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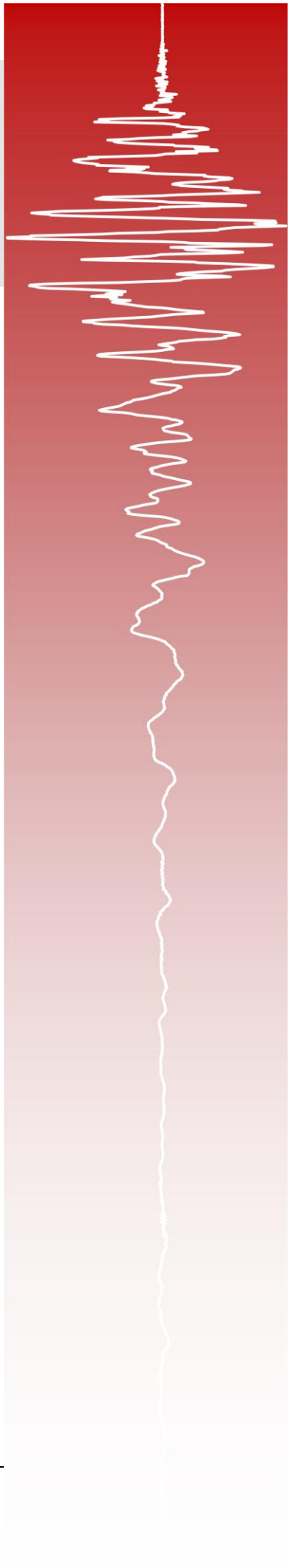

Submission regarding

SESOC Practice Note: Design of Conventional Structural Systems Following the Canterbury Earthquakes

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0. Preface

This document is a submission to the Canterbury Earthquakes Royal Commission from Compusoft Engineering Limited and is intended as a response to the Practice Note submitted to the Royal Commission by the Structural Engineering Society of New Zealand (SESOC Management Committee 2011). The SESOC document is referred to through the remainder of this document as "the practice note". The main headings and heading numbering from the SESOC document have been adopted in this document to aid with cross referencing between the two documents. Mirroring of the SESOC numbering is the reason that (unusually) this Compusoft Engineering Limited submission begins at section zero.

0.1. Overview Comments

Compusoft Engineering Limited supports SESOC in its position to respond to a request from the Royal Commission of Inquiry, and is aware and acknowledges that this response was made under considerable time pressure. However, we have a number of concerns related to the form of the response:

- The practice note is openly based on an internal document prepared by and for Holmes Consulting Group, and we contend that the format as presented reflects this origin. Consequently we contend that its: name, style, focus, and in many cases, its content is NOT worthy of a SESOC Submission to the Royal Commission.
- Compusoft Engineering Limited noted that the practice note gives the impression of having been authored by SESOC. The practice note was in fact authored by the SESOC Management Committee. While this distinction may be considered pedantic, we feel it should be noted that no draft of the document was circulated to those outside of the Management Committee prior to the practice notes appearance on the Royal Commission website on 21st December 2011.
- Compusoft Engineering Limited are of the view that the document as it currently stands should not be classified as a "Practice Note". The term "Practice Note" is typically associated with short, focussed advisories on specific areas of engineering. A name that more accurately reflects the nature

of the SESOC document would be preferable, for example "Interim Design Advisory".

To remedy these concerns, Compusoft Engineering Limited believe the SESOC submission should be rewritten by a team of knowledgeable structural engineers, headed by the SESOC President. This could be achieved in a short period of time.

0.2. Content

As noted in the previous section, Compusoft Engineering Limited has two holistic concerns regarding the content and focus of the practice note:

The first of these concerns is that many of the requirements presented in the practice note could be summarised as "ensure compliance with the current loadings and materials standards". A simple statement requesting compliance with existing standards would reduce the size of the SESOC submission.

Secondly, the submission tends to confuse the design requirements of life safety and damage avoidance. It should be clearly noted in the practice note that the only performance requirement for buildings at the ultimate limit state according to the current New Zealand Building Code is life safety. While many Christchurch building owners have been disadvantaged by damage to their buildings, Compusoft Engineering Limited do not believe that this should necessarily lead to damage avoidance being mandated for low recurrence events. It is important to bear in mind that Building Code and New Zealand Standard requirements are minimum compliance levels only, and that engineers should educate their clients so that they understand the expected performance of structures. This will allow clients to make informed decisions about their tolerance for risk, damage, and downtime. It is further noted that New Zealand design standards already contain provisions for designing structures with a high chance of remaining operational after very large earthquakes, and that any client is theoretically capable of requiring their structure to be designed according to these provisions.

1. Introduction

Compusoft Engineering Limited agree that:

"most modern structures (post-1995) have performed acceptably"

with the obvious exceptions to the statement generally being the result of inadequate design. Compusoft Engineering Limited would, in fact, extend the statement quoted above to include structures design from approximately 1982 onwards.

We note that the definition provided is the Building Act definition of a residential structure, not a non-residential structure as implied by the text. This is potentially confusing.

Compusoft Engineering Limited is of the view the "SESOC Requirement" should be reclassified as "SESOC Recommendation", noting that SESOC has no authority to enforce requirements beyond current codes of practice.

2. Loadings and design philosophy

2.1. Seismic loads

Compusoft Engineering Limited agree fully with the concerns raised in the practice note regarding the behaviour of buildings design for "nominal" ductility, i.e. $\mu = 1.25$. We have particular concerns about the performance of highly irregular structures designed for nominal ductility. In such instances we are not convinced that local ductility demands can be reliably determined using typical analysis techniques. We are of the firm opinion that the decision to use "nominal ductility" level loads should not reward engineers with the ability to design a structure using significantly less stringent design and detailing requirements, except in the case where a structure is demonstrated to be "highly" regular. An appropriate definition of what constitutes "highly regular" could be developed relatively easily by an appropriate panel of experts, for example the committee for the New Zealand Design Actions Standard (NZS 1170.5 2004).

We agree that New Zealand Standards should increase the emphasis placed on capacity design and provision of reliable ductile load paths, and that this emphasis should include structures designed using "nominal ductile" loads.

2.2. Design approach

This section presents a general discussion not relevant to design for the Life Safety limit state. That said, Compusoft Engineering Limited believe that the structural engineering profession

should place greater emphasis on promoting base isolation to clients and the general public, and not necessarily only for buildings that contain "high value or critical contents". We feel that base isolation is currently, and unfairly, perceived to be unviable for general structures.

In addition, greater emphasis should be placed by practising engineers on the importance of ensuring non-structural items comply with the requirements of the New Zealand Design Actions Standard (NZS 1170.5 2004) for Parts and Components. This emphasis would require more interaction between structural engineers and others involved in the design and build process.

2.3. Resilience

Increasing the strength of buildings will reduce damage, but will only marginally increase "resilience". Resilience can more effectively be increased through an introduction of redundancy of structure and more rigorous design and review practice. Increasing the magnitudes of design strengths are of no use if detailing and construction standards are not in place.

Compusoft Engineering Limited considers that this section is currently quite unclear. If we understand it correctly, the implication is that the MCE level earthquake should differ depending on the importance level of a structure, for example that for an IL4 structure the MCE level actions should be 1.8×1.5×"ULS actions for an IL2 structure", where the 1.8 factors relates to the return period factor, "R", and the 1.5 factor relates to the margin of the MCE actions being "at least 1.5 to 1.8 times the ULS level".

If the understanding above is correct, Compusoft Engineering Limited believes that this is an unnecessarily and unrealistically severe requirement. While it is not realistic to place a precise figure on the likelihood of such actions, we note that a multiplier of 1.8×1.5 = 2.7 on the 500 year/ULS earthquake actions is likely to equate to a return period of the order of 12000 years. This value has been obtained based on curve fitting to the "average" return period factor used in the New Zealand Design Actions Standard (NZS 1170.5 2004). It is worth considering that for many areas of New Zealand a multiplier of 2.7 on 500 year actions would result in an even longer return period, as can be extrapolated from Figure 1, which has been taken from the commentary of the Design Actions Standard.

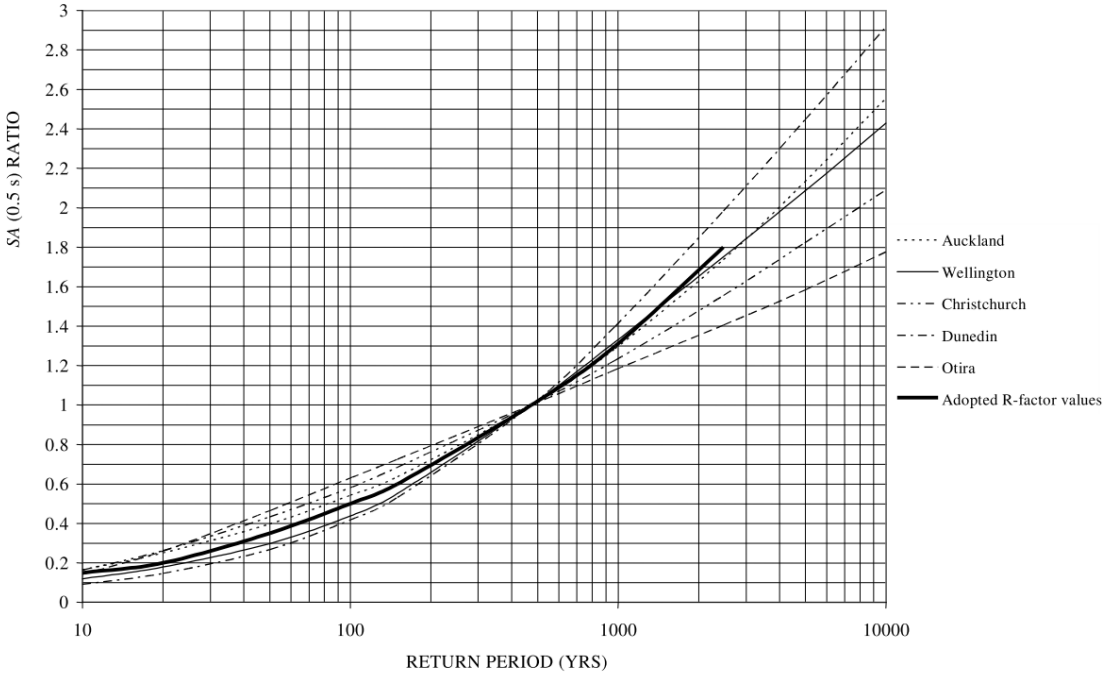

Figure 1: Relationship between R factor and return period for New Zealand locations m (from NZS 1170.5 2004)

2.4. Building configuration and redundancy

Compusoft Engineering Limited do not believe that this section provides any new information to the engineering profession.

2.5. Acceptance of proprietary systems

Compusoft Engineering Limited believes that all proprietary structural systems must be certified rigorously by an accredited authority. It would be helpful if a database of such certifications were maintained by a suitable body, perhaps SESOC or the Department of Building and Housing. It is particularly important that this certification must include imported products such as structural steel and steel reinforcement.

3. Concrete walls

Compusoft Engineering Limited generally agrees with the comments made regarding reinforced concrete walls. However, we feel that the proposed minimum reinforcement requirement would be more transparent if expressed as:

$$\rho_n = \frac{\sqrt{2.5 f_c'}}{4 f_y}$$

which we believe would more clearly indicate the intent that the reinforcement content is based on 2.5 times the specified concrete strength.

Considering the proposed equation further, it is not clear that the equation presented by SESOC (and in modified form above) is sufficient to ensure that it achieves the desired behaviour. This is because it is still seemingly based around an assumption that the direct tensile strength of concrete is equal to 0.25×sqaure root compressive strength. This is erroneous, with the lower characteristic tensile strength normally being taken as approximately 0.36×square root compressive strength, and the upper characteristic tensile strength potentially being as high as 1.0×square root compressive strength. On this basis, we propose that it could be necessary for the minimum reinforcement ratio to be as high as:

$$\rho_n = \frac{\sqrt{2 f_c'}}{f_y}$$

with the equation based on an assumption that the concrete compressive strength could be twice the specified strength, and the tensile strength could be equal to the square root of the compressive strength.

3.9. Precast Panel Embedded Anchors

Compusoft Engineering Limited is in agreement with the recommendations of this section. However, it is our opinion that the recommendations be expanded to explicitly exclude any connection that relies solely on the tensile capacity of concrete from being used to resist seismic actions. This would include drill-in anchors in unreinforced concrete, or effectively unreinforced sections of concrete.

4. Concrete moment resisting frames

Compusoft Engineering Limited are of the opinion that the problem of yielded reinforcement in moment resisting frames has been overstated, and that in a number of cases demolition has been recommended for structures that could have been economically repaired. We further note that well designed ductile moment resisting frames possess an inherent high degree of

redundancy due to their ability to distribute plasticity throughout the structure. Further, we note that when "accurately" assessed, the ductility demands on existing frames are far lower than suggested by their "design" ductility levels. This is supported by the behaviour of many frames during the Christchurch earthquakes, where apparent ductility demands have been much lower than might have been anticipated.

On the basis of the points made above, Compusoft Engineering Limited believes that the SESOC recommendation that moment resisting frames be limited to nominally ductile actions is unduly onerous. The motivation for this recommendation appears to be driven by an economic rather than a life safety measure, and as such is relevant for discussions between engineers and owners rather than as a general recommendation.

The SESOC recommendations related to detailing frames for resilience and to account for elongation effects appear to differ little from current New Zealand code requirements.

5. Steel moment resisting frames

Compusoft Engineering Limited has a similar opinion of this section as outlined by our comments on section 4.

5.4. Composite Beams and Precast Flooring

It should be noted that composite flooring involving precast units often do not satisfy the shear stud criteria that would allow NZS 3404 design guidance to be used, and that specialist guidance should be used to determine composite capacity.

6. Steel braced frames

6.1. Ductile EBF's

Compusoft Engineering Limited again refer to our comments in section 4 as these apply similarly to this section.

7. Steel connections

Compusoft Engineering Limited have no specific comments on this section, beyond restating our view that much of the document simply states "follow accepted best practice and current design standards".

8. Precast flooring systems

Compusoft Engineering Limited believes that SESOC should strongly promote the use of in-situ floors for concrete structures. Whether such floors are reinforced or prestressed they undoubtedly offer the most robust solution available. A possible avenue for driving this adoption would be for government to require their use in new public buildings.

9. Floor and roof diaphragms

Compusoft Engineering Limited note that recent University of Canterbury publications (Gardiner et al. 2008) offer a possible improvement for development of diaphragm design actions.

The SESOC requirement that mesh reinforcement not be used in diaphragms is sensible.

10. Transfer structure

Compusoft Engineering Limited believes that all structures requiring specific design should be **independently** peer reviewed, and do not believe it should be permissible to review structural elements such as transfer structures in isolation.

11. Seismic joints

Compusoft Engineering Limited has no specific comments on this section.

12. Foundation issues

Compusoft Engineering Limited have no specific comments on this section. However, we are in agreement that mixed foundation types have a high degree of complexity and a resultant likelihood of producing poor structural performance.

13. Shallow foundations

Compusoft Engineering Limited agrees that raft foundations have generally performed satisfactorily.

14. Deep foundations

Compusoft Engineering Limited has no specific comments on this section.

15. Stairs

Compusoft Engineering Limited broadly agree with the comments made in this section.

16. Precast cladding panels

Compusoft Engineering Limited have no specific comments on this section.

17. Conclusions and summary of main issues

Compusoft Engineering Limited believes that the SESOC practice note submitted to the Royal Commission has a number of overall issues that require rectifying. These issues have been outlined, but in summary are:

- Outlining requirements that simplify to "follow best practice and the current New Zealand Standard".
- Confusing the requirements of life safety and damage avoidance. Despite the significant inconvenience to building owners resulting from earthquake damage in Christchurch, Compusoft Engineering Limited do not believe that this should be used to justify mandatory damage avoidance design for low recurrence events.

In addition to the issues of content and focus summarised above, Compusoft Engineering Limited remain concerned that the SESOC submission was authored by the SESOC management committee in isolation and without providing members with an opportunity to comment, or even notifying them, prior to submission of the document to the Royal Commission.

18. References

Gardiner, D. R., Bull, D. K., and Carr, A. J. (2008). "Internal Forces of Concrete Floor Diaphragms in Multi-Storey Buildings." *NZSEE Conference*, Wairakei, New Zealand, 1–8p.

NZS 1170.5. (2004). *Structural design actions, Part 5: Earthquake Actions - New Zealand*. Standards New Zealand, Wellington, New Zealand, 154p.

NZS 3101. (2006). *Concrete Structures Standard*. Standards New Zealand, Wellington, New Zealand, 646p.

SESOC Management Committee. (2011). *Practice Note: Design of Conventional Systems Following the Canterbury Earthquakes*. The Structural Engineering Society of New Zealand, Christchurch, New Zealand, 39p.