CBI			
CI/SfB			
Date: January 1998			

CONFERENCE PAPER

NO. 35 (1998)

The Development and Acceptance of Innovations under a Performance-based Building Code

R C Cooney

Presented at the CIB/ASTM/ISO/RILEM Symposium,
Applications of the Performance Concept in Building,
Israel, December 1996

This paper was funded by the Building Research Levy.

ISSN: 0111-7505

THE DEVELOPMENT AND ACCEPTANCE OF INNOVATIONS UNDER A PERFORMANCE-BASED BUILDING CODE

R C Cooney
Building Research Association of New Zealand (BRANZ)
Private Bag 50 908, Porirua City, New Zealand

ACKNOWLEDGEMENT

This paper was funded by the Building Research Levy.

ABSTRACT

BRANZ has for more than 25 years been assisting proprietors with the development and acceptance into the market of innovative building products and systems. Most of this experience was with a building control system which used prescriptive solutions, with the ability for local councils to approve alternatives. BRANZ has now had nearly four years of experience with a performance-based building code and related legislative and administrative system which is, in part, intended to encourage innovations and make the acceptance of these easier.

BRANZ's experience is that the present system, whilst developed and introduced after extensive evaluation of other overseas systems, has usually made the development and introduction of innovations more difficult and expensive for proprietors, approving authorities and research, testing and consulting agencies. The main reasons are the lack of quantified requirements for many performances and of appropriate test and calculation verification methods, the introduction of quantified durability provisions and the concurrent introduction of more onerous consumer protection legislation. The impact of the durability provisions is discussed in another paper [3].

The net result though of the new system is that properly used innovations are resulting in buildings which are more likely to achieve their expected performances than under the previous system. Even though the cost of introducing the innovations is proving to be greater, time should show that the life cycle costs of buildings will be reduced.

1. THE NEW ZEALAND BUILDING CONTROL STRUCTURE

Building codes around the world which are termed "performance-based" vary considerably in their content and format and also operate in differing legislative structures. These variables usually have an effect on how successfully the code can be used in terms of introducing innovation. Therefore, before explaining how the introduction of innovations under the NZ building code is working out in practice the NZ structure of building controls is first explained.

The highest level relevant document in NZ is The Building Act 1991 [1], being an Act of the NZ Parliament passed in 1991 and which has been fully in effect since January 1993. It describes in general terms why the construction, use and demolition of buildings needs to be controlled in regard to public health, safety and amenity objectives and for other matters of national importance such as economic and environmental issues. A few matters affecting buildings are contained in some other Acts of Parliament but are excluded for the purposes of this paper. Matters which only affect the value of a building such as aesthetics (eg the decorative nature of surface finishes) are not included.

The *Building Act 1991* establishes a structure of management of the controls involving a separate Government agency (the Building Industry Authority - BIA), the Territorial Local Authorities (TAs or local councils) and Building Certifiers (BCs) and processes used by them to monitor that buildings are built, used and demolished in accordance with the Government's objectives. Included in these is a provision for a national building code to be incorporated in building regulations and for the national accreditation by the BIA of building products and systems which have been demonstrated as being able to satisfy the appropriate provisions of the code.

The *Building Regulations 1992* [2] describe in more detail some of the processes to be employed by the BIA, the TAs and BCs and include as a schedule The Building Code (the "Code" or, as most commonly referred to, the " NZBC").

The *NZBC* defines the aspects of building performance which are required to be the subject of control. These are split up into 35 sections by building function, each of which contains an Objective, Functional Requirement and Performance statement (an example is given in Appendix 1). The Objectives and Functional Requirements, and most Performance statements, are written in subjective terms with only a few Performances containing quantitative measures.

That is the extent of the law before any specific building project begins to be designed and specified - no prescription whatsoever. The prescription (ie how to design and build) is contained in what are called "Approved Documents" published by the BIA or in solutions proposed by the designer and commonly referred to as " Alternative Solutions".

Approved Documents come in two main forms - "Verification Methods", being methods of design or test and " Acceptable Solutions", being methods of construction - both of which are approved by the BIA as means of satisfying the appropriate NZBC requirements. The Approved Documents either prescribe the methods and solutions or endorse other documents. Nearly 80 % of such other documents are Standards published by Standards New Zealand and other national Standards bodies, the remaining 20 % being documents published by other organisations. If the proposed design of a building appropriately incorporates provisions from Approved Documents the TAs and BCs are legally bound to approve the design as complying with the NZBC.

Alternative Solutions can be documents prepared by any organisation or other body/person which satisfy the TA or BC on reasonable grounds that the NZBC provisions will be achieved for the particular building being proposed.

BIA Accreditation is a process whereby an innovation intended to satisfy part of the NZBC is first subjected to a technical appraisal by a competent independent organisation. That appraisal and associated technical literature for the innovation is then evaluated by the BIA, which issues an Accreditation if appropriate. Under the terms of the accreditation TAs and BCs must accept that innovation in a building proposal if the conditions of the accreditation are intended to be complied with.

There is another issue which is important when discussing New Zealand's recent experiences with introducing a performance-based code. Prior to the changeover in 1992 the building control system was imperfect, in that many innovations were being introduced into the market place with less than perfect supporting evaluation and testing documentation. A few of these have failed to perform but most have been successful to date. It is fair to say however, that some are hidden in the building structure and are intended to perform in extreme situations such as earthquakes and strong winds and have not been so tested.

That is not to say that the present system, in comparison, is working perfectly because it isn't yet, but the new building control structure, together with other legislative changes such as that providing for consumer guarantees, is now demanding a much greater accountability and hence scrutiny of innovative proposals.

2. DEVELOPING INNOVATIONS

Almost all innovations are intended as alternatives to products and systems with an established record of performance already being used in buildings,. Individual products are usually part of a system of construction (eg a cladding as part of an external walling) whereas an innovative system is usually a more complete entity.

Under the previous system of building controls the required performance of buildings and their parts was poorly defined and seldom quantified. Prescriptive means of construction had mostly evolved from a skilled tradespersons' base. Test methods and related pass/fail criteria had often been developed from an acceptable product or system. Calculation methods were comparatively few. The emphasis tended to be on individual products, and innovations were therefore developed more as substitutes for products which had stood the test of time. The assessment and proving of the innovations was often done on a comparison of the readily identifiable and measurable characteristics such as strength, stiffness and form. More subtle performance characteristics such as water vapour permeability tended not to be recognised and it was also not considered important that the proven product may have had some characteristics (eg strength) well in excess of those needed. Mostly the process worked, perhaps because a single product seldom works on its own in terms of achieving a building performance attribute and the inherent redundancies in the systems and the complete buildings usually coped with any small deficiency of a part. Included in the innovations which failed are a number of claddings, most of which had a record of performance overseas but which were not suited to the much harsher natural environment in New Zealand.

The introduction of a code which identifies all of the expected performance characteristics of a building, coupled with the increasing trend to reduce costs through the elimination of redundancies and excesses of performance, has made the situation more difficult for the proprietors, their consultants and the approving bodies. The continual advancement of science and engineering in the understanding of building performance is on the one hand providing more tools for assessing performance, but on the other hand is raising more questions about factors affecting performance, for which there are often no immediate answers.

The single largest difficulty is that, without quantification of the required performances and related conditions, proving compliance can be difficult. Some of the NZBC Performance statements relate only to a single building type and one aspect of performance and are able to be quantified where such a performance has been established (refer to Appendix 1). However, most relate to a wide range of building types and conditions and the quantification is quite extensive. Comparatively few have been quantified by research to date. One area that has been well investigated is structural stability, but even in such an established discipline some parameters still require researching and redundancies eliminating.

BRANZ' view is that this quantification of performance should most appropriately be located in the code, whereas the BIA and Australasian Standards bodies believe that they should be in Verification Methods.

The timber weatherboard as a cladding on New Zealand houses is an interesting example of where research is required. It has evolved over decades from an unfinished nominally one inch (25 mm) thick rough-sawn timber plank fixed in an overlapping manner by early European settlers. Today it comes in a range of profiles and in a number of situations is not keeping rainwater out of a building. How such a cladding system works still requires further research.

Should a proprietor then choose to introduce a new cladding using a material other than solid timber and with a different profile, the choice of testing and evaluation methods is not straightforward. For example, direct comparison of stiffness with the original system may not be appropriate as the original may be stiffer than is needed simply because it came from a nominal timber thickness and species. Considerations of air and water movement through joints, temperature and moisture stability, thermal resistance, durability etc all need to be considered individually and, in some cases, in combination. It is the building system and building element systems which have to perform a building code function and seldom an individual product. If a similar innovative product has not been introduced previously there are unlikely to be developed testing and calculation methods and the first innovator faces significant costs and uncertainties.

3. INTRODUCING INNOVATIONS TO THE MARKET

"Innovation" is taken here to mean a method of construction or form of building arrangement which is not covered by an Acceptable Solution. It therefore has to be accepted through gaining BIA Accreditation or by acceptance by a TA or Building Certifier (BC) as an alternative solution, either by demonstrating compliance through Verification Methods or by some other means. At a later date, through common usage, it may be documented for general use such that it is incorporated into an Acceptable Solution.

An innovation which is a form of construction is usually one of two kinds. Either it is a proprietary product from a manufacturer, or it is a " one-off" for a particular building and constructed from a number of products and materials.

Proprietors usually have little option but to engage independent agencies such as BRANZ to conduct tests and assessments on the product and to produce a technical opinion (usually termed an " appraisal") in relation to its intended use in terms of satisfying the provisions of the code. In theory they can do this themselves and, indeed, not so long ago under the previous control system they often did, but now usually the TAs, and certainly the BIA, require independence. There is a cost to the proprietor for this independence, but in return a greater assurance of likely performance for the end user. After more than 20 years of experience the industry has now mostly accepted the need for and cost of this process.

Such appraisals can then be used as part of the documentation to support the application for building consent from a TA or BC, for the use of that product or system in a proposed building or buildings. This process in theory has to be repeated for each and every intended such use, although many proposed uses are similar or the same and the TA or BC has a record of the appraisal on file and becomes familiar with its contents so that eventually the application for consent often does not specifically mention or contain a copy of the appraisal. The marketing of the innovation by the proprietor to each approving body is in effect done only once. One of the difficulties though has been that TA staff have often not been sufficiently skilled to properly assess or monitor proposals incorporating such appraised innovations and a number of inappropriate applications have been approved and incorporated into buildings. Greater education of TA staff is under way.

The other option for a proprietor is to submit the appraisal to the BIA and achieve national accreditation. This accreditation means that approving bodies can accept, without further evaluation, the proposed use of the innovation other than checking that the scope and conditions are complied with, thus saving the proprietor time and money in marketing the innovation to each such body. However, the BIA's apparent obsessive preoccupation with the accuracy and consistency in the documentation has made this a very slow and expensive process. Proprietors' opinions are that the cost is not worth the marketing advantage or risk reduction and hence many opt not to go to this stage.

"One-off" alternative solutions require detailed justification, but this is often done subjectively by comparison with Acceptable Solutions which fulfil a similar function, usually on comparatively small products or inexpensive buildings and where there is a low risk of failure. Where there is a higher risk in a comparatively inexpensive building, the cost of such justification by the designers is usually not warranted and Acceptable Solutions are used as a compromise between what the owner wants and what they can afford. This is putting pressure on the industry to collectively come up with and share the cost of more Acceptable Solutions. For larger innovations and buildings a fully detailed analysis or testing, especially a fire engineering solution or proof testing, can usually be justified. The acceptance of alternative solutions is also showing up the need for greater education of the consultants detailing them and the TA staff approving them.

4. GOING THE PERFORMANCE WAY - THE COSTS

New Zealand's change to a performance-based code has come as part of a package of legislative reforms and during a time of continual developments in the industry and the economy. The change from a predominantly prescriptive control system to a performance-based one has not resulted in any noticeable change in the rate of introduction of innovations into the industry. There are few situations where a direct cost comparison between introducing innovations under the two systems can be obtained. The following are thus general observations and impressions.

The BIA, Standards New Zealand and research organisations are under some pressure to conduct the research needed to continue to quantify performances. Verification Methods also need to be prepared which can be used to show compliance with the performances. Generally these will be prepared by the research community, who also will usually be responsible for their maintenance as the small market size will not support this work from the sales of the publications containing the methods. The work needed is extensive and expensive and will stretch into the distant future. This is a continuing cost on the industry and building owners in general.

In this regard New Zealand and other smaller countries need to be involved with and draw as much as possible on international efforts.

The cost of developing and proving innovations can usually only be borne by proprietors who can achieve the required returns from sales. For many innovations this is not feasible yet the innovation is beneficial to the industry and the community. Thus Acceptable Solutions need to be continually developed for these. Overseas solutions can be adopted for New Zealand's unique conditions where appropriate.

The more specific performance requirements and the increased accountability being demanded by the system means that proprietors have had to face increased costs for the development and acceptance of their innovations.

Owners wanting something different in the way of "one-off" alternatives usually have to pay more for that difference.

TAs have needed to pay increased staff training costs to raise the skill level of their staff so that they are able to properly assess innovative proposals.

5. SUMMARY

The introduction of a performance-based building code into New Zealand has not changed the nature and rate of the introduction of innovations into the market. For a number of reasons, not all directly related to the code, the cost of introducing innovations has increased.

The new building control system has provided a potentially more certain environment for the continuing introduction of innovations into buildings, that is, more certainty that the buildings incorporating these innovations will meet the continually increasing expectations and needs of the community that healthy, safe and user-friendly buildings are provided.

This greater certainty of performance comes at an initial cost which is being borne by the industry and community. In time this expected improved performance should bear fruit as reduced building life-cycle costs for the country.

The processes can be further improved by a faster pace of researching the quantification of expected performances, by a relaxation of scrutiny of appraisals for accreditation by the BIA and by improved education of the industry in the basic building science technologies.

6. REFERENCES

[1] NZ Government, *Building Act 1991*, Wellington, 1991.

[2] NZ Government, *Building Regulations 1992*, Wellington, 1992.

[3] W R Sharman and A F Bennett, *The Building Industry's Response to the Durability Requirements of the New Zealand Building Code*, in Proc CIB-ASTM-ISO-RILEM 3rd International Symposium Applications of the Performance Concept in Building, Tel-Aviv, 1996.

APPENDIX 1
(an extract from the New Zealand Building Code)

CLAUSE G7 - NATURAL LIGHT

Objective

G7.1 The objective of this provision is to safeguard people from illness or loss of amenity due to isolation from natural light and the outside environment.

Functional Requirement

G7.2 Habitable spaces shall provide adequate openings for natural light and for a visual awareness of the outside environment.

(Requirement G7.2 shall apply only to Housing, old people's homes and early childhood centres)

Performance

G7.3.1 Natural light shall provide an illuminance of no less than 30 lux at floor level for 75-% of the standard year.

G7.3.2 Openings to give awareness of the outside shall be transparent and provided in suitable locations.

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Moonshine Road, Judgeford
Postal Address - Private Bag 50908, Porirua City
Telephone - (04) 235-7600, FAX - (04) 235-6070
Internet - http://www.branz.org.nz
E-mail - postmaster@branz.co.nz

NEW ZEALAND OFFICES

AUCKLAND

Telephone - (09) 526-4880
Fax - (09) 526-4881
419 Church Street
PO Box 112569
Penrose

CHRISTCHURCH

Telephone - (03) 366-3435
Fax - (03) 366-8552
GRE Building
79-83 Hereford Street
PO Box 496

AUSTRALIAN OFFICE

Telephone - (00612) 9960 0072
Fax - (00612) 9960 0066
Level 1 Bridgepoint, 3 Brady Street, Mosman, Sydney
PO Box 420, Spit Junction, NSW 2088