BUILDING PERFORMANCE

Practice Advisory 6: Achieve best practice every step of the way

This Practice Advisory highlights concerns about general design and construction practices, as well as recommended actions you can take to maintain professional standards.

The advisory should be read in conjunction with the cover note for the 'Practice Advisories 1 to 6 – Maintain professional standards'.

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Of interest to Building consent authorities, Builders, Designers, Engineers

Concerns and recommended actions

We have produced this guidance to highlight concerns and implications about general design and construction practices, as well as recommended actions you can take to maintain professional standards.

Description of concern	Possible implications for the performance of the structure	Recommended action
6.1 Diaphragm load paths Inadequate or impractical load paths are provided through diaphragms and transfer diaphragms.	**Damage to floor diaphragms in a major earthquake may be significant and may result in failure of the floor to transfer earthquake and gravity loads.**	**Be clear on the viability and robustness of load paths from concept to final design.** • Review NZS 3101: 2006 Section 13 – Design of Diaphragms. • Refer general structural concept texts such as: White R et al, Structural Engineering, SESOC Journal, Puzzle Series 2003.
6.2 Diaphragm detailing Inadequate consideration of detailing requirements of local effects due to steps in diaphragms, penetrations, or re-entrant corners in diaphragms. Inadequate consideration to confirm primary structural load paths for transfer diaphragms.	**Significant localised damage to the diaphragm in a major earthquake and possible loss of integrity of the structure.**	**Ensure all links are robust and capable of performing when deformed by earthquake actions. Beware of lightly reinforced toppings and penetrations for stairs/lifts etc. Confirm that a clear structural load path is provided for all transfer diaphragms. Give consideration to the effects of variations in relative stiffness of the diaphragm and primary load resisting elements.** • Review NZS 3101 Section 13, note Clause 13.3.3. Ensure structural analysis allows for accurate determination of the design actions in local discontinuities such as re-entrant corners. • Refer SAFE slab design software as one means of analysing steps or re-entrant corner in slabs.

6.3 New methods and forms of construction New methods and unusual forms of construction can introduce significant uncertainties to structural performance.	**The use of unusual forms of construction and products not proven as being fit for purpose can result in a serious reduction in structural performance and safety.**	**Ensure all new products and systems have been appropriately tested and formally approved by a recognised authority before using them in building construction.** A risk-based approach, taking into consideration the likelihood and consequences of an incorrect design, could be used to set the level of specialist expertise, scale modelling, peer review, proof testing and other steps needed to ensure the completed structure will satisfy the design intention.
6.4 Detailing requirements for reinforcement Inadequate consideration of the detailing requirements for curtailment of reinforcement in tension zones and bond stress in areas of high shear.	**Significant damage in a major earthquake but unlikely to lead directly to collapse of the structure.**	**Detail reinforcement rigorously with appropriate input from a CPEng structural engineer.** Review NZS 3101 Concrete Structures Standard Section 8, Clause 8.6.12.4. • Refer Park R, Paulay T, Reinforced Concrete Structures, Chapter 13 The Art of Detailing.
6.5 Anchoring of spiral reinforcement in columns Spiral and hoop reinforcing in columns and piles is not being correctly anchored into core concrete in some circumstances.	**Serious implications for performance in major seismic events. The columns and piles can fail in a brittle manner if the confining effect of spirals and hoops is lost.**	**Anchor both ends of every section of spiral reinforcement with a 135 degree hook. If welded splices are necessary they should be carried out in accordance with AS/NZS 1554. Welding must not affect the main reinforcing bars.** • Refer NZS 3101 Section 8.
6.6 Rebending of reinforcement Rebending reinforcing on site can seriously affect the strength and ductility of the bar.	**Serious reduction in load carrying capacity may occur with possible collapse for some parts of structures.**	**Rebending is discouraged.** Give consideration to design details that avoid the requirement for rebending. If it is unavoidable, then it must be done in accordance with manufacturers' recommendations. • Covered in NZS 3101 Section 5, Clause 5.3.2.8. • Also NZS 3109 Concrete Construction, Section 3 Clauses 3.3.4 to 3.3.6. • Refer to MBIE's report on Grade 500E steel reinforcement.
6.7 Reinforcing for lateral bursting Poor consideration of the lateral bursting forces associated with cranked reinforcing bars.	**Can lead to damage and some loss of strength.**	**Place special reinforcement to provide restraint against the lateral bursting forces.**
6.8 Grade 8.8 bolts Welding of high strength (Grade 8.8 and above) bolts will seriously affect their ductility.	**Depending on the importance of the member to which the bolts are fastened, welding can cause serious failure as the bolts can fail in a brittle manner.**	**No welding of high strength bolts should be carried out. This includes tack welding.** Bolts can be fixed in position through the use of temporary frames or adhesive. See details in HERA Report R4-58.
6.9 Shear design of beams Shear design of: • beams supporting precast flooring • shell beams may be carried out using unconservative values for the contributory width.	**Likely to be of concern, especially where the structure is subjected to major earthquake actions. Localised serious damage in a major earthquake could result, such as brittle failure of beams and floor supports.**	**Always adopt a conservative approach in assessing shear capability to avoid brittle failures.** • Review NZS 3101 Part 1 Section 18, Clause 18.5.6. Note that the width to be used in determining shear capacity will vary as a function of the location along the beam (plastic hinge zone vs. non-hinge zone). • Refer Bull DK,1984. Park R Behaviour of structural concrete frames with precast concrete shell beams subjected to seismic loading.
6.10 Uneven loading Insufficient consideration of uneven loading arrangements or imposed lateral displacements, especially when checking punching shear on cast in-situ slabs/column heads.	**When not considered in design the situation could lead to unsatisfactory performance, possibly partial collapse of a floor and even the overall collapse of the structure.**	**Consider non-uniform loading, or effect of displacement when determining critical member actions.** • Refer NZS 3101 Commentary Clauses C12.7.1 and C12.7.7.7.3.

6.11 Precast concrete Precast concrete is not covered adequately in NZS 3101. A view that precast concrete hollow-core floors performed poorly in recent earthquakes in California.	**Specific implications are dealt with in other items in this table.** The performance of precast concrete hollow-core floors in California is not directly comparable to New Zealand situations due to different methods of design and construction.	**Refer NZS 3101, Chapter 18.** • Refer CAE Guidelines for the Use of Structural Concrete in Buildings, University of Canterbury, Christchurch, New Zealand. 2nd Edition December 1999.
6.12 Saw cuts in diaphragms Uncontrolled saw cuts in diaphragm slabs reduce transfer capacity through reducing concrete depth and potentially cutting reinforcement.	**Can seriously affect diaphragm performance as noted in Item 1.**	**Designers:** Indicate position and maximum depth of saw cuts clearly. Warn of dangers of cutting too deep or in a different location. Specify a concrete mix that minimises shrinkage by minimising water content, maximising aggregate size. **Contractors:** Do not carry out saw cuts in diaphragms (including slab on grade) without obtaining the approval from the designer. Use good curing practices, refer NZMP 3100: 1999 The Guide to Concrete Construction.
6.13 Buckling restraint In reinforced concrete construction tie-bars between the column and floor system in one-way frames must be sufficient to provide restraint against column buckling.	**In steel construction the degree of lateral restraint provided must be correctly assessed to ensure sufficient restraint against column buckling.** Lack of proper column restraint can lead to premature failure of the columns and overall structure.	**Reinforced Concrete:** Design, detail and provide reinforcement in accordance with NZS 3101 Section 18, Clause 18.6.6. Floor system must be able to provide sufficient restraint to prevent column buckling and separation of the columns and diaphragm. Generally require larger of 5% of maximum axial load in column or 20% column shear from lateral forces. **Structural Steel:** Provide detailing that will ensure the member is restrained to the degree assumed in the design calculations. • Refer NZS 3404, Section 1.3 and 4, Clause 4.8, Section 5, Clause 5.4, Section 6, Clause 6.7. • Refer HERA Report R4-92, Restraint Classifications for Beam Member Moment Capacity Determination to NZS 3404: 1997. • Refer Nethercot L, Lateral stability of steel beams and columns: common cases of restraint, SCI 1992.
6.14 Composite steel beams Over-estimation of theoretical shear stud capacity in precast floor systems on composite steel beams.	**Could lead to under-design of composite members and significant damage under service or ultimate loads.**	**Note reduction in shear stud capacities.** • Refer HERA Report R4-113. Notes from a seminar on composite construction, especially sessions 2.2 and 4.2. Consider the effects of accumulated creep and shrinkage and moment continuity effects on stud capacity.
6.15 Serviceability Performance of composite floor systems. Serviceability considerations (deflection, vibration) may control the size and spacing of support members and slab thicknesses in composite floor systems (insitu-slab on steel deck supported on composite steel beams).	**The floor system may undergo excessive deflections, especially in local areas, or undergo excessive vibration under in-service conditions.**	**These are well covered in design guidance.** • Refer HERA Report R4-107.

All guidance related to B1 Structure (https://www.building.govt.nz/building-code-compliance/b-stability/b1-structure/)

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