SRIA
Steel Reinforcement Institute of Australia

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SEISMIC DESIGN AND DETAILING OF REINFORCED CONCRETE STRUCTURES

The SRIA in conjunction with the Concrete Institute of Australia and supported by the Australian Earthquake Engineering Society recently completed a series of National Seminars dealing with this important topic, which were based around the publication of our new *Guide to Seismic Design and Detailing of Reinforced Concrete Buildings in Australia*. Designers realised that earthquake design should not be considered as a specialised field, but should be part of their everyday design process. Some of the interesting points that were covered in the seminar include:

a) Earthquakes occur relatively frequently in Australia. On average Australia will experience a shallow earthquake of magnitude 6 or more once every 10 years (equivalent to the 2011 Christchurch earthquake), and one shallow earthquake of magnitude 5 or more every two years (equivalent to those in Newcastle and Adelaide).

b) Only a few reinforced concrete buildings in Australia do not need to be designed for earthquakes: Class 10 (non-habitable) buildings and Class 1 (domestic) buildings, provided that they are less than 8.5 m in height, have a hazard factor $k_pZ \le 0.11$ and the construction material type is covered by Australian Standards.

c) There is a fundamental difference between designing for wind and earthquake loads: both have a typical recurrence interval of 1:500 years, but the structure is designed statically for the full wind load, whereas it is only designed statically for a small portion of the actual earthquake load. The majority of the earthquake forces are accommodated by the ductility of the structure.

d) Ductility of the structure is provided through adequate reinforcement design and appropriate detailing. Design and detailing can either be in accordance with the body of AS 3600 or Appendix C of AS 3600. What is the difference? In accordance with the body of AS 3600 provides the structure with a ductility factor, $\mu \le 2$ (known as an ordinary moment-resisting frame), and the additional provisions of Appendix C, a ductility factor of $2 < \mu \le 3$ (known as an intermediate moment-resisting frame).

e) How to decide which approach to use? The answer to this is found in AS 1170.4 Earthquake actions in Australia. As the ductility of the structure increases, more of the earthquake load can be accommodated by the ductility of the structure, and consequently, the static design load is reduced through applying the factor S_p/μ in either the simplified or equivalent static design approaches when determining the static design earthquake load. Providing the additional reinforcement detailing in accordance with Appendix C will introduce sufficient frame ductility so that the lateral force resisting elements within the building are able to meet the ductility demand.

f) Floor slabs within buildings act as diaphragms to transfer lateral loads to the lateral force resisting elements. These are not covered in AS 3600 but failure, excessive deflection, inadequate connection to the lateral supporting members or reinforcement detailing, may result in local or overall failure of the structure.

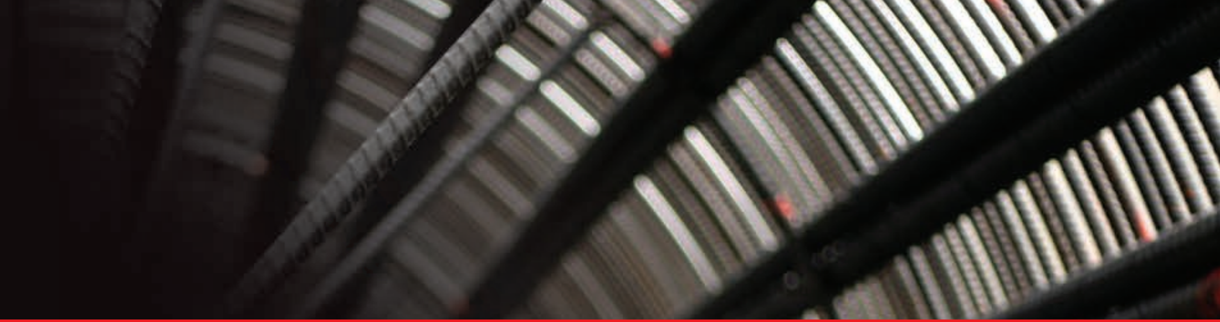
g) In terms of reinforcement detailing, the use of internal fitments having a 90° cog at one end is not recommended for columns of intermediate moment-resisting frames or columns designed above the balance point (particularly for special confinement regions). This is because in line with overseas practice, the Christchurch earthquake has demonstrated that the cover concrete is lost once the drift of the column reaches about 1.5% in a seismic event. As cogs are anchored in the cover concrete, once it is lost, the fitment can no longer adequately laterally restrain the longitudinal bar within the column. Once fitments fail, the column usually fails, followed by the structure.

h) With the design of walls, these often slender and under reinforced elements may not provide the required ductility without careful design and detailing of the reinforcement. Walls with high strength concrete and/or low reinforcement percentages are at risk of forming a single crack as a result of the drift of the wall, which may exceed the strain capacity of the reinforcement, leading to yielding or even fracture of the steel. Instead, designers need to design and detail adequate reinforcement to ensure a ductile response where a series of smaller cracks develop.

i) The practice of using a higher strength concrete to avoid the provision of boundary elements in walls (Appendix C), creates a worse situation: higher strength, less ductile concrete with walls having the same reinforcement ratio.

j) Some of the lessons learnt from the Christchurch earthquake including: maintaining load paths, anchoring beam bars in the confined column core, reducing loads on columns, the importance of drift compatibility and connection of diaphragms to lateral load-resisting elements of the structure.

k) In the new Royal Adelaide Hospital (Australia's, if not the world's most expensive building), the post-disaster function of the building, and the requirement that ceilings and partition walls remain serviceable after an earthquake, governed the seismic design of the building. The adequate attachment of non-structural parts and components required sourcing of seismic rated fixings.



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l) Transfer beams within a structure should be designed elastically ($\mu = 1$) to ensure that these critical elements do not fail as was evident in the Christchurch earthquake.

m) Simple reinforcement detailing such as the provision of structural integrity reinforcement at columns improves life safety by allowing some membrane action in the case of punching shear failure.

WEBINAR AVAILABLE

Following the successful completion of the National Seismic Seminars, the full seminar is now available on the CIA web site (www.concreteinstitute.com.au) under Webinars, for those interested in learning more about some of the issues involved when designing and detailing buildings for seismic loads. Perhaps as a series of lunchtime presentations to staff.

The speakers included some of Australia's leading experts in the field of seismic design: Professor Paul Somerville (President of the AEES), Peter McBean (Joint Managing Director, Wallbridge and Gilbert and Vice President of AEES), John Woodside (Principal, J Woodside Consulting and primary author of the SRIA's new Guide), Dr Helen Goldsworthy (Associate Professor, School of Engineering, University of Melbourne), Scott Munter (Executive Director, SRIA) and Eric Lume (National Engineer, SRIA)

GUIDE TO SEISMIC DESIGN AND DETAILING OF REINFORCED CONCRETE BUILDINGS IN AUSTRALIA

The Seismic Guide will always be available as a free pdf download from the SRIA website at **www.sria.com.au** but following the National Seminar Series on seismic design we are now also offering a premium colour printed copy for your reference library. This will save on colour printing and the inconvenience of binding. The SRIA has intentionally kept this printed publication at a base discounted cost of only $37 including GST & postage to ensure that every Australian designer/specifier has access to this important information.

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