mm* | + / - 1.5mm | EN 12467 |
| Panel Thickness | 8mm | + / - 0.8mm | EN 12467 |
| Panel Mass (EMC) | 15.7kg/m$^2$ | | |
| Fire Resistance Limits (FRLs) | Up to 120/120/120, -/180/180 | | Refer to System Engineering section or Gyprock® The Red Book™ |
| Bushfire Construction | BAL 29 (Construction for Bushfire Attack Level 29 for an external wall) | | AS 3959 – 8 |
| Weatherproofing | Has passed testing at a serviceability wind pressure of +2.5kPa and -2.7kPa, and an ultimate wind pressure of +7kPa and -7kPa (Rigid Air Barrier required for pressures above 1.5kPa) | | AS 4284 |
| Cyclonic Conditions | Passed at 7kPa | | AS 4040.3 |

## A4 Manufacturer and manufacturing plant(s)

## A5 Installation requirements

Refer to Page 3 of this certificate and the following:

1. Cemintel Design and Installation Guide – Surround Series – External Installation dated 03/2020
2. Cemintel Design and Installation Guide – Surround Series – Internal Installation dated 03/2020

## A6 Other relevant technical data

- Technical Datasheets for Bradford Thermoseal™ Wall Wrap, Enviroseal ProctorWrap (CW) Wall Wrap, and Enviroseal ProctorWrap (RW) Wall Wrap with nominal thickness <1.0mm for all three products.
- Technical Datasheet for Bradford Acoustigard partition rolls

## APPENDIX B – EVALUATION STATEMENTS

### B1 Evaluation methods

The system has been assessed as complying with the identified Performance Requirements of the NCC 2019 BCA Volumes 1 and 2. This involved a review of product specifications, test reports, installation manuals, and associated documentation.

1. **Structural assessment:**
   - Volumes 1 & 2 – A2.2(2) / A5.2(1)(d) & (e) – A report issued by an Accredited testing Laboratory – Cyclone Testing Station, James Cook University (NATA accreditation No. 14937) and a report from a professional engineer
2. **Weatherproofing assessment:**
   - Volumes 1 & 2 – A2.2(2) / A5.2(1)(d) & (e) – A report issued by an Accredited testing Laboratory – Ian Bennie and Associates (NATA accreditation No. 2371) and a report from an appropriately qualified person
3. **Fire Resistance assessment:**
   - Volumes 1 & 2 – A2.3(2) / A5.2(1)(d) – An assessment report issued by an Accredited testing Laboratory – BRANZ Ltd (IANZ accreditation No. 37)
4. **Non-Combustibility (General Concessions):**

   **A. Sarking-type material**
   - Volumes 1 & 2 – A2.3(2) / A5.2(1)(d) – A report issued by an Accredited testing Laboratory – Insulation Research Laboratory (NATA accreditation No. 993)
   - Volumes 1 & 2 – A2.3(2) / A5.2(1)(d) – A report issued by an Accredited testing Laboratory – AWTA Product Testing (NATA accreditation No. 1356)

   **B. Insulation material**
   - Volumes 1 & 2 – A2.3(2) / A5.2(1)(e) – An assessment report from an appropriately qualified person – CSIRO
   - Volumes 1 & 2 – A2.2(2) / A5.2(1)(d) – A report issued by an Accredited testing Laboratory – Insulation Research Laboratory (NATA accreditation No. 993)
5. **Fire Hazard Properties assessment:**
   - Volume 1 – A2.3(2) / A5.2(1)(e) – An assessment report from an appropriately qualified person – Warrington Australia Pty Ltd
   - Volume 1 – A2.3(2) / A5.2(1)(d) – A report issued by an Accredited testing Laboratory – Insulation Research Laboratory (NATA accreditation No. 993)
   - Volume 1 – A2.3(2) / A5.2(1)(d) – A report issued by an Accredited testing Laboratory – AWTA Product Testing (NATA accreditation No. 1356)
6. **Resistance to Bushfire Attack assessment:**
   - Volumes 1 & 2 – A2.3(2) / A5.2(1)(f) – Another form of documentary evidence (assessment against specifications in referenced document – AS 3959:2018)

**B2 Reports**

| Evaluation methods | Related Supporting Evidence as listed below |
|---|---|
| Structural Assessment | Numbers 1, 2, 3, & 4 |
| Weatherproofing Assessment | Numbers 5 & 6 |
| Fire Resistance assessment | Numbers 7 & 8 |
| Non-Combustibility (General Concession) | Numbers 9, 10, 11, 12, & 13 |
| Fire Hazard Properties assessment | Number 14 |
| Resistance to Bushfire Construction assessment | Number 15 |

## Structure

1. **Test Report from a NATA accredited testing laboratory (Accreditation No: 14937) for Connection Testing Cyclic Simulated Wind Load Strength Testing and Assessment of the Cyclic Wind Load Capacity of CSR Cemintel Creative Façade System from James Cook University, Report No. TS1055 Revision A (dated: 26 April 2017)**
   *This document contains the test results of a Cemintel Creative Façade (8mm & 9mm nominal thickness) sample for resistance to simulated cyclic wind load, carried out in accordance with AS 4040.3.*
2. **Test Report from a NATA accredited testing laboratory (Accreditation No: 14937) for Assessment of the Cyclonic Wind Load Capacity of CSR Express Wall Façade System from James Cook University, Report No. TS584 (dated 4 August 2003)**
   *This document contains the test results of a Cemintel Creative Façade (9mm nominal thickness) sample for resistance to simulated cyclic wind load, carried out in accordance with AS 4040.3. Reappraisal Test Report Summary from a NATA accredited testing laboratory (Accreditation No: 14937) for Assessment of the Cyclonic Wind Load Capacity of CSR Express Wall Façade System from James Cook University, Report No. TS584 (dated 31 December 2016). This document contains the re appraisal test results of a CSR ExpressWall Façade (9mm nominal thickness) sample for resistance to simulated cyclic wind load, carried out in accordance with AS 4040.3.*
3. **Certification of CSR Surround Façade System by David Beneke Consulting, Report 2013-28-LO-1002 (dated 17 July 2019)**
   *This document certifies the maximum top hat spans and spacings of Surround façade system in accordance with normal engineering practice and principals, test methods and the relevant Australian Standards.*
4. **Durability opinion of CSR ExpressWall Metal Components from Branz, Report No. DZ0073 (dated 20 September 2004)**
   *This document contains the opinion of the likely resistance of the ExpressWall system components in relation to durability and Category 4 (Severe Marine) or less, for a minimum service life of 15 years.*

**Weatherproofing**

5. **Test Report for Air Infiltration, Water Penetration and Structural ULS of Cemintel Creative Façade System, Report No. 2016-108-S1 (dated 24 February 2017 amended 28 March 2017)**
   *This document contains the test results of the Cemintel Creative Façade System for Water Penetration, carried out in accordance with AS 4284:2008.*
6. **Report from AECOM consultancy advice pertaining to the Cemintel Creative (now known as Surround) Facade System (dated 07 June 2019).**
   *This advice confirms the compliance of this product with AS 4284:2008, based on the test results of Report No. 2016-108-S1, by Ian Bennie and Associates.*

**Fire Resistance**

7. **Test Report for Fire Resistance of CSR Steel Framed Wall Systems from Branz, Report No. FAR 2357 Issue 12 (dated: 06 July 2017)**
   *This document contains the test results of the CSR steel framed system for resistance to fire, carried out in accordance with AS 1530.4:2014.*
8. **Test Report for Fire Resistance of CSR Timber Framed Walls from Branz, Report No. FAR 2303 Issue 3 (dated: 24 December 2015)**
   *This document contains the test results of the CSR timber framed system for resistance to fire, carried out in accordance with AS 1530.4:1997.*

**Non-Combustibility (General Concession)**

A. **Sarking-type material**

9. **Test Report for Flammability Index of Bradford Thermoseal™ Wall Wrap from Insulation Research Laboratory, Report No. NR-17201 (dated: 1 May 2017)**
   *This document contains the test results of the Bradford Thermoseal™ Wall Wrap carried out in accordance with AS 1530.2:1993 for flammability index.*
10. **Test Report for Flammability Index of Enviroseal ProctorWrap (CW) Wall Wrap from AWTA, test No. 16-006359 (dated: 12 December 2016)**
    *This document contains the test results of the Bradford Thermoseal™ Wall Wrap carried out in accordance with AS 1530.2:1993 for flammability index.*
11. **Test Report for Flammability Index of Enviroseal ProctorWrap (RW) Wall Wrap from AWTA, test No. 17-000553 (dated: 17 February 2017)**
    *This document contains the test results of the Bradford Thermoseal™ Wall Wrap carried out in accordance with AS 1530.2:1993 for flammability index.*

B. **Insulation**

12. **Assessment Report for combustibility of Bradford Glasswool insulation batts from CSIRO, Report No. FCO-2812a (dated: 19 November 2015)**
    *This document provides an assessment of Bradford Glasswool insulation batts and were not deemed combustible when tested to the requirements of AS 1530.1:1994.*
13. **Test Report for combustibility of Bradford Acoustigard from Insulation Research Laboratory, Report No. NR-17002 (dated: 22 March 2017)**
    *This report contains the results of Bradford Acoustigard insulation batts carried out in accordance with AS 1530.1:1994 and were not deemed combustible.*

## Fire Hazard Properties

14. **Assessment Report for Group Number and Smoke Growth Rate Index (SMOGRARC) from Exova Warrington, Report No. 45759 Revision 10.1 (dated 15 November 2019)**
    *This report shows the assessment undertaken to determine the likely fire hazard properties of the CSR wall and ceiling lining products if tested in accordance with AS ISO 9705:2003 (R2016) and AS5637.1:2015*

## Resistance to Bushfire Attack

15. **Cemintel® Construction Guide for Bushire Areas (dated October 2019)**
    *This guide provides information on Cemintel® wall cladding products and systems to meet the requirements of each BAL when assessed against specifications in AS 3959:2018*

# **Appendix 3 –** Bradford ProctorWrap Sarking - AWTA Product Testing

AWTA PRODUCT TESTING

Australian Wool Testing Authority Ltd - trading as AWTA Product Testing
A.B.N 43 006 014 106
**1st Floor, 191 Racecourse Road, Flemington, Victoria 3031**
**P.O Box 240, North Melbourne, Victoria 3051**
**Phone (03) 9371 2400  Fax (03) 9371 2499**

# TEST REPORT

**Client :** Proctor Group Australia
Unit 8, 171-175 Newton Road
Wetherill Park NSW 2164

**Test Number :** 16-006359
**Issue Date :** 12/12/2016
**Print Date :** 13/12/2016
**Order Number :** 00016232

**Sample Description**

Clients Ref : "ProctorWrap  Commercial Wall  (CW)"
3 Ply Spun bonded polyolefin membrane
Colour : Grey/White
End Use : Pliable building membrane
Nominal Mass per Unit Area/Density : 132g/m2
Nominal Thickness : 0.5mm

**AS 1530.2-1993**

**Methods for Fire Tests on Building Materials, Components and Structures.**
**Part 2: Test for Flammability of Materials**

| | | | |
|---|---|---|---|
| Date Tested | | 12/12/2016 | |
| Flammability Index | | 1 | |
| | Length | Width | |
| Spread Factor | 0 | 0 | |
| Heat Factor | 1 | 1 | |
| Maximum height (d) | | | |
| Mean | 1.5 | 1.6 | |
| Coefficient of Variation | 0.0 | 12.9 | % |
| Heat (a) | | | |
| Mean | 1.5 | 1.5 | °C.min |
| Coefficient of Variation | 0.0 | 0.0 | % |
| Number of Specimens Tested | 6 | 6 | |
| Observation | Visible smoke, melting dripping debris | | |

These test results relate only to the behaviour of the test specimens of the material under the particular conditions of the test, and they are not intended to be the sole criterion for assessing the potential fire hazard of the material in use.

Specimens were tested face,back,face,back.







Accredited for compliance with ISO/IEC 17025

| | | |
|---|---|---|
| - Chemical Testing | : Accreditation No. | 983 |
| - Mechanical Testing | : Accreditation No. | 985 |
| - Performance & Approvals Testing | : Accreditation No. | 1356 |

AWTA LIMITED

Samples and their identifying descriptions have been provided by the client unless otherwise stated. AWTA Ltd makes no warranty, implied or otherwise, as to the source of the tested samples. The above test results relate only to the sample or samples tested. This document shall not be reproduced except in full and shall be rendered void if amended or altered. This document, the names AWTA Product Testing and AWTA Ltd may be used in advertising providing the content and format of the advertisement have been approved by the Managing Director of AWTA Ltd.

0204/11/06

APPROVED SIGNATORY

MICHAEL A. JACKSON B.Sc.(Hons)
MANAGING DIRECTOR