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A Durability Assessment Tool for the New Zealand Building Code

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ABSTRACT

Materials and construction methods continue to evolve. The empirical knowledge derived from traditional building practice is often insufficient for predicting durability problems with emerging materials and construction techniques. Consequently the capability for robust durability assessment of new products and techniques is an essential platform for supporting an innovative, dynamic building industry.

The New Zealand Building Code (NZBC) is primarily performance-based: only for a few classes of materials, such as timber and concrete, do prescriptive 'deemed-to-satisfy' solutions exist. For other situations, the Code offers only the advice that suitable durability performance may be demonstrated through laboratory testing, a documented history of use, or by analogy with the behaviour of similar building components. Little further guidance is provided concerning how these criteria might be satisfied in practice.

In response, this paper describes the development of an overarching durability verification framework for assessing building materials, components and systems under the NZBC. The aims of the project include systematising existing durability knowledge and verification methods, identifying critical knowledge gaps to guide future research, and making this information available in a convenient manner to a wide range of potential users. The latter goal is achieved through the development of an interactive web-based interface to the underlying information.

KEYWORDS

Durability, verification, knowledge, database.

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1 INTRODUCTION

It is hardly surprising that a strong demand for robust durability research and information has featured repeatedly on building industry needs surveys. Functional and durable construction is essential both for the health and well-being of owners and occupiers and the credibility of the industry. Consequently, the consideration of materials performance is critical over the entire building life-cycle, from initial construction to in-service maintenance, and finally renovation, alteration or retrofitting.

Furthermore, while operation normally accounts for the largest proportion of environmental costs over the life-cycle of a building, the intrinsic service life of the structure lies at the core of the concept of sustainable construction. Until durability performance can be predicted accurately, the feasibility of assessing the sustainability merits of alternative construction styles at the design stage remains doubtful.

2 DURABILITY UNDER THE NZBC

Ensuring that buildings have an appropriate durability has always been an important aspect of building regulations. This is emphasised by the current NZBC, which includes the functional requirement that: "*Building materials, components and construction methods shall be sufficiently durable to ensure that the building, without reconstruction or major renovation, satisfies the other functional requirements of this code throughout the life of the building*" [Building Industry Authority 1992].

The NZBC is a performance-based rather than prescriptive code, intended to permit innovative solutions and minimise the constraints placed on building design or choice of materials and techniques, providing the mandated minimum performance levels are achieved. The Code's B2 Durability clause is the single exception to this philosophy, setting default lifetimes for building elements depending on their criticality of function and ease of replacement (Table 1). These durability provisions apply to any part of the building which is fulfilling another Code requirement (e.g. structural stability or fire performance) but do not extend to aesthetic considerations.

Table 1. A summary of the performance requirements for building elements specified by the NZBC B2 Durability clause. Note that the mandated service life allows for routine maintenance, but not reconstruction or major renovation.

Nature of Building Element	*Required Service Life*	*Typical Examples*
(i) Provides structural stability, *or* (ii) Difficult to replace, *or* (iii) Failure undetectable thorough normal maintenance regimes	50 years	▪ Load-bearing walls ▪ Buried electrical wiring ▪ Building wraps behind masonry veneer walls
(i) Moderately difficult to replace, *or* (ii) Failure undetectable during everyday occupancy of building	15 years	▪ Building envelope cladding ▪ Sealants and flashings
(i) Easily replaced, *and* (ii) Failure readily apparent	5 years	▪ Architectural coatings ▪ External gutters

The reason for retaining this prescriptive aspect in an otherwise performance-based code is essentially one of consumer protection: it was considered inappropriate to allow the service life of buildings to be effectively set by market forces, particularly given that a significant proportion of owners would have little expertise in evaluating the relative benefit of construction styles and materials [Bennett 1998]. Note that despite this prescription, the choice of materials for producing building elements of the required durability is left unregulated.

2.1 Industry reaction

Specifying durability in terms of building element service life has a number of drawbacks. These include the issues of perception involved in judging difficulty of replacement and the potential mismatch between Code requirements and the expectation of owners who, for example, are often surprised to discover the roof of their house only needs to last 15 years. Chown and Oleszkiewicz [1997] offer some of the most telling criticism of this approach, noting that it may only be truly practical where the building element in question is essentially inaccessible (so that service life is independent of maintenance) and the rate of deterioration under the in-service environment is known. Otherwise, building designers, certifiers and owners assume a significant burden in determining and documenting material and component service life in various environments, based on an assumed level of maintenance. Often the information necessary to do this rigorously is not readily available.

This contention is supported by a survey of construction industry perspectives on the issue of durability and the B2 clause in particular [Clark and Bennett 2001]. As shown in Fig. 1, lack of reliable information was widely cited by survey respondents across all sectors of the industry as a primary barrier to the achievement of durability design.

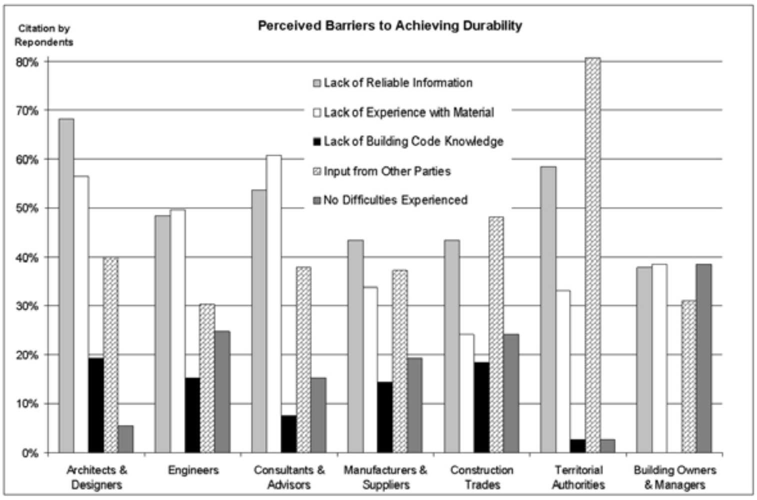

Figure 1. Perceived barriers to achieving the NZBC durability requirements, as identified by surveying the New Zealand construction industry. Data from Clark and Bennett [2001].

Perhaps the perception of an absence of reliable information is unsurprising, given that the same respondents identified ‘trade literature’, ‘industry information’ and ‘past experience’ as the most important sources of information concerning the durability of building materials (Fig. 2). It is also notable that the industry places a good deal of reliance on fitness-for-purpose systems appraisals similar to the European Agrément system.

One particular disappointment, given the reliance on trade literature, is that manufacturers have proven reluctant to invest the time and money necessary to establish reliable service life; formal declarations of Reference Service Life and the tabulation of modification factors, as described in ISO 15686-1 [ISO 2000], are almost unknown despite the usefulness of the concept.

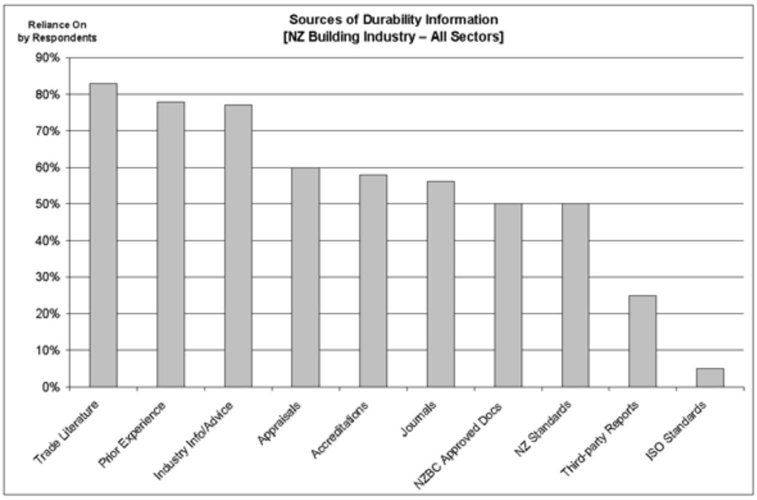

Figure 2. Importance of durability information sources, ranked from survey respondents in the New Zealand construction industry. Data from Clark and Bennett [2001].

2.2 Establishing compliance

Part of this difficulty arises because, despite the unquestioned importance of the subject, there is no broadly applicable methodology available to verify that building materials, components and construction methods will meet the performance requirements of the NZBC B2 Durability clause. Manufacturers and, especially, the statutory bodies responsible for certifying buildings as compliant with the Code, frequently wish to rapidly assess the expected service life of a new material, or even a conventional one in a new environment. The absence of a list of specific test methods that will generate a 5, 15 or 50 year durability rating is consequently a source of frustration.

For a restricted range of building materials and techniques, the NZBC incorporates the concept of ‘Acceptable Solutions’; prescriptive construction methodologies that, followed to the letter, will ensure Code compliance. Acceptable Solutions primarily exist for time-honoured construction methods (e.g. timber-framed or concrete construction, earth buildings) that draw on a background of many years’ actual service history and development under New Zealand conditions. Even where an Acceptable Solution ordinarily covers durability compliance, the situation becomes complex when new materials with uncertain capability and interactions are introduced. A topical example in New Zealand is the marketing of copper azole (CuAz) and alkaline copper quaternary (ACQ)-based preservatives as a replacement for the environmentally less favourable copper-chrome-arsenic (CCA) treatment traditionally used to improve the durability of *Pinus radiata* timber. Recent research [Kear et al 2007] has demonstrated a significantly enhanced risk of zinc corrosion with these newer treatments, placing into question the established specifications for galvanised fastenings. When such developments occur, there is a pressing need both to effectively disseminate the research findings to practitioners and to provide robust guidelines for assessing the durability of the new materials.

In cases where an explicit durability evaluation is required, the NZBC documents an approved verification methodology, known as B2/VM1. Unfortunately B2/VM1 offers only the generic guidance that proof of performance should be demonstrated by in-service history, laboratory testing, or analogy with similar products/situations. Anyone involved with materials testing will appreciate that this advice is both valid and a profound over-simplification of the process required. In practice, there is no shortage of durability-related test methods for a vast variety of materials and potential applications. However, a considerable amount of skill is necessary to collate and synthesise this information in a reliable and appropriate fashion. Examples of the need for expert judgement include: considering whether the degradation methods in accelerated tests (heat, moisture cycling, freeze-thaw, UV exposure etc) are appropriately matched to real-world causes of deterioration; assigning quantitative service life predictions on the basis of qualitative rankings of observed durability; and assessing likely variation in performance due the different macro- and micro-climates, materials interactions, intensity of use and maintenance that come with a specific instance of use on a particular building.

The provision of additional information is an obvious next step to ameliorating these difficulties and removing the barriers to durability design identified in Clark and Bennett [2001]. The standards published, and in preparation, for the ISO 15686 series on 'Design Life' provide valuable guidance and a uniform approach to the assessment of durability. However, whether this knowledge can easily be assimilated into future Code revisions remains unresolved. Also, the intent of these documents is not to provide details on the durability of specific materials, or even prescriptive methodologies for the determination of durability. Consequently, to solve the practical and immediate challenges faced by the New Zealand construction industry, there is a demand for more specific guidance documents that will take into account the properties of construction materials, their potential uses, and their performance in the environments within which they are likely to be used. The BRANZ Durability Assessment Tool is a response to this need.

3 BRANZ DURABILITY ASSESSMENT TOOL

BRANZ is an independent provider of information, research, materials testing and consultancy services to the building and construction industry, with a predominant focus on the needs of New Zealand clients. The Durability Assessment Tool is an initiative to improve the breadth, completeness and cogency of durability information available to the local industry. In essence, it involves the compilation of a database of authoritative and independent durability and compatibility information that covers the building components and materials commonly used in residential construction. Ultimately it is anticipated that this will be delivered as an interactive web-based tool, with the potential to generate an audit trail for verification of compliance with the service life requirements of the NZBC. To succeed in this role, the database will serve both as a convenient 'roadmap' to existing Acceptable Solutions and as an actively evolving repository of new information and research, generated both at BRANZ and elsewhere.

The delivered tool is intended to be helpful to people with a wide range of knowledge and experience. Envisaged users include designers, statutory bodies, manufacturers and wholesalers, in addition to building science researchers.

3.1 Expected outcomes

The Durability Assessment Tool is explicitly expected to provide the following benefits:

- A catalogue of existing durability information, including précis of, and references to, current Acceptable Solutions.
- A resource for the development of compliance methods for novel building materials and a means of exposing these ideas to the wider industry for critique.
- An explicit mapping of gaps in durability knowledge for current building materials and environments of use, serving to focus the direction of future research.
- A potential method to demonstrate the compliance of a building with the B2 Durability clause of the NZBC.

On a broader theme, the hope is to provide the industry with the appropriate knowledge, tools and confidence to produce durable buildings that meet or exceed their owner's expectations of performance. Research by Nana [2003] has also demonstrated the potential for a substantial economic benefit from efficiency gains in building and construction due to a knowledge-rich construction sector.

The choice of a computer-driven database over printed material for delivery reflects both the need to manage the complexity of the collected information and the increased use of online resources for information seeking due to time scarcity. The integrated and commercially-neutral nature of the web tool is intended to counter two of the principal drawbacks of online research: sophisticated search engines such as Google are domain independent, which can lead to information overload – 1.4 million hits for 'building durability' – while portals specifically targeted to the construction industry are often compromised by their marketing focus.

3.2 Design

The current framework for communication with the database, shown in Fig. 3, has a modular structure designed to provide answers to three basic questions:

1. *What are the **Performance Requirements** of the NZBC for a nominated building component?* To begin, the user selects the building components of interest, either by keyword search or point & clicking on interactive graphical models of a house. The database returns the corresponding required service life. The durability demand for the component is a function of location and purpose, not composition, so this information can be easily updated with future revisions to the Code.

2. *Which **Verification Methods** are suitable to demonstrate the requisite performance?* At this point the user defines the composition of the component and the environment under which it has to perform. From this, the database returns an existing ***Acceptable Solution*** (typically existing national standards containing durability test methods), an appropriate ***in-house BRANZ verification method***, or the answer that ***no reliable service life prediction*** method is presently available. Fig. 4 shows an example screenshot. These two modules together (*Performance* and *Verification*) will determine B2 Durability clause compliance for the NZBC, and may be all some users (e.g. statutory authorities) are likely to be interested in.

3. *What **Specialist Advice** underlies this information?* This module provides the justification for the earlier material and a compendium of durability information organised under uniform tabbed subject headings, as shown in Fig. 5, which will grow and develop as new information such as research results become available. Gap analysis of this collection of information also generates the roadmap for future research.

The purpose of this structure is to provide a clear division between normative and informative material (i.e. Code requirements vs advice) and it simplifies modification in case of changes to mandated durable life. The structure also allows a single model to be maintained for multiple classes of user.

3.3 Project status

With the preliminary design concept developed, current effort at BRANZ is focussed on populating the database with sufficient information to allow the most pressing gaps in current durability knowledge to be identified and prioritised. A working prototype of the interactive web tool is currently in development for distribution to interested parties to provide the feedback necessary to evolve improvements in the interface and functionality.

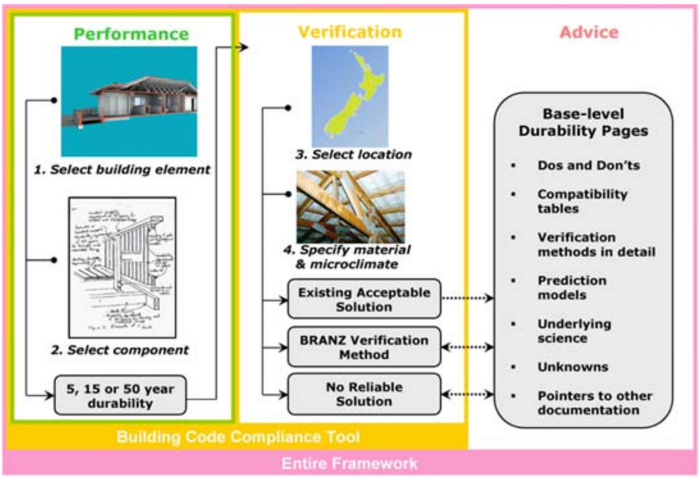

Figure 3. Conceptual framework of the Durability Assessment Tool.

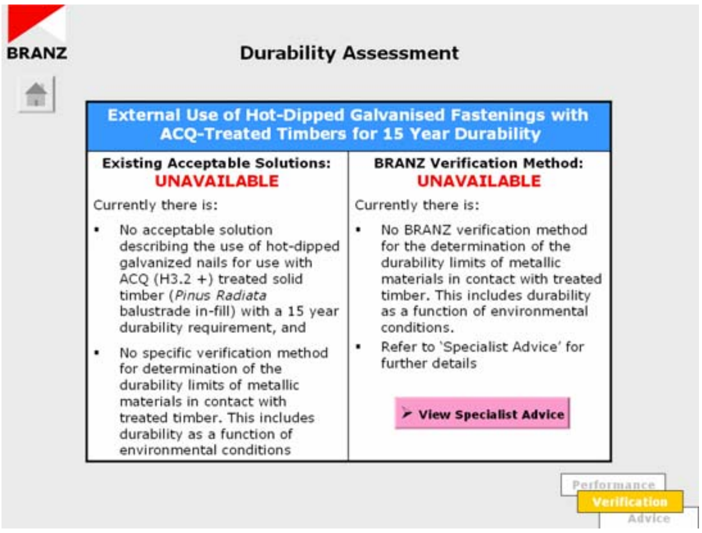

Figure 4. Example results from 'Verification' module use of for hot-dipped galvanised fastenings.

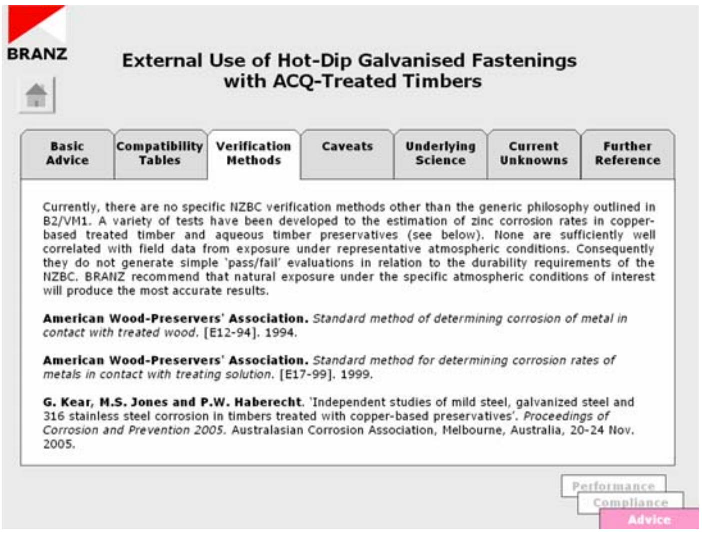

Figure 5. Example guidance from 'Advice' module for ascertaining durability of hot-dipped galvanised fastenings when used with ACQ-treated timber.

4 CONCLUSIONS

New Zealand has had a mandatory requirement for durability in its national Building Code since 1992. In theory this should have stimulated industry awareness of the issues behind achieving appropriate service life of building materials and foster an active interest in the development of standards and methodologies that could facilitate good durability design.

In practice, the transition from prescriptive to performance-based solutions has not been without its difficulties and the potential innovative and economic benefits have yet to be fully realised. New Zealand is a small country and there are few independent organisations with the technical resources and breadth of expertise to carry out rigorous assessments of materials durability. This is particularly evident when new, or composite, building systems are introduced to the market.

While based on sound scientific and engineering precepts, durability assessment remains as much art as science. This should change as the adoption of uniform assessment philosophies facilitates reliability-based service life prediction techniques. However, from a pragmatic perspective it is still essential that researchers, manufacturers and standards bodies continue to develop and refine predictive test methods for individual materials and their applications. It is hoped that the Durability Assessment Tool will prove a compelling initiative to collect these methods in a convenient and user-friendly form, promulgate them through the construction industry and stimulate the development of new ideas and techniques.

ACKNOWLEDGMENTS

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