Supporting Construction
—A Guide to Fire Safety

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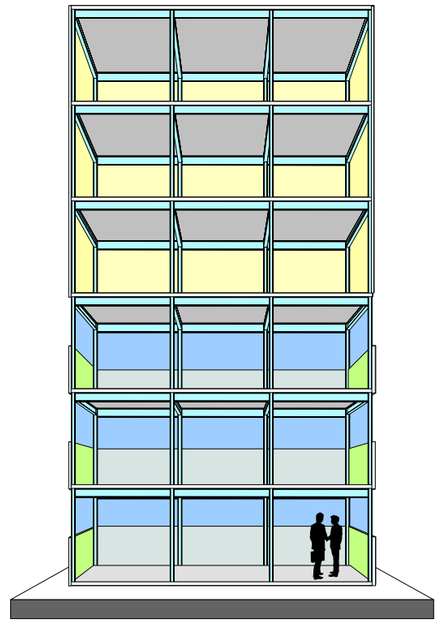

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contents

Introduction 1

Steel Construction 2
The Support of Another Part Provisions 3
This Publication 4

The Clause Explained 5

The Basic Concept of the Provisions 6
The main intent 6
Key terminology 6
Application of the Provisions - Examples 8
Multi-class (multiclassified) building 8
Single-class building 9
Situations Where the Provisions Do Not Apply 10
Element providing lateral support to an external wall 10
Element providing support within a carpark 12
Roof providing lateral support in a building 14
Column providing lateral support to a wall 16
Element providing lateral support to a fire wall or fire-resisting wall 18

Discussion 21

Basis for Exceptions to the Provisions 22
Element providing lateral support to an external wall 22
Element providing support within a carpark 23
Roof providing lateral support in a building 24
Column providing lateral support to a wall 25
Element providing lateral support to a fire wall or fire-resisting wall 26

Clarification of Particular Issues 27

Fire Compartments and Floors 28
Non-essential Elements 31

Research Basis 33

Research Basis 34
Resulting Outcomes 35

References 37
Acknowledgement 37
Appendix A: ESA/M of Steel Sections 38

Abbreviations used:

ESA/M = The ratio of exposed surface area to mass per unit length (see Appendix A for ESA/M of steel sections).

FRL = Fire-resistance level—the grading periods in minutes determined in accordance with BCA Specification A2.3 for the following criteria -
(a) *structural adequacy*; and
(b) *integrity*; and
(c) *insulation*,
and expressed in that order.
Note: A dash means that there is no requirement for that criteria. For example, -/-/- means there is no requirement for an FRL.

FSF = Fire-source feature— means-
(a) the far boundary of a road adjoining the allotment; or
(b) a side or rear boundary of the allotment; or
(c) and external wall of another building on the allotment which is not a Class 10 building.

Definition: **Bare steel** — steel members which have no fire-protective coating.

Introduction

Steel Construction

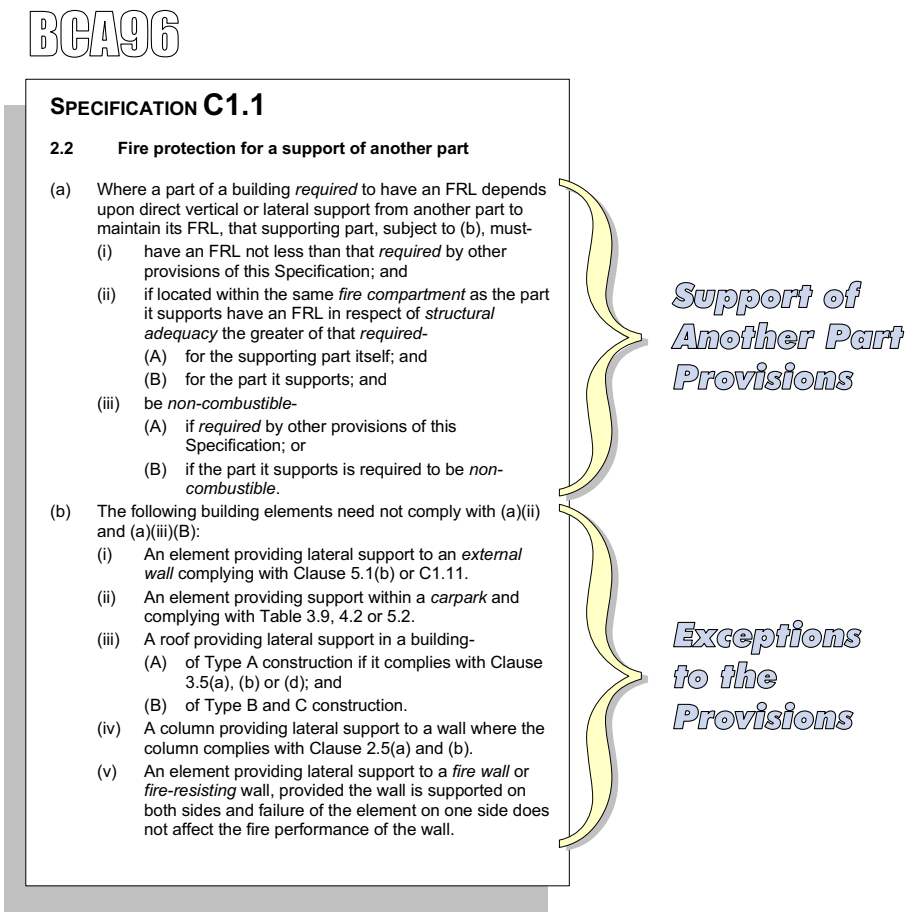
Steel construction is competitive with other forms of construction and offers many advantages including greater usable space, increased flexibility (the ease with which the building can be modified), greater speed of construction, and reduced foundation costs.

The increased use of steel construction has been assisted by changes to the Building Code of Australia (BCA) [1,2] which permits the use of bare steel in many situations. The benefit is significant with savings of up to 25% of the erected steelwork costs. These changes have come about as a result of research programs which have allowed a more realistic understanding of fire and its effect on buildings.

The Support of Another Part Provisions

Changes to the building regulations are often complicated and the resulting *implications* not well understood by building practitioners, particularly those not directly involved with the administration of the regulations. As a result, some of the benefits from regulatory changes are not being realised in practice.

One area of regulatory reform which does not appear to have been well understood is that associated with the *support of another part* provisions in the BCA (Specification C1.1, Clause 2.2).

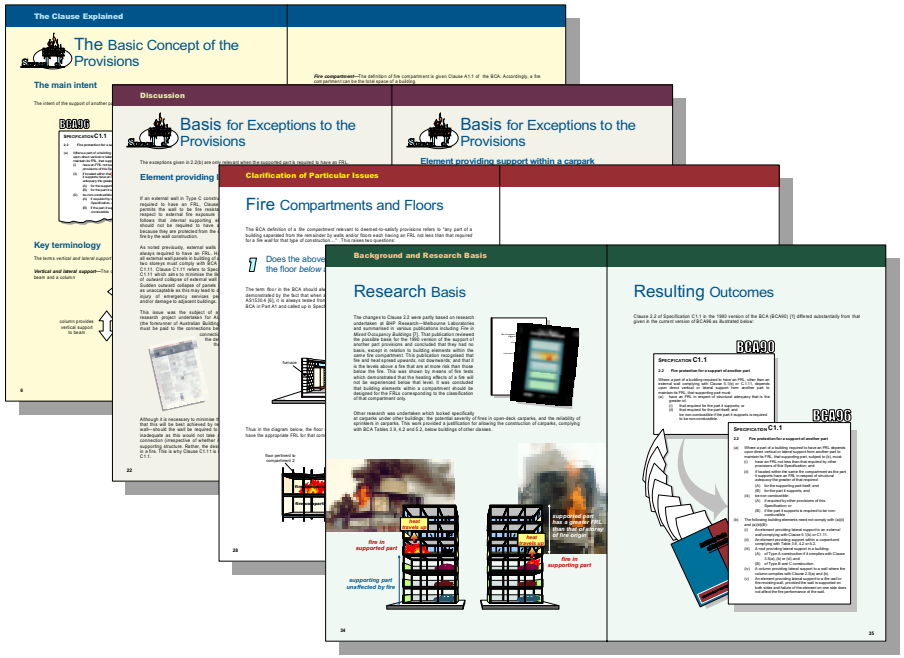


In the 1996 version of the BCA (BCA96) [2], there are exceptions to the provisions and there are many situations for which it is deemed unnecessary to satisfy the provisions of this clause.

This Publication

The purpose of this publication is to:

- illustrate the basic concept of the provisions—Clause 2.2(a)
- illustrate the exceptions to the provisions—Clause 2.2(b)
- explain the basis for the exceptions given in Clause 2.2(b)
- clarify particular issues relating to the current provisions
- outline the research basis leading to the current provisions

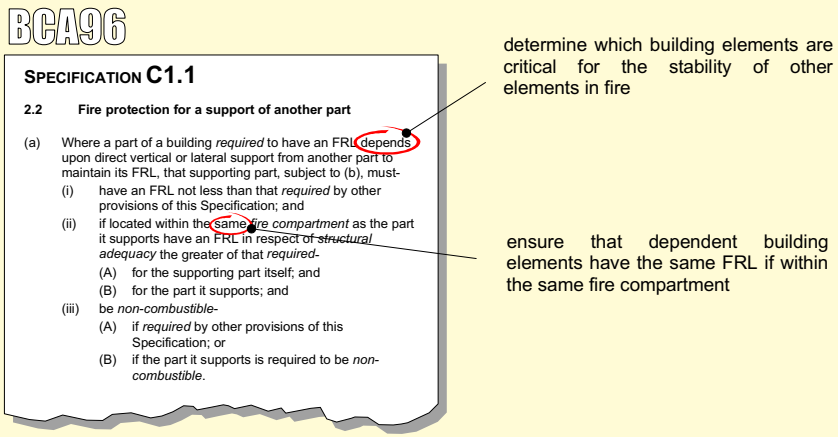


The Clause Explained

The Basic Concept of the Provisions

The main intent

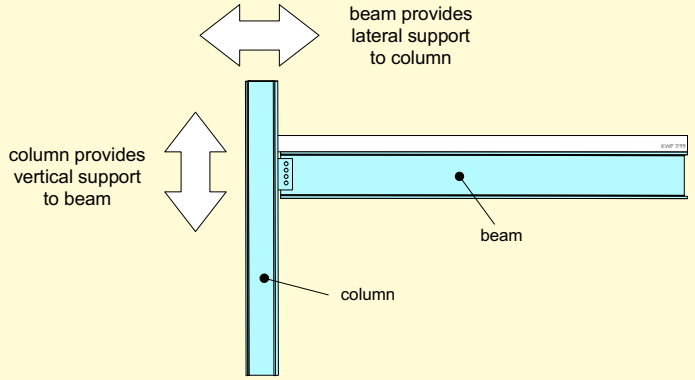
The intent of the support of another part provisions is to get the designer to:



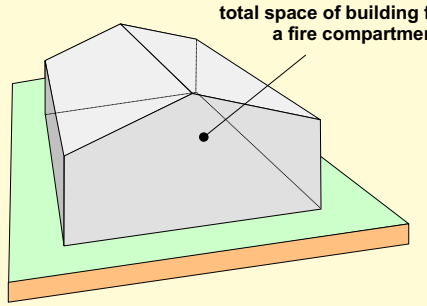
Key terminology

The terms *vertical and lateral support* and *fire compartment* are central to this clause.

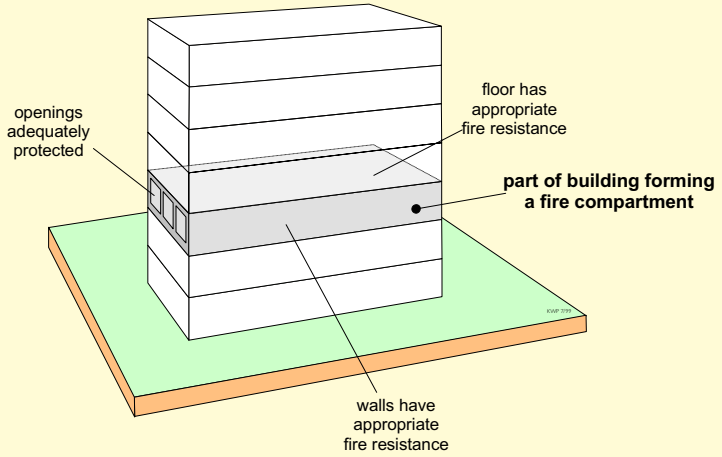
Vertical and lateral support—The diagram below shows vertical and lateral support provided between a beam and a column



Fire compartment—The definition of fire compartment is given Clause A1.1 of the BCA. Accordingly, a fire compartment can be the total space of a building.



It can also be any part of a building separated from the remainder by barriers such as walls and/or floors having an appropriate FRL or resistance to the spread of fire with any openings adequately protected.

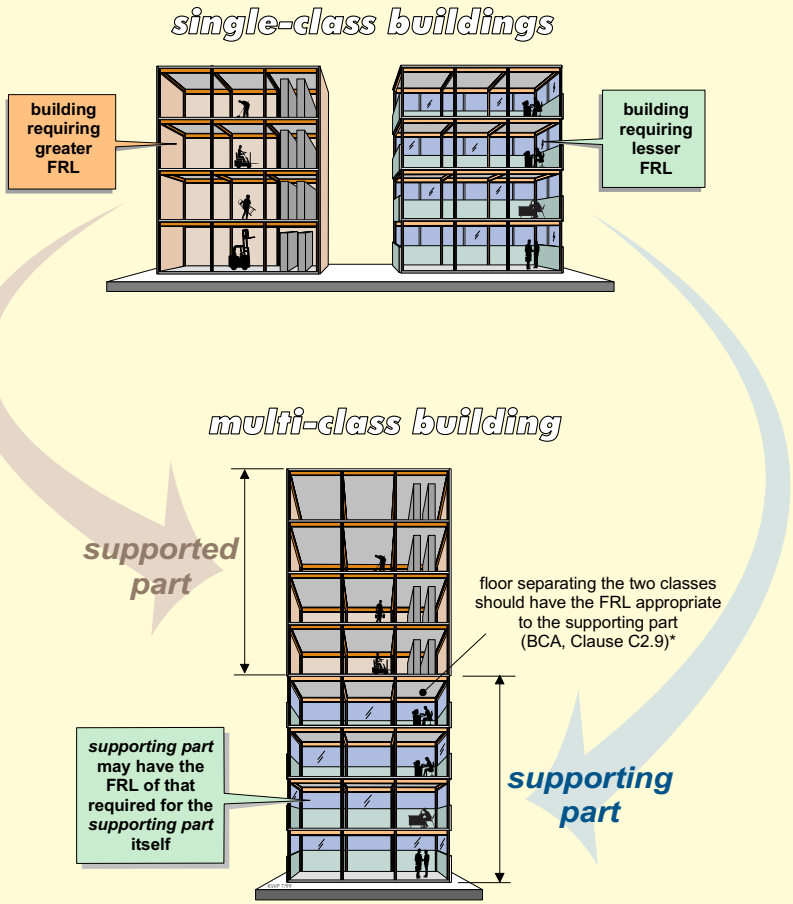


The issue of what constitutes a fire compartment is further discussed under *Fire Compartments and Floors* on pages 28-30 of this publication.

Application of the Provisions - Examples

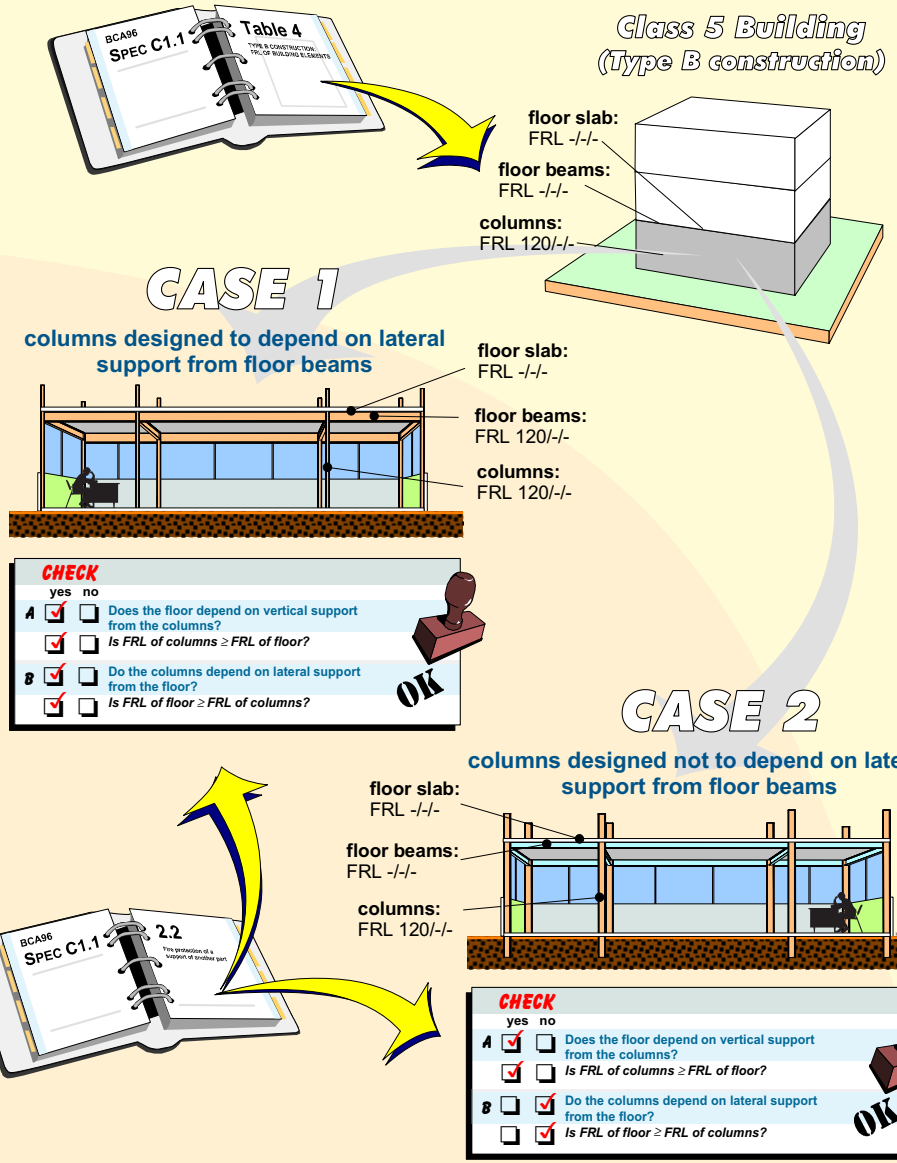
Multi-class (multiclassified) building

The concept that building elements must have an FRL appropriate to the relevant fire compartments is very significant for multi-storey, multi-class buildings. This is illustrated below:



* This issue is further discussed under *Fire Compartments and Floors* on pages 28-30 of this publication.

Single-class building



Situations Where the Provisions Do Not Apply

Clause 2.2(b) lists five situations where the provisions of Clause 2.2(a)(ii) and (a)(iii)(B) do not apply. These are now considered in order. A detailed discussion of these situations is given in the next section—*Basis for Exceptions to the Provisions.*

Element providing lateral support to an external wall

BCA96

SPECIFICATION C1.1

2.2 Fire protection for a support of another part

(a) Where a part of a building *required* to have an FRL depends upon direct vertical or lateral support from another part to maintain its FRL, that supporting part, subject to (b), must-

- (i) have an FRL not less than that *required* by other provisions of this Specification; and
- (ii) if located within the same *fire compartment* as the part it supports have an FRL in respect of *structural adequacy* the greater of that *required*-
  - (A) for the supporting part itself; and
  - (B) for the part it supports; and
- (iii) be *non-combustible*-
  - (A) if *required* by other provisions of this Specification; or
  - (B) if the part it supports is required to be *non-combustible*.

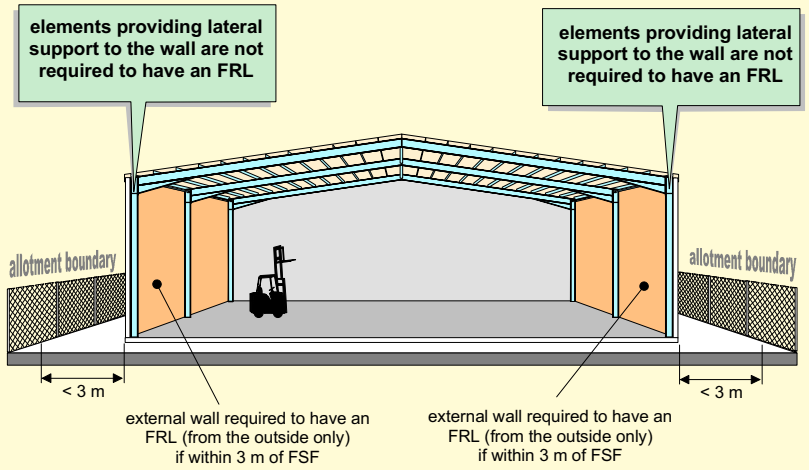
(b) The following building elements need not comply with (a)(ii) and (a)(iii)(B):

- (i) An element providing lateral support to an *external wall* complying with Clause 5.1(b) or C1.11.
- (ii) An element providing support within a *carpark* and complying with Table 3.9, 4.2 or 5.2.
- (iii) A roof providing lateral support in a building-
  - (A) of Type A construction if it complies with Clause 3.5(a), (b) or (d); and
  - (B) of Type B and C construction.
- (iv) A column providing lateral support to a wall where the column complies with Clause 2.5(a) and (b).
- (v) An element providing lateral support to a *fire wall* or *fire-resisting* wall, provided the wall is supported on both sides and failure of the element on one side does not affect the fire performance of the wall.

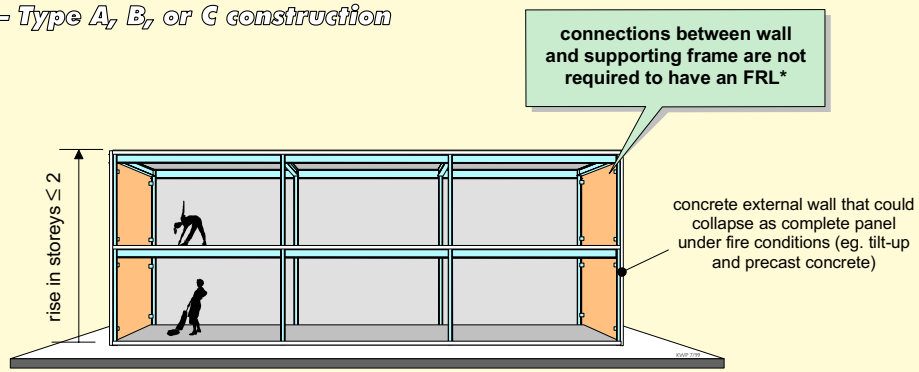
***Clause 5.1(b)**—This states that external walls for Type C construction need to be fire resistant from the outside only*

***Clause C1.11**—This is aimed at minimising the likelihood of outwards collapse of external walls under fire conditions*

Clause 5.1(b) — Type C construction



Clause C1.11 — Type A, B, or C construction



* If the connections are critical to prevent outward collapse of the wall, they must be designed to achieve this outcome (see BCA Clause C1.11 and further discussion on page 22).

Situations Where the Provisions Do Not Apply

Element providing support within a carpark

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SPECIFICATION C1.1

2.2 Fire protection for a support of another part

(a) Where a part of a building *required* to have an FRL depends upon direct vertical or lateral support from another part to maintain its FRL, that supporting part, subject to (b), must-

(i) have an FRL not less than that *required* by other provisions of this Specification; and

(ii) if located within the same *fire compartment* as the part it supports have an FRL in respect of *structural adequacy* the greater of that *required*-

(A) for the supporting part itself; and

(B) for the part it supports; and

(iii) be *non-combustible*-

(A) if *required* by other provisions of this Specification; or

(B) if the part it supports is required to be *non-combustible*.

(b) The following building elements need not comply with (a)(ii) and (a)(iii)(B):

(i) An element providing lateral support to an *external wall* complying with Clause 5.1(b) or C1.11.

(ii) An element providing support within a *carpark* and complying with Table 3.9, 4.2 or 5.2.

(iii) A roof providing lateral support in a building-

(A) of Type A construction if it complies with Clause 3.5(a), (b) or (d); and

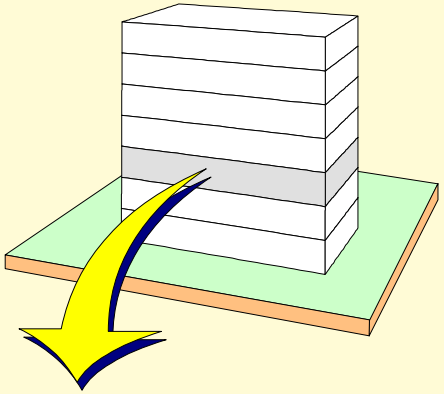
(B) of Type B and C construction.

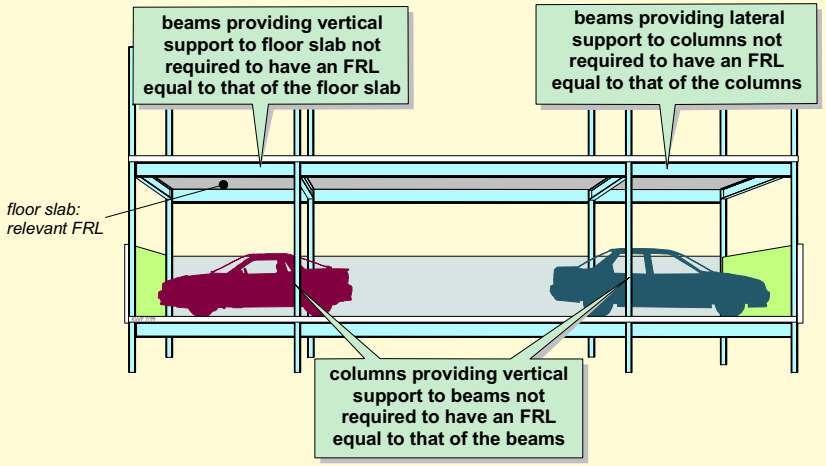
(iv) A column providing lateral support to a wall where the column complies with Clause 2.5(a) and (b).

(v) An element providing lateral support to a *fire wall* or *fire-resisting* wall, provided the wall is supported on both sides and failure of the element on one side does not affect the fire performance of the wall.

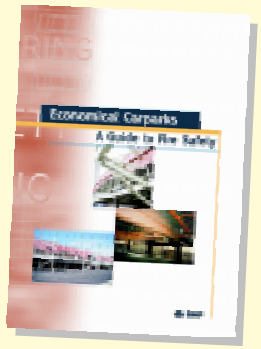
Table 3.9, 4.2 or 5.2 *—This was added to allow what is currently permitted for open-deck or sprinklered carparks*

Table 3.9, 4.2 or 5.2 — open-deck or sprinklered carparks in Type A, B or C construction





The specific BCA deemed-to-satisfy provisions for carparks and multiclassified buildings incorporating carparks have been described in detail in another publication [3]. This publication also presents some *alternative solutions* for multiclassified buildings incorporating carparks.



Situations Where the Provisions Do Not Apply

Roof providing lateral support in a building

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SPECIFICATION C1.1

2.2 Fire protection for a support of another part

(a) Where a part of a building *required* to have an FRL depends upon direct vertical or lateral support from another part to maintain its FRL, that supporting part, subject to (b), must-

(i) have an FRL not less than that *required* by other provisions of this Specification; and

(ii) if located within the same *fire compartment* as the part it supports have an FRL in respect of *structural adequacy* the greater of that *required*-

(A) for the supporting part itself; and

(B) for the part it supports; and

(iii) be *non-combustible*-

(A) if *required* by other provisions of this Specification; or

(B) if the part it supports is required to be *non-combustible*.

(b) The following building elements need not comply with (a)(ii) and (a)(iii)(B):

(i) An element providing lateral support to an *external wall* complying with Clause 5.1(b) or C1.11.

(ii) An element providing support within a *carpark* and complying with Table 3.9, 4.2 or 5.2.

(iii) A roof providing lateral support in a building-

(A) of Type A construction if it complies with Clause 3.5(a), (b) or (d); and

(B) of Type B and C construction.

(iv) A column providing lateral support to a wall where the column complies with Clause 2.5(a) and (b).

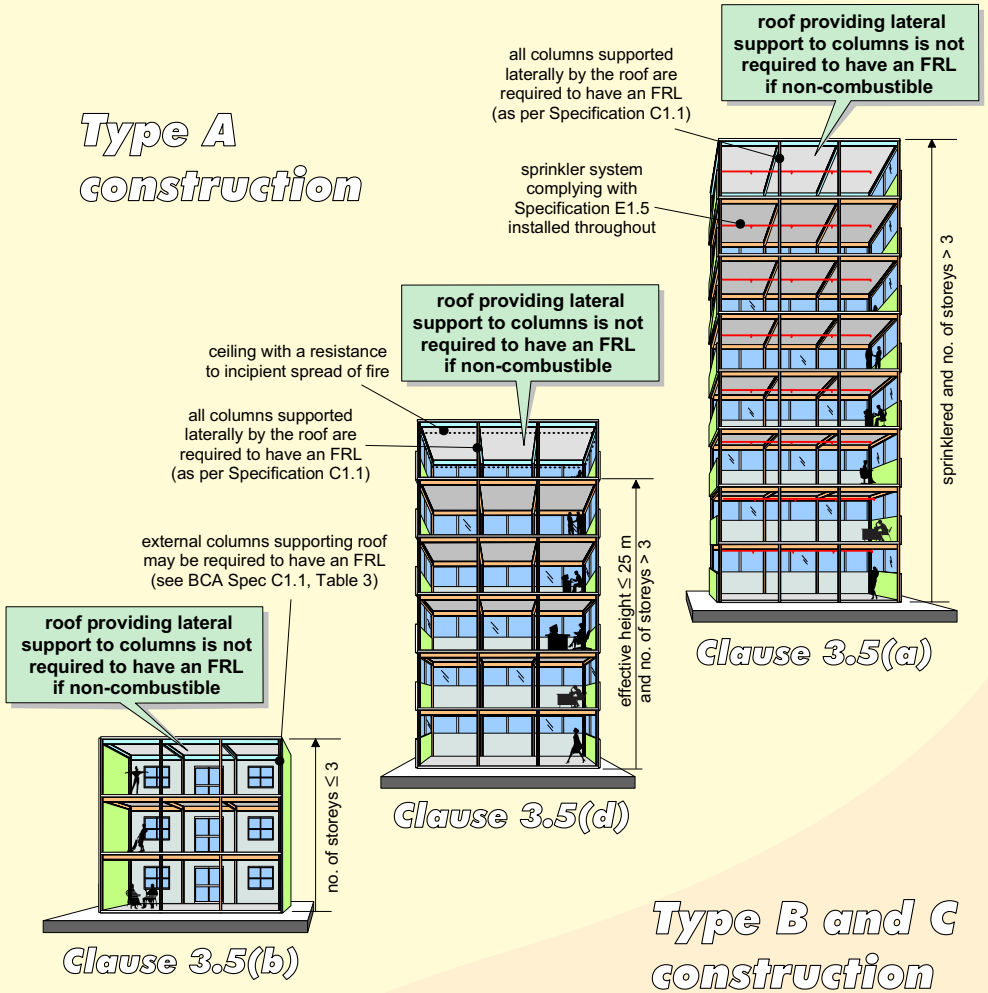
(v) An element providing lateral support to a *fire wall* or *fire-resisting* wall, provided the wall is supported on both sides and failure of the element on one side does not affect the fire performance of the wall.

Clause 3.5(a)—*has a sprinkler system complying with Specification E1.5 installed throughout*

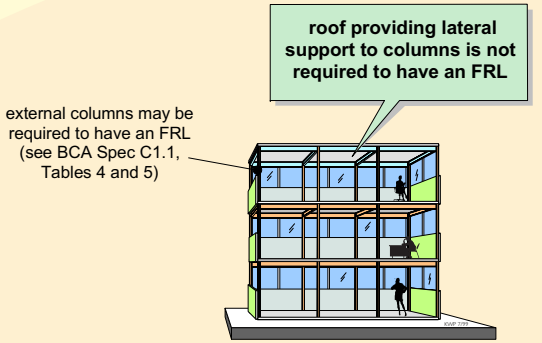
Clause 3.5(b)—*has a rise in storeys of 3 or less*

Clause 3.5(d)—*has an effective height of not more than 25 m and the ceiling immediately below the roof has a resistance to the incipient spread of fire to the roof space of not less than 60 minutes*

Type A construction



Type B and C construction



Situations Where the Provisions Do Not Apply

Column providing lateral support to a wall

BCA96

SPECIFICATION C1.1

2.2 Fire protection for a support of another part

(a) Where a part of a building *required* to have an FRL depends upon direct vertical or lateral support from another part to maintain its FRL, that supporting part, subject to (b), must-

(i) have an FRL not less than that *required* by other provisions of this Specification; and

(ii) if located within the same *fire compartment* as the part it supports have an FRL in respect of *structural adequacy* the greater of that *required*-

(A) for the supporting part itself; and

(B) for the part it supports; and

(iii) be *non-combustible*-

(A) if *required* by other provisions of this Specification; or

(B) if the part it supports is required to be *non-combustible*.

(b) The following building elements need not comply with (a)(ii) and (a)(iii)(B):

(i) An element providing lateral support to an *external wall* complying with Clause 5.1(b) or C1.11.

(ii) An element providing support within a *carpark* and complying with Table 3.9, 4.2 or 5.2.

(iii) A roof providing lateral support in a building-

(A) of Type A construction if it complies with Clause 3.5(a), (b) or (d); and

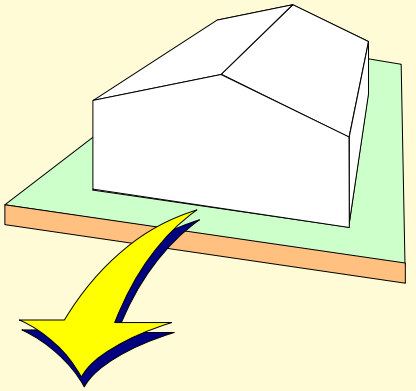
(B) of Type B and C construction.

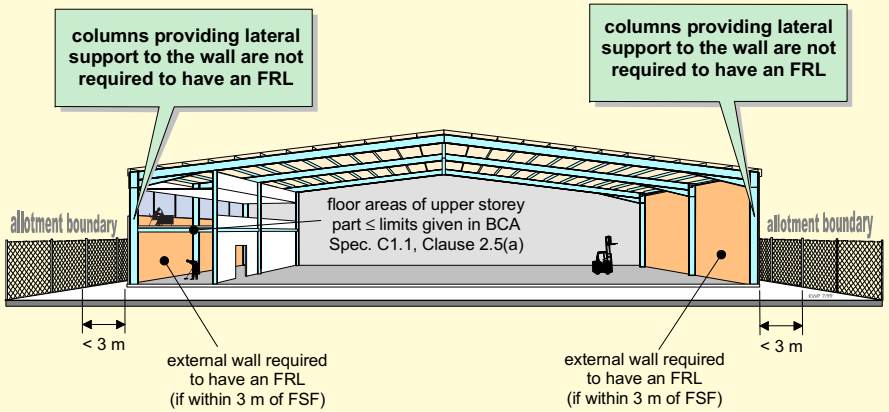
(iv) A column providing lateral support to a wall where the column complies with Clause 2.5(a) and (b).

(v) An element providing lateral support to a *fire wall* or *fire-resisting* wall, provided the wall is supported on both sides and failure of the element on one side does not affect the fire performance of the wall.

This clause states that steel columns in a single-storey building (which may contain a 2 storey part) need not have an FRL

Clause 2.5(a) and (b) — Type A, B or C construction





Situations Where the Provisions Do Not Apply

Element providing lateral support to a fire wall or fire-resisting wall

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SPECIFICATION C1.1

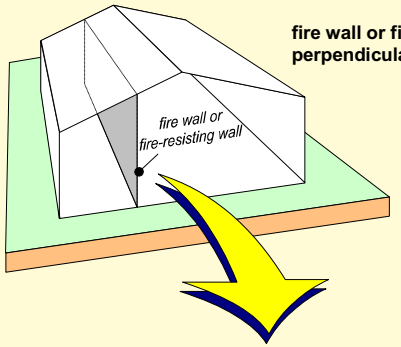
2.2 Fire protection for a support of another part

(a) Where a part of a building *required* to have an FRL depends upon direct vertical or lateral support from another part to maintain its FRL, that supporting part, subject to (b), must-

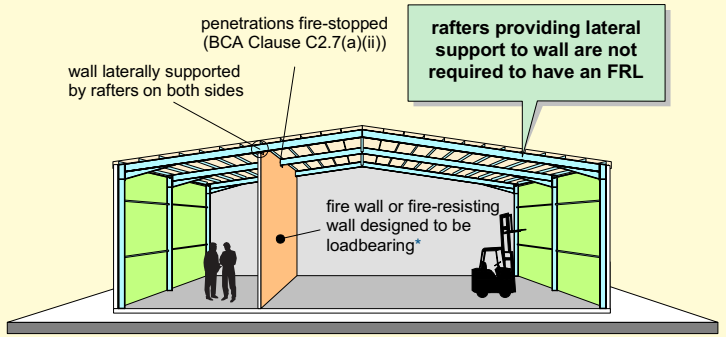
- (i) have an FRL not less than that *required* by other provisions of this Specification; and
- (ii) if located within the same *fire compartment* as the part it supports have an FRL in respect of *structural adequacy* the greater of that *required*-
  - (A) for the supporting part itself; and
  - (B) for the part it supports; and
- (iii) be *non-combustible*-
  - (A) if *required* by other provisions of this Specification; or
  - (B) if the part it supports is required to be *non-combustible*.

(b) The following building elements need not comply with (a)(ii) and (a)(iii)(B):

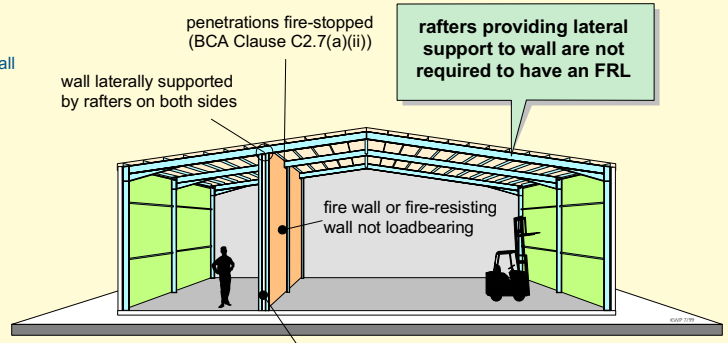
- (i) An element providing lateral support to an *external wall* complying with Clause 5.1(b) or C1.11.
- (ii) An element providing support within a *carpark* and complying with Table 3.9, 4.2 or 5.2.
- (iii) A roof providing lateral support in a building-
  - (A) of Type A construction if it complies with Clause 3.5(a), (b) or (d); and
  - (B) of Type B and C construction.
- (iv) A column providing lateral support to a wall where the column complies with Clause 2.5(a) and (b).
- (v) An element providing lateral support to a *fire wall* or *fire-resisting* wall, provided the wall is supported on both sides and failure of the element on one side does not affect the fire performance of the wall.



Type A, B or C construction

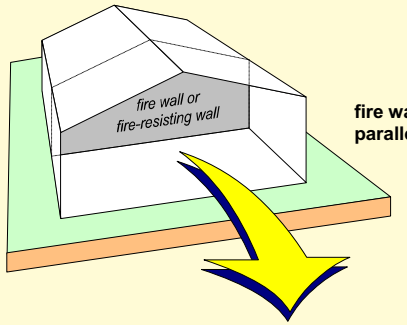


*designed to carry additional load from the roof assuming fire on one side of wall



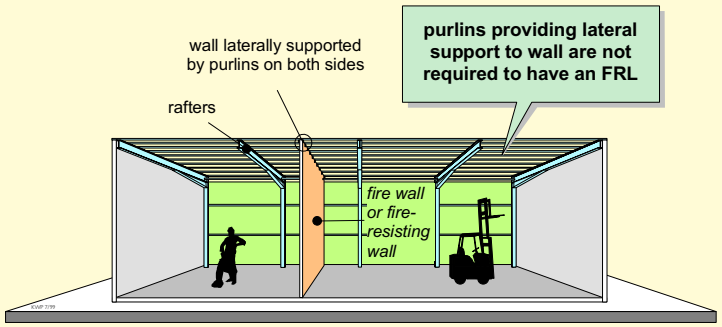
Situations Where the Provisions Do Not Apply

Element providing lateral support to a fire wall or fire-resisting wall (continued)



fire wall or fire-resisting wall parallel to rafters

Type A, B or C construction



Discussion

Basis for Exceptions to the Provisions

The exceptions given in 2.2(b) are only relevant when the supported part is required to have an FRL.

Element providing lateral support to an external wall

If an external wall in Type C construction is required to have an FRL, Clause 5.1(b) permits the wall to be fire resistant with respect to external fire exposure only. It follows that *internal* supporting elements should not be required to have an FRL because they are protected from the external fire by the wall construction.

As noted previously, external walls are not always required to have an FRL. However, all external wall panels in building of one and two storeys must comply with BCA Clause C1.11. Clause C1.11 refers to Specification C1.11 which aims to minimise the likelihood of *outward* collapse of external wall panels. Sudden outward collapse of panels is seen as unacceptable as this may lead to death or injury of emergency services personnel and/or damage to adjacent buildings.

BCA96

SPECIFICATION C1.1

2.2 Fire protection for a support of another part

(a) Where a part of a building ... depends

(b) The following building elements need not comply with (a)(ii) and (a)(iii)(B):

(i) An element providing lateral support to an *external wall* complying with Clause 5.1(b) or C1.11.

(ii) An element providing support within a *carpark* and complying with Table 3.9, 4.2 or 5.2.

(iii) A roof providing lateral support in a building-

(A) of Type A construction if it complies with Clause 3.5(a), (b) or (d); and

(B) of Type B and C construction.

(iv) A column providing lateral support to a wall where the column complies with Clause 2.5(a) and (b).

(v) An element providing lateral support to a *fire wall* or *fire-resisting* wall, provided the wall is supported on both sides and failure of the element on one side does not affect the fire performance of the wall.

This issue was the subject of a major research project undertaken for AUBRCC (the forerunner of Australian Building Codes Board (ABCB)) in which it was found that specific attention must be paid to the connections between the supporting structure and the attached wall panels. Such connections can be subject to forces which are generated not only because of the deformation of the panels but also due to differential movement between the panel and the supporting structure. There are many possible solutions; however one, which was the subject of a considerable research effort, is described in the technical publication, *Support of External Walls in Fire* [4] and gives some standard connection details suitable for single storey steel-framed buildings.

deformable column tie

Although it is necessary to minimise the likelihood of external panels collapsing outwards, it is not considered that this will be best achieved by requiring the relevant connections, etc, to have the same FRL as the wall—should the wall be required to have an FRL. In its simplest form, specification of an FRL would be inadequate as this would not take account of the potentially large forces that could develop within the connection (irrespective of whether it is cool or hot) due to differential movement between the walls and supporting structure. Rather, the designer must assess the likely real performance of the proposed solution in a fire. This is why Clause C1.11 is not considered to fall within the scope of Clause 2.2 (a) of Specification C1.1.

Basis for Exceptions to the Provisions

Element providing support within a carpark

The exclusion of open-deck or sprinklered carparks from Clause 2.2(a) is deliberate and related to the fact that building elements within the carpark levels designed in accordance with BCA Clauses 3.9, 4.2 and 5.2 of Specification C1.1 have different levels of fire resistance. For example, the floor slabs are required to have an FRL of 60/60/60 whereas the beams and columns can be of bare steel provided the elements have an exposed surface area-to-mass ratio (ESA/M) less than the specified values. The reason for this apparent anomaly is two-fold:

BCA96

SPECIFICATION C1.1

2.2 Fire protection for a support of another part

(a) Where a part of a building ... depends

(b) The following building elements need not comply with (a)(ii) and (a)(iii)(B):

(i) An element providing lateral support to an *external wall* complying with Clause 5.1(b) or C1.11.

(ii) An element providing support within a *carpark* and complying with Table 3.9, 4.2 or 5.2.

(iii) A roof providing lateral support in a building-

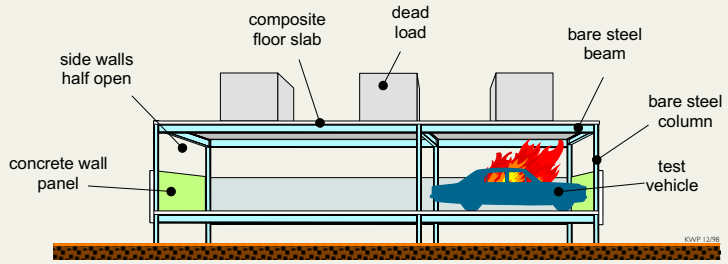
(A) of Type A construction if it complies with Clause 3.5(a), (b) or (d); and

(B) of Type B and C construction.

(iv) A column providing lateral support to a wall where the column complies with Clause 2.5(a) and (b).

(v) An element providing lateral support to a *fire wall* or *fire-resisting* wall, provided the wall is supported on both sides and failure of the element on one side does not affect the fire performance of the wall.

i. Fire tests have indicated the appropriateness of the limiting values of ESA/M specified by Tables 3.9, 4.2 and 5.2 of Specification C1.1 for steel beams and columns within carparks. The tests were conducted in a carpark building with a concrete floor slab having a thickness of 120 mm which would normally be considered to achieve an FRL, with respect to insulation, of 120 minutes. However, the fires experienced had a much lower severity than that represented by a standard fire exposure of 120 minutes. Therefore, an FRL of 60/60/60 was specified for the floor slabs in open-deck or sprinklered carparks as this was considered to be likely to correspond to a *practical* minimum with respect to the concrete floor construction generally used in these buildings. The FRL required in open-deck or sprinklered carpark buildings is substantially less than this but it is difficult to construct a concrete slab with a lower inherent fire resistance.



ii. In multiclassified buildings incorporating carparks, where the carpark forms the lower levels, the carpark floor slab must provide fire separation with respect to a fire in the level *above* the carpark. It is considered that an FRL of 60/60/60 is appropriate in this situation which is discussed further in this publication in *Fire Compartments and Floors* (see pages 28-30).

Basis for Exceptions to the Provisions

Roof providing lateral support in a building

Clause 2.2 (b)(iii) recognises that roofs which do not have an FRL may be attached to supporting building elements which are required to have an FRL.

In the case of a sprinklered building, the failure of the roof is seen as unlikely due to the fact that insufficient heat will be generated to result in distress of the roof. In the case of unsprinklered buildings having a effective height of up to 25 m, the provision of a fire-resistant ceiling (ie. a ceiling with a resistance to incipient spread of fire) is seen as providing sufficient protection to the roof.

Roofs of buildings of up to three storeys (Type A, B and C) are not required to have an FRL. Possible reasons for this are shown below.

BCA96

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(i) An element providing lateral support to an *external wall* complying with Clause 5.1(b) or C1.11.

(ii) An element providing support within a *carpark* and complying with Table 3.9, 4.2 or 5.2.

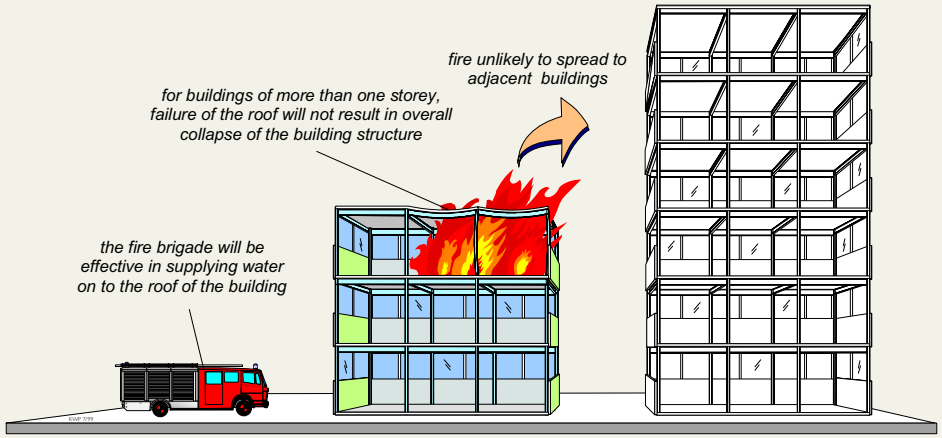
(iii) A roof providing lateral support in a building-

(A) of Type A construction if it complies with Clause 3.5(a), (b) or (d); and

(B) of Type B and C construction.

(iv) A column providing lateral support to a wall where the column complies with Clause 2.5(a) and (b).

(v) An element providing lateral support to a *fire wall* or *fire-resisting* wall, provided the wall is supported on both sides and failure of the element on one side does not affect the fire performance of the wall.



Basis for Exceptions to the Provisions

Column providing lateral support to a wall

Clause 2.2(b)(iv) allows the use of bare steel columns in combination with external walls having an FRL (and internal walls other than fire walls and common walls), and relates to the vast majority of single-storey factories and warehouses. This clause, in combination with the previous one, means that bare steel construction can be used for the majority of single-storey steel frames, even if the external walls are required to have an FRL. This concession has been permitted on the basis of real-life experience.

BCA96

SPECIFICATION C1.1

2.2 Fire protection for a support of another part

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(iii) A roof providing lateral support in a building-

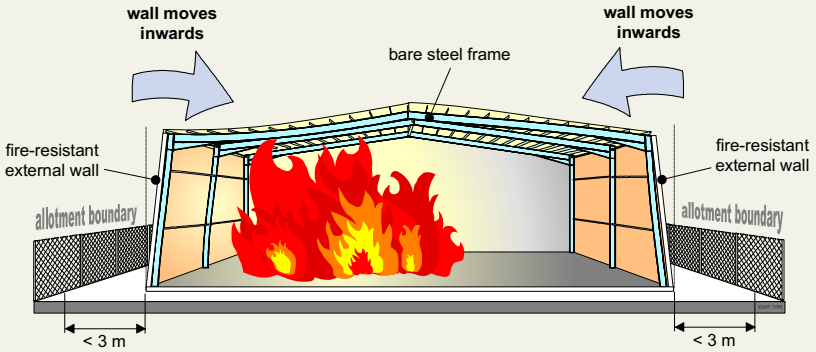
(A) of Type A construction if it complies with Clause 3.5(a), (b) or (d); and

(B) of Type B and C construction.

(iv) A column providing lateral support to a wall where the column complies with Clause 2.5(a) and (b).

(v) An element providing lateral support to a *fire wall* or *fire-resisting* wall, provided the wall is supported on both sides and failure of the element on one side does not affect the fire performance of the wall.

A detailed study of the behaviour of these buildings in fire has been undertaken and is described in [5].



This study, based on analytical considerations, concluded that bare steel frames, when used in combination with concrete external walls (which may be required to have an FRL) will *not* collapse outwards (thereby avoiding potential injury to emergency services personnel or damage to adjacent property) and will provide a level of fire separation essentially equivalent to that which would be achieved should the columns and rafters be protected.

Basis for Exceptions to the Provisions

Element providing lateral support to a fire wall or fire-resisting wall

Clause 2.2(b)(v) recognises that it is reasonable to assume that a fire is restricted to a single fire compartment. This is implicitly assumed throughout the BCA and means that although elements supporting one side of a fire wall may become very hot and perhaps collapse, the wall will remain in place provided elements within the other compartment (in which the supporting elements are cool) provide adequate lateral and/or vertical support.

BCA96

SPECIFICATION C1.1

2.2 Fire protection for a support of another part

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(i) An element providing lateral support to an *external wall* complying with Clause 5.1(b) or C1.11.

(ii) An element providing support within a *carpark* and complying with Table 3.9, 4.2 or 5.2.

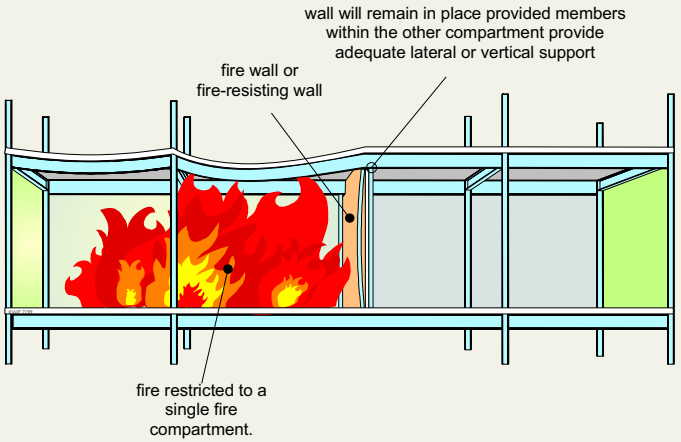
(iii) A roof providing lateral support in a building-

(A) of Type A construction if it complies with Clause 3.5(a), (b) or (d); and

(B) of Type B and C construction.

(iv) A column providing lateral support to a wall where the column complies with Clause 2.5(a) and (b).

(v) An element providing lateral support to a *fire wall* or *fire-resisting* wall, provided the wall is supported on both sides and failure of the element on one side does not affect the fire performance of the wall.



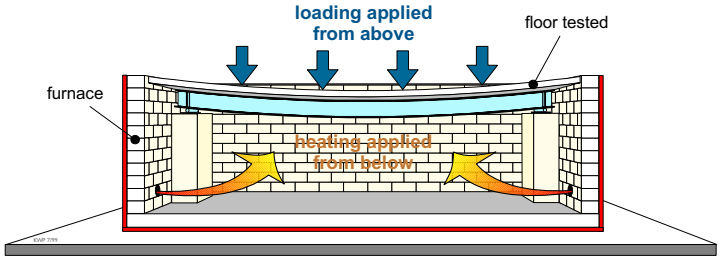
Clarification of Particular Issues

Fire Compartments and Floors

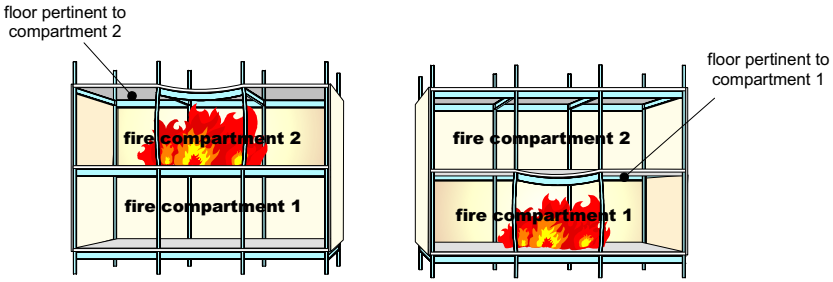
The BCA definition of a *fire compartment* relevant to deemed-to-satisfy provisions refers to "any part of a building saparated from the remainder by walls and/or floors each having an FRL not less than that *required* for a *fire wall* for that type of construction...." . This raises two questions:

1 Does the above definition imply that the floor *above* and the floor *below* are within the same fire compartment?

The term *floor* in the BCA should always be taken as referring to the *floor above*. That this is the case, is demonstrated by the fact that when a floor is tested under standard fire test conditions in accordance with AS1530.4 [6], it is always tested from below, never from above. This testing standard is referenced by the BCA in Part A1 and called up in Specification A2.3.



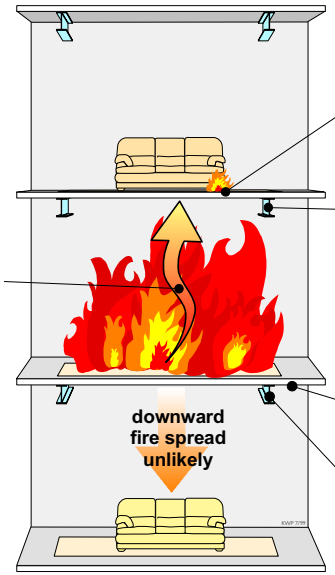
Thus in the diagram below, the floor should be considered as the *floor above* the compartment and should have the appropriate FRL for that compartment (see also BCA Clause C2.9).



There are a number of reasons why it is appropriate for the floor *above* to be the focus rather than the floor below.

compartment of fire origin

The severity of a fire is generally significantly less at the bottom of a compartment compared with the top, due to shielding from the fire load and lower heating due to bouyancy of hot gases.



floor *above*

Combustibles are often in contact with the upper surface of the floor (e.g. carpet, stored items). This may result in fire spread if the unexposed surface temperatures become too high or gaps or fissures develop.

The supporting elements and the slab are exposed to the same fire as that in the compartment of fire origin.

floor *below*

Significant combustibles are rarely positioned in direct contact with the *underside* of the floor and fire spread is therefore unlikely.

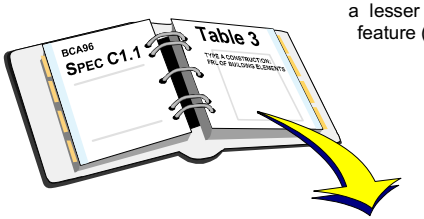
The fire will have little influence on the supporting beams, as heating of the beam will only occur via conduction through the slab and the bottom flange and web will remain cool.

In summary, the FRL required by the floor *below* with respect to a fire in the compartment *above* can be substantially less than that specified for the floor above. Nevertheless, the above comments assume that the floor slab below will remain in place throughout a fire and will have some resistance to heat flow. What then, is an acceptable FRL for the floor slab that will be consistent with current deemed-to-satisfy provisions? An FRL of 60/60/60 is considered appropriate.

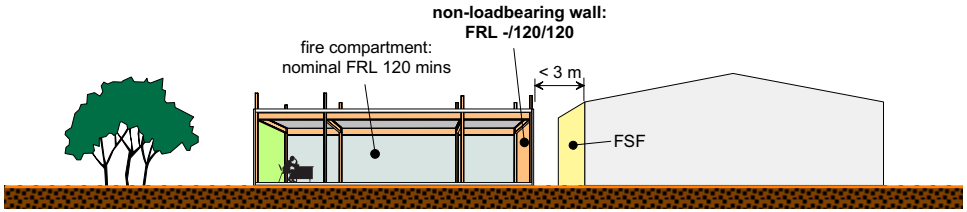
2 What FRLs are required within a fire compartment?

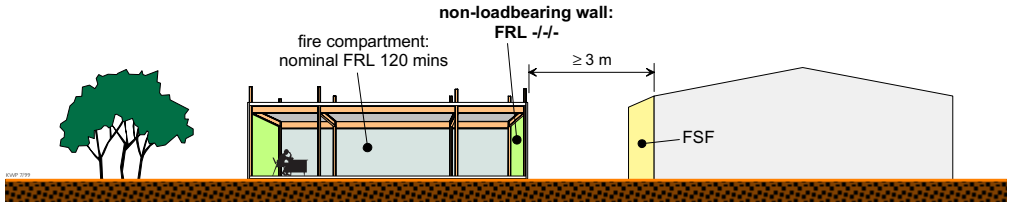
If the BCA definition is taken literally, the relevant boundary elements (floor above and walls) must have the same FRL as that required for a fire wall within the compartment.

However, this would appear to be in contradiction to other parts of the BCA: for example, Table 3 of Specification C1.1 allows non-loadbearing external walls to have a lesser FRL depending on the distance to the fire-source feature (FSF).



Class 5 Building
(Type A construction)





The fact that the BCA allows the use of building elements having a lesser FRL within a fire compartment means that it is intended that such is acceptable and the use of such elements is not considered to compromise the level of fire safety within a building. It is the opinion of the authors that the definition of *fire compartment* in BCA (Clause A1.1 Fire compartment (b)(ii)) should read as follows:

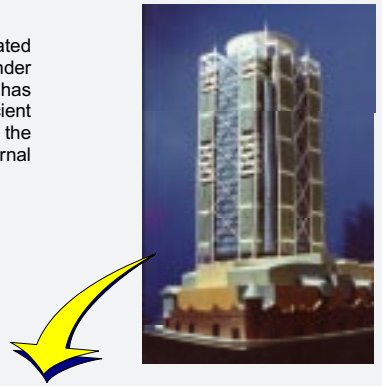
> ***Fire compartment — any part of a building separated by walls and/or floors each having an FRL not less than that required by the deemed-to-satisfy provisions of the relevant Part***

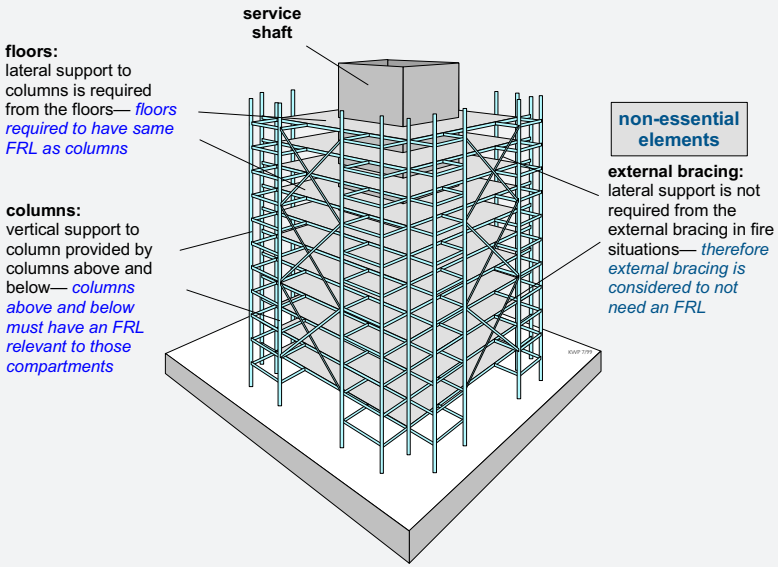
Non-essential Elements

The term *non-essential element* refers to a building element that has a significant role in non-fire conditions (eg. to limit deflection under extreme wind or service loads) but no *necessary* function under fire conditions. That is, the engineer has designed the building such that if such an element was absent, this would not prevent any supported element from achieving the required FRL.

Example 1: External bracing

The external bracing shown for the illustrated building has been provided to limit lateral drift under extreme wind conditions. However, the building has been designed, such that in fire situations, sufficient lateral support to the columns is provided by the floors and the braced service shaft—the external bracing not being required for this purpose.



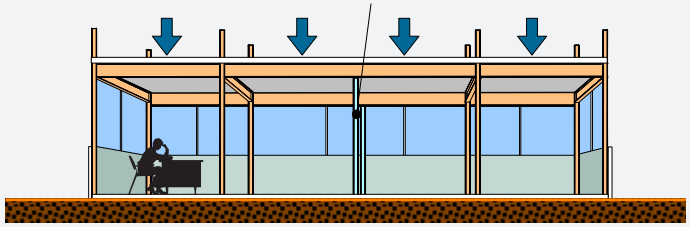


Example 2: Propping column

Similarly, the column at the midspan of the beam shown below has been designed to limit deflection under imposed live loads but is not needed for beam support under fire conditions.

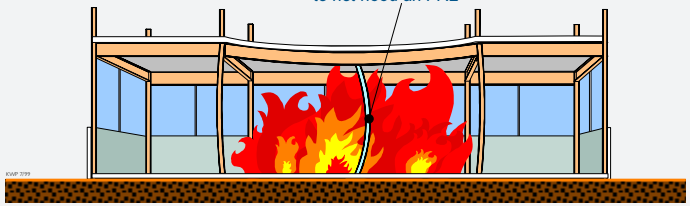
non-essential elements

propping columns: designed to limit deflection under imposed live loads



propping columns: not needed for beam support under fire condition

∴ propping columns are considered to not need an FRL



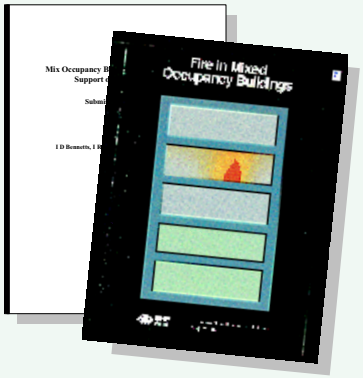
Since failure of a non-essential element in fire will not reduce the fire resistance of the supported elements below the required values, it follows that this element does not need to have an FRL. This, however, is not recognised by the BCA deemed-to-satisfy provisions as these elements may be required to have an FRL by Specification C1.1 (eg. *all* internal columns in a Class 5, Type A construction are required to an FRL of 120/-/-).

It is recommended therefore, that non-essential elements need not have an FRL

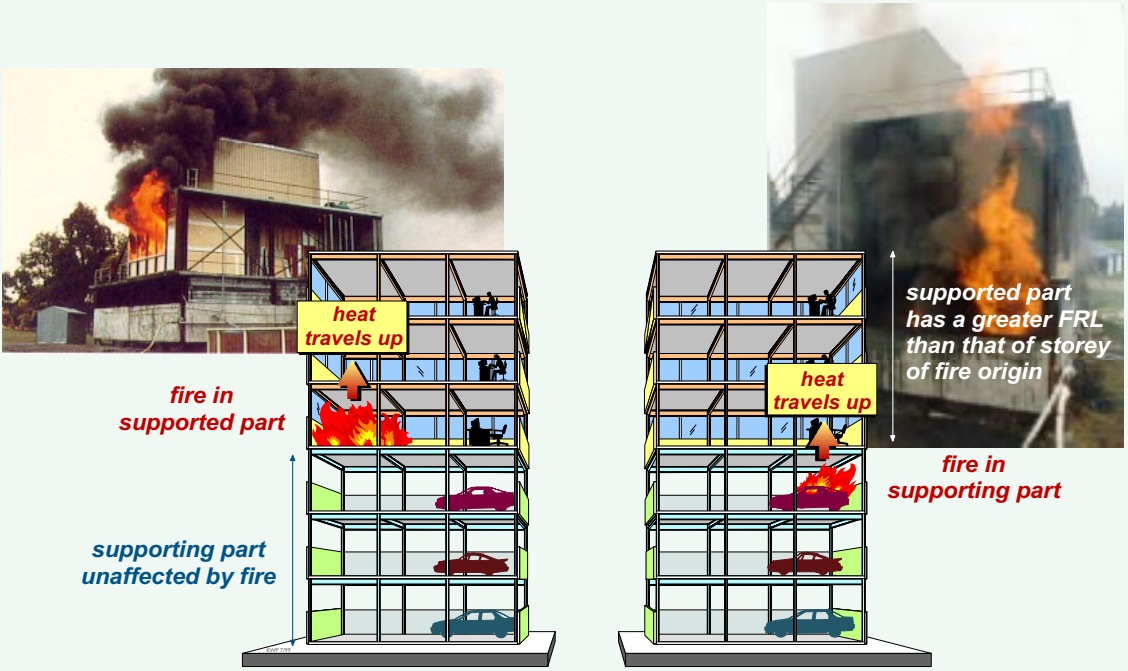
Research Basis

Research Basis

The changes to Clause 2.2 were partly based on research undertaken at BHP Research—Melbourne Laboratories and summarised in various publications including *Fire in Mixed Occupancy Buildings* [7]. That publication reviewed the possible basis for the 1990 version of the support of another part provisions and concluded that they had no basis, except in relation to building elements within the *same* fire compartment. It recognised that fire and heat spread *upwards*, not downwards; and that it is the levels *above* a fire that are at more risk than those below the fire. This was shown by means of fire tests which demonstrated that the heating effects of a fire will not be experienced below that level. It was concluded that building elements within a compartment should be designed for the FRLs corresponding to the classification of that compartment only.



Other research was undertaken which looked specifically at carparks under other buildings; the potential severity of fires in open-deck carparks, and the reliability of sprinklers in carparks. This work provided a justification for allowing the construction of carparks, complying with BCA Tables 3.9, 4.2 and 5.2, below buildings of other classes.



Resulting Outcomes

As a result of the changes, Clause 2.2 of Specification C1.1 in the 1990 version of the BCA (BCA90) [1] differed substantially from that given in the current version of BCA96 as illustrated below:

BCA90

SPECIFICATION C1.1

2.2 Fire protection for a support of another part

Where a part of a building required to have an FRL, other than an external wall complying with Clause 5.1(b) or C.1.11, depends upon direct vertical or lateral support form another part to maintain its FRL, that supporting part must-

(a) have an FRL in respect of structural adequacy that is the greater of-
  (i) that required for the part it supports; or
  (ii) that required for the part itself; and
  be non-combustible if the part it supports is required to be non-combustible.

BCA96

SPECIFICATION C1.1

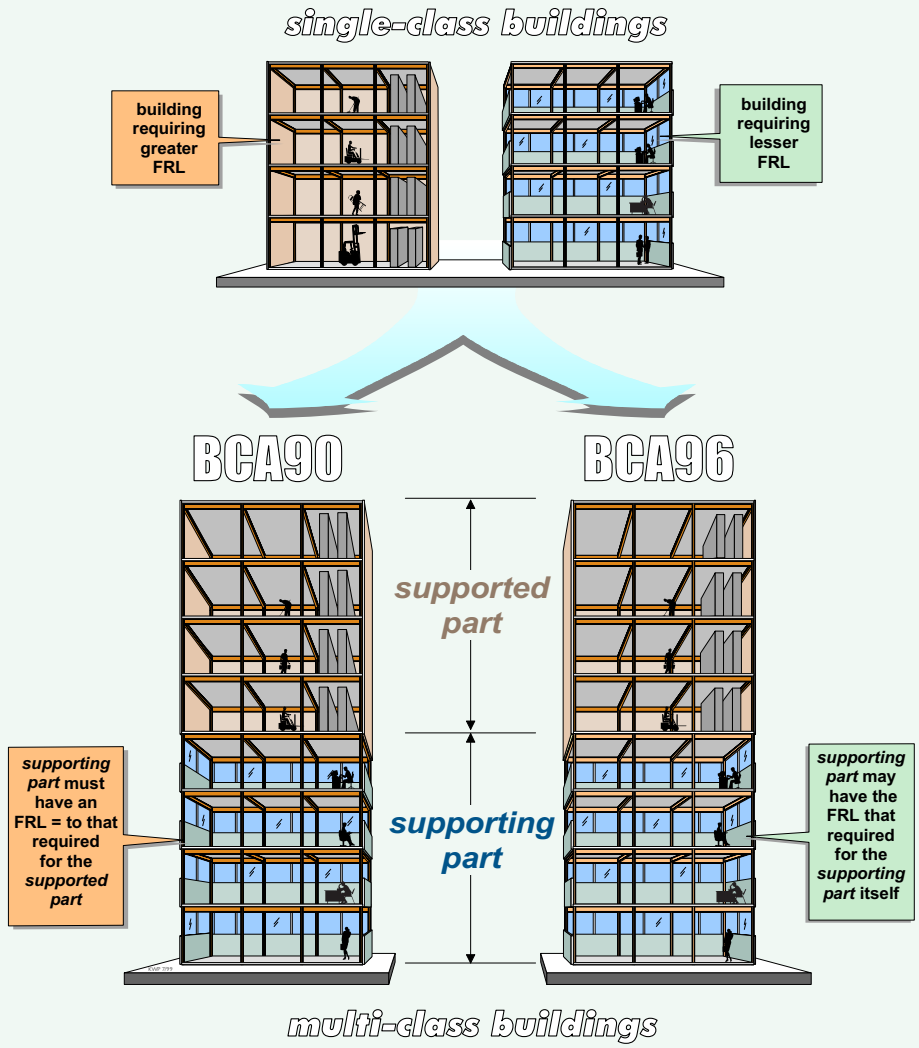
2.2 Fire protection for a support of another part

(a) Where a part of a building *required* to have an FRL depends upon direct vertical or lateral support from another part to maintain its FRL, that supporting part, subject to (b), must-
  (i) have an FRL not less than that *required* by other provisions of this Specification; and
  (ii) if located within the same *fire compartment* as the part it supports have an FRL in respect of *structural adequacy* the greater of that *required*-
    (A) for the supporting part itself; and
    (B) for the part it supports; and
  (iii) be *non-combustible*-
    (A) if *required* by other provisions of this Specification; or
    (B) if the part it supports is required to be *non-combustible*.

(b) The following building elements need not comply with (a)(ii) and (a)(iii)(B):
  (i) An element providing lateral support to an *external wall* complying with Clause 5.1(b) or C1.11.
  (ii) An element providing support within a *carpark* and complying with Table 3.9, 4.2 or 5.2.
  (iii) A roof providing lateral support in a building-
    (A) of Type A construction if it complies with Clause 3.5(a), (b) or (d); and
    (B) of Type B and C construction.
  (iv) A column providing lateral support to a wall where the column complies with Clause 2.5(a) and (b).
  (v) An element providing lateral support to a *fire wall* or *fire-resisting* wall, provided the wall is supported on both sides and failure of the element on one side does not affect the fire performance of the wall.

Resulting Outcomes

The implications of these changes are most significant for multi-storey, multi-class buildings as illustrated below:



Clause 2.2 of Specification C1.1 in BCA96 has been developed on the basis of research findings. The resulting clause removes much of the ambiguity in the BCA in relation to supporting construction and permits the use of cost-effective steel construction in many situations.

References

[1] "Building Code of Australia", Australian Building Codes Board, 1990.

[2] "Building Code of Australia 1996", Volume 1—Class 2 to 9, Australian Building Codes Board, 1996.

[3] Bennetts, I. D., Poh, K. W., and Thomas, I. R., "Economical Carparks—A Guide to Fire Safety", BHP Steel, Marketing—Construction and Engineering, March 1999.

[4] Bennetts, I. D. and O'Meagher, A, J., "Support of External Walls in Fire", BHP Structural Steel Development Group, Technical Note Issue No. 1, March 1995.

[5] O'Meagher, A. J., Bennetts, I. D., Dayawansa, P. H., and Thomas, I. R., "Design of Single Storey Industrial Buildings for Fire Resistance", Journal of the Australian Institute of Steel Construction, Vol. 26, No. 2, May 1992.

[6] AS1530.4—1997, "Methods for Fire Tests on Building Materials, Components and Structures Part 4: Fire-Resistance Tests of Elements of Building Construction", Standards Australia, 1997.

[7] Thomas, I. R., Almand, K. H, Bennetts, I. D., Proe, D. J., and Lewins, R. R., "Fire in Mixed Occupancy Buildings", BHP Melbourne Research Laboratories Report Number MRL/PS69/89/004, August 1989.

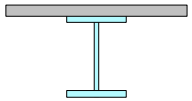
Acknowledgement

The authors wish to thank Mr N. Bowen and Mr E. Calvert of the Australian Building Codes Board, who reviewed an early draft of this publication, as did Mr A. Ng and Ms C. O'Toole of BHP Steel.

Appendix A:
ESA/M of Steel Sections
(m^2/tonne)

BEAMS
(3-side exposure to fire)

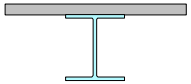
welded beams



section	ESA/M
1200WB455	8.51
423	9.10
392	9.79
342	10.4
317	11.1
278	12.1
249	12.6
1000WB322	10.0
296	10.8
258	11.8
215	13.4
900WB282	10.7
257	10.7
218	13.0
175	15.3
800WB192	13.1
168	14.5
146	16.5
122	18.9
700WB173	13.0
150	14.3
130	16.3
115	18.4

section	ESA/M
500WC440	5.41
414	5.78
383	6.21
340	7.30
290	8.51
267	9.22
228	10.7
400WC361	5.48
328	6.11
303	6.56
270	7.34
212	9.25
181	10.7
144	13.4
350WC280	6.08
258	6.54
230	7.30
197	8.49

hot-rolled sections



section	ESA/M
610UB125	14.9
113	16.3
101	18.1
530UB 92.4	17.8
82.0	19.9
460UB 82.1	17.7
74.6	19.4
67.1	21.4
410UB 59.7	21.9
53.7	24.1
360UB 56.7	21.1
50.7	23.4
44.7	26.3
310UB 46.2	23.2
40.4	26.2
250UB 37.3	24.7
31.4	29.0
200UB 29.8	26.3
180UB 22.2	27.1
150UB 18.0	28.3

section	ESA/M
310UC158	9.66
137	11.0
118	12.7
97	15.3
250UC 89.5	13.9
72.9	16.8
200UC 59.5	16.8
52.2	18.9
46.2	21.2
150UC 37.2	20.3
30.0	24.6

hollow sections

section	ESA/M
457.0×12.7CHS	10.3
9.5CHS	13.7
6.4CHS	20.2
406.4×12.7CHS	10.4
9.5CHS	13.7
6.4CHS	20.2
355.6×12.7CHS	10.4
9.5CHS	13.8
6.4CHS	20.3
323.9×12.7CHS	10.4
9.5CHS	13.8
6.4CHS	20.3
273.1×9.3CHS	14.2
6.4CHS	20.4
4.8CHS	27.0
219.1×8.2CHS	16.1
6.4CHS	20.5
4.8CHS	27.1
168.3×7.1CHS	18.7
6.4CHS	20.7
4.8CHS	27.3
114.3×6CHS	22.4
4.8CHS	27.7
88.9×5.5CHS	24.7
4.8CHS	28.1

section	ESA/M
250×250×9.0SHS	14.6
6.0SHS	21.7
200×200×9.0SHS	14.7
6.0SHS	21.8
5.0SHS	26.0
150×150×9.0SHS	14.9
6.0SHS	22.0
5.0SHS	26.2
125×125×9.0SHS	15.1
6.0SHS	22.1
5.0SHS	26.3
100×100×9.0SHS	15.4
6.0SHS	22.4
5.0SHS	26.6
89×89×6.0SHS	22.5
5.0SHS	26.7
75×75×6.0SHS	22.8
5.0SHS	27.0

COLUMNS
(4-side exposure to fire)

welded columns

section	ESA/M
1200WB455	9.61
423	10.3
392	11.1
342	11.5
317	12.4
278	13.3
249	13.7
1000WB322	11.2
296	12.1
258	13.1
215	14.8
900WB282	12.1
257	13.3
218	14.6
175	17.0
800WB192	14.7
168	16.1
146	18.4
122	20.9
700WB173	14.5
150	16.0
130	18.3
115	20.6

section	ESA/M
500WC440	6.55
414	6.99
383	7.52
340	8.77
290	10.2
267	11.1
228	12.9
400WC361	6.59
328	7.33
303	7.88
270	8.22
212	11.1
181	13.0
144	16.1
350WC280	7.33
258	7.89
230	8.82
197	10.3

hot-rolled sections

section	ESA/M
610UB125	16.7
113	18.3
101	20.3
530UB 92.4	20.0
82.0	22.4
460UB 82.1	20.0
74.6	21.9
67.1	24.2
410UB 59.7	24.8
53.7	27.4
360UB 56.7	24.1
50.7	26.8
310UB 46.2	26.8
250UB 37.3	28.6

section	ESA/M
310UC158	11.6
137	13.3
118	15.3
96.8	18.4
250UC 89.5	16.8
72.9	20.3
200UC 59.5	20.2
52.2	22.8
46.2	25.6
150UC 37.2	24.4
30.0	29.7