BUILDING PERFORMANCE

Statement of proposal to amend Verification Method B1/VM1 and ban loop bar connections in precast concrete double-tee flooring

September 2017

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

New Zealand Government

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INTRODUCTION

Intended audience

This document outlines proposals that are intended to be read by structural engineers, building consent authorities and people within the concrete and steel industries. The proposals relate to design and construction requirements for concrete and steel structures.

Purpose of this statement of proposal

The Ministry of Business, Innovation and Employment (MBIE) seeks your views on proposals to:

- update the Building Code Verification Method for B1 Structure B1/VM1 to cite the latest amendment of NZS 3101:2006 Concrete Structures Standard: Part 1 - The Design of Concrete Structures (i.e. Amendment 3)
- update the Building Code Verification Method for B1 Structure B1/VM1 to replace sections of NZS 3404:Part 1:1997 Steel Structures Standard to reflect current practice for steel fabrication and construction
- ban the use of the loop bar or pigtail hanger connection detail associated with the support of precast concrete flange hung double-tee flooring units.

How to provide your feedback

MBIE invites written comments on the proposals in this document by **5:00pm, Monday, 20 November 2017**.

You are welcome to make submissions on some or all of these proposals. Key questions are provided throughout the document to guide your responses.

You can download a submission form at www.mbie.govt.nz/info-services/building-construction/consultations/building-code-verification-method-b1-vm1-update-and-proposed-loop-bar-ban-2017 and send your submission by:

- email to buildingfeedback@mbie.govt.nz, with subject line "Consultation – Amendments to B1/VM1 and loop bar connection ban 2017"

- post or courier to: -

  Consultation – Amendments to B1/VM1 and loop bar connection ban 2017 -
  Building Performance and Engineering -
  Ministry of Business, Innovation and Employment -
  Level 5, 15 Stout Street -
  P O Box 1473 -
  Wellington 6143 -

What happens to your feedback

Your feedback will contribute to decisions on the proposed amendments and ban. It will also become official information which means it may be requested under the Official Information Act 1982 (OIA).

The OIA specifies that information is to be made available upon request unless there are sufficient grounds for withholding it. If we receive a request, we cannot guarantee that feedback you provide us with will not be made public. Any decision to withhold information requested under the OIA is reviewable by the Ombudsman.

More information

To find out more, or to make a comment, go to www.mbie.govt.nz/info-services/building-construction/consultations and click on "Building Code Verification Method B1/VM1 update and proposed loop bar ban 2017".

Materials to be incorporated by reference described above are:

- - available for inspection free of charge at the Ministry of Business, Innovation and Employment, 15 Stout Street, Wellington

or

- - able to be purchased from
    - Standards New Zealand, 15 Stout Street, Wellington or online at www.standards.govt.nz
    - BSI New Zealand Ltd, Level 10, 21 Queen Street, Auckland 1010, or online at - https://www.bsigroup.com/en-NZ/ . -

BACKGROUND

A Verification Method is a document published by MBIE that provides an approved means to comply with the New Zealand Building Code. A Verification Method is not mandatory to use, but if followed, it provides a means of compliance for the building design.

A Verification Method for structural building design is B1/VM1, which cites NZS 3101:2006 (Concrete Structures Standard) and NZS 3404:1997 (Steel Structures Standard). This makes the Concrete Structures Standard and the Steel Structures Standard part of an approved means to comply with the Building Code.

The Canterbury Earthquake Royal Commission recommended changes to the provisions in NZS 3101:2006 'Concrete Structures Standard: Part 1 - The Design of Concrete Structures' (Concrete Structures Standard). Some of the recommendations relating to the Concrete Structures Standard have now been implemented via Amendment 3, which was published in August 2017.

The latest version of the Concrete Structures Standard (Amendment 3) has addressed industry concerns over the potential earthquake performance of pre-cast concrete floor systems that were observed in the Canterbury earthquakes and the more recent 14 November 2016 Kaikōura earthquakes. These concerns included:

- the impact of beam elongation on precast floor systems
- maintaining composite connection of the precast flooring to the in situ topping
- precast floor support details.

Further action is recommended to limit the use of the loop bar (sometimes referred to as the pigtail) hanger connection detail associated with flange hung double-tee flooring units following the unacceptable performance of the detail in Statistics House. The loop bar detail was considered by an expert panel to contribute to the collapse of some floor units in the Kaikōura earthquake.

Some provisions in NZS 3404: Part 1:1997 Steel Structures Standard are out of date and do not align with current industry practice. Modifications to the Steel Structures Standard are proposed to be made in B1/VM1 that would update the Verification Method to be in line with the standards and practices that are currently used in the steel industry. The modifications relate to:

- correcting references to Standards that are cited in NZS 3404
- updating references for nuts, bolts and washers
- steel fabrication
- steel erection
- modification of existing structures
- architecturally exposed structural steel.

The changes described in this document would:

- update the Verification Method B1/VM1
- ban the use of loop bar hanger connection details for precast concrete double-tee flooring units.

UPDATING VERIFICATION METHOD B1/VM1

Proposed changes to B1/VM1

MBIE proposes to amend the Verification Methods B1/VM1 to:

- reference the latest version of NZS 3101:2006 Amendment 3 Concrete Structures Standard
- modify the citation of NZS 3404: Part 1:1997 Steel Structures Standard
- include editorial and technical amendments for clarity.

The proposal to amend Verification Method B1/VM1 to include the latest version of NZS 3101 (i.e. Amendment 3) and update some provisions of the Steel Structures Standard is the preferred option. This option achieves the objective to:

- maintain the verification method to ensure current knowledge and practices are - incorporated in the Verification Method B1/VM1 -
- avoid confusion as to which standards apply to provide a means of compliance with the Building Code
- implement recommendations from the Canterbury Earthquakes Royal Commission and the Statistics House Investigation in the Verification Method.

Benefits and costs of the proposal

Option	Cost	Benefit
Status Quo	The cost of leaving the Verification Method unchanged is that over time the standards and practices specified in the Verification Method will diverge from industry good practice. Technical deficiencies in the Verification Method would also remain. Over time, building consents would become more complex and difficult to process, as designs that follow current Standards and good industry practice would increasingly differ from the Verification Method	There are no benefits to leaving the Verification Method unchanged.
Proposed amendment to B1/VM1	There is an immediate cost to publish the Verification Method and to purchase the Standards that are referenced in the amendment, though many designers and suppliers have on-line subscriptions reducing cost impact.	The benefit of updating the Verification Method is that it will reflect the current Standards and good industry practice.

Question 1 Do you have any comments on the options for B1/VM1?

B1/VM1 references

The following Standards are proposed to replace previous versions of the Standards that are currently referenced in B1/VM1.

NZS 3101.1:2006	Concrete Structures Standard. Part 1 – The Design of Concrete Structures. Amendment 1, 2, 3 (amendment 3 added)

The following Standards are proposed to be newly referenced in B1/VM1. They are currently not referenced.

AS/NZS 1163:2016	Cold-formed structural steel hollow sections
AS/NZS 1554.1:2014	Structural steel welding – Part 1: Welding of steel structures. Amendment 1 and 2
AS/NZS 1594:2002	Hot-rolled steel flat products
AS/NZS 3678:2016	Structural steel – Hot-rolled plates, floorplates and slabs
AS/NZS 3679.1:2016	Structural steel – Part 1: Hot-rolled bars and sections
AS/NZS 3679.2:2016	Structural steel – Part 2: Welded I sections
AS/NZS 5131:2016	Structural steelwork – Fabrication and erection
BS EN 14399-1:2015	High-strength structural bolting assemblies for preloading, General requirements
BS EN 14399-2:2015	High-strength structural bolting assemblies for preloading, Suitability for preloading
BS EN 14399-3:2015	High-strength structural bolting assemblies for preloading, System HR. Hexagon bolt and nut assemblies
BS EN 14399-5:2015	High-strength structural bolting assemblies for preloading, Plain washers

Question 2 Do you agree with the proposed changes to the B1/VM1 references?

Changes to Verification Method B1/VM1

Current Text	Proposed Changes	Explanation
2.2.5 AS/NZS 1170 Part 0, Clause 5.2 Structural models Delete (a) to (d) in Clause 5.2 and replace with: "(a) Static **and**/or dynamic response. (b) Elastic **and**/or non-elastic (plastic) response. (c) Geometrically linear **and**/or geometrically non-linear response. (d) Time-independent **and**/or time-dependent behaviour." **COMMENT** Each of the modelling approaches (a), (b), (c) and (d) allows only one method. This is unnecessarily restrictive since designers may decide to use both approaches for a particular building. Accordingly, "or" has been replaced with "and/or".		Paragraph 2.2.5 is deleted. Paragraph 2.2.5 is no longer needed as the modifications in paragraph 2.2.5 were incorporated into the Standard in 2011 as part of Amendment 3.
3.1 NZS 3101: Part 1 subject to the following modifications: a) Replace clause 4.8 **External walls that could collapse outward in fire** with: **4.8 External walls that could collapse inwards or outwards in fire** **4.8.1 Application**	**3.1 NZS 3101: Part 1** subject to the following modification:	Replace paragraph 3.1 to cite NZS 3101 Amendment 3 unmodified, except that the modification to NZS 3101 clause 18.7.4 (g)(ii) will remain.

Current Text	Proposed Changes	Explanation
This clause applies to external walls which could collapse inwards or outwards from a building as a result of internal fire exposure. All such walls shall: (a) Be attached to the building structure by steel connections; (b) Be restrained by these connections, when subject to fire, from inwards or outward movement of the wall relative to the building structure; and (c) Comply with the appropriate provisions of this Standard for walls. **4.8.2 Forces on connections** The connections between each wall and the supporting structure shall be designed to resist all anticipated forces. In the absence of a detailed analysis, the connections shall be designed to resist the largest of: (a) The force resulting from applying Clause 2.2.4 of Verification Method B1/VM1; (b) for walls fixed to a flexible structure of unprotected steel, the force required to develop the nominal flexural strength of the wall at its base; (c) for walls fixed to a rigid structure such as reinforced concrete columns or protected steel columns or another wall at right angles, the		

Current Text	Proposed Changes	Explanation
force required to develop the nominal flexural strength of the wall at mid-height. b) Amend Clause **9.3.9.4.13 Minimum area of shear reinforcement** In Clause 9.3.9.4.13(c) delete the words after "750 mm" and substitute "and the depth of the precast unit is equal to or less than 300 mm and the overall depth is equal to or less than 400mm." c) Amend Clause **18.7.4 Floor or roof members supported by bearing on a seating** Add to the end of Clause 18.7.4 (g)(ii) add an additional sentence: "The details given by C18.6.7(e) may be applied to hollow-core units where the depth of the precast unit is equal to or less than 300 mm." d) Amend NZS 3101 Clause **5.3.2.6 Ductile welded wire fabric** Delete the clause and replace with: "Welded steel mesh shall be Ductility Class E in accordance with Paragraph 14 of this Verification Method unless the conditions of Clause 5.3.2.7 for the use of lower ductility welded wire fabric are satisfied."	Amend Clause **18.7.4 Floor or roof members supported by bearing on a seating** Add to the end of Clause 18.7.4 (g)(ii) an additional sentence: "The details given by C18.6.7(e) may be applied to hollow-core units where the depth of the precast unit is equal to or less than 300 mm."	The modification to clause 18.7.4 in NZS 3101 is retained in B1/VM1

Current Text	Proposed Changes	Explanation
5.1 NZS 3404: Part 1	**5.1 NZS 3404: Part 1** subject to the following modifications: **5.1.1 Clause 2.2.1 Specification** In clause 2.2.1 a) replace "AS 1163 Structural steel hollow sections AS 1594 Hot-rolled steel flat products", with "AS/NZS 1163 Cold-formed structural steel hollow sections AS/NZS 1594 Hot-rolled steel flat products" **5.1.2 Clause 2.3.1 Steel bolts, nuts and washers** In clause 2.3.1 add the following to the end of the clause "BS EN 14399-3 High-strength structural bolting assemblies for preloading, System HR. Hexagon bolt and nut assemblies BS EN 14399-5: High-strength structural bolting assemblies for preloading, Plain washers" **5.1.3 new Clause 3.10 Documentation** Insert the following after clause 3.9, "Clause 3.10 Documentation The requirements in AS/NZS 5131 Section 4.1.1	Replace paragraph 5.1 with the text in the "Proposed Changes" column of this table. The changes have been made to update requirements in NZS 3404 and incorporate Standards that reflect current industry practice

Current Text	Proposed Changes	Explanation
	General shall be applied." **5.1.4 Clause 9.3.1 Bolts and bolting category** In clause 9.3.1.2 replace "and AS 1559" with ", AS 1559, BS EN 14399.1, BS EN 14399.2, BS EN 14399.3 and BS EN 14399.5". **5.1.5 Section 14 Fabrication** Replace section 14 Fabrication with the following, "14 Fabrication The fabrication of steel structures shall be in accordance with AS/NZS 5131. Construction categories for the purposes of this standard shall be determined in accordance with Appendix C of AS/NZS 5131." **5.1.6 Section 15 Erection** Replace section 15 Erection with the following, "15 Erection The erection of steel structures shall be in accordance with AS/NZS 5131. Construction categories for the purposes of this standard shall be determined in accordance with Appendix C of AS/NZS 5131. **5.1.7 Section 16 Modification of Existing Structures** Replace Section 16 Modification of existing structures	

Current Text	Proposed Changes	Explanation
	with the following, "16 Site modifications during erection and modification and repair of existing structures Site modifications during erection and modification and repair of existing structures shall be in accordance with AS/NZS 5131 Section 14 Site modifications during erection and modification and repair of existing structures." **5.1.8 new Section 18 Architecturally Exposed Structural Steelwork** Insert the following after section 17, "18 Architecturally exposed structural steelwork The requirements in AS/NZS 5131 Section 10 Architecturally exposed structural steelwork shall be applied." **5.1.9 Appendix D** Replace Appendix D Inspection of Welding to AS/NZS 1554.1 with the following, "Appendix D Inspection of Welding The recommendations in AS/NZS 5131 Appendix I Inspection of Welding and Bolting. (Informative) should be used." **5.1.10 Appendix K** Replace Appendix K Standard test for evaluation of slip factor (normative) with the following,	

Current Text	Proposed Changes	Explanation
	"Appendix K Standard test for evaluation of slip factor (normative) The requirements in AS/NZS 5131 Appendix G Standard test for evaluation of slip factor shall be used." **5.1.11 Appendix L** Replace Appendix L Inspection of bolt tension using a torque wrench (informative) with the following, "Appendix L Inspection of bolt tension using a torque wrench (informative) The recommendations in AS/NZS 5131 Appendix H Inspection of bolt tension using a torque wrench should be used." **5.1.12 new Appendix R** Insert the following after Appendix Q, "Appendix R Selection of materials for the avoidance of lamellar tearing (informative) The guidance in AS/NZS 1554.1 Appendix H Selection of materials for the avoidance of lamellar tearing should be used."	

Question 3 Do you agree with the proposed changes to Verification Method B1/VM1?

PROPOSED BAN OF LOOP BAR CONNECTIONS IN PRECAST CONCRETE DOUBLE-TEE FLOORS

MBIE proposes to ban the use of the loop bar (sometimes referred to as the pigtail) hanger connection detail associated with the support of precast concrete flange hung double-tee flooring units.

Section 26 of the Building Act 2004 (the Building Act) allows the MBIE Chief Executive to issue a warning about, or ban the use of, a building method or product if they consider on reasonable grounds that the use of that building method or product has resulted in, or is likely to result in, a building or building work failing to comply with the Building Code. In the case of the loop bar detail in double-tee flooring, MBIE considers that the detail as generally used does not comply with Clause B1.3.1 of the Building Code.

Using a building method or product that is banned is an offence under the Building Act and has an associated fine on conviction of up to $200,000. Building consent authorities must have regard to a ban when considering compliance with the Building Code and must not issue a building consent if it could result in someone breaching a ban.

The loop bar detail in double-tee flooring

The loop bar, or pigtail, hanger connection detail is associated with the support of precast concrete flange hung double-tee flooring units. A schematic showing a typical example of this connection detail is given in Figure 1.

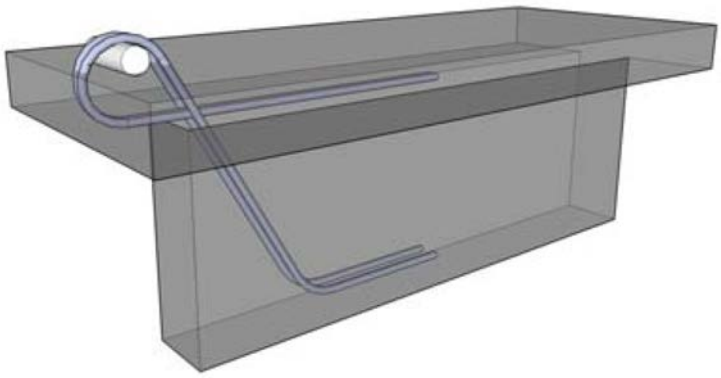

Figure 1 Typical loop bar connection of double-tee flooring

The detail comprises one or more reinforcing bars which extend from the web of the precast unit and rise up over the edge of the support into the flange of the unit where they are looped around a transverse bar and extend horizontally back through the flange of the precast unit.

Additional features that are sometimes associated with this detail are:

- short transverse bars that are tack-welded to the loop bend
- use of round bars for the bars forming the loop
- no presence of shear steel, such as stirrups, in the supported flange
- absence of a bearing strip
- inadequate anchorage of the bars forming the loop
- no armouring of supports.

The typical loop bar detail does not comply with the Concrete Structures Standard (NZS 3101). This is because:

- the detail relies on the tensile strength of concrete
- the plain round bars have inadequate anchorage
- the bar bend diameters are smaller than those permitted by NZS 3101
- the shear stress in the double-tee flange is likely to exceed the shear stress permitted by NZS 3101.

Compliance of the detail is usually sought as an alternative solution based on laboratory tests. The available published test data and the original design methodology is not considered valid in light of current concrete design practice. Moreover, the poor performance of this detail in Statistics House during the 2016 Kaikōura earthquakes, has confirmed its unsatisfactory seismic performance.

Shortcomings of the loop bar connections for flange hung double-tee flooring were issued by the Structural Engineering Society New Zealand (SESOC) in 2009. The use of loop bar connections has decreased since 2009 but has not stopped.

Stopping the use of loop bar details in double-tee flooring

If nothing is changed the loop bar connection of flange hung double-tee flooring could continue to be used if specific design shows the detail complies with the Building Code. The previous technical advice issued by SESOC indicates that the concept of the loop bar connection detail as currently implemented is fundamentally non-compliant, unreliable in an earthquake event and therefore its use should not be encouraged.

Proposed ban

The proposal to issue a ban on the use of the loop bar connection detail associated with the support of precast concrete flange hung double-tee flooring units, which would make it illegal to use the detail in new building work, is the preferred option. A ban is the most effective option to stop the use of the loop bar detail.

The ban is proposed to cover all new building work, meaning it would apply to all types of buildings and to both new construction and alterations.

Benefits and costs of the proposal

Option	Cost	Benefit
Status Quo	The main cost to leaving the loop bar connection detail as a design option is that buildings may be constructed that are structurally less robust in an earthquake than equivalent buildings that do not incorporate the detail. Loop bar connections as they are typically detailed do not comply with the Verification Method B1/VM1, so an alternative means of compliance with the Building Code must be used.	There are no benefits to leaving the loop bar connection detail as a design option.
Proposal to issue a ban	The main cost associated with banning the use of the loop bar detail is that building designs that are currently being developed may need to be modified. Very few, if any, construction projects are expected to be affected by the ban as the use of the loop bar detail nowadays is low. Consultants and/or precast concrete suppliers who use the loop bar detail would need to modify their double-tee floor unit designs. People who use a banned building method can be prosecuted, with an associated fine of up to $200,000.	The benefit of banning the use of the loop bar detail is that potentially non-compliant double-tee flooring would be avoided, providing greater confidence in the earthquake performance of buildings with double-tee precast floors.

Question 4 **Do you have any comments on the proposal or other options to stop the use of loop bar details in double-tee flooring?**

TIMING OF B1/VM1 AMENDMENT

B1/VM1 effective date: 1 February 2018

It is proposed that the amendment to the Verification Method B1/VM1 will be published with an effective date of 1 February 2018.

B1/VM1 transition period: three months

It is proposed that the existing version of the Verification Method B1/VM1 (Amendment 15) will remain in force, as if not amended, until 30 April 2018 (the proposed Cessation Date), a period of three months.

The table below illustrates how the proposed transitional provisions will work, with an explanation to follow:

	Before 1 February 2018 the Effective Date*	**Between 1 February 2018 (Effective Date*) to 30 April 2018 (Cessation Date*)**	**From 1 May 2018 (after the Cessation Date*)**
Existing Verification Method B1/VM1 Amendment 15	If used, will be treated as complying with the Building Code	If used, will be treated as complying with the Building Code	No longer available for use
Amended Verification Method B1/VM1 Amendment 16	Not available in this period	If used, will be treated as complying with the Building Code	If used, will be treated as complying with the Building Code

* The actual Effective Date and actual Cessation Date may change following the consideration of feedback received.

Under the proposed transitional arrangements:

- the existing Verification Method, B1/VM1 Amendment 15, if used for building consent applications lodged before the Cessation Date, will be treated as complying with the relevant provisions of the Building Code. A code compliance certificate may be issued after 30 March for building work consented before 30 March on the basis of the existing B1/VM1 Amendment 15
- the amended Verifications Method, B1/VM1 Amendment 16, if used for building consent applications lodged after the Effective Date, will be treated as complying with the relevant provisions of the Building Code
- to avoid doubt, in the period between the Effective Date and the Cessation Date, building consent applications will be treated by building consent authorities as complying with the relevant provisions of the Building Code if they correctly use either i) the existing B1/VM1 Amendment 15 or ii) the amended B1/VM1 Amendment 16.

Question 5 Do you agree with the proposed B1/VM1 transition arrangements?

TIMING OF THE PROPOSED BAN

Ban in force from 1 February 2018

It is proposed that the ban of the loop bar detail for double-tee flooring units will be issued, and come into force, on 1 February 2018.

After the ban comes into force it would be an offence to use the loop bar detail in double-tee flooring units in designs and construction that does not have a building consent. This is a strict liability offence with an associated fine on conviction of up to $200,000.

The ban is not proposed to cover the use of loop bar details that are part of building work done under a building consent issued before the ban comes into force. That is, it would not be an offence to complete construction, which includes loop bar details, after the ban is issued. A code compliance certificate could be issued for any building work completed in accordance with a building consent that has been granted before the ban came into force, in accordance with section 28(3) of the Building Act.

The table below illustrates how a ban on loop bar details would affect design and construction:

	Before 1 February 2018*	**From 1 February 2018*** **(ban in force)**
design	The loop bar detail can be used if it complies with the Building Code.	It is an offence to use the loop bar detail in designs.
construction	The loop bar detail can be constructed in accordance with a building consent.	It is an offence to use the loop bar detail in construction, except construction may be completed for a building consent granted before the ban comes into force.
building consents	A building consent may be issued if the loop bar detail complies with the Building Code.	A building consent must not be issued for loop bar details that fall within the scope of the ban.
code compliance certificates	A code compliance certificate may be issued for construction, which includes loop bar details, in accordance with a building consent.	A code compliance certificate may only be issued for construction, which includes loop bar details, if the building consent has been granted before 1 February 2018.

* The date that the ban is in force from may change following the consideration of feedback received. -

Question 6 Do you agree with the proposed timing if a ban is issued?