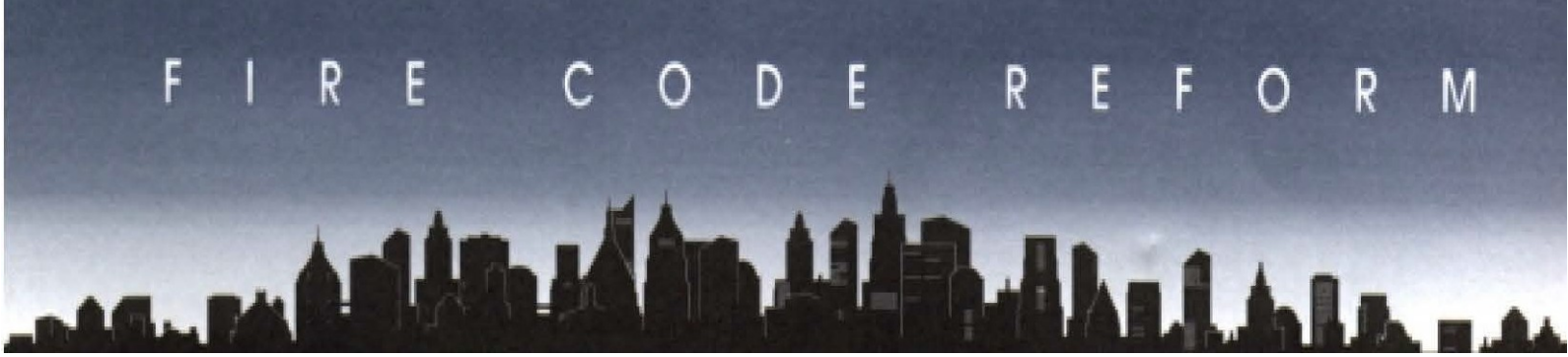

Project Report
FCRC PR 00-01

Fire Resistance And Non-Combustibility

Evaluation of Non-Combustibility Requirements.

FCRC Project 3 Part 4
Fire Resistance and Non-Combustibility

Fire Code Research Reform
Program February 2000

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Comments

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Fire Code Reform Centre

PROJECT 3 Part 4

FIRE RESISTANCE AND NON-COMBUSTIBILITY

EVALUATION OF NON-COMBUSTIBILITY REQUIREMENTS

February 2000

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Fire Code Reform Research Program

Project 3

REQUIREMENTS FOR FIRE RESISTANCE AND NON-COMBUSTIBILITY

PART 4

EVALUATION OF NON-COMBUSTIBILITY REQUIREMENTS

FEBRUARY 2000

EXECUTIVE SUMMARY

As part of brief for Fire Code Reform Centre Project 3, Fire Resistance and Non-Combustibility, the project team was required to address the following aspects of non-combustibility

- examine the basis of existing requirements for non-combustibility in the BCA
- establish the role of non-combustibility in delivering fire-safety objectives.

While the BCA defines non-combustibility as "not deemed combustible under AS 1530.1 — Combustibility Test for Materials", the traditional purpose of non-combustibility was simply to prevent the involvement of the building fabric in a fire. The requirement has subsequently been adopted as the fundamental level of control of fire spread. In this study the term "non-combustible" is used to describe materials that fulfil both these aims.

The study has been tackled by three routes. The first was to carry out a historical investigation of how non-combustibility requirements have grown up in the BCA and to establish what the regulators had in mind when introducing such controls. Secondly, a review was carried out of requirements that cover non-combustibility in overseas codes, and in particular the test methods used. Thirdly, the BCA clauses were analysed in terms of the goals established in Part I of Project 3 for fire safety requirements, to determine what exactly the non-combustibility requirement was attempting to achieve.

These reviews have suggested that there are a number of possible purposes behind non-combustibility requirements, many of which could be met in other ways. The project team has considered each relevant BCA clause to see whether there is a case for retaining the non-combustibility requirement, or whether the fire-safety objectives identified may be met with greater internal consistency and external simplicity by other means.

The team investigated the feasibility of using analytical approaches to establish the role of non-combustibility and its contribution to fire safety. In a code as complex as the BCA, this was not found to be an appropriate method of tackling the problem. Instead, the role of non-combustibility in each BCA clause was considered individually. The recommendations for change contained in this report are therefore based on the expert opinion of the project team members, both as to the purpose of the requirements and as to how best they might be met.

The outcomes of this report are recommendations for change, which in eight clauses remove the non-combustibility requirement because it is superfluous, and in another thirty clauses replace it with an alternative requirement. In undertaking this process, the project team has sought as far as possible to harmonise with the outcomes of Fire Code Reform Centre Project 2, Fire Performance of Materials, and with Project 3 Part 2 on fire resistance and the provision of smoke barriers. In twelve clauses it is the opinion of the team that there is no alternative that would satisfy the intention of the regulations, and therefore the non-combustibility requirement has been retained in these cases. The report is a research report only and additional work might be needed incorporate recommendations into the BCA.

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1. INTRODUCTION

1.1. BACKGROUND

Fire Code Reform Project 3 is one of a series of projects designed to introduce flexibility and modern technology into the "deemed to satisfy" prescriptions of the Building Code of Australia (BCA) and to develop a fully engineered risk-assessment approach to building fire safety.

The objectives of Project 3 are:

- To examine the basis of existing requirements for non-combustibility and fire resistance in the BCA[1].
- By considering likely fire severities, to establish the basis on which fire resistance levels should be specified to achieve the regulatory intent and objectives of the BCA.
- To establish the levels of performance required for different methods of construction and occupancy categories.
- To establish the role of non-combustibility in delivering the fire-safety objectives.

Part 1 of this project examined the basis for requirements for fire resistance. This was achieved by reviewing the fire safety objectives of the BCA as part of a coherent whole, and analysing the contribution to these objectives of the various fire safety sub-systems. This approach yielded a rational set of performance levels for fire resistance. The same broad approach is adopted here, in that the contribution of non combustibility to the same fire safety objectives is assessed and recommendations for change made where appropriate.

1.2. CONTEXT

The BCA has grown up over the years with a number of different requirements that control the use of construction materials. Fire Code Reform Centre (FCRC) Project 3 has as its brief to examine the requirements for fire resistance and non-combustibility within the BCA, and FCRC Project 2 is looking at the use of materials that are controlled by the current AS 1530, Methods for Fire Tests on Building Materials, Components and Structures Part 3 - Simultaneous Determination of Ignitability, Flame Propagation, Heat Release and Smoke Release. The BCA appears to see the control of fire resistance, combustibility and the Early Hazard Indices (material flammability) as distinct. However, from the point of view of fire initiation, growth and development in the context of protection of occupants, the assessment of materials performance is possibly not best dealt with in this disjointed way. FCRC Project 2 has recommended that moves be made towards different test methods for materials control, and it is appropriate in that light to re-examine the role of the combustibility test.

[1] The term "BCA" refers to the Building Code of Australia. At the start of this project, BCA 1990 Amendment No 9 was current. The recommendations have since been updated to refer to BCA 1996 Amendment 6. All reference to the BCA is to the National clauses without state variations

It is the purpose of this report to consider where non-combustibility is used in the BCA, to determine the purpose for which it is being used in each clause that calls it up, and to investigate whether or not greater effectiveness might be achieved if the material performance were to be controlled in a different way.

1.3. REASONS FOR CHANGE

The purpose of the analysis to be carried out in this report is to reduce complexity and introduce a rational and transparent approach to the control of construction materials. The non-combustibility test as called up in the BCA suffers from some fairly obvious problems. The main one is that many materials, which are accepted from experience and common practice to be effectively non-combustible, fail when subjected to the test procedure. Such materials include pre-finished metal sheeting, plasterboard and some bonded laminates. A list therefore has to be included in the BCA that deems to be non-combustible a range of materials which would otherwise not be permitted for use in certain circumstances. This is an unsatisfactory state of affairs, which needs to be addressed.

Non-combustibility is not always an appropriate measure of the performance that it is attempting to control. The objective of each requirement must first be established and then an appropriate test must be selected. Where the BCA appears to be using non combustibility to ensure that a smoke barrier will maintain its integrity, a less stringent test might be more suitable; where flame spread and fire development are the issue, state-of-the-art tests used to control flame spread and smoke generation might suffice. In this way, the numbers of tests required for materials may be reduced and the purpose of the requirements is clarified.

1.4. APPROACH ADOPTED

Several approaches were considered and investigated. In the first instance it was proposed that typical scenarios in which non-combustibility would be called up should be considered. A modelling exercise was then carried out to determine the effect of deleting or altering the non-combustibility requirement. The effect was judged in terms of potential fire severity and threat to occupants. The difficulties with this approach became apparent fairly rapidly. Fire modelling techniques at their current stage of development are not sensitive to any great extent to the use of different lining and construction materials as regards fire growth and the threat to those attempting to make their escape. The limitations of modelling in this context have been discussed in detail as part of FCRC Project 2. A thorough analysis of each instance of non-combustibility in the BCA would take into account all possible fire scenarios. Such a detailed analysis is not possible, and the effects of altering the requirements cannot be easily assessed.

In the final analysis, the study has been tackled by three routes. The first was to carry out a historical investigation of how non-combustibility requirements have grown up in the BCA and to establish what the regulators had in mind when introducing such controls. Secondly, a review was carried out of requirements that cover non combustibility in overseas codes, and in particular the test methods used. If a change in test method is to be recommended, it is important that the proposed method is internationally accepted. Thirdly, the BCA clauses were analysed in terms of the

goals established in Part 1 of Project 3 for fire safety requirements, to see what exactly the non-combustibility requirement was trying to achieve. Armed then with these three assessments, the project has considered each relevant clause. The Project 3 working group has therefore assembled a range of information and, in its expert opinion, generated the recommendations contained within this report.

2. HISTORICAL PERSPECTIVE

2.1. SUMMARY

During the course of this study, an independent review of the history of current requirements for non-combustibility in the BCA was commissioned. The detailed analysis carried out during this review involved a search of documentation relating to the introduction of the regulations and discussions with those familiar with the background to the regulations. The review is presented in Appendix 1.

The review noted that requirements for non-combustibility became part of Australian building regulations for a number of reasons, including:

1. as a supplement to fire resistance to preclude the need for active intervention in "fully protected" construction,
2. as a provision for smoke control,
3. to prevent ignition of external walls and structures, and hence to prevent fire spread from building to building, and
4. as a low fire resistance level.

2.2. OUTCOMES

The review looks in detail at each of the roles of non-combustibility, and suggests areas where further investigation is warranted. In particular, the following individual issues for examination are drawn out in the conclusions to that review:

1. The basic issue - the necessity or otherwise for any requirement for non-combustibility no matter how defined and the significance of any contribution it might make in isolation or in combination with a requirement for a fire resistance rating.

2. Alternatives to the present *concept* of non-combustibility in terms of definition and assessment.

3. Examination of the fire-tests of the BCA in general against the background of the future objectives of the BCA. For example

   (a) Could the standard fire-resistance test be modified to eliminate the need, at least in some instances, for a requirement for non-combustibility to be combined with a requirement for an FRL?

   (b) Would a criterion after the style of the American finish rating or the Australian incipient-spread-of-fire rating be a sufficient control of fire-rated combustible construction?

   (c) Could a requirement for an FRL (as presently determined or as amended) replace the requirement for non-combustibility in smoke-compartmentation and, if so, what levels should the set?

(d) Could control of the early-fire-hazard properties of materials be usefully extended to liberalise requirements for non-combustibility?

4. Examination of each remaining requirement for non-combustibility in the BCA as to its necessity or even usefulness. For instance, does drencher-protected construction need to be non-combustible?

5. The question arises as to whether every fire-protection (including smoke protection) provision of the BCA or proposed reformation of the BCA should be examined as to the usefulness of including a non-combustibility requirement, particularly if the approach to this aspect of materials-control is modified in response to the issues raised above. One way of tackling such a task would be to use, say, the Australian Model Uniform Building Code (AMUBC) as an aide memoire; to compare individual requirements of the BCA with individual requirements of the AMUBC as to whether deregulation was justified.

2.3. FUTURE DIRECTIONS

The particular points noted above have guided the thinking and approach to the assessment of the value of non-combustibility within the context of Project 3. It is noted that the ultimate objectives of the BCA with regard to the *performance* of buildings and their components (and the questions of the definition and assessment of performance) will be basic to any examination of present approaches and of whether or not conservation or change would be useful.

Details of clauses that control combustibility, comparing BCA 1990 with its antecedents, are given in Appendix 2.

Changes in fire protection design and fire-fighting practice have resulted in changes of approach to the regulations, but have not always been reflected in comprehensive amendment to the clauses themselves. While the original objectives give a guide to why requirements were introduced, the requirements need to be re-examined in the light of current BCA objectives. This activity is described in Chapter 5.

3. APPROACHES ADOPTED IN OVERSEAS BUILDING CODES

3.1. SUMMARY

The Project 3 team commissioned a study to look at the use of non-combustibility in regulations overseas with a view to

3.1.1. establishing whether or not the approach overseas differs significantly from that in the BCA and to

3.1.2. assess whether different test methods are used overseas that might be of use in Australia.

The review is presented in Appendix 3.

The review concludes that Australian building regulations belong to a widely distributed group with a common approach to fire protection. The group puts personal safety as its priority and property protection is subordinated to it. Personal safety is equated with ease (speed) of evacuation and the protection of the evacuees from fire and its products during evacuation. Escape paths must lead from all parts of the building to a place of safety *outside* the building and there is a common implication that evacuation means evacuation from the building.

Materials of construction are controlled according to the dangers they present, first, to people during evacuation and subsequently to successful containment of the fire. The availability of active fire-suppression and fire-fighting measures mitigates the rigour of passive controls.

Throughout the group the combustibility of materials was originally, and generally still is, regulated according to risk through the control of types of construction. The greater the risk of fire and the complexity (which means the duration) of evacuation, the greater the number of components required to be non-combustible. The non-combustibility of the component was to be absolute according to a test pretty well common throughout the group.

Over the last two decades or so there has developed a trend to the scaling of the combustibility of materials according to risk and moves towards the introduction of materials controls that are seen as more appropriate to regulatory objectives than non combustibility.

It is difficult, however, to escape the impression that *all* the current international discussions about fire-properties and the pros and cons of various methods of demonstration, although important and potentially valuable, are overly influenced by the fact that the established proscription was on "combustibility" which, because of an ambiguity of definition, came to mean a variety of fire-properties in a variety of contexts.

A requirement for non-combustibility now persists in modern building codes at two levels. There is still the traditional purpose of preventing the involvement of the building fabric in the fully developed fire but the requirement has been adopted also as the fundamental level of control of whether fire spreads or not.

3.2. OUTCOMES

Comparisons of the various international uses of non-combustibility immediately raise the question of the relevance to building regulation of non-combustibility as presently measured. The review, apart from assessing how non-combustibility is used in various codes, then went on the look at the value of the concept and how it is and should be applied.

The earliest regulators saw virtue in materials that, in lay terms, don't burn. They observed the behaviour of materials in building fires and they nominated particular materials for particular uses knowing that they provided the levels of safety they sought. Then, in an effort to liberalise the regulations by moving from the specific to the generic, they encapsulated their requirement in the word "non-combustible". Their scientific advisers at the time took them at their word and steered them into calorimetry - measurement of the heat derivable from a material - as the appropriate demonstrator of compliance. The concept of what was to be measured was, by a not unusual inversion of scientific method, determined by the way it was measured.

At least some of the limitations imposed on materials and components were immediately recognised by the regulators and measures taken to ease them. This reaction is currently accelerating to the extent that in some circles there is an opinion that the prescription of non-combustibility should be rescinded altogether. But the first question to be asked in regard to the appropriateness of non-combustibility to the regulation of fire-protection would appear to be not whether non-combustibility might or might not be important but when it might be important.

Non-combustibility, even the prescnption of particular non-combustible materials, means no more than that something will remain after the fire has burnt itself out. But what remains might be a heap of rubble. There is no guarantee of the persistence of a barrier or a component capable of loadbearing or of stability in general. In short, non combustibility cannot be relied on to compensate for shortcomings in FRL. What should not be overlooked is the necessity to control the internal temperature of combustible fire-barriers (and composites generally) and consequently the possibility of perpetuating destructive distillation.

3.3. FUTURE DIRECTIONS

There appear to be building components for which a requirement for non-combustibility is appropriate, readily met and imposes no untoward restriction on industry. Having said that, it also appears that concerns about the possible limitations of test methods - the appropriateness of particular fire-tests, whether they properly estimate the severity of the hazard or properly reproduce the fire-situation - have resulted in the persistence of a requirement for non-combustibility as a safety net and, in some cases, a safety net of dubious reliability.

But the practice of overseas performance codes of placing non-combustibility into hierarchies of reactions to fire is still worthy of careful consideration. Of these the British applications seem the most thoughtful (while adopting the simplest approach to testing). Such a development could well establish the proper place of non combustibility. At present it is the universally accepted base out of which branch a wide variety of test methods vigorously defended by the industries that have invested in them and all of which appear to have served their countries well.

The practice suggests also that, with the adoption of the performance concept, there is no need to abandon a particular test directed towards a particular fire situation on the grounds that it does not reproduce every fire situation.

International approaches to fire-regulation indicate that the central issue with regard to materials control is the correct identification of the various fire hazards, their proper quantification and the nomination of reliable predictors of successful control. It could well be that field research has discovered particular situations where present methods are wanting. It is towards the development of reliable predictors for these situations that laboratory research needs to be directed.

However, before the possibility of changing the current Australian test method is considered, the purpose of each BCA clause requiring non-combustibility needs to be considered in detail.

4. AIMS OF NON-COMBUSTIBILITY IN THE CONTEXT OF THE CURRENT BCA

4.1. PURPOSE

In this chapter, the task is to see what the aims of non-combustibility requirements should be in the context of the other fire safety requirements of the BCA.

4.2. APPROACH

4.2.1. Global objectives

Part 1 of this Project examined the objectives of fire resistance levels. In order to establish the specific objectives, it was necessary to study the global objectives of fire safety. Based on BCA 1990, the following global objectives were identified as the intentions behind the provisions of the BCA:

- to keep loss of life in building fires to a very low level (it is assumed that there is a relationship between injury and loss of life in fire, such that the reduction in risk to life automatically implies a reduction in risk of injury)
- to limit property damage by introducing measures to control fire size and to prevent fire spread from premises on fire to neighbouring premises
- to provide protection to firefighters in the execution of their duty.

Since that time a performance-based BCA, BCA 96, has been issued. In BCA 96 the relevant objectives are clearly stated, as follows (Clause numbers are those ofBCA 96):

CO1 The objective of this Section is to-
- (a) safeguard people from illness or injury due to a fire in a building; and
- (b) safeguard occupants from illness or injury while evacuating a building during a fire; and
- (c) facilitate the activities of emergency services personnel; and
- (d) avoid the spread of fire between buildings; and
- (e) protect *other property* from physical damage caused by structural failure of a building as a result of fire.

D01 The objective of this Section is to-
- (a) provide, as far as is reasonable, people with safe, equitable and dignified access to-
- (i) a building; and
- (ii) the services and facilities within a building; and
- (b) safeguard occupants from illness or injury while evacuating in an emergency

EO1 The objective of this Part is to-
- (a) safeguard occupants from illness or injury while evacuating during a fire; and
- (b) provide facilities for occupants and the *fire brigade* to undertake fire-fighting operations; and
- (c) prevent the spread of fire between buildings.

The objectives derived in Part 1 of this Project are similar to those in the BCA, but place more importance on fire brigade intervention and limiting property damage.

4.2.2. Context

In Part 1 it was further acknowledged that the role of any component or aspect of a building which contributes to fire safety could not be studied in isolation. Any such review must be sufficiently comprehensive to analyse the objectives in the context of all relevant building and occupant characteristics.

4.2.3. Building systems

Non-combustibility is one aspect of materials control; materials control can be considered to be a building system. On review it was considered that materials control contributed to achievement of the following fire safety aims:

- reduce risk of ignition
- keep fire small
- protect escape routes from fire (but not smoke*)
- limit fire spread

* Smoke in this context is smoke generated by the fire that might enter the escape route from outside. Such smoke would be prevented from entering the escape route by compartmentation, or exhausted by the smoke control system.

4.2.4. Building characteristics

Certain building characteristics that contribute to fire safety are also influenced by the combustibility of materials of construction. In particular, the degree of combustibility

(a) contributes to the fire load ofa building, and

(b) is one aspect of the "nature of materials" that effects the way in which a fire develops.

Control of fire load was seen as contributing to achievement of the following fire safety aims:

- reduce risk of ignition
- keep fire small
- protect escape routes from smoke, fire, collapse

- limit fire spread
- protect fire fighters from smoke, fire, collapse
- protect neighbours from fire, collapse.

Control of the nature of materials (in this instance, non-combustibility) could be said to contribute to achievement of the same fire safety aims, although in Part I it was not seen as contributing to the protection of escape routes.

A more detailed discussion on the contributions of various systems and building characteristics is given in Chapter 6 of the Report on Part I "Objectives and Performance Levels for Fire Resistance" of the project. Tables from Chapter 6 are reproduced i Table 4/1 and 4.2 of this Report.

4.2.5. Occupant characteristics

The risk to life from fire in buildings changes very markedly with parameters which govern the behaviour of occupants. In particular, whether the occupants may be asleep or otherwise slow to respond is of great importance in determining the time which will be taken for evacuation to be completed. This in turn affects the fire resistance requirements of some barriers and structures, or alters the significance of some of the systems which might be installed. These characteristics are included in Table 4.2.

Table 4.1 Fire Safety Aims and the Contribution of Building System

Matrix Showing some possible building systems that can contribute to achieving the fire safety aims.

Fire Safety Aims \ Building Systems		Detection	Alarms	Escape Routes	Management	Control of materials	Occupant fire fighting	Smoke control	Sprinklers	Communications	Internal fire barriers	Brigade fire fighting	Structure	Boundary fire barriers
Reduce risk of ignition					■	■								
Alert people		■	■		■				■	■				
Keep fire small		■				■	■		■					
Provide escape routes				■										
Protect escape routes	from smoke							■	■		■			
	from fire					■								
	from collapse								■				■	
Limit fire spread						■			■		■	■		
Protect fire fighters	from smoke							■	■					
	from fire								■		■	■		
	from collapse								■			■	■	
Protect neighbours	from fire								■			■		■
	from collapse								■			■	■	

Table 4.2 Fire Safety Aims and the Contribution of Building Characteristics

Matrix showing some building characteristics that could contribute to achieving fire safety aims

Fire Safety Aims \ Building Characteristics		Length of Escape Route	Capacity of Escape Route	Alertness of Occupants	Confinement of Occupants	Building height	Fire Load	Ventilation	Compartment Area	Compartment Volume	Nature of materials	Building location	Distance to Brigade
Reduce risk of ignition							■				■		
Alert people				■									
Keep fire small							■				■		
Provide escape routes		■	■	■	■	■							
Protect escape routes	from smoke	■		■	■	■	■	■	■	■			
	from fire				■		■	■	■	■			
	from collapse						■	■	■	■			
Limit fire spread						■	■	■	■	■	■		
Protect fire fighters	from smoke	■				■	■	■	■	■	■		■
	from fire						■	■	■	■	■		■
	from collapse					■	■	■	■	■	■		■
Protect neighbours	from fire						■	■	■	■	■	■	■
	from collapse						■	■	■	■	■	■	■

4.3. SPECIFIC AIMS OF NON-COMBUSTIBILITY

In Table 4.1 the influence of non-combustibility appears in the system entitled control of materials. In other words, this project has identified that control of materials contributes significantly to the following building fire safety aims:

- reduce risk of ignition
- keep fire small
- protect escape routes from fire
- limit fire spread

Though non-combustibility is not the only way material control is exercised in the BCA we will expect to find that the use of non-combustibility requirements is generally satisfying one or more of these aims. However, as noted in the historical review, there do seem to be occasions within the BCA where the use of the non combustibility requirements is in fact to provide an internal barrier, generally to block the passage of smoke but in some cases to prevent fire spread for a limited time. On these latter occasions the aim is better achieved using a fire resistance requirement, for consistency with other requirements within the BCA.

In the building characteristics sense (see Table 4.2), the nature of materials achieves the same aims as listed above but it also needs to be noted that combustible construction materials increase the fire load. In places where it is identified that the BCA intends to limit fire load by use of a non-combustibility clause then the intent from Table 4.2 could be to:

- protect escape routes
- protect firefighters
- protect neighbours

as alternatives to the aims outlined above.

Section 2 of this report outlined how the non-combustibility requirements in the regulations arose and gives some clue as to what the regulators intended. As the BCA now stands these original intentions may not be reflected in the way the requirements more generally have developed with time. Therefore it is useful to review the non combustibility clauses with the breadth of the regulations in mind, and the specific aims as listed above as possible functions for each clause. This will be carried out at the end of the following Section.

5. METHODOLOGY

5.1. REVIEWS CARRIED OUT

The historical and international reviews have revealed that building codes use non-combustibility requirements for a number of purposes. These have grown with time and have not necessarily been set in the wider context of other requirements that control the use of construction materials. There certainly appears to be a case for simplification within the BCA, and indeed within the other codes reviewed.

The requirement for non-combustibility cannot be divorced from the test method that is used to determine it. That much is very plain from the international review. Many codes have gone down similar paths in adopting calorimetric test methods, and have then had to compromise on the strict definition of non-combustibility in order to permit a range of practical construction materials believed from long practice to be acceptable. The international review does not therefore provide insight into alternative test methods that are used elsewhere and which give useful results, but rather highlights the fact that the BCA is not alone in having a set ofrequirements that lack simplicity and consistency.

5.2. THE PROCESS

A number of steps have been taken m order to rationalise the non-combustibility provisions of the BCA:

1. Each clause that calls up non-combustibility has been carefully examined, first to determine its historical intent and then to determine its current purpose. The results are presented in Appendices 2 and 4.

2. The clauses have been grouped according to the function they perform, and consideration has been given to what material properties the non combustibility test is trying to achieve for each group.

3. Taking into account the material properties, the best available test method for use in each case has been selected.

5.3. THE AIMS OF CLAUSES

In assembling Appendix 4, the aims for fire safety measures discussed in Section 4 of this report have been used to guide the assessment of the role of non-combustibility in the various BCA clauses. In most cases there is relatively little doubt as to what these aims are, though in some instances, the current function of non-combustibility differs in the opinion of the working group members from the historical role identified in Appendix 2.

On examining Appendix 4, it is seen that the outcomes of the non-combustibility clause assessments fall into 4 categories, namely:

- the requirement does not have any identifiable function and should be removed
- the requirement may be interpreted in the same way as other materials control requirements dealt with under FCRC Project 2 (flame spread and smoke generation), and should be dealt with using the same test methods
- the requirement performs the function of ensuring that a barrier would remain in place for a short period of time and would prevent the migration of smoke to areas remote from the fire
- the requirement is there to limit fire load, and therefore cannot be replaced by an alternative to the non-combustibility requirement.

5.4. MATERIALS PROPERTIES

For each group, the non-combustibility test is currently being used to assess distinctly different material properties. The next step is to consider what material properties would best indicate achievement of the required performance.

- There is no problem for those situations where non-combustibility is superfluous.
- For those requirements where the performance is that of controlling flame spread, the materials properties (and hence the recommended test methods) should be in line with current controls on the early fire hazard properties of materials as amended from time to time.
- For those situations where non-combustible construction is acting as a barrier to smoke, the barrier will need to retain its integrity at the temperatures to which it is likely to be exposed, until either the fire is brought under control or the fire directly attacks the barrier. Materials that do not deform or emit gases, or in other words remain stable, at 300°C will be suitable. This is a conservative value, and corresponds to the normal practice of using plasterboard for smoke barriers.
- For those elements where the non-combustibility requirement is there to control fire load, it is important that the element should not burn, and non-combustibility is the relevant material property.

5.5. TEST METHODS

Having established which material properties are to be measured, suitable tests must now be selected. In FCRC Project 2, the chosen selection criteria were that the tests should provide appropriate control, be international, be repeatable and reproducible and be cost effective. There should only be a change in test method if the proposed method offers advantages over the current test.

- Review of overseas requirements has shown that there is little difference in combustibility tests used in different countries, and for situations where non combustibility is to remain as a requirement it is recommended that there should be no change to the test method.
- For those clauses that control flame spread and fire growth in the early stages of the fire, the purpose is the same as for materials considered in Fire Code Reform Project 2. Currently, BCA controls rely on AS 1530.3, the Early Fire Hazard Test. FCRC Project 2, which provides a detailed examination of this test on the control of flame spread, recommends use of the ISO Room Test for control of flame

spread on wall and ceiling linings, with the possibility of predicting performance in the ISO Room using the Cone Calorimeter or other suitable small-scale tests. To replace non-combustibility, materials that do not reach !MW after exposure to 300 kW, would appear appropriate (see Fire Performance of Wall and Ceiling Linings - Final Report, Fire Code Reform Centre Project 2 Stage A).

- One possibility for predicting the performance of smoke barriers is to use the furnace test to measure a very low fire resistance level. However, in the early stages of the test while the furnace is heating, there are wide variations in results (see Furnace Exposure of Insulated Sandwich Panel Systems, V.P.Dowling and K.G.Martin, Journal of Thermal Insulation Vo! 9, July 1985). In the furnace temperature rises rapidly to temperatures in excess of 800°C, but a smoke barrier will not be exposed to temperatures above 300°C. AS 1530.4, Fire Resistance Test of Elements of Building Construction, is therefore not a suitable test for assessing the performance of smoke barriers. The smoke barrier requirement will be met by materials that do not warp, lose their integrity or give off smoke (in other words that remain stable) at 300°C, but no single test measures these properties. Of the tests available, AS 1530.5, Test for Piloted Ignitability, gives the closest approximation to the required performance. The test is described as examining the ability of a surface, when exposed to radiant heat, to produce volatile gases which would sustain ignition in the presence of a small ignition source. For the present application the applied heat flux should be 10 kW/m^2, which corresponds to a maximum surface temperature of approximately 300°C. Materials that do not ignite at this irradiance are suitable for use as smoke barriers. AS 1530.5 is technically identical with ISO 5657, Fire tests - reaction to fire - ignitability of building products. Before AS 1530.5 is adopted for regulatory purposes, we suggest that a series of tests should be run to determine the performance of commonly used materials under different test conditions and to select suitable performance criteria.

6. RECOMMENDATIONS FOR CHANGE TO THE BCA

It is recommended that, on the basis of the foregoing analysis, the BCA clauses identified in this report be amended as indicated in the table below. The recommendations take into account the projects team's views on the use of test methods as discussed in section 5.4 and 5.5 of this report. This introduces greater consistency and simplicity into the BCA requirements.

Table 6.1 Recommendations for change to the BCA

"Non-combustible" is superfluous for:

BCA Clause	Description	Recommended Change to BCA	Discussion
C2.6(c,d,f)	Spandrels and slabs separating openmgs in Type A buildings	Delete "non-combustible"	FRL is sufficient without non-combustibility
C3.13(a)	Covers on openings in sanitary compartments in Type A buildings	Delete "is non-combustible or"	FRL option provides better protection
Dl.8(a)(i)	External enclosure stairway	Delete "non-combustible"	FRL together with flame spread controls provide sufficient protection
D2.ll(a)	Enclosure of fire-isolated passageways	Delete "be non-combustible and"	FRL provides sufficient protection
G2.3(a)	Hearth construction	Delete "non-combustible"	Non-combustible IS superfluous as anything similar to stone, concrete or masonry is non-combustible
Spec G3.8 2.3(b), 2.4.1	Heat-collector plates for sidewall sprinklers in atriums	Delete "non-combustible"	If the heat-collector plates must be "suitable", there is non need to require them to be non-combustible
G3.4(b)	Frames of drencher-protected glass as bounding walls in atria	Delete "non-combustible"	If the drenchers also protect the frames, there is no need for the frames to be non-combustible
Spec 2.5(d) Cl.I	Drencher-protected curtain walls and panel walls	Delete "of non-combustible construction and"	The drenchers provide sufficient protection

The aim of requirements is to reduce the time to untenable conditions and control flame spread, as for Project 2.

C2.7(b)(iii)(C)	Roof covering of lower of two adjoining buildings separated by fire wall (option)	Delete "non-combustible" and replace with control on flame spread (materials that do not reach flashover in the ISO room corner test at 300kW would be suitable for this application).	In controls of this type, the recommendations of FCRC Project 2 are appropriate. There is no requirement for the roof framing to be non-combustible, indicating that it is only flame spread and not compartmentation that is a concern.
Dl.8	External stair	Delete reference to "non-combustible construction" and replace control on flame spread (materials that do not reach flashover in the ISO room corner test at 300kW would be suitable for this application).	In controls of this type, the recommendations of FCRC Project 2 are appropriate
Spec Cl.1 2.4(a)	Concession to allow combustible finish, lining or attachment to wall or roof	This clause will need rewriting or deleting in the light of the findings of Project 2 stage b relating to fire spread via façades.	

Spec Cl.l 2.5(c)	Structures on roofs	Replace the requirement for the structure to be non-combustible with control on flame spread (materials that do not reach flashover in the ISO room corner test at 300kW would be suitable for this application).	The purpose of this control is not to reduce the fire load, which will be small. Nor is it to provide a barrier to enable safe escape, as there are unlikely to be people present. It is more likely to prevent fire spread and in controls of this type, the recommendations of FCRC Project 2 are appropriate
Spec Cl.l 2.5(f)(ii)(B)	Columns supporting balconies, verandahs and in Type A buildings	Delete "non-combustible" and replace with control on flame spread (materials that do not reach flashover in the ISO room corner test at 300kW would be suitable for this application).	Non-combustibility is used to prevent fire spreading up the columns. In controls of this type, the recommendations of FCRC Project 2 are appropriate
Spec Cl.l 2.7(b)	Bottom of shaft laid on ground	Delete "non-combustible" and replace with control on flame spread (materials that do not reach flashover in the ISO room corner test at 300kW would be suitable for this application).	In controls of this type, the recommendations of FCRC Project 2 are appropriate
Spec Cl.l 3.l(b)	External walls, common walls and floor framing of lift pits in Type A buildings	Delete "non-combustible" and replace with control on flame spread (materials that do not reach flashover in the ISO room corner test at 300kW would be suitable for this application).	In controls of this type, the recommendations of FCRC Project 2 are appropriate

Spec Cl.1 3.l(e)	Non-loadbearing fire- resisting internal walls- Type A	For internal walls, delete "non- combustible" and replace with control on flame spread (materials that do not reach flashover in the ISO room corner test at 300kW would be suitable for this application). Leave in requirement for non-combustibility for shafts.	In controls of this type, the recommendations of FCRC Project 2 are appropriate
Spec Cl.1 3.5	Roofs in Type A buildings (option - for details see clause)	Delete "non-combustible" and replace with control on flame spread (materials that do not reach flashover in the ISO room corner test at 300kW would be suitable for this application).	There is no requirement for the roof framing to be non-combustible, indicating that it is only flame spread and not compartmentation that is a concern. The recommendations of FCRC Project 2 are appropriate
Spec Cl. 1 3.8(a)	Roofs and parts of certain walls in open spectator stands and indoor sports stadiums of Type A	Delete "non-combustible" and replace with control on flame spread (materials that do not reach flashover in the ISO room corner test at 300kW would be suitable for this application).	Again, flame spread is the issue rather than survival of the barrier.
Spec Cl. 1 3.8(b)	Columns and loadbearing walls supporting roof only in open spectator stands and sports stadiums of Type A	Delete "non-combustible" and replace with control on flame spread (materials that do not reach flashover in the ISO room corner test at 300kW would be suitable for this application).	Non-combustibility is used to prevent fire spreading up the columns and across the roof. In controls of this type, the recommendations of FCRC Project 2 are appropriate
Spec Cl. 1 3.8(c)	Non loadbearing parts of certain external walls in open spectator stands and sports stadiums of Type A	Delete "non-combustible" and replace with control on flame spread (materials that do not reach flashover in the ISO room corner test at 300kW would be suitable for this application).	As above

Spec Cl. l 4.l(b)	External walls, common walls and floor framing of lift pits in Type B buildings	Delete "non-combustible" and replace with control on flame spread (materials that do not reach flashover in the ISO room corner test at 300kW would be suitable for this application).	In controls of this type, the recommendations of FCRC Project 2 are appropriate
Spec Cl.l 4. l(f)	Non-loadbearing fire-resisting internal walls and shafts in certain buildings Type B	Delete "non-combustible" and replace with control on flame spread (materials that do not reach flashover in the ISO room corner test at 300kW would be suitable for this application).	In controls of this type, the recommendations of FCRC Project 2 are appropriate
Spec Dl.12 2(e)	Floor covering beneath a fire door to an escalator etc	This clause will need rewriting or deleting in the light of the findings of Project 2 Stage b relating to fire spread via floor coverings.	

The aim of the requirements is to provide a smoke barrier:

C2.5(d)(i)	Smoke-proof walls in hospitals	Delete "non-combustible" and replace with the requirement that the material should not ignite at an applied heat flux of 10 kW/m^2 when tested in accordance with AS 1530.5, Test for Piloted Ignitability*.	The construction acts as a barrier to the spread of smoke. The ignitability test is considered to be the most appropriate test for the required performance
C2.5(g)	Roof covering for ancillary use areas in hospitals (option)	Delete "non-combustible" and replace with the requirement that the material should not ignite at an applied heat flux of 10 kW/m^2 when tested in accordance with AS 1530.5, Test for Piloted Ignitability*.	As above

C2.10(b)(ii) (now C2.10(a) (ii)B)	Non-loadbearing lift shafts in Type B buildings (other than patient care areas in hospitals)	Delete "non-combustible" and replace with the requirement that the material should not ignite at an applied heat flux of 10 kW/m^2 when tested in accordance with AS 1530.5, Test for Piloted Ignitability*.	As above
C2.14	Smoke-proof walls dividing long corridors in Class 2 and 3 buildings	Cross-reference to C2.5(d) - no change needed.	As above
C3.13(d)	Doors or hoppers to garbage shafts in Type A buildings	Delete "non-combustible" and replace with the requirement that the material should not ignite at an applied heat flux of 10 kW/m^2 when tested in accordance with AS 1530.5, Test for Piloted Ignitability*.	As above
D2.4(b)	Separating construction for rising and descending flights of stairs in fire- isolated exits	Delete "non-combustible" and replace with the requirement that the material should not ignite at an applied heat flux of 10 kW/m^2 when tested in accordance with AS 1530.5, Test for Piloted Ignitability*.	As above
D2.7(d)	Enclosure of services or equipment in public corridors	Delete "non-combustible" and replace with the requirement that the material should not ignite at an applied heat flux of 10 kW/m^2 when tested in accordance with AS 1530.5, Test for Piloted Ignitability*.	As above

D2.1 l(b) (i)	Roof covering of fire- isolated passageway (option)	Delete "non-combustible" and replace with the requirement that the material should not ignite at an applied heat flux of 10 kW/m^2 when tested in accordance with AS 1530.5, Test for Piloted Ignitability*.	As above
G3.5	Balustrade around balcony in atrium	Delete "non-combustible" and replace with the requirement that the material should not ignite at an applied heat flux of 10 kW/m^2 when tested in accordance with AS 1530.5, Test for Piloted Ignitability*.	As above
Spec Cl.1 4.1(h)	Service shafts in certain Type B buildings	Delete "non-combustible" and replace with the requirement that the material should not ignite at an applied heat flux of 10 kW/m^2 when tested in accordance with AS 1530.5, Test for Piloted Ignitability*.	As above
Spec Cl.1 4.1(i)	Floors above space for cars in Class 2 or 3 Type B buildings (option)	Delete "non-combustible" and replace with the requirement that the material should not ignite at an applied heat flux of 10 kW/m^2 when tested in accordance with AS 1530.5, Test for Piloted Ignitability*.	As above

Spec Cl.l 5.l(e)	Floors above and columns in space for cars in Class 2 or 3 Type C buildings (option)	Delete "non-combustible" and replace with the requirement that the material should not ignite at an applied heat flux of 10 kW/m^2 when tested in accordance with AS 1530.5, Test for Piloted Ignitability*.	As above
Spec E2.2(b) 4	Smoke baffies/ curtains	Delete "non-combustible" and replace with the requirement that the material should not ignite at an applied heat flux of 10 kW/m^2 when tested in accordance with AS 1530.5, Test for Piloted Ignitability*.	As above
Spec Hl.3 6(a)	Proscenium curtains	Delete "non-combustible" and replace with the requirement that the material should not ignite at an applied heat flux of 10 kW/m^2 when tested in accordance with AS 1530.5, Test for Piloted Ignitability*.	As above
Spec Hl.3 4	Combustible material must not cross proscenium wall	Delete "non-combustible" and replace with the requirement that the material should not ignite at an applied heat flux of 10 kW/m^2 when tested in accordance with AS 1530.5, Test for Piloted Ignitability*.	As above

* *Before AS 1530.5 is adopted for regulatory purposes, we suggest that a series of tests should be run to determine the performance of commonly used materials under different test conditions and to confirm suitable performance criteria.*

The requirement controls fire load:

Cl.7(a)	Open spectator stands and indoor sports stadiums with one tier of seating	Leave in requirement for non- combustible construction.	Retention is recommended. However, the requirement that open spectator stands and indoor sports stadiums with one tier of seating be non-combustible does not appear to be strongly life-safety related. It may have been introduced as a property protection measure. If this is the case its deletion should be considered
C2.6(e)	Infill between spandrel and curtain wall or panel wall in unsprinklered Type A buildings	Leave in requirement for non- combustible material.	This appears to be intended to prevent the passage of smoke and/or fire through gaps between spandrels and outer walls. An alternative would be to specify FRLs for the system of construction rather than individual elements.
C3.l(a)(ii)	Small sub-floor ventilators in walls	Leave in requirement for non-combustible construction.	A non-combustibility requirement for such elements seems appropriate if their use is retained. However, concern is expressed with this clause as ventilators, whether combustible or not, represent an embedded failure in integrity that seems at odds with the requirement for an FRL.

D2.2(a), alternative construction D2.3	Stairways or ramps in fire-resisting shafts	Leave in requirement for non-combustible materials.	Such stairs and ramps need to be suitable for use by escaping occupants, while they may still be able to escape. A low FRL would achieve the same purpose but would be unnecessarily onerous.
G2.4(a)	Hopper giving access to charging chute of incinerator	Leave in requirement for non- combustible construction.	Non-combustibility is an appropriate requirement for elements intentionally and regularly in contact with fire.
Spec Cl.1 2.2(a)(iii)	A part supporting another part that is required to be non-combustible (except for elements listed in Spec Cl.1 clause 2.2(b))	Leave in requirement for non-combustible construction.	The requirement will apply in only the limited number of cases where non-combustibility is still used. Even then, the requirement might not always be necessary - it depends on the design of the element required to be non-combustible and its purpose. It may be perfectly satisfactory that some supporting elements are combustible.
Spec Cl.1 3.1(e)	Non-loadbearing shafts- Type A	Leave in requirement for non- combustible construction.	Because of the small dimensions of the shafts, very stringent flame spread controls are needed and these are best achieved by non-combustibility
Spec Cl.1 3.4(a)	A roof superimposed on a concrete slab roof (alternative to FRL)	Leave in requirement for non- combustible construction (for non loadbearing walls, the requirement is to control flame spread).	Ignition of the roof in inaccessible areas could go undetected for long enough that fire spread or a large fire resulted.

Spec Cl.l 3.10	Class 2 buildings < 4 storeys - alternative to Type A or timber framing	Leave in requirement for non- combustible material.	Requirements for multi-storey timber framed construction are complex and rely on a number of systems. They are outside the scope of this part.
Spec Cl.l 4.l(h)	Non load-bearing shafts in certain Type B buildings	Leave in requirement for non- combustible material.	Because of the small dimensions of the shafts, very stringent flame spread controls are needed and these are best achieved by non-combustibility
Spec Cl.l 4.3	Class 2 buildings <3 storeys - alternative to Type B or timber framing	Leave in requirement for non- combustible construction.	Requirements for multi-storey timber framed construction are complex and rely on a number of systems. They are outside the scope of this part.
Spec C3.15 3(a)	Materials close to unfilled metal pipe	Leave in requirement for non- combustible material.	As there is a possibility of such pipes when exposed to fire becoming hot for long periods, it is appropriate that adjacent materials be non-combustible.
Further considerations			
Al.l	Definitions	Update as appropriate	
Cl.7(a)	Open spectator stands and indoor sports stadiums with one tier of seating	Consider the appropriateness of this requirement in the light of the objectives of the BCA	
C2.6(e)	Infill between spandrel and curtain wall or panel wall in unsprinklered Type A buildings	The wording of the clause should be change to ensure that the floor/wall system is continuous	

C3.l(a)(ii)	Small ventilators in sub- floor spaces	The possibility of such ventilators impairing fire resistance, especially of the fire walls, should be examined
Spec Cl.l 2.2(a)(iii)	Support to be NC if supported part is NC	Clause might need to be rewritten in the light of other changes
Spec Cl.l 2.5(e) (now Cl.12)	Materials deemed to be non-combustible	This clause should be reviewed on completion of BCA changes
Spec Cl.l 2.6(b)	Concession on FRL and NC for small mezzanines	This clause should be reviewed in the light of other changes, including any proposed changes to FRLs.
Spec Cl.l 3.1 (c) (iii)	Fire-rated wall to extend to a fire-rated roof or NC covering (Type A construction)	The wall system should have an appropriate FRL.
Spec Cl.l 3.6	Roof lights in a roof whose covering must be NC	Review this clause in the light of changes to the roof covering requirements.
Spec Cl.l 3.10	Multi-storey timber framed construction	The role of non-combustibility in these systems, especially that of insulation, needs further investigation before any change is made to the regulations.
Spec Cl.l 4.1 (d) (iii)	Fire-rated wall to extend to a fire-rated roof or NC covering (Type B construction)	The wall system should have an appropriate FRL.
Spec Cl.l 4.3	Multi-storey timber framed construction	The role of non-combustibility in these systems, especially that of insulation, needs further investigation before any change is made to the regulations.
Spec Cl.10 3(a) (iii)	Certain combustible linings to be attached to NC substrate	This is a flame spread issue and needs examination in the light of recommendations of Project 2

7. CONCLUSIONS

International approaches to fire regulation indicate that the central issue with regard to materials control is the correct identification of the various fire hazards, their proper quantification and the nomination of reliable predictors of successful control. The review has discovered situations where the present methods of control are wanting.

The current BCA requirements for non-combustibility address two issues. First, there is the traditional purpose of preventing the involvement of the building fabric in a fire. Second, they provide a fundamental control on fire and smoke spread, either to enhance the survival of smoke barriers or to prevent surface flame spread. The current test, AS 1530.1, Combustibility Test for Materials, is appropriate only as a control of involvement of the building fabric in fire. There are building components for which such a control is appropriate, can be readily met and does not impose untoward restrictions on the building industry. For other building components there are limitations on the appropriateness of the test as an estimate of the severity of hazard which have resulted in the inappropriate use of non-combustibility as a safety net of dubious reliability. Non-combustibility is not an appropriate control for the survival of smoke barriers, nor for the control on surface flame spread.

Based on these conclusions, the Working Group investigated the feasibility of using analytical approaches to establish the role of non-combustibility and its contribution to fire safety. In a code as complex as the BCA, this was not found to be an appropriate method of tackling the problem. Instead, the role of non-combustibility in each BCA clause was considered individually. The recommendations for change contained in this report are therefore based on the expert opinion of the project team members, both as to the purpose of the requirements and as to how best they might be met.

The outcomes of this report are recommendations for change to the BCA, which in eight clauses remove the non-combustibility requirement because it is superfluous, and in another thirty clauses replace it with an alternative requirement. In its considerations and in making recommendations, the project team has sought as far as possible to harmonise with the outcomes of Fire Code Reform Centre Project 2 on issues relating to surface flame spread, and with Project 3 Part 2 on fire resistance and the provision of smoke barriers. In ten clauses it is the opinion of the team that there is no alternative that would satisfy the intention of the regulations, and therefore in these cases the non-combustibility requirement has been retained.

APPENDIX 1

BCA REQUIREMENTS FOR NON-COMBUSTIBILITY - AN HISTORICAL PERSPECTIVE

BCA REQUIREMENTS FOR NON-COMBUSTIBILITY

1. SUMMARY

1.1. The historical purposes of requirements for non-combustibility.

Requirements for non-combustibility became part of Australian building regulations for a variety of purposes:

- As a requirement distinct from fire-resistance

  (i) to preclude the necessity for active intervention if fire broke out in "fully protected" construction;

  (ii) to supplement fire-resistance during evacuation;

- As a protection from the short-comings of the Australian standard test for fire-resistance;
- For the protection of external walls and external structures from radiation;
- For the protection of people from radiation;
- As a sufficient provision for smoke-control;
- As a low, or second-order, fire-resistance level.

1.2. A change in approach to post-war regulations.

The first post-war regulations ranked types of construction in terms of the necessity for active intervention of which the highest rank needed no active intervention at all. The present trend towards deregulation of requirements for non-combustibility stems, in part, from a change in regulatory approach - an assumption that there will always be intervention. There is evidence to suggest also that requirements for non combustibility were made more stringent than necessary by features of the Australian standard test for combustibility and, at least in certain cases, were rendered necessary by features of the Australian standard test for fire-resistance.

1.3. Necessary matters for analysis and research.

The processes of fire-code reform therefore necessarily involve

analysis of those requirements for non-combustibility remaining in the BCA for consistency with the new approach; and

examination of the tests and criteria the BCA adopts for materials and structures.

2. FIRE-RESISTANCE LEVEL AND NON-COMBUSTIBILITY

From the Australian regulatory point of view, fire-resistance level and non-combustibility are distinct concepts. For the purposes of the BCA, fire-resistance level is a measure of the ability to act as a temporary barrier to the spread of fire or to continue to fulfil a structural function during a fire. An element of construction with any of the standard FRLs is not necessarily, nor need it be, non-combustible. Non combustible, on the other hand, means just that or, for materials deemed non combustible by the regulators, merely difficult to ignite and not given to sustained combustion. A non-combustible element of construction might have no practical capacity as a fire barrier.

3. HISTORICAL

3.1. Influence of post-war building studies.

The single, most significant influence on post-war Australian building regulations were the post-war building studies (PWBS) undertaken by the British Ministry of Works. PWBS No 20 on the "Fire Grading of Buildings - Part 1 General Principles and Structural Precautions" [1] was published in 1946. It laid the bases for the AMUBC types of construction which ultimately devolved into the BCA types of construction.

The post-war building studies established the concept of types of construction incorporating various overall degrees of fire-resistance. Non-combustibility of the *internal* construction of buildings (in addition in this case to non-combustibility of external walls) became part and parcel of what the writers of the post-war building studies designated "fully protected construction". Buildings of fully protected construction and, by implication of the fire-resistance requirements, each compartment in them were to survive fire (the complete burn-out of contents) and to prevent any spread of the fire without the intervention of the fire-brigades or, more generally, of any active protection.

Justification was in the following terms (paragraph 59):

> "Although a relatively high standard of fire resistance may be obtained with certain combustible elements of structure by taking special precautions, their incorporation in buildings of Types 1 - 3 (fully protected - Ed.) construction would defeat the object aimed at in those types. For example, a timber floor joist may be protected by means of plugging and special ceilings so that it affords 1 hour or more of fire resistance under test conditions, but fire on the upper surface may ignite the structure and lead to complete burn-out."

Although there is no incontrovertible reference to the sort of behaviour of timber described in 5.01 and 5.02 below, the writers might have known of it. Fire in a building with such floors would need at least inspection by firemen to ensure that no incipient fire was present and thereby "defeat the object aimed at in those types".

There were concessions to strongly entrenched building practices:

Timber doors "which attain the required grade" (paragraph 59);

Decorative linings, floor surfacings, window frames and similar non-structural parts "provided the proper precautions are taken where necessary" (paragraph 136).

Other types of construction intended for adoption for buildings involving progressively lower risk to people and property were designated type 4 - partially protected construction, type 5 - externally protected construction, type 6 - non combustible construction and type 7 - combustible construction. These were not intended to survive a fire without the intervention of the fire brigades and were required therefore to have progressively less stringent fire-protective measures particularly for the internal construction.

Even so, it can be read into the proposals that there was an overall policy that, at a level appropriate to the type of construction and the limits imposed on buildings of that type of construction, the building *fabric* itself should

be as refractory as practicable, and

not contribute *unduly* to the fire load.

The same impression is given by CEBS Bulletin 9 [2] (an exposition of the Australian regulators' approach to the fire-protection of buildings) in its brief reference to non combustibility:

"The likelihood of fire, and the potential severity of a fire, increase with the availability of combustible material. Combustible materials should be kept to a minimum. There are practical limitations to the application of this principle, but a non-combustible building material is to be preferred if it satisfies requirements other than those which pertain to fire".

The correlation of the severity of restrictions on combustibility with type of construction linked them with the degree of risk to *people.* From the regulatory point of view, people are exposed to the risk of death or injury from fire during the evacuation phase of fire in a building. The correlation was, therefore, ultimately with time for evacuation.

3.2. External walling

A distinction (knowledgeable but made without comment) was made between external and internal fire-rated walls. The fire rating of an external wall is not sufficient in itself to prevent the spread of fire from another building. If the outer surface of the wall is ignited by radiation or impingement, an FRL might be sufficient to prevent transfer to the interior of the building but fire *has* been transferred *to* the building. The requirement of non-combustibility is necessary to prevent the spread. This is a particular case of the necessity for a requirement of non-combustibility for radiation-shielding dealt with more generally in section 7 below.

3.3. The transfer to Australia.

The types of construction proposed by the post-war building study and what they became in Australian regulations were as follows:

PWBS No 20	AMUBC	BCA 1990	Description in RDs Nos. 4 [3] and 15 [4]
Types 1, 2 & 3	Type 1	Type A	Fully protected construction - "structurally capable of resisting fire until the fire exhausts itself in the absence of fire-fighting help, or, in technical jargon, … capable of resisting 'burnout' of the contents".
Type 4	Type 2	Absorbed into Type A (for the most part).	Partially protected construction - "…the internal construction 1s not intended to survive a fire unless the fire brigade can quell it at an early stage". [Note "internal"].
Type 5	Type 3	Type B	Externally protected construction - "… only the external walls are likely to survive any but a mild and short-lived fire, and even the external walls may topple in a protracted
Type 6	Type 4	Ceased to be a separate type	Non-combustible construction - "… the only virtue of the construction is that, unlike Type 5 construction, the material of the building will not itself burn, but that otherwise it is not intended to offer much resistance to a fire".
Type 7	Type 5	Type C	Combustible construction - " .... both the contents of the building and the building fabric itself can burn as one".

By the time the proposals of the post-war building studies found their way (twenty years later and by way of the regulations of Victoria and New South Wales) into RD No. 1 [5] more concessions had been introduced, for example the conditional approval of timber floor and roof framing in type-1C - fully protected lightweight construction.

3.4. The trend of deregulation of non-combustibility by AUBRCC.

The progressive mitigation and elimination of the requirement of non-combustibility have been a response mainly to representations by the timber industry, rarely to representations by other industries, although other industries benefit when amendments are in general terms rather than specific ("timber") terms.

It must be pointed out, however, that deregulation followed (and its trend was compatible with) a basic change in approach during the progressive development of the BCA - an assumption that, on the balance of probabilities, there would always be active intervention in fires in buildings and professional organisation of, and assistance with, evacuation.

Multistorey timber-framed construction was introduced into the AMUBC after research undertaken by the timber industry was presented to AUBRCC. (The research was notable *inter alia* for its demonstration of the dominant influence of active fire protection on risk-reduction). The endorsement of the use of fire-rated timber columns in single-storey construction was as much a response to a plea for equitable treatment with the steel industry as anything else. (It might be noted that the elimination of this sort of distinction could be seen as a development of the disappearance of the old type-4 as a distinct type of construction). The size of timber battens permitted to cross the tops of fire-walls is dictated not by research but by industrial practice. Such battens are quite capable of spreading fire from one side of the wall to the other and the possibility that they might take some time to do so is an additional danger. This form of construction demands that it become standard practice that, in the event of fire on one side of the wall, the battens receive particular attention from the brigades before they leave the site. (See 5.02 below).

It is noted that the batten concession was not extended to proscenium walls (clause 4 of Specification Hl.3). Was this intentional or an oversight?

4. THE DEFINITION OF NON-COMBUSTIBILITY

One can't escape the impression that, in many cases, the regulators sought construction that was merely difficult to ignite and slow to support combustion rather than incombustible but the problems of definition and reproducibility forced them into acceptance of the Australian standard method of test for combustibility. The criterion imposed by the standard is an absoluteness of incombustibility. (For a description of the test see paragraph 3.2 of HAA). The adoption of the standard is alleviated to some extent by the inclusion in the regulations of a list of building materials which "although combustible are deemed non-combustible". The list has steadily grown over the years. Other requirements could be instances of this - the use of fire-protective coverings to combustible construction [Specification Cl. l - 5.1(e)(ii)], the specification of large lumps of dense hardwood for stair-treads [D2.3], the implicit correlation in G3.3(b)(i) between 35-mm timber and non-combustibility and certain approvals of "material that does not significantly increase the hazards of fire" [Specification Cl.10 - 7(j)]. Massive hardwood construction could solve the problem presented by the single-tier grandstand at the country picnic racecourse. (Such construction is difficult to specify in performance terms except by reference to deemed-to-comply construction).

Specifications A2.4 and Cl.10 are also instances of the regulatory acceptance of combustibles and their control rather than their proscription.

5. FEATURES OF THE AUSTRALIAN FIRE-RESISTANCE TEST

5.1. The fire-resistance test is a **static** test.

Unprotected timber, in particular unprotected hardwood, achieves fire-resistance ratings by developing charred layers that insulate and slow (without necessarily stopping) the combustion of the inner parts of posts and beams. Although the atmosphere within the furnace might be, by definition, turbulent there are not the strong drafts of everyday fires that tend to remove the char and expose progressively more timber. Nor should it be assumed that the char prevents combustion. (If timber didn't continue to burn once properly ignited we wouldn't use it in a slow-combustion stove, let alone an open fire-place).

For these reasons, a fire in a timber building, even if the building has the FRLs demanded of fully protected construction, needs the attention of the brigades if the danger of eventual collapse is to be circumvented.

Such a building, therefore, does not fulfil the *'performance requirement'* of fully protected construction as conceived by the writers of the post-war building studies, of the AMUBC and of the earliest versions of the BCA - an ability to survive without intervention.

5.2. Post-test behaviour of the prototype specimen is immaterial to the Australian rating.

The possibility discussed in 5.01 highlights another aspect of the standard test. After dutifully fulfilling all the criteria for any of the standard periods, the construction could lose its fire-resistance but, provided the change was detectable only by retesting, still be credited with its rating.

This necessitates not only conservatism in setting safety margins within the required FRLs but also great confidence in the margins set.

A more sinister aspect of the behaviour of timber than that described in 5.01 is demonstrated by construction that achieves a rating by protective encasement. If by the time the construction has achieved the required rating the timber has reached temperatures at which destructive distillation has started, the process will continue inside the encasement, even in the absence of ventilation, and the structure will eventually collapse. Automatic sprinkler systems cannot arrest such behaviour. With such construction, firemen have to actually strip off the protection in order to extinguish the fire.

(Note that American codes regulate against this possibility by means of a "finish" rating - a limit on the temperature reached within the casing rather after the style of our limits on temperatures within ceilings imposed to prevent the incipient spread of fire within the ceiling space).

The regulatory conditions under which combustible, fire-rated construction can be considered to fulfil the implicit performance requirement for fully protected construction (survival without intervention) need careful research. The plastics

industry has not yet entered the fray. The materials engineers will remember certain classes of concrete additive which made the compressive strength of the concrete peak at 28 days. In more general terms; once a regulation specifies a test criterion, products will be developed to fulfil it and to fulfil it *literally* and *economically.*

6. CONCRETE OR MASONRY

It could well be that it was consideration of the features of the fire-resistance test noted above that led the earliest regulation writers to seek robustness combined with non-combustibility in loadbearing construction and at least non-combustibility in non loadbearing construction, particularly for the surrounds of shafts. [For example, AMUBC 16.7(12) which became subclauses 3.l(d) and (e) of Specification Cl.land 16.9(9) which became 4.l(e) and (f)].

Note, however, that the pre-AMUBC regulations tended very strongly towards materials prescription and this tended in turn to carry over into at least the earliest ISCUBR drafts. For example, the draft Victorian regulations of 1943 [6] and the regulations themselves (Uniform Building Regulations Victoria 1969 [7]) defined framed fire-resisting construction (clause 706 in the draft, 705 in the UBRs) as

> "that type of construction in which the imposed loads are carried on columns and beams or on reinforced concrete walls where same are used for shaft enclosures… ; and

bearing wall protected construction (clause 707/706) as

> "that type of construction in which the walls are of masonry or reinforced concrete…".

7. PROTECTION FROM RADIATION

7.1. It is pointed out in 3.02 above that the fire rating of an external wall is not sufficient in itself to prevent the spread of fire from another building. If the outer surface of the wall is ignited by radiation or impingement an FRL might be sufficient to prevent transfer to the interior of the building but fire *has* been transferred. The requirement of non-combustibility is therefore necessary to prevent the spread of fire from building to building ifthere is no active intervention.

7.2. The requirement of the non-combustibility of external walls persisted for all types of construction up to and including BCA 1988 but was dropped for type-C in the first issue of BCA 1990. There is some inconsistency (or is it an apprehension of the failure of active systems) with the general concession of Specification C1.1 - clause 2.S(d) which requires drencher-protected curtain walls to be non-combustible. (Compare the requirement in G3.4(b) for drencher-protected glazing to be m non combustible framing - introduced in 1990).

7.3. External stairways and their enclosures (D1.8) are similarly vulnerable to radiation. Note, however, that, in the concessions granted balconies in clause 2.S(f) of Specification C1.1, in only type-A construction is there a requirement for non combustibility and that requirement is confined to "supporting columns".

7.4. A similar argument could be made to justify the combination of FRL and non combustibility for spandrels and slab-projections in C2.6. The FRL is necessary for storey-to-storey protection from fire in the building and the non-combustibility for protection from fire outside it. (The parallel requirement for non-combustibility of the fire-stopping behind curtain walls is a reasonable requirement).

7.5. An example of the usefulness of non-combustibility for radiation shielding in the absence of a fire rating is the balustrade on the edge of a balcony in an atrium. It is there to shade people from radiation during the brief period when it is practicable to escape from the balcony but there is no compartmenting function. An FRL should not be necessary but the balustrade mustn't get on fire.

8. SMOKE COMPARTMENTATION

8.1. It can be deduced that a requirement for non-combustibility appeared to the regulators to be appropriate for aspects of smoke compartmentation and there is evidence in the regulation documents that ISCUBR very consciously adopted such a measure as a policy. In RD No. 43 [8] which contained the first drafts of what was eventually to become Section D, the commentary on clause 24.29 (the clause was subsequently redrafted and renumbered) correlates the requirement for fire-resistance ratings with "the need for fire protection" and the requirement for non-combustibility with "the need for smoke protection". There is an implication here that a fire rating is commensurate with a protracted period of compartmentation. Although the period might not correspond to the rating, the implication is generally sound.

8.2. Smoke walling is intended to protect people from smoke and to do so only during the evacuation of the compartment or the building. In other words it fulfils its function during the early stages of a fire. But there should be negligible possibility of its ignition or of its becoming (when heated) a source of smoke itself. In such circumstances, non-combustibility recommends itself as a desirable and as a sufficient requirement.

8.3. There is a further implication here. If the smoke wall is called upon to act as a fire-barrier for a short time during the evacuation of the smoke compartment, its "cold face" should not reach a temperature that would injure a person who touched it. (The insulation criterion of the standard test for fire-resistance level would not achieve this).

8.4. Smoke curtains are more severely exposed than smoke walls. They are meant at least to prevent the lateral movement of smoke and commonly (and in a more important function) to funnel smoke up through ventilators. In the latter case particularly, the smoke is hot and is carrying sparks. It would be therefore sufficient for the smoke to raise the temperature of a combustible curtain only to the level for piloted ignition for a spark to ignite it. On the other hand, the curtain has no fire compartmentation role and non-combustibility is a sufficient requirement. (Note, however, that the ISCUBR writers, knowing the propensities of heated asbestos cement, required smoke curtains to be also shatterproof).

9. NON-COMBUSTIBILITY AS A SECOND ORDER FRL

There is evidence of the adoption by the regulators of non-combustible construction as construction with a low, but sufficient (in their judgement) level of fire-resistance. Examples are as follows:

9.1. Buildings or compartments from which escape should be sufficiently quick to justify there not being an FRL.

Single-tier open spectator stands and indoor sports stadiums [C1.7];

Various parts of type-A open spectator stands and indoor sports stadiums [clause 3.8 of Specification C1.1];

Smoke-walls that fulfil a brief fire-compartmentation function [C2.5 particularly];

Enclosure of services in required exits [D2.7(d)].

9.2. Where flame (fire-plume) enclosure rather than fire-compartmentation (with specific FRLs) is seen as sufficient.

Non-combustibility requirements for roof coverings [clauses 3.l(c), 4.l(d), 5.1(d) of Specification C 1.1].

9.3. A sufficiency of protection from external sources of fire.

Non-combustibility of roof coverings for the top enclosure of fire-isolated passageways [D2.7(d)].

9.4. Considerations of both 9.02 and 9.03

Non-combustibility requirements for roof coverings [clause 3.5 of Specification C1.1].

Non-combustibility requirements for roof coverings and supporting construction [clause 3.4 of Specification C1.1].

Structures on roofs enclosing only specific services [clause 2.5(c) of Specification CI. I].

10. CONCLUSIONS

10.1. Non-combustibility in general.

With regard to requirements for the non-combustibility of materials, the progressive development of Australian building regulation has been characterised by mitigation and elimination. Rarely (in only one instance of significance?) has the requirement been imposed where it wasn't before.

In any analysis of the building regulations for the purposes of fire-code reform, however, the overall issue of the possibility of its usefulness mustn't be overlooked.

10.2. Individual items for investigation.

This outline of the history of requirements for non-combustibility in Australian building regulations raises also a number of individual issues for examination.

1. The basic issue - the necessity or otherwise for any requirement for non combustibility no matter how defined and the significance of any contribution it might make in isolation or in combination with a requirement for a fire-resistance rating.

2. Alternatives to the present *concept* of non-combustibility m terms of definition and assessment.

3. Examination of the fire-tests of the BCA in general against the background of the future objectives of the BCA. For example

   (a) Could the standard fire-resistance test be modified to eliminate the need, at least in some instances, for a requirement for non-combustibility to be combined with a requirement for an FRL?

   (b) Would a criterion after the style of the American finish rating or the Australian incipient-spread-of-fire rating be a sufficient control of fire-rated combustible construction?

   (c) Could a requirement for an FRL (as presently determined or as amended) replace the requirement for non-combustibility in smoke-compartmentation and, if so, what levels should the set?

   (d) Could control of the early-fire-hazard properties of materials be usefully extended to liberalise requirements for non-combustibility?

4. Examination of each remaining requirement for non-combustibility in the BCA as to its necessity or even usefulness. For instance, does drencher protected construction need to be non-combustible?

5. The question arises as to whether every fire-protection (including smoke protection) provision of the BCA or proposed reformation of the BCA should be examined as to the usefulness of including a non-combustibility requirement, particularly if the approach to this aspect of materials-control is modified in response to the issues raised above. One way of tackling such a task would be to use, say, the AMUBC as an aide memoire; to compare individual requirements of the BCA with individual requirements of the AMUBC as to whether deregulation was justified.

It is noted that the ultimate objectives of the BCA with regard to the *performance* of buildings and their components (and the questions of the definition and assessment of performance) will be basic to any examination of present approaches and of whether or not conservation or change would be useful.

11. THE PRESENT PROVISIONS AND THEIR ANTECEDENTS

Appendix 2 is a tabulation of provisions of the BCA that control combustibility and summaries of their development.

12. REFERENCES

1. POST-WAR BUILDING STUDIES No 20 - FIRE GRADING OF BUILDINGS - PART 1 GENERAL PRINCIPLES AND STRUCTURAL PRECAUTIONS, Ministry of Works, HMSO, London, 1946.

2. CEBS BULLETIN No 9 - FIRE PROTECTION IN BUILDINGS, J.W.Drysdale, October 1965.

3. ISCUBR RD 4 - FIRE PROTECTION : A DISCUSSION OF PRINCIPLES, D.V.Isaacs, May 1965.

4. ISCUBR RD 15 - FIRE ZONING (The principles of fire-zoning and draft regulations), D.V.Isaacs, May 1966.

5. ISCUBR RD 1 - FIRE PROTECTION PART 1 (Draft regulations), D.V.Isaacs, January 1965.

6. DRAFT UNIFORM BUILDING REGULATIONS - VICTORIA, 1943.

7. UNIFORM BUILDING REGULATIONS - VICTORIA, 1969.

8. ISCUBR RD 43 - MEANS OF EGRESS AND INTERNAL MOVEMENT, D.V.Isaacs, January 1969.

APPENDIX 2

CLAUSES THAT CONTROL COMBUSTIBILITY:

A COMPARISON BETWEEN BCA 1990 AND ITS ANTECEDENTS

CLAUSES THAT CONTROL COMBUSTIBILITY

A COMPARISON BETWEEN BCA 1990 AND ITS ANTECEDENTS

Notes: An asterisk indicates a removal of a requirement for non-combustibility that appeared in earlier regulations or draft regulations. The bracketed clause numbers are those of the present version of the clause or, if the clause number has been reused, of the last version before deregulation.

The letters NC mean "non-combustible" or "non-combustibility".

BCA 1990 CLAUSE No	CATEGORY	REMARKS
Al.l	-	Definitions of "combustible" and "non-combustible" - really no significant change from AMUBC.
Cl. 7(a) Single-tier spectator stands	Second order FRL.	RD92/18. RD is of 1992 and arose from a variations-reduction conference. It indicates only that proposal would eliminate an NSW variation. This provision was always linked to an intention to provide for the bush - simple timber stands for the picnic races. This has not yet been managed.
C2.5(b)(iii)(A) Smoke-proof wall in a patient-care area..	Smoke-compartmentation	No data on origin. E23 papers say discussion of compartmentation of9a's should await comment (on draft for public review) from health authorities
C2.5(b)(vi) Ancillary areas in patient-care areas. Introduced with Amndt 5.	Fire-compartmentation?	Requirement for walls to extend to NC roof covering just copies similar requirements elsewhere in the BCA.
C2.6(a)(iii) Protective spandrel to be NC.	Radiation control	No significant change from the AMUBC. Part 22 of the AMUBC is said to be based inter alia on existing NSW and Victorian regulations
C2.6(b) - By invoking (a). Protective panel wall or curtain wall.	Radiation control.	Both AMUBC and 1986 say "spandrel or other vertical construction". 1990 is just more specific
C2.6(c) Constuction complying with (a) with gaps packed with NC stuff.	Radiation control, smoke-compartmentation, fire-compartmentation.	No significant change from the draft BCA of 1986 which forms a transition from AMUBC to BCA. AMUBC just says no voids.
C2.6(d)(iii) Protective slab to be NC.	Radiation control.	No significant change from AMUBC. Introduced with RD 49 (1970).
C2.7(c) Battens crossing fire walls. Amndt 7 introduced	Relaxation of fire-compartmentation.	No significant change from AMUBC to the first issue of BCA 1990. Amndt 7 introduced the present batten concession.

the concession.		RD30 (cl967) proscribes batten crossings of walls between row houses. Walls had to be of concrete or masonry. RD44 dealt with each class separately and proscibed crossings in each case. RD53 [23.1(4)] generalised the proscription in its AMUBC form.
C2.7(d)(iii) NC of a lower roof.	Second order FRL in presence of sprinklers.	No significant change from AMUBC. Introduced without comment with AMUBC Amndt 12 of September 1985 which dealt with the case of different rooflevels on each side of the fire wall.
C2.10(b)(ii) Separation of lift shafts - NC in type B.	Second order FRL.	RDsl92, 206,226 The equivalent clause in the AMUBC was applied to types 1, 2 & 3 and was identical with C2.10(a). Concession for non-loadbearing shaft walls was introduced with RD192 as part of the elimination of fire zones.
C3.l(a)(iii) NC ventilators in subfloor and cavity walls.	Radiation control?	No significant change from AMUBC. Not worth a great deal of attention - except that requirements for ventilators are made part and parcel of an exception.
C3.13(a) Openings in shafts - sanitary compartments.	Second order FRL and smoke-compartmentation	No significant change from AMUBC. NC as alternative to -/30/30. Originally a concession from 22.12(1) which became C3.13(d)- see below. Sanitary compartments were seen as less of a risk than other shafts.
C3.13(d) Ditto Garbage shafts	Second-order FRL and smoke-compartment-ation.	No significant change from AMUBC The concession for garbage shafts wasn't in RD49 (early 1970).It appeared in RD53 without explanation. A matter of convenience with hoppers and a sufficiency of protection?
C3.15(b)(i) Proximity of combustibles to a pipe.	Basic fire-compartmentation	Not relevant to this project. (Introduced with the 1986-draft BCA [C5.12(a)].
C3.15(d)(iii) Deemed-to-satisfy solutions but not for pipes conveying flammables.	Basic fire-compartmentation	Not relevant to this project.
D1.8 (Introduction) External stairs to be NC.	Radiation control.	No significant change from AMUBC which was the same as RD48 of early 1970. No comment is made in RD48 on this requirement. A recognition of current practice with external fire escapes - which is obviously sensible.
Dl.8(a)(i)	Radiation control	No significant change from AMUBC which

Enclosure of ditto	and fire-compartmentation.	was the same as RD48 of early 1970. No comment is made in RD48 on this requirement. Fire-rating combined with NC.
D2.2(a) Stairways and ramps inside fire-resisting shafts.	Basic ignition and fire-spread control - second line of defence against fire entering the shaft.	Stairs: Up to and including 1986 the requirement prescribed concrete [reinforced, precast and prestressed of particular thicknesses] and finishes of prescribed EFH properties [cfD2.3/16.13(2)]. Ramps: 16.14 and C3.10 (1986) required NC and a 1hr rating BCA 1988 et seq. generalised these but dropped the 1hr rating.
D2.3 Ditto not in fire-resisting shafts	Basic ignition and fire-spread control - second line of defence against fire entering the shaft.	NC and resistance to ignition is by implication [density and thickness of timber are spelled out]. AMUBC was confined to class 2s but otherwise the same.
D2.4(b) Separation of rising and descending flights.	NC as a supplement to FRL.	No significant change from AMUBC. NC and fire-resistance combined. RD43 (January '69) was the first draft of Part 24. Clause 24.31 required FR but didn't mention NC. This appeared in a more rudimentary form in RD33 of December '67. The comment in RD43 refers to overseas origins ("the principle is well established overseas")and suggests the purpose might have been misunderstood. RD53 (Series 2 - 1970) presented the AMUBC requirement.
D2.7(d) (Conclusion) Enclosure of installations in exits.	Smoke-compartmentation.	No significant change from AMUBC. Note that BCA indicates the intention as the enclosure of smoke from the installation.
D2. ll(a) (Introduction) Enclosure of fire-isolated passageways	NC as a supplement to FRL	No significant change to NC component from AMUBC nor from RD53. The same clause doesn't seem to appear in RD43. The latter did regulate corridors leading to open space to be of concrete or masonry extending to the soffit of the floor above.
D2. ll(b)(i) Ditto - walls reaching an NC roof covering.	Second-order FRL	See notes on D2.ll(a) above.
Table E.2.2 - Class 2,3 4 Public corridors - subclause (b)	Smoke-control.	New. Amndt 7 recast the whole part. This subclause, while requiring construction to C2.5(b)(iii), presents a concession on non- combustibility - but is not all that clear.
G2. l(c)(ii) Chimneys mustn't leak	Smoke-control and basic ignition and	Part G2 is about heating appliances, fireplaces, chimneys, flues and incinerator

smoke nor hot gases to nearby combustibles G2.3(a) Intro G2.3(a)(iv) G2.4(a)(i)	fire-spread control.	chutes. It applies to class ls as well as everything else and therefore goes for NC rather than FR. No significant change from AMUBC and doesn't merit a lot of analysis.
G3.4(b) (Introduction) Bounding walls in atria - drencher-protected glass as alternative to fire-	Fire-compartmentation - second order FRL in the presence of drencher	In the draft BCA of 1986 the nearest equivalent clause, C3.3(3)(c), is primarily concerned with openings but there is here again that implication of correlation between smoke-compartmentation and NC.
G3.5 NC balustrade aound the balcony.	Radiation control	No significant change from the draft BCA of 1986.
(G4.2 - First issue of BCA 1990)	-	Walls separating SOUs in Class 2 and Class 3 don't have to be of concrete or masonry. Exemption was first granted in the draft BCA of 1986. G5.2 of BCA 1988 granted exemption from 5.l(d)(i) of Specification Cl.l. The requirement did not appear in the first issue of BCA 1990 which granted an exemption from a non-existent provision. Amndt 5 corrected this.
SPECIFICATIONS		
A2.3		
[5(a)(ii) before Amndt 5] Packing behind column protection.		5(a)(ii) became Cl.8(b)(i) but the requirement for NC of the packing material disappeared. An accidental omission?
[5(b) Introduction before Amendt 5] Fire-stopping of gaps in floors around columns.		This requirement became C3.17 but the requirement for NC of the plug disappeared. An accidental omission?
Cl.1		
2.2(b) Support to be NC if the supported part is to be NC	Compatibility of category with that of the supported part.	No significant change from AMUBC.
2.4(a) (Introduction) Combustibles on facades.	Relaxation of radiation control.	AMUBC placed embargo on combustibles on facades of types 1 & 2. The draft BCA of 1986 gave concessions for buildings not over 8 storeys. BCA 1988 introduced present concessions
2.5(b) Timber columns allowed in single storey buildings	Uncoupling of NC and FRL and relaxation of FRL	Introduced via RD 279.
2.5(c) (Introduction)	Second-order FRL	No significant change from AMUBC.

NC structures on roofs	and radiation control	Appeared in its AMUBC form in RD47 - the revision of Series 1 "to 1970". No supporting arguments are attached.
2.5(c)(vi) "other service units that are non-combustible." Note implication that the contents of the structure are generally NC.	Second-order FRL and radiation control	As above
2.5(d) Curtain walls and panel walls need not have an FRL if they are non-combustible and drencher-protected	Radiation control and second-order FRL in the presence of drencher protection	First proposed for the AMUBC in RD209. In the form that appeared in BCA1986, the FRL requirement was removed (note that one would expect the NC requirements of C3.5(l)(a), C3.6(l)(a) and C3.7(2) still to apply) generally from walls not within specific distances of FSFs and from walls within those distances if the walls were drencher-protected and, in type-1 and type-2 construction, if they were also NC. The latter would appear to be redundant in view ofC3.5(l)(a) and C3.6(l)(a); it's not really implicit in the intro that the NC requirements were also removed. BCA1988 removed mention of type of construction - no FRL if outside the specific distances or NC and drencher protected. The first issue of BCA 1990 removed reference to distance from FSF - to avoid FRL must be NC and drencher-protected
2.S(e) Materials deemed non- combustible	-	List has been progressively extended but concept hasn't changed from the beginning.
2.S(f)(ii)(B) Columns supporting balconies on facades in type- A	Radiation control?	RD92/18 This resulted from a variations-reduction conference. No relevant explanations in the RD. (The committee should really have addressed the second panels of Tables 3 and 4.)
2.6(b) (Introduction) Small mezzanines need no FRL nor to be NC provided…	-	No significant change from AMUBC. Appeared in RD47 (Series 1 "revised to 1970") but no supporting documentation has been found.
2.7(b) Bottom of a shaft needn't have FRL if NC and laid on the ground.	Second-order FRL	Whole of clause 2.7 appeared in Amndt 1. No documentation can be found although it might be in AUBRCC minutes somewhere before April 1991.
3.l(b). NC required of floors	NC combined with FRL for "type-1"	Under 16.7(l)(a) of the AMUBC, in type-1 construction everything needing an FRL

of lift pits and floor-framing of lift pits	construction.	must be NC. Then came concessions. See also 16.8(l)(a) and 16.9(1). Was the problem that NC of floors would knock out a common form of construction? Was it finally solved by taking advantage of the separation achieved in 1986 and removing the general requirement for floors but leaving in that for lift-pit construction?
3.1(c)(iii) Fire-rated wall to extend to a fire-rated roof or an NC covenng.	Second-order FRL.	Clause 16.7(10) ofRD30 (circa 1967) and 16.7(11) ofRD47 (its revision "to 1970") are the same as AMUBC 16.7(ll)(a)(ii) which required extention to a fire-rated roof etc. or to the covering of any other roof. There was no mention ofNC of the covering.
3.1(c)(iii) continued Batten concession introduced with Amndt 7		There was a general requirement for NC in type-1 construction and, perhaps, an assumption that roof-coverings were NC.
3.l(d) Loadbearing internal walls etc to be concrete or masonry.	NC and robustness combined with FRL.	No significant change from AMUBC 16.7(10)(a) of RD30 & 16.7(ll)(a) of RD47 are the same as AMUBC.
3.1(e) Non-loadbearing internal walls etc to be NC.	NC combined with FRL.	16.7(12)(b) of the AMUBC allowed "plaster on metal lath" or its equivalent as a concession to concrete or masonry. Specification Cl.8 was the generalisation of the "plaster on metal lath or something no less hard" requirement. Hence its intrusion into 3.l(e) ofBCA 1988. BCA 1990 was a correction of this.
3.4(a) NC roof superimposed on a concrete slab.	Radiation control.	No significant change from AMUBC. RD47 is the same as the AMUBC. No parallel clause in RD30 but 16.19 of RD30 allowed a FR/NC roof to be covered with a built-up membrane. This became 16.22 in AMUBC and C3.5(13) in the draft BCA of 1986.
1.5 (Introduction) Roof need not be FR if its covering is NC and…	Radiation control and second-order FRL.	There has been lots ofrewriting of this clause but with no significant change to the general requirement for NC of the covering since AMUBC. In RDs 30 and 47 the requirement for NC was not general but depended on class, rise and so on.
3.6 Roof lights in a roof whose covering must beNC.	Radiation control and second-order FRL.	RD92/06 - Introduced from a reduction of variations conference. Discussion was around glass roofs, i.e. no suggestion of allowing combustible panels.
3.8(a)	Second-order FRL	All three concessions were introduced into

Open spectator stands - NC roof needn't have anFRL		the draft BCA of 1986 via RD277 - A list of amendments to the "Uniform Building Code" proposed by Victoria in 1986. All three were to become 16.7(14) but became C3.5(16) in BCA1986. There is no record of discussion even in the AUBRCC papers
3.8(b) Ditto certain columns and LB walls		
3.8(c)(i) & (ii) Ditto NBL parts of certain external walls		
3.l0(a)		This is the multistorey, timber-frame construction introduced with Amndt 7.
3.l0(b)		The various requirements for non-combustibility (including the requirement for concrete or masonry) would reduce risks that might arise from the nature of the fire- resistance test as applied to combustibles. The batten concession arose here.
3.l0(c)		ditto
4.l(b) NC required of floors of lift pits and floor framing of lift pits	NC combined with FRL.	See notes on 3.1(b). This is a retention of a "type-1" requirement in type-B construction. Lift shafts were probably seen as posing a somewhat greater threat as fire- transmitters than the rest of the construction.
4.1(d)(iii) FR wall to extend to an FR roof or an NC covering. Batten concession introduced with Amndt 7.	Second-order FRL.	The AMUBC requirement was confined to classes 2 and 3. This persisted in earlier versions of the BCA but was generalized in the first issue of BCA 1990.
4.1(e) Loadbearing internal walls and loadbearing fire walls to be of concrete or masonry.	NC and robustness combined with FRL.	No significant change from AMUBC nor from RD47 [16.9(9)] or RD30 [16.9(7)].
4.l(f) Non-loadbearing internal walls that need an FRL to be NC.	NC combined with FRL	The AMUBC requirement in 16.9(9)(b) for concrete, masonry, plaster on metal lath or its equivalent was generalised in the draft BCA of 1986 but invoked Specification Cl.8. This was corrected in BCA 1988. See notes on 3.l(e).
4.l(h) Service shafts in certain classes to be NC	NC combined with FRL.	In the AMUBC, this was part of 16.9(9)(b). See notes on 4.l(f).

4.l(i) Fire-protective covering above space for cars or storage.	Second-order FRL.	Nominal fire-protection to the floor above a garage or storage area in a class 2 or 3. This clause has been recast for clarification but there is no significant change from AMUBC
4.3(a)		Multistorey, timber-frame construction. See notes on 3.10.
4.3(b)		ditto
[5.l(b)(i) 1988]		The various requirements for external walls, the outer parts of external walls, fire walls, internal walls bounding sole-occupancy units etc in type-C (type-5) construction to be of concrete, masonry, plaster on metal lath or its equivalent or merely non- combustible persisted in various forms up to and including BCA 1988 but were eliminated from the first issue of BCA 1990
[5.l(b)(ii) 1988]		
[5.l(c)(i) 1988]		
[5.l(c)(ii) 1988]		
[5.l(d)(i)		
[5.l(d)(ii)		
5.1(d) Vertical extent of partition walls in class 2 & 3 - to NC roof sheeting or above combustible roof sheeting.	Second-order FRL	The only significant changes from 16.11(8) of the AMUBC were the first issue of BCA 1990 introduced "the floor next above" Amndt 7 introduced the batten concession and deleted the exemption that applied when there was only one sole-occupancy unit in the top storey. [cf 16.11(9) of the AMUBC
5.1(e) Coverings to the undersides of floors above garages and storage areas in classes 2 and 3 and exemptions.	Second-order FRL.	No significant change from AMUBC 16.11(10) and 16.11(11).
[5.l(h) 1988]		A requirement for NC in external walls of classes 7b and 8b in 16.11(5) of the AMUBC was deleted with the first issue of BCA1990.
Cl.9		
4(a) (Introduction) External wall to extend to NC roof or eaves.	Second-order FRL	SpecificationC1.9 has been extensively rewritten and rearranged from one BCA to the next. This requirement first appeared in the draft of 1986 [C6.l(l) & C6.1(3)] then in 3(a) of BCA1988. The first issues of the BCA made no mention of vertical extent - corrected in Amndt 3.

4(a) Construction of external walls	Second-order FRL	The draft BCA of 1986 included one specific requirement for concrete or masonry. Later editions of the BCA reverted to the present form. BCA1990 allows masonry as an alternative to an FRL of 60/60/60 "when tested from the outside" but, this is not a requirement for NC. The latter has really been deleted. Note that the requirement for NC for buildings over 2 storeys disappeared in 1988.
2. (generally) 3. External walls of class 10s. No requirement for NC.		A requirement for certain class-10a walls to be NC or lined with NC material persisted into the issue that included the second amendment. From the third amendment, BCA1990 has recognized compliance with clause 4. Requirement for NC has therefore gone. See notes on clause 4(a) above.
5(d)(ii) and (iv) Exemption for carports Reintroduction ofNC	Second-order FRL, basic fire-compartmentation	Amndt 3 exempted carports from 5(a), 5(b) and 5(c) provided separation is NC.
6(b)(ii) and 6(c) - first item. Allowable encroachments	Radiation control	Up to and including BCA1988 there was no mention ofNC. Amndt 2/3 the NC requirement into 6(b)(ii) and Amndt 4 introduced the NC requirement into 6(c).
7 Separating walls	NC in combination with FRL	1988 required (a) C or Mand extension to NC upper construction, (b) 60/60/60 if class1/class1 or class1/class10 on different allotments, OR (c) be lined with NC material if class10a/class10a on different allotments but it's not clear whether and which are alternatives. BCA1990 has kept a NC "requirement" only in relation to the vertical extent of separating walls - to a NC roof covering or above it. Amndt 7 introduced the batten concession.
[8 First issues of BCA1990 Floors between SOUs to be lined with NCJ		Deleted with Amndt 3 because this sort of building became a class 2 - see 5.l(e) of Specification C1.1.
9 Combustible rooflights	Second-order FRL and radiation control	In the first issue ofBCA1990 conditions were imposed on combustible roofights in roofs *required* to have a NC covering. The latter is never really a requirement anywhere but rather a feature of which advantage can be taken.
Cl.10		
3(a)(iii)	Second-order FRL?	No significant change from 16.19(4)(a)(iii)

Combustibles to be attached to NC substrates.		of the AMUBC. It's rather after the style of a second-order ignition and fire-spread control
C3.15		
3(a) (Introduction) Proximity of metal pipe to combustibles	Basic fire-compartmentation.	Not very relevant. Note also that the application of the specification to pipes containing combustibles is not permitted.
7(a) Properties of fire- stopping material	NC combined with FRLs. Basic fire-compartmentation	There is an implicit, but not explicit requirement that fire-stopping be NC
D1.12		
2(e) A floor covering under a fire door	Basic fire-compartmentation	The specification was introduced in the first issue of BCA1990.
E2.2vis a visE2.6		
2. lO(b)(iii) NC of smoke curtain around a floor openmg.	Smoke-compartmentation, smoke control.	Probably derived from 3(b). See below. An example of uncontroversial requirement for NC. cfNC as requirement for smoke-compartmentation generally.
3(b) NC of smoke curtains in general	Smoke-compartmentation, smoke control	First introduced with BCA1988 required compliance with AS 2655.
G3.8		
2.3(b) NC of collector plates.	Second-order FRL	Introduced in the first issue of BCA1990. Quite uncontroversial; the requirement is quite reasonable.
2.4.1 (Introduction) Ditto	Second-order FRL	See notes on 2.3(b).
Hl.2		
4 Smoke reservoirs to NC.	smoke-compartmentatio, smoke-control.	Introduced in BCA1988 cf comments above on clauses from Specification E2.2/E2.6/E2.4. Can be treated as part of a general requirement imposed on construction intended for smoke compartmentation and smoke separation.
Hl.3		
6(a) NC of proscenium curtain.	Second-order FRL.	Introduced as G4.3(2)(a) of the draft BCA of 1986. (Derived from Theatres and Public Halls regulations?) Note that (b) offers a combustible alternative provided EFH properties are limited and there is a comprehensive drencher system.
4 Timber purlins not to cross proscenium wall	Fire-compartmentation	Introduced in G4.2(3) of the draft BCA of 1986 although this was a more general provision. (Derived from Theatres and Public Halls regulations?) Note that this hasn't attracted the batten concession.

APPENDIX 3

REQUIREMENTS FOR NON-COMBUSTIBILITY

FOREIGN APPROACHES

REQUIREMENTS FOR NON-COMBUSTIBILITY

FOREIGN APPROACHES

1. INTRODUCTION

1.1. Codes with a common approach to fire-safety.

The group to which Australian building regulations belong has a world-wide distribution and includes North America, Europe, South Africa, Japan, other south east-Asian countries, New Zealand and a number of Pacific Islands. Characteristic of the group are certain common concepts with regard to fire-protection. Those germane to the present discussion are

(i) that the safety of people is by far the primary consideration;

(ii) that, irrespective of the individual characteristics of any building, the people who resort to it or its environs must not be exposed to an unacceptable level ofrisk;

(iii) that this level of risk (the level of safety that must be maintained) is common to all public buildings;

(iv) that irrespective of the extent to which the regulations might or might not be concerned with the protection of property, an owner of a building must put the safety of adjacent property before that of his own.

There are four further pertinent characteristics of the codes within this group:

(v) While the necessity for regulations for fire-protection in buildings stems from their contents, the regulations themselves are almost confined to the building fabric.

(vi) It is recognised that the source of fire in a building can be internal or external.

(vii) The spread of the fully developed fire from (and to) adjacent property is controlled by regulation of the materials of and openings in external walls *vis-a-vis* proximity.

(viii) The rigour of passive controls is mitigated by the availability of active controls.

The performances required of both passive and active fire-protective measures in building construction are therefore graded according to the risks imposed by size, occupancy and proximity.

1.2. The effect on the basic approach to fire-protection.

The principle that puts personal safety first and the safety of property second has led to the adoption of an approach to regulation for fire-protection that has two distinct aspects. They correspond, in time of application and with some overlapping, to the initial and subsequent stages of a building fire.

The initial stage - low but steadily increasing temperatures and heat flux.

The primary provisions are for prompt evacuation from the fire-affected area during which the spread of the fire and the production of heat and smoke within that area are controlled through short-term, reaction-to-fire criteria.

The subsequent stage - development to flash-over followed by high but comparatively stable temperatures and heat flux and eventual consumption of the fire-load.

The secondary provisions are for the containment of the fire within the fire-affected area.

1.3. The effect on materials of construction.

The concepts listed in 1.01 have determined policy with regard to materials of construction. With most materials controls, for example fire-resistance levels and the early-fire-hazard properties of materials (the dangers to people during the initial stage of a fire), graduated scales of requirements have been imposed that accord with the risks and these controls are imposed at the product level.

This is not quite the case with combustibility. The gradation of requirements for combustibility was originally introduced into building regulations at the level of the building as a whole. This was done through the regulation of types of construction. At the level of the product an absolute standard was originally laid down. A building component was either combustible or non-combustible. This is still the formal position with the Building Code of Australia 1990.

1.4. Measurement of non-combustibility.

The problems of definition and reproducibility forced building regulators throughout the world into acceptance of a virtually common standard method of test for combustibility. The concept was dominated by the science of calorimetry which was dedicated to measuring calorific value - the amount of heat energy that can be derived from a fuel. AS 1530.1, ASTM E 136, CAN/ULC-Sll4, CAN4-Sll4-M80, ISO 1182, BS 476: Part 4, SABS 0177 Part V and the Japanese Ministry of Construction's Notification No. 1828 are for all intents and purposes much the same. They all use a vertical, cylindrical calorimeter with much the same temperature regime.

The criterion imposed by the standards tends towards an absoluteness of incombustibility. Even the test method (NFPA 259) developed by the National Fire Protection Association for its Life Safety Code falls into this category. According to Janssens [1], although ostensibly a measure of so-called "limited" combustibility, for combustibles common in building construction the test effectively measures gross heat of combustion. No information has been received directly from France, but apparently, in order to classify materials as non-combustible, gross heat of combustion is measured with an oxygen bomb calorimeter and an upper limit of 2.5 MJ/kg is imposed. Although a limit, it is apparently an 'absolute limit' - there is no scaling.

1.5. The grading of buildings by combustibility.

Post-war Building Studies No 20 on the "Fire Grading of Buildings - Part 1 General Principles and Structural Precautions" [2], published in 1946 and ISCUBR Regulation

Document 4 "Fire Protection: A Discussion of Principles" 3, the earliest explanatory paper on the Australian Model Uniform Building Code, published in 1965, both graded types of construction along the following lines:

Fully protected construction:

"structurally capable of resisting fire until the fire exhausts itself in the absence of fire fighting help, or, in technical jargon, ... capable ofresisting 'burnout' of the contents".

Partially protected construction:

"the internal construction is not intended to survive a fire unless the fire brigade can quell it at an early stage". [Note "internal"].

Externally protected construction:

"only the external walls are likely to survive any but a mild and short-lived fire, and… even

the external walls may topple in a protracted fire".

Non-combustible construction:

"the only virtue of the construction is that, unlike (combustible) construction, the material of the building will not itself burn, but that otherwise it is not intended to offer much resistance **to a fire".**

Corn bustible construction:

"both the contents of the building and the building fabric itself can bum as one".

Note that the definitions did not presume the attendance of the fire-fighting services.

According to Janssens [1], North American model codes are conceptually very similar.

In descending order of safety they are

"fire-resistive"

"non-combustible"

"exterior protected combustible" "heavy timber" and

"combustible".

The correlation of type of construction with combustibility has been progressively diluted over the years (certainly in Australian building regulations) by redefinition of type of construction in terms of the nature and the extent of compartmentation and the dominance of fire-resistance level. But, although type-1 construction might require the adoption of more non-combustible products than type 5, the building as a whole could not be non-combustible in any strict, practicable sense. In other words, there was ambiguity of definition at this level.

2. THE GRADATION OF COMBUSTIBILITY

2.1. The grading of products by combustibility

There has always been a trend towards a gradation of controls of combustibility at the product level. The AMUBC-based regulations contained a list of materials that although combustible were deemed to be incombustible. This mitigation of the rigour of the definition, which amounted to a tacit introduction of "limited combustibility", has carried over into the Building Code of Australia. The list has grown steadily over the years.

2.2. United Kingdom.

The British Building Regulations have introduced a quantified concept of limited (as distinct from absolute) combustibility. A scale of relative combustibilities is based on a mixture of prescriptive descriptions of acceptable materials and performance - the duration of flaming and rises in temperature - in tests to BS 476.11, a derivative of BSA 476.4. The scale has three levels of combustibility and a total of seventeen building components are listed for which one or more of the levels is an acceptable fulfilment of the regulatory objective.

Descriptions of each of the three levels, the items expected to fall within each level and explanatory paragraphs selected from the Approved (guidance) Document are set below. They provide a truncated indication of the British approach to the uses of non combustibility and limited combustibility. Presumably the development of **ISO** test methods (and prescriptive material specifications) acceptable to the UK as a member of the European community will lead to an expansion of the current list.

The descriptions of what are accepted as non-combustible materials, the first tier, are as follows:

> (a) Any material which when tested to BS 476: Part 11 does not flame nor cause any rise in temperature on either the centre (specimen) or furnace thermocouples.
>
> (b) Totally inorganic materials such as concrete, fired clay, ceramics, metals, plaster and masonry containing not more than I per cent by weight or volume of organic material. (Use in buildings of combustible metals such as magnesium/aluminium alloys should be assessed in each individual case).
>
> (c) Concrete bricks or blocks meeting BS 6073: Part 1:1981.
>
> (d) Products classified as non-combustible under BS 476: Part 4: 1970.

Materials and components that are listed in the approved documents as acceptable if non-combustible in these terms, the mandatory requirements (BI, B2 etc) within which they fall and a resume of the conditions of their acceptability are as follows:

Ladders (BI - Means of escape).

"Fixed ladders should not be used as a means of escape for members of the public, and should only be intended for use in circumstances where it is not practical to provide a conventional stair, for example as access to plant rooms that are not normally occupied".

Refuse Chutes (B3 - Internal fire spread (structure)).

There is a description of the purpose and practice of compartmeutatiou and then -

"Openings iu compartment walls ... or compartment floors should be limited to those for:

(a) …

(b) …

(c) refuse chutes ofuou-combustible construction;…".

Suspended Ceilings and their Supports (B3 - Internal fire spread (structure)).

"Concealed spaces or cavities in the construction of a building provide a ready route for smoke and flame spread. This is particularly so in the case of voids above other spaces in a building, eg above a suspended ceiling or in a roof space. As any spread is concealed, it presents a greater danger… "

"Where the concealed space is over an undivided area which exceeds 40 m (in both directions on plan) there is no limit to the size of the cavity if:

(a) .....

(b) .....

(c) .....

(d) the surface of the ceiling exposed in the cavity is Class O and the supports and fixings in the cavity are of non-combustible construction;…"

Pipes (B3 - Internal fire spread (structure)).

To be acceptable, pipes passing through a compartment wall must conform to Table 15 of the approved document which sets out acceptable uses of pipes in various situations and of various sizes and materials including "non-combustible materials".

Flue Walls (B3 - Internal fire spread (structure)).

To be acceptable, flue walls passing through a compartment floor or built into a compartment wall must conform to Diagram 35 of the approved document which nominates that the flue wall must have a fire-resistance of at least half that of the floor or wall and also that it must be of non-combustible construction.

Car Parks (B3 - Internal fire spread (structure)).

"Buildings or parts of buildings used as parking for cars and other light vehicles are unlike other buildings in certain respects which merits some departures from the usual measures to restrict fire spread within buildings." The approved document then goes on with a discussion generally pointed towards justifications of *inter alia* low fire resistance requirements. It then proceeds with provisions common to all car parks including ".....all materials used in the construction of the building, compartment or separated part should be non-combustible …". Certain surface finishes, fire-doors and attendant's kiosks are excepted.

Materials of limited combustibility form the second and third tiers. The second tier is as follows:

"(a) Any non-combustible material listed in Table A6.

(b) Any material of density 300 kg/m3 or more, which when tested to BS 476: Part 11, does not flame and the rise in temperature on the furnace thermocouple is not more than 20°C.

(c) Any material with a non-combustible core at least 8mm thick having combustible facings (on one or both sides) not more than 0.5mm thick. (Where a flame spread rating is specified, these materials must also meet the appropriate test requirements)."

Materials and components that are acceptable if of limited combustibility in these terms, the mandatory requirements within which they fall and a resume of the conditions of their acceptability are as follows:

Stairs (B1 - Means of escape).

"Every escape stair and its associated landings should be constructed of materials of limited combustibility in the following situations:

a. if it is the only stair serving the building, or part of the building, unless it is of two or three storeys and is in Purpose Group l(a) [flats or maisonettes].

b. if it is within a basement storey (this does not apply to a private stair in a maisonette).

c. if it serves any storey having a floor level more than 20 m above ground or access level, or

d. if it is external, except in the case of a stair that connects the ground floor or paving level with a floor or flat roof not more than 6 m above or below ground level.

There is further guidance on external escape stairs in paragraphs 2.45 and 4.35.

e. if it is a firefighting stair (see Section 17).

In satisfying the above conditions combustible materials may be added to the upper surface of these stairs (except in the case of firefighting stairs)."

Materials above a Suspended Ceiling (B3 - Internal fire spread (structure)).

"Concealed spaces or cavities in the construction of a building provide a ready route for smoke and flame spread. This is particularly so in the case of voids above other spaces in a building, eg above a suspended ceiling or in a roof space. As any spread is concealed, it presents a greater danger… "

"Where the concealed space is over an undivided area which exceeds 40 m (in both directions on plan) there is no limit to the size of the cavity if:

(a) .....

(b) .....

(c) .....

(d) the surface of the ceiling exposed in the cavity is Class 0 and the supports and fixings in the cavity are of non-combustible

(e) …

(f) …

(g) any other materials in the cavity are of limited combustibility".

Reinforcement/Support for Fire-stopping (B3 - Internal fire spread (structure)).

"To prevent displacement, materials used for fire-stopping should be reinforced with (or supported by) materials oflimited combustibility in the following circumstances:

(a) in all cases where the supported span is greater than 100 mm, and

(b) in any other case where non-rigid materials are used (unless they have been shown to be satisfactory by test)".

Roof Coverings (B3 - Internal fire spread (structure)).

The approved document requires concealed spaces to be subdivided with exceptions that include

"(f) between double-skinned corrugated or profiled insulated roof sheeting, if the sheeting is a material of limited combustibility and both surfaces of the insulating layer have a surface spread of flame of at least 0 or 1 (see Appendix A) and make contact with inner and outer skins of cladding (see Diagram 32)".

(Note: 0 is considered the *highest* classification. Hence the requirement for "at least 0 or 1).

Roof Coverings (B4 - External fire spread).

The approved document provides detailed information on the circumstances in which combustible roof coverings are acceptable. Controls are imposed in terms of occupancy, size of building, proximity to boundaries and proximity of other areas of limited combustibility.

Similarly, the areas and proximity of plastics rooflights are controlled and a plastics rooflight must be surrounded by 3 m of materials of limited combustibility.

Roof Deck (B3 - Internal fire spread (structure)).

The approved document describes acceptable construction for a roof deck (and its roof covering) that crosses a fire-barrier wall. The part of the deck in the immediate vicinity of the wall (up to 1.5 m each side) is to be of limited combustibility.

Class O Materials

The inclusion of this item in the list of materials that are to be of limited combustibility provides the link between non-combustibility and the early-fire-hazard properties of materials. See the quotations from Appendix A of the approved document on the following pages.

Ceiling Tiles or Panels of any Fire-protecting Suspended Ceiling of Type D (B3 - Internal fire spread (structure)).

Fire-protecting suspended ceilings are those that contribute to the fire-resistance of the floor above. Those intended to be the most effective are Type D of which the panels and insulation are to be of limited combustibility.

Compartment Walls and Floors in Hospitals (B3 - Internal fire spread (structure)).

The guidance document on means of escape discusses the special problems of evacuation of hospitals and similar institutions. It refers to specialized documents published by the Department of Health and the Home Office.

Walls and floors in hospitals designed in accordance with Department of Health guidelines (for evacuation) and which are required to have fire-resistances of 60 minutes or more are required also to be of limited combustibility.

Materials of limited combustibility that form the third (lowermost) tier are described as follows:

> "Any of the materials (a), (b), or (c) above, or:
>
> d. Any material of density less than 300 kg/m3, which when tested to BS 476: Part 11, does not flame for more than 10 seconds and the rise in temperature on the centre (specimen) thermocouple is not more than 35°C and on the furnace thermocouple is not more than 25°C."

The two items that are acceptable if of limited combustibility in these terms, the mandatory requirements within which they fall and a resume of the conditions of their acceptability are as follows:

Insulation Material in External Walls (B4 - External fire spread).

Paragraph 12.7 of the approved document explains the danger of combustibles m external walls and of combustible insulation in ventilated cavities. It then proceeds:

"In a building with a storey at more than 15 m above ground level, insulation material used in the external wall construction should be of limited combustibility". Certain cavity walls of masonry are exempted.

Insulation above a Fire-protecting Suspended Ceiling of Type D (B3 - Internal fire spread (structure)).

See the item above about ceiling tiles or panels of a fire-protecting suspended ceiling of type D.

What might be especially noted about the British approach is that, first, overfulfilment of a requirement is no impediment and second, and more importantly, the reference to Class O materials. This reference provides the link with short term reactions to fire - the controls directed at the initial stage of a fire referred to in paragraph 2.02. Appendix A of Approved Document B establishes the link and indicates its implications as follows:

"Non-combustible materials

A7 Non-combustible materials are defined in Table A6 either as listed products or in terms of performance when tested to BS 476: Part 4: 1970 or Part 11: 1982.

Only these materials may be used where there is a prov1s10n for non combustibility and also for the specific applications in the elements listed in Table A6. Non-combustible materials may be used whenever there is a requirement for materials of limited combustibility.

"Materials oflimited combustibility

AS Materials of limited combustibility are defined in Table A7 by reference to the method specified in BS 476: Part 11: 1982. Table A7 also includes composite products (such as plasterboard) which are considered acceptable, and where these are exposed as linings they should also meet any appropriate flame spread rating.

"Internal linings

A9 Flame spread over wall or ceiling surfaces is controlled by providing for the lining materials or products to meet given performance levels in tests appropriate to the materials or products involved.

AIO To restrict the use of materials which ignite easily, which have a high rate of heat release and/or which reduce the time to flashover, maximum acceptable 'fire propagation' indices are specified. These are determined by reference to the method specified in BS 476: Part 6: 1981 or 1989. Index of performance (I) relates to the overall test performance, whereas subindex (i_1) is derived from the first three minutes of test.

All Lining systems which can be effectively tested for 'surface spread of flame' are rated for performance by reference to the method specified in BS 476: Part 7:1971 or 1987 under which materials or products are classified 1, 2, 3 or 4 with Class 1 being the highest.

A12 The highest product performance classification for lining materials is Class 0. This is achieved if a material or the surface of a composite product is either:

a. composed throughout of materials of limited combustibility, or

b. a Class 1 material which has a fire propagation index (I) of not more than 12 and subindex (i_1) of not more than 6.

Note: Class O is not a classification identified in any British Standard test".

Continuity is indicated by Table A8 of the regulations which is reproduced on the following page

Typical Performance Ratings of Some Generic Materials and Products
A reproduction of Table 48 of the Building Regulations 1991

Rating	Material or product
Class 0	1. any non-combustible material or material of limited combustibility.(Composite products listed in Table A7 must meet the test requirements given in paragraph A12(b)). 2. brickwork, blockwork, concrete and ceramic tiles. 3. plasterboard (painted or not, or with a PVC facing not more than 0.5mm thick) with or without an air gap or fibrous or cellular insulating material behind. 4. woodwool cement slabs. 5. mineral fibre tiles or sheets with cement or resin binding.
Class 3	6. timber or plywood with a density more than 400 kg/m3, painted or unpainted. 7. wood particle board or hardboard, either treated or painted. 8. standard glass reinforced polyesters

the product level as determined by means of ASTM E 136, CAN/ULC-Sl 14 or NFPA 259. There are also similar requirements for the adoption of masonry or concrete in particular cases, for example for fire-walls.

Over the last decade or two, US researchers have pushed for the replacement of the various cylindrical-calorimeter (ISO 1182-type) tests with testing by means of a cone calorimeter and have found supporters world wide.

The advocates of the cone-calorimeter test claim that the important fire-property of a building material is its rate of heat-release and that this is best measured in oxygen consumption calorimeters of which the cone calorimeter is the appropriate bench scale apparatus. It necessarily provides gradations of rate of heat-release. To provide the bases for controls for the two stages of a building fire - the early (evacuation from the compartment) stage as well as the later (containment of the developed fire) stage - the cone calorimeter has been adapted to provide measures also of ignitibility and of smoke-production and toxicity. Methods to predict flame-spread in various circumstances have been developed or are under development in various parts of the world.

2.4. New Zealand.

New Zealand building regulations appear to be an amalgam of Australian and UK regulations adapted as necessary to peculiarly New Zealand requirements. Non combustibility is defined as conformity with AS 1530.1 and BS 476.4. The requirement is absolute; BS 476.11 is not invoked.

Non-combustibility is imposed on a range of heating and burning appliances (chimneys, fireplaces, flue-linings, hearths) principally as nominations of acceptable materials and to a less extent as a requirement for conformity with the standards. In the broader area of the overall building fabric, non-combustibility is required of certain surface finishes both external and internal. Unless the fire-compartment is sprinklered, floor coverings are controlled in the escapeways of all occupancies and throughout institutional occupancies providing accommodation of one form or another. To be acceptable, floor coverings are required to be

> "either *non-combustible* or have a low radius of effects of ignition (assessed according to BS 5287) when tested to the BS 4790 *standard test* for flammability of floor coverings… ".

The acceptability of external surface finishes to external walls depends on occupancy, number of storeys and proximity to the boundary. In the tabulation of acceptabilities there is an interesting tiering. As height, proximity and vulnerability of occupancy increase, the requirement steps from an ignitability index of O to non-combustibility.

While the correlation of this particular hazard with height and occupancy can be challenged, it can be deduced that the regulation writers recognized that the real danger was ignitability and decided that there should be no likelihood of ignition. But an lg of zero as determined according to AS 1530.3 means that there is no ignition at only a specific level of radiation which might be less than that emitted by a fire plume. Hence the move to non-combustibility as the next available choice.

This feature of the NZ regulations has led Sojer and Wade of the Building Research Association of New Zealand to explore the appropriateness of cone-calorimeter

testing as an alternative to both AS 1530.3 and AS 1530.1/BS 476.4, principally because of the greater range of heat flux commonly used with that apparatus [4].

2.5. South Africa.

South Africa has a building code after the style of BCA 1990 with generalized requirements followed by descriptions of deemed-to-satisfy materials and systems. In some respects the classification of buildings is more finely subdivided (from the point of view of risk) and fire-protection intrudes somewhat further into the single detached dwelling. Test methods for the early-fire-hazard properties of finishing materials (generally wall and ceiling surface finishes) and of floor coverings and the test method for combustibility (at 750°C) are specified in SABS 0177 Parts III, IV and V and are similar to those in their British counterparts in the BS 476 series.

Requirements for non-combustibility are spread throughout the code but all such requirements are ameliorated by the exception of the usual list of materials deemed non-combustible, by the exception of (other) particular materials and components in particular cases and by the exception of "combustible materials that have been favourably evaluated by the Council of the South African Bureau of Standards or the CSIR". This is a common formula.

Control of combustible roof coverings is by way of the control of attachment to non combustible substrates or the control of areas and of proximity to the boundary and to each other. Large roof spaces in unsprinklered buildings are to be subdivided by non combustible barriers. Suspended ceilings are to be of non-combustible materials and, where advantage is taken of the exceptions noted above, the sizes of fire compartments below the ceiling are restricted in taller, unsprinklered buildings. Similarly, ceiling spaces that form the plenums of air-control systems are to be subdivided with non-combustible construction.

Suspended floors are to be non-combustible. Raised access floors are subject to controls similar to those imposed on suspended ceilings.

There is an interesting restriction on partition walls and part1t10ns which are apparently subdividers within single-occupancy fire-compartments. In places of detention, hospitals and residential institutions, partitions attract a fire-resistance of 60 minutes and in offices, dormitories and residences including single, detached houses they attract a fire-resistance of 20 minutes. In addition, partitions erected above the third storey in any building must be either

non-combustible; or

represent a fire-load of no more than 5 kg/m^2 of floor area.

In the control of the fire-hazard properties of finishes, first, ceilings are generally required to be non-combustible and the classification systems of SABS 0177 Parts III and IV do not extend to them. For floor coverings and wall finishes, non combustibility is integrated into the classification systems and, although it is implied that the primary concern is with the spread of fire and the generation of heat, smoke and toxic fumes (what would be regarded in BCA 1990 as early-fire-hazard properties), the commentaries to the SA clauses repeatedly refer to the possibility also of *significant* contribution to the fire-load. Within the systems of classification for floor and wall finishes, the requirement for non-combustibility 1s confined to car

parks, plant rooms, high-risk industrial buildings, certain areas of high- and moderate risk storage buildings and the basements of places of detention, hospitals and residential institutions. Wall finishes are not permitted at all in the basements of multi-unit residential buildings including hotels. The overall surface-finish classifications are confined to areas actually used for the purposes to which the building classifications apply.

2.6. Germany.

The organisation of regulatory responsibilities in Germany is similar to that in Australia. Individual codes differ from state to state of the federation while their administrators agree to adopt so far as is practicable a Model Building Code (for domestic buildings) and Model Regulations (for other types of building). The fire regulations of the models are being progressively developed in anticipation of the harmonisation of regulations among members of the European community. In this, Germany is taking a leading part. Its Model Building Code was last rewritten in 1993 to align it with European trends.

It is worth drawing attention to an important influence on the current evolution of materials control in Germany (and in Europe generally). The code-writers recognise that inroads are being made into the effectiveness of fire-fighting services by curtailment of funds and the logistic difficulties presented by traffic in modern cities. Their reaction has been to enhance in-house fire-protection in compensation with a trend towards the adoption of a "self-contained fire-safety concept" [5].

This is noteworthy in the light of Australian developments. The BCA assumes the attendance of the fire-authorities at every building fire whereas the earliest AMUBC based regulations did not [6].

In regard to combustibility and reaction to fire the German codes are similar in concept to the UK building regulations. Tests and criteria for "non-combustibility" are not isolated from those of other materials controls. None of the reaction-to-fire tests is isolated; they collectively form a hierarchy that ranks materials from the really non combustible e.g. concrete, to the "easily flammable" e.g. loose wood wool. (The unmodified use of the "easily flammable" isn't permitted anyway). This hierarchy is, in turn, part of the wider, overall fire-protection hierarchy embracing all passive and active systems. German code writers are apparently very conscious also of what they see as the necessity for reaction-to-fire controls to be appropriate to the circumstances in which materials are used - shape, orientation, nature of the surface, lamination and assembly with other materials.

German developments are conveniently discussed in broader European terms.

2.7. European Community.

There is among members of the European community a long-term ambition to move from a product-classification system, which is prescriptive and within which class is defined essentially in terms of its test method, to a truly performance-based system in which tests and test-results would be judged on the basis of their ability to provide the data necessary for a fire-engineering approach to design. This is, however, a very long-term ambition.

Present regulatory activities in the European community are confined to facilitating the flow of building products (materials and components) between member countries in the current regulatory framework. The hierarchy referred to in 3.06 classifies materials in terms of whether the material is to be permitted or not to contribute (as fuel) to the intensity and duration of a fire and it is at these levels that their properties are controlled. Those that must make "no contribution to fire" or at most only a "very limited contribution to fire" are classes Al and A2 (Germany) or classes A and B (European Union). Those materials that, while recognized as contributing or 'reacting' to fire, are permitted to be used are classes Bl and B2 (Germany) or classes C, D and E (European Union).

What is seen as relevant to the refractory classes is exposure to the fully developed fire with the level of heat flux at more than 60W/m^2. Testing is primarily by calorimeter.

The less refractory classes are seen primarily as part1c1pating in the building fire during its outbreak and early development. Testing is very much reaction-to-fire testing as understood in Australia. Exposure is at most 40W/m^2, on a limited area and decreasing over the surface - exposure to a burning waste-paper basket - (class El/classes C and D) - down to exposure to a flame no more than 20 mm high on a limited area of the product - a match - (class B2/class E). Note that the fire sources are contents. This approach leads to the following hierarchy of test methods [7]. (It is characteristic of the European struggle towards commonality that the agreement to methods of test in this hierarchy is "in principle").

The European Hierarchy of Test Methods

Reaction-to-fire Testing and Classification

Products other than flooring coverings	Floor coverings
Bomb Calorimeter Test (ISO 1716) Small Furnace Test (ISO 1182)	
Single Burning Item Test (SBI) Small Flame Test (ISO 11925-2)	Radiant Panel Test (ISO 9239) Methanamine Pill Test

The first of the following tables is a selection of minimum requirements from the German Model Building Code for single, detached dwellings, small blocks of flats and bigger blocks. The second has been abridged from the model regulations for German department stores of over 2000 m^2. They illustrate how the hierarchy is implemented. (Apparently, in adopting and adapting the models, the German states exercise some choice between Bl and B2 and Al and A2).

Minimum Requirements from the German Model Building Code for three Sorts of Domestic Building (December 1993).

Component	Single, detached single-storey houses	Multi-unit housing of up to three storeys and less than 7 m to the level of the upper floor.	Multi-unit housing where the level of the uppermost floor is between 7 m and 22 m above ground level.
Loadbearing walls.	B2	Fire resistant of 30 minutes plus B2.	Fire resistant of 90 minutes plus B2.
Non-loadbearing external walls and facades.	B2	B2	A or a fire resistance of 30 minutes.
their surfaces and insulations.	B2	Normally B1 but B2 may be permitted.	B1 but supports may be B2.
Separating walls between units.	Only one unit - not applicable.	Fire resistant of 30 minutes plus B2.	Fire resistant of 90 minutes. (Highest storey in lofts 30 minutes).
Fire walls. (There are additional requirements for stability).	No fire walls - not applicable.	More than two units: Fire resistant of 90 minutes plus A. Otherwise: Fire resistant of 90 minutes plus B2.	Fire resistant of 90 minutes plus A.
Floors.	B2	Fire resistant of 30 minutes plus B2.	Fire resistant of 90 minutes plus B2.
Stairs: supporting members	B2	More than two units:A or a fire resistant of 30 minutes. Otherwise: B2.	Fire resistant of 90 minutes.
Stairs: walls floor coverings.	B2	More than two units:A. Otherwise: B2.	A

Minimum Requirements from the German Model Regulations for Department Stores over 2000 m^2 (1995).

Component	Single storey sprinklered	Single storey unsprinklered	Multistorey sprinklered	Multistorey unsprinklered
Loadbearing member.	B2	Fire-resistance of 30 minutes.	Fire-resistance of 90 minutes.	Fire-resistance of 90 minutes.

Loadbearing external wall.	B1	Fire-resistance of 30 minutes.	Fire-resistance of 90 minutes.	Fire-resistance of 90 minutes.
Non-loadbearing external wall.	B1	B1	B1	A
Facade of an external wall.	B1	B1	B1	A
Ceiling.	A	Fire-resistance of 30 minutes.	Fire-resistance of 90 minutes.	Fire-resistance of 90 minutes.
Suspended ceiling.	A, B2 if the ceiling space is sprinklered.	A	A, B2 if the ceiling space is sprinklered.	A
Ceiling panels.	A	A	A	A
Roof support.	B2	Fire-resistance of 30 minutes.	A	Fire-resistance of 90 minutes.
Roof deck.	A	A	A	A
Roof (including covering and insulation).	Resistance to burning brands: DIN 4102.7.	Resistance to burning brands: DIN 4102.7.	Resistance to burning brands: DIN 4102.7.	Resistance to burning brands: DIN 4102.7.

Note that, although the classification A (Al or A2) is purportedly a control on the contribution of the component to a fully developed fire, it enters these tables as both a control on early reaction to fire and as a fire-resistance rating of or somewhat below 30 minutes.

3. CONCLUSIONS

3.1.The appropriateness of the concept.

Comparisons of the various international uses of non-combustibility immediately raise the question of the relevance to building regulation of non-combustibility as presently measured.

The earliest regulators saw virtue in materials that, in lay terms, don't burn. They observed the behaviour of materials in building fires and they nominated particular materials for particular uses knowing that they provided the levels of safety they sought. Then, in an effort to liberalise the regulations by moving from the specific to the generic, they encapsulated their requirement in the word "non-combustible". Their scientific advisers at the time took them at their word and steered them into calorimetry - measurement of the heat derivable from a material - as the appropriate demonstrator of compliance. The concept of what was to be measured was, by a not unusual inversion of scientific method, determined by the way it was measured.

At least some of the limitations imposed on materials and components were immediately recognised by the regulators and measures taken to ease them. This reaction is currently accelerating to the extent that in some circles there is an opinion

that the prescription of non-combustibility should be rescinded altogether. But the first question to be asked in regard to the appropriateness of non-combustibility to the regulation of fire-protection would appear to be not whether non-combustibility might or might not be important but when it might be important. This brings us to a more detailed consideration of the adoption of the concept in the more modern codes.

Building regulations are concerned to control fire-properties in a variety of situations and the requirement for non-combustibility is persisting in all of them. There are, firstly, some uses of non-combustibility which appear to be uncontroversial and difficult of reasonable alternatives; for example, the UK requirement for the non combustibility of plant-room ladders, the common requirement for the non combustibility of external fire-escapes, of certain insulation, of the components of fire-places, hearths, chimneys and the walls of flues and refuse chutes. Non combustibility or limited non-combustibility of stairs, coupled with control of surface finishes inside a fire-rated shaft can preclude the spread of fire into the shaft.

For control of the earliest stages of a fire, absolute non-combustibility appears as the ultimate limit of early-fire-hazard properties. This is demonstrated by its entry into the South African tables of graded requirements for floor and wall coverings and, somewhat more ambivalently into the German regulations. The New Zealand regulators obviously recognise ignitability as the immediate danger arising from the exposure of an external wall to a fire-plume and require non-combustibility in what they see as the most dangerous situations. In fact, their present methods of test pretty well constrain them to require non-combustibility in the most dangerous cases.

Ceilings and suspended ceilings are widely seen as a special problem. Usually, a fire will spread more quickly across a ceiling than across a floor. The additional concern with a suspended ceiling is that a fire can become fully developed in the ceiling space before being detected. In both cases, evacuation can be significantly hampered. It is therefore common to require non-combustibility of ceilings and/or the components of a ceiling within the ceiling space.

Looking at the subject more broadly it can be seen that the entry of non combustibility into the hierarchies of fire-control must mean that it will take a place in the hierarchies. As an early-fire-hazard index, it must represent the safest level although there might be few situations (escape-shafts devoid of contents?) where its invocation would be justified. But non-combustibility enters the hierarchy also as an adjunct to, or even a level of, fire-resistance. This is controversial.

The question of the non-combustibility of fire-barriers is complicated by issues circumstantial to the specification of fire-resistance levels. On the one hand there is the adoption of curtailed FRLs; for example, the acceptance of, say, a 60-minute barrier to contain a 90-minute load on the grounds of rapidity of evacuation or lower risk of fire. On the other hand there are doubts about the margins of safety implicit in the assignment of statutory fire loads to particular compartments and doubts about the margins of safety implicit in the attribution to everyday construction of an FRL derived from a laboratory artefact. In all these cases, it appears to be assumed that non-combustibility presents a second chance of sorts, that some barrier will remain, that some structure will continue to bear load.

But non-combustibility is not in itself a solution to these problems. Non combustibility, even the prescription of particular non-combustible materials, means

no more than that something will remain after the fire has burnt itself out. But what remains might be a heap of rubble. There is no guarantee of the persistence of a barrier or a component capable of loadbearing or of stability in general. In short, non combustibility cannot be relied on to compensate for shortcomings in FRL. What should not be overlooked is the necessity to control the internal temperature of combustible fire-barriers (and composites generally) and consequently the possibility of perpetuating destructive distillation.

There remains the practice in South Africa and Europe (or at least at present in Germany) of imposing non-combustibility as a control on the degree to which the building fabric might increase the fire-load. Two questions arise: whether such an addition is likely to be significant and, if it is, whether it might be compensated for by an increase in the statutory FRL.

3.2. Future directions.

There appear to be building components for which a requirement for non combustibility is appropriate, readily met and imposes no untoward restriction on industry. Having said that, it also appears that concerns about the possible limitations of test methods - the appropriateness of particular fire-tests, whether they properly estimate the severity of the hazard or properly reproduce the fire-situation - have resulted in the persistence of a requirement for non-combustibility as a safety net and, in some cases, a safety net of dubious reliability.

But the practice of overseas performance codes of placing non-combustibility into hierarchies of reactions to fire is still worthy of careful consideration. Of these the British applications seem the most thoughtful (while adopting the simplest approach to testing). Such a development could well establish the proper place of non combustibility. At present it is the universally accepted base out of which branch a wide variety of test methods vigorously defended by the industries that have invested in them and all of which appear to have served their countries well. The practice suggests also that, with the adoption of the performance concept, there is no need to abandon a particular test directed towards a particular fire situation on the grounds that it does not reproduce every fire situation.

International approaches to fire-regulation indicate that the central issue with regard to materials control is the correct identification of the various fire hazards, their proper quantification and the nomination of reliable predictors of successful control. It could well be that field research has discovered particular situations where present methods are wanting. It is towards the development of reliable predictors for these situations that laboratory research needs to be directed.

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APPENDIX 4

ASSESSMENT OF CLAUSES IN THE BCA THAT CONTROL COMBUSTIBILITY

ASSESSMENT OF CLAUSES IN THE BCA THAT CONTROL COMBUSTIBILITY

The letters NC mean "non-combustible" or "non-combustibility".

BCA 1996 CLAUSE No	BCA Text	Comments	Recommended action
Al.l	**Combustible** means- *(a)* Applied to a material - combustible as determined by AS 1530.1. *(b)* Applied to construction or part of a building - constructed wholly or in part of combustible materials. **Non-combustible** means- *(a) Applied to a material - not deemed* combustible *as determined by AS 1530.1* - Combustibility Tests for Materials. *(b) Applied to construction or part of a building - constructed wholly of materials that are not deemed combustible.*	Definitions	Update as required
Cl.7(a) Single-tier spectator stands	(a) An open spectator stand or indoor sports stadium may be of Type C construction and need not comply with the other provisions of this Part if it contains not more than 1 tier of seating, is of non-combustible construction, and has only changing rooms, sanitary facilities or the like below the tiered seating. (b) In (a), one tier of seating means numerous rows of tiered seating incorporating cross-overs but within one viewing level.	Originally introduced to address the need for survival - property protection. Does not affect life safety.	Consider global objectives
C2.5(d)(i)	A class 9a building must comply with the following:	The intent is to	Apply

BCA 1996 CLAUSE No	BCA Text	Comments	Recommended action
Smoke-proof wall in a patient-care area.	(a) patient care areas must be divided into fire compartments not exceeding 2000 m^2. (b) Ward areas- (i) where the floor area exceeds 1000 m^2, must be divided into areas not more than 1000 m^2 by walls with an FRL of not less than 60/60/60; and (ii) where the floor area exceeds 500 m^2, must be divided into areas not more than 500 m^2 by smoke proof walls complying with (d); and (iii) where division of ward areas by fire-resisting walls under (a) and (b)(i) is not required, any smoke proof walls required under (b)(ii) must have an FRL of not less than 60/60/60. (c) Treatment areas must be divided into floor areas not more than 1000 m^2 by smoke proof walls complying with (d). (d) A smoke-proof wall must- (i) be non-combustible and extend to the underside of the floor above, to the underside of a non-combustible roof covering or to the underside of a ceiling having a resistance to the incipient spread of fire to the space above itself of not less than 60 minutes; and (ii) not incorporate any glazed areas unless the glass is safety glass as defined in AS 1288; and (iii) only have doorways which are fitted with smoke doors complying with Specification C3.4; and (iv) have all openings around penetrations and the junctions of the smoke-proof wall and the remainder of the building stopped to prevent the free passage of smoke; and (v) incorporate smoke dampers where air-handling ducts penetrate the wall, unless the duct forms part of a smoke management system required to continue air movement through the duct during a fire.	restrict the passage of smoke to the next compartment for a (limited) time.	requirement for smoke barriers

BCA 1996 CLAUSE No	BCA Text	Comments	Recommended action
C2.5(g) Ancillary areas in patient-care areas. Introduced with Amndt 5.	(g) The following ancillary use areas located within a patient care area must be separated from the patient care area by walls with an FRL of not less than 60/60/60 and extend to a non-combustible roof covering, the floor above or a ceiling with a resistance to the incipient spread of fire, the doorway being protected with fire doors having an FRL of not less than - /60/30 : (i) A kitchen and related food preparation areas having a combined floor area of more than 30 m^2. (ii) A room containing a hyperbaric facility (pressure chamber). (iii) A room used predominantly for the storage of medical records having a floor area of more than 10 m^2. (iv) A laundry, where items of equipment are of the type that are potential fire sources (eg gas fire dryers).	Requirement is to control fire spread, but non-combustible roof probably does not help.	Apply requirement for smoke barriers
C2.6(c) Protective spandrel to be NC.	If in a building (other than an open-deck carpark or an open spectator stand) which is required to be of Type A construction and does not have a sprinkler system complying with Specification El.5, any part of a window or other opening in an external wall, (except openings within the same stairway)- (a) is above another opening in the storey next below; and (b) its vertical projection falls no further than 450 mm outside the lower opening (measured horizontally), the openings must be separated by- (c) a spandrel which- (i) is not less than 900 mm in height; and (ii) extends not less than 600 mm above the upper surface of the intervening floor; and (iii) is of non-combustible material having an FRL not less than 60/60/60; or (d)-(f) ..	FRL gives sufficient protection	Delete non-combustibility requirement.
C2.6(d) - By	If in a building (other than an open-deck carpark or an open spectator stand) which	FRL gives	Delete non-

BCA 1996 CLAUSE No	BCA Text	Comments	Recommended action
invoking (a). Protective panel wall or curtain wall.	is required to be of Type A construction and does not have a sprinkler system complying with Specification El.5, any part of a window or other opening in an external wall, (except openings within the same stairway)- (a) is above another opening in the storey next below; and (b) its vertical projection falls no further than 450 mm outside the lower opening (measured horizontally), (c) the openings must be separated by- (d) a spandrel which- (i) is not less than 900 mm in height; and (ii) extends not less than 600 mm above the upper surface of the intervening floor; and (iii) is of non-combustible material having an FRL not less than 60/60/60; or (d) part of a curtain wall or panel wall that complies with (c); or (e)-(f) …	sufficient protection	combustibility requirement
C2.6(e) Constuction complying with (a) with gaps packed with NC stuff.	If in a building (other than an open-deck carpark or an open spectator stand) which is required to be of Type A construction and does not have a sprinkler system complying with Specification El.5, any part of a window or other opening in an external wall, (except openings within the same stairway)- (a) is above another opening in the storey next below; and (b) its vertical projection falls no further than 450 mm outside the lower opening (measured horizontally), the openings must be separated by- (c)-(d) … (e) construction that complies with (c) behind a curtain wall or panel wall and has any gaps packed with a non-combustible material that will withstand thermal expansion and structural movement of the walling without loss of seal against fire and smoke; or	The floor/ wall system must be continuous.	Change wording of clause to reflect this.

BCA 1996 CLAUSE No	BCA Text	Comments	Recommended action
	(f) ..		
C2.6(f)(iii) Protective slab to be NC.	If in a building (other than an open-deck carpark or an open spectator stand) which is required to be of Type A construction and does not have a sprinkler system complying with Specification El.5, any part of a window or other opening in an external wall, (except openings within the same stairway)- (a) is above another opening in the storey next below; and (b) its vertical projection falls no further than 450 mm outside the lower opening (measured horizontally), (c) the openings must be separated by-(c)-(e) .. (d) a slab or other horizontal construction that- (i) projects outwards from the external face of the wall not less than 1100 mm; and (ii) extends along the wall not less than 450 mm beyond the openings concerned; and (iii) is non-combustible and has an FRL of not less than 60/60/60	FRL gives sufficient protection.	Delete requirement for non-combustibility
C2.7(c) Battens crossing fire walls. Amndt 7 introduced the concession.	(a) A fire wall must be constructed in accordance with the following: (i) The fire wall has the relevant FRL prescribed by Specification C1.1 for each of the adjoining parts, and if these are different, the greater FRL, except where Tables 3.9, 4.2 and 5.2 of Specification Cl. l permit a lower FRL on the carpark side. (ii) Any openings in a fire wall must comply with the Deemed-to-satisfy provisions of Part C3. (iii) Building elements, other than roof battens with dimensions of75 mm x 50 mm or less, must not pass through or cross the fire wall unless the required fire resisting performance is maintained. (b) ..	This is an FRL issue - the barrier is to protect neighbours and the system should meet the FRL requiremen t	Reword accordingly. Note: Recent amendments have deleted the reference to **"non-**combustible" in this clause (the concession for roof battens

BCA 1996 CLAUSE No	BCA Text	Comments	Recommended action
	(c)A part of a building separated from the remainder of the building by a fire wall is treated as a separate fire compartment if it is constructed in accordance with (a) and the fire wall extends to the underside of (i) a floor having an FRL required for a fire wall; or (ii) the roof covering		used to apply to "timber or other non-combustible material".
C2.7(b)(iii)(C) NC of a lower roof.	(b)A part of a building separated from the remainder of the building by a fire wall may be treated as a separate building for the purposes of Deemed-to-satisfy Provisions of Sections C, D and E if it is constructed in accordance with the following: (i) - (ii) .. (iii) Where the roof of one of the adjoining parts is lower than the roof of the other part, the fire wall extends to the underside of- (A) the covering of the higher roof, or not less than 6 m above the covering of the lower roof; or (B) the lower roof if it has an FRL not less than that of the fire wall and no openings closer than 3 m to any wall above the lower roof; or (C) the lower roof if its covering is non-combustible and the lower part has a sprinkler system complying with Specification El.5.	Aim is to stop the roof burning above the sprinkler system.	Materials control issue - consider in light of Project 2 output.
C2.10(b)(ii) Separation of lift shafts - NC in type B. (now C2.10(a)(ii)B)	Lifts connecting more than 2 storeys, or more than 3 storeys if the building is sprinklered, (other than lifts which are wholly within an atrium) must be separated from the remainder of the building by enclosure in a shaft in which- (a) .. (b) in a building required to be of Type B construction- the walls are- (i) in accordance with (a) if the shaft is - (A) loadbearing; or (B) located within a patient care area in a Class 9a building	Reference to "loadbearing" is inappropriate. This is a smoke control issue.	Apply requirement for smoke barriers

BCA 1996 CLAUSE No	BCA Text	Comments	Recommended action
	(ii) of non-combustible construction if the shaft is non-loadbearing and is not located within a patient-care area in a Class 9a building; and (c) ..		
C2.14 Public corridors in Class 2 and 3 buildings	In a Class 2 or 3 building, a *public corridor,* if more than 40 m in length, must be divided at intervals of not more than 40 m with smoke-proof walls complying with C2.5(d).	The intent is to restrict the passage of smoke for a (limited) time.	Apply requirement for smoke barriers
C3.l(a)(ii) NC ventilators in subfloor and cavity walls.	(a)The deemed-to-satisfy provisions of this Part do not apply to-... (ii)non-combustible ventilators for sub-floor or cavity ventilation, if each does not exceed 45 000 mm² in face area and is spaced not less than 2 mfrom any other ventilator in the same wall;	If such holes are allowed in fire walls, then the FRL is over-stringent.	Non-combustibility requirement should remain
C3.13(a) Openings in shafts - sanitary compartments.	In a building of Type A construction, an opening in a wall providing access to a ventilating, pipe, garbage or other service shaft must be protected by- (a) if it is in a sanitary compartment - a door or panel which, together with its frame, is non-combustible or has an FRL of not less than - /30/30; or (b)-(d) ..	This is a fire resistance issue.	Delete non-combustible alternative.
C3.13(d) Ditto Garbage shafts	In a building of Type A construction, an opening in a wall providing access to a ventilating, pipe, garbage or other service shaft must be protected by- (a)-(c) .. (d) if the shaft is a garbage shaft - a door or hopper of non-combustible construction.	This is a fire resistance issue.	Apply requirement for smoke barriers
Dl.8 (Introductio n) External stairs to be	An external stairway may serve as a required exit instead of a fire-isolated stairway in a building with an effective height of not more than 25 m if the stairway	Non-combustible constructio n is	Replace with materials control

BCA 1996 CLAUSE No	BCA Text	Comments	Recommended action
NC. (now Dl.8(a)(i))	(including any connecting access bridges) is of non-combustible construction throughout, and-	required to prevent flame spread.	from Project 2.
Dl.8(a)(i) Enclosure of ditto (now Dl.8(d))	(a) if any part of the stairway is exposed to, and less than 6 m from, a window, doorway, except a doorway complying with C3.4 serving the external stairway, or the like in an external wall of the building served by the stairway- (i) the stairway must be enclosed for its full height above the lowest level of the window or doorway by non-combustible construction with an FRL of not less than 60/60/60; and	FRLwith materials control from Project 2 gives sufficient protection.	Delete "non-combustible". (already deleted from the BCA)
D2.2(a) Stairways and ramps inside fire-resisting shafts.	A stairway or ramp (including any landings) that is required to be within a fire- resisting shaft must be constructed- (a) of non-combustible materials; and (b) so that if there is local failure, it will not cause structural damage to, or impair the fire-resistance of, the shaft.	Basic ignition and fire-spread control - second line of defence against fire entering the shaft.	Non-combustibility requirement should remain
D2.3 Ditto not in fire-resisting shafts	In a building having a rise in storeys of more than 2 , required stairs and ramps (including landings and any supporting structural members) which are not required to be within a fire-resisting shaft, must be constructed according to D2.2, or only of- (a) reinforced or prestressed concrete; or (b) steel in no part less than 6 mm thick; or (c) timber that- (a) has a finished thickness of not less than 44 mm; and (b) has an average density of not less than 800 kg/m3 at a moisture content of 12%;and (c) has not been joined by means of glue unless it has been laminated and glued with resorcinol formaldehyde or resorcinol phenol formaldehyde glue.	Alternative construction to D2.2	Non-combustibility requirement should remain

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D2.4(b) Separation of rising and descending flights.	If a stairway serving as an exit is required to be fire-isolated- (a) there must be no direct connection between- (i) a flight of stairs rising from a storey below the lowest level of access to a road or open space; and (ii) a flight of stairs descending from a storey above that level; and (b) any construction that separates or is common to the rising and descending flights of stairs must be (i) non-combustible; and (ii) smoke proof in accordance with C2.5(d).	Project 2 controls apply	Apply requirement for smoke barriers
D2.7(d) (Conclusion) Enclosure of installation s in exits. (recent minor changes to text not shown)	(a) Access to service shafts and services other than to fire-fighting or detection equipment as permitted in Section E, must not be provided from a fire-isolated stairway, passageway or ramp. (b) An opening to any chute or duct conveying hot products of combustion must not be located in any part of a required exit or any corridor, hallway, lobby or the like leading to a required exit. (c) Gas or other fuel services must not be installed in a required exit. Services or equipment comprising- (i) electricity meters, distribution boards or ducts; or (ii) central telecommunications distribution boards or equipment; or (iii) electrical motors or other motors serving equipment in the building, (d) may be installed in (iv) a required exit, except for fire-isolated exits specified in (a); or (v) in any corridor, hallway, lobby or the like leading to a required exit, if the service or equipment is enclosed by non-combustible construction or a fire-protective covering with doorways or openings suitably sealed against smoke spreading from the enclosure.	This is a fire resistance issue.	Apply requirement for smoke barriers

BCA 1996 CLAUSE No	BCA Text	Comments	Recommended action
D2.ll(a) (Introductio n) Enclosure of fire-isolated passageway s.	(a) The enclosing construction of a fire-isolated passageway must be non- combustible and have an FRL when tested for a fire outside the passageway in another part of the building of- (i) if the passageway discharges from a fire-isolated stairway or ramp - not less than that required for the stairway or ramp shaft; or (ii) in any other case - not less than 60/60/60. (b) ..	FRL requirement is sufficient.	Delete "non-combustible".
D2.1 l(b)(i) Ditto - walls reaching an NC roof covenng.	(a) .. (b) Notwithstanding (a)(ii), the top construction of a fire-isolated passageway need not have an FRL if the walls of the fire-isolated passageway extend to the underside of- (a) a non-combustible roof covering; or (b) a ceiling having a resistance to the incipient spread of fire of not less than 60 minutes separating the roof space or ceiling space in all areas surrounding the passageway within the fire compartment.	This is a fire spread issue.	Apply requirement for smoke barriers
G2.l(c)(ii) Chimneys mustn't leak smoke nor hot gases to nearby combustible s.	G2.1 deleted in BCA 96		
G2.3(a)	G2.3 An open fireplace, or solid-fuel burning appliance in which the fuel-burning compartment is not enclosed must have- (a) a hearth constructed of stone, concrete, masonry or similar non-combustible material so that-	Non-combustible is superfluous	Delete non-combustible from (a).

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	(i) - (iii).. (iv) *combustible* material situated below the hearth but not below that part *required* to extend beyond the fireplace opening or the limits of the fireplace is not less than 155 mm from the upper surface of the hearth; and		
G2.4 (a)	If an incinerator is installed in a building any hopper giving access to a charging chute must be- (i) *non-combustible;* and	Relates to the presence of fire in the building	Non-combustibility requirement should remain
G3.4(b) (Introduction) Bounding walls in atria - drencher-protected glass as alternative to fire-rated walls.	Bounding walls must- (a) ..; or (b) be constructed of fixed toughened safety glass, or wired safety glass in non- combustible frames, with- (a) any door openings fitted with a self-closing smoke door complying with Specification C3.4; and (b) the walls and doors protected with wall-wetting systems in accordance with Specification G3.8; and (c) a fire barrier with an FRL of not less than -/60/30 installed in any ceiling spaces above the wall.	The drenchers should be designed to protect the frames	Delete "non-combustible"
G3.5 NC balustrade around the balcony.	If a bounding wall separating an atrium from the remainder of the building is set back from the perimeter of the atrium well, a balustrade that is imperforate and non- combustible, and not less than 1 m high must be provided.	Barrier to resist the spread of fire.	Apply requirement for smoke barriers

SPECIFICATIONS

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Cl.1 2.2(a)(iii) Support to be NC if the supported part is to be NC	(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) iflocated 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.	A part that supports another part must share the properties of the supported part.	Clause might need to be rewritten in the light of other changes.
Cl.1 2.4(a) (Introduction) Combustibles on facades.	(a) A combustible material may be used as a finish or lining to a wall or roof, or in a sign, sunscreen or blind, awning, or other attachment to a building element which has the required FRL if- (i) the material is exempted under Clause 7 of Specification Cl .10 or complies with the Early Fire Hazard Indices prescribed in Clause 2 of Specification Cl .1O; and (ii) it is not located near or directly above a required exit so as to make the exit unusable in a fire; and (iii) it does not otherwise constitute an undue risk of fire spread via the facade of the building. (b) ..	Flame spread issue.	Control by material properties - see Project 2.
Cl.1 2.S(b) Timber	a) .. (b) Timber columns - A timber column may be used in a single storey building	Concession on non-combustible	Review in light of other

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columns allowed in single storey buildings	if: (i) in a fire wall or common wall the column has an FRL not less than that listed in the appropriate Table 3, 4 or 5; and (ii) in any other case where the column is required to have an FRL in accordance with Table 3, 4 or 5, it has an FRL of not less than 30/-/-. (c)-(f) ..	construction.	changes.
Cl.1 2.5(c) (Introduction) NC structures on roofs (recent minor changes to text not shown)	(a)-(b) .. (c) Structures on roofs - A non-combustible structure situated on a roof need not comply with the other provisions of this Specification if it only contains one or more of the following: (i) Hot water or other water tanks. (ii) Ventilating ductwork, ventilating fans and their motors. (iii) Air-conditioning chillers. (iv) Window cleaning equipment. (v) Lift equipment. (vi) Other service units that are non-combustible and do not contain combustible liquids or gases. (d)-(f) ..	Flame spread issue.	Apply Project 2 controls.
Cl.1 2.5(c)(vi) "other service units that are non-combustible." (now 2.5(c)(ii)E	See above	Flame spread issue.	Apply Project 2 controls.
Cl.1 2.5(d) Curtain walls and	(a)-(c) .. (d) Curtain walls and panel walls - A requirement for an external wall to have an FRL does not apply to a curtain wall or panel wall which is of non-combustible	Fire resistance issue.	Apply requirement for smoke barriers

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panel walls need not have an FRL if they are non-combustible and drencher-protected.	construction and fully protected by automatic external wall-wetting sprinklers. (e)-(f) ..		
Cl.1 2.S(e) Materials deemed non-combustible. (now Cl.12)	(a)-(d) .. (e) Non-combustible materials - The following materials, though combustible or containing combustible fibres, may be used wherever a non-combustible material is required: (i) plasterboard; (ii) perforated gypsum lath with a normal paper finish; (iii) fibrous-plaster sheet conforming to AS 2185 Specification for Fibrous Plaster Products; (iv) fibre-reinforced cement sheeting; (v) pre-finished metal sheeting having a combustible surface finish not exceeding 1 mm thickness and where the Spread-of-Flame Index of the product is not greater than O; (vi) bonded laminated materials where- (A) each laminate is non-combustible; and (B) each adhesive layer does not exceed 1 mm in thickness; and (C) the total thickness of adhesive layers does not exceed 2 mm; and (D) the Spread-of-Flame Index and the Smoke-Developed Index of the laminated material as a whole does not exceed O and 3 respectively. (f) ..	Illustrates the inappropriateness of the current non-combustibility test.	Review on completion of project.
Cl.1 2.S(f)(ii)(B)	(a)-(e) .. (f) Balconies and verandahs - A balcony, verandah or the like and any	Structural stability of the	Apply Project 2 controls

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Columns supporting balconies on facades in type- A	incorporated supporting part, which is attached to or forms part of a building, need not comply with Tables 3, 4 and 5 if- (i) .. (ii)in Type A construction- (A) it is situated not more than 2 storeys above the lowest storey providing direct egress to a road or open space; and (B) any supporting columns are of non-combustible construction.	balcony is unlikely to be a concern. Control is needed on flame spread up the external face of the building	
Cl.1 2.6(b) (Introduction) Small mezzanines need no FRL nor to be NC provided	(a) .. (b) A mezzanine and its supports need not have an FRL or be non-combustible provided- (a) the total floor area of all the mezzanines in the same room does not exceed 1/3 the floor area of the room or 200 m^2, whichever is the lesser; and (b) the FRL of each wall and column that supports any other part of the building within 6 m of the mezzanine is increased by the amount listed in Table 2.6.	Concessio n on non-combustibi lity	Revisit in light of other changes.
Cl.1 2.7(b) Bottom of a shaft needn't have FRL if NC and laid on the ground.	Shafts required to have an FRL must be enclosed at the top and bottom by construction having an FRL not less than that required for the walls of a non- loadbearing shaft in the same building, except that these provisions need not apply to- (a) the top of a shaft extending beyond the roof covering, other than one enclosing a fire-isolated stairway or ramp; or (b) the bottom of a shaft if it is non-combustible and laid directly on the ground.	Flame spread and smoke control issue.	Apply Project 2 controls.
Cl.1 3.l(b). NC required of floors of lift pits and floor-framing of lift	In a building required to be of Type A construction- (a) .. (b) external walls, common walls and the flooring and floor framing oflift pits must be non-combustible; and (c)-(f) ..	Combinati on of fire resistance and flame spread.	Apply Project 2 controls.

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pits			
Cl.1 3.l(c)(iii) Fire-rated wall to extend to a fire-rated roof or an NC covenng.	In a building required to be of Type A construction- (a)-(b) .. (c) any internal wall required to have an FRL must extend to- (i) the underside of the floor next above; or (ii) the underside of a roof complying with Table 3; or (iii) if under Clause 3.5 the roof is not required to comply with Table 3, the underside of the non-combustible roof covering and, except for roof battens with dimensions of 75 mm x 50 mm or less, must not be crossed by timber or other combustible building elements; or (iv) a ceiling that is immediately below the roof and has a resistance to the incipient spread of fire to the roof space between the ceiling and the roof of not less than 60 minutes; and (d)-(f) ..	As discussed previously.	Wall system must have appropriate FRL..
Cl.1 3.l(d) Loadbearing internal walls etc to be concrete or masonry.	In a building required to be of Type A construction- (a)-(c) .. (d) a loadbearing internal wall and a loadbearing fire wall (including those that are part of a loadbearing shaft) must be of concrete or masonry; and (e)-(f) ..	Requirement provides robustness combined with fire resistance.	This is not a requirement for non-combustibility and should not be considered under this project.
Cl.1 3.l(e) Non-loadbearing internal walls etc to	In a building required to be of Type A construction- (a)-(d) .. (e) a non-loadbearing- (i) internal wall required to be fire-resisting; and	Requiremen t is to prevent flame spread. More stringent	For walls, apply materials control from Project 2. For shafts, leave

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beNC.	(ii) lift, ventilating, pipe, garbage, or similar shaft that is not for the discharge of hot products of combustion, must be of non-combustible construction; and (f) ..	requirements are needed for shafts	mnon-combustibility
Cl.1 3.4(a) NC roof superimposed on a concrete slab.	A roof superimposed on a concrete slab roof need not comply with Clause 3.1 as to fire-resisting construction if- (a) the superimposed roof and any construction between it and the concrete slab roof are non-combustible throughout; and (b) the concrete slab roof complies with Table 3.	Possible flame spread through unoccupied space and contribution to fire growth.	Leave requirement for non-combustibility
Cl.1 3.5 (Introduction) Roof need not be FR if its covering is NC and	A roof need not comply with Table 3 if its covering is *non-combustible* and the building- (a) has a sprinkler system complying with Specification El.5 installed throughout; or (b) has a rise in storeys of 3 or less; or (c) is of Class 2 or 3; or (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.	This is a flame spread issue	Apply materials control from Project 2
Cl.1 3.6 Rooflights in a roof whose covering must be NC.	If a roof is required to have an FRL or its covering is required to be non-combustible, rooflights or the like installed in that roof must- (a) have an aggregate area not more than 20% of the roof surface; and (b) be not less than 3 m from-	Consistency of system performance.	review in light of other changes

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Cl.1 3.8(a) Open spectator stands - NC roof needn't have an FRL.	In an open spectator stand or indoor sports stadium, the following building elements need not have the FRL specified in Table 3: (a) The roof if it is non-combustible.	Materials control issue.	Apply Project 2 controls.
Cl.1 3.8(b) Ditto certain columns and LB walls	In an open spectator stand or indoor sports stadium, the following building elements need not have the FRL specified in Table 3 :.. (b) Columns and loadbearing walls supporting only the roof if they are non- combustible.	Flame spread issue.	Apply Project 2 controls.
Cl.1 3.8(c)(i) & (ii) Ditto NBL parts of certain external walls.	In an open spectator stand or indoor sports stadium, the following building elements need not have the FRL specified in Table 3 :.... (c) Any non-loadbearing part of an external wall less than 3 m- (i) from any fire-source feature to which it is exposed if it has an FRL of not less than - /60/60 and is non-combustible; or (ii) from an external wall of another open spectator stand if it is non-combustible.	Flame spread issue.	Apply Project 2 controls.
Cl.1 3.l0(a) (recent minor changes to text not shown)	(a) A Class 2 building having a rise in storeys of not more than 3 may be constructed using- (i) timber framing throughout; or (ii) non-combustible material throughout; or (iii)a combination of (i) and (ii), provided- (iv) any fire wall or internal wall required to be fire-resisting that extends to the underside of the non-combustible roof covering is, except for roof battens with dimensions of 75 mm x 50 mm or less, not crossed by timber or other combustible	This is a complex system involving the contribution of structure and insulation to fire load and FRL	Leave as is - further investigation required

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	building elements; and (v) any insulation installed in the cavity of a wall required to have an FRL is non-combustible; and (vi) the building is fitted with an automatic smoke alarm system complying with El.7. (b)-(c) ..		
Cl.1 3.l0(b) (recent minor changes to text not shown)	(a) .. (b) A Class 2 building having a rise in storeys of not more than 4 may have the top three storeys constructed in accordance with (a) provided the lowest storey is used solely for the purpose of parking motor vehicles or for some other ancillary purpose and the construction of that storey, including the floor between it and the storey above, is of concrete or masonry. (c) ..	As above	As above
Cl.1 3.l0(c)	(a)-(b) .. (c) In a Class 2 building complying with (a) or (b) and fitted with a sprinkler system, any FRL criterion prescribed in Table 3- (i) for any floor and any loadbearing wall, may be reduced to 60, except any FRL criterion of 90 for an external wall must be maintained when tested from the outside; and (ii) for any non-loadbearing internal wall, need not apply if- (A) it is lined on each side with 13 mm standard grade plasterboard or similar non-combustible material; and (B) it extends- (aa) to the underside of the floor next above; or (bb) to the underside of a ceiling with a resistance to the incipient spread of fire of 60 minutes; or	As above.	As above

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	(cc) to the underside of a non-combustible roof covering; and (C) any insulation installed in the cavity of the wall is non-combustible; and (D) any construction joint, space or the like between the top of the wall and the floor, ceiling or roof is smoke sealed with intumescent putty or other suitable material; and (E) any doorway in the wall is protected by a self-closing, tight fitting, solid core door not less than 35 mm thick.		
Cl.1 4.l(b) NC required of floors of lift pits and floor framing of lift pits	In a building required to be of Type B construction- (a) .. (b) the external walls, common walls, and the flooring and floor framing in any lift pit, must be non-combustible ; and (c)-(i) ..	Combination of fire resistance and flame spread.	Apply Project 2 controls.
Cl.1 4.l(d)(iii) FR wall to extend to an FR roof or an NC covenng. Batten concession introduced with Amndt 7.	In a building required to be of Type B construction- (d) any internal wall which is required to have an FRL, except a wall that bounds a sole-occupancy unit in the topmost (or only) storey and there is only one unit in that storey, must extend to- (i) the underside of the floor next above if that floor has an FRL of at least 30/30/30; or (ii) the underside of a ceiling having a resistance to the incipient spread of fire to the space above itself of not less than 60 minutes; or (iii) the underside of the roof covering if it is non-combustible and, except for roof battens with dimensions of75 mm x 50 mm or less, must not be crossed by timber or other combustible building elements; or (iv) 450 mm above the roof covering if it is combustible, ...	Fire resistance issue.	Wall system must have appropriate FRL
Cl.1	In a building required to be of Type B construction-	Robustness and	This is not a

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4.l(e) Loadbearing internal walls and loadbearing fire walls to be of concrete or masonry.	(a)-(d) .. (e) a loadbearing internal wall and a loadbearing fire wall (including those that are part of a loadbearing shaft) must be of concrete or masonry; and (f)-(i) ..	fire resistance.	requirement for non-combustibility and should not be considered under this project.
Cl.1 4. l(f) Non-loadbearing internal walls that need an FRL to be NC.	In a building required to be of Type B construction- (a)-(e) .. (f) a non-loadbearing internal wall required to be fire-resisting must be of non-combustible construction; and (g)-(i) ..	Flame spread issue.	Apply Project 2 controls
Cl.1 4. l(h) Service shafts in certain classes to be NC. (recent minor changes to text not shown)	In a building required to be of Type B construction- (a)-(g) .. (h) lift, ventilating, pipe, garbage, and similar shafts which are not for the discharge of hot products of combustion and not loadbearing, must be of non- combustible construction in- (i) a Class 2, 3 or 9 building; and (ii) a Class 5, 6, 7 or 8 building if the shaft connects more than 2 storeys; and (i) ..	Flame spread issue with very stringent requiremen t because of shaft dimensions	Leave non-combustible requirement
Cl.1 4. l(i) Fire-protective covering above space for cars or	In a building required to be of Type B construction- (a)-(h) .. (i) in a Class 2 or 3 building, except where within the one sole-occupancy unit, or a Class 9 building, a floor separating storeys or above a space for the accommodation of motor vehicles or used for storage or any other ancillary purpose,	Fire resistance issue.	Apply requirement for smoke barriers

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storage.	must- (i) be constructed so that it is at least of the standard achieved by a floor/ceiling system incorporating a ceiling which has a resistance to the incipient spread of fire to the space above itself of not less than 60 minutes; or (ii) have an FRL of at least 30/30/30. (iii) have a fire-protective covering on the underside of the floor, including beams incorporated in it, if the floor is combustible or of metal.		
Cl.1 4.3(a)	(a) A Class 2 building having a rise in storeys of not more than 2 may be constructed using- (i) timber framing throughout; or (ii) non-combustible material throughout; or (iii) a combination of (i) and (ii), provided- (iv) any fire wall or internal wall required to be fire-resisting that extends to the underside of the non-combustible roof covering is, except for roof battens with dimensions of 75 mm x 50 mm or less, not crossed by timber or other combustible building elements; and (v) any insulation installed in the cavity of a wall required to have an FRL is non-combustible ; and (vi) the building is fitted with an automatic smoke alarm system complying with Specification E2.2a. (b) ..	Complex system involving contributio n of structure and insulation to fire load and FRL	Leave as is - further investigation required
Cl.1 4.3(b) (recent minor changes to text not	(a) .. (b) In a Class 2 building complying with (a) and fitted with a sprinkler system, any FRL criterion prescribed in Table 4- (c) (i) for any loadbearing wall, may be reduced to 60, except any FRL criterion of	Non-combustibil ity used to increase fire resistance.	Use appropriate FRLs except for cavity insulation (to be addressed

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shown)	90 for an external wall must be maintained when tested from the outside; and (ii) for any non-loadbearing internal wall, need not apply, if- (A) it is lined on both sides with 13 mm standard grade plasterboard or similar non-combustible material; and (B) it extends- (aa) to the underside of the floor next above if that floor has an FRL of at least 30/30/30 or is lined on the underside with a fire-protective covering; or (bb) to the underside of a ceiling with a resistance to the incipient spread of fire of 60 minutes; or (cc) to the underside of a non-combustible roof covering; and (C) any insulation installed in the cavity of the wall is non-combustible ; and (D) any constructonjoints, spaces and the like between the top of the wall and the floor, ceiling or roof is smoke sealed with intumescent putty or other suitable material.		in later stages of Project 2)-beyond the scope of this project
Cl.1 5.1(d) Vertical extent of partition walls in class 2 & 3 - to NC roof sheeting or above combustible roof sheeting.	In a building required to be of Type C construction- (a)-(c) .. (d) in a Class 2 or 3 building an internal wall which is required by Table 5 to have an FRL must extend- (i) to the underside of the floor next above if that floor has an FRL of at least 30/30/30 or a fire-protective covering on the underside of the floor; or (ii) to the underside of a ceiling having a resistance to the incipient spread of fire to the space above itself of not less than 60 minutes; or (iii)to the underside of the roof covering if it is non-combustible, and except for roof battens with dimensions of 75 mm x 50 mm or less, must not be crossed by timber or other combustible building elements; or (iv)450 mm above the roof covering if it is combustible; and	System must have appropriate fire resistance.	Wall system must have appropriate FRL

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	(e) ..		
Cl.1 5.1(e) Coverings to the undersides of floors above garages and storage areas in classes 2 and 3 and exemptions.	In a building required to be of Type C construction- (a)-(d) .. (e) in a Class 2 or 3 building, except where within the one sole-occupancy unit, or a Class 9 building, a floor separating storeys , or above a space for the accommodation of motor vehicles or used for storage or any other ancillary purpose, and any column supporting the floor, must- (i) have an FRL of at least 30/ 30/ 30; or (ii) have a fire-protective covering on the underside of the floor including beams incorporated in it and around the column, if the floor or column is combustible or of metal.	System must have appropriate fire resistance.	Apply requirement for smoke barriers
Cl.10 3(a)(iii) Combustibles to be attached to NC substrates.	In a fire-isolated stairway, fire-isolated passageway, or fire-isolated ramp in a Class 2 to 9 building- (a) a material, other than a sarking-type material used in a ceiling or used as a finish, surface, lining or attachment, must have a- (i) Spread-of-Flame Index of 0; and (ii) Smoke-Developed Index of not more than 2; and (iii) if combustible, be attached directly to a non-combustible substrate and not exceed 1 mm in finished thickness; and (b) ..	Flame spread issue.	Changes recommended by Project 2.
C3.15 3(a) (Introduction) Proximity of metal pipe to combustibles. (recent minor	(a) A metal pipe that is not normally filled with liquid must not penetrate a wall, floor or ceiling within 100 mm of any combustible material, and must be constructed of- (i) copper alloy or stainless steel with a wall thickness of at least 1 mm; or (ii) cast iron or steel (other than stainless steel) with a wall thickness of at least 2 mm.		Non-combustibility requirement to remam.

BCA 1996 SPECIFICATION /CLAUSE No	BCA Text	Comments	Recommended action
changes to text not shown)	(b) An opening for a metal pipe must- (i) be neatly formed, cut or drilled; and (ii) be no closer than 200 mm to any other service penetration; and (iii) accommodate only one pipe. (iii) A metal pipe must be wrapped but must not be lagged or enclosed in thermal insulation over the length of its penetration of a wall, floor or ceiling unless the lagging or thermal insulation fulfils the requirements of Clause 7. (iv) The gap between a metal pipe and the wall, floor or ceiling it penetrates must be fire-stopped in accordance with Clause 7.		
C3.15 7(a) Properties of fire-stopping material.	(a) Material: The material used for the fire-stopping of service penetrations must be concrete, high-temperature mineral fibre, high-temperature ceramic fibre or other material that does not flow at a temperature below 1120oC when tested in accordance with AS 1038.15, and must have- (i) demonstrated in a system tested in accordance with C3.15(a) of the BCA that it does not impair the fire-resisting performance of the building element in which it is installed; or (ii) demonstrated in a test in accordance with (e) that it does not impair the fire- resisting performance of the test slab. (b)-(e) ..	Although related, there is no mention of non-combustibility	No change.
D1.12 2(e) A floor covering under a fire door.	An escalator, moving walkway or non-required non-fire-isolated stairway or pedestrian ramp- (a)-(d) .. (e) when a fire door is closed the floor or any covering over the floor beneath the fire door must not be combustible. (f)-(o) ..	Flame spread issue.	Tobe considered by Project 2B
E2.2b	(a) A fire compartment must be divided at ceiling level into smoke reservoirs	Fire resistance	Apply

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4 NC of smoke curtain around a floor openmg.	formed by smoke baffies/curtains of non-combustible and non-shatterable construction. (b) The horizontal area of a smoke reservoir must not exceed 2000 m2 and in enclosed walkways and malls of a Class 6 building must not exceed 60 m in length. (c) Smoke reservoirs must be of sufficient depth to contain the smoke layer and must not be less than 500 mm below an imperforate ceiling or roof. (d) (i) Within a multi-storey fire compartment, a non-combustible bulkhead or smoke baffie/curtain must be provided around the underside of each opening into a building void to minimise the spread of smoke to other storeys. (ii) The depth of the bulkhead or smoke baffie must be not less than the depth of the smoke reservoir provided under (c) plus an additional 400 mm	issue.	requirement for smoke barriers
G3.8 2.3(b) NC of collector plates.	The floor of the atrium must be protected by sprinklers with- (a) the use of sidewall pattern sprinkler heads together with overhead sprinklers where dictated by the dimensions of the atrium; and (b) sprinkler heads of the fast response type, installed with suitable non-combustible heat collector plates of 200 mm minimum diameter to ensure activation by a rising fire plume.	If the heads are suitable they are presumably non-combustible.	Delete non-combustible
G3.8 2.4.1 (Introduction) Ditto	Where an atrium is separated from the remainder of the building by walls or doors incorporating glazing, a wall wetting system with suitable non-combustible heat collector plates of 200 mm diameter must be provided to protect the glazing as follows: (a) On the atrium side of the glazing - to all glazed walls which are set back more than 3.5 m from the atrium well. (b) On the atrium side of the glazing - to all glazed walls which are not set back, or are set back 3.5 m or less, from the atrium well, for all levels which are less than- (i) 12 m above the floor of an atrium or the floor of the highest storey where the	If the heads are suitable they are presumably non-combustible.	Delete non-combustible

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	bounding wall is set back more than 3.5 m from the atrium well if a Class 2, 3, 5 or 9 part of the building is open to the atrium; or (ii) 20 m above the floor of an atrium or the floor of the highest storey where the bounding wall is set back more than 3.5 m from the atrium well if a Class 6, 7 or 8 part of the building is open to the atrium. (c) On the side of the glazing away from the atrium well - to all glazing forming part of bounding wall at each storey.		
Hl.3 6(a) NC of proscenium curtain.	A curtain required by Clause 5 must be- (a) a fire safety curtain- (i) made of non-combustible material; and (ii) capable of withstanding a pressure differential of0.5 kPa over its entire surface area; and (iii) so fitted that when fully lowered it inhibits the penetration of smoke around the perimeter of the opening, from the stage; or (b) a curtain- (i) having a Spread-of-Flame Index not greater than O and a Smoke-Developed Index not greater than 3; and (ii) protected by a deluge system of open sprinklers installed along the full width of the curtain.	Fire resistance issue.	Apply requirement for smoke barriers
Hl.3 4 Timber purlins not to cross proscenium wall.	Timber purlins or other combustible material must not pass through or cross any proscenium wall.	Fire resistance/ smoke spread issue.	Apply requirement for smoke barriers