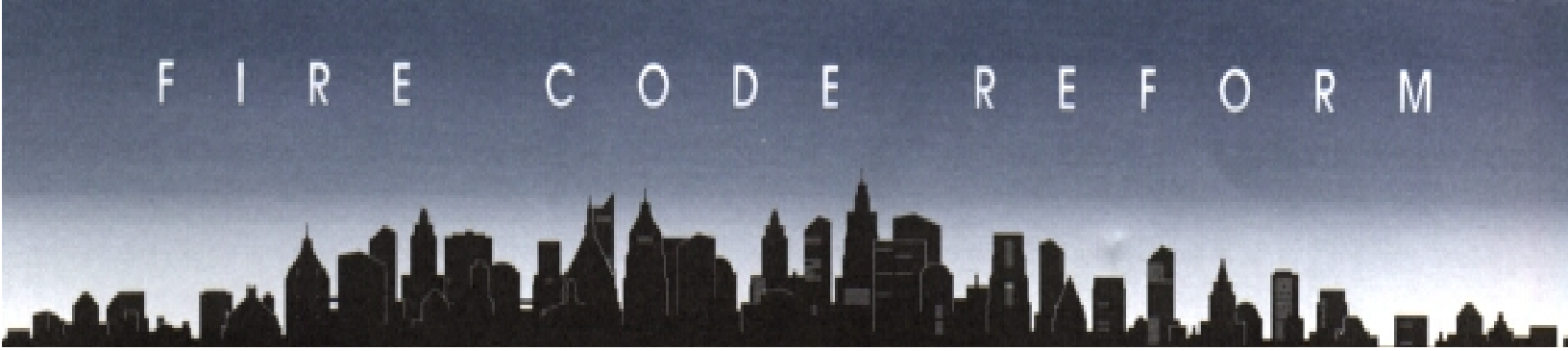

Project Report
FCRC-PR 96-02 (Volume 1)

Final Report on the Restructure of BCA Fire Provisions

FCRC Project 1
Restructure BCA Fire Provisions

Fire Code Research Reform Program
April 1996

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Background

The Fire Code Reform Research Program is funded by voluntary contributions from regulatory authorities, research organisations and industry participants.

Project 1 of the Program required comprehensive analysis of all fire related clauses within the prescriptive provisions of BCA 90 and reallocation of them into fire engineering sub-system format. The aim was to identify the levels of fire-safety performance being achieved by buildings constructed in accordance with these provisions and to provide benchmarks for ongoing development in other projects of the Program of the performance-based approach to building fire-safety design.

Volumes 1 and 2 of this Project Report FCRC-PR 96-02 were produced by CSIRO – Division of Building, Construction and Engineering of 14 Julius Avenue, Riverside Corporate Park, Delhi Road, North Ryde, New South Wales 2113 at the conclusion of its involvement in this work as principal consultant.

Acknowledgements

Since inception of the Fire Code Reform Research Program in 1994 the Australian Building Codes Board has been its principal financial contributor. Substantial funds have also been provided by Forest and Wood Products Research and Development Corporation and generous contributions have been received from a number of industrial and financial entities and individual donors.

The Board and management of Fire Code Reform Centre Ltd acknowledge with sincere thanks receipt of all these financial contributions. The company also acknowledges the permission of CSIRO – Division of Building, Construction and Engineering to re-produce and publish this document.

Comments

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FIRE CODE REFORM CENTRE
PROJECT 1

Final Report on the
Restructure of
BCA Fire Provisions

Volume 1

April 1996

CSIRO

PREFACE

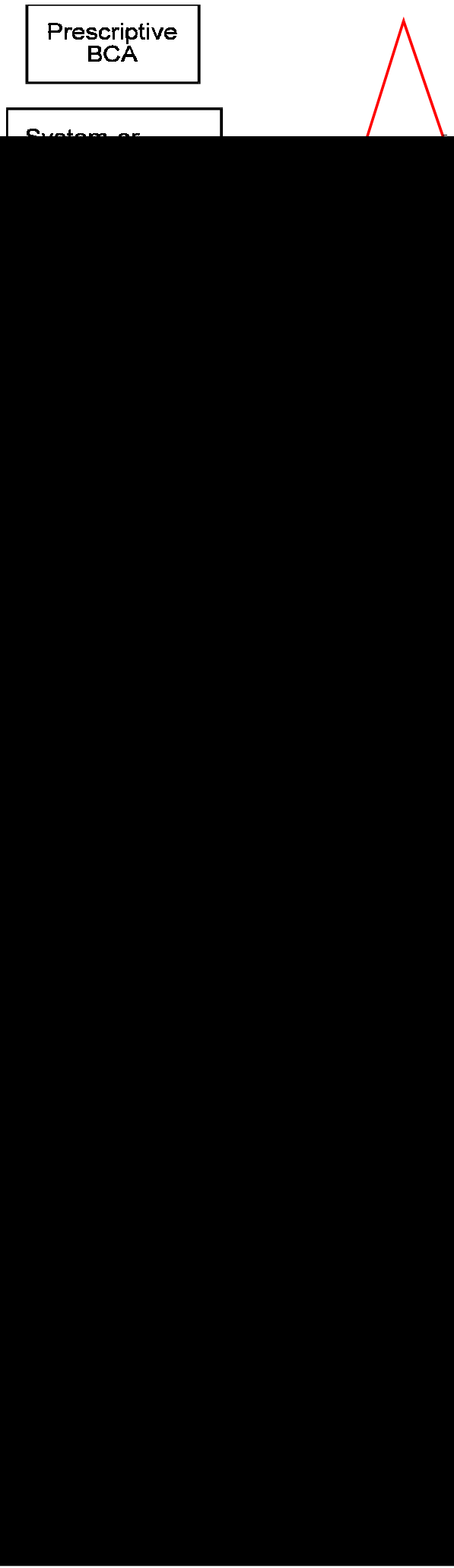
In June 1994 the Fire Code Reform Centre Ltd was established to undertake a comprehensive program of research to reform the present fire regulations. The Centre represents a collaboration between the regulatory authorities, industry and fire research organisations. The aim of the centre is to identify and sponsor research, education and other activities necessary to bring about reform of the building regulations. It brings together the reform agenda of the regulatory authorities and the needs of designers and industry to move towards a more performance oriented, engineering approach to fire safety.. The funding for the Centre and the program of research is from all of the collaborating parties, each contributing about $A0.5M per annum towards the five-year program.

The aim of the Fire Code Reform Research Program is to introduce a cost-effective, fully engineered approach to fire safety regulations. The series of research projects is designed to:

- recast fire safety aspects of the Building Code of Australia (BCA) in terms of the performance of fire-safety sub-systems;
- rationalise current BCA prescriptions whilst maintaining acceptable life safety performance;
- develop a methodology to evaluate the performance of building fire safety systems and sub-systems on a risk-assessment basis; and
- develop a Fire Safety Design Code to provide an engineering basis for building fire safety and an alternative means of compliance with the BCA.

The outcome of the identified research program will have major impact on the way buildings will be built in the future

The progression towards a flexible, system-oriented BCA (in which the required performance of each fire-safety sub-system is clearly expressed) and the development of the Fire Safety Design Code is illustrated in the following diagram:


Prescriptive
BCA

Codes Board, Mr Ernest Calvert and Mr Norman Bowen and Mr Steven Durnford of the Building Codes Committee for their valuable comments.

The research team would like to express their gratitude to all organisations and individuals who have supported this work through their contributions and participation in the work of the Fire Code Reform Centre Limited. In particular, thanks are due to the Australian Building Codes Board who have devoted a significant proportion of their budget to fund the Fire Code Reform Program and Mr Claude Eaton, Business Manager Fire Code Reform Centre Limited, without whose fund raising efforts this work would not have been possible.

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INTRODUCTION

The Building Code of Australia (BCA), in common with many building codes around the world, is essentially a prescriptive document with regard to the fire safety provisions. The need to move to a performance-based code has been recognised and work is in progress of transforming the document to a performance basis. The first draft of this document has been released recently and this superimposes a hierarchical objective structure on the existing BCA provisions but does not address the current "deemed-to-satisfy" provisions.

A key aspect of any performance regulation is the stipulation of the objectives and expected levels of performance. These objectives have only been broadly stated in the past but need to be expressed in meaningful terms to enable them to be used for design. One of the aims of this project was to dissect the existing regulatory provisions for fire safety in order to better understand the implicit performance contained within the "deemed-to-satisfy" provisions. This process will permit the specification of objectives at the fire safety system level, clearly identifying the role and expected level of performance of each element of the fire safety system.

The other major objective of this project was to restructure the existing provisions into a tabular form. This arrangement enables ready identification of the fire safety systems that contribute to the overall fire safety of a building. The entry in the table represents the level of performance of the various elements of the fire safety systems required to satisfy the BCA. Each line in the table is a system specification and each column represents one component of the fire safety system.

Arrangement in this tabular form will provide a framework which will readily permit the addition of alternative solutions. Subsequent projects will build upon the framework in their detailed study of the requirements for particular sub-systems and in the introduction of alternative solutions to the design of safe buildings. Particularly, Project 4 will evaluate the level of risk represented by each combination (a row in the table) and the performance requirements may be subsequently reviewed to ensure a consistent level of performance. The ability to choose between equivalent accepted solutions will provide the flexibility that designers seek and will lead to more economic buildings.

DEFINITIONS

Fire-safety System	The combination of all attributes of a building that contribute to the safety of the building and its occupants if there is a fire.
System Element	A component of the fire-safety system that is specified in the BCA and for which varying levels of performance are required, depending on the nature of the building under consideration.
Building Identity	*(or Building ID)* A unique identification of a building or fire compartment based on usage and physical parameters.

Designator	An alpha-numeric identification for a group of requirements that relate to a particular level of performance of a specified system element.
Descriptor	A description of the performance required by the BCA of a particular system element to achieve the level of fire safety required in a particular group of buildings.
Application	Limits on the application of an acceptable solution that are not specified by the building identity (Building ID).
Acceptable Solution	A solution based on the technical requirements of the BCA that satisfies the descriptor.

PROJECT DESCRIPTION

A building protects its occupants and its neighbours against fire through a variety of passive and active system elements. The walls of even the simplest building will hinder the spread of smoke and fire (the system element of compartmentation) and there will always be ways to get out of the building (the egress system element). If the householder installs a smoke alarm, we have a fire-detection system element and a warning system element. The purpose of performance regulation is to permit each system element to be put together in the widest variety of ways and to facilitate interaction between the system elements so that deficiencies in one are compensated by superfluity in others and a statutory overall level of safety is achieved. For example, in a single-storey, one-room building we could put the roof on posts and thereby dispense with compartmentation but optimise the egress system element. This is often called a "trade-off".

In converting the Building Code of Australia from a prescriptive code to a performance code we recognize that the present prescriptions represent levels of safety and methods of design and construction acceptable to the community and its building authorities. At the start, the objective and outcomes expected of Project 1 were therefore defined as follows:

Objective:

To restructure the present fire-safety provisions of the Building Code of Australia into a tabular framework that will enable the implicit level of performance of each fire-safety system to be quantified. The tabular structure will facilitate future expansion by allowing the addition of new “alternative solutions”.

Outcomes:

1. Statements of the objectives behind the fire-safety provisions of the Building Code of Australia.

2. Lists of buildings, categorized by use, for each of which a separate, common set of fire-safety provisions is presently specified.
3. A list of fire-safety system elements that are presently specified in the Building Code of Australia.
4. Descriptions of the regulatory requirements imposed on the fire-safety system elements that are presently specified in the Building Code of Australia.
5. Tables of requirements for alternative fire-safety systems.
6. A draft Regulation Document for submission to the ABCB containing proposed amendments to the Building Code of Australia.
7. Final report including references to anomalies and items needing further resolution.

The objective can be represented by the following diagram:

	Fire-safety system element ⇒		*eg active smoke management*		
Building identity ⇓					
eg single storey detached dwelling			List of BCA requirements representing level of performance		

The process involved identifying groups of buildings for which there are unique sets of requirements for design for fire in the BCA. Requirements were then grouped in terms of system elements and each system element was analysed for implied levels of performance. A description was written for each level of performance and the BCA requirements were recast in the form of acceptable solutions, to suit the tabular structure.

Revised outcomes

During the course of the project it was found that, although the objective remained unchanged, in order to achieve it the outcomes had to be modified. The numbers in

brackets below, following the modified outcomes, correspond to the outcomes as originally defined.

Part 1 of this report details how the project was executed and includes recommendations to the Australian Building Codes Board (6 & 7).

Part 2 is the recasting of the fire-protection provisions of the Building Code of Australia as a performance code for code writers(6) and code users and contains:

1. How to use Part 2.
2. Building/Compartment ID selection tables (2).
3. System designator selection tables.
4. System element details (3) comprising: designator
   descriptor (1 & 4)
   application
   acceptable solution (5).

The Building/Compartment ID selection tables allow the user to select a building or fire compartment based on its use and geometry. Having selected a Building/Compartment ID, the user then determines the levels of performance required for each of the fire safety system elements. These levels are presented in a table, the Fire Code Requirements Chart (FCRChart), in which each row represents a combination of levels of performance of fire safety system-elements that together provide an approriate level of safety for the building or compartment under consideration. Each level of performance has a unique designator. Alternative combinations of acceptable fire safety system elements for a particular building are shown in separate rows within the chart but have the same Building ID.

Each level of performance within each system element has a descriptor which describes what the system element must do. Each descriptor has a number of system designators (each corresponding to a different group of buildings for which there might be a slightly different way of achieving the same end result) and each designator has corresponding system element details. The current prescription within the BCA is included in the system element details as an acceptable solution, with the application separated from the requirement.

CODE ANALYSIS

Buildings and Fire Compartments

The first task was to identify buildings for which unique sets of requirements existed within the fire provisions of the BCA. A preliminary examination of the BCA showed that, when defined by use, there were considerably more than the 13 classes and subclasses defined in Section A of the Code. For example, open spectator stands, schools, patient-care areas in hospitals and open-deck carparks have quite distinct uses

and quite distinct sets of requirements. A list of 24 classes and sub-classes for use in the project was agreed upon and is shown in Appendix A.

Once all the sub-classes for which different requirements apply had been identified, the building geometry limits that define different Types of Construction (Type A, B and C) were analysed. Significant features were found to be rise in storeys, effective height (both of which apply to buildings) and maximum floor area and volume (which apply to fire compartments). When all possible combinations were taken into consideration, an initial list of over 2,000 Building Identities was generated. This list was then culled to group buildings for which requirements were not unique, and a list of 391 Building IDs remained. The list is included in Appendix B.

Code Structure

The next process involved analysing the BCA to categorize the types of clauses it contains and the relationships between them. For the purposes of Project 1, clauses fell into three categories:

a) Statements of intention, which describe the performance required of systems, of parts of systems or even of components of buildings.

b) Requirements, which specify how a particular building element or system should be designed or constructed.

c) Tools, which give details of how to measure, how to calculate etc.

Since the purpose of the project was to take a fresh look at the *requirements* of the fire-safety system elements and provide accurate descriptions, the present *statements of intention* were used only as a check on the proposed descriptors. They did not play a major role in the project.

Requirements make up the main volume of the BCA. In some cases the requirement describes one way of fulfilling the intention to the satisfaction of the authorities (while alternatives are implicitly accreditable); in other cases compliance with the requirements is mandatory. This difference was noted but, although epitomizing the difference between performance and prescriptive codes, was of no significance to Project 1. A feature of the BCA is that a clause specifying a requirement is often extended to limit its application; the importance of application and its intricate relationship with Building ID was not appreciated until towards the end of the project (see “Drafting the final output”).

Intentions and tools are related to one or more requirements.

The content of clauses is inconsistent. In some cases intentions and acceptable solutions are included in one clause, in other cases the intention is in one clause and the acceptable solution in another. Many clauses contain a number of requirements which apply to different buildings. It was therefore necessary to break the clauses down into smaller pieces for comprehensive consideration. Each separate, individual requirement was called an “acceptable”.

Many clauses contain information which only leads the user to another clause or specification - although they will sometimes include a limitation or an extension of application. This point is illustrated by the clauses which determine Type of Construction. Type of construction is not a requirement in itself; it is a means of identifying a group of requirements, such as fire-resistance level, that apply to a group of buildings with certain characteristics. The "directional" nature of clauses needs to be taken into account in a detailed analysis of requirements and care must be taken not to lose any information on application within these clauses.

Items within buildings

Requirements exist to ensure that buildings perform in certain ways or contain certain provisions. The next task was to consider the performance expected of the building as embodied in the requirements. The application of requirements varies from individual items or components within a building to complete system elements. The nature of the performance demanded by a requirement depends upon the object to which it applies. For example, a requirement for an external wall to have an FRL implies a different performance from the requirement for an internal wall to have an FRL. In order to gain an understanding of the implied performance, some time was spent considering the items to which each requirement applies.

System Elements

Once BCA clauses had been broken down into discrete requirements and the items to which each requirement applied had been identified, it was time to start thinking in terms of fire safety system elements. The research group derived a list of system elements which they believed would accommodate all the requirements for design for fire within the BCA. The initial list differed only slightly from the final one. For example, it included compartmentation as one system element; fire fighting as one system element, and materials control was not considered to be a separate system element although tenability was.

The final list was produced on the basis that it was easier to start with many system elements and combine them where necessary; later fragmentation could be difficult. The final 14 system elements were extended to 16 when it was agreed to consider compartmentation to prevent smoke spread, compartmentation to prevent fire spread and compartmentation to prevent both the spread of smoke and the spread of fire as three separate systems. Although most compartmentation requirements hinder the spread of both fire and smoke, there are certain areas where the requirements have a more specific application. Smoke seals are not designed to reduce the spread of fire; spandrels will have little effect on the spread of smoke. For convenience of analysis, the system element of combined smoke and flame compartmentation was created as the majority of compartmentation requirements apply to both. A 17th system was later added to accommodate emergency power supply for essential services. The system elements used in the project and their definitions are listed below:

SYSTEM ELEMENTS

ID:	**1**
Name:	**Structure**
Description:	The system of loadbearing elements that contribute to the ability of a building and components of a building to stay up for as long as necessary (eg for people to escape or for the building not to collapse), irrespective of whether or not they are required to be fire resisting. Note that a floor might not be required to have an FRL but it is tacitly expected to stay in place till people are out of the room.
ID:	**2**
Name:	**Escape paths**
Description:	Physical components of the travel path including number of exits, travel distance, stair dimensions, steepness, widths, handrails but excluding the surrounding construction (this is compartmentation).
ID:	**3**
Name:	**Active smoke management**
Description:	Every active control of the extent of spread of smoke, other than smoke compartmentation. The system includes roof vents, shutting down air-conditioning systems, switching air conditioning to the smoke-control mode, smoke fans etc. but excludes materials control and smoke curtains.
ID:	**4**
Name:	**Fire suppression**
Description:	Active fire suppression systems including automatic sprinklers and deluge systems but excluding external drencher systems (these are part of the exposure control system) and hand-held fire-fighting appliances.
ID:	**5**
Name:	**Fire detection**
Description:	Anything on which reliance is placed to detect fire. The system might be used for a variety of purposes like sounding alarms but the alarms are not part of the detection system.
ID:	**6**
Name:	**Warning**
Description:	Anything that warns occupants and fire-fighters of a fire. Includes warning occupants and alerting fire control stations.
ID:	**7**
Name:	**Building management**
Description:	Aspects of building and occupant management that are intended to promote safety, including maintenance of essential services, personnel training etc. Probably not currently addressed in the BCA except to the extent that it provides for the fire authorities'

management of egress and maintenance of safety installations.

ID: **8**
Name: **Materials control**
Description: Fire and smoke properties of materials, including control of fire load, early-fire-hazard properties and the combustibility of the structure, its linings and furnishings and its contents.

ID: **9**
Name: **Occupant fire fighting**
Description: Everything that is provided for fire intervention by the building occupants, including hose reels and fire extinguishers.

ID: **10**
Name: **Brigade fire fighting**
Description: Everything that is provided for fire intervention by the fire brigade, including hydrants, facilities for fire engines, facilities for fire-fighters and fire control rooms.

ID: **11**
Name: **Means of communication**
Description: Everything that assists communication during an incident including intercommunication between fire wardens, between fire fighters and between fire wardens/fire fighters and occupants but excluding general alarm and warning systems.

ID: **12**
Name: **Smoke compartmentation**
Description: Barriers intended to confine smoke, including smoke barriers and smoke reservoirs, that are not part of flame and smoke compartmentation.

ID: **13**
Name **Flame compartmentation**
Description: Barriers intended to confine fire, including walls and wall-wetting systems, spandrels and protection of openings that are not part of general compartmentation.

ID: **14**
Name: **Exposure control**
Description: Everything on the outside of the building that inhibits the spread of fire from one building to another or from a fire-source feature to a building. It include drenchers, FRLs of external walls (including external walls that separate fire compartments) and distances from fire-source features.

ID: **15**
Name: **Wayfinding**
Description: The means that assist building occupants to find their way to a

	place of safety, including exit signs, emergency lighting, some aspects of exit location but excluding communication.
ID:	**16**
Name:	**Flame and smoke compartmentation**
Description:	Barriers intended to confine both smoke and fire.
ID:	**17**
Name:	**Standby power supply**
Description:	The means of maintaining power supply to essential services in an emergency.

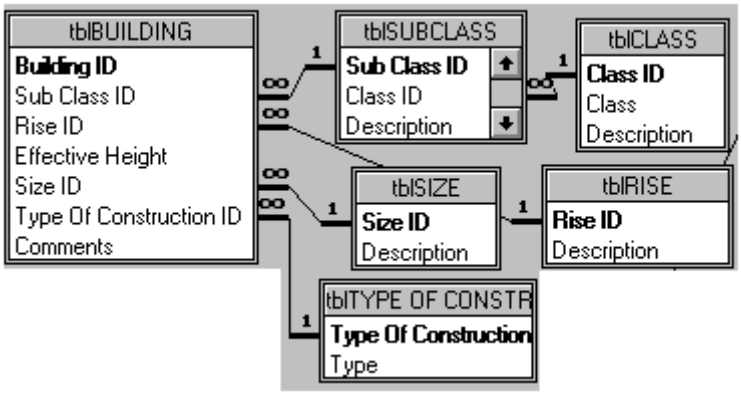
The definitions of the system elements gave the researchers the information needed to assign requirements to system elements. Each requirement had to be carefully considered to see to which system element it applied. In some cases, a requirement contributed towards the performance of more than one system element (for example, the FRL of an external wall contributes to both the structural system and exposure control). Throughout the project the general rule "if in doubt, leave it in" was applied. In the later stages of analysis, misplaced requirements were easily spotted.

The requirements of the BCA fitted well into the chosen list of system elements and the definitions provided any necessary guidance.

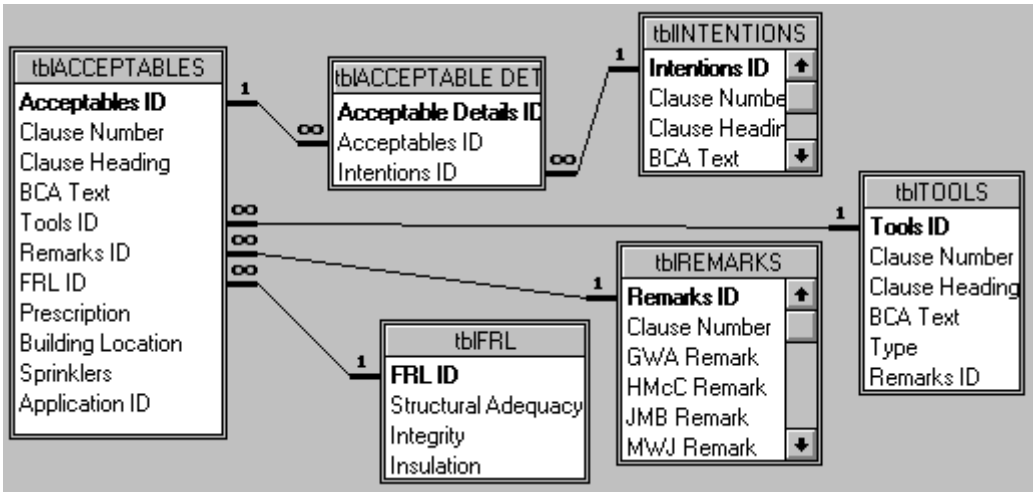
SOFTWARE

From the first consideration of building identities, it was apparent that the task in hand was enormous. Given the complexities and extent of the analysis, computer software would be needed. In this area, the previous experience of members of the team in developing software based on the BCA proved invaluable. Existing knowledge was extended and built upon to develop a system that would fulfil the needs of the project and provide a basis for future development of regulation-support software. Various packages were considered including spreadsheets, expert systems and databases. A relational database provided the necessary links between the information and Microsoft Access was chosen for its ability to accommodate text and its graphic display of relationships.

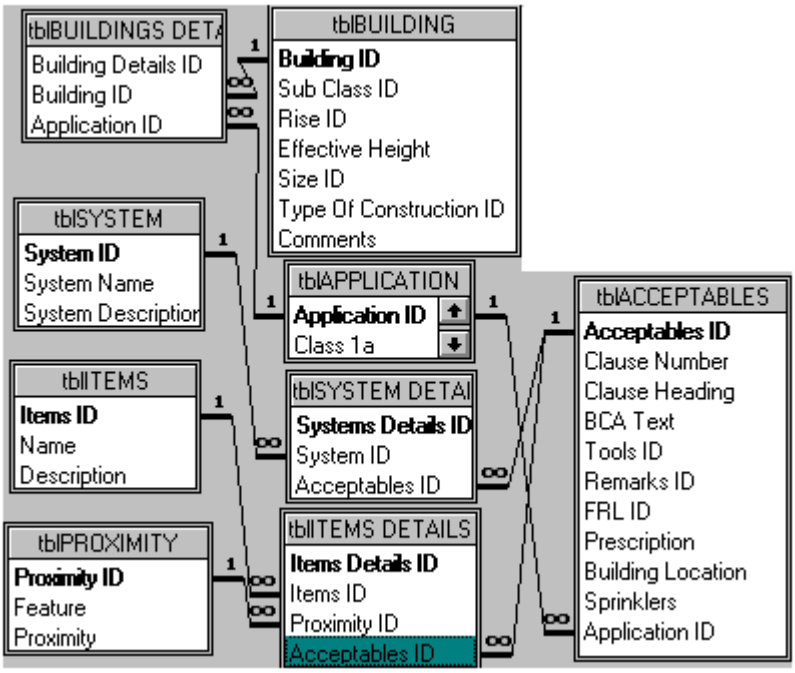
The database was first used to generate Building Identities. Tables of class, sub-class, size (floor area/volume) and rise (rise in storeys) were created and linked, together with effective height, to generate the list of Building Identities. The Building IDs were also linked to type of construction, since many requirements in the BCA are specified in this way.



Forms were then developed to input the text of the BCA. Requirements (including the text of the BCA) were entered into the table "Acceptables", each requirement being identified by an "Acceptables ID", and tables were developed for "Intentions" and "Tools". Fire Resistance Levels were entered in a separate table for possible future reference and a table was included for "remarks". Generation of remarks encouraged the researchers to think about the requirements of the BCA in terms of system elements and the performance of items.



"Acceptables" were linked to items and the appropriate system elements, and applications were linked back to Building IDs (note that in this case "application" refers to the building properties or characteristics that define Building ID). A table "proximity" was included to identify the proximity of an item to a site boundary, but neither this nor the table "items" were subsequently used in this project.



When all the links had been completed, the database allowed lists of the requirements that applied to each system element within each building to be generated. The lists were exported to Excel for analysis, taking advantage of the easy interface between Excel and Access. A diagram of the full database structure and the input forms is given in Appendix C.

ANALYSING THE SYSTEM ELEMENTS

Grouping requirements

The next process was to group the BCA requirements into "levels" of performance for each system element. Lists of requirements applying to each system element for each Building ID were generated using Access. Printouts of these requirements for just one system generated a stack of papers some 30cm high. It was obvious that assistance was needed to analyse the levels of performance being achieved by each building. Excel spreadsheets provided the necessary tool.

Each system element was analysed separately and the initial analysis was carried out on the Acceptable IDs (each acceptable correspond to a single, indivisible BCA requirement). Lists of Acceptable IDs for each Building ID were exported from Access into Excel spreadsheets. Buildings which had identical sets of Acceptable IDs were grouped together. The Acceptable IDs were then sorted on frequency of occurrence, with the most commonly occurring Acceptables IDs appearing at the top of the spreadsheet. "Blocks" of Acceptable IDs applying to the most buildings could generally be considered as the base level of performance required of that system element.

Different levels of performance were indicated by the different "blocks" of Acceptable IDs (some discretion was used in studying the "blocks", as the number of different buildings to which a requirement applies does not necessarily reflect the frequency of use of that requirement). Each "block" was given an alpha-numeric designator. In some cases different Acceptable IDs were considered to achieve the same level of system element performance in different buildings (for example, different FRLs achieve the same level of performance in different classes of building). In these cases the designator was sub-divided by use of lower case letters.

Details of the processes involved in the analysis and an example of an Excel table showing "blocks" of Acceptable IDs are given in Appendix D.

Deriving System Element Descriptors

By studying the wording applying to each Acceptable ID, an attempt was made to describe the function performed by each "block". This gave a "descriptor" for the level, a description of what the researchers believed to be the intent of the regulators in imposing their requirements for that system element for the buildings under consideration. In some cases, especially those systems involving materials control and fire resistance levels, the BCA text gave insufficient guidance to the researchers to make a firm statement of the intent. This is indicated in the text of the "Restructured BCA Fire Provisions" and further details can be found in the following "Considerations for each system element".

Considerations for each system element

System element 1 - Structure

For structure, only those Fire Resistance Levels that relate to structural adequacy were considered. The principle "levels" were based on Type A, B and C construction and separate levels were included for carparks.

An attempt was made to derive descriptors based on the original objectives of the BCA (and those of its predecessor the AMUBC), modified to suit changes made over the years to the technical requirements. Although historic evidence indicated that:

for Type A construction, the structure must be sufficiently fire resistant to continue to function after a fire;

for Type B construction, the structure must be sufficiently fire-resistant to:

(a) continue to function until the building occupants have reached a place of safety;

(b) continue to function to permit fire-fighters access to the fire;

(c) continue to maintain the integrity of the outer walls of the building or fire compartment to prevent the spread of fire; and

(d) avoid the likelihood of collapse onto adjacent property; and

for Type C construction, the structure must be sufficiently fire-resistant to continue to function until the building occupants have reached a place of safety,

there was insufficient evidence to convince the researchers that these levels were being achieved by the current requirements and no descriptors were included.
The objectives of requirements for structure will be further studied in Project 3.
Additional (often alternative) levels of structural performance are introduced by concessions for the storey immediately below the roof and concessions for columns in low-rise buildings and by requirements for support of another part, protection of construction around mezzanine floors, and protection of floors separating storeys where occupants might be sleeping.

System element 2 - Escape paths

An escape path is made up of a series of segments such as stairs, ramps, corridors, doorways and thresholds for each of which there are different levels of requirement (eg public and private stairs). The overall level of performance required of an escape path in a building is the combination of all these levels (alternatively, but rather absurdly, it could be said that each part is a separate system element).
Levels of performance for each segment were identified and the level of performance for each segment for each building was tabulated, grouped in terms of safety, availability and capacity. However, the analysis became too complex for the limited resources of Project 1 and it was not possible to present the information in an easily accessible way to the user (the table would be a very useful tool for the designer and researcher, given further development). Consequently, the majority of requirements were identified as a general "level", the quality of escape path suitable for able-bodied people to move around and escape from any building. For each requirement the elements of safety, availability and capacity were identified.
Access for people with disabilities constitutes a distinct level, and at present the requirements apply to a limited range of buildings. The BCA text was left unchanged here as the Access Technical Advisory Committee of the ABCB is currently considering major changes.
Additional levels of escape path are imposed for rigging lofts and infrequently-used accessways, lifts and in theatres.

System element 3 - Active smoke management

This was one of the most straightforward systems as different levels can be easily recognised. Care was taken with possible options, as many alternatives to smoke control are provided by other system elements (for example, fire suppression).

System element 4 - Fire suppression

There is only one main level of fire suppression. The variations for atriums were sufficient to constitute another level and an additional level was included for occupancies with special problems.

System element 5 - Fire detection

Detection is not specified separately in the BCA, but there are distinct levels. Some are implicit in other systems (eg sprinklers). Untangling the clauses was

a tedious but rewarding process. Levels of detection are set by the area in which fire will be detected - is it local or is it widespread? - and the speed of detection needed to operate emergency systems effectively.

System element 6 - Warning

As with detection, the level of warning is not separated in the BCA. Levels vary with the extent of warning - is it local or throughout the building? - and with the nature of the warning issued. Is it just a warning bell or two-way communication?

System element 7 - Building management

At present, the only requirement that depends on building management is maintenance of essential services.

System element 8 - Materials control

Materials control contributes to the effective functioning of many other system elements so it is hard to specify levels. As non-combustibility was included as part of materials control, the first level is that materials should not release significant heat. Control of roofing materials and wall construction to prevent fire spread by compartmentation (there is an element of durability here), control of smoke generation, control of fire spread in escape paths and control of rate of growth of fire all provide additional levels for which it was not always possible to derive appropriate descriptors. Special requirements exist for theatres and auditoriums. Late in the analysis, it was agreed that the use of lightweight construction should be included under materials control.

System element 9 - Occupant fire fighting

This system element was straightforward as there are only two levels- the use of hose reels and extinguishers.

System element 10 - Brigade fire fighting

Fire fighters depend on hydrants, emergency lifts and fire control centres in various combinations for various buildings. Fire fighters also need to be able to access the building.

System element 11 - Means of communication

Means of communication was considered separately from warning and did not include warning bells. It therefore applied only where a two-way communication system was required, or informative notices (other than those covered by wayfinding) were displayed.

System element 12 - Smoke compartmentation

Certain aspects of compartmentation are designed solely to prevent smoke spread and this form of compartmentation was considered separately. Aspects include the use of smoke doors, containing smoke within a roof space and the exclusion of smoke from exitways. Smoke must not spread from one compartment to another. The function can be clearly seen in the requirements.

System element 13 - Flame compartmentation

In some cases the spread of smoke is of no consequence but fire spread must be prevented. In particular, power supplies must not be put at risk, and fire must not spread from one compartment or floor to another through openings in external walls. People outside a building must not be exposed to flame. Again, the function is quite clearly seen in the requirements.

System element 14 - Exposure control

Exposure control includes the control of fire spread through external walls, but there is debate as to whether control is to or from a building and reference to direction of fire spead was omitted from the descriptors. Again the original documentation on the objectives behind the setting of different types of construction was considered to derive suitable descriptors. Space around buildings also provides exposure control, but this must not be confused with access for fire fighters.

System element 15 - Wayfinding

Wayfinding covers signs and illumination of exit paths, with special levels provided in theatres. The purpose (and effectiveness) of certain signs is questionable. Is a sign that tells you not to use a stair in a fire part of wayfinding? And will it really prevent people from using the stair? It is included in this system element as it has a place in the BCA.

System element 16 - Flame and smoke compartmentation

Flame and smoke compartmentation is currently represented in the BCA in terms of Type A, Type B and Type C construction modified by a variety of concessions including multi-storey timber-framed construction. The objective of each "Type" and the boundaries between them are not always clear and so an attempt was made to study the variations in requirements between buildings for each building element. The table thus derived (for Type A buildings only) was enormous and it was agreed that the analysis was beyond the scope of Project 1. Consideration was confined to the original "Types" of construction, together with those special situations that give rise to clearly identifiable additional levels. Representing the complexities of the BCA requirements in an accessible way is not easy. However, the detailed analysis enabled the requirements to be grouped in terms of building elements and these groupings were used in the representation of the acceptable solutions, while sticking to the familiar groups of classifications used in BCA Specification C1.1.

Many requirements have the function of maintaining compartmentation (at whatever level is otherwise required). These requirements have been included in each of the systems representing a "Type" of construction. The user can now locate the FRL and all additional requirements for a building element in one spot, without having to seek out a string of hidden exceptions. Given the limitations of time and budget for Project 1, this was seen to be a satisfactory, if not perfect, solution. The detailed analysis will be continued as part of Project 3.

Once again, the original documentation on the intentions behind the types of construction was consulted to derive suitable descriptors. History indicated that the intent of compartmentation is:

Type A compartmentation - Fire must be confined to the fire compartment and floor (except certain permitted interconnected floors) on which it originated. Fire must be confined to the area in which it originated for long enough for the building occupants to escape.
Type B compartmentation - Fire must be confined to the fire compartment in which it originated. Fire must be confined to the area in which it originated for long enough for the building occupants to escape.
Type C compartmentation - Fire must be confined to the fire compartment in which it originated for long enough for the building occupants to escape.
Multi-storey timber-framed construction **-** Fire must be confined to the area in which it originated for long enough for:
(a) building occupants to escape; and
(b) the fire brigade to suppress the fire.
However, there was insufficient evidence to show that these levels were being achieved by current requirements and the researchers agreed not to include descriptors.
The current recognition of compartmentation in the BCA has evolved through a series of amendments which has lead to some inconsistency of expression. If levels of compartmentation are clearly acknowledged, the requirements for the "envelope" surrounding the compartment could be concisely stated. Such changes would increase the clarity of the regulations. This is a challenge for future code writers.

System element 17 - Standby power supply

The requirements for a standby power supply are called up by many systems for most buildings. For convenience, they were considered to be a separate system element.

DRAFTING THE FINAL OUTPUT

Drafting system element details

Details of the BCA system elements, the various levels required of those system elements and the BCA requirements that define those levels could now be drafted in terms of -

Designator: the alpha-numeric identification for the group of requirements that together define the particular level of performance of the specified fire-safety system element.

Descriptor: the description of the performance required by the BCA of the particular system element to achieve the level of fire safety required in a particular group of buildings.

Application: limits on the application of an acceptable solution that are not specified by the Building ID.

Acceptable solution: the technical "requirement" (a specification of material or construction) nominated in the BCA as satisfying the descriptor.

Designators and Descriptors

By this stage, the designators and descriptors for each "level" of performance of each system element had been agreed. The analysis generated lists of requirements for each designator in the form of extracts from the BCA. For the document to be useful to code users outside the research team, these lists of the requirements had to be drafted in an easy-to-use way.

Application

Application was

> confined to application of the acceptable within the system element as defined by the designator, and
>
> put before the acceptable solution.

Most of the information in the BCA relates to the application of requirements rather than the requirements themselves and, although application can be divided into two sorts, applications relating to Building ID; and application at the other end of the scale - the final, detailed context in which the accepable is applicable, there is no need to repeat application relating to the Building ID here. The user of the reconstituted performance code (the Fire Code Requirement Chart) already knows which building is being considering (having selected a Building ID).
Extracting the application relating to the detailed context from the BCA text and presenting it before the requirement gives the user an immediate check on the relevance of the requirement to the particular situation. Separating application and requirement also assists in future analysis of the appropriateness of the requirements. In drafting the system element details, the application related to detailed context was separated and included as "Application", leaving fairly succinct requirements (for example the element must have an FRL for structural adequacy 60) as "Acceptable Solutions". In some cases, where the detailed context was different for different Building IDs, it has been necessary to leave mention of building class, for example, in the "Application".

Acceptable solutions

In places (notably smoke control) the BCA offers a number of alternative solutions. These are represented by alternative rows of designators for the relevant building within the Fire Code Reqirement Chart. Once the alternatives have been identified and represented in this way, there is no need to mention the existance of alternatives within the text of the solutions. However, it is important that all alternatives are picked up and accounted for.

In general, the BCA does not contain concessions. Requirements called "concessions" are usually alternative solutions using different combinations of system elements. These are included as a separate row in the Fire Code Reqirement Chart. In some cases, a "concession" is a lower requirement for a particular group of buildings; again, these are reflected in the Fire Code Requirement Chart. Wherever possible any remaining "concessions" have been identified and written in positive terms, as an alternative acceptable system element.

An effort has been made to delete as many cross-references as possible. Where the text is short, cross-referenced information has been included in the acceptable solution. Where cross-reference is to a comprehensive specification, the whole specification has been included as an appendix to the system element details.

Checking building identities

Throughout the process of generating system element details, care was taken to maintain the list of Building IDs to which each designator applied. Once the acceptable solutions had been drafted, a check was made to ensure that each Building ID was correct. This involved checking each designator for each building, some hundreds of thousands of combinations and many hours tedious work.

Generating the Fire Code Requirement Chart

The hub of the process is the Fire Code Requirement Chart, which lists the designators for each system element against each Building ID, and identifies alternative solutions. The applicable designators were generated in Excel, checked manually and imported into the Fire Code Requirement Chart.
Alternative solutions then had to be identified. Eventually it should be possible to identify every alternative, however minor, listed in the BCA. But when the multiplying effect of different alternatives is taken into account, this would make the Fire Code Requirement Chart enormous (there would be at least 500 alternative combinations for most buildings, which would suggest a need for rationalisation). For the purposes of this project, it was agreed to identify only those alternatives that constitute complete alternative system elements. This confined the issues to:

- the use of sprinklers in buildings (especially carparks);
- multi-storey timber-framed construction;
- large isolated buildings;
- low-rise residential buildings; and
- smoke hazard management systems.

Nonetheless, the Fire Code Requirement Chart still contains 16 possible options for some buildings, as many as (or perhaps more than) can be represented in hard copy. A chart with all possible options identified could be represented easily using computer software, and this would be the ultimate way of presenting the regulations.
The alternatives were then included as separate rows within the Fire Code Requirement Chart. Again, all entries were checked carefully to ensure that all alternatives had been identified.

PROJECT OUTPUT

Future use of Project 1

The original intention of Project 1 was to produce the information required for subsequent research projects, and to make recommendations to the ABCB on amendment of the BCA. As the project progressed, it became clear that the output would be of use to a wider audience. The succinct descriptors, the regrouping of clauses in terms of system elements, the removal of concessions and the

simplifications inherent in the subdivision of application have led to a restructure of the BCA that could well be helpful to all code users. The project has thus become a complete rewrite of the fire protection provisions of the BCA, with recommendations that it should be called up as an alternative to the present structure for design and construction for fire protection.

The regrouping allows researchers to identify more readily the different levels of performance required within each system element and makes it easier to identify apparent anomalies or gaps in the current regulations. The designer has the benefit of a concise statement of requirements for the system element to be designed, given in one place within the code and with limited cross referencing.

BCA Development

In order to derive a performance code from its prescriptive antecedents, it is necessary to derive performance statements which reflect the level of performance represented by the prescriptions. If the BCA is to be a useful performance code, and if existing solutions are to form the basis of future acceptable solutions, performance statements must be based upon the performance of the present system elements. Project 1 has taken a careful look at the performance currently being achieved. The requirements are now grouped in such a way that the task of later projects to evaluate the "correctness" of present acceptable solutions and propose new, cost-effective "alternative solutions" is simplified.

System element descriptors make demands on the builder to build in certain ways. These demands do not allow the flexibility of a proper performance code. The next step in the development of a performance-based BCA is to introduce statements of objective for each of the system element descriptors, that clearly state the intent of the requirements without limiting the method of construction. Combinations of objectives corresponding to the combinations of system element descriptors given in the Fire Code Requirement Chart then satisfy the overall level of risk.

During the course of the project, a number of anomalies within the BCA were noted. A list of these anomalies is included in Appendix E.

REMARKS

The Project, which was initially seen as a minor regrouping of clauses within the BCA, turned out to be much larger than expected. During its course, a large database was developed which provides a powerful tool for accessing BCA requirements. The first process, that of generating building identities, showed that the BCA is a very complex document. Identifying fire-protection system elements within the BCA and providing detailed definitions of them was the key to comprehensive analysis. Considering the function of each requirement in the regulations and assigning it to appropriate system elements was the next important step.

The final stages of the project - drafting the acceptable solutions and determining where alternative solutions exist - took much longer than expected. The volume of

work was enormous, and many of the processes could not be shared as consistency of drafting style was important. But the reward for the effort involved is that the output has a wider market than was originally perceived.

CONCLUSIONS

The project has identified the performances of fire-safety system elements inherent within the BCA. It has generated a basis for the development of new performance-based fire regulations, first in the form of alternative prescriptions which represent equivalent levels of risk and later in the development of a fully risk-based code. The process of assessing present prescriptions against the level of risk will be simplified by the new code structure.

During the course of the project, the researchers refined their ideas for the ideal structure of performance-based regulations. The need for flexibility in the demands made for the performance of system elements can be clearly seen in the Fire Code Requirement Chart. It is only by allowing this flexibility that new, economical solutions can be developed that represent an equivalent level of risk of the overall fire-safety system.

Lastly, a process has been developed for the conversion of prescriptive regulations to performance regulations. The process could be applied to any set of regulations for which system elements can be identified.

Appendix A

BCA Buildng sub-classes

Class	Sub-class ID	Description
1a	61	no sub-class
1b	62	no sub-class
2	63	internal parts of a class 2 sole-occupancy unit
2	74	common areas in a class 2 building
3	3	the residential part of a school
3	64	internal parts of a class 3 sole-occupancy unit
3	75	common areas in a class 3 building
4	65	no sub-class
5	66	no sub-class
6	67	no sub-class
7	6	open-deck car park
7	8	public car park other than an open-deck car park
7	78	class 7 other than a public carpark
8	69	no sub-class
9a	9	class 9a (except patient care areas)
9a	10	class 9a (patient care areas)
9b	11	indoor sports stadium
9b	13	open spectator stand
9b	17	early childhood centre
9b	18	school
9b	22	theatres, stages and public halls
9b	71	no sub-class
10a	72	no sub-class
10b	73	no sub-class

Appendix B

Building IDs

Building ID	Class	Class Description	Rise in storeys	Effect. Height	Size Description	Type
1	1a	no sub-class	unlimited	any	unlimited	0
2	1b	no sub-class	unlimited	any	unlimited	0
3	2	internal parts of a class 2 sole-occupancy unit	1 storey	<25 m	unlimited	C
4	2	internal parts of a class 2 sole-occupancy unit	2 storeys	<25 m	unlimited	B
5	2	internal parts of a class 2 sole-occupancy unit	2 storeys	>25 m	unlimited	B
6	2	internal parts of a class 2 sole-occupancy unit	>2 storeys	<25 m	unlimited	A
7	2	internal parts of a class 2 sole-occupancy unit	>2 storeys	>25 m	unlimited	A
8	2	common areas in a class 2 building	2 storeys	<25 m	unlimited	B,C
9	2	common areas in a class 2 building	2 storeys	>25 m	unlimited	B,C
10	3	internal parts of a class 3 sole-occupancy unit	1 storey	<25 m	unlimited	C
11	3	internal parts of a class 3 sole-occupancy unit	2 storeys	<25 m	unlimited	B
12	3	internal parts of a class 3 sole-occupancy unit	2 storeys	>25 m	unlimited	B
13	3	internal parts of a class 3 sole-occupancy unit	>2 storeys	<25 m	unlimited	A
14	3	internal parts of a class 3 sole-occupancy unit	>2 storeys	>25 m	unlimited	A
15	3	the residential part of a school	1 storey	<25 m	unlimited	C
16	3	the residential part of a school	2 storeys	<25 m	unlimited	B
17	3	the residential part of a school	2 storeys	>25 m	unlimited	B
18	3	the residential part of a school	>2 storeys	<25 m	unlimited	A
19	3	the residential part of a school	>2 storeys	>25 m	unlimited	A
20	4	no sub-class	1 storey	<25 m	unlimited	C
21	4	no sub-class	2 storeys	<25 m	unlimited	B
22	4	no sub-class	2 storeys	>25 m	unlimited	B
23	4	no sub-class	3 storeys	<25 m	unlimited	A
24	4	no sub-class	3 storeys	>25 m	unlimited	A
25	4	no sub-class	>3 storeys	<25 m	unlimited	A
26	4	no sub-class	>3 storeys	>25 m	unlimited	A
27	5	no sub-class	<3 storeys	<25 m	3,000m2/18,000m3	C
28	5	no sub-class	2 storeys	>25 m	3,000m2/18,000m3	C
29	5	no sub-class	<3 storeys	<25 m	18,000m2/108,000m3	C
30	5	no sub-class	2 storeys	>25 m	18,000m2/108,000m3	C
31	5	no sub-class	<3 storeys	<25 m	>18,000m2/108,000m3	C
32	5	no sub-class	2 storeys	>25 m	>18,000m2/108,000m3	C
33	5	no sub-class	<3 storeys	<25 m	5,500m2/33,000m3	B
34	5	no sub-class	2 storeys	>25 m	5,500m2/33,000m3	B
35	5	no sub-class	<3 storeys	<25 m	8,000m2/48,000m3	A
36	5	no sub-class	2 storeys	>25 m	8,000m2/48,000m3	A
37	5	no sub-class	3 storeys	<25 m	5,500m2/33,000m3	B
38	5	no sub-class	3 storeys	>25 m	5,500m2/33,000m3	B
39	5	no sub-class	3 storeys	<25 m	18,000m2/108,000m3	B
40	5	no sub-class	3 storeys	>25 m	18,000m2/108,000m3	B
41	5	no sub-class	3 storeys	<25 m	>18,000m2/108,000m3	B
42	5	no sub-class	3 storeys	>25 m	>18,000m2/108,000m3	B
43	5	no sub-class	3 storeys	<25 m	8,000m2/48,000m3	A
44	5	no sub-class	3 storeys	>25 m	8,000m2/48,000m3	A
45	5	no sub-class	>3 storeys	<25 m	8,000m2/48,000m3	A
46	5	no sub-class	>3 storeys	>25 m	8,000m2/48,000m3	A
47	5	no sub-class	>3 storeys	<25 m	18,000m2/108,000m3	A
48	5	no sub-class	>3 storeys	>25 m	18,000m2/108,000m3	A
49	5	no sub-class	>3 storeys	<25 m	>18,000m2/108,000m3	A
50	5	no sub-class	>3 storeys	>25 m	>18,000m2/108,000m3	A
51	6	no sub-class	<3 storeys	<25 m	2,000m2/12,000m3	C
52	6	no sub-class	2 storeys	>25 m	2,000m2/12,000m3	C
53	6	no sub-class	<3 storeys	<25 m	18,000m2/108,000m3	C
54	6	no sub-class	2 storeys	>25 m	18,000m2/108,000m3	C
55	6	no sub-class	<3 storeys	<25 m	>18,000m2/108,000m3	C
56	6	no sub-class	2 storeys	>25 m	>18,000m2/108,000m3	C
57	6	no sub-class	<3 storeys	<25 m	3,500m2/21,000m3	B
58	6	no sub-class	2 storeys	>25 m	3,500m2/21,000m3	B

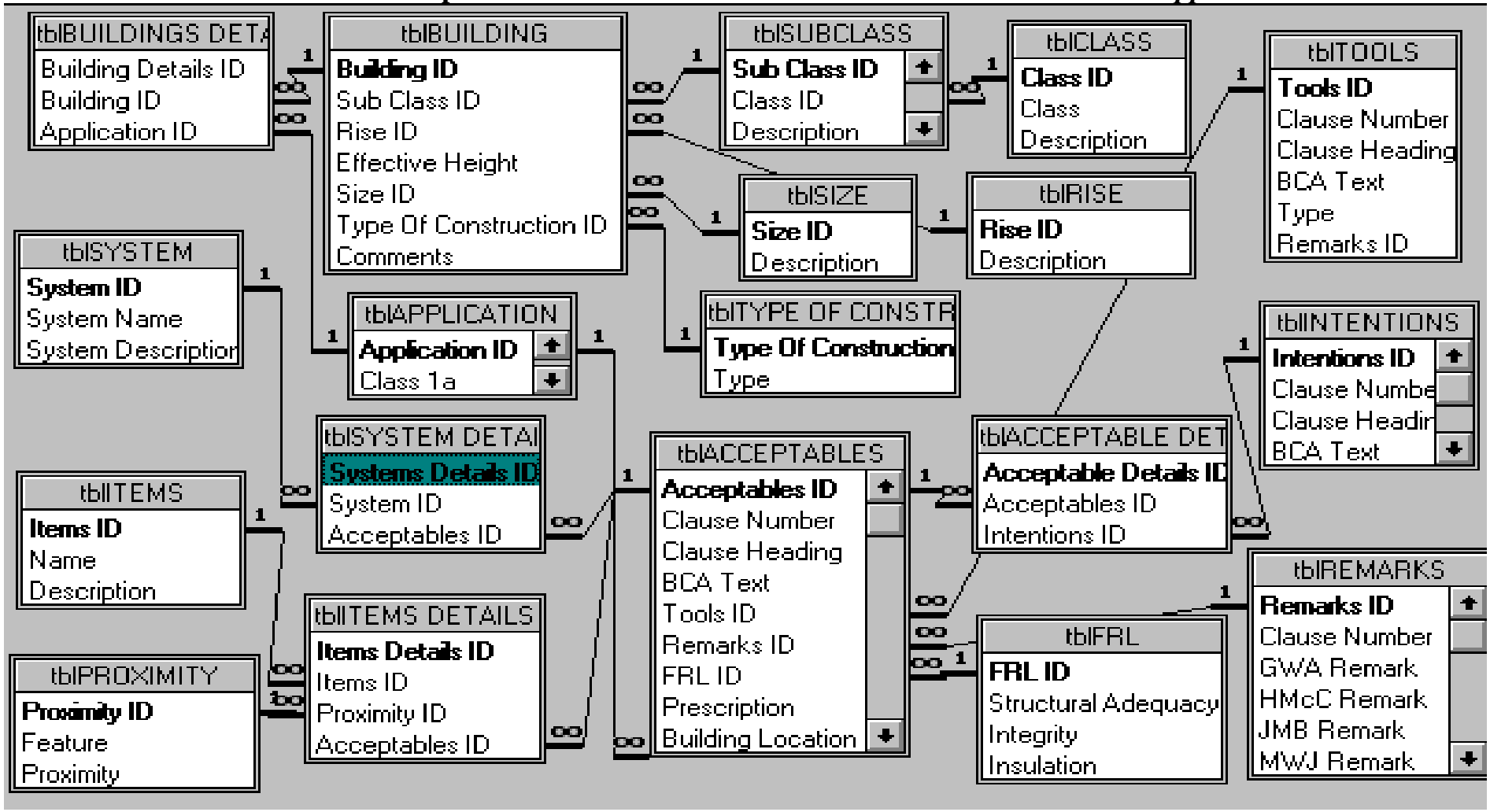
59	6	no sub-class	<3 storeys	<25 m	5,000m2/30,000m3	A
60	6	no sub-class	2 storeys	>25 m	5,000m2/30,000m3	A
61	6	no sub-class	3 storeys	<25 m	3,500m2/21,000m3	B
62	6	no sub-class	3 storeys	>25 m	3,500m2/21,000m3	B
63	6	no sub-class	3 storeys	<25 m	18,000m2/108,000m3	B
64	6	no sub-class	3 storeys	>25 m	18,000m2/108,000m3	B
65	6	no sub-class	3 storeys	<25 m	>18,000m2/108,000m3	B
66	6	no sub-class	3 storeys	>25 m	>18,000m2/108,000m3	B
67	6	no sub-class	>3 storeys	<25 m	5,000m2/30,000m3	A
68	6	no sub-class	>3 storeys	>25 m	5,000m2/30,000m3	A
69	6	no sub-class	>3 storeys	<25 m	18,000m2/108,000m3	A
70	6	no sub-class	>3 storeys	>25 m	18,000m2/108,000m3	A
71	6	no sub-class	>3 storeys	<25 m	>18,000m2/108,000m3	A
72	6	no sub-class	>3 storeys	>25 m	>18,000m2/108,000m3	A
97	7	open-deck car park	<3 storeys	<25 m	unlimited	C
98	7	open-deck car park	2 storeys	>25 m	unlimited	C
130	7	open-deck car park	3 storeys	<25 m	unlimited	B
131	7	open-deck car park	3 storeys	>25 m	unlimited	B
138	7	open-deck car park	>3 storeys	<25 m	unlimited	A
139	7	open-deck car park	>3 storeys	>25 m	unlimited	A
144	7	public car park other than an open-deck car park	<3 storeys	<25 m	2,000m2/12,000m3	C
145	7	public car park other than an open-deck car park	2 storeys	>25 m	2,000m2/12,000m3	C
146	7	public car park other than an open-deck car park	<3 storeys	<25 m	18,000m2/108,000m3	C
147	7	public car park other than an open-deck car park	2 storeys	>25 m	18,000m2/108,000m3	C
148	7	public car park other than an open-deck car park	<3 storeys	<25 m	>18,000m2/108,000m3	C
149	7	public car park other than an open-deck car park	2 storeys	>25 m	>18,000m2/108,000m3	C
150	7	public car park other than an open-deck car park	<3 storeys	<25 m	3,500m2/21,000m3	B,C
151	7	public car park other than an open-deck car park	2 storeys	>25 m	3,500m2/21,000m3	B,C
152	7	public car park other than an open-deck car park	<3 storeys	<25 m	5,000m2/30,000m3	A,C
153	7	public car park other than an open-deck car park	2 storeys	>25 m	5,000m2/30,000m3	A,C
154	7	public car park other than an open-deck car park	3 storeys	<25 m	3,500m2/21,000m3	B
155	7	public car park other than an open-deck car park	3 storeys	>25 m	3,500m2/21,000m3	B
156	7	public car park other than an open-deck car park	3 storeys	<25 m	18,000m2/108,000m3	B
157	7	public car park other than an open-deck car park	3 storeys	>25 m	18,000m2/108,000m3	B
158	7	public car park other than an open-deck car park	3 storeys	<25 m	>18,000m2/108,000m3	B
159	7	public car park other than an open-deck car park	3 storeys	>25 m	>18,000m2/108,000m3	B
160	7	public car park other than an open-deck car park	3 storeys	<25 m	5,000m2/30,000m3	A,B
161	7	public car park other than an open-deck car park	3 storeys	>25 m	5,000m2/30,000m3	A,B
162	7	public car park other than an open-deck car park	>3 storeys	<25 m	5,000m2/30,000m3	A
163	7	public car park other than an open-deck car park	>3 storeys	>25 m	5,000m2/30,000m3	A
164	7	public car park other than an open-deck car park	>3 storeys	<25 m	18,000m2/108,000m3	A
165	7	public car park other than an open-deck car park	>3 storeys	>25 m	18,000m2/108,000m3	A
166	7	public car park other than an open-deck car park	>3 storeys	<25 m	>18,000m2/108,000m3	A
167	7	public car park other than an open-deck car park	>3 storeys	>25 m	>18,000m2/108,000m3	A
168	8	no sub-class	<3 storeys	<25 m	2,000m2/12,000m3	C
169	8	no sub-class	2 storeys	>25 m	2,000m2/12,000m3	C
170	8	no sub-class	<3 storeys	<25 m	18,000m2/108,000m3	C
171	8	no sub-class	2 storeys	>25 m	18,000m2/108,000m3	C
172	8	no sub-class	<3 storeys	<25 m	>18,000m2/108,000m3	C
173	8	no sub-class	2 storeys	>25 m	>18,000m2/108,000m3	C
174	8	no sub-class	<3 storeys	<25 m	3,500m2/21,000m3	B
175	8	no sub-class	2 storeys	>25 m	3,500m2/21,000m3	B
176	8	no sub-class	<3 storeys	<25 m	5,000m2/30,000m3	A
177	8	no sub-class	2 storeys	>25 m	5,000m2/30,000m3	A
178	8	no sub-class	3 storeys	<25 m	3,500m2/21,000m3	B
179	8	no sub-class	3 storeys	>25 m	3,500m2/21,000m3	B
180	8	no sub-class	3 storeys	<25 m	18,000m2/108,000m3	B
181	8	no sub-class	3 storeys	>25 m	18,000m2/108,000m3	B
182	8	no sub-class	3 storeys	<25 m	>18,000m2/108,000m3	B
183	8	no sub-class	3 storeys	>25 m	>18,000m2/108,000m3	B
184	8	no sub-class	3 storeys	<25 m	5,000m2/30,000m3	A
185	8	no sub-class	3 storeys	>25 m	>18,000m2/108,000m3	A
186	8	no sub-class	>3 storeys	<25 m	5,000m2/30,000m3	A
187	8	no sub-class	>3 storeys	>25 m	5,000m2/30,000m3	A
188	8	no sub-class	>3 storeys	<25 m	18,000m2/108,000m3	A
189	8	no sub-class	>3 storeys	>25 m	18,000m2/108,000m3	A

190	8	no sub-class	>3 storeys	<25 m	>18,000m2/108,000m3	A
191	8	no sub-class	>3 storeys	>25 m	>18,000m2/108,000m3	A
192	9a	class 9a (except patient care areas)	1 storey	<25 m	2,000m2/12,000m3	C
193	9a	class 9a (except patient care areas)	1 storey	<25 m	3,500m2/21,000m3	B
194	9a	class 9a (except patient care areas)	1 storey	<25 m	5,000m2/30,000m3	A
195	9a	class 9a (except patient care areas)	1 storey	<25 m	18,000m2/108,000m3	C
196	9a	class 9a (except patient care areas)	1 storey	<25 m	>18,000m2/108,000m3	C
197	9a	class 9a (except patient care areas)	2 storeys	<25 m	3,500m2/21,000m3	B
198	9a	class 9a (except patient care areas)	2 storeys	>25 m	3,500m2/21,000m3	B
199	9a	class 9a (except patient care areas)	2 storeys	<25 m	5,000m2/30,000m3	A
200	9a	class 9a (except patient care areas)	2 storeys	>25 m	5,000m2/30,000m3	A
201	9a	class 9a (except patient care areas)	2 storeys	<25 m	18,000m2/108,000m3	B
202	9a	class 9a (except patient care areas)	2 storeys	>25 m	18,000m2/108,000m3	B
203	9a	class 9a (except patient care areas)	2 storeys	<25 m	>18,000m2/108,000m3	B
204	9a	class 9a (except patient care areas)	2 storeys	>25 m	>18,000m2/108,000m3	B
205	9a	class 9a (except patient care areas)	>2 storeys	<25 m	5,000m2/30,000m3	A
206	9a	class 9a (except patient care areas)	>2 storeys	>25 m	5,000m2/30,000m3	A
207	9a	class 9a (except patient care areas)	>2 storeys	<25 m	18,000m2/108,000m3	A
208	9a	class 9a (except patient care areas)	>2 storeys	>25 m	18,000m2/108,000m3	A
209	9a	class 9a (except patient care areas)	>2 storeys	<25 m	>18,000m2/108,000m3	A
210	9a	class 9a (except patient care areas)	>2 storeys	>25 m	>18,000m2/108,000m3	A
211	9a	class 9a (patient care areas)	1 storey	<25 m	2,000m2/12,000m3	C
212	9a	class 9a (patient care areas)	2 storeys	<25 m	2,000m2/12,000m3	B
213	9a	class 9a (patient care areas)	2 storeys	>25 m	2,000m2/12,000m3	B
214	9a	class 9a (patient care areas)	>2 storeys	<25 m	2,000m2/12,000m3	A
215	9a	class 9a (patient care areas)	>2 storeys	>25 m	2,000m2/12,000m3	A
218	9b	no sub-class	1 storey	<25 m	3,000m2/18,000m3	C
219	9b	no sub-class	1 storey	<25 m	18,000m2/108,000m3	C
220	9b	no sub-class	1 storey	<25 m	>18,000m2/108,000m3	C
221	9b	no sub-class	1 storey	<25 m	5,500m2/33,000m3	B
222	9b	no sub-class	1 storey	<25 m	8,000m2/48,000m3	A
223	9b	no sub-class	2 storeys	<25 m	5,500m2/33,000m3	B
224	9b	no sub-class	2 storeys	>25 m	5,500m2/33,000m3	B
225	9b	no sub-class	2 storeys	<25 m	18,000m2/108,000m3	B
226	9b	no sub-class	2 storeys	>25 m	18,000m2/108,000m3	B
227	9b	no sub-class	2 storeys	<25 m	>18,000m2/108,000m3	B
228	9b	no sub-class	2 storeys	>25 m	>18,000m2/108,000m3	B
229	9b	no sub-class	2 storeys	<25 m	8,000m2/48,000m3	A
230	9b	no sub-class	2 storeys	>25 m	8,000m2/48,000m3	A
231	9b	no sub-class	>2 storeys	<25 m	8,000m2/48,000m3	A
232	9b	no sub-class	>2 storeys	>25 m	8,000m2/48,000m3	A
233	9b	no sub-class	>2 storeys	<25 m	18,000m2/108,000m3	A
234	9b	no sub-class	>2 storeys	>25 m	18,000m2/108,000m3	A
235	9b	no sub-class	>2 storeys	<25 m	>18,000m2/108,000m3	A
236	9b	no sub-class	>2 storeys	>25 m	>18,000m2/108,000m3	A
237	9b	indoor sports stadium	1 tier seating	any	3,000m2/18,000m3	C
258	9b	open spectator stand	1 storey	<25 m	18,000m2/108,000m3	C
262	9b	open spectator stand	2 storeys	<25 m	5,500m2/33,000m3	B
263	9b	open spectator stand	2 storeys	>25 m	5,500m2/33,000m3	B
270	9b	open spectator stand	>2 storeys	<25 m	8,000m2/48,000m3	A
275	9b	open spectator stand	>2 storeys	>25 m	>18,000m2/108,000m3	A
333	9b	early childhood centre	1 storey	<25 m	3,000m2/18,000m3	C
334	9b	early childhood centre	1 storey	<25 m	18,000m2/108,000m3	C
335	9b	early childhood centre	1 storey	<25 m	>18,000m2/108,000m3	C
336	9b	early childhood centre	1 storey	<25 m	5,500m2/33,000m3	B
337	9b	early childhood centre	1 storey	<25 m	8,000m2/48,000m3	A
338	9b	early childhood centre	2 storeys	<25 m	5,500m2/33,000m3	B
339	9b	early childhood centre	2 storeys	>25 m	5,500m2/33,000m3	B
340	9b	early childhood centre	2 storeys	<25 m	18,000m2/108,000m3	B
341	9b	early childhood centre	2 storeys	>25 m	18,000m2/108,000m3	B
342	9b	early childhood centre	2 storeys	<25 m	>18,000m2/108,000m3	B
343	9b	early childhood centre	2 storeys	>25 m	>18,000m2/108,000m3	B
344	9b	early childhood centre	2 storeys	<25 m	8,000m2/48,000m3	A
345	9b	early childhood centre	2 storeys	>25 m	8,000m2/48,000m3	A
346	9b	early childhood centre	>2 storeys	<25 m	8,000m2/48,000m3	A

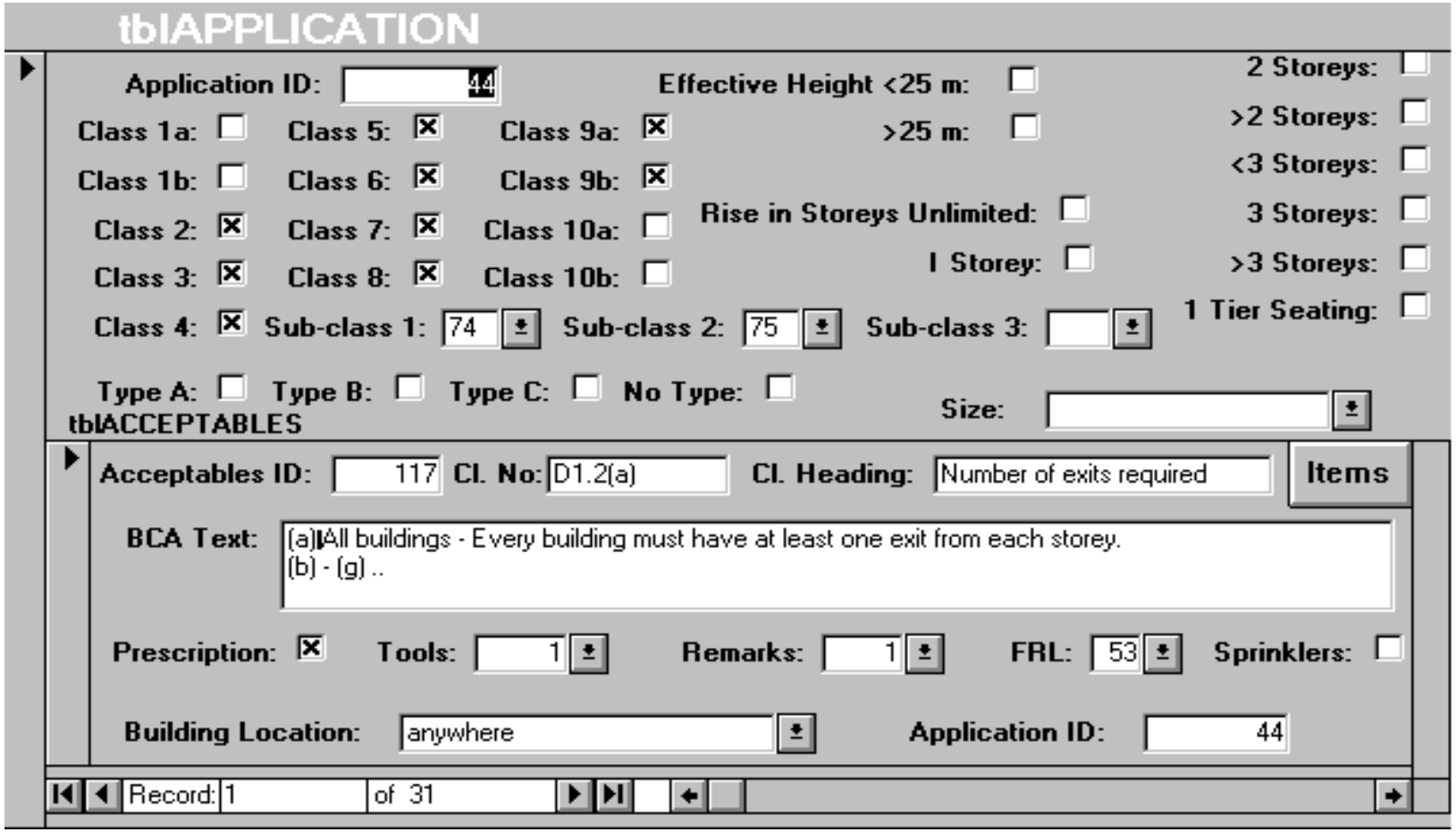
347	9b	early childhood centre	>2 storeys	>25 m	8,000m2/48,000m3	A
348	9b	early childhood centre	>2 storeys	<25 m	18,000m2/108,000m3	A
349	9b	early childhood centre	>2 storeys	>25 m	18,000m2/108,000m3	A
350	9b	early childhood centre	>2 storeys	<25 m	>18,000m2/108,000m3	A
351	9b	early childhood centre	>2 storeys	>25 m	>18,000m2/108,000m3	A
352	9b	school	1 storey	<25 m	3,000m2/18,000m3	C
353	9b	school	1 storey	<25 m	18,000m2/108,000m3	C
354	9b	school	1 storey	<25 m	>18,000m2/108,000m3	C
355	9b	school	1 storey	<25 m	5,500m2/33,000m3	B
356	9b	school	1 storey	<25 m	8,000m2/48,000m3	A
357	9b	school	2 storeys	<25 m	5,500m2/33,000m3	B
358	9b	school	2 storeys	>25 m	5,500m2/33,000m3	B
359	9b	school	2 storeys	<25 m	18,000m2/108,000m3	B
360	9b	school	2 storeys	>25 m	18,000m2/108,000m3	B
361	9b	school	2 storeys	<25 m	>18,000m2/108,000m3	B
362	9b	school	2 storeys	>25 m	>18,000m2/108,000m3	B
363	9b	school	2 storeys	<25 m	8,000m2/48,000m3	A
364	9b	school	2 storeys	>25 m	8,000m2/48,000m3	A
365	9b	school	>2 storeys	<25 m	8,000m2/48,000m3	A
366	9b	school	>2 storeys	>25 m	8,000m2/48,000m3	A
367	9b	school	>2 storeys	<25 m	18,000m2/108,000m3	A
368	9b	school	>2 storeys	>25 m	18,000m2/108,000m3	A
369	9b	school	>2 storeys	<25 m	>18,000m2/108,000m3	A
370	9b	school	>2 storeys	>25 m	>18,000m2/108,000m3	A
428	9b	theatres, stages and public halls	1 storey	<25 m	3,000m2/18,000m3	C
429	9b	theatres, stages and public halls	1 storey	<25 m	18,000m2/108,000m3	C
430	9b	theatres, stages and public halls	1 storey	<25 m	>18,000m2/108,000m3	C
431	9b	theatres, stages and public halls	1 storey	<25 m	5,500m2/33,000m3	B
432	9b	theatres, stages and public halls	1 storey	<25 m	8,000m2/48,000m3	A
433	9b	theatres, stages and public halls	2 storeys	<25 m	5,500m2/33,000m3	B
434	9b	theatres, stages and public halls	2 storeys	>25 m	5,500m2/33,000m3	B
435	9b	theatres, stages and public halls	2 storeys	<25 m	18,000m2/108,000m3	B
436	9b	theatres, stages and public halls	2 storeys	>25 m	18,000m2/108,000m3	B
437	9b	theatres, stages and public halls	2 storeys	<25 m	>18,000m2/108,000m3	B
438	9b	theatres, stages and public halls	2 storeys	>25 m	>18,000m2/108,000m3	B
439	9b	theatres, stages and public halls	2 storeys	<25 m	8,000m2/48,000m3	A
440	9b	theatres, stages and public halls	2 storeys	>25 m	8,000m2/48,000m3	A
441	9b	theatres, stages and public halls	>2 storeys	<25 m	8,000m2/48,000m3	A
442	9b	theatres, stages and public halls	>2 storeys	>25 m	8,000m2/48,000m3	A
443	9b	theatres, stages and public halls	>2 storeys	<25 m	18,000m2/108,000m3	A
444	9b	theatres, stages and public halls	>2 storeys	>25 m	18,000m2/108,000m3	A
445	9b	theatres, stages and public halls	>2 storeys	<25 m	>18,000m2/108,000m3	A
446	9b	theatres, stages and public halls	>2 storeys	>25 m	>18,000m2/108,000m3	A
448	10a	no sub-class	unlimited	any	unlimited	0
449	10b	no sub-class	unlimited	any	unlimited	0
451	9b	indoor sports stadium	1 tier seating	any	18,000m2/108,000m3	C
452	9b	indoor sports stadium	1 tier seating	any	>18,000m2/108,000m3	C
453	2	common areas in a class 2 building	1 storey	<25 m	unlimited	C
456	2	common areas in a class 2 building	>2 storeys	<25 m	unlimited	A
457	2	common areas in a class 2 building	>2 storeys	>25 m	unlimited	A
458	3	common areas in a class 3 building	1 storey	<25 m	unlimited	C
459	3	common areas in a class 3 building	2 storeys	<25 m	unlimited	B,C
460	3	common areas in a class 3 building	2 storeys	>25 m	unlimited	B,C
461	3	common areas in a class 3 building	>2 storeys	<25 m	unlimited	A
462	3	common areas in a class 3 building	>2 storeys	>25 m	unlimited	A
501	7	class 7 other than a public carpark	<3 storeys	<25 m	2,000m2/12,000m3	C
502	7	class 7 other than a public carpark	2 storeys	>25 m	2,000m2/12,000m3	C
503	7	class 7 other than a public carpark	<3 storeys	<25 m	18,000m2/108,000m3	C
504	7	class 7 other than a public carpark	2 storeys	>25 m	18,000m2/108,000m3	C
505	7	class 7 other than a public carpark	<3 storeys	<25 m	>18,000m2/108,000m3	C
506	7	class 7 other than a public carpark	2 storeys	>25 m	>18,000m2/108,000m3	C
507	7	class 7 other than a public carpark	<3 storeys	<25 m	3,500m2/21,000m3	B
508	7	class 7 other than a public carpark	2 storeys	>25 m	3,500m2/21,000m3	B
509	7	class 7 other than a public carpark	<3 storeys	<25 m	5,000m2/30,000m3	A
510	7	class 7 other than a public carpark	2 storeys	>25 m	5,000m2/30,000m3	A

511	7	class 7 other than a public carpark	3 storeys	<25 m	3,500m2/21,000m3	B
512	7	class 7 other than a public carpark	3 storeys	>25 m	3,500m2/21,000m3	B
513	7	class 7 other than a public carpark	3 storeys	<25 m	18,000m2/108,000m3	B
514	7	class 7 other than a public carpark	3 storeys	>25 m	18,000m2/108,000m3	B
515	7	class 7 other than a public carpark	3 storeys	<25 m	>18,000m2/108,000m3	B
516	7	class 7 other than a public carpark	3 storeys	>25 m	>18,000m2/108,000m3	B
517	7	class 7 other than a public carpark	3 storeys	<25 m	5,000m2/30,000m3	A
518	7	class 7 other than a public carpark	3 storeys	>25 m	5,000m2/30,000m3	A
519	7	class 7 other than a public carpark	>3 storeys	<25 m	5,000m2/30,000m3	A
520	7	class 7 other than a public carpark	>3 storeys	>25 m	5,000m2/30,000m3	A
521	7	class 7 other than a public carpark	>3 storeys	<25 m	18,000m2/108,000m3	A
522	7	class 7 other than a public carpark	>3 storeys	>25 m	18,000m2/108,000m3	A
523	7	class 7 other than a public carpark	>3 storeys	<25 m	>18,000m2/108,000m3	A
524	7	class 7 other than a public carpark	>3 storeys	>25 m	>18,000m2/108,000m3	A

Database Relationships *Appendix C*



Data entry form



Analysing the system elements - procedures

1 Identifying applicable clauses
Not all Acceptables contribute to the level of performance of a system element. From the table of Acceptables for each Building ID for each system element, all Acceptables that did not effect the level of performance of that system element were deleted. Care was taken not to delete details of application in this process.

2 Identifying buildings with identical sets of Acceptable IDs
Since the likelihood of different lists having identical totals when Acceptable IDs were summed was very small, totals were used to group identical buildings. Totals were calculated for each lists of Acceptable IDs for each building and the lists were sorted in ascending order. A visual check was made to ensure that lists were identical - in only one or two cases were lists with the same total found to be different. The Building IDs of identical lists were then stored in an Excel "note" attached to the first Building ID in the group. (In Excel, SUM columns, SORT on totals left to right, record Building IDs in cell notes and delete duplicate lists).

3 Calculating frequency of occurrence of Acceptable IDs
The frequency of occurrance of each Acceptable was obtained by aligning like Acceptables within each column and calculating the number of occurrences. (In Excel, paste a list of all Acceptables for the system element, use VLOOKUP to check whether each Acceptable is present in the list for each group of Building IDs. If it is present paste the Acceptable ID in the appropriate column, otherwise paste N/A. To the right of the new table, generate a column called COUNT. Use the COUNT function to calculate the number of occurrences of each Acceptable in each row.)

4 Sorting Acceptable IDs in order of frequency of occurrance
Acceptable IDs were then sorted in order of frequency of occurrance, so that those that occured most often were at the top of the list. (In Excel, SORT table top to bottom on COUNT column). The sorted lists of Acceptable IDs were then imported into Access and the text of the Acceptables was printed in order of frequency of occurrance.

5 Identifying performance "levels"
The text of the Acceptables was studied to see what "levels" of performance were expected of buildings. Starting with the most frequently occurring Acceptables - those that apply to all (or most) buildings - what could reasonably be considered to be the basic performance required of a system element was described in words. The Acceptables that must currently be followed to satisfy this performance were listed. The next most frequently occurring Acceptables were then studied; these indicated additional/alternative performance required of certain buildings.The process was continued until all systems had been described.

System 4 - Fire Suppression

Building group	"1	"218	"73	"20	"192	"168	"27	"51		
Acceptables ID	Acceptables ID	Acceptables ID	Acceptables ID	Acceptables ID	Acceptables ID	Acceptables ID	Acceptables ID	Acceptables ID		Frequency
704	704	704	704	704	704	704	704	704		8
708	708	708	708	708	708	708	708	708		8
709	709	709	709	709	709	709	709	709		8
718	718	718	718	718	718	718	718	718		8
751	751	751	751	751	751	751	751	751		8
752	752	752	752	752	752	752	752	752		8
753	753	753	753	753	753	753	753	753		8
262		262	262	262	262	262	262	262		7
652		652	652	652	652	652	652	652		7
804				804	804	804	804	804		5
714		714			714		714			3
715			715			715		715		3
189							189	189		2

Appendix E

Apparent anomalies requiring attention in the BCA

Buildings under construction

Requirements for buildings under construction are currently included in the BCA. Since the building changes its geometry (rise in storeys etc) as it progresses, it is difficult to accommodate these requirements in the new structure. Requirements might be better placed under the Construction Safety Act or Workcover.

Classification

Classification based on usage is an important element of Fire Code Reform. Some "sub-classifications" in the BCA indicate an alternative form of construction and are not based on building usage and geometry (eg sprinklered carpark, class 2 building complying with C1.5). This form of expression is inappropriate for a performance code as the alternatives are hidden and the implicit levels are not clear.

There is another problem with the way classification is currently handled in the BCA. In most cases, requirements for the class apply to all buildings and additional requirements apply in certain cases (eg theatres). But this is not always so. In some classes (eg Class 7) the class is not the "base" to which special requirements are added. Requirements that apply to a "Class 7 building" do not apply to certain carparks - perhaps carparks should be a separate class altogether? Class 9b consists of a number of very different buildings which could benefit from separate classification. Similarly, some requirements that apply to a Class 2 building do not apply to the internal parts of a sole occupancy unit. And where do Class 4 parts of buildings fit in (see comments on smoke control)? Classification is an area that requires properly researched rationalisation.

Open spectator stands and indoor sports stadiums

There is difficulty determining the type of construction for an open spectator stand or indoor sports stadium - how do you determine the rise in storeys? And the type of construction? Both are subject to exemptions. C1.7 allows either (1 tier seating) to be of type C construction under certain circumstances. C2.1(b) allows all open spectator stands to have unlimited floor area. The requirements are very confusing and need separating and clarifying.

"Required"

The use of the word "required" is confusing in performance regulation. All that is "required" is compliance with the intention, so there is no such thing as a "required" exit, for example. Perhaps a new definition is needed?

Type of construction

C1.1 The introductory wording of C1.1 regulates types of construction rather than the building: 'A building must be of the type of construction specified in Table C1.1 or of a more fire-resistant type of construction.'

C1.1(b) is a definition and should be in the definitions - and could be better written.

External walls

C1.11 C1.11 takes into account only the likelihood of concrete walls in low rise buildings collapsing outward. The danger is not confined to buildings of one and two storeys and, although masonry is not subject to this specific clause, both reinforced and unreinforced masonry walls can collapse as more or less complete panels.

If the subclause C1.11(a) were generalised and subclause C1.11(b) particularised. The latter, with its dependent specification, would then cover a substantial proportion of the sorts of building that inspired the requirement but the designer of any sort of external wall would be specifically required to give appropriate consideration to its behaviour in a fire and pressure would be placed on the manufacturers of the various types of masonry to provide design and construction guides to match Specification C1.11.

Fire resisting construction

Spec C1.1 clause 3.10(c)(ii)(D) - Intumescent putties are meant to create fire barriers rather than smoke barriers - we do not believe they are appropriate here (and in several other places), if a smoke barrier is all that is needed.

Clause 4.1(g) - "internal columns and internal walls"

Clause 4.1(i) - fire-resistance of floors in these circumstances should not be seen only in terms of compartmentation. In loadbearing-wall construction the floors are commonly employed to determine the effective column lengths of walls. The burn-out of an intermediate floor would double the column length of the wall already bowing thermally towards fire. Such a structural action could cause the collapse of at least the corresponding floor in the next-door unit and, in the extreme, the collapse of the wall and the building above it. This situation should be addressed in the BCA.

Fire resistance of Class 1 Buildings

Spec C1.9 This specification needs redrafting in line with requirements for other classes of building, so that the fire resisting requirements for a building in a fixed location on a site can be determined.

We believe that smoke spread with Class 1 buildings, especially from garages, should be addressed.

Clause 6(a) is not a requirement but a definition.

Smoke doors

Spec. C3.4 Clause 3.1 is in the wrong place. It is a requirement about the performance of smoke doors that, on the basis that performance is the business of the body of the code and specifications are concerned with credences, should be in the body of the code and not tucked away in a specification that is a set of credences for C3.4 and is numbered as such.

Compartmentation

Definitions and use of the concepts of building and fire compartment are not clear in the BCA. Type of construction is basically the degree of compartmentation required of a building of which type-A comprises the most stringent suite of requirements (ie. the most fire-resistant type of construction), type-C is the least stringent and type-B is in between. Compartmentation needs to be defined in terms of these levels of performance, and the means of achieving the levels (ie how to build a sufficiently fire-resistant "envelope") could then be succinctly stated in specifications. Projects 1 and 3 will assist in sorting out the existing requirements. Meanwhile:

Definition of "fire wall" Some of the confusion is caused by the definition of "fire wall", for which at least three interpretations are possible. The wall could be

(a) A wall that subdivides a building or a storey for the purposes of C2.5(b)(iv), C2.7 or C2.8; or

(b) A wall the FRL of which corresponds to that required of a fire-wall in Tables 1, 2 or 3; or

(c) Any fire-rated wall of Tables 1, 2 and 3. (The definition does not say "..... The FRL required **of a fire wall** under Specification C1.1"). This confusion needs sorting out.

Floor areas

Floor areas limit the application of many requirements in the BCA. In Project 1, floor areas and volumes were used to establish building identities. Several problems were encountered in developing a suitable breakdown of requirements:

Table E2.2 Floor area limits in Table E2.2 (smoke control) do not correspond to the floor area limits in Section C. In some cases the difference is small (eg 5,500m² c/f 5,000m²). At present the areas in Table E2.2 are picked up in the text of the acceptable solutions rather than in the Building IDs. Since the floor areas that dictate changes in requirements were originally somewhat arbitrary, it is possible that corresponding floor areas could be derived for Sections C and E. A small research project could result in considerable simplification.

Floor areas and volumes In some cases (eg for class 9a buildings, Table E2.2 and requirements for fire control centres) floor areas are defined without a corresponding volume. This should be corrected where appropriate.

Building or fire compartment? It is not always clear whether floor areas apply to buildings or fire compartments, or what they should apply to - this also requires investigation.

Large isolated buildings

C2.3 and C2.4 These clauses are often misinterpreted. The clauses specify the circumstances in which buildings may exceed the limits of Table C2.2 irrespective of the type of construction. They do not, however, absolve the building from compliance with C1.1 and the other requirements pertinent to type of construction. Therefore, if for instance a building must be of type-A construction because of its height in storeys, the FRLs for exposure-control in Table 3 of Specification C1.1 still apply.

The original concept was surely that here were buildings that, provided we got the occupants out safely, could be left to burn down if the owner found that more economical than fire-protection. But then along came the fire authorities who said "No! It doesn't matter whether the building is the only one in the middle of the Nullarbor Plain, we've got to get out there and save it or at least contain it!" Hence all the business about vehicular access and so on.

Is C2.3 (and its ancillaries C2.4 and C2.5) meant to apply to a 9a?

Another question is raised by the use in C2.3(a)(ii) of the words "....the building is of **any Class** ...". Does this apply buildings of classes 2 and 3? And what about C2.3(b)? These questions are relevant to C2.3(c) and the possibility that there are classes 2 or 3 among classes 5, 6, 7, 8 and 9s on the one allotment.

Class 9a buildings

C2.5 C2.5 is badly organized. C2.5(a) applies to a 9a building generally. C2.5(b) suggests that you can fulfil this objective while confining your attention to patient-care areas.

If the clause is intended to apply only to patient-care areas, (and we suspect it is) (a) should say so - "The patient-care areas of class-9a buildings ...." - then all the rest of the clause falls into place. Otherwise (b) must invoke Part C2 generally and further attention must be paid to C2.5(iv) and (v) - see comment below.

C2.5(b)(iii) C2.5(b)(iii)(A) is an example of a not uncommon feature of the BCA. The subclause is ostensibly about the characteristics of a wall that is to be smoke-proof but non-combustibility and resistance to the incipient spread of fire are not necessary to smoke-compartmentation. So the wall clause is being used to regulate roof and ceiling and to impose a degree of flame-compartmentation.

C2.5(b)(iv) and C2.5(b)(v) These subclauses are so drafted that they apply to all fire compartments in 9a buildings, not just to patient-care areas - with a bit of

vagueness about the openings in external walls. It is doubtful that this is the intention.

Lift shafts

C2.10 Lifts connecting more than 2 storeys are required to be separated from the rest of the building by enclosure in a shaft, but the clause gives no details of the construction of the shaft. The table in Specification C1.1 for Type C construction does not mention lift shafts. Presumably it was not envisaged that a lift in Type C construction would connect many storeys, but this could happen - if the building was mainly below ground. This leads on to the question, "is Type C construction suitable for such a building?".

Protection of openings

C3.4 These methods of protection are for the openings in external walls that are the subjects of C3.2 and C3.3 - cross-reference would clarify this.

C3.5 It is not that the insulation requirement ***must*** be 30 but that it ***may be as low as*** 30.

C3.11(b)(ii) This clause requires protection of a doorway in a wall that is not required to have an FRL (a non-lodbearing wall in the bounding construction of a sole-occupancy unit where MSTFC is used and the building is fitted with sprinklers).

C3.11 For class 4 parts the BCA wording in (c) is "doorways that provide access to any other internal part of the building". We believe this wording should be adopted for Class 2 and 3 in place of (a)(i) - (iv).

Exits

Path of travel to an exit <u>Any</u> point on the floor is in the path of travel to an exit, so there is no need to say so.

D1.2(b), (c) and (d) The inclusion of the phrase "in addition to any horizontal exit" in these subclauses has the potential to create anomalies with D1.11 and D1.11(c) and D1.11(d) in particular. See the comment on the definition of "fire wall" and on D1.11.

D1.3(a) Is the "extra storey" here pre-empting storeys that aren't defined as storeys or is it another extra? If the accommodation of motor vehicles is limited to three the "level" they occupy isn't a storey.

D1.3(b)(i) and (iii) If the exit (stair) passes through even one storey it's connecting two storeys that aren't consecutive. The problem with D1.3 is that it is supposed to tell you where exits must be fire-isolated and then tries to

tell you where they needn't be. We need a separate clause (the wording of D1.12(c) is better).

D1.4(a)(i)(B) Can one go down stairs for 20 m to get to the "single exit" or is it the entrance doorway of the sole-occupancy unit that is at the level of egress to a road or open space? And why should it be a "single" exit? What it appears to be trying to say is

> "If the entrance doorway is on the storey at the level of egress to a road or open space it may be up to 20 m from an exit (even if there is only one exit to a road or open space)"

- but there is no need to say the bracketed bit. The number of exits is going to be determined either by travel distance or D1.2 anyway.

D1.4(c)(i) Even the ***minimum*** distance mustn't exceed 40 m.

D1.4(c)(ii) Same difficulty over "single" as in D1.4(a)(i)(B).

D1.4(d)(ii) See comment on D1.4(c)(i)

D1.4(e) A *required* exit.

D1.4(f) The superimposition of the maximum of 60 m on the individual maxima of 40 m and 20 m is confusing. If the distance within the room is no more than (say) 30 m then the overall distance would appear to be limited to 50 m. The critical distance is the 40 m. The next 20 m could be increased in some cases.

D1.7(b) In D1.7(b)(ii)(B), surely 20m is not the distance ***to*** the unimpeded path of travel, but the length of it. "Not further than" should be "no longer than".

D1.11(c) In the light of D1.2(b), does this mean that you can't count a horizontal exit as a required exit until you reach the stage of requiring more than two exits? Presumably the number of horizontal exits can be as big as you like so long as you don't count the surplus ones. Isn't D1.2(b) sufficient?

D1.11(d)(ii) The requirement of D1.11(d) is a mistake. There is no need for the occupants of the safe side of the fire-wall to congregate at the horizontal exits. They would only get in the way of the refugees from the other side.

D1.12(a) Wording! You can have any and all of these things in a patient care area so long as you don't ***use*** them.

D1.12(b)(iv) & Spec.D1.12. Is the construction specified in Specification D1.12 really non-fire-isolated?

D1.12(b) This clause refers to buildings that are "sprinklered throughout" (no italics). The implication is that any degree of sprinkling is sufficient,

whereas in fact a BCA-defined sprinkler system is probably required (ie an AS2118 Spec E1.5 system). We have assumed this is so. Ernie Calvert also points out that the sprinkler system referred to in Specification C1.1 clause 3.10 should probably be a domestic sprinkler system. These "levels" of sprinkler systems require investigation.

D1.12(d) This clause does not appear to make sense, since (b) and (c) cover everything (that is not class 9a) and so there is not an escalator that is not "permitted" by either (b) or (c). If (d) is there to prevent the possibility of two escalators indirectly connecting 3 storeys (say with the access to the road from the middle storey), then "directly or indirectly" should be included in (c). Or is (d) trying to tell us that we can ignore (c) and connect any two storeys - even 2 storeys right at the top of a high-rise building?

D2.4 If the two flights are in separate shafts - a common arrangement would be a flight from the upper storeys and a flight from the basement arriving at a ground foyer on opposite sides of a lift well - we must be careful that this requirement does not overrule the requirements for bounding construction in Specification C1.1;

Another consideration is that once there are two shafts, one of them might not have to be fire-isolated.

It might be better to require the 60/60/60 or more of construction that separates ***and*** is common to .....

Should 60/60/60 be -/60/60 for non-loadbearing construction?

D2.14(a) A common error of wording in regulations (and Australian standards). It is intended to say ".... landings with a gradient of not more than 1:50 ...".

D2.16(h) The hypothetical test in (h)(ii) doesn't really do the job. On a stair with a baluster at each nosing the sphere would not pass through "above the nosings" because the balusters would get in the way.

D3.2 Wording. In (a) wouldn't it be sufficient to have access to "***a***" doorway at the entrance floor?

In (b) and (c) "any" can be taken to mean "any one". Better to say "all carparking spaces" and "all other buildings".

Services and equipment

E1.4(b)(v) This should apply whatever the water supply - metered or not.

E1.4(b)(ii)&(iii) The implication of E1.4(b)(ii)(A) is that the hose reel does not have to cover the whole unit (c/f (B)). But (iii) says you must have complete coverage anyway. This conflict could be removed by deleting the requirement for coverage in (B) and deleting the words "of the

storey" in (iii). A similar problem exists for hydrants in E1.3. In this case coverage is addressed in the Standard.

E1.7 This clause does not require smoke detectors in class 4 parts of buildings - but Specification E1.7 gives requirements for these in clauses 2 and 8. The way class 4 parts of buildings are handled needs attention throughout the BCA - perhaps the internal parts of all residential sole-occupancy units should be considered separately?

E2.2(b) The final provision of this subclause requires each sole-occupancy unit in a class 2 or a class 3 to be treated "as a separate fire compartment". This suggests that the code writers are conscious of the potential confusion in the code about what constitutes a fire compartment and what doesn't and the lack of definition in the definition of "fire wall". Even in type-C construction the walls bounding a sole-occupancy unit are required to be fire-rated although not to the same levels as the common walls and fire walls of Table 5 of Specification C1.1. See comment on "compartmentation".

E2.2(d) E2.2(d) says absolutely nothing and shouldn't be there.

Table E2.2 We have assumed that floor areas in Table E2.2 apply to fire compartments - even for class 7 and 8 and basements (see comments on floor areas).

Table E2.2 Class 9a - Health-care Buildings - This seems to say that to satisfy the credences for active smoke-management, a treatment area that is served by a zone smoke- control system complying with AS 1668.1 must have also a smoke- exhaust system complying with Specification E2.2.

Table E2.2 There are no specific requirements for Class 9 buildings in Specification E2.2, so these should not be mentioned in Table E2.2 (2nd entry under class 9a - "provisions applying to a Class 9 building").

E3.4(a)(ii) You don't have to have lifts in a building so you don't have to have an emergency lift even in a multistorey 9a with patient care areas above ground-floor level.

What if you have a patient care area in a basement?

E3.4(b) Why is it that only where the emergency lift serves a patient care area in a 9a must it be connected to the standby power supply (when you've got one)?

It should be "serving a patient care area in a Class 9a building" not the other way about.

SpecE1.8 Clause 7(c) Wording at the very end of (c) - "required" should not be in italics. The BCA does not require areas for paths of travel.

E4 Emergency lighting - Why do we illuminate shafts for an escalator, moving walkway, or non required non fire isolated stairway or pedestrian ramp if we're not allowed to use them in a fire?

Excessive fire hazard We have assumed that occupancies of excessive fire hazard would never be Class 2, 3 or 4. The BCA should be amended to reflect this.

Atriums

Class of building An atrium can exist in a building with a rise in storeys of 1 - there might be more storeys below ground. But do requirements apply to an atrium in a Class 1 or Class 10 building? We do not believe this is intended, and suggest the BCA should be amended accordingly.

G3.6 The purpose of roof-wetting systems in atriums requires investigation - at present under Fire Code Reform they are considered to be part of fire suppression and exposure control. And do they apply to atriums in buildings of Type B and C construction?

But there is a discrepancy between G3.6 and clause 2.2 of Specification G3.8. In order to "have the FRL prescribed in Table 3 of Specification C1.1" the roof must have one or other of the FRLs in the bottom panel of the table and, if it is a pitched roof and exposed to an FSF, it must also have the appropriate FRL of the top panel of the table.

The requirement for an FRL or for the sprinkler trade-off therefore becomes, in terms of system elements, one or more of the following:

(Lateral) flame compartmentation.

Exposure control (*from* an FSF).

Exposure control (*of* an FSF - that is, protection of an adjacent building).

The requirement in clause 2.2 of Specification G3.8 is not the same and does not lead to the same conclusion.

SpecG3.8 Clause 4.1 is superfluous because we have to put in an AS 2220 system anyway (cl 5).

We have assumed that clause 7 says nothing in addition to E2.2. If this is so, it should be deleted.