

DESIGN FOR DURABILITY – A REVIEW OF NEW ZEALAND PRACTICE

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ABSTRACT

The activities of ISO TC 59 SC 14, CIB W80 and CIB W94 are all focussed on improving the service life of buildings and their parts. This paper reports on a review of design for durability as practised in the construction industry in New Zealand in 2000. The review was organised as part of the activities of CIB W94 and also reflects the responsibilities and interests of the two organizations sponsoring the review.

New Zealand has had a mandatory requirement for durability in its national Building Code since 1992. In theory, this should have resulted in an increased awareness of the issues behind achieving appropriate durability through the design process, and an active interest in the development of standards and methodologies that could facilitate good durability design.

This paper identifies which sectors of the construction industry are involved in 'design', and how formalised their role is. The response from each sector was analysed to determine their awareness of durability requirements (both regulatory and customer sourced), sources of durability information and knowledge of underlying durability principles.

The state of design for durability in New Zealand is summarised and areas where improvement is desirable are identified. Initiatives to advance in these areas are briefly discussed.

KEYWORDS

Durability design; CIB W94; Performance-based codes; Buildings.

INTRODUCTION

Most societies have an interest in producing infrastructure that performs satisfactorily over its intended design life. Traditionally, this has meant designers and owners looked for ways to enhance the durability and longevity of buildings and other infrastructure. While this has resulted in an increased understanding of materials performance, societal, demographic and technological changes often result in a building becoming obsolete before it reaches the end of its useful life. The objective of the designer is not simply to make a building last as long as possible, but to ensure the building is capable of meeting the design life specified by the client and any local and central government regulations. To achieve this, there must be a consideration of materials performance in the design and materials selection process, as well as the provision of maintenance requirements to building owners. A considerable amount of information has been published on assessing the durability of individual materials and components, and national and international standardisation bodies have prepared many standardised test methods. Guidance on how to carry out service life prediction has also been published by the RILEM 140-TSL/CIB W80 committee (Masters and Brandt, 1989) and more latterly, ISO TC59/SC14/WG1 (ISO, 2000). Methodologies that assist in the assessment of durability are important, but do not by themselves, ensure that appropriate design decisions are made. A link between the often-complex information that can result from a durability assessment and the designer is required. Some initiatives in this area have already been taken with British Standards Institution publishing BS 7543 and the Architectural Institute of Japan publishing

a guide for service life planning (AIJ, 1993). CIB Working Commission W94 '*Design for Durability*' was formed to help further the link between service life prediction and design.

The objectives of W94 are:

- To provide an international focal point for discussions on design approaches for utilising the knowledge on building materials and durability of components, established by PSL (prediction of service life) research.
- To initiate research to develop an internationally accepted design methodology which makes it easy and natural for a designer to include durability in the design procedure.
- To formulate a theoretical basis for the development of information systems for the durability design process.
- To provide practical knowledge on building design as a basis for recommendations on an international and national level, design guides and education.
- To provide guidelines for the presentation of research results in scientific publications in order to improve communication between researchers and practitioners.

One of the current activities of CIB W94 is to assess what the current state of the art in design for durability is in various countries. A questionnaire form has been posted on the homepage <http://www.iris.ba.cnr.it/webiris/CIBW94/questio.htm> to find out how designers address design for durability and therefore identify ways in which it can be improved.

NEW ZEALAND SITUATION

Building regulations in New Zealand until 1992 were prescriptive and specified how buildings should be built. Durability was implicit in the standards referenced in the regulations but no particular design life was set out. This changed in 1993 when a performance-based national building code replaced the previous regulations. One of the unique features at the time it was introduced, was the provision of a durability clause that set default lifetimes for buildings and their components. The New Zealand Building Code (NZBC) covers health and safety. Aesthetic and comfort issues are not relevant to this legislation.

More details on the NZBC and its durability requirements can be found in Bennett (1998), and only a summary is given here. The basic tenet of the regulations is that buildings have a default life of 50 years unless a lesser life is nominated. Longer design lives may be specified under contract law but are not part of the NZBC requirement. Items that provide structural stability, items that are difficult to access or replace and items where failure would be difficult to detect have a 50-year durability requirement. Easy to access and replace items have a 5-year requirement and items that fall between the 5 and 50-year criteria have a 15-year requirement. Prospective builders/designers/owners are obliged to provide evidence that a proposed building will comply with the durability provisions before permission to build is given. Some ways to provide acceptable evidence can be:

- showing compliance with 'Approved Documents'
- using 'Accredited' components and systems.
- history of use.
- expert opinion.

A survey of the industry's familiarity with the durability requirements in 1995 showed that the general knowledge of the clause was limited and compliance relied primarily on existing 'Approved Documents'. Given that seven years have passed, it might be anticipated that New Zealand designers should now be familiar with designing for durability and that newly constructed buildings should have a high level of code compliance.

The five years elapsed since the first review of the NZBC's durability clause made it appropriate to carry out a second review in 2000. As part of the review process, feedback from a wide range of industry participants was required. A survey of industry was proposed to provide feedback on industry experiences with the NZBC B2 Durability requirements. The survey would also answer some of the questions posed by the CIB W94 survey.

SURVEY

The survey was designed with three components. Firstly, a postal survey was sent to approximately 200 industry participants. Secondly, seventy additional participants were selected for face-to-face interviews. The third part was an open invitation to any interested party with comments on durability to send comments directly to the organisers. The latter invitation was publicised in trade journals to ensure wide industry coverage. A database of approximately 12,000 industry members maintained by BRANZ for industry publications was used as the main source for sample selection. The three largest centres were heavily represented in the sample and several smaller and more rural regions also included to ensure feedback reflected a wide cross-section of industry members.

Table 1. Target survey sample

	<i>Target Postal</i>	<i>Target Interviews</i>	<i>Total Targets</i>	<i>Completed Postal</i>	<i>Completed Interviews</i>	<i>Total</i>	<i>% of targets</i>
<i>Architects</i>	20	6	26	15	7	22	85%
<i>Designers</i>	20	6	26	13	0	13	50%
<i>Engineers</i>	28	8	36	13	7	20	56%
<i>Manufacturers</i>	25	8	33	9	8	17	52%
<i>Roofers</i>	6	2	8	6	2	8	100%
<i>Builders</i>	25	8	33	17	5	22	67%
<i>Plumbers</i>	7	3	10	7	0	7	70%
<i>Owners</i>	25	8	33	8	5	12	39%
<i>Consultants</i>	10	3	13	9	4	13	100%
<i>TAs & Certifiers</i>	35	12	47	28	8	36	77%
<i>Window Suppliers</i>	6	2	8	2	1	3	38%
<i>Painters</i>	6	4	10	0	1	1	10%
TOTALS	213	70	283	127	48	175	62%

Response rate from postal targets **60%**

Response rate from interview targets **69%**

Total response rate **62%**

The survey was set up to gain information about a number of topics. One of the most important aims was to identify who is involved in specifying materials and systems. This has often been considered the domain of the designer and engineer, but feedback to BRANZ has indicated that a wide range of trades and owners are either specifying or, influencing the specification of materials. If this is the case, then it is unlikely that all of these participants would be familiar with materials performance issues. It was of equal interest to find out who each participant in the construction process considered was responsible for durability decisions.

RESULTS AND DISCUSSION

As shown in Table 1, the rate of completion for the survey was 69% for interviews and 60% for the postal surveys, giving a total response rate of 62%.

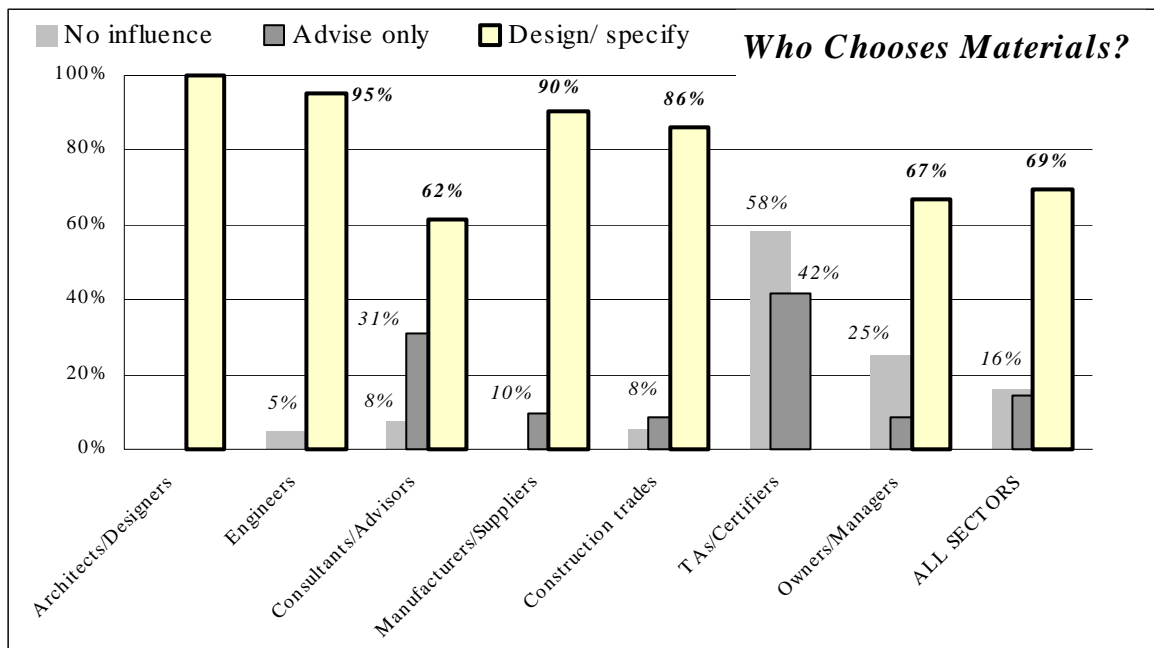
Who is involved in specifying materials?

Figure 1 summarises the responses from those surveyed as to their role in specifying materials. Not surprisingly all architects and designers acknowledged that this was part of their role. The high response from engineers (95%) is also not surprising given their traditional role in building design. Building consultants, with 62% response as involved in materials selection, cover a wide range of expertise and are often involved in proposing remedial work following investigation of building faults.

More surprising is the high response from some of the other respondents surveyed. Manufacturers have always played an important role in materials design through the provision of technical literature that allows designers and engineers to select the appropriate material for a specific use, and the design of proprietary building components or systems intended to be installed in a building. That 90% of the manufacturers who responded are involved in specifying materials suggests that their role has increased somewhat over the past decade. Part of the reason may be because of the increasing use of 'design and build' building elements where the detailed design is handled by the manufacturer (an example of this would be a proprietary skylight where the manufacturer specifies the required flashings, fixings, glass etc.). As noted later in this paper, an increase in perceived legal liability due to the inclusion of a durability clause into the NZBC may also be influencing this change.

Builders and roofers/plumbers clearly indicated that they are specifying as well as advising clients on materials selection. However, similar to the situation for manufacturers, an owner is likely to select a base material but will leave the tradespeople to choose all of the underlying support components that are necessary to turn the material into a complete system. An example of this will be an owner selecting a particular type of roofing material, with the roofer then selecting the flashings, fixings, ties, gutters, underlays and so on as necessary to turn that material into a functional roof.

Figure 1. Who chooses materials?



Territorial authorities (TAs) and building certifiers are responsible for ensuring that building plans are compliant with the NZBC. As such, specifying materials would create a conflict of interest with their role of checking for code compliance. While not specifying, they are clearly having a significant impact on materials selection as seen in the high response level for advice by this group. Owners are also playing a role in selecting materials.

The high level of involvement of those normally considered outside the design profession in materials specification, may be in part explained by differences in the commercial building sector and domestic housing construction. With commercial building projects, involvement of designers and engineers is effectively obligatory since most involve specific design. Most houses however, are built to conform with a non-specific design Standard NZS 3604 (Standards New Zealand, 1999) which is called up as a means of showing compliance with aspects of the NZBC. This means that specialist design and engineering input can be dispensed with and owners and builders can produce their own plans. Many architects also use the non-specific design Standard wherever possible. Professional designers are thought to be fully involved (from design to completion) with the minority of new houses, a situation that has remained

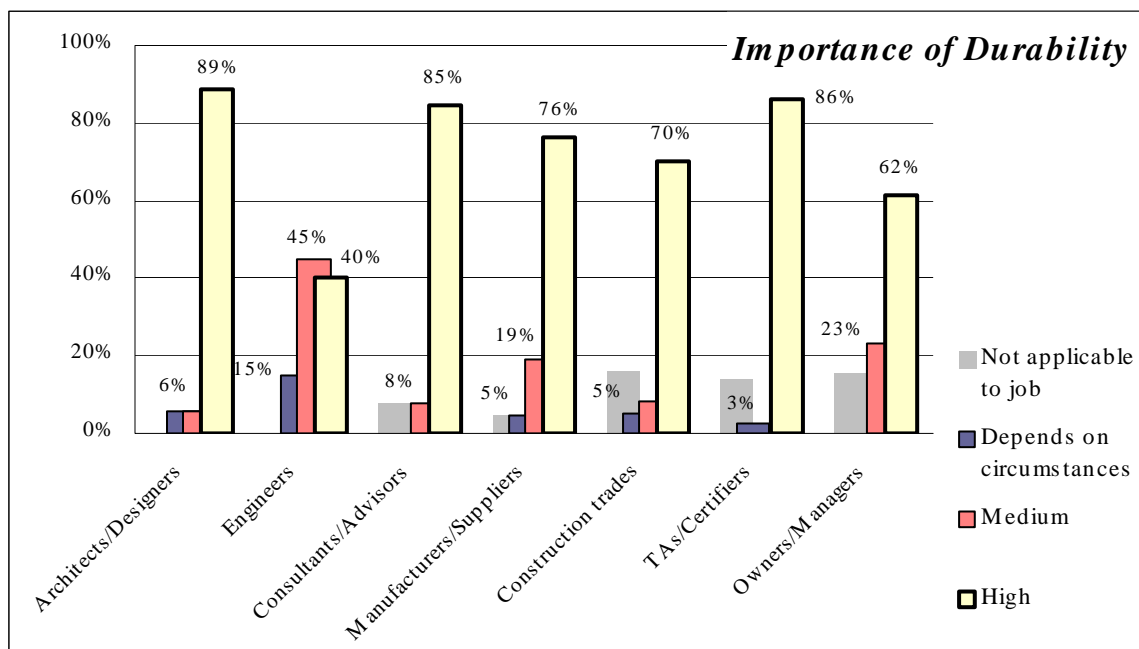
largely unchanged during the past century. Most new houses are still produced by housing development companies, who produce a range of standard pre-approved designs that allow a limited range of owner-selected options on materials. Here again, owners may choose some base materials, but will rely on others to provide the necessary support components.

How important are durability issues?

Figure 2 summarises the responses as to the importance of durability. Durability was rated as an important issue by most of the groups surveyed. Surprisingly, it received the lowest rating from engineers who were split between considering durability as being of high and of medium importance. Engineers are in most cases involved in the structural design of a building and while specific durability requirements were not mandatory in New Zealand prior to 1992, the client’s expectation of the life of a structure has generally been more than 50 years. For many engineers therefore, the introduction of NZBC B2 has had little effect on engineering design practice.

Comments from many of those interviewed indicated that durability has become increasingly important since the introduction of the NZBC, with particular emphasis coming recently from the Standard referred to earlier in this paper (NZS 3604:1999), which has focussed attention by including a section that deals with durability issues for the first time. This is the most commonly used building standard by house designers and builders, and is likely to directly influence these sectors.

Figure 2. Importance of durability



What does durability mean?

Figure 3 summarises the responses from those surveyed as to what the term durability meant to them. It was expected that it would mean different things to different sectors, and respondents were able to choose any number of meanings from a provided list of options, and to add additional meanings should they choose to. As expected, the most popular answer was in line with that implied by the Building Code i.e. assuming normal maintenance, the length of time that a building element continues to perform its function. The next most popular answer was “A NZ Building Code Term”. The latter leads to the former, so that these two meanings may be jointly considered. Not surprisingly, all TAs, building certifiers, manufacturers, engineers and architects chose one or both of these meanings. However, it was interesting to note that other meanings were also considered to have a bearing on durability. Warranties were particularly important to owners, manufacturers and the construction trades. To owners, this is presumably because they receive the warranties and perceive them as a ‘certificate’ of durability. To the others, this appears to be because they are the ones who supply the warranties.

As mentioned earlier in the paper, there appears to have been a growing recognition of perceived liability since the inclusion of durability requirements in the NZBC, and interviews have revealed this to be a major reason for the concentration on this as one meaning of durability. Appearance was also an important meaning for designers and the construction trades. The explanation given during interviews was that this is what would first prompt owners to think that something was wrong with the material, and to seek some remedial action. This response by homeowners was also observed during the most recent BRANZ house condition survey (Clark et al, 2000).

Figure 3. Meaning of durability

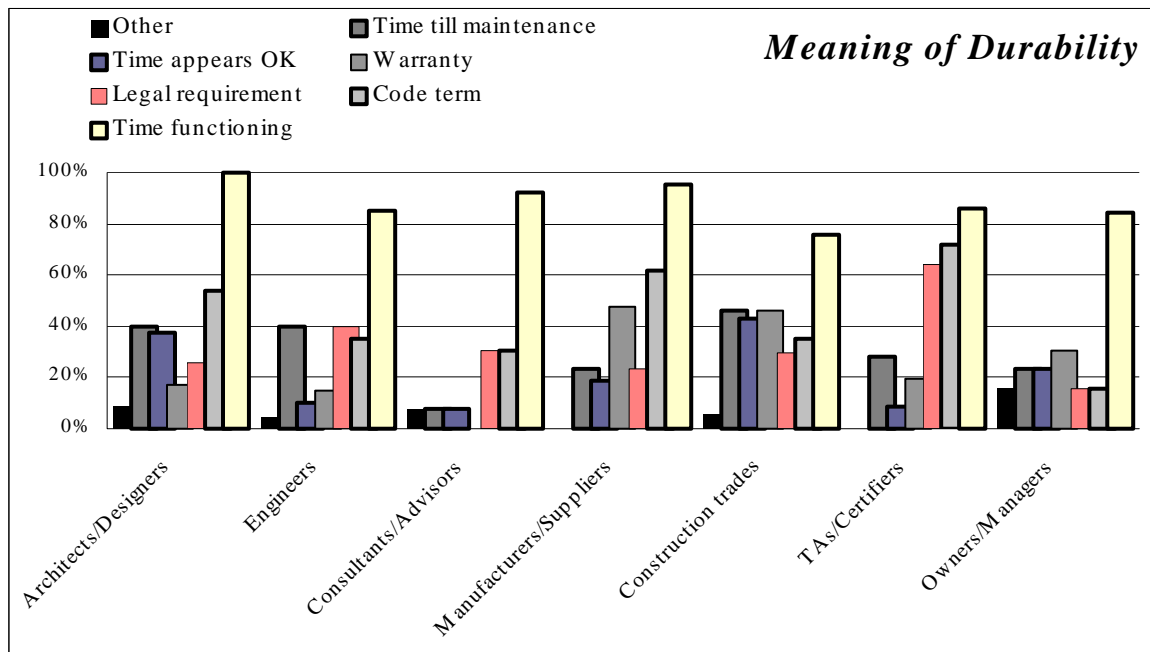
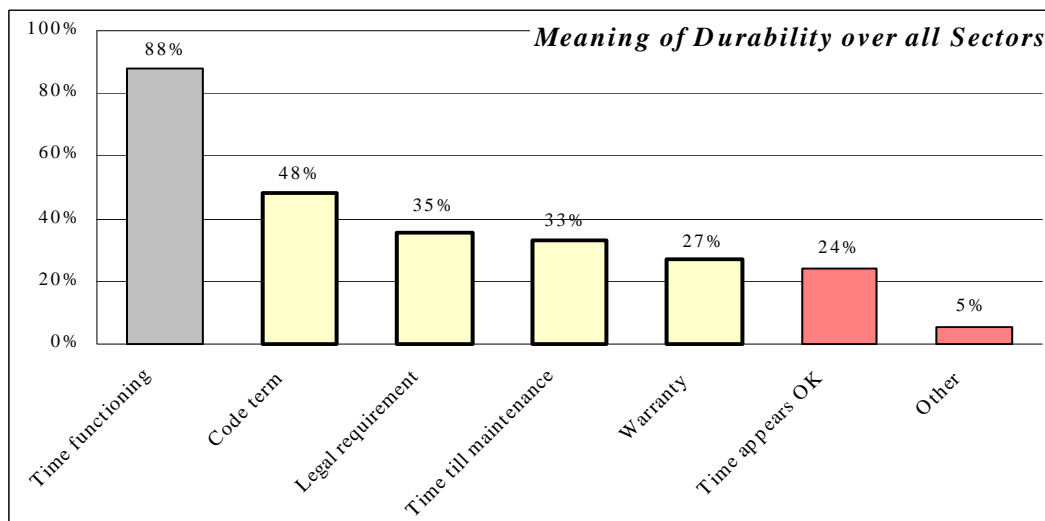


Figure 4 shows these meanings over all of the sectors surveyed. As shown, a third of the respondents chose “the amount of time before maintenance is needed” as one meaning of durability. Sectors most likely to choose this meaning were design professionals and the construction trades. Architects and engineers when questioned on this during interviews commented that it was because of the role of maintenance in durability. With good maintenance, they argued, a building’s life may be extended indefinitely, and more emphasis should therefore be placed on this as a prime requirement for durability.

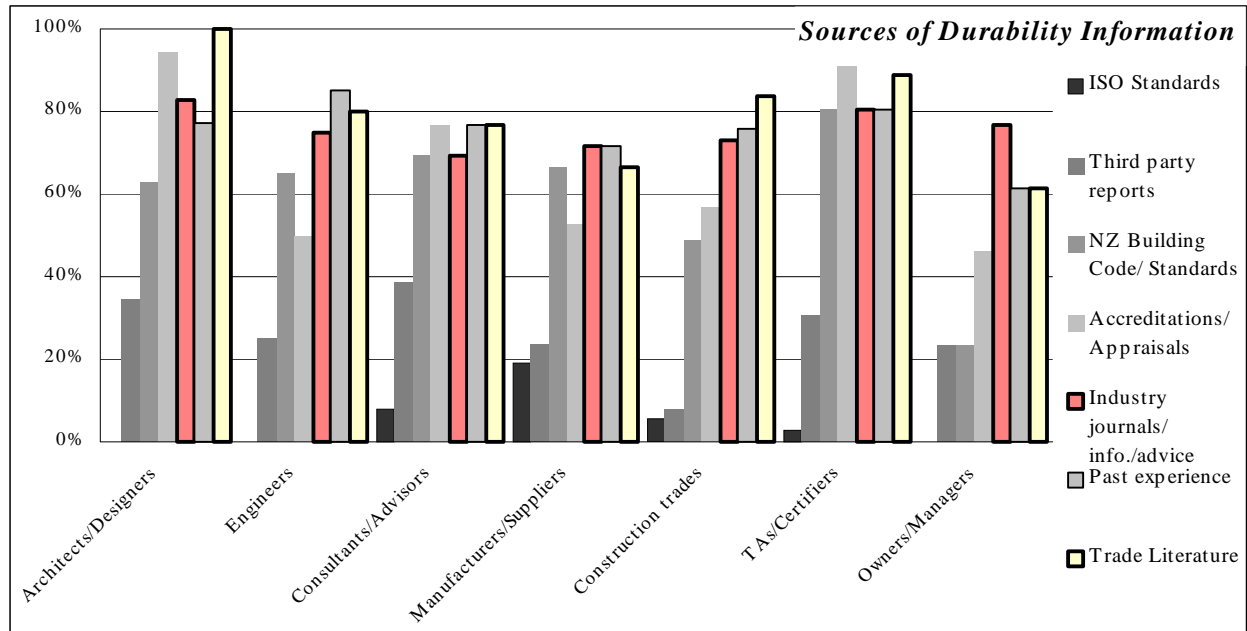
Figure 4. Meaning of durability (across all sectors)



Where do they get their information?

Figure 5 summarises the responses as to the source of information about durability. The two most common sources were trade literature and past experience.

Figure 5. Sources of durability information



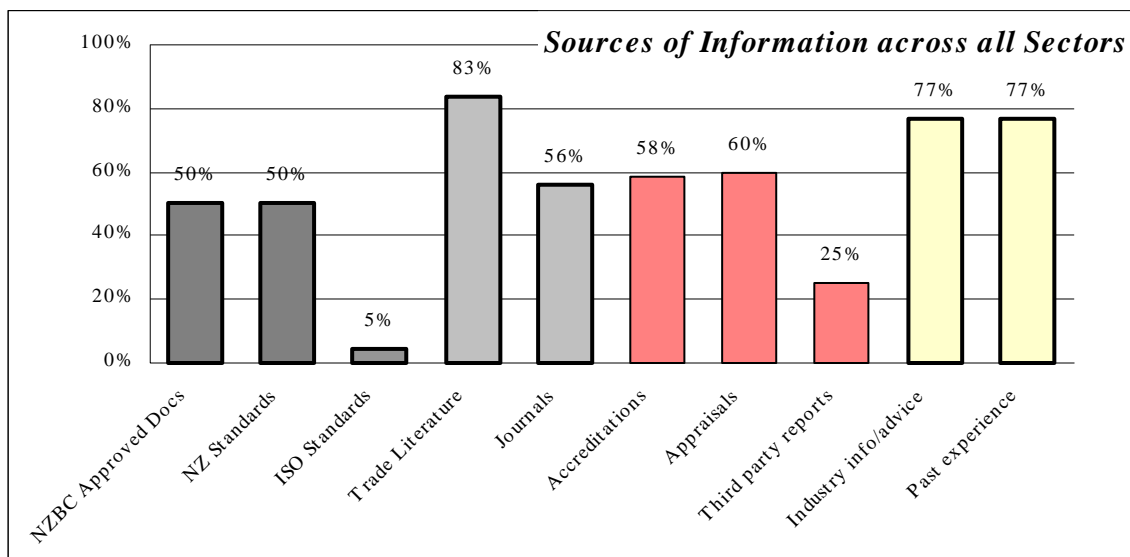
It is probably to be expected that architects, engineers and builders should see trade literature as being the most important source of information, particularly on new materials and products. It was more surprising that those responsible for enforcing the Building Code (Territorial Authorities/building certifiers) also found it important, and interviews revealed that more detailed information was sought from manufacturers than in the past, with recommendations as to maintenance often being kept as part of the compliance documentation. The reason given for this was the increased risk of liability in regard to durability issues.

Not surprisingly, Territorial Authorities also listed the NZBC and New Zealand Building Standards as important sources of information on durability. However this was not so in the other sectors, with less than 60% listing these as usual sources. Well under 40% of architects and designers regularly used the NZBC and relevant standards in relation to durability issues, although all of them rated durability as being very important. During interviews, the main reason given for this possible inconsistency was that they had always treated durability as very important, and that legislation did not affect that. Durability issues were treated in the same way as they were before the Building Act came into force, and that their design aims were well above the minimum levels set by the Code.

Very few of those surveyed listed ISO Standards as a source of information, with manufacturers being the only sector showing any significant level of use. The ISO standards referred to were product standards rather than those being developed by ISO TC59/SC14.

Figure 6 aggregates the sources of information across all of the sectors.

Figure 6. Sources of durability information across all sectors



Barriers to design for durability (dfd) in New Zealand

Respondents were asked to identify what problems they had when assessing durability. Figure 7 summarises the responses. No sector identified knowledge of the NZBC as being a significant barrier to design for durability, with the highest figure being just over 20%.

TAs found the lack of appreciation of the importance of durability to be a major barrier with over 80% quoting this. This would appear to indicate that officials perceive a high degree of apathy throughout the building industry. However, this perception appears to be at odds with the industry’s responses on the importance of durability as shown in Figure 2 of this paper. This could be related to the nature of this survey, as it seems logical that those in the industry who are indeed apathetic form a major portion of the 40% who did not respond to the questionnaire. However, it could also relate to the possibility that, although designers consider durability important, they do not necessarily appreciate the importance of communicating their durability decisions to the Territorial Authorities. More industry education about NZBC durability requirements, along with improved communication between those responsible for enforcing these requirements and those sectors specifying materials, is needed to overcome these particular barriers.

The most important barriers listed by sectors other than TAs relate to lack of information, whether in the form of actual experience of materials’ performance or reliable information for choosing materials or considering substitutions. This is not surprising when considered against the sources of information shown in Figure 5, as past experience and trade literature were the most important sources identified by industry sectors. Comments from interviews revealed that there is less trust in test results than in actual local use over a long period of time, and in the objectivity of information supplied by those who are trying to sell a product. It appeared from the interviews that the more experienced the respondent, the more conservative was the approach to new materials and systems. While schemes that assess products and systems for fitness for purpose (such as BIA Accreditations and BRANZ Appraisals) and third party reports can be considered to be objective and reliable, these were not listed as major sources of information. From comments by interviewees, this appeared to be due to the limited number of these that are available relative to the large numbers of materials on the market. In particular, access to third party reports appeared to be a problem. Many of these reports are commercially sensitive and not distributed widely by their owners.

The provision of more durability information to those involved in specifying materials is an obvious next step to help further design for durability in New Zealand. The documents published (ISO, 2000) and in preparation in the ISO 156856 series on 'Design Life' will provide guidance for those assessing

durability, and these may have a place within the Approved Documents referenced in the NZBC. The ISO 15686 series will not however, provide details on the durability of specific materials, nor even prescriptive methodologies for determining durability. The New Zealand building industry will need to ensure that resources are made available to develop more specific guidance documents which take into account materials' properties, their uses and the environments within which they are used, based, on the principles within ISO 15686.

Figure 7. Barriers to design for durability

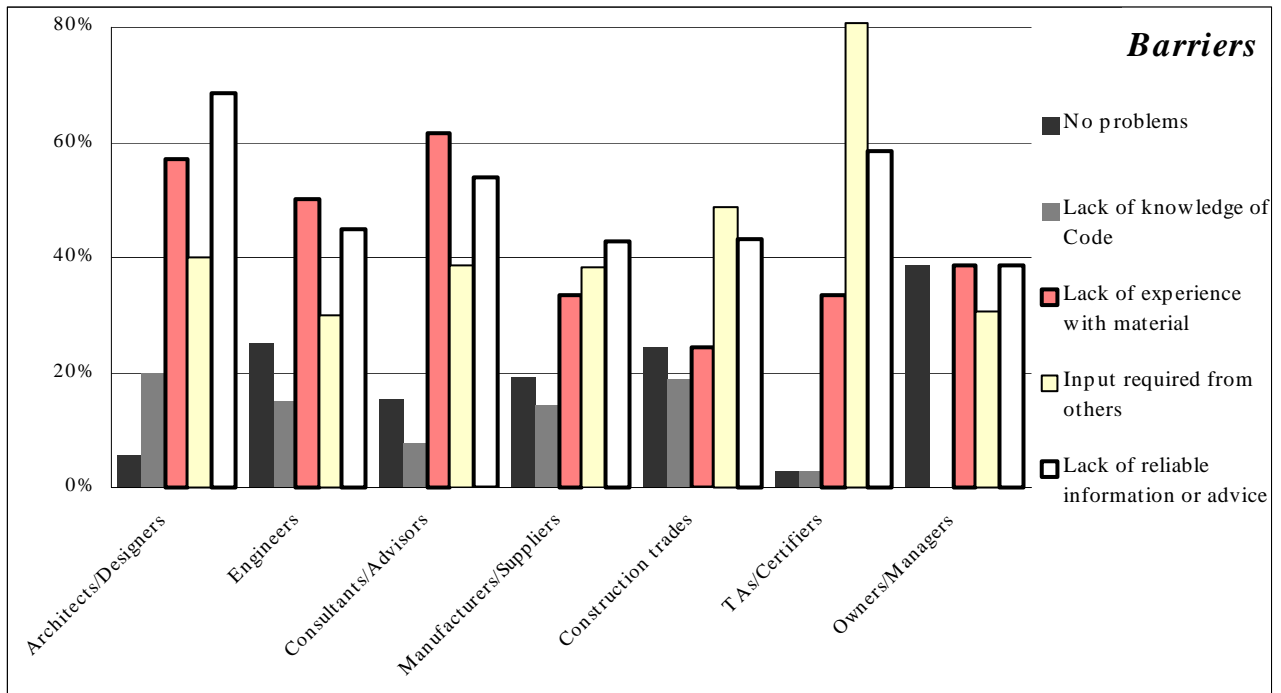
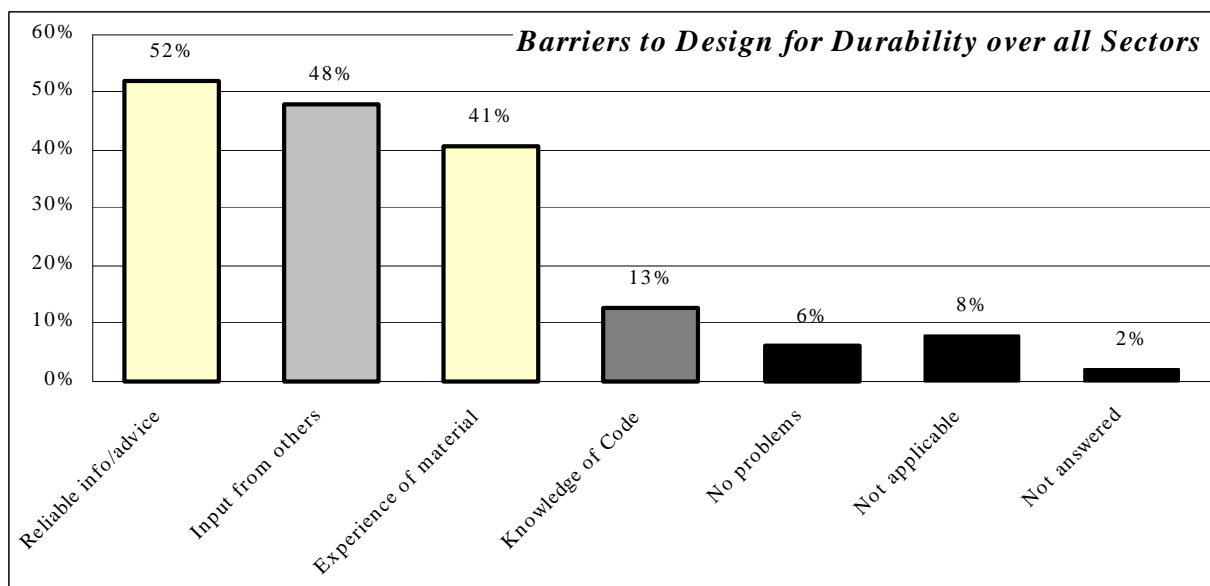


Figure 8 aggregates the perceived barriers across all of the sectors, and shows the low importance placed on knowledge of the Code requirements.

Figure 8. Barriers to dfd over all sectors



CONCLUSION

From the analysis completed to date of the collected data, some conclusions may be drawn at this point:

Who is involved in choosing materials?

Most sectors of the building industry play an important role in the selection of materials used in New Zealand buildings, either by specifying or by contributing towards the specification of building materials. Every sector appears to have some influence on choices made.

How important are durability issues?

No sector identified durability as being of low importance, with more than half rating it as being very important to their decisions in regard to building materials. It appears that the importance has been increasing since the advent of the NZBC, and more so since the introduction of new durability requirements in the most commonly used building standard referenced by the Code.

What does durability mean?

More than 90% of those surveyed included continued functional performance as being the prime meaning of durability, although less than half of the non-regulatory sectors included durability as also meaning a New Zealand Building Code term. It seems that 'generic' meanings of durability are most important to the practising sectors of the building industry.

Where do they get their information?

Information from manufacturers and suppliers of building materials, and past experience (both their own and that of others) were the most commonly used sources of information on durability. Less than half of those surveyed regularly used the NZBC and Standards, with very few indicating any use of ISO resources.

Barriers to design for durability in New Zealand

Only the regulatory sector of the industry considered that the lack of appreciation of the importance of durability was a major barrier to design for durability. Other sectors all reported that the lack of objective, reliable information was the major barrier. No sector considered that the lack of knowledge of Code requirements was a problem.

Ways to overcome these barriers

Two approaches appear to have merit in reducing barriers to the better use of design for durability in New Zealand. The first is raising the awareness of the NZBC requirements throughout all industry sectors involved in specifying materials and ensuring that appropriate durability information has been provided by specifiers before building plans are approved. The second is to make available more information on materials performance in New Zealand to help specifiers choose materials which meet regulatory and/or client durability requirements.

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