FIRE ENGINEERING REPORT

External Walls of BCA Class 7b and 8 buildings of Type C Construction within 3m of the boundary, comprising 0.42mm BMT Monoclad steel sheeting insulated with 15mm Promina 60 board

Report Number: 2275300-RPT01-Ver5
Date: 18 March 2016

Client:

Promat Australia Pty Ltd

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Testing. Advising. Assuring.

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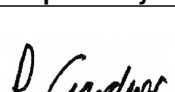
5	Update of Report to BCA 2016	18.03.2016		
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REVISION HISTORY

No.	Comment / Reason for Issue	Issue Date	Prepared By*	Reviewed By*
0	Update of WFRA 40981B V3.0 to BCA 2008	28.05.2008	Vincent Chow	Nabeel Kurban
1	Correction to revision history	30.05.2008	Vincent Chow	Nabeel Kurban
2	Update of Report to BCA 2010	13.08.2010	Peter Gardner	Keith Nicholls
3	Update of Report to BCA 2013	29.04.2013	Peter Gardner	Keith Nicholls / Simon Krishnan (Qld RPEQ No.13510)
4	Update of Report to BCA 2014	12.08.2014	Peter Gardner	Keith Nicholls / Simon Krishnan (Qld RPEQ No.13510)

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EXECUTIVE SUMMARY

Exova Warringtonfire Aus Pty Ltd (EWFA) had been appointed by Promat Australia Pty Ltd to formulate an alternative fire safety design solution specific to the use of *Stramit Uniguard – Fire Resisting Wall System* as an external wall system for BCA Class 7b and 8 buildings of Type C Construction within 3m of the boundary, against the Building Code of Australia 2016 (BCA).

Version 5 of this Report updates the Report in consideration of BCA 2016. Promat Australia Pty Ltd has confirmed on 01.03.2016 that the product has not changed since the original assessment was procured.

The wall system comprises a 15mm thick Promina 60 calcium silicate board overlaid externally with a 0.42 – 0.48 BMT (Bare Metal Thickness) *Stramit® Corrugated*, *Stramit® Monoclad®* or *Stramit Longspan®*, steel cladding fixed to horizontal battens.

The wall system varies from the BCA Deemed-to-Satisfy Provisions for external walls within 3m of the boundary in that it has been evaluated against the requirements of the BCA 2016 Verification Method CV1 in lieu of being subjected to a standard fire resistance test.

The proposed alternative fire safety design solution, specific to the use of the subject proprietary Stramit wall system (Uniguard) in circumstances described in this report, has been considered against the relevant BCA Performance Requirements CP1 and CP2 to the extent that they apply to fire spread to the building via the external walls.

Based on the discussion in this report, technical specification derived in Appendix A, Test Report 40981 and Appendix B of AS1530.4-2005 it is the opinion of Exova Warringtonfire Aus Pty Ltd that the proposed fire safety design solution satisfies the relevant BCA Performance Requirements CP1 and CP2.

It should be noted that this report must be submitted to the relevant regulatory authorities having jurisdiction and relevant stakeholders at the preliminary design stage to obtain acceptance of the proposed Alternative Solution.

Approval for the use of any material, form of construction or design in a building is subject to the relevant building regulations in each jurisdiction. No liability is accepted if this report is not accepted by stakeholders or the relevant regulatory authorities.

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1 INTRODUCTION

This report presents a fire engineering analysis of a proposed alternative fire safety design solution specific to the use of *Stramit Uniguard – Fire Resisting Wall System* as an external wall system within 3m of a boundary for Class 7b and 8 buildings of Type C Construction, as defined in the Building Code of Australia 2016 (BCA)[1].

The external wall system tested comprised a 15mm thick Promina 60 calcium silicate board overlaid externally with a 0.42 BMT (Bare Metal Thickness) Stramit Monoclad® steel cladding on the external face.

The BCA Deemed-to-Satisfy Provision C1.1 prescribe that for this Classification and Type of Construction, load bearing external wall elements are to have the respective fire resistance levels when tested from the outside only:

- Located less than 1.5 metres from a fire source feature – 90/90/90 FRL.
- Located 1.5 metres to less than 3 metres from a fire source feature – 60/60/60 FRL.

An alternative fire safety design solution is proposed to use the subject Stramit Uniguard Fire Resisting Wall System as an external wall element, evaluated against BCA Verification Method CV1 to demonstrate compliance with BCA Performance Requirements CP1 and CP2.

Whilst BCA Verification Method CV1 defines the acceptance criterion for the exposure of external walls to a radiant heat flux, it is necessary to derive further acceptance criteria to manage the potential of ignition of the contents of the building and ignition of the wall itself[3]. The derivation of these acceptance criteria, additional to BCA Verification Method CV1, is provided in Appendix 1 - *Interpretation and Application of Verification Method CV1 for Class 7b and 8 buildings of Type C Construction*.

The wall system has been tested by subjecting it to a radiant heat flux of 80 kW/m². Results of the test are reported in WFRA 40981A[2] and analysis of the results against the acceptance criteria presented in this report. The requirements of BCA Deemed-to-Satisfy Provision C1.8 have not been included in this report.

[1] Building Code of Australia 2016, Australian Building Codes Board, 2016.
[2] 3m×3m Radiant panel test on an External Wall comprising Monoclad zinc alumel steel sheeting and 15mm thick Promina 60 board. Warrington Fire Research Aust Pty Ltd., Project No. 40981, Melbourne 2003
[3] Babrauskas, V., "Ignition of Wood: A Review of the State of the Art", Journal of Fire Protection Engineering, Vol 12, No. 3, 2002.

2 DESCRIPTION OF TESTED WALL SYSTEM FOR THE PROPOSED ALTERNATIVE SOLUTION

The tested wall system comprises a 15mm thick Promina 60 board overlaid with a Monoclad steel cladding (Figure 2.1) on the exposed (external) face (refer Figure 2.3 and Figure 2.4). The panel boards are nominally 1220mm × 2440mm × 15mm and are butt-jointed without treatment. The Monoclad steel cladding panels are 0.42 BMT (code MC42ZA) and 762mm ± 4mm wide. They are screw-fixed through the Promina 60 board into horizontal steel girts (C15012, Figure 2.2) and are installed with 1 flute overlap on the exposed face.

Figure 2.1 – 0.42 BMT Monoclad steel cladding

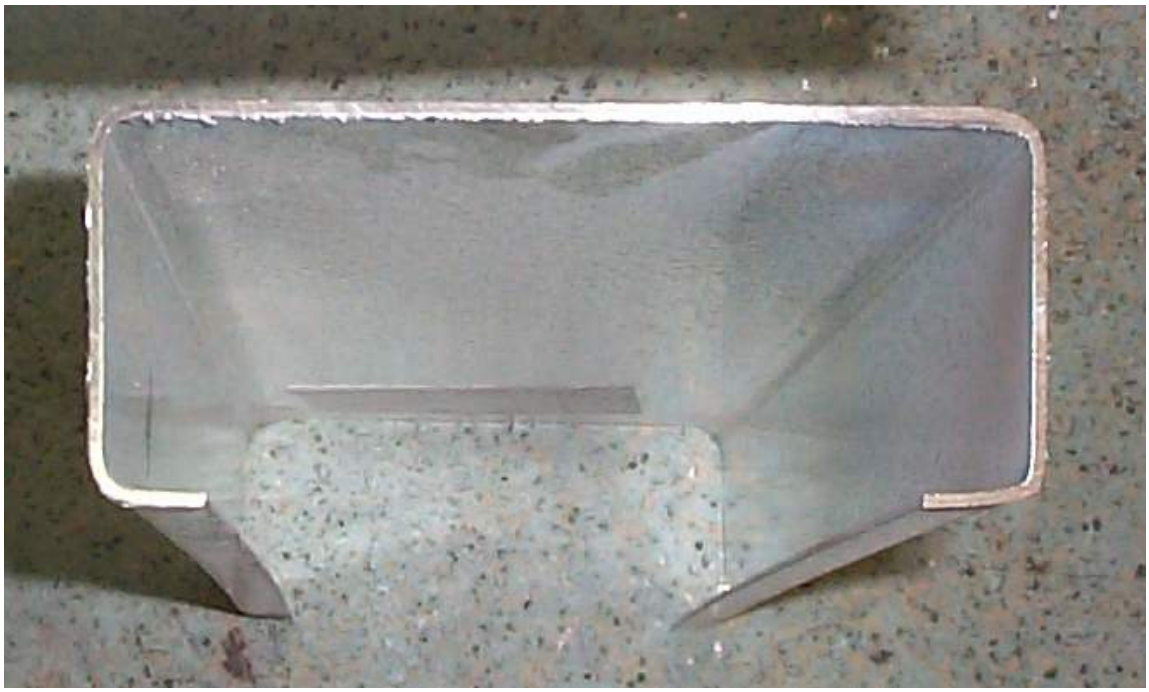

Figure 2.2 – C15012 steel purlins

Figure 2.3 – Exposed side of wall system

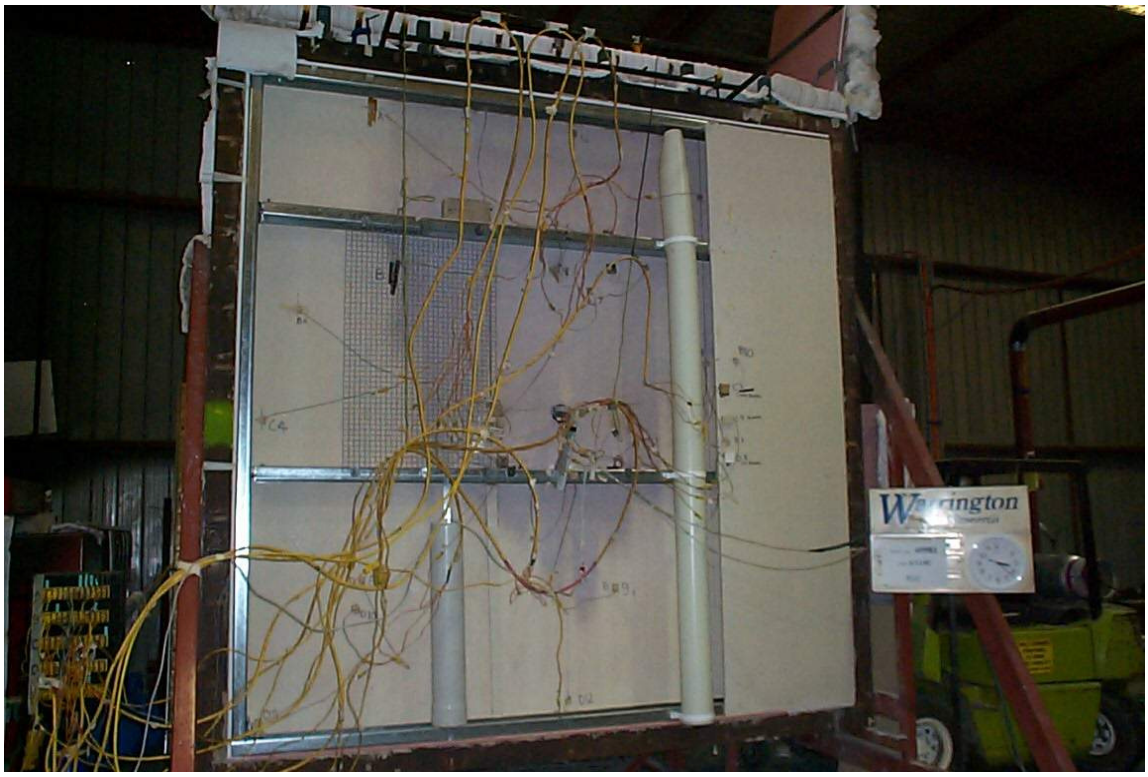

Figure 2.4 – Unexposed side of wall system

3 EXTENT OF VARIATION FROM DEEMED-TO-SATISFY PROVISIONS AND THE RELEVANT PERFORMANCE REQUIREMENTS

3.1 RELEVANT BCA DEEMED-TO-SATISFY PROVISION

BCA Specification C1.1 Table 5 prescribes that a load bearing external wall building element within 1.5m of a fire source feature is to achieve an FRL of 90/90/90 for buildings of Type C construction. In addition, BCA Clause 5.1 (b) stipulates, *"an external wall that is required by Table 5 to have an FRL need only be tested from the outside to satisfy the requirement*."

Compliance with BCA Deemed-to-Satisfy Provision C1.8 relating to the resistance of the wall from static pressure, impact and surface indentation has not been included in the scope of this analysis.

3.2 PROPOSED FIRE SAFETY DESIGN SOLUTION

In lieu of evaluating the prescribed fire resistance level, the proposed alternative fire safety design solution will be analysed for resistance to fire spread and structural adequacy, when exposed to an incident radiation heat flux of 80kW/m^2 on the external face, commensurate to the relevant BCA Performance Requirements.

3.3 ACCEPTABLE BCA ASSESSMENT METHODS

In order to demonstrate compliance with the BCA, Clause A0.1 requires compliance with the BCA Performance Requirements.

Clause A0.2 states that compliance with the Performance Requirements can only be achieved by:

BCA Clause A0.2

The Performance Requirements can only be satisfied by a —
(a) Performance Solution; or
(b) Deemed-to-Satisfy Solution; or
(c) combination of (a) and (b).

As permitted by A0.2(c), a combination of A0.2 (a) and (b) will be used to demonstrate compliance.

Clause A0.5 identifies assessment methods that are to be used for determining that a Performance Solution complies with the BCA Performance Requirements.

BCA Clause A0.5

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

3.4 RELEVANT BCA PERFORMANCE REQUIREMENTS

The ability of external walls to resist fire spread and maintain structural adequacy when exposed to external fires will be assessed against the relevant BCA Performance Requirements. These have been identified as BCA Performance Requirements CP1 and CP2 having regard for the requirements of A0.07.

These BCA Performance Requirements require consideration to the spread of fire between buildings. Commentary to BCA Objective CO1 in the Guide to the BCA questions the following *Should the greater degree of fire protection be in the building on fire, or should it be in the building at potential risk of the fire spreading? Generally, the BCA provisions aim to minimise*

the spread of fire from the building on fire, but there are some provisions that limit the spread of fire from an adjacent building.

The Guide to the BCA further states that *if an Alternative Solution to the Deemed-to-Satisfy Provisions in Section C is being used, it may be appropriate to assess it using the Section C Deemed-to-Satisfy Provisions for guidance purpose*.

As the building is of Type C Construction, guidance in the BCA Deemed-to-Satisfy Provisions is provided in BCA Specification C1.1 Clause 5.1 (b) that stipulates *that an external wall that is required by Table 5 to have an FRL need only be tested from the outside to satisfy the requirement*. This provides indication to the BCA intended hazard for fire spread for Type C Construction circumstances. Support of this direction of fire hazard is reinforced by BCA Deemed-to-Satisfy Provision C3.2 which prescribes that if wall wetting sprinklers are used to protect openings in the external wall, they be located on the outside. Therefore, this analysis will only consider resistance to an external fire.

3.4.1 BCA Performance Requirement CP2 – Spread of Fire

The primary BCA Performance Requirement is CP2 (a) (iii), which states:

BCA Performance Requirement CP2
(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.

3.4.2 BCA Performance Requirement CP1 – Structural Adequacy

Since the BCA Deemed-to-Satisfy Provisions also require a level of structural stability when exposed to external fire conditions BCA Performance Requirement CP1 will also be considered.

BCA Performance Requirement CP1
A building must have elements which will, to the degree necessary, maintain structural stability during a fire appropriate to- (a) the function or use of the 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.

3.5 REGULATORY ASSESSMENT

As identified previously, the relevant BCA Deemed-to-Satisfy Provisions prescribe that the fire resistance levels of an external wall in a building of Type C Construction need only be considered from the external side. The issue of fire spread between buildings is identified in BCA Performance Requirement CP2 (a)(iii).

It therefore follows that the suitability of an external wall in a building of Type C Construction, which is designed to resist fire spread and maintain structural adequacy when exposed to fire, need only be considered from the external side to demonstrate equivalency to the BCA Deemed-to-Satisfy Provisions. This is appropriate provided all factors in BCA Performance Requirement CP2 (b) being consistent with a building which complies with the BCA Deemed-to-Satisfy Provisions.

The method of regulatory assessment by the Authorities Having Jurisdiction is therefore a determination of the proposed Alternative Solution against BCA Performance Requirement CP2(a)(iii) and compliance with the BCA Deemed-to-Satisfy Provisions for other parts of BCA Performance Requirement CP2, as permitted in BCA Clause A0.2(c).

The proposed Alternative Solution for BCA Performance Requirement CP2 (a)(iii) can then be determined using the BCA Verification Method CV1 (b), which identifies a heat flux of 80 kW/m^2 that the building must withstand without ignition when located on the boundary.

BCA Verification Method CV1(a) is concerned with the ability of the wall to withstand fire exposure from the internal side, which is not relevant to this analysis since compliance with the BCA Deemed-to-Satisfy Provisions applies to BCA Verification Method CV1(a), as discussed above.

4 ACCEPTANCE CRITERIA

The following sub-sections describe the derivation of criteria that were adopted for this analysis:

4.1 BCA VERIFICATION METHOD CV1

CV1 states:

Compliance with CP2(a)(iii) to avoid the spread of fire between buildings on adjoining allotments is verified when it is calculated that-

(a) a building will not cause heat flux in excess of those set out in column 2 of Table CV1 at locations within the boundaries of an adjoining property set out in column 1 of Table CV1 where another building may be constructed; and

(b) when located at the distances from the allotment boundary set out in column 1 of Table CV1, a building is capable of withstanding the heat flux set out in column 2 of Table CV1 without ignition.

Table CV1

Column 1	Column 2
Location	Heat Flux (kW/m2)
On boundary	80
1 m from boundary	40
3 m from boundary	20
6 m from boundary	10

BCA Verification Method CV1 therefore indicates that if the external wall of a single storey building of Type C Construction can withstand 80 kW/m^2 without ignition, when tested only from the outside, then it would meet Performance Requirement CP2(a)(iii) of the BCA 2016 for buildings of Type C Construction.

In addition, if structural members maintain their structural adequacy when the external wall is exposed to a radiation heat flux of 80kW/m^2 from the outside it is considered that BCA Performance Requirement CP1 has been satisfied for Class 7b and 8 buildings of Type C Construction.

4.2 TECHNICAL SPECIFICATION

The technical specification described in Appendix A derived the following analysis criteria based on exposure to a radiation heat flux. The technical specification also derived a standard exposure with the incident radiation progressively increasing from 0 to 80kW/m^2 during the first 30 minutes after which it is maintained at approximately 80kW/m^2 up to a period of 240 minutes:

1. Ignition of the non-fire exposed face of the element (i.e. continuous flaming for more than 15s) shall not occur during the 240 minute test.
2. The measured radiant heat flux emitted from the non-fire side and from any feature more than 0.01m^2 shall not exceed 10kW/m^2 during the 240 minute test. This can be measured directly using a radiometer or the non fire side temperature can be measured in accordance with AS 1530.4:1997 and a limiting temperature of 435℃ applied to the mean temperature of the non-fire side or feature.
3. The element shall remain imperforate (no straight through gaps form) during the 240 minute test.
4. The mean temperature of structural steel members on the inside of the wall system should not exceed 400℃ during the 240 minute test.
5. The temperature at any point on the non fire side shall not exceed 380℃ during the first 60 minutes of the test when measured by thermocouples complying with AS 1530.4-1997.

4.3 AS1530.4-2005 - ALTERNATIVE AND ADDITIONAL TEST PROCEDURES FOR ELEMENTS OF CONSTRUCTION

The test protocol developed above and subsequent testing of the prototype against this specification, as reported in WFRA Report 40981A was undertaken before the release of AS1530.4-2005.

AS1530.4-2005 includes additional protocols in Appendix B which address alternative test procedures, for elements of construction considering specific radiant heat exposure conditions as well as temperature heating regimes.

Differences between AS 1530.4:2005 have been reviewed in Appendix C and are considered not to effect the conclusions drawn in the report.

5 TEST RESULTS

Test 40981 was undertaken on a representative section of wall subjected to an incident radiation heat flux progressively increasing to 80kW/m^2 during the first 30 minutes of the test and then being maintained at 80kW/m^2 for the remainder of the 240 minute test. The following tables summarise the results of Test 40981, against the analysis criteria summarised in Section 3.5.

Table 5.1 – Summary of Test Results

Acceptance criteria / Failure Criteria	Required time (min)	Time criteria exceeded (min)	Criteria satisfied (Yes/No)
Ignition of the non-fire exposed face of the element (i.e. continuous flaming for more than 15s)	240	No failure at 240	Yes
Mean temperature on the non-fire exposed face exceeds 435℃	240	No failure at 240	Yes
Wall remains imperforate	240	No failure at 240	Yes
Mean temperature of steel structural members exceeds 400℃	240	No failure at 240	Yes
Maximum temperature at any point on the non-fire exposed face exceeds 380℃	60	70	Yes

6 ACCEPTABLE VARIATIONS TO TESTED SYSTEM

6.1 BATTENS BETWEEN STRAMIT® CLADDING AND PROMINA® 60 BOARD

Proposed variation to the system is to incorporate 12.5mm deep galvanised batten over Promina® board and under the steel cladding. The connection of the battens will be via the fixings for the steel cladding.

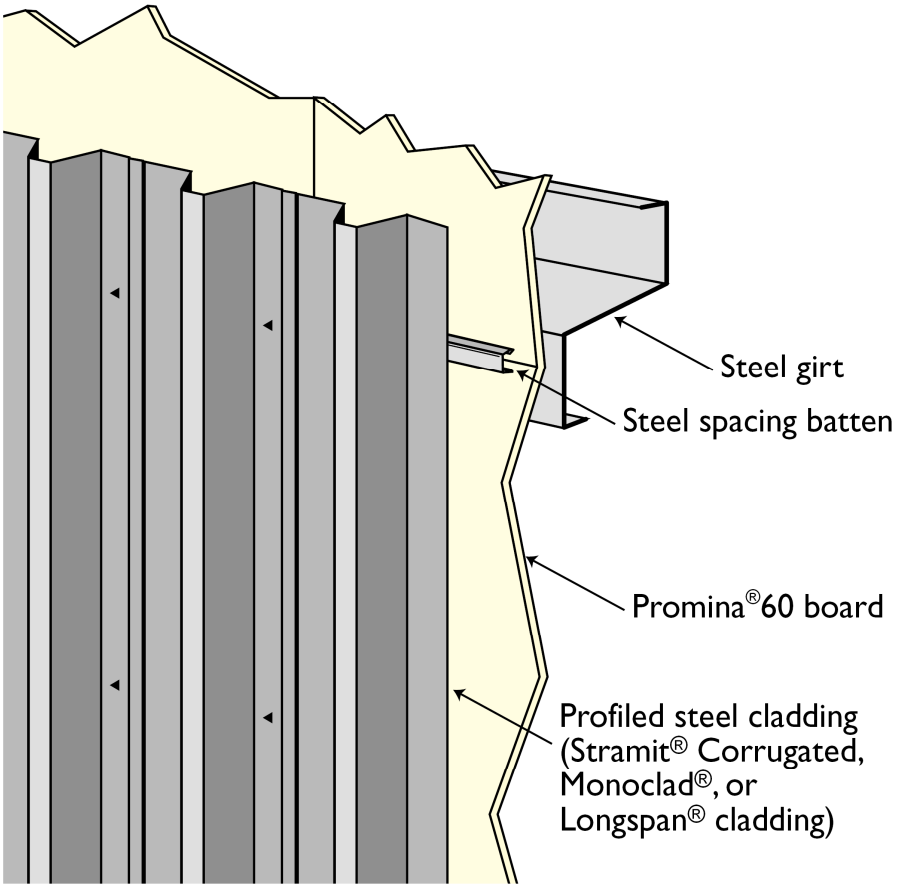

Figure 6.1 – Section of proposed system

By incorporating a gap between the sheeting and the Promina board, heat transfer by conduction and radiation will be reduced and some heat will be lost from of the cavity via convection.

The loss of heat and the less effective conduction and radiation through joints will result in lower overall temperatures on the non fire side and reduced variation between the temperatures at the joins the temperatures in the field of the sheet on the unexposed side.

Based on the discussion above and in absence of any detrimental effects it is considered that incorporating battens between the Stramit® cladding and the Promina® 60 board will not impair the fire performance of the of the tested prototype reported in WFRA 40981A.

6.2 VARIATION TO THE STEEL CLADDING PROFILE

It is proposed that various profiles of steel cladding below be used in lieu of the 0.42mm BMT Stramit Monoclad® (4.28kg/m^2).

Table 6.1 – Proposed Alternative Cladding Profiles

Cladding Profile	BMT (mm)	Mass in Zincalume finish kg/m2	Minimum Fixings per width of cladding sheet (1200mm)
Stramit Monoclad®	0.48	4.86	4
Stramit Corrugated	0.42	4.28	4
Stramit Corrugated	0.48	4.86	4
Stramit Corrugated	0.60	6.02	4
Stramit Longspan®	0.42	4.66	4
Stramit Longspan®	0.48	5.29	4

It is proposed that the cladding shall be fixed to battens with fixings that pass through battens at a maximum spacing of 300mm centres (4 per 1200mm width).

As proposed cladding profiles have the same or greater mass (kg/m^2) the heating response of the proposed cladding will be slower. It is therefore considered the proposed cladding profiles will not impair the fire performance of the tested prototype reported in WFRA 40981A.

6.3 VARIATION TO PERIMETER DETAILS OF THE WALL

The proposed system incorporates details that exclude embers from entering the system at the perimeter.

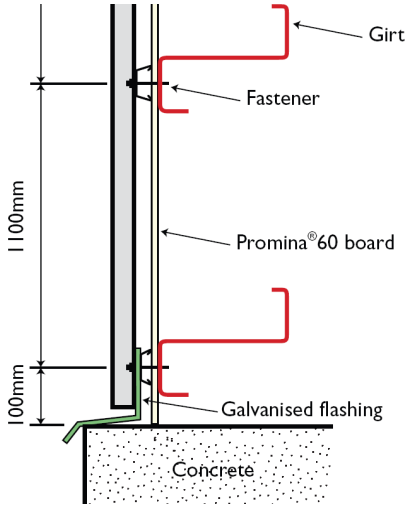

Figure 6.2 – Base Detail: Option 1

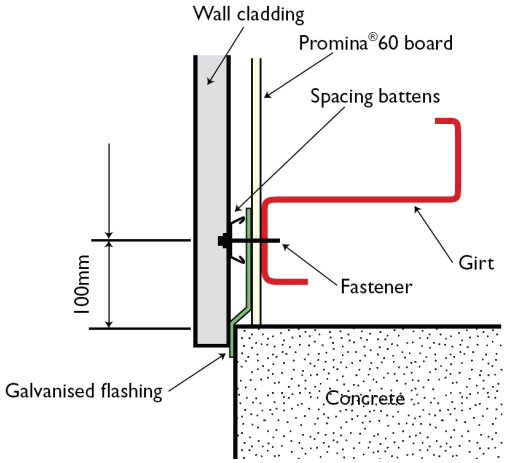

Figure 6.3 – Base Detail: Option 2

The proposed base wall details (Figure 6.2 and Figure 6.3) make use of galvanised metal flashings that will remain in place when exposed to radiation. This will exclude embers from freely entering under the Promina® 60 board at the base of the wall and would not impair the performance of the tested prototype reported in WFRA 40981A.

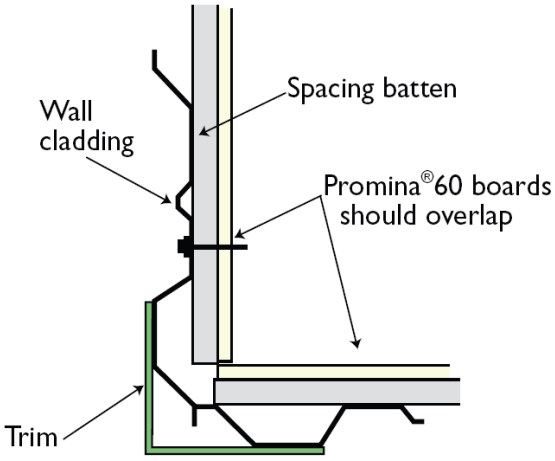

Figure 6.4 – Corner Detail

The proposed corner detail (Figure 6.4) incorporates metal trim profiles that will act to prevent embers from freely entering the building at the corners. This proposed construction and would not impair the performance of the tested prototype reported in WFRA 40981.

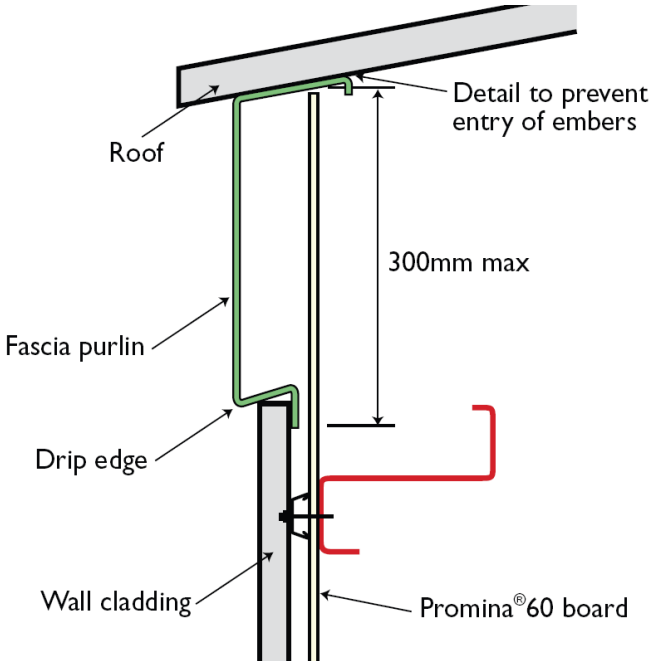

Figure 6.5 – Head Details

The proposed head detail (Figure 6.5) incorporates mineral wool inserted into gaps created under the cladding to prevent embers from freely entering the building at the top of the wall. This proposed construction would not impair the performance of the tested prototype reported in WFRA 40981A.

6.4 VARIATION TO THE STRUCTURAL STEEL FRAMING PROFILE

It is proposed that various structural profiles may be used in lieu of the 1.5mm BMT Stramit Z girts tested in WFRA 40981A.

The girts act to laterally support the wall system during wind events and laterally stabilise them during the fire and span horizontally between support columns. The girts do not support any vertical load from above and therefore only support vertical loads consisting of their self weight.

Based on the above discussion it is considered that provided the girts do not significantly buckle and continue to laterally support the cladding without resulting in collapse, the fire resistance of the wall system will not be significantly impaired. The structural capacity of these elements is discussed below.

It is proposed that the above requirement can be met by various structural sections as listed below;

Section	Minimum Section Depth (mm)	Steel Thickness (mm)
Stramit C Section Purlins	100	1.2
Stramit Z Section Purlins	100	1.2
Stramit Top-hats	64	0.75

It is considered that provided the temperature of the proposed structural sections above do not exceed 400 degrees then by reference to BS 5950-8-2003 they will retain at least 50% of their structural capacity.

With reference to WFRA 40981A, the critical temperatures on the sheet are summarised below;

Location	Temperature At 120mins (°C)	Temperature At 240mins (°C)
Vertical Butt Join	239	356
Inner face Central Girt	315	304

The above temperature indicate that the tested purlin reached equilibrium before 120 minutes and the temperature dropped off as the section temperature became more uniform, increasing its ability to shed heat.

As the proposed sections are thinner and smaller they are expected to heat up faster, though be more effective at shedding heat as they are thinner. Therefore, the proposed sections are considered likely to reach a similar maximum temperature than the tested sections, though not exceed the limiting temperature of 400 degrees.

Based on the discussion above and in absence of any detrimental effects it is considered that incorporating battens between the Stramit® cladding and the Promina® 60 board will not impair the fire performance of the of the tested prototype reported in WFRA 40981A.

7 CONCLUSION

The BCA Deemed-to-Satisfy Provisions of BCA 2016 prescribe that a load bearing external wall system for a Class 7b & 8 buildings (factories and warehouses) of Type C Construction have a fire resistance level (FRL) of at least 90/90/90, if located less than 1.5 metres from a fire source feature.

The proposed fire safety design solution for the external wall is a proprietary Stramit wall system (Uniguard) which comprises a 15mm thick Promina 60 board overlaid with 12.5mm deep horizontal battens and any of the cladding profiles nominated in Table 7.1 on the exposed (external) face and nominated framing from Table 7.2 on the unexposed face. The perimeter details (Figure 6.2 to Figure 6.5) of this report are required to prevent embers from entering the building.

Table 7.1 – Alternate Cladding Profiles

Cladding Profile	BMT (mm)
Stramit Monoclad®	0.42
Stramit Monoclad®	0.48
Stramit Corrugated	0.42
Stramit Corrugated	0.48
Stramit Corrugated	0.60
Stramit Longspan®	0.42
Stramit Longspan®	0.48

Table 7.2 – Alternate Girt Framing Profiles

Section	Minimum Section Depth (mm)	Steel Thickness (mm)
Stramit C Section Purlins	100	1.2
Stramit Z Section Purlins	100	1.2
Stramit Top-hats	64	0.75

The proposed alternative fire safety design solution, specific to the use of the subject proprietary Stramit wall system (Uniguard) in circumstances described in this report, has been considered against the relevant Performance Requirements CP1 and CP2 of BCA 2016 to the extent that they apply to fire spread to the building via the external walls.

Based on the discussion in this report, technical specification derived in Appendix A, Test Report 40981 and Appendix B of AS1530.4-2005 it is the opinion of Exova Warringtonfire Aus Pty Ltd that the proposed fire safety design solution satisfies the relevant BCA Performance Requirements CP1 and CP2.

It is the responsibility and authority of the relevant regulatory authority to approve or refuse any submission in relation to a specific site and building. No liability is accepted if this report is not accepted by stakeholders or the relevant regulatory authorities.

8 VALIDITY / DISCLAIMER

This report is prepared for the subject proprietary Stramit wall system (Uniguard) as described in this report only and applies to this specific form of construction when used in Class 7b and 8 buildings of Type C construction only designed to comply fully with the BCA Deemed-to-Satisfy Provisions except for BCA Specification C1.1 for external wall building elements.

This report has mainly addressed the primary fire risk management objectives stated in the Building Code of Australia 2016 (life safety and to a minor extent property protection). Other fire risk management objectives such as asset protection, minimisation of business interruption, continuity of community service, and moral obligation were outside the scope of this report and hence have not been considered.

The recommendations/observations in this report were based on the information provided by Promat Australia Pty Ltd and Stramit Building Products. Any modifications or changes to the building including additional variations from the BCA Deemed-to-Satisfy Provisions for fire safety, or amendments to the Building Code of Australia 2016 and referenced standards may invalidate the findings of this report. These items should be referred to Exova Warringtonfire Aus Pty Ltd to allow consideration to be made of the extent that these changes may have to the outcome of the fire engineering analysis detailed in this report.

Any variation to the fixing details must not be varied without a formal assessed by a Registered Testing Authority.

It should be noted that this report must be submitted to the relevant regulatory authorities having jurisdiction and relevant stakeholders at the preliminary design stage to obtain acceptance of the proposed alternative fire safety design solution.

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

Attention is drawn to the conditions of use depicted at the front of this report.

APPENDIX A INTERPRETATION AND APPLICATION OF BCA VERIFICATION METHOD CV1 FOR CLASS 7B AND 8 BUILDINGS OF TYPE C CONSTRUCTION

A.1. INTRODUCTION

Based on the extensive use of BCA Verification Method CV1, the need has been identified for the verification method to be interpreted and a more detailed specification provided to ensure consistent application of the method. In particular, it is necessary to develop appropriate pass / fail criteria to enable external walls systems to be evaluated in a manner consistent with the objectives of the Building Code of Australia 2016 (BCA).

This document presents the specification for an appropriate pass / fails criteria for consideration to fire spread, commensurate to the relevant BCA Performance Requirements that was adopted for this analysis.

A.2. OVERVIEW OF BCA VERIFICATION METHOD CV1

CV1 states the following:

Compliance with CP2(a)(iii) to avoid the spread of fire between buildings on adjoining allotments is verified when it is calculated that-

(a) a building will not cause heat flux in excess of those set out in column 2 of Table CV1 at locations within the boundaries of an adjoining property set out in column 1 of Table CV1 where another building may be constructed; and

(b) when located at the distances from the allotment boundary set out in column 1 of Table CV1, a building is capable of withstanding the heat flux set out in column 2 of Table CV1 without ignition.

Table CV1

Column 1	Column 2
Location	Heat Flux (kW/m^2)
On boundary	80
1 m from boundary	40
3 m from boundary	20
6 m from boundary	10

A.3. EVALUATION OF THE ABILITY OF A BUILDING TO WITHSTAND LEVELS OF HEAT FLUX WITHOUT IGNITION

A.3.1. Limiting Heat Flux from Non-Fire Exposed Face

Examining the limiting incident radiant heat flux values from BCA Table CV1, a value of 20kW/m^2 is specified at a distance of 3m from the boundary. BCA Deemed-to-Satisfy Provision C3.2 permits unprotected openings at distances greater than 3m. Therefore, an appropriate acceptance criterion for the verification method would be that the building element does not ignite and the emitted radiant heat flux from the non-fire-exposed face of the element is maintained below 20kW/m^2.

Ignition is assumed to mean flaming ignition as opposed to glowing /charring ignition to be consistent with criteria adopted by test methods, such as AS 1530.4-2005.

The limiting radiant incident heat flux is further supported by the Guide to the BCA which provides the following examples illustrating the amount of radiant heat necessary to ignite common materials used in buildings and their construction as follows:

Item	Limiting radiant incident heat flux
Timber	Ignition in the absence of a spark 35 kW/m²
	Ignition in the presence of a spark 20 kW/m²
Curtain materials	Ignition in the absence of a spark 20 kW/m²
	Ignition in the presence of a spark 10 kW/m²

Therefore, if it is required that the wall remains imperforate, a limiting value of 20kW/m^2 is appropriate. To provide a reasonable margin of safety, a value of 10kW/m^2 will be adopted on the inside (non fire exposed) side of the wall to address the potential piloted ignition of curtaining materials and the like, should burning embers penetrate the facade.

The surface temperature at which a radiation level of 10kW/m² is emitted can be calculated from the standard radiation formula as follows:

$$q = \phi\varepsilon\sigma(T_s + 273)^4 \quad (1)$$

where T_s = temperature of surface emitting radiation (°C)

q = radiation level (kW/m²)

ϕ = configuration factor

ε = emissivity

σ = Stefan-Boltzmann's constant (5.67×10-8 W/m².K^4)

Rearranging,

$$T_s = \left(\frac{q}{\phi\varepsilon\sigma}\right)^{0.25} - 273 \quad (2)$$

For the situation of a large wall, the configuration factor may be considered to be close to 1. Assuming an emissivity of 0.7, the surface temperature required to generate a radiation of 10kW/m² is about 435°C, using equation (2).

Therefore, the primary criteria for the analysis should be:

- Ignition of the non-fire exposed face of the element (i.e. continuous flaming for more than 15s).
- The measured radiant heat flux emitted from the non-fire side and from any feature more than 0.01m^2 shall not exceed 10kW/m^2. This can be measured directly using a radiometer or the non fire side temperature can be measured in accordance with AS1530.4-2005 and a limiting temperature of 435°C applied to the mean temperature of the non fire side or feature.
- The element shall remain imperforate.

For the majority of applications of BCA Class 7b and 8 buildings, it is unlikely that significant quantities of combustible materials would be stacked in contact with the inner face of the external wall of a building due to the provision of girts and other elements. However, if the building contents are in contact with the internal face of an external wall there could be a localised increase in the temperature at the interface and the materials may be coincident with joints and small openings. It is therefore considered appropriate to introduce a supplementary criterion.

In his review on the ignition of wood, Babrauskas[3] noted that the ignition temperatures at heat fluxes sufficient to cause flaming are 300–365°C for piloted ignition and 380-400°C for spontaneous ignition.

Since the wall is required to be imperforate, a maximum surface temperature rise limit of 380°C measured at any position by thermocouples covered with pads as prescribed in AS 1530.4-2005 is considered reasonable for the supplementary criterion.

A.3.2. Period for application of the supplementary maximum unexposed face temperatures for external walls of Class 7b and 8 Buildings of Type C Construction.

The BCA classification of building and Type of Construction on adjacent allotments cannot be specified or predetermined and therefore it is not possible to characterise the duration of a fire on an adjacent allotment, and therefore, the period of potential external fire exposure.

It is noted that experimental data is available that shows for many applications, the duration for which a fire burns at a high intensity is often short (of the order of 10-20 minutes) but there have been fire incidents where fires have burned for longer durations at high intensities. These longer durations have been considered for the primary criteria assuming no fire brigade intervention.

For the primary criteria which are considered applicable to most applications and required to be consistent with the requirements of BCA Verification Method CV1 and BCA Deemed-to-Satisfy Provision C3.2, an exposure period of 240 minutes inclusive of a 30 minute heating period (refer Figure A.1) is considered reasonable since it would be expected to address the majority of fire durations assuming no fire brigade intervention.

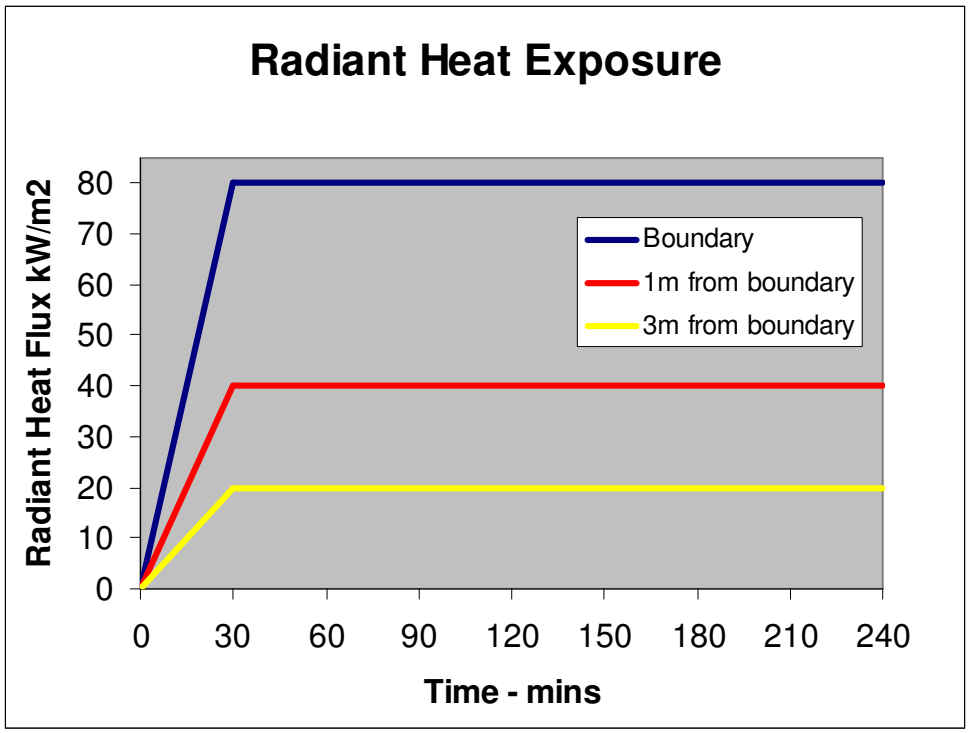

Figure A.1. The radiant heat flux exposures for various distances from the boundary

However, for the purposes of determining the required period that should be applied to the additional criteria of a maximum limiting temperature rise at any point, fire brigade intervention is considered.

Fire Brigade Intervention

Appendix D shows a general application of the Fire Brigade Intervention Model for industrial buildings using conservative values for rural areas. It is recognized that in extreme cases some periods may be longer (eg. isolated country areas, but the frequency of high density industrial buildings in such areas would also be low). Using the target response times for fire brigades as a benchmark, the time of arrival was calculated to be approximately 18.5 minutes, whilst the 90 percentile target for most brigades is under 8 minutes. If the initial fire brigade response has the ability to suppress the fire and/or protect exposures, the threat of fire spread would have been reduced after approximately 23.5 minutes. If additional resources have to be called to protect exposures or the like, it will be approximately 52.5 minutes before the exposures are protected.

The time of an alarm call to the fire brigade will be taken as the time the fire breaks out of the building. At this stage, strong visual, audible and olfactory cues would be provided over large distances. If the building of fire origin is fitted with an automatic fire detection or suppression system connected to a monitoring service or is occupied at the time of the fire a much earlier response would be expected.

Based on the above discussion a reasonable period for application of the supplementary maximum temperature rise criteria would be 60 minutes.

Occupant Evacuation

Appendix C provides a conservative estimate of the time for evacuation of a BCA Class 7b or 8 building of Type C Construction. Evacuation would be expected to be completed within 30 minutes of the breakout of the fire indicating that the 60 minute period for the supplementary requirement for the maximum temperature rise includes a reasonable margin of safety.

A.4. CRITERION FOR STRUCTURAL ADEQUACY OF EXTERNAL WALLS

The BCA Deemed-to-Satisfy Provisions prescribe that load bearing external wall elements within 3 metres of a fire source feature for a Class 7b or 8 building of Type C Construction have a fire resistance level having a structural adequacy component. Therefore, it is considered reasonable that an acceptance criterion be provided to reflect this provision.

BCA Performance Requirement CP1 states that elements are to maintain structural stability, to the degree necessary, during a fire. Therefore, external walls should ensure that the structural adequacy of internal members and members in the external walls is maintained when the external wall is exposed to radiant heat from a building on the adjoining allotment.

The residual load-bearing capacity of members can be assessed based on critical temperatures for steel and concrete members. For tests performed on unloaded specimens a critical temperature of 400°C can be adopted for steel elements in contact with the wall to minimise the risk of premature failure. Structural adequacy shall be maintained throughout the 240 minute test.

A.5. SUMMARY OF FAILURE CRITERIA

In summary, the primary criteria for analysis using BCA Verification Method CV1 should be:

- Ignition of the non-fire exposed face of the element (i.e. continuous flaming for more than 15s).
- The measured radiant heat flux emitted from the non-fire side and from any feature more than 0.01m^2 shall not exceed 10kW/m^2. This can be measured directly using a radiometer or the non fire side temperature can be measured in accordance with AS 1530.4:2005 and a limiting temperature of 435°C applied to the mean temperature of the non fire side or feature.
- The element shall remain imperforate.

In addition,

- The temperature at any point shall not exceed 380°C during the first 60 minutes of the test when measured by thermocouples complying with AS 1530.4-2005.
- The mean temperature of structural steel members should not exceed 400°C during the 240 minute test.

A.6. VALIDITY

This document has been prepared to document the derivation of proposed acceptance criteria for external walls of BCA Class 7b and 8 buildings of Type C Construction as defined in the Building Code of Australia 2016. Whilst due care has been taken during the preparation of this document, no liability will be accepted for any loss or damage resulting from the use of this document in anyway unless the use of the document for a particular application is additionally supported in writing by Exova Warringtonfire Aus Pty Ltd and appropriate test data.

APPENDIX B EVACUATION CALCULATIONS

Based on the requirements of BCA Deemed-to-Satisfy Provisions D1.4 and D1.5 the maximum travel distance to an exit should not exceed 40m.

Assuming a travel speed of 1.2 m/s, the time for evacuation once the occupants have received a fire cue and decided to evacuate would be 34s, assuming no queuing etc. Say 1 minute.

Based on BCA Table D1.3, the maximum occupant density for a factory or storage building is 0.2 person/m^2 (5 persons/m^2 from BCA Table D1.13). The maximum area of a building of Type C Construction is prescribed in BCA Deemed-to-Satisfy Provision C2.2 to be 2,000 m^2. Therefore, the maximum number of occupants would be 400.

Assuming all occupants choose to evacuate through one single leaf doorset, it would take approximately 400s for the entire population to pass through a single door. Say 7 minutes.

A fully developed fire in an adjacent building would tend to provide strong cues and multiple visual, audible and olfactory cues. The fire brigade would be expected to arrive on site within 18.5 minutes of the fire breaking out of the adjacent building.

A conservative allowance of 5 minutes after fire brigade arrival for commencement of fire brigade intervention has been included.

Therefore a very conservative estimate of the evacuation time would be:

Period	Time
Instruction to evacuate from Fire Brigade	18.5 minutes
Preparation and alert time	5 minutes
Travel time	1 minute
Queuing time	7 minutes
Total	~ 32 minutes

APPENDIX C COMMENTARY OF AS1530.4-2005 AND TECHNICAL SPECIFCIATION OF BCA VERIFICATION METHOD CV1

Appendix B7 of AS1530.4-2005 provides an *informative* guide on alternative test procedures, for elements of construction. In a similar vain to fire resistance testing, they are provided as verification methods for the assessment of construction elements considering specific heating regimes and exposure conditions.

It defines a method for carrying out a fire resistance test on elements exposed to different levels of radiant heat using a 3 m × 3 m furnace. The test may be used to obtain data to assess the performance of external walls using verification methods such as CV1 and CV2 of the BCA.

BCA Table CV1 and CV2 are provided to determine exposure conditions to satisfy BCA Verification Method CV1 and CV2.

The performance criteria provided with the appendix states that *the performance of the specimen may be assessed against the criteria specified in Section 3. Additional criteria, such as ignition of the face exposed to radiant heat, may also be applicable.*

The criteria for failure in AS1530.4-2005 are therefore also considered applicable to radiant heat exposure tests. Determination of structural adequacy, integrity and insulation are to be recorded, as well as a radiation component.

Therefore, the expression of results of a radiant heat exposure test to AS1530.4-2005 would state the following:

Fire performance of the walls when exposed to rr kW/m^2 of radiant heat:

(a) structural adequacy, xx minutes; and

(b) integrity yy minutes; and

(c) insulation zz minutes.

NOTE: An alternate heating regime to the standard heating regime specified in Section 2 has been adopted. The results above should not be used as evidence of performance when subjected to the standard heating regime.

This would also be provided with the incident radiant heat flux/time measurements in lieu of the furnace temperature, as stated in Clause B7.4.6 (a) of AS1530.4-2005.

The failure criteria for each component can therefore be stated as follows:

C.1. STRUCTURAL ADEQUACY

Failure in relation to structural adequacy shall be deemed to have occurred upon collapse.

This has been considered similar to condition 4 in Section 4.2 which limits the mean temperature of structural steel members on the inside of the wall system.

C.2. INTEGRITY

Failure in relation to integrity shall be deemed to have occurred upon collapse, the development of cracks, fissures, or other openings through which flames or hot gases can pass, or upon other occurrences. It is deemed to have collapsed when -

- A 6 mm gap gauge can be passed through the specimen so that the gap gauge projects into the furnace and can be moved a distance of 150 mm along the gap;
- Sustained flaming on the surface of the unexposed face for 10 s or longer constitutes integrity failure.

This has been considered similar to conditions 1 and 3 in Section 4.2 with limits in the ignition of the non-fire exposed face of the element (sustained flaming on the surface of the unexposed face for at least 15s in lieu of 10s) and remaining fully imperforate during the test.

C.3. INSULATION

Failure in relation to insulation shall be deemed to have occurred when measurement of insulation is made by thermocouples on the unexposed face and is deemed to have failed when—

1. the average temperature of the unexposed face of the test specimen, as measured by the thermocouples specified in Clause 2.2.3.1, exceeds the initial temperature by more than 140 K; or
2. the temperature at any location on the unexposed face of the test specimen exceeds the initial temperature by more than 180 K.

The temperature at any point on the non fire side not exceeding 380°C was used in the analysis presented in this report based on the discussion in Appendix A.3.1 and the observed performance of combustible materials placed against the test specimen during the test described in report 40981A.

C.4. RADIATION

Failure in relation to radiation shall be deemed to have occurred when the calculated total heat flux at a distance of 365 mm exceeds 10 kW/m^2. This is to be determined in accordance with Appendix A of AS1530.4-2005.

This has been considered as condition 2 in Section 4.2 which provides temperature limits corresponding to 10kW/m^2 at the un-exposed surface of the building element, rather than at a distance of 365mm from the unexposed surface.

APPENDIX D SUPPORTING FBIM ANALYSIS

Activity	Resources	Unit Rate		No. of Units		Activity Time		Elapsed Time	
Fire alarm received by fire brigade								0.0	
notification (assumed by phone call 10 minutes after initiation)		0	s	1		0.0	s	0.0	s
Dispatch resources and travel to fire scene									
Integraph dispatches initial response appliances		30	s	1		30.0	s	30.0	s
firefighters dress, assimilate information and depart station	FF1-6	480	s	1		480.0	s	510.0	s
Initial response appliance travel times to arrival on scene									
- Pumper 1	FF1-3	60	kph	10	km	600	s	1110	s
- Pumper 2	FF4-6	60	kph	10	km	600	s	1110	s
Initial access to site and fire assessment									
P1 & P2 travel through security gate to fire area	FF1-6	8	kph	0	km	16	s	1126	s
OIC investigates fire affected area and assesses exposures	FF1	1	m/s	100	m	83	s	1210	s
radio for additional resources	FF1					30	s	1240	s
additional resources dispatched		60	s	1		60	s	1300	s
OIC discusses building layout and access with security personnel	FF1 & security	90	s	2		240	s	1480	s
Dispatch of additional resources									
firefighters dress, assimilate information and depart station	FF8-12	480	s	1		480	s	1780	s
2nd alarm response appliance travel times to arrival on scene									
- Water tanker 1	FF8-12	60	kph	20	km	1200	s	2980	s
- Rescue 1	FF13-16	60	kph	20	km	1200	s	2980	s
- Pumper 3	FF17-20	60	kph	20	km	1200	s	2980	s
Prepare for firefighting & lay hose lines									
firefighters dismount appliance P1 and don BA	FF2-3	133	s			133	s	1259	s
connect 65mm diameter feed hose from hydrant to P1 and charge	FF2	99	s	1		99	s	1358	s
remove and connect 65mm diameter hose from P1 to branch	FF3	62	s	1		62	s	1321	s
dismount appliance 2 and don BA	FF4-6	133	s			133	s	1259	s
connect 65mm diameter feed hose from hydrant to P2 and charge	FF5	99	s	1		99	s	1358	s
remove and connect 2 off 65mm diameter hose from P2 to branch	FF5-6	62	s	1		62	s	1420	s
prepare monitor of P2	FF6	30	s	1		30	s	1450	s
Apply water to exposures and fire									
charge delivery hoses from P1	FF2	37	s	1		37	s	**1395**	s
maintain control of P1	FF2	duration of fire							
protect exposures of building with hose lines	FF3-4	duration of fire							
charge delivery hoses from P2	FF5	37	s	1		37	s	1457	s
maintain control of P2	FF5	duration of fire							
maintain P2 monitor	FF6	duration of fire							
Arrival of additional 2nd alarm resources									
WT1 travels through security gate	FF7-9	2	kph	0	km	36	s	3016	s
R1 travels through security gate	FF10-12	2	kph	0	km	36	s	3016	s
P3 travels through security gate	FF13-15	2	kph	0	km	36	s	3016	s
firefighters dismount appliance WT1 and don BA	FF7-9	133	s			133	s	3149	s
firefighters dismount appliance R1 and don BA	FF10-12	133	s			133	s	3149	s
firefighters dismount appliance P3 and don BA	FF13-15	133	s			133	s	3149	s
provide hose lines for exposure protection and undertake water relay to ensure supply	FF7-15	duration of fire							