2 March 2012

The Executive Director
Canterbury Earthquakes Royal Commission
PO Box 14053
CHRISTCHURCH
Attention Justine Gilliland

Dear Justine

SESOC Practice Note- Design of Conventional Structural Systems following the Canterbury Earthquake.

On 21 December 2011 the Canterbury Earthquakes Royal Commission released the SESOC practice note of the above title. Comments on the document were sought by the 2 March 2012. The following comments are provided by Dene Cook the current Chairman of the NZS3101 committee (Concrete Design Standard). As the NZS3101 is not sitting at the moment only limited email consultation within the members of the NZS3101 committee was possible. However, the SESOC practice note is a significant document so some limited comment from the committee was considered appropriate.

Before delving into the fine detail of the practice note it is worth outlining the role Standard committee's play in ensuring the performance requirements of the Building Act are achieved.

National Standards play an important role in the provision of appropriately designed and constructed buildings representing current understanding and best practice. Their relevance and importance being recognised by citation in the Building Compliance Documents. Each Standard has a committee formed by nomination from stakeholder groups to ensure robust investigation and debate over the development of the Standard. This process has generally served New Zealand well over many years, though the sustainability of the current Standard development model is now questionable.

The committees charged with maintaining our Standards do so entirely at their own cost. Expert committee members volunteer their time and often cover the cost of their travel to Wellington for committee meetings. This model has worked well in the past when duty to ones country was considered an honorable activity. However, with changing societal values the day of the diligent volunteer may be ending and the funding model for Standard development needs urgent review. The aim of a review being to ensure that New Zealand's highly regarded world class building Standards are not undermined in the future due to the

unavailability of appropriate individuals to contribute due to financial pressures. Standard committees need to represent all stakeholders to ensure that commercial interests are not over represented.

The following comments are provided as comments on the SESOC practice note released 21 December 2011. Only comments pertaining to the NZS 3101 Standard are discussed. It is however recognized that there is a hierarchy within the building regulatory framework, and then a further hierarchy within the NZ Standard with the loading standard (NZS1170.5) dictating the design philosophy which material standards such as NZS3101 need to follow. It is therefore imperative that the NZS 1170.5 Standard committee addresses some of the suggestions in the SESOC paper and provides guidance on the future direction of NZS1170.5.

In the SESOC submission section 3 (Concrete Walls), section 4 (concrete moment resisting frames), section 8 (Precast Flooring Systems), and section 9 (Floor and roof diaphragms), have a strong concrete focus and therefore our comments are confined to these sections.

The comments provided are relatively short. It is however envisaged that subject to the Department of Housing and Buildings support, the NZS 3101 committee will be reconvened in 2012 with the intention of reviewing these and other comments in greater detail. In addition the NZS 3101 committee has been working with the University of Canterbury to formulate research required to refine potential ideas for improvements in the detailing of reinforced concrete structures. Researchers at the University of Auckland have also registered interest in assisting

Section 3 Concrete walls

On 25 November 2011, a workshop was held with the aim of indentifying any issues arising out of the Canterbury earthquakes which could represent opportunities for improvement in the Concrete Design Standard (NZS3101). Although this meeting predates the SESOC document, walls were identified as an area where, although performance of wall building was generally very good, small changes in detailing may result in even better performance.

Below are extracts from the SESOC publication followed by comments from a NZS3101 perspective. Numbering of sections corresponds to the numbering in the SESOC publication.

3.1 Singly reinforced walls

SESOC requirement	*Singly reinforced walls should be designed for nominally ductile (μ = 1.25) actions. Typically provide closed stirrup cages at each end of a wall segment to confine the anchorage of the horizontal reinforcing steel (refer to figure 2) unless the required $V^* \leq \phi V_c$, or $\varepsilon_c < 0.001$.*
Comments	The most predominant use of singly reinforced walls is low rise commercial buildings. The reinforcement of these are typically dictated by minimum reinforcing requirements. They have low ductility demand and low shear stress so would already comply with the above recommendation. Upon its formation the NZS3101 committee will look further into this recommendation. The present NZS3101 requirements of singly reinforced walls are based upon research conducted by Branz and the Universities of Auckland and Canterbury. These studies demonstrated good performance at ductility factors considerably greater than being suggested by SESOC so robust debate of the SESOC requirements is required. The proposed trigger for providing confining reinforcement around the end of shear reinforcement requires further thought particularly when axial loads are large resulting in a larger ϕV_c.

3.2 Double reinforced walls.

SESOC requirement	*Refer to Section 3.4 for requirements to address local bar buckling. Typically provide closed stirrup cages*

at each end of a wall segment to confine the anchorage of the horizontal reinforcing steel (refer to figure 3) unless $V^* \leq \phi V_c$, or $\varepsilon_c < 0.001$.

Comments

Much of the proposed detailing appears to already be within NZS3101:06. Relevant clauses being 11.4.6.2 and 11.4.6.3.

3.3 Wall Thickness

SESOC requirement

Minimum wall thicknesses should be used as shown in Table 1:

Table 1: Minimum Wall Thicknesses

Construction	Floor starters	Thickness
Any[1]	D10	150mm
Any[1]	D12	175mm
Any[1]	XD10	200mm
Any[1]	XD12	250mm
Precast[2]	-	200mm[3]

Notes:

1. *wall thickness limited by development of hooked floor starters (assumes f'c>30 MPa, cover > 40mm, no more than 300mm concrete cast below the starter)*
2. *wall thickness limited by precast panel splices – refer to Section 3.8 below*
3. *unless greater wall thickness required for development of floor starters*

Comments

The SSEOC document does not mention many of the references within NZS3101 which determine the appropriate minimum wall thicknesses bar diameters being only one of the requirements. Dimensional limitations of walls are described in section 11.4.2 of NZS3101. The above suggested wall thicknesses have been derived from current NZS3101 requirements for anchorage of hooked bars. The important aspect is that the anchorage of the connection can be achieved. This must occur regardless of wall thickness. A Standard needs to portray design rules which can be universally applied. Developing minimum wall thickness based upon common anchorage details will mean that development of better systems and details will be stifled.

3.4 Local Bar buckling

SESOC requirement

For nominally ductile walls, full anti-buckling and confinement (NZS3101:2006, clause 11.4.6) should be provided over the full length of the compression zone - unless it can be shown that the wall has sufficient capacity to resist 1.5 times the ULS forces without yielding any bars.

For the plastic hinge zone of ductile walls, transverse reinforcement shall be provided over the full wall length as follows;

- *Confinement of the boundary regions shall be provided in accordance with NZS3101:2006, clause 11.4.6 – modified to provide confinement over the full length of the compression zone.*
- *Transverse reinforcement in the central portion of the wall shall satisfy the anti-buckling requirements of NZS3101:2006, clause 11.4.6.3, as shown in figure 5.*

Comments

Confinement and limitation of bar buckling is an area which the NZS3101 workshop also identified as requiring further research. Although it is recognized that work is required in this area the SESOC requirement do appear to be excessively conservative. The implication of these requirements for nominally ductile elements would mean that singly reinforced wall could only be used if yielding of reinforcement was not occur in the maximum creditable event (2500 year return period event). Given the generally good performance of these structures in Christchurch this suggestion requires further refinement.

The first suggestions for ductile walls relates to the extent of the zone for which confinement should be supplied. NZS3101 requires that only the part of the compression zone where excessive strains are expected should be confined. This being based upon research with walls and columns. There may be justification for an extension of the zone of confinement more for anitbuckling rather than confinement.

The suggestion of providing anti buckling reinforcement along the entire length of the wall requires research. This represents a significant departure from how walls are presently constructed both here and overseas. Any change, if required, should be based upon testing.

3.6 Minimum reinforcement.

SESOC requirement

The minimum reinforcing content should be calculated in accordance with NZS3101:2006 (clause 11.3.11.3), using the specified 28 day strength.

$$\rho_n \geq \frac{0.4\sqrt{f'_c}}{f_y},$$

A clause defining minimum (f'_c) and maximum ($2 \times f'_c$) acceptable concrete strengths should also be included in the Specification.

Comments

The above recommendation is based upon the present 2006 NZS3101 rules but modified on the assumption that the actual compressive strength of the concrete is 2.5 times that specified. It represents a 58% increase in the minimum reinforcing required. It should be noted that in the 2006 the minimum reinforcing contents for ductile walls were increased by 92% above the requirements which have existed since the 1982 version of NZS3101. Care is needed to ensure that any lessons learnt from the Christchurch earthquakes are applied appropriately. It may be that the issue of raising minimum reinforcement in walls has already been adequately addressed in the 2006 revision of NZS3101. This is an issue the NZS3101 committee will review.

3.7 Distribution of reinforcement

SESOC recommendation

Reinforcing should be lumped at the ends of a wall, with minimum reinforcing distributed along the web

Comments

There is conflicting evidence regarding the desirability of lumping reinforcement at the ends of walls. Further

review of the available literature is recommended before such a requirement should be introduced into Standards.

3.8 Precast panel Splices

SESOC Requirement	*Precast panel splices must allow for de-bonding of reinforcement where yielding is expected.* *Drossbach ducts must be fully confined*
Comments	The requirements for connections in precast elements are covered in NZS3101 by clause 18.6.5. Whether it is appropriate to include this level of detail about proprietary systems in NZS3101 or in an industry design guide needs to be debated. However the need to ensure that connections behave in a ductile manner is agreed and a requirement of NZS3101.

3.9 Precast Panel Embedded Anchors

SESOC Requirement	*Shallow embedded connections shall not be used for primary structural load paths.*
Comments	Although not specifically related to shallow embedment items, NZS3101 already covers the requirement for considering the primary load path in clause 18.6.1

3.10 Compatibility effects in Gravity Structures

SESOC Requirement	*All gravity frames and members in wall structures shall be detailed to accommodate $1.5/S_p$ times the ULS drifts. This may be achieved by detailing the gravity columns for ductility in accordance with the seismic design provisions of the relevant materials Standard, for both confinement and shear.*
Comments	All gravity columns designed to NZS3101 are already detailed to ensure ductility. This requirement was introduce into the standard in 1995

4 Concrete Moment Resisting Frames

We concur with the SESOC conclusion that concrete moment resisting frames generally performed as expected. A yielding frame system, be it concrete or steel, is not likely to be a low damage system.

4.1 Frame Ductility

SESOC Recommendation	*Conventional concrete moment resisting frames should be limited to nominally ductile (μ=1.25) actions, but detailed for resilience (refer below).*
Comments	This recommendation stems from a desire to minimize the cost of damage post a ULS earthquake. This represents a significant departure from the philosophy embodied within NZS1170.5 and enshrined within the NZ Building Code. Decades of research have demonstrated that concrete moment resisting frames can be detailed to withstand high ductility demand. Guidance from the Department of Building in Housing would be required before such a change could be introduced.

4.3 Frame Elongation

SESOC Requirement	*Floor diaphragms must be detailed to accommodate significant frame elongation where any yielding of conventional moment resisting frames is expected (note that this may not be possible to achieve).* *Where conventional moment resisting frames are designed to remain elastic, geometric elongation of approx 0.5% should be considered in design and detailing of floor diaphragms.*
Comments	The need to cover frame dilatancy is already covered by clause 18.8.1.2. of NZS3101:06 There could be value in providing further guidance in the commentary of this clause in line with the above.

8 Precast Flooring Systems

8.3 Rib and Timber Infill

SESOC Requirement	*Prestressed ribs should be detailed with stirrups over the transfer length of the strands and with sufficient height to develop in the topping.*
Comments	This already occurs. Dialogue will be required with the authors to fully understand the intention of this comment.

8.4 Seating Details

SESOC Requirement	*The following figures provide typical seating details for commonly used precast flooring systems*

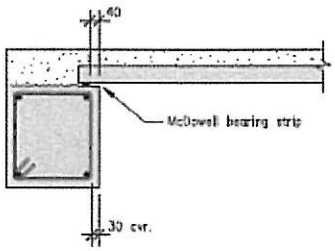

Figure 1: Flat slab seating

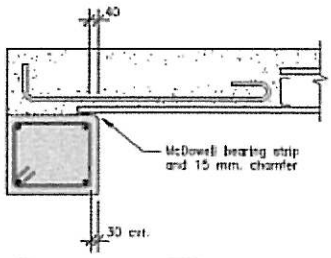

Figure 2: Hollowcore seating

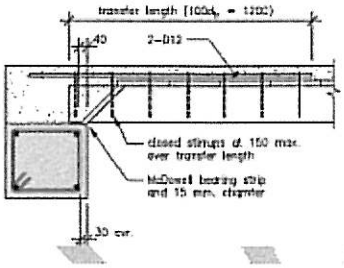

Figure 3: Interspan rib seating

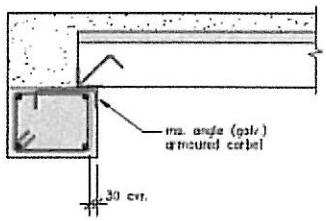

Figure 4: Web supported tee seating

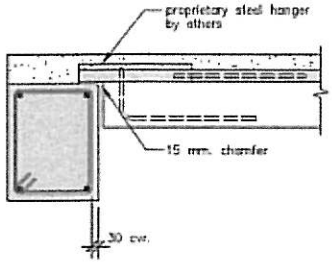

Figure 5: Flange hung double tee seating

Comments	These are consistent with what is already specified within NZS3101

8.5 Sliding Joints

SESOC Recommendation	*Double structure should be provided at seismic joints in preference to sliding details.* *Sliding seating details for precast flooring should be avoided.*
Comments	Further dialogue with the SESOC authors is required as the intent of the above is not clear.

9 Floor and Roof Diaphragms

9.1 Collector elements

SESOC Requirement	*Collector elements must be designed for the lesser of 1.5 times the ULS actions or over-strength actions as appropriate. Where compressive stresses exceed the strut and tie limits (conservatively taken as 0.5 f'_c), confinement should be provided in accordance with NZS3101:2006, clause 10.3.10.6.*
Comments	The basic tenet here is that the connection between the diaphragm and the main structural element should be stronger than the elements it connects to. This concept is equally applicable to concrete diaphragms connecting to concrete or steel primary members or equally to timber diaphragms connect to timber shear walls. As such any such requirement should be incorporated into NZS1170.5 to ensure consistency between materials.

9.2 Suspended Floor

SESOC Requirement	*Absolute minimum topping thickness of 75mm. Wire meshes (hard drawn or ductile) are NOT to be used in floor diaphragms*
Comments	At present the minimum topping thickness specified in NZS3101 is 50mm. NZS3101 does require shear stresses to be checked to ensure that this thickness is appropriate. Increasing minimum thicknesses unnecessarily will result in heavier structures and larger inertia forces. In 2006 NZS3101 introduced the requirement that all mesh shall be high ductility mesh (Class E). The recent changes to the reinforcement requirements of domestic floor slabs now means that class E mesh is now far more readily available. High ductility mesh may have advantages over conventional reinforcement (of similar ductility) in that the large number of small diameter bars in mesh may in some instances enhance performance.

As identified earlier the above comments are relatively short. However it is envisaged, the NZS3101 committee will be reconvened in 2012 with the intention of reviewing these and other comments in much greater detail.

Yours sincerely

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