BUILDING PERFORMANCE

Practice Advisory 19: Improving earthquake performance of non-structural elements

Good performance of non-structural elements during earthquakes can save lives and costs, and relies on well-managed processes during the design, procurement and construction project phases. This Practice Advisory advises how to improve the performance of non-structural elements during earthquakes.

This information was confirmed as current in December 2016.

Published on 23 November 2016

Of interest to Building consent authorities, Proprietary component manufacturers/importers, Building owners, Contractors, Building services engineers, Fire engineers, Maintenance personnel, Designers, Architects, Structural engineers

ISBN: 978-0-947524-81-4 (Online)

This Practice Advisory is issued as guidance information in accordance with section 175 of the Building Act 2004 and, if used, does not relieve any person of the obligation to consider any matter to which the information relates according to the circumstances of the particular case. This document is not a compliance document in terms of the Act and not a substitute for professional advice.

Purpose

To alert building professionals to the need for a well-planned and coordinated approach to prevent poor performance of non-structural elements in earthquakes.

Non-structural elements

Non-structural elements are those elements within a building that are not considered to be part of either the primary or secondary structural systems. Examples of non-structural elements include components such as mechanical and electrical plant, ducting, pipework, cable trays, suspended ceilings, light non-load bearing partitions, and cladding systems such as brick veneer.

Note: This definition of non-structural elements is slightly more restrictive than used in some technical literature. Elements that require significant structural engineering design, such as pre-cast panels, parapets, and heavy internal partitions should be considered as secondary structural elements (refer to Practice Advisory 20 (https://www.building.govt.nz/building-code-compliance/b-stability/b1-structure/practice-advisory-20/)). This aligns with the definitions for non-structural and secondary structural elements used in The Seismic Assessment of Existing Buildings Guidelines (http://www.eq-assess.org.nz).

> Make non-structural element design and construction monitoring the responsibility of an engineer with suitable competency and qualifications in structural engineering, such as a Chartered Professional Engineer (CPEng), who is appropriately experienced in the application of earthquake actions in the design of buildings.

> Use a solution that has been verified to comply with the Building Code or consult a structural engineer for seismic connection and separation details if you are a building services or mechanical engineer responsible for the design of non-structural elements.

Issues of concern

The damaging earthquakes in Canterbury (2010/2011) and Wellington (2013) have highlighted many instances of poor performance of non-structural elements, particularly in multi-storey buildings.

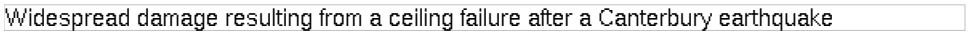

Figure 1: Widespread damage resulting from a ceiling failure after a Canterbury earthquake

The failure of non-structural elements during earthquakes can be a life-safety hazard and cause significant disruption and economic loss. Attention to the design of non-structural elements is required to show that these elements meet the provisions of the New Zealand Building Code (https://www.building.govt.nz/building-code-compliance/).

While primary and secondary structural elements are designed and detailed as part of the structural engineering design of a building, non-structural elements can be overlooked or poorly managed during the design, procurement, or construction phases of the project.

Building Code requirements and supporting documents

The Building Code Clause B1 Structure (https://www.building.govt.nz/building-code-compliance/b-stability/b1-structure/) requires all building elements to have a low probability of failure when exposed to the physical conditions likely to be experienced within their lifetime.

A building element is any structural or non-structural component or assembly, incorporated into or associated with the operation of a building. Non-structural elements are therefore required to accommodate earthquake actions.

The earthquake design for non-structural elements will generally be in accordance with referenced standards in the Acceptable Solutions and Verification Methods for Building Code Clause B1 Structure.

These include:

- NZS 1170.5:2004 Structural Design Actions Part 5: Earthquake Actions – New Zealand, for determining the specific design earthquake actions.
- NZS 3101:2006 Concrete Structures Standard, NZS 3404:2009 Steel Structures Standard and AS/NZS 4600:2005 Cold-formed Steel Structures Standard for the specific design of restraints for non-structural elements.
- NZS 4219:2009 Seismic Performance of Engineering Systems in Buildings and NZS 4541:2013 Automatic Fire Sprinkler Systems for the design of building services components.

A commonly used standard for the design and installation of suspended ceilings is AS/NZS 2785 Suspended Ceilings – Design and installation. It should be noted that AS/NZS 2785 does not provide a solution for earthquake actions. Therefore seismic restraints for suspended ceilings should be specifically designed and detailed in accordance with Verification Method B1/VM1.

Non-structural elements and their connections, both individually and as part of a system, must also meet the applicable durability requirements of Clause B2 according to their location and use.

Designing and detailing for earthquake actions

Careful detailing is required for non-structural elements so they can resist earthquake actions. Critical details, such as connections, restraints and, where required, flexible elements and/or separations should be identified and documented.

There are generally two ways to detail non-structural elements and their connections:

1. Using details or proprietary systems verified as being compliant with the Building Code. These can be prescribed in Acceptable Solutions, standards or in literature developed by technical groups.

2. Using details which have been subject to specific engineering design. Details that result from a specific design should generally be the responsibility of an engineer with competency in structural engineering in the application of earthquake actions, such as a Chartered Professional Engineer (CPEng).

Significant damage during the Canterbury earthquakes was caused by non-structural elements such as ceilings and in-ceiling services clashing. This was caused by insufficient clearance and/or stiffness incompatibilities. When determining clearances for non-structural elements use the clearance requirements of NZS 4219, where appropriate, or determine the clearance requirements taking into account construction tolerances, movements due to temperature change and the displacements that can arise from earthquake actions.

Figure 2 shows typical pipework restraint details taken from NZS 4219.

Figure 2: Examples of pipework restraint taken from page 62 of NZS 4219:2009 © Standards New Zealand
Reproduced with permission from Standards New Zealand under licence number LN001215.

For owners/designers

Ensure the connections of all non-structural elements comply with the Building Code.

Pay particular attention to ceiling systems. It is important that these elements are properly restrained against earthquake shaking to prevent them from collapsing on people, cutting off escape routes, or failing to support critical ceiling-mounted emergency evacuation components.

For manufacturers/importers of proprietary non-structural/building services components

Ensure proprietary non-structural/building services components, whether manufactured in New Zealand or overseas, are capable of meeting New Zealand seismic performance criteria (by either calculation or testing).

Buildings with low-damage systems

Take care with buildings that incorporate low-damage primary systems that have the potential for large displacements in earthquakes. These displacements will need to be accommodated by non-structural elements. Systems that reduce actions such as base isolation of a building are an effective way of protecting the structure and its contents.

Fit-outs

It is important that architects and other parties collaborate and seek specialist engineering advice for seismic restraints and detailing associated with building fit-outs, particularly when a structural engineer is not directly involved with the fit-out project.

Coordinate design

Effective earthquake performance of non-structural building elements and systems depends on good communication between all stakeholders.

Early engagement of key stakeholders in the design process facilitates good design and can help avoid problems later. Stakeholders may include the:

- design coordinator, for example, an architect, engineer or project manager
- specialist non-structural seismic engineers
- structural engineers
- building services engineers
- fire protection engineer
- suspended ceiling manufacturers/suppliers
- building consent authority (BCA).

Early coordination of non-structural systems helps avoid conflicting specifications and work plans. In addition, it will minimise procurement issues by providing a better basis for costing and tendering the work and making the process of issuing a Building Consent and Code Compliance Certificate easier.

For owners

Be aware that owners are responsible for their buildings.

Engage the building's structural design engineer, or consider engaging specialists with similar expertise, for the seismic design of non-structural

elements, to prepare construction details for the work and to coordinate the work of the relevant disciplines.

For engineers/designers

Include a section on non-structural elements in the Design Features Report as well as providing relevant information in the specification and on the drawings.

For BCAs

Check that the design documentation adequately covers non-structural elements. The details for non-structural elements may be part of the main contract or be the subject of a separate contract depending on the engagement circumstances.

Construction monitoring

On-site construction monitoring is crucial to verify that design details are built as intended

Particular attention should be applied to critical design information, such as fixing/anchorage details, flexible joints/connections, and seismic clearances, for example:

- Clearances or flexible joints between non-structural elements (non-load bearing walls, ducting, pipework etc.) and the building structure.
- Flexible joints or couplings across seismic gaps.
- Separations between non-structural elements.

For owners

Allow for construction monitoring, preferably by the designer or others briefed by the designer.

For BCAs

Check that the design details have been built in accordance with the consented documents before issuing the Code Compliance Certificate.

Restraint of building contents is also very important

Building owners and occupants are responsible for the restraint of building contents. NZS 4104:1994, Seismic restraint of building contents, is a standard that describes how building contents, including tall or heavy items such as bookcases, ovens, and pianos can be restrained.

References

1. Standards New Zealand. NZS 1170.5: 2004. Structural Design Actions Part 5: Earthquake Actions - New Zealand.

2. Standards New Zealand. NZS 3404. Parts 1 and 2: 2009. Steel Structures Standard.

3. Standards Australia/Standards New Zealand. AS/NZS 4600: 2005. Cold-formed Steel Structures Standard.

4. Standards New Zealand. NZS 4104: 1994 Seismic restraint of building contents.

5. Standards New Zealand. NZS 4219: 2009. Seismic Performance of Engineering Systems in Buildings.

6. Standards New Zealand. NZS 4541: 2013. Automatic Fire Sprinkler Systems.

7. Standards Australia/Standards New Zealand. AS/NZS 2785: 2000. Suspended Ceilings – Design and Installation.

8. Standards New Zealand. NZS 3101. Parts 1 and 2: 2006. Concrete Structures Standard.

9. Department of Building and Housing (2014). New Zealand Building Code Handbook (https://www.building.govt.nz/building-code-compliance/building-code-and-handbooks/building-code-handbook/).

10. Ministry of Business Innovation and Employment (MBIE) (2014). Acceptable Solutions and Verification Methods for New Zealand Building Code Clause B1 Structure (https://www.building.govt.nz/building-code-compliance/b-stability/b1-structure/b1-acceptable-solutions-and-verification-methods/).

11. Institution of Professional Engineers (2014). Practice Note 1 - Guidelines on Producer Statements (https://www.engineeringnz.org/documents/93/Practice_Note_1_Guidelines_on_Producer_Statements.pdf) [PDF 1.4 MB].

12. Ministry of Business, Innovation and Employment (MBIE) (2013). Guidance on the use of Certificates of Work, Producer Statements, and Design Features Reports by Chartered Professional Engineers under the new Restricted Building Work regime (https://www.building.govt.nz/building-code-compliance/canterbury-rebuild/certificates-of-work-guidance/).

Further information resources

1. New Zealand Society for Earthquake Engineering Inc. (NZSEE) et al (2016). The Seismic assessment of existing buildings (draft) (http://www.eq-assess.org.nz/). Retrieved from www.eq-assess.org.nz

2. Federal Emergency Management Agency E-74 (FEMA E-74), (2012). Reducing the Risks of Non-Structural Earthquake Damage – A Practical Guide (https://www.fema.gov/fema-e-74-reducing-risks-nonstructural-earthquake-damage) (4th Ed).

3. New Zealand Society for Earthquake Engineering Inc. (NZSEE) (March 2016). Bulletin of the New Zealand Society For Earthquake Engineering, Vol.49, No. 1, Special Issue on Seismic Performance of Non-structural Elements (SPONSE).

4. MacRae, G.A., Pampanin, S., Dhakal, R., Palermo, A., Baird, A., & Tasligedik, S. (2012). Review of Design and Installation Practices for Non-structural Components (http://www.naturalhazards.org.nz/NHRP/Publications/Research-Publications/Short-Term-Recovery-Programme#non-structure). National Research Hazard platform.

5. Tasligedik, A.S., Pampanin, S., Palermo, A. (2011). Damage Mitigation Strategies of 'Non-Structural' Infill Walls: Concept and Numerical-Experimental Validation Program (https://ir.canterbury.ac.nz/handle/10092/6135). Paper presented at the New Zealand Society for Earthquake Engineering Inc., 9th Pacific Conference on Earthquake Engineering, Building an Earthquake Resilient Society, Auckland, New Zealand.

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

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

New Zealand Government

This information is published by the Ministry of Business, Innovation and Employment's Chief Executive. It is a general guide only and, if used, does not relieve any person of the obligation to consider any matter to which the information relates according to the circumstances of the particular case. Expert advice may be required in specific circumstances. Where this information relates to assisting people:

- with compliance with the Building Act, it is published under section 175 of the Building Act
- with a Weathertight Services claim, it is published under section 12 of the Weathertight Homes Resolution Services Act 2006.