THE BUILDING CODE SYSTEM AND A FUTURE DIRECTION FOR STANDARDS THAT SUPPORT THE NZ CONCRETE INDUSTRY

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SUMMARY

This paper provides background on the New Zealand Building Code System – a performance-based system that allows multiple ways to demonstrate compliance with the New Zealand Building Code. Whilst the use of Standards is not mandatory they should still be promoted to provide a consistent means of demonstrating compliance. However, the users need to be confident that the Standards are being maintained. Support for the ongoing maintenance of Standards has been challenging in recent times and industry and Government agencies need to collaborate to turn this around.

This Paper looks at the current suite of Standards that support the concrete industry. A new framework to rationalise the existing Standards to provide a more logical framework is proposed. The focus is on making the framework user centric and ensuring the documents covered by the framework capture the latest developments and best practice.

It is recognised that what is proposed for the concrete industry also needs to fit within a wider standards system for loading requirements and the design and property requirements for other materials. Alternative frameworks that could involve adopting Standards used in other jurisdictions are suggested and/or extending the joint standards framework with Australia that has already partially developed. Next steps to seeking feedback on implementing new frameworks, developed in collaboration with industry and Government are suggested.

INTRODUCTION

New Zealand operates a performance-based building code system that permits users multiple ways to demonstrate compliance with the Building Code. Standards are one way of demonstrating compliance and their use is not mandatory under the current building legislation. Notwithstanding this, the concrete industry is expected to remain a standards-centric industry where the use of Standards is encouraged to achieve consistent outcomes for design and construction in concrete.

Confidence in the Standards is dependent on them remaining relevant and incorporating the lessons learnt from research and real events such as earthquakes. The average time since the last amendment of a number of primary design Standards exceeds what could be considered good practice. At present, updating Standards that support the building code system is proving extremely challenging. Government agencies have traditionally been the backbone to New Zealand Standards development but in more recent times they are proving elusive in providing support.
This paper provides an overview of the New Zealand Building Code System and then looks more specifically at the Standards that support the concrete industry. A more rational framework for the Standards documents that serves the concrete Industry is proposed and how this can fit within the wider Structural Standards framework. Suggestions on next stages to progress the implementation of a new framework are made.

THE NEW ZEALAND BUILDING CODE SYSTEM

The Building Act 2004 provides the framework for the building control system in New Zealand. It provides requirements for the construction, alteration, demolition and removal of new and existing buildings, and the inspection and maintenance of specified systems, such as fire sprinklers and lifts. Figure 1 illustrates the hierarchy of New Zealand building controls and the various compliance pathways.

The purpose of the Building Act 2004 (New Zealand Government, 2004) is to ensure that:

- people can use buildings safely and without endangering their health
- buildings have attributes that contribute appropriately to the health, physical independence and wellbeing of the people who use them
- people who use a building can escape from the building if it is on fire
- buildings are designed, constructed and able to be used in ways that promote sustainable development.

The requirements that describe how building work must perform to meet the legislation are found in Schedule 1 of the Building Regulations 1992, otherwise known as the Building Code. The Building Code sets out performance criteria that building work must meet. It covers aspects such as structural stability, fire safety, access, moisture control, durability, and energy efficiency. The Building Code does not prescribe how work should be done, but states how completed building work and its parts must perform.

Figure 1. Hierarchy and components of the Building Control System
The Building Code consists of two preliminary clauses (covered in the General Provisions) and 37 specific technical clauses (covered in seven primary technical areas). Refer figure 2 which indicates the primary clause areas with subclauses beneath each one (e.g. A1, A2, B1, B2, etc.). Each technical clause has three levels that describe the requirements for the clause. The three levels are:

1. Objective - Social objectives the building must achieve.
2. Functional requirement – The functions the building must perform to meet the Objective.
3. Performance - The performance criteria the building must achieve. By meeting the performance criteria, the Objective and Functional requirement can be achieved.

![Primary New Zealand Building Code Clauses](image)

Compliance with the Building Code can be demonstrated using various pathways. Understanding the New Zealand building control framework will help decide which path is most suitable when designing and constructing building work. An important aspect to note is that the use of Standards to demonstrate compliance is not mandatory. The various pathways are now described:

**Acceptable Solutions** and **Verification Methods** provide details for construction that, if followed, result in compliance with the Building Code. They are published by the Ministry of Business, Innovation and Employment (MBIE). A design that complies with an Acceptable Solution or Verification Method must be accepted by a building consent authority as complying with the Building Code.

**Verification Methods** are tests or calculation methods that prescribe one way to comply with the Building Code. Verification Methods can include calculation methods, using recognised analytical methods and mathematical models or the results from laboratory tests on prototype components and systems. Examples of Verification Methods include NZS 3101 and NZS 4230.

**Acceptable Solutions** are typically simple step-by-step instructions that show a way to comply with the Building Code. Examples of Acceptable Solutions include NZS3604 and NZS4229.

An **Alternative Solution** is a building solution that differs, in part or wholly, from the solutions offered by the Acceptable Solution or Verification Method, and achieves compliance with the performance requirements of the Building Code to the satisfaction of the building consent authority. There may be a number of reasons for the use of an Alternative Solution such as there not being an Acceptable Solution or Verification Method for the proposed construction or the building work may incorporate unusual design features that fall outside the scope of an Acceptable Solution or Verification Method.
Other methods of demonstrating compliance with the Building Code include Product Certification and a Determination. The Building Act contains provisions for a voluntary Product Certification scheme that enables product manufacturers to have their products certified as meeting nominated performance requirements of the Building Code. Building products or methods that are used in accordance with a Product Certificate must be accepted by a building consent authority as complying with the Building Code. A Determination is a binding decision made by MBIE. It provides a way of solving disputes, that typically relate to a decision made by a building consent authority, on whether a building or building work complies with the Building Code.

Further information on the Building Code and how to comply with it can be found in the MBIE New Zealand Building Code Handbook (MBIE, 2014).

DEVELOPMENT OF NEW ZEALAND CONCRETE DESIGN STANDARDS

The most recent amendment of the Concrete Structures Standard NZS 3101 was issued in August 2017 and in April 2018 this amendment was cited as the verification method that provides a means of demonstrating compliance for concrete design with the structural provisions of the New Zealand Building Code.

This new amendment of NZS 3101 is the next advancement in the NZS 3101 series which first appeared in 1970 as the provisional NZS 3101:1970P and has had several amendments since its first publication. The early development of NZS 3101 took place at a time when New Zealand was a world leader in advancing concrete design techniques, particularly with respect to detailing for earthquakes and the development of the capacity design method. The pioneering research work led by Park, Pauly and Priestley and seminal textbooks such as Reinforced Concrete Structures (Park & Pauly, 1975) and Seismic Design of Reinforced Concrete and Masonry Buildings (Paulay & Priestley, 1992) helped influence concrete design worldwide, particularly in countries with similar levels of seismicity. For more comprehensive coverage of the development of New Zealand concrete design standards refer to the Concrete Buildings (C5) Section of the Guidelines for the Seismic Assessment of Existing Buildings (Joint Committee, 2018).

As previously stated in this paper, the New Zealand Building Code system is performance based and a designer does not need to follow the provisions of NZS 3101 and can use Alternative Solutions in conjunction with, or totally separate to, a cited Standard such as NZS 3101 as long as the building code performance requirements for the relevant building code clauses are met and the building consent authority can satisfy itself that the performance requirements are met. It is considered appropriate by the author that a cited Standard is still the basis of design for most concrete designs to ensure consistency for all those involved in the design, consenting and construction process. This cited Standard needs to easily demonstrate compliance with the Building Code and be user-friendly and easy to follow. The use of an Alternative Solution should be the exception and more relevant when bespoke design solutions are required.

Consideration for the next version of a Concrete Structures design standard that meets the performance requirements of the New Zealand Building Code now needs to take place. This needs to coordinate with the overall system of related standards, both within the immediate family of concrete standards and the families of standards for loading and other construction materials. It also needs to acknowledge where New Zealand structural design and material production standards fit in a global market.
PROPOSED FRAMEWORK FOR STANDARDS THAT SUPPORT THE NEW ZEALAND CONCRETE INDUSTRY

As it stands, numerous New Zealand Standards for the design, production and testing of concrete exist and some have not had any maintenance for a number of years. In fact, the average age of concrete related standards since their last revision or amendment is 18 years. It is therefore timely that the New Zealand concrete industry gives serious consideration to developing a new framework of standards that support design and construction in concrete. Table 1 indicates the current state and a potential future framework. The existing suite of concrete related standards are listed on the left-hand columns. The right-hand columns propose a reduced number of concrete related standards, with rationalization and amalgamation of the existing standards into four of five ‘primary’ Concrete Standards and still providing the same coverage for the aspects of concrete design, production and testing.

To support the development of a new framework of standards for concrete design and manufacture in New Zealand a key question is - who will lead (and fund) this? With government agencies in recent times becoming increasingly hands off in such matters it can be anticipated that industry may need to take the lead. However, backing and funding for developing a new (or even maintaining the old) framework should still be sought (and provided) by the relevant government agencies, acknowledging their obligations under legislation such as the Building Act. This will be discussed further in this paper.

MAINTENANCE OF STANDARDS IN NEW ZEALAND

New Zealand currently struggles to maintain its suite of structural design and material production standards and the timely delivery of amendments to structural standards is proving challenging. Several factors contribute to this situation:

- There is very limited investment and support coming from relevant central government agencies to develop and maintain the standards that support regulatory aspects such as building code compliance – previous initiatives in 2016/2017 by the Building System Performance (BSP) branch in MBIE (MBIE, 2017) to implement a long-term standards development programme have stalled.
- There is a limited pool of structural experts in New Zealand, who tend to be the main contributors to updating standards, and these individuals are generally overcommitted and cannot dedicate adequate time to participate in a Standards process.
- Participating in standards committees is a voluntary and unpaid process – with key people often in demand for paid commissioned work the willingness of potential committee members to get involved in a process that is not financially rewarded is challenging – some consideration to rewarding committee members who are giving up commercial time may be necessary to encourage key people to participate.
- New Zealand does not operate Standing Committees that provide continual monitoring on the maintenance and development needs of standards. The existence of standing committees can facilitate succession planning and better inform the ongoing research needs that need to be undertaken to support future standards amendments.

This situation has been documented in an Engineering NZ Paper (ENZ, 2018). In comparison, other jurisdictions routinely maintain Standing Committees and issue updated versions of Standards on regular cycles. For example, the American Concrete Institute document ACI318 Building Code Requirements for Structural Concrete is routinely revised and re-issued every three to four years providing confidence to users that the document is being maintained.
Table 1. Existing Concrete Standards and a proposed new framework

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<thead>
<tr>
<th>Existing Concrete Standards</th>
<th>Proposed Concrete Standards Framework</th>
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<tr>
<td>NZS 3112.4:1986 (1986)</td>
<td>Methods of test for concrete - Tests relating to grout</td>
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<tr>
<td>NZS 3122:2009 (2014)</td>
<td>Specification for Portland and blended cements (General and special purpose)</td>
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<tr>
<td>NZS 3101</td>
<td>Design of Concrete Structures (incorporating storage of liquids)</td>
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<td>NZS 3104</td>
<td>Concrete production (incorporating methods of testing concrete)</td>
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<tr>
<td>NZS 3109</td>
<td>Concrete Construction (incorporating specification for surface finishes NZS3114)</td>
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<tr>
<td>NZS 3122</td>
<td>Specification for cements</td>
</tr>
<tr>
<td>NZS 3121</td>
<td>Specification and tests for water, sands and aggregate for concrete production</td>
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Notes 1. Bracketed years indicate the year the most recent amendment was published
2. Standards that relate to concrete masonry construction and reinforcing are not included
FUTURE CONSIDERATIONS FOR A CONCRETE STRUCTURES DESIGN STANDARD AND HOW IT COULD FIT IN A WIDER FRAMEWORK

Acknowledging that New Zealand struggles to develop and maintain structural standards, and with a focus on the concrete structures design standard, adopting a concrete structures design standard from another jurisdiction (with any necessary modifications) for New Zealand application could also be considered. Three potential options as an alternative to amending NZS 3101 are:

- **ACI 318: Building Code Requirements for Structural Concrete** - Cited in the International Building Code, used widely across the United States, Asia and South America
- **Eurocode 2: Design of Concrete Structures** – used across European nations and some Asian countries
- **Develop a joint AS/NZS concrete structures Standard**

An overarching objective should be to maintain consistency with the other primary structural design standards used in New Zealand and this could point to a joint AS/NZS for concrete design being a logical option. The Loadings (AS/NZS 1170), Timber Structures (NZS/AS 1720.1), Composite Structures (AS/NZS 2327) Steel Structures and Aluminium Structures Standards (AS/NZS 1664.1) are either jointed, going through the process of being jointed, or are giving serious consideration to being joint Standards. Table 2 presents a proposed suite of joint AS/NZS structural standards mirroring the Eurocode framework and it is apparent that concrete (and concrete masonry) may become the lone material standards that sits outside a joint Standard framework.

It should be recognised that if New Zealand concrete and/or masonry standards maintain an independent approach to their development it does not necessarily present a disadvantage to the concrete industry, as long as the cited Standard provides a user-friendly method of demonstrating compliance with the New Zealand Building Code. It could however lead to a lack of coordination and consistency between the different families of standards that designers and material producers need to use and the concrete industry Standards may require a different funding mechanism for their ongoing development and maintenance.

It is also of note that the most recent amendment of the Australian Concrete Structures standard (AS 3600) was issued in 2018 (Standards Australia, 2018) and contains new requirements for the design for earthquake actions, promoting it from its previous Appendix status in the 2009 AS 3600 edition to be a new section and this at least indicates that Australia are taking earthquake requirements more seriously.

It is suggested by the author that an options analysis should be undertaken to test the merits of adopting documents that are used in other jurisdictions such as ACI 318 and Eurocode 2, developing a joint AS/NZS concrete structures Standard or justify if maintaining NZS 3101 is an acceptable approach.

Whether or not an alternative concrete design Standard document is cited or a new joint document developed, it should not be seen as New Zealand losing control or its respect in the development of concrete Standards but an acknowledgement of the increasing need to collaborate and consolidate within a global setting – the New Zealand researchers who contribute to the development of Standards regularly collaborate with their international counterparts.

In the experience of the author, as a member of the committee that developed the joint standard AS/NZS 2327 for composite structures, it was a very collaborative experience between the New Zealand and Australia experts, with New Zealand contributors leading the development of the sections on fire and earthquake. Further successful outcomes should be anticipated with similar collaboration by either participating in development of joint AS/NZS Standards or by contributing to other international Standards, where the New Zealand members take the lead on key sections such as the design requirements for earthquake actions.
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<tr>
<td>EN 1991 Eurocode 1 – Actions on Structures</td>
<td>AS/NZS1170 parts 0-3 and AS1170.4</td>
<td>AS/NZS 1170 parts 0-4 &amp; NZS1170.5</td>
<td>AS/NZS 1170</td>
<td>1-General Actions 2-Wind Loads 3-Snow Loads</td>
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<tr>
<td>EN 1992 Eurocode 2 – Design of Concrete Structures</td>
<td>AS3600</td>
<td>NZS3101</td>
<td>AS/NZS BBBB</td>
<td>1-Material requirements and testing methods 2-Concrete Construction requirements 3-General Design requirements 4-Fire requirements</td>
</tr>
<tr>
<td>EN 1993 Eurocode 3 - Design of Steel Structures</td>
<td>AS4100</td>
<td>NZS3404</td>
<td>AS/NZS CCCC</td>
<td>1-Material requirements incorporating fabrication, erection and testing methods 2-General Design requirements 3-Fire Requirements</td>
</tr>
<tr>
<td>EN1994 Eurocode 4 – Design of Composite Structures</td>
<td>AS2327</td>
<td>AS/NZS 2327</td>
<td>1-General design requirements 2-Fire requirements</td>
<td></td>
</tr>
<tr>
<td>EN 1995 Eurocode 5 – Design of Timber Structures</td>
<td>AS1720</td>
<td>NZS3603</td>
<td>AS/NZS 1720</td>
<td>1-Material and testing requirements 2-General Design requirements</td>
</tr>
<tr>
<td>EN1996 Eurocode 6 – Design of Masonry Structures</td>
<td>AS3700</td>
<td>NZS4230</td>
<td>AS/NZS DDDD</td>
<td>1-Material and testing requirements 2-General Design Requirements</td>
</tr>
<tr>
<td>EN 1997 Eurocode 7 – Geotechnical Design</td>
<td>Coverage provided by MBIE/NZGS geotechnical earthquake engineering modules</td>
<td>AS/NZS EEEE</td>
<td>1-Ground investigation and testing 2-Retaining Wall design</td>
<td></td>
</tr>
<tr>
<td>EN 1998 Eurocode 8 – Design of Structures for Earthquake Resistance</td>
<td></td>
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<td>Not required and covered in the actions/material standard</td>
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* Some of these joint Standards exist at present or are in development
CHALLENGES AND OPPORTUNITIES TO UPDATE STANDARDS AND IMPLEMENT A NEW STANDARDS FRAMEWORK

To progress a new systemised framework for structural design and material production Standards that support regulatory processes, such as compliance with the building code, backing from Government agencies will be necessary and should be provided. This will require a considerable step change from the current levels of support and investment Government agencies are providing towards standards development.

There should be no impediment to the Government providing the necessary funding for Standards development in New Zealand. The Vote Building and Housing Memorandum Account, obtained from building consent application fees, that funds the operation of the building regulator, has now accumulated to a surplus in excess of $42 million as at June 2018 (MBIE, 2018). The previous National party led Government gave strong support to increase investment in Standards development and while the building regulator has in recent times focussed on subsidising access to some Standards documents that provide a means of compliance with the Building Code there does not appear to be any commitment from the building regulator or Standards NZ that structured investment in the development and maintenance of Standards is going to occur. This lack of support does not respect fundamental principles of the Building Act 2004 that recognise *the importance of standards of building design and construction in achieving compliance with the building code* (New Zealand Government, 2004). In essence the Government has a duty to invest money obtained from the Building levy to maintain processes and systems that support consistent and efficient compliance with the building code.

Funding from Government sources could also potentially be given to funding access to and/or development of Standards that are used in other jurisdictions so that they can be applied for New Zealand application. For example, the costs associated with subscribing to the ACI suite of Standards or Eurocode suite could be explored, and this can then be compared to the costs associated with developing/maintaining specific New Zealand Standards.

Industry should also play its part by providing leadership on what the industry needs are and help shape what will be the best system going forward for concrete design, production and testing Standards. One of the key drivers to forming Concrete NZ with its sector groups was the ability to combine its resources so that it could lead and take ownership when required of updating Standards that support the concrete industry. A recent example of the concrete industry taking this lead in updating Standards is Concrete NZ performing the project management and principal funder role to update the specification for concrete production NZS 3104.

Whatever direction is taken in the field of Standards development that support the concrete industry, whether it be implementing a new framework and/or the adoption or development of new Standards, it will need to be supported by a full education and training programme to ensure new requirements are understood by the members of the concrete industry. This is certainly not an overnight process and could well take five to ten years – commencing in 1975 with the establishment of an action programme in the field of construction, the Commission of the European Community took fifteen years to develop the first generation of European Codes.

NEXT STEPS

To further progress points made in this paper three key actions are suggested. These actions intend to seek feedback from the concrete and structural engineering communities in the first instance, with subsequent potential involvement from the building regulator and/or Standards NZ, to determine what the preferred options may be. The suggested next steps are:
1. Further explore the development of new family of concrete Standards that support concrete design/production/testing in New Zealand – seek concrete industry feedback - CNZ and CNZ sector groups led.

2. Undertake an options analysis to determine a preferred option for a future Concrete Structures design standard that supports compliance with the New Zealand building code – 4 options initially present themselves:
   - Continue maintaining/updating NZS 3101
   - Adopt Eurocode 2 (with any modifications) for NZ application
   - Adopt ACI 318 (with any modifications) for NZ application
   - Develop a joint (AS/NZS 3600) Concrete Structures Standard

Seek industry feedback – focussing on the structural design community – CNZ/CNZLS led.

3. Undertake consultation on an overall framework for structural design Standards that support regulatory processes such as building code compliance, determining whether a complete suite of joint standards should be pursued or should an adoption of another suite of standards such as Eurocode or ISO be pursued – to be **Engineering NZ/SESOC led** supported by relevant industry organisations (CNZ, HERA, SCNZ, TDS) with input from the **BSP Branch in MBIE** and **Standards NZ** and potentially involving Standards Australia and other relevant Australian associations/societies (the Engineers Australia Structural College).

A potential interim method to test some of these options will be to conduct an on-line survey with members of the Leaned Society, Concrete NZ Sector Groups and the wider structural engineering community. The author would welcome your feedback on the options proposed.

REFERENCES


