Information Technology Support for Performance Regulation

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ABSTRACT

Modern regulations control the performance of our built environment rather than the methods and materials of construction. The designer has freedom to fulfil specified objectives any way he chooses, but he must show that he is fulfilling the regulatory intention, and fulfilling it well enough. How does he convince the building surveyor that his building will provide an acceptable level of compliance? Where does he find the information to justify his choice of solutions to the regulatory problems? And where does the regulator find the information needed to determine whether or not a proposed solution is acceptable?

The answers lie in the sea of regulatory information and research that is the source of all building regulation. Required levels of compliance are implicit in traditional, prescriptive regulations. Background research data, legal rulings, records of committee decisions, articles, advisory notes, commentaries, accreditation reports, common practice - all give an indication of the level of compliance that society and the regulators are willing to accept and help the designer and the regulator establish criteria of acceptance. This vast array of knowledge helps the regulator determine the intentions of existing regulations and write realistic rules for the performance of buildings.

But where does the search for knowledge begin? Information technology can structure the search and help find a way through the jungle of data, macheteing obstructions to the introduction of innovative solutions. A structured, selective search can give the regulator access to all the data he needs to support his arguments, allowing the full realisation of the benefits of performance regulation. Linked to a powerful expert system that assists and checks his passage through the regulations, CSIRO is creating an IT system to facilitate these benefits.

Key Words
information technology; regulation; performance; accreditation; credences

Building Regulation in an Ever-changing Environment

Man has done much to change the face of the earth. For most of us, buildings stretch as far as the eye can see. We work, we eat, we sleep, we shop in a multitude of buildings that reflect the ever-changing face of fashion. Rarely do we consider the safety of the

colonnades through which we walk; rarely do we consider the health hazards imposed on us by the buildings in which we work. Society expects a certain level of safety, a certain level of health protection. It expects and generally accepts that certain standards are achieved and maintained.

If every builder and building designer had the knowledge and the dedication to achieve society's expected level of safety, there would be no need for building regulation. However, this is not the case, and some control is needed to ensure that our built environment remains safe to the required level.

These controls take the form of building regulations. Regulation ensures that certain standards are maintained for all society. In Australia, our regulations address matters of safety, health and amenity. There is an undercurrent of pressure to introduce requirements for energy conservation and already some states have incorporated such requirements.

As the needs and expectations of the community change, so must regulation. It must be capable of addressing the needs of increasingly dense populations and of addressing changing environmental conditions. We may need protection from the increasing levels of sound generated by our neighbours or changing weather patterns may increase the risk of damage by strong winds. Always there are certain aspects which need control and these can be stated as regulatory intentions. Accompanying each of these intentions is a level of fulfilment which is expected by society. So the questions the regulator must ask are:

What must we do?
How well must we do it?

A Brief History of Building Regulation

It is a quirk of human nature that we like to tell each other exactly what to do in certain circumstances, rather than spelling out what has to be achieved. We are more likely to tell our children not to climb on the railing than to tell them to be careful not to fall. The weakness of this logic is that it presupposes that children know that they can fall from a railing. Building regulation is no different. From the earliest days the rules have been expressed in terms of what we must do rather than what we are trying to achieve.

By 2000 BC dwelling houses in Mesopotamia were in the form of a square plan with an internal open court. A typical two storey house had the kitchen and ablution facilities on the ground floor and family living areas on the first. Rooms opened into a drained courtyard. This design addressed aspects of safety, health and amenity and provided a level of habitation commensurate with the expectations of society. At this stage there was no regulatory control.

From the burning of Rome in AD 64, when Nero prescribed fire-proof material for the outer walls of houses, to many of our modern regulations, building regulations have given us a recipe to follow. If we follow the recipe we believe that society will be suitably protected. Following the Great Fire of London in 1666, four types of housing

were prescribed. All had specified wall thicknesses and timber floors and roofs of specified scantlings. Presumably each of these forms of construction represented an acceptable level of risk of fire-spread, but this was not stated in the regulations. Incidentally, the separating construction provided levels of soundproofing and security that society then came to expect. These secondary benefits were inherent in generic building materials. At that time, the materials available for construction were stone, timber, plaster, brick and tile. With such a limited range of materials, descriptive building regulation was hardly restrictive. It is interesting to note that the introduction of new materials coincided with a fresh look at the regulations.

An increase in the availability and diversity of materials, the liberation of architectural concepts and the need for greater economy in building construction have contributed to today's need for a more flexible approach to regulation. Following the industrial revolution and the introduction of steel in construction, floor areas increased and buildings became taller. This led to a need to control different aspects of buildings, such as egress. In some areas new technologies have allowed a relaxation of previous requirements. An example is where fire resisting construction may not be necessary if modern sprinkler systems are installed. Lifts, which earlier this century were considered a fire hazard, are now being used as part of the accepted evacuation plan.

The concept of habitation in those days of industrial revolution and now has not changed appreciably. Probably society has a more co-ordinated approach to achieving its expectations. But technological advances in science and communication have enabled us to examine problems in a different light. In order to accommodate changes and allow a flexible approach to building, there is a world-wide swing towards the formulation of "performance" regulation. This kind of regulation clearly states the regulatory intention, and may state some level of fulfilment. Descriptions of ways in which the intention can be fulfilled may be included in the regulations, but these become just some of a host of ways of fulfilling the regulatory intention. Alternative solutions, possibly using innovative materials and designs, may be developed to fulfil the regulatory intention, and may be accepted within the ambit of the law as an alternative "credence" (or means of compliance).

Building regulation is forever changing. Natural disasters such as Cyclone Tracy and major fires like the Great Fire of London lead to a re-examination of requirements and levels of fulfilment. Cultural changes and the use of modern technology now allow us to consider the performance of building materials and systems and to conduct detailed studies on the risks involved in alternative systems. Although these levels of risk were implicit in previous prescriptive regulations, they were not openly acknowledged. By spelling out acceptable levels of risk in a full performance hierarchy, credences can be finely adjusted to reflect these levels. Ultimately building regulations may consist only of a number, a percentage representing an acceptable level of risk to life, supported by appropriate credences.

Building Regulation in Australia

A uniform code for Australia

Building regulation in Australia developed separately within the different states and was based on overseas regulation and local practice. It was not until 1964 that a committee of representatives of each of the states was formed to develop a model code for the whole of Australia. This was the Interstate Standing Committee on Uniform Building Regulations - ISCUBR - and it produced the Australian Model Uniform Building Code - the AMUBC. In 1982 a government initiative established the Australian Uniform Building Regulation Co-ordinating Council (AUBRCC), whose role was to convert the model code to a national code that could be called up directly by all states and territories. AUBRCC has spent the past ten years formulating the Building Code of Australia (BCA). The BCA has now been adopted by all states and territories except Tasmania.

The Commonwealth Experimental Building Station (EBS), predecessor of CSIRO DBCE, had a long association with building regulations. In 1949 EBS convened a meeting of representatives from all States to discuss the need for fire research. Subsequently EBS became technical adviser to a series of meetings to discuss fire protection in buildings and the need for a uniform approach towards building regulations. In 1955 EBS became technical adviser to the state of Victoria, assisting in the incorporation of the latest technological developments in the Victorian Building Regulations. When the New South Wales Ordinance was to be amended EBS was again involved. EBS took this opportunity to coordinate the technical provisions of Victoria and New South Wales as the basis for uniform building regulations for all the States.

Building regulations have two components. Technical requirements become mandatory by means of administrative provisions. The BCA addresses technical issues only. Administrative provisions are still handled by the individual states. It is important to ensure that administrative provisions do not impinge on the technical content and use of the regulations, allowing a diminution of achievement of objectives. This problem can be avoided if the scope of the administrative provisions is clearly defined in the technical requirements. This will elude the pressures of local consumer interests, which could otherwise influence the technical requirements through manipulation of the administrative provisions. In some states the separation of technical and administrative requirements has not yet been fully realised. There is a need to ensure that technical nuances do not enter into the administrative provisions.

Despite the existence of a national code, each state initially incorporated a series of variations, often in order to maintain the status quo. A major rationalisation has recently occurred and in many cases consideration of aspects of building performance has led to the elimination of state variations.

Democratic government in Australia operates at three levels - federal, state and local. There are eight States in Australia with 914 local councils that administer over 500 regulations related to building. Recently, AUBRCC initiated a project on the consolidation of all regulations relating to building within Australia. In considering the final report, CSIRO found that, without a performance structure in which regulatory intentions are clearly spelled out, it is hard to establish a basis for comparison of regulations in different areas. By considering the intention of each regulation, a comparison can be used to ensure that consolidation is logical and consistent. A

suitable framework for comparison of regulations is given in Appendix A: Model for Consolidation of Building Regulations Based on Use.

The building regulation cycle

In Australia our regulations respond to the pressures of our changing environment by a process based on regulation documents (RDs). These documents give details of proposed changes to the regulations, together with a summary of any background research or reasons behind the proposed change. They may be the result of the orderly progress of building research or medical research or they may be initiated by commercial pressures or by popular demand (often following an emotive tragedy or natural disaster) or by some perceived danger that has led to a major research project. Each state has the opportunity to vote and comment on the proposed change, which may then be modified or directly incorporated into the regulations.

The generation and modification of building regulations has a definable cycle and can be expressed in the following way:

GENERIC CYCLE	AUSTRALIAN REGULATION CYCLE
a) Event	a) Existing BCA requirement becomes inapt
b) Knee-jerk reaction/ overkill	b) Industry/regulators initial reaction
c) Problem solving	c) research/RD/Executive decision process
d) Codification and diffusion	d) Amendment to BCA
e) Structured impact	e) State implementation through legislation

The effects of major disasters on the formulation of building regulations can be analysed using this cycle. A recent earthquake in Newcastle, NSW, precipitated an investigation into the adequacy of Australian building regulations in areas of seismic activity. The outcome was a change to the zoning map in the Australian standard called up in the regulations to reflect a changed perception of the risk of seismic activity and a fine tuning of structural requirements for certain forms of construction in areas prone to earthquakes. Because of their performance nature, there was no need to change the regulations themselves.

The cycle can be represented as follows:

NEWCASTLE EARTHQUAKE (I989) CYCLE

a) Earthquake rocks Newcastle, causing structural damage to buildings and the loss of lives
b) Public demand to rewrite regulations
c) Experts apply their intellectual rigour to the collected data on the disaster
d) the Standards Association of Australia (SAA) Earthquake Code's zoning map for earthquake activity is upgraded as a matter of urgency. No place in Australia is now considered safe from earthquake. This reflects a changed perception of the risk
e) The upgraded earthquake code is adopted by the BCA.

The effects of Cyclone Tracy on building regulation were very different and more

varied. An initial response to damage from storm surge was to allow no construction within 4.5 m. of the highest astronomical tide line. This restriction meant that there could be no development in some of the more affluent coastal suburbs around Darwin. It was not long before the restrictions were ignored and reconstruction started. Changes to the technical regulations were eventually overridden by changes to the "administrative" provisions. On the structural side, immediately following the cyclone a costly "belt and braces" approach was used to ensure appropriate levels of safety. It was not long before data gathered from the damaged buildings was used to research new methods of fixing and construction. The resultant changes to the regulations, based on thorough research, were not as extensive as originally expected.

CYCLONE TRACY (1974) CYCLE

a) Storm surge & high winds resulting in approx. 53% of houses destroyed and the loss of lives

b) Over conservative new storm surge map; dubious implementation
Over conservative requirements for reconstruction creating problems for re-settlement

c) Experts apply their intellectual rigour to the collected data on the disaster, eg
the distinction of design load for strength and the design load for serviceability when considering the structural integrity of a building; and
the 'links in the strength chain' when considering wind forces in creating upwards and sideways loads

d) A profusion of knowledge and application leads to a new Building Manual emphasising the level of performance required for cyclone conditions

e) Implementation of the Building Manual through legislation.

Performance regulation

At the formation of AUBRCC, Australia acknowledged the need for performance-based regulations. Progress in this direction has been slow, but statements of objective are now included at the start of each section of the regulations and some requirements have been written in terms of building performance. In order to support a full performance structure, a National Accreditation Scheme has been established. This allows a designer or builder to gain accreditation of an innovative design or product that does not comply with a credence within the regulations and to have that design or product accepted at a national level. CSIRO administers the National Accreditation Scheme on behalf of AUBRCC. Appendix B: Formalising National Accreditation - Flowchart, illustrates the present national accreditation process.

Performance and Information Technology

Once control of the built environment is based on performance, any solution becomes acceptable provided it fulfils that performance. But how do we show that it has reached the required level of fulfilment? In many cases, the level of fulfilment will not be given in a simple numeric form that can be easily measured. The level of fulfilment will often be hidden in the credences, which in turn are based on the old prescriptive regulations. In order to determine the intention of old regulations, and establish a basis for

comparison for new solutions, it may be necessary to search the documentation on which the old regulations were based. This documentation will be in many forms, resulting from the processes of regulatory evolution that we have described. Documents may consist of records of research projects, committee decisions, overseas regulations, past regulations, interpretations and commentaries, administrative provisions *etc*. All this information will be needed to derive new performance-based regulations, and to establish the level of compliance of alternative solutions for accreditation. CSIRO is developing a Regulation Knowledge System that will provide easy access to this information in a form that will be appropriate for the use of code developers, building regulators, designers, industry and those involved with accreditation.

The CSIRO Regulation Knowledge System

Functions and objectives

The system is designed to capture documentation from all of sources that relate to the BCA and enable requests to be processed by the user. The initial users will be building regulators involved in the development of building regulations. The system will later be extended to assist in other regulation-related activities such as national accreditation of products and national registration of products. Selected documents will be available for viewing, printing, editing and for inclusion in reports. It is important to maintain the integrity of the records at all times.

The framework of the system has three major components:

- data (identification and integrity),
- maintenance (system and information),
- procedures (relational and hierarchical).

User requirements

As we have seen, building regulations have an inherent structure of regulatory intention and level of fulfilment. The level of compliance is commensurate with the level of risk that is acceptable to society. In framing new regulations, the regulators have to consider knowledge from a variety of sources such as existing regulations, research experience, designs and publications. The data base system will facilitate a structured approach that will enable the development and use of regulations in terms of building performance. Through an interactive front end the system user can access menu items. These provide information from the various sources and the structure to help that examination.

The system will:

- trace the development of each provision in the regulations back through its antecedents to its inception;
- trace the development of state variations;
- facilitate the analysis of requirements in terms of regulatory intentions as a basis for
  - further development of the regulations;

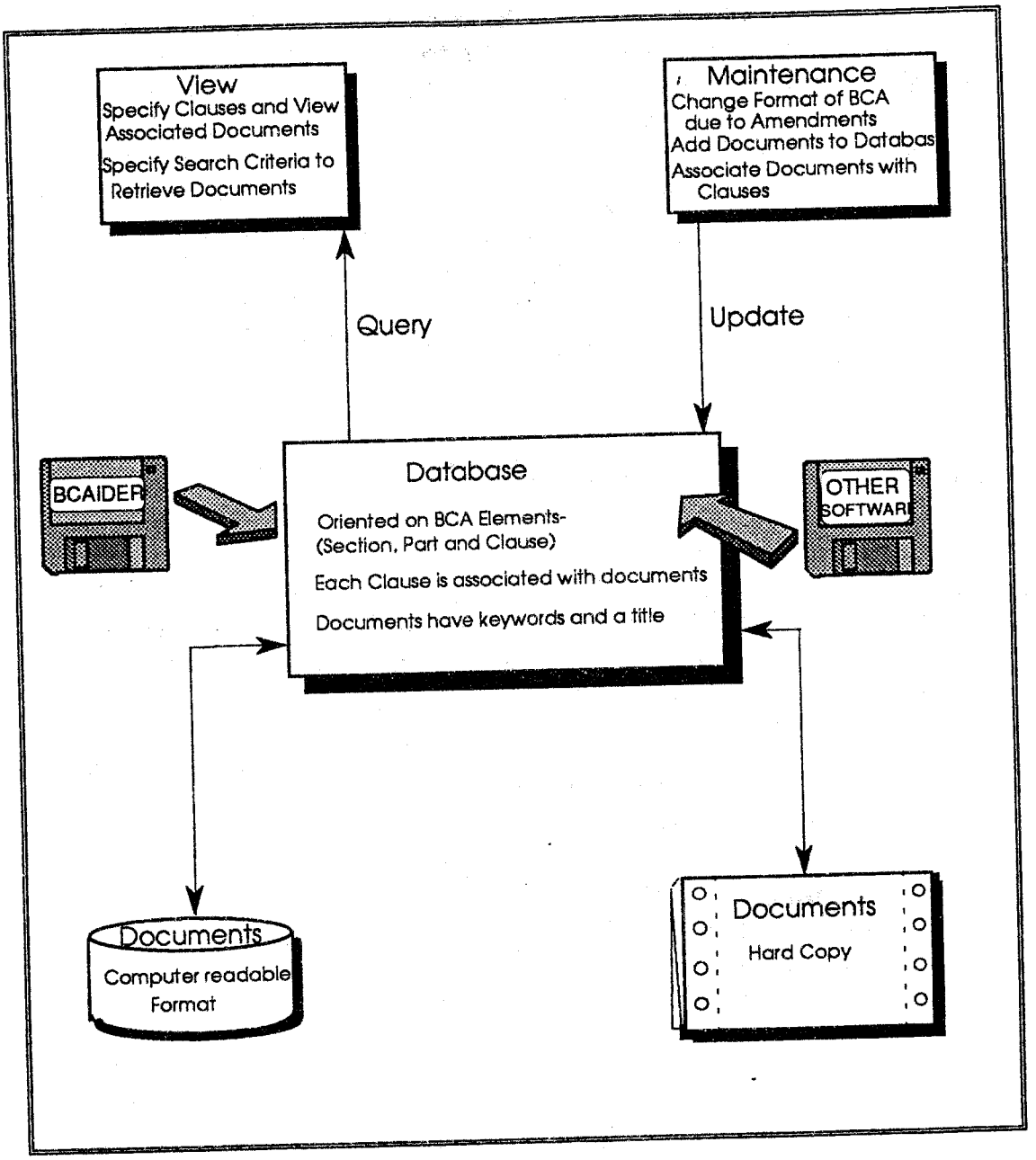

FIGURE 1: REGULATION KNOWLEDGE SYSTEM MODEL

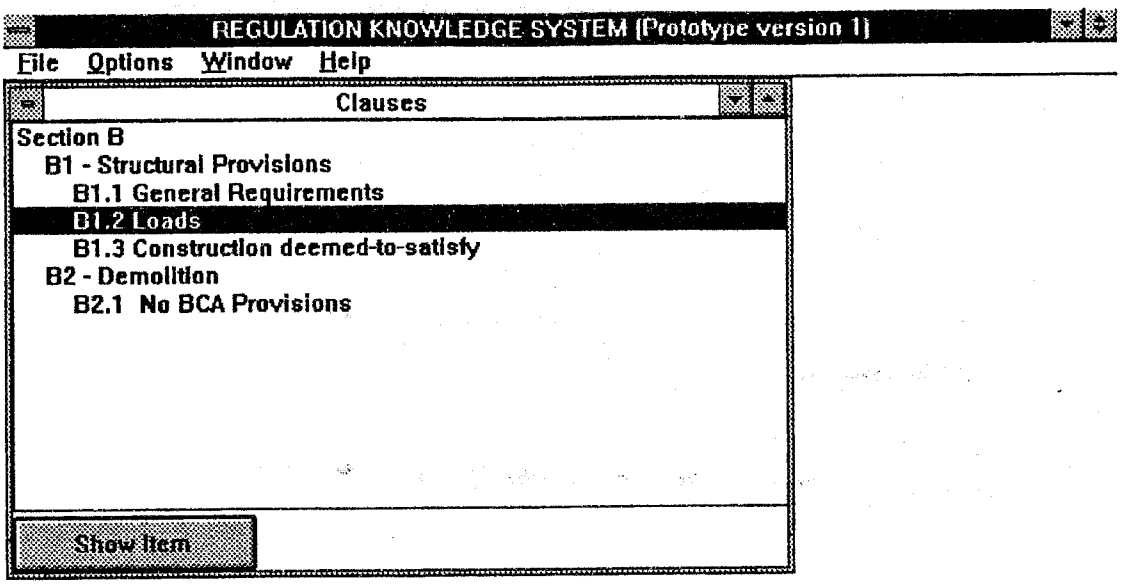

FIGURE 2: SELECTION OF BCA CLAUSE

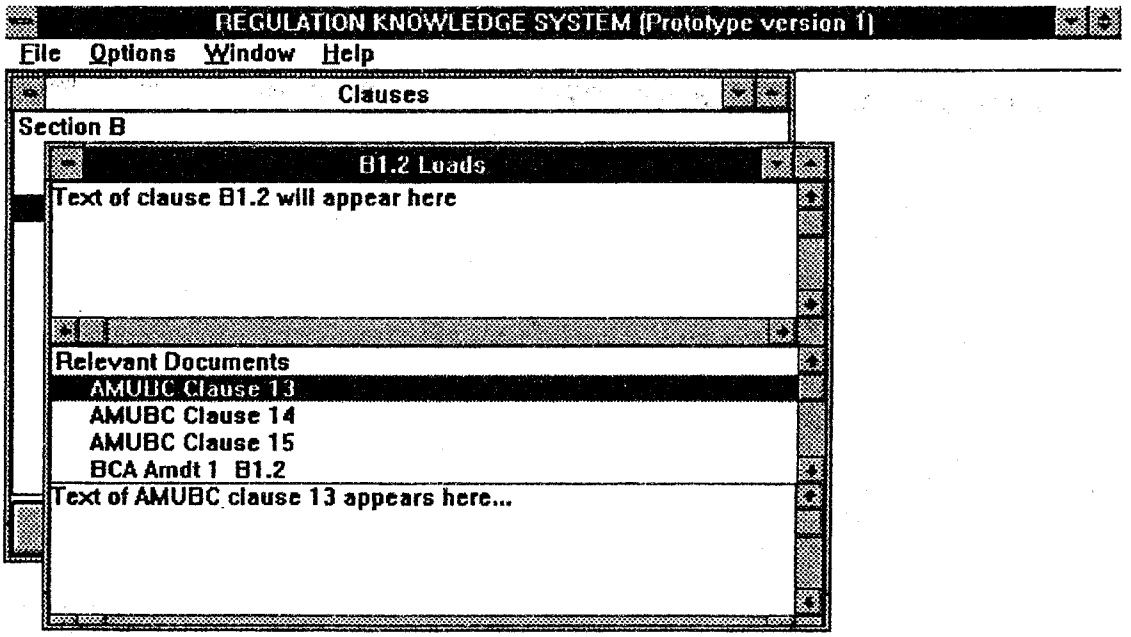

FIGURE 3: TEXT DISPLAY - BCA CLAUSE & RELEVANT DOCUMENT

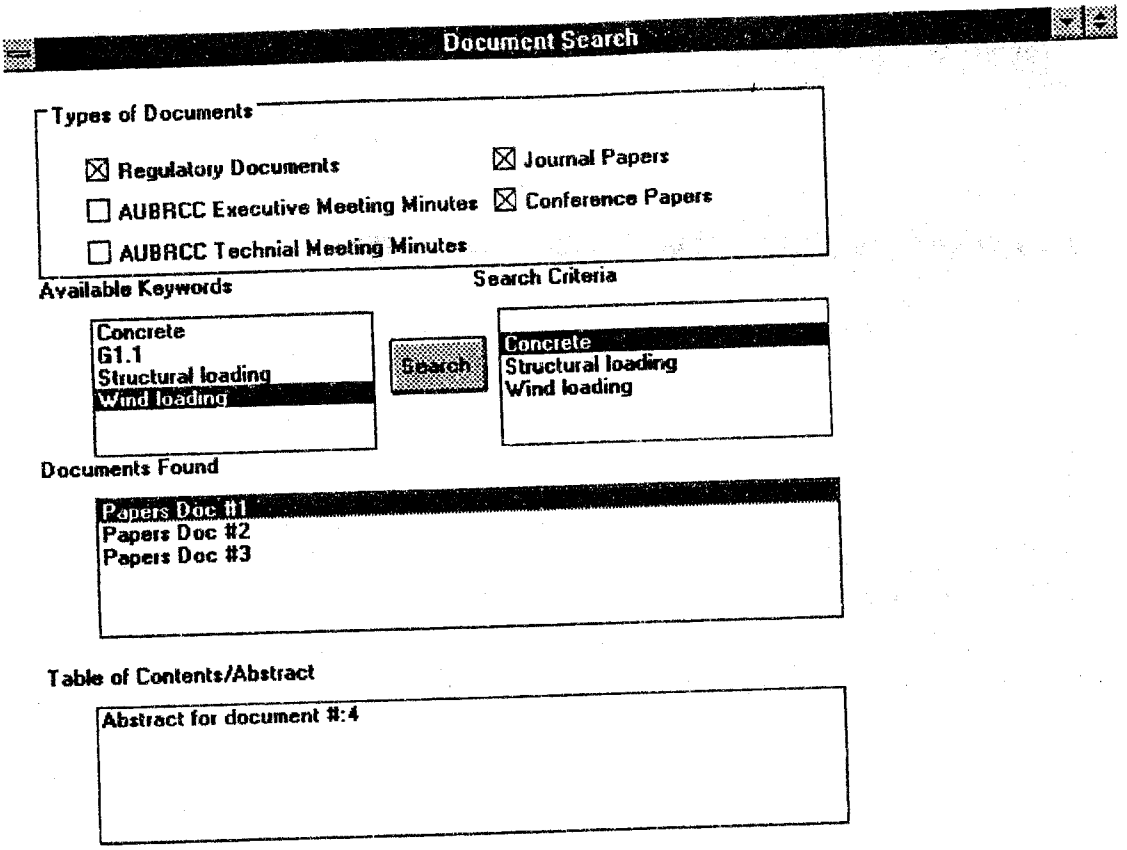

FIGURE 4: DOCUMENT SEARCH

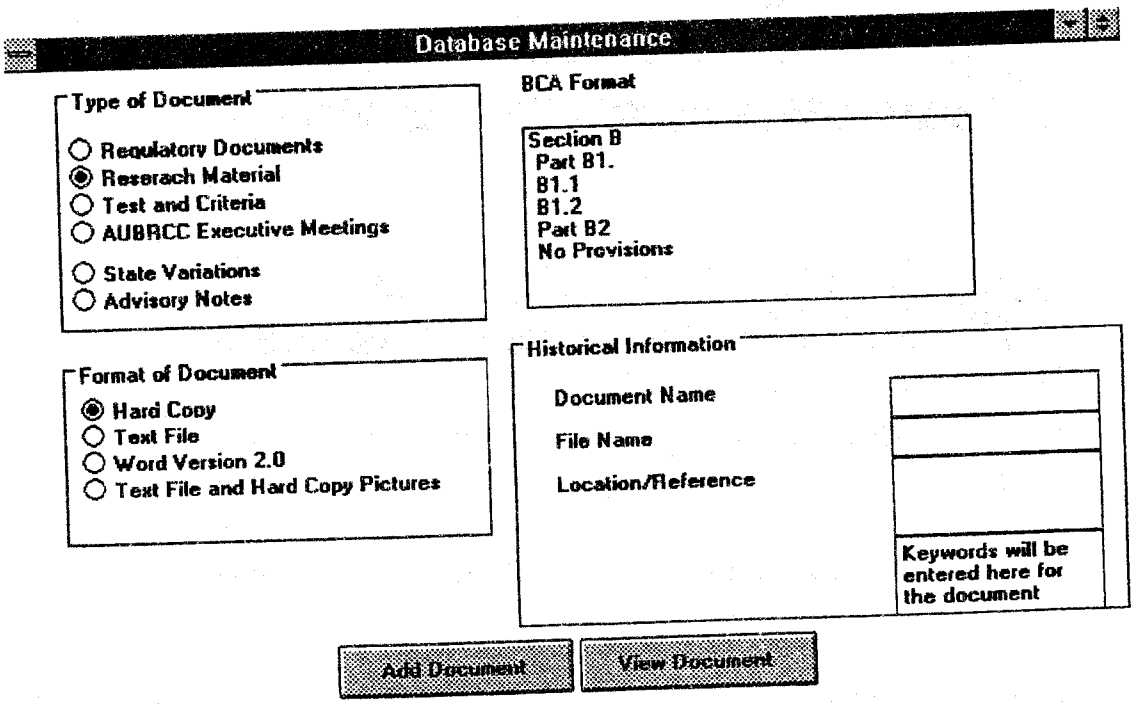

FIGURE 5: MAINTENANCE - ADDING & VIEWING DOCUMENT

- the development and validation of credences;
- the progressive elimination of state variations.

System model

The system model has been developed from the user requirements. It provides a structure for the design of the prototype - see Figure 1: Regulation Knowledge System Model.

Prototype design

The prototype structure has modules that provide flexibility. This flexibility allows

- the user to address diverse requirements;
- the range of users to be maximised;
- the database to be linked to related software; and
- the integrity of the data to be preserved.

Central to the structure is the use of BCA elements (section, part or clause) and keywords. Access to information is through the selection of a clause. See Figure 2: Selection of a BCA Clause and Figure 3: Text Display-BCA Clause & Relevant Document which are sample screens from the prototype. The prototype presents a screen listing clauses. The functions (view, maintenance and copy) described in the system model are performed on the BCA element.

Processing user requests

In altering an element a building regulator must ascertain the regulatory intention and must consider the level of fulfilment, taking into consideration any credences. This is the structure of the BCA. In all transactions with the database system the acknowledgement of this is fundamental. For the level of fulfilment to change a regulatory document has to be prepared and the proposed changes must have the approval of the AUBRCC executive.

There are two ways of retrieving documents. The first is by BCA element. The user specifies which element he/she wishes to review. The reference documents and related BCA clauses for that particular element are then displayed. A document or its abstract (if available) and the BCA clauses may be viewed or searched for a string of text. Reference documents include the BCA clauses and their antecedents. See sample screen shown as Figure 4: Document Search.

Alternatively, text can be retrieved by keywords. The database system will incorporate keywords from the BCA and other building regulation sources. The keyword system will include synonym control. Keywords will be represented on a word wheel which will access equivalent terms. Ideally an abstract which will include the appropriate keywords, will be written for each document. Each abstract will then be searched for the keywords. The user specifies keyword(s). A keyword may be a concept such as a

swimming pool, a clause number or any string of text. The user may specifies the type of document he/she wishes to retrieve or retrieve all relevant documents. The titles and abstracts of the specified documents and the BCA elements are then searched to match these keywords. The documents and elements that include the keywords are retrieved, and the user specify a document to work on.

Whichever approach is used to select information, the user will want the information delivered in a way that is useful to him/her. First, the user selects the type of information he/she wants from the system

- titles of relevant documents and linked BCA clauses
- full text or abstract of the selected relevant document or linked BCA clause.

See sample screen shown as Figure 3.

Once the user has identified relevant references, the information can be presented in these forms:

- on the computer screen
- as printed copy
- as a computer file or
- imported into a report generator system or a word processing package. This allows the document to be edited, parts selected and so on. The edited version can then be printed or saved on file.

System maintenance

Maintenance is an important aspect of the system. As new documents become available they must be added to the database. Any new information that is entered in the database will be identified by BCA element and keywords. See Figure 5: Maintenance-Adding and Viewing a Document and Figure 6: Maintenance-Linking a Document to a BCA Clause which are sample screens from the prototype.

First, the user specifies the type of document. The format of the document is entered (ie hard copy, text file or a combination of both) followed by the name of the document, its location and other historical information. If the document is in a computer file then the name of the file is specified. The elements of the BCA the document is related to are then entered, together with any available abstract. It may be necessary to write an abstract if none is available and if the document is not short enough to justify full text search. The abstract must refer to each relevant item in the document in standard terms. Even a short document might justify an abstract if its nomenclature is non-standard.

The document details are then added to the database. If the document is in a computer file it is taken from the specified location and copied into the database system for future retrieval. If the related BCA elements are specified then links between the elements and the document are specified. The addition of the document is then confirmed.

BCA amendments

Normally the user is shown the current BCA wording. If the BCA is to be amended the

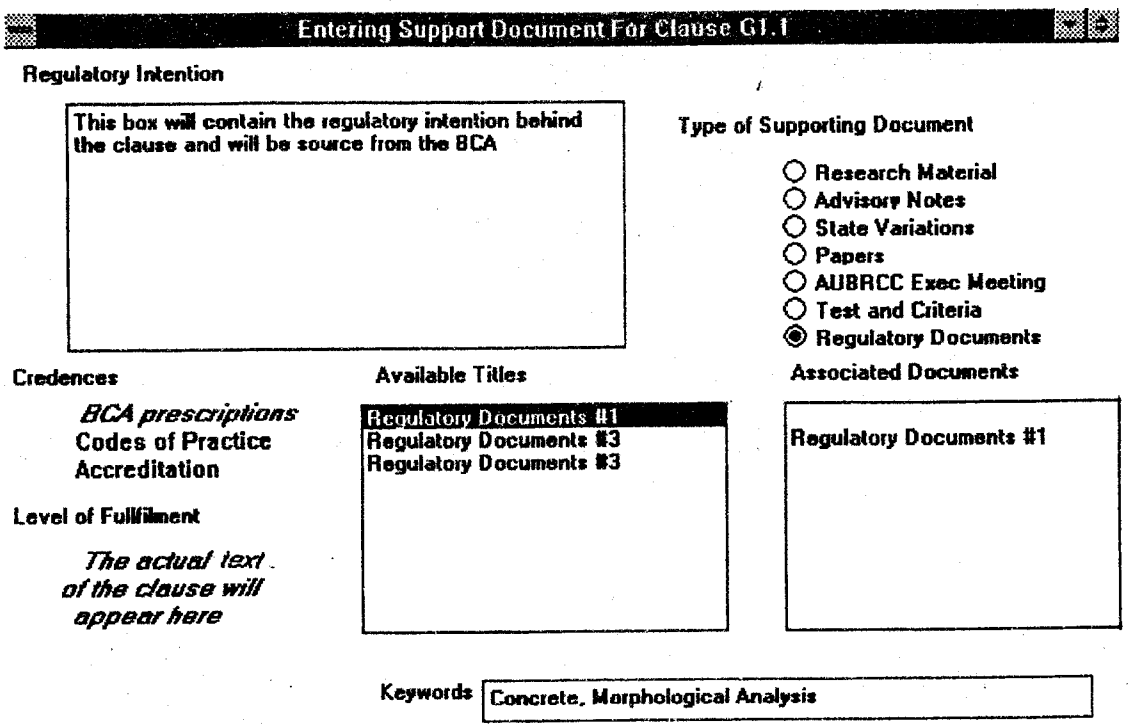

FIGURE 6: MAINTENANCE - LINKING A DOCUMENT TO A BCA CLAUSE

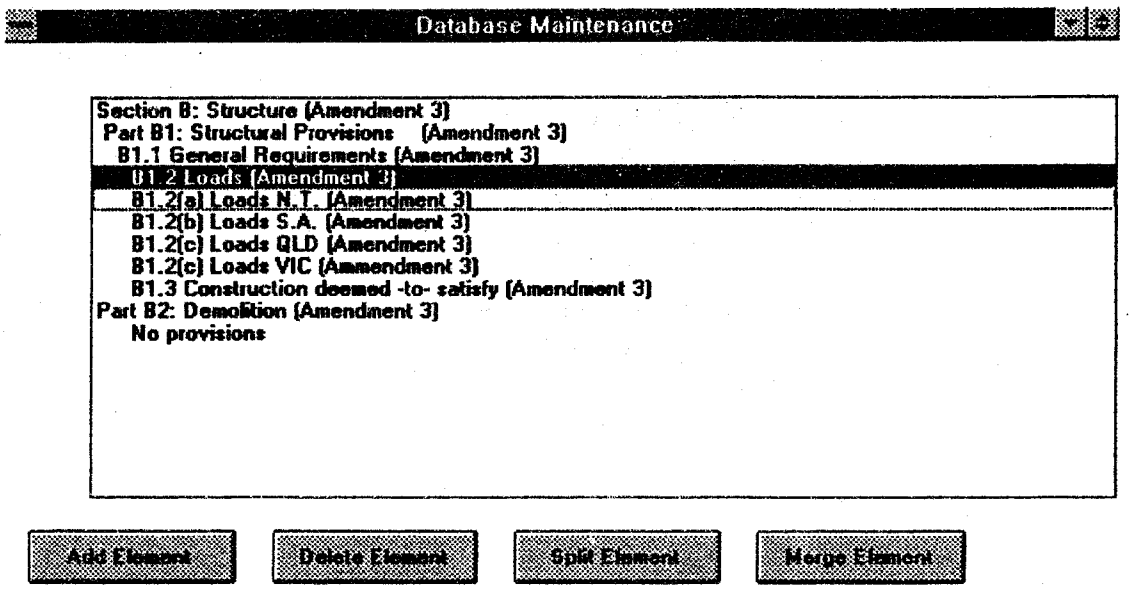

FIGURE 7: MAINTENANCE - BCA AMENDMENT

BCA wording must be changed. An element is defined by its clause number(or part or section number) together with the appropriate BCA edition and amendment number. Therefore B1.1 (BCA 1990, Amendment 3) specifies a clause but B1.1 is too general to specify a clause. For each clause that is to be amended the following is completed:

- Create an element for the new amendment.
- Specify the last predecessor of the new element.
- Specify the documents (already entered into the system) that relate directly to that particular element.

The new element is added to the database. It inherits the history of its predecessor. The documents that resulted in the new element are associated with the element and the entry is confirmed. See Figure 7: Maintenance-BCA Amendment which is a sample screen from the prototype.

Associating clauses with documents

At times it will be necessary to associate BCA clauses with documents within the system. For this transaction, the documents and clauses must already be added to the system. The user first specifies a clause and the documents to be attached to that clause are then specified. The system will provide the clause intention, the level of fulfilment that must be achieved (or some indication of where this can be found) and credences. All documents in the system of a specific type are then listed. The user may see the keywords associated with these documents and then associate them with a clause (see Figure 6). Again, confirmation of the entry is provided.

Interaction with other software systems

The regulation knowledge system is being developed in a Windows environment and is designed to be compatible with as wide a range of software as possible. CSIRO has already developed a successful interactive software package to assist code users to check for compliance with the BCA. The BCAider takes the user step by step through the regulations, breaking each clause down into a series of easy-to-answer questions and recording areas of non-compliance. BCAider incorporates the variations for each state and gives the user access to context-sensitive commentary on the regulations. It provides on-line access to compendia of tested products and interfaces with the Australian Standards CDROM of building standards. It is essential that the regulation knowledge system should interface with BCAider to allow the user access to as wide a range of information as possible.

Future directions

Future development of the regulation knowledge system includes possible incorporation of overseas regulations, especially those of our near neighbours in New Zealand. The system will be linked with information management systems and compendia of tested products already being developed by CSIRO. An accreditation and registration module to facilitate handling of applications for accreditation or registration

is also envisaged.

As stated earlier, the system's initial users will be building regulators. However it is intended to extend the user group to include people who are involved in building activities such as designing, building and manufacturing. The system we are currently developing is based on the processes used by the regulators and code developers. In order to develop systems suitable for use by other users, it may be necessary to develop new interfaces that reflect their particular needs. Questions that need to be addressed are:

What is the user's product? and
How can the user make use of the data?

Conclusion

The structure of building regulations however, wherever and whenever they are written is one of regulatory intentions and levels of fulfilment. Whatever the regulatory problem, the solution always lies in the answer to the two questions

What must we do? and
How well must we do it?

Regulation is based on an unbelievable mass of documentation, much of which is often overlooked. If all this information is presented within a framework of intention and level of fulfilment, then logical, flexible and comprehensive regulation can be achieved.

CSIRO has acknowledged the importance of this structure and is formulating a regulation knowledge system that will streamline the production of clear, logical regulations. By careful management of available information technology, we hope to enhance the writing and interpretation of our regulations, a process that could save Australia billions of dollars each year.

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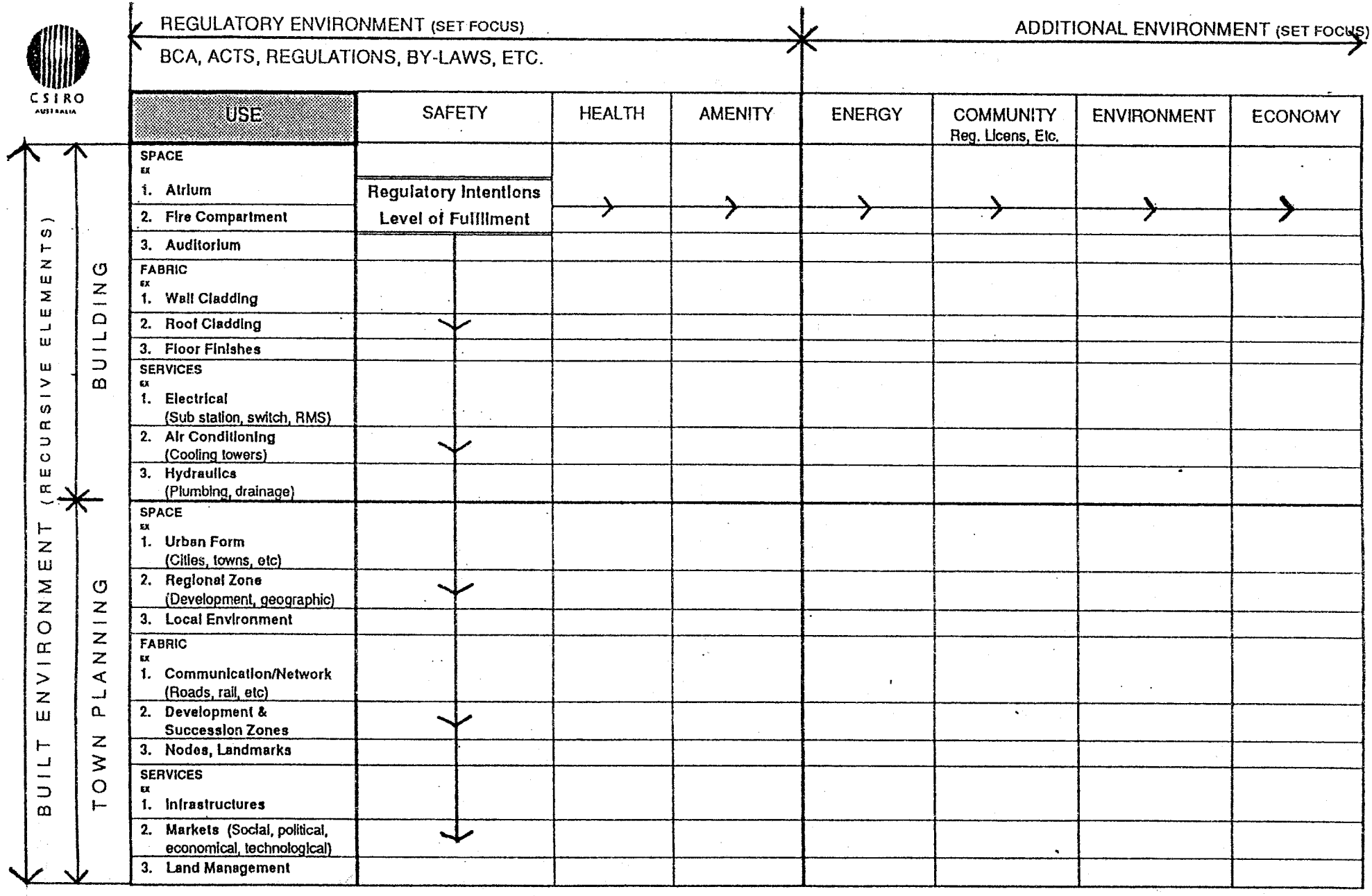
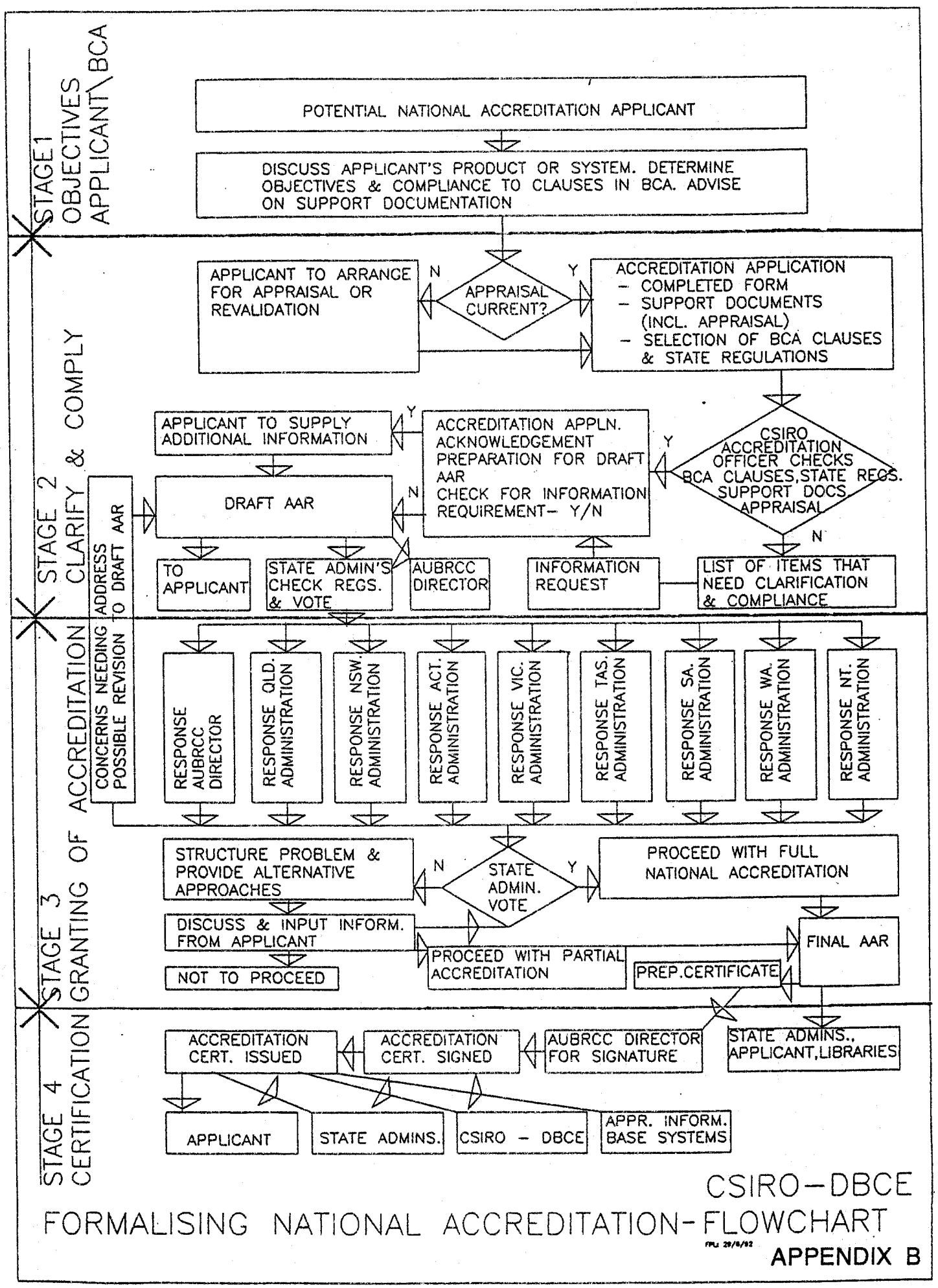


APPENDIX A MODEL FOR CONSOLIDATION OF BUILDING REGULATIONS BASED ON USE - CSIRO, DBCE
DEVELOPED BY PAMS - Frank Leong, Howard Leslie, Jane Blackmore - November 1992

Repoduced from Leong et al.(1992), Comments on Consolidation of Building Regulations in Australia



CSIRO–DBCE

FORMALISING NATIONAL ACCREDITATION-FLOWCHART

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APPENDIX B