NO.83
(1988)

BUILDING RESEARCH ASSOCIATION OF NEW ZEALAND

REPRINT

CI/SfB
(Agn)
UDC 681.3.06:69

Knowledge-based systems for Building Technology in New Zealand

A.H. Dechapunya and
R.S. Whitney

Reprinted from *Proceedings of Symposium on Knowledge-based Systems in Civil Engineering,* August 1988, Monash University, Clayton.

branz
BUILDING RESEARCH ASSOCIATION OF NEW ZEALAND

KNOWLEDGE-BASED SYSTEMS FOR BUILDING TECHNOLOGY IN NEW ZEALAND

A. H. Dechapunya
Building Research Association of
New Zealand,
NEW ZEALAND

R. S. Whitney
Coal Research Association of New Zealand
NEW ZEALAND

ABSTRACT

The aim of BRANZ AI research has been to investigate the potential of knowledge-based systems (KBS) for building codes as part of an integrated information resource for the building industry.

At present, the Association's AI environment is a VAX/VMS based local area network with Prolog and Class. The Class knowledge engineering language has been developed by KBS Research Unit, Auckland University. This co-operation with Auckland University has been a key feature of the KBS development, as has the involvement of BRANZ computing, scientific and field staff.

The paper will discuss research aspects of the development of a number of KBS, including: FIRECODE, DAMP, SEALANT, ADHESIVE, WALLBRACE, SEISMIC and SUBLOORBRACE.

A field trial of KBS is to be undertaken on the Association's computerised information service (BRANZLINEO), available to the building industry via a nation-wide packet-switching network. The KBS included in the trial, WALLBRACE and SUBFLOORBRACE, will allow building inspectors to check the wall and subfloor bracing in house designs.

Future uses of Information Technology by the building industry will include both computerised building controls and intelligent CAD systems for all stages of design, planning and construction. KBS research issues in respect of these developments are discussed.

INTRODUCTION

This paper discusses the various issues in the application of expert systems to the dissemination of information. The history of BRANZ involvement in expert systems is discussed including the essential part that the universities have played.

BRANZ is an industry Research Association funded primarily by the New Zealand building industry by means of a levy on new building. Government grants have also been received in the past. The BRANZ mission statement is:

> "To benefit the New Zealand community by identifying and satisfying the technological information needs of the the building industry."

BRANZ is in the information business, with the daunting task of providing information to a large and diverse industry. Moreover, it is an industry which is often disinterested because, like most others, it is already swamped with information. It is necessary, therefore, to be able to provide the information that is needed, when it is needed, in a useful form.

BRANZ first became aware of the potential of knowledge-based systems (KBS) in early 1984 when the Association was asked by Victoria University to provide an expert for their KBS work. A BRANZ staff member provided knowledge on moisture damage in houses for an expert system DAMP developed by Sachdeva (1985).

This led BRANZ to look closely at this new technology. The Association concluded that KBS had the potential to improve information transfer throughout the building industry, particularly in the areas of building codes, building design, diagnosis of problems, and materials selection. The use of expert systems to assist in the use of building codes and regulations was of particular interest because of moves in New Zealand towards a rationalised system of building controls.

At this time BRANZ was in the process of computerising its Library using a VAX 750, with the intention of making the Library and other databases available to the building industry via Pacnet, (Hissink, 1985). KBS were seen as having the potential of adding to this planned information service (Whitney and Dechapunya, 1985). Thus, BRANZ KBS work has from the start been directed towards producing KBS for a VAX-based system.

In 1985 a Prolog interpreter was purchased. A commercial shell was evaluated on the BRANZ VAX. While many shells were to become available for PCs, there was and still is a shortage of suitable software for a VAX-based system. This led to a cooperative research contract in late 1985 with the Computer Science Department, University of Auckland to develop a KBS for a building code.

The work was a success (Buis et al, 1986,1987; Hosking et al, 1987) with several results. One was a knowledge base for parts 2 and 6 from DZ

4226:1984 Draft New Zealand Standard "Design for fire safety". Another was an expert system building tool known as Class. The most important result was the beginning cooperation with the university. The authors believe that this cooperative research has enabled BRANZ to keep abreast of the technology with relatively small in-house resources.

The BRANZ AI environment began to develope with the delivery of the first Class interpreter in 1986. It exists within the BRANZ local area network which consists of high-speed communication equipment connecting computers and printers, terminals and plotters. The network provides user-oriented computing requirements to all BRANZ staff. It contains:

PDP 11/24	- Real time machine, primarily for experimental work.
VAX 11/750	- Information machine, provides on-line information systems.
MVAX 2	- Management machine, used for general management and planning acivities.
MVAX 2	- Computing and KBS machine, used for scientific work, statistical analysis, and KBS work.

DAMP was rewritten using Class. In 1987 and 1988 SEALANT and ADHESIVE (Fromont and Watkinson, 1988) KBS were developed in-house.

A much improved version of Class (compiler-based) is now up and running on the BRANZ local area network (Mugridge et al, 1987; Hamer et al, 1988). The combination of the Class compiler with a Quintus Prolog compiler allows knowledge-based systems to be developed more quickly with applications running at least 20 times faster than the original Class system. Features in this version include rollback, external interface, browser, when rules, and constraints on user inputs.

Field trials of KBS are planned shortly (Fowkes, Sharman and Dechapunya, 1988). The field trials will involve building inspectors from two cities (Wellington and Manakau). Two KBS, WALLBRACE and SUBFLOORBRACE are being developed for the trial. WALLBRACE is being developed by Auckland University and SUBFLOORBRACE is being developed in-house. These KBS will allow building inspectors to check that wall and subfloor bracing in plans submitted to them comply with the building code requirements, and will allow alternative bracing options to be considered.

A research strategy for the use of information technology in the building industry was developed and became part of the BRANZ research programme.

KBS PROTOTYPES

FIRECODE

The FIRECODE system (Buis et al, 1987) is an expert system for assisting a user to check a building design against a fire safety standard. A design is checked to ensure that, in the case of a fire, the maximum time taken to exit the building is not excessive. This checking involves representing the various spaces within the building and reasoning about the usage of those spaces.

The FIRECODE project was chosen both for the initial development of the Class System, and to demonstrate the viability of expert systems for building codes. FIRECODE tackled the "means of egress" section of the Draft New Zealand Standard DZ 4226:1984, "Design for Fire Safety". The draft code was used, with one of the drafting committee available as a consultant. In addition, the Chairman of the Drafting Committee was a BRANZ staff member, and was able to spend time in checking FIRECODE. This was done by checking through the printed knowledge base and relating it back to the draft code, as well as working through simple examples.

For various reasons the draft standard itself is unlikely to be adopted in its present form. It it is hoped the existence of the expert system will be of value in future revisions.

DAMP

DAMP (Trethowen, 1987) is intended to be used as a diagnostic aid for moisture problems frequently encountered in New Zealand houses. The system asks questions in order to determine the likely cause of the moisture problem. It then displays it, along with a discussion of the problem and a number of actions that can be taken.

The DAMP knowledge base was originally developed by Sachdeva (1985). As mentioned earlier, it has now been rewritten using Class and considerably enlarged and improved.

The DAMP knowledge base has been evolving for many years and is still evolving. It began with published literature, fifteen to twenty years of operating an advisory service in BRANZ, now dealing with well over 5000 calls/year. This leads fairly naturally into a decision tree classification of symptoms, and indeed a precursor to DAMP was a diagnostic tree, shown at a trial of the system in Germany in 1987.

The formal process involved in preparing the DAMP knowledge base showed that in spite of the apparently complex nature of moisture problems in buildings, there are in fact only three factors: observable symptoms, sources of moisture, and processes for transferring moisture from its source to the location of its symptom. DAMP has been built around this observation. There are, however, many clues in the space and time patterns of the symptoms, which are used by the human expert in forming a diagnosis. Many of these are difficult to express, and their significance changes according to details of building construction, climate, and usage.

ADHESIVE

ADHESIVE (Fromont and Watkinson, 1988) is designed to help choose a suitable adhesive for a given use. It can be used by the builder, joiner, home handyman, small factory user or specifier of ADHESIVEs. The system classifies the preferred adhesives for bonding materials as used in the building industry.

At least one of the materials involved must be wood (or timber particles/fibres, or timber-veneer). The term wood includes (natural) timbers, and wood-based sheet products such as plywood, particle boards, hardboards and fibreboards. (Note that glued laminated beams, trusses, and finger-jointed products all use natural timber.)

ADHESIVE was developed at BRANZ by a knowledge engineer in collaboration with a materials scientist. It was largely based on a British Standards for construction adhesives and an information bulletin the materials scientist had recently prepared. One of the key techniques used in the KBS was to set out the information on paper in the form of a large scale decision tree. The knowledge engineer was able to discuss this tree with the expert, to ensure the reasoning behind the decisions was understood.

SEALANT

The aim of this system is to help the user select the sealant or sealants most suited to the particular joints. The system does this by asking questions (e.g., "Where is the joint situated?", "What are the materials comprising the joint?", "How much movement is there at the joint?"-if the user does not know, the system will assist in calculating it-, "How long do you want the sealant to last?", "Do you want to paint over it?").

It is assumed that the sealant will be applied on site; factory applied systems have not been considered.

WHAT HAVE WE LEARNT?

Two things that will dictate the successful use of KBS technology are:

- the environment in which applications are developed and that in which they are delivered

- the selection of the subject domains.

Environment

KBS environment needs to continue to evolve. The environment needs to allow knowledge engineers to develop knowledge bases and evaluate software tools, and experts to test or audit the knowledge bases. The teamwork approach is essential in BRANZ KBS development because of the diverse skills required. Thus, the environment must be flexible and capable of high performance.

A flexible environment is one in which KBS and conventional work can coexist. One that fits a teamwork approach. One in which the products can be distributed easily and conveniently throughout the BRANZ local area network. In a high performance system, the combination of hardware and software must be such that they will not be a bottleneck in the KBS development. The rate of development of KBS is influenced by the ease of using the system and the rate of output from it.

Recruiting staff is a universal problem. It is especially difficult to recruit a knowledge engineer in New Zealand. Thus, the environment is very important: software must be easy to learn; hardware must be adequate; experts must be part of the team; and access to KBS research expertise must be available.

BRANZ KBS environment has evolved to become multidisciplinary due to the nature of KBS work. For each project, a working group (knowledge engineer, expert, information system coordinator and project manager) was formed to monitor the progress of the project and to provide a forum for discussion and exchange of information. The development environment is such that:

- the knowledge engineer has free access to the expert,
- the knowledge engineer has access to the KBS Research Unit at the University of Auckland,
- the flexiblity and modularity of the Class language allow the knowledge engineer to divide the problem into parts. Each part can be rapidly prototyped as a stand-alone system,
- the expert can test the stand-alone system from the terminal in their own room and give feedback to the knowledge engineer.

Hardware

The hardware provides the framework for teamwork, where all people involved in the development of KBS have access to the systems at any time. This is especcially useful for incremental checking of all phases of system development. Compatibility and networking capability between the development and delivery systems is essential, so that the end product can be transferred to the delivery system without modification.

The present knowledge engineering environment comprises terminals connected to the BRANZ local area network. It is being proposed that the terminals should be replaced with workstations. Two basic reasons for these changes: the first is that KBS research and development requires large computing resources and the sharing of central processing units has created some problems both for knowledge engineers and other users of the system, the second is that Class is now in the development phase to improve the human interface by the use of graphics and windowing. Thus, clearly, there is a need to utilize workstation technology for both research and development. BRANZ framework of hardware would allow a workstation to integrate without a problem.

Software

It became clear early in the BRANZ KBS programme that the biggest issue was software tools needed for the development and running of KBS. Initially, the Association was considering a Prolog interpreter but quickly learnt that the use of traditional AI languages, such as Prolog and Lisp, in KBS research and development would be a wrong strategy for BRANZ considering its limited staff. BRANZ came to the conclusion that a knowledge engineering language was needed. The FIRECODE project led to the decision to use Class for KBS development.

The FIRECODE project showed that it was possible to develop a computerised version of a code. It highlighted the magnitude of the task and the need for good software tools. The shortcomings of the interpreted version of Class were obvious, providing the impetus for a compiled version. This project also identified the need for codes to be logically structured, with good cross-referencing links, if they are to be computerised. The very process of computerisation can identify deficiencies and ambiguities in a code (Hosking et al, 1987).

The ADHESIVE and SEALANT projects identified a future area for the development of Class. Many of the operations were essentially database manipulation. It may have been better to hold this information in a separate database, rather than in the knowledge base, to be accessed by Class with a database interface facility.

Class is a knowledge engineering and knowledge representation language. It consists of a language and facilities that assist a knowledge engineer in the development of a KBS (Mugridge et al, 1987; Hamer et al, 1988).

Class is a very clean language, due to the philosophy that each new language feature forms a network with the existing features, making the language flow continuously rather than discretely.

The power of Class to represent classes of aggregate objects make it a most suitable language for constructing KBS based on codes and design applications.

Class has two environments: one for development and the other for the end-user. The development environment allows a knowledge engineer to perform a number of interactive functions which include: editing, loading, compiling, browsing, and debugging. The knowledge engineer links the developed systems with a custom run-time interface to produce the end-user system. Class features are presented in Appendix A.

Subject Domains

The DAMP project has highlighted the need to have a subject domain with a "well defined boundary". Moisture problems do not form such a domain, covering rain penetration, condensation, moisture movement, and extending to other areas such as insulation, corrosion, fungal and microbiological decay, paint problems, SEALANTs and, especially, human behaviour. As such it may not be possible to complete this knowledge base. Initially it is likely that BRANZ would only be prepared to release DAMP to trained building technologists, who could interpret, check and add to the output.

A subject domain should also have a high degree of technical information reliability, a good presentation level, available human experts, and a reasonable life expectancy.

User

Before a KBS is commenced, it is important to have a clear idea of who the users will be and how they will use the KBS. The system must be seen to offer a significant benefit to users. The possible benefits are an enhancement in performance over other methods with respect to:

- speed
- cost
- effort
- reliability
- problem-solving capability
- flexibility

Both the SEALANT and ADHESIVE projects illustrated the need for a clear idea of the objectives of a KBS and its intended audience. The intention was to suggest generic type of SEALANTs and ADHESIVEs for use. The industry would probably like an extra feature - a listing of currently available brandnames of each generic type. The inclusion of brandnames would considerably increase the size of the KBS, and also raises several legal and policy matters which have not yet been resolved.

This highlighted the importance of communication between users and developers of information systems. At BRANZ this is provided by the BRANZ Information System Coordinator, whose duties include:

- taking responsibility for the online service,
- investigating the appropriate domain of information systems,
- establishing priorities for the development of systems,
- resolving data ownership issues,
- participating in human interface development,
- approving developed systems for distribution on BRANZLINE, and
- marketing the information systems.

Maintenance of the Knowledge Bases

One of the aims of developing a KBS is to preserve the knowledge of an expert. However, a knowledge base, like other software applications, needs to be maintained. This implies that the existence of a knowledge base would not completely free the subject expert, the expert would still have to continue to update the knowledge.

Cooperative Research

KBS technology is advancing rapidly with the spin-offs from global research starting to emerge. BRANZ can not take full advantage of this wave of technology because it has minimal computer staff resources. As it would not have been possible to undertake this expert system development on its own, the ability to use the universities' expertise has been essential. On the other hand, BRANZ has a large resource of building knowledge expertise and information, as well as a good idea of the market needs for this information. The involvement of BRANZ and others with similar backgrounds has been essential to the further development of knowledge-based systems in the universities.

The Associations cooperative research with the KBS Research Unit at the University of Auckland, is the correct strategy for the BRANZ KBS programme. It gives all of the flexibility BRANZ requires: a source code is provided, unlimited licenses, easy access to developers and research expertise, greater control of language direction.

It is interesting to note that the relationship between Auckland University and BRANZ is evolving continuously. It started with the common interest in AI technology which resulted in the FIRECODE contract. Now, although the contract is still being used as the funding mechanism the relationship has become more a partnership.

BRANZ has demonstrated that it is possible to successfully undertake KBS work using the available local resources.

WHAT ARE WE DOING?

BRANZLINE is the main focus of BRANZ work at the moment. As well as the KBS applications that have been discussed in this paper, the association is investigating database and infobase technologies. It is also important to keep up with the hardware and communications advances, which over the next few years should allow a considerable enhancement of the features of the Association's service to the building industry.

A field trial (Fowkes et al, 1988) for KBS was deemed necessary to assess their viability for the building industry. A working group was set up within BRANZ to examine the possibilities and to identify an interested user group which would be prepared to participate.

Contact has been established with two groups of city council building inspectors, they have expressed keen interest in the concept.

None of the then existing KBS prototypes was appropriate for the trial as discussed here. After discussion with the user groups, two new applications were selected for the field trial: WALLBRACE and SUBFLOORBRACE.

WALLBRACE

This system can be used to check that the wallbracing elements of a light timber frame building satisfy the requirements of Clause 6.3 of NZS 3604 :1984 "Code of practice for Light Timber Frame Buildings not requiring specific design". The system also aids a designer in meeting those requirements (Mugridge and Hosking, 1988). Wall bracing checks are required on all housing permit applications to local councils, so a large and continuing use of this KBS can be foreseen.

Other benefits include:

- Ready access to an accurate and consistent system.
- The time for building inspectors to check wall bracing could be greatly reduced.
- The work to date has identified a number of inconsistencies in the code. This will lead to improvements in it.
- The system extends knowledge beyond that provided in the code.

This system is being developed by the KBS Research Unit at Auckland University using a BRANZ staff member as the subject expert.

SUBFLOORBRACE

This system can be used to check proposed designs and assist in the designing of the subfloor bracing of light timber frame buildings as defined in NZS 3604 :1984 "Code of practice for Light Timber Frame Buildings not requiring specific design".

The system will provide a means of rapidly checking that a proposed design for subfloor bracing complies with the standard. It will also provide assistance in designing subfloor bracing for compliance with the standard or, alternatively, provide advice on subfloor bracing.

FUTURE RESEARCH WORK

A recent survey of BRANZ potential research topics identified information technology as being seen as having considerable value to the building industry. The knowledge industry is now being recognised as the fastest growing sector of the economy.

BRANZ strategy is to create a dynamic environment whereby, given there is a requirement for an information package to be disseminated, the right solution can be employed.

KBS Objectives

BRANZ KBS programme objectives in the next 3-5 years can be summarized as follows:

- To investigate how knowlege-based system technology can be applied to facilitate the application of research findings and technical information.
- To provide the building industry with easy access to appropriate expert knowledge.
- To publish and make available KBS technology research findings.
- To test the capabilities of the Class language in the development and delivery of knowledge-based systems.
- To investigate knowledge representation of the information and requirements within building standards and codes.
- To identify guidelines for the development of future codes of practice and to facilitate their use.
- To provide solutions to building technology problems relevant to the building industry.
- To gain experience in using KBS technology for constructing code and design related systems.
- To identify the resource implications of all phases of KBS work.
- To provide an efficient and productive environment for all phases of collecting, developing, storing, transmitting, processing and accessing knowledge.
- To be ready for the spin-offs from AI global research.
- To evaluate the benefits of KBS techniques as compared to conventional techniques.

Future Research Topics

The following shows the topics that BRANZ could be working on:

* NZ Building Code: The aim of this work would be to assist codewriters and administrators in the production of a New Zealand building code. Computerisation of building codes can be tackled from two perspectives. More basically, computerisation can be used to assist in the development of a rational, consistent and efficient building code. New Zealand's current review and major restructuring of its building controls, provides a unique opportunity to computerise the code from its inception. The other focus for research in this area is to help the industry use codes. FIRECODE, WALLBRACE and SUBFLOORBRACE have been projects with this emphasis. Another cooperative project with Auckland university is SEISMIC, an earthquake code KBS. It is to assist building designers to interpret and apply PART C Earthquake Provisions of DZ4203:1986 (Hosking et al, 1988).

● Integrated Computer-aided Buiding Design and Construction: The links between CAD, database, knowledge base, and various building modelling packages such as thermal modelling will produce an integrated and intelligent environment for building design and construction.

* Tools for Assisting BRANZ Staff: Over the last few years BRANZ staff have learned to apply information technology to their work. The result has been a better working environment. There are a number of areas where the technology can be further applied such as image processing, document processing etc.

● Intelligent Building - residential: The application of information technology to the home environment will make a home more enjoyable to live in. It should address household activities such as personal care, house maintenance, communications, security, entertainment, and energy management. The emphasis should be on help for elderly and handicapped people. The coming of ISDN will mean that all NZ homes will be potential BRANZLINE customers.

* Intelligent Building - commercial: This addresses such things as integrated power and communication wirings, and the automation of HVAC equipment.

● Automated Construction: Use of automation and robotics to aid in the construction process.

KBS FOR BUILDING TECHNOLOGY IN NEW ZEALAND

SUMMARY

BRANZ is an information-based organization. Expert systems are potentially a powerful means of presenting knowledge to the building industry.

BRANZ is a suitable place for developing knowledge bases for several reasons. The Association has close links with the building industry, and so it can anticipate potential needs for specific systems. Experts are available at BRANZ. Furthermore, the development is a logical extension of the present computerized information system.

A combination of the right subject domains and the right environment will dictate the success of the KBS programme. Currently, building codes and design problems are seen by BRANZ as the best area from which to choose subject domains.

BRANZ KBS environment needs to continue to evolve in order to keep up with the rate of change of information technology, the growing need of information, and the increasing recognition of the value of information.

Cooperation with Auckland University has been an important strategy in the BRANZ KBS programme. This cooperation has also provided the University with the means to enrich its staff and students in KBS technology.

Class is an excellent language for constructing building codes and design applications. It is being used to develop a number of applications, two of which will be made available for field trials in the 1988-89 year.

BRANZ involvement with research in information technology over the last few years has confirmed that it is not a good strategy to wait for the technology to settle down before utilizing it. As the technology is advancing rapidly, with no sign that it will slow down, active involvement is necessary to ensure the best tools are used.

Knowledge-based systems have the potential to play an important role in the management and transfer of information. The BRANZ KBS programme has utilised university research expertise, knowledge from building technologists and BRANZ communication channels to the building industry, to ensure that the industry benefits from new information technologies.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the contribution made by their colleages at BRANZ and in particular: Roger Fowkes, Harry Trethowen (DAMP), Denis Bastings (FIRECODE), Wayne Sharman (SEALANT), Philip Watkinson (ADHESIVE), Joe ten Broeke (WALLBRACE and SUBFLOORBRACE) Andrew King (SEISMIC), and Christopher Lee (SUBFLOORBRACE). BRANZ would like to acknowledge John Hosking, Rick Mugridge, John Hamer and Chris Fromont of the KBS Research Unit, Auckland university; Grant Coupland (FIRECODE) and John Cranston (SEISMIC).

REFERENCES

Buis, M., (1986): The construction of expert systems. MSc thesis, University of Auckland, Auckland, New Zealand

Buis, M., Hamer, J., Hosking, J.G. and Mugridge W.B.: (1987) An expert advisory system for a fire safety code. Proc. 2nd Aust. Conf. on Expert Systems, Sydney Australia, 92-109.

Buis, M., Hamer, J., Hosking, J.G. and Mugridge W.B.: (1987) An expert advisory system for a fire safety code. In Applications of Expert Systems, J.R. Quinlan (ed), Addison-Wesley, 85-101.

Dechapunya, A.H. (1987). Environment for Research and Development in KBS Proc. 2nd N.Z. conference on Expert Systems Auckland, N.Z., BRANZ Reprint No. 62

Fowkes, A.H.R.,Dechapunya A.H. and Smith, A.G. (1986). The Development of the BRANZ Computerised Information Service. CIB Conference

Fowkes, A.H.R., Sharman, W.R., and Dechapunya, A.H. (1988). The Development of Marketable Knowledge-based Systems. Proc. 3rd NZ conference on Expert Systems Wellington, N.Z.

Fromont, C.J. and Watkinson, P.J. (1988). A Knowledge-based System on the Selection of ADHESIVEs for Wood or Wood-based Substrates Proc. 3rd NZ conference on Expert Systems Wellington, N.Z.

Gevarter, W,B. (1987). The Nature and Evaluation of Commercial Expert System Building Tools. Computer, May 1987

Hamer, J., Hosking, J.G. and Mugridge, W.B.: (1988) The evolution of Class Language. Proc. 3rd NZ conference on Expert Systems Wellington, N.Z.

Hissink, M.D. (1985). Local Data bases in New Zealand, BRANZ, Conference Paper 8

Hosking, J.G., Mugridge, W.B. and M. Buis: (1987) Expert systems for regulations and codes. Proc. 2nd New Zealand Conf. on Expert Systems, Auckland, N.Z., BRANZ Reprint No 66

Hosking, J.G., Mugridge, W.B. and Buis M.: (1987)
FIRECODE: A case study in the application of expert systems techniques to a design code. Environment Planning and Design B, 14, 267-280.

Hosking, J.G., Mugridge W.B. and Hamer J.: (1987)
A knowledge-level analysis of the DAMP problem,
Proc. 10th New Zealand Computer Conference,
Christchurch, New Zealand, R-29 - 40

Hosking, J.G., Lomas S. and Mugridge W.B.: (1988)
The Development of an Expert System for Seismic Loading
Symposium on Knowledge-based Systems in Civil Engineering
Melbourne, AUSTRALIA

Mugridge, W.B., Hamer, J. and Hosking J.G.: (1987)
Class language - a language for building expert systems.
Proc. 2nd New Zealand Conf. on Expert Systems,
Auckland, N.Z., BRANZ Reprint No 67

Mugridge, W.B. and Hosking J.G.: (1988)
The development of an expert system for wall bracing design.
Proc. 3rd NZ conference on Expert Systems
Wellington, N.Z.

Sachdeva, P. (1985).
DAMP- a Diagnostic System for Architectural Moisture Damage Problems.
The Australian Computer Journal, Vol. 7 No. 1

Trethowen, H.A. (1987).
The Knowledge base - Will the Frog turn into a prince?
Proc. 2nd N.Z. conference on Expert Systems
Auckland, N.Z., BRANZ Reprint No. 61

Whitney, R.S. and Dechapunya, A.H. (1985)
The Development of a BRANZ Computerised Building Technology Information Resource.
AUBEA/AOSITE 85 Conference, BRANZ Reprint No. 40

Whitney, R.S. and Dechapunya, A.H. September (1985).
The Building of a System
Interface: Journal of the NZ Computer Society Inc.

Whitney, R.S. (1987).
Knowledge-based Systems for Building Technology
Proc. 2nd N.Z. conference on Expert Systems
Auckland, N.Z., BRANZ Reprint No. 60

APPENDIX A

SUMMARY OF CLASS FEATURES

Functional Uses	Class version 2.6 attributes
Classification	Yes
Code Interpretation	Yes
Design	Yes
Selection	Yes
Knowledge Representation	
- Object-oriented	Yes
- Deep world representation	Yes
- Inheritance	Yes
- Procedural attachment	Yes
- If-Then rules	Yes
- Uncertainty	No
Inference	
- Forward chaining	Limited
- Backward chaining	Yes
- Classification	Yes
- When rule	Yes
- Procedural control	Yes
- Context (viewpoints, worlds)	In next version
Knowledge Engineering Environment	
- Ease of learning	Acceptable
- Documentation	Adequate
- Online documentation	Yes
- Development Speed	Satisfactory
- Interactive environment	Yes
- Knowledge checking	Yes
- Compiling	Yes
- Debugging	Yes
- Browsing	Yes
- Windowing	In next version
- Graphics	In next version
End User Interface	
- Line menu	Yes
- Rollback	Yes
- Online help	Yes
- Session saved	Yes
- Runtime speed	Acceptable
- Explanation	Limited
- Windowing	In next version
- Graphics	In next version

System Interface

- Interface to operating system	Yes
- C interface	Yes
- Prolog interface	Yes
- Database interface	In next version

Others

Programming languages used	Prolog, C
Compilable	Yes
Operating systems	VMS, UNIX

Knowledge-based systems for building
technology in New Zealand

BUILDING RESEARCH ASSOCIATION OF NEW ZEALAND INC.
HEAD OFFICE AND LIBRARY, MOONSHINE ROAD, JUDGEFORD.

The Building Research Association of New Zealand is an industry-backed, independent research and testing organisation set up to acquire, apply and distribute knowledge about building which will benefit the industry and through it the community at large.

Postal Address BRANZ, Private Bag, Porirua

ISSN 0111–7459