NZSEE GUIDELINE FOR DESIGN OF SEISMIC ISOLATION SYSTEMS FOR BUILDINGS

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Overview

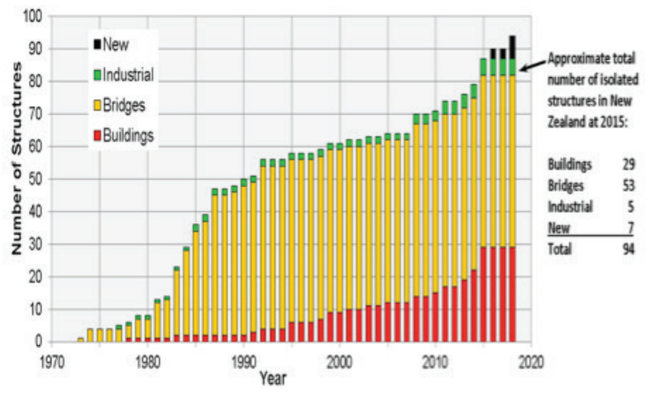
UC Quake Centre is managing the NZSEE-led project to prepare a guideline for the design of seismic isolation systems for buildings in New Zealand. The project is funded by MBIE, EQC, NZSEE, SESOC and NZCS.

Following the Canterbury Earthquakes there has been a strong market-driven interest in the use of base isolation in buildings to provide more damage resistant performance. Since 2011 around fifteen buildings have been built or retro-fitted with isolation in Christchurch alone. The Canterbury Earthquakes Royal Commission recommendations 66-69 called for MBIE to promote further knowledge and guidance around the use of low damage design technologies, of which seismic isolation is arguably the best proven.

The guideline is intended to be used as part of Alternative Solution designs for compliance with the New Zealand Building Code. The guideline is written in code and commentary format compatible with NZS 1170.5. The document may eventually be cited under Section 175 of the Building Act which provides for the Chief Executive of MBIE to publish guidance documents.

The group preparing the document is drawn from the major consultancies designing base-isolated buildings.

The guideline has been drafted and is currently being edited for a first round of international peer review.



Growth in numbers of isolated structures in New Zealand

Isolated buildings in Christchurch as at 2015

Isolated building types

Four isolated building types are designated and designers must determine which type they will design for and follow the requirements and criteria for that type.

Type 1. Simple regular and low-rise superstructures. Design to remain elastic and using simple equivalent static analysis.

Type 2. Normal superstructures not meeting Type 1 requirements. Designed for nominally ductile behaviour and using at least modal response spectrum analysis methods.

Type 3. Complex superstructures and those for which some ductility may be assumed, or the isolation plane does not provide the full displacement demand on the system. Nonlinear Time History Analysis is required.

Type 4. Brittle superstructures including existing structures.

Isolator device types covered by the guideline include elastomeric (including lead rubber) bearings together with flat sliders, curved surface sliders and viscous damper devices.

Low damage performance-based design and limit states

The guideline recommends a Damage Control Limit State (DCLS) and a Collapse Avoidance Limit State (CALS) for isolated buildings. This approach requires that the overall building, including isolators and rattle space, is explicitly capable of surviving the displacement demands for the rare earthquake event referred to in NZS 1170.5.

The approach is consistent with the current Low Damage Design guideline that MBIE is developing, which includes similar performance objectives and performance assessment criteria. An important part of the low damage design approach is to not only delay the onset of damage to the building (as a whole including secondary elements and fitout) but to also consider how to make any damage repairable within targeted cost and time constraints. An important principle is to communicate the damage control objectives with the building owner and occupants through the Design Features Report.

Design seismic loadings for isolated buildings

The guideline includes change to the long period portions of the NZS 1170 design spectra, which typically govern the design of isolated buildings. The corner period at which the constant displacement part of the spectrum starts has been extended from 3 seconds to 4 or 5 seconds for some geographical locations. This has the effect of increasing displacement demands on isolation systems in those areas.

Design displacement spectra are directly provided, allowing designers to represent seismic demands in acceleration-displacement response spectra (ADRS) format. This format is convenient for designing isolated structures using simplified capacity spectrum methods for determining base shear and displacement demands and system response. ADRS demand spectra are further modified for isolated structures to account for increased (hysteretic) damping that that will be available from typical isolation systems.

Design of isolated buildings

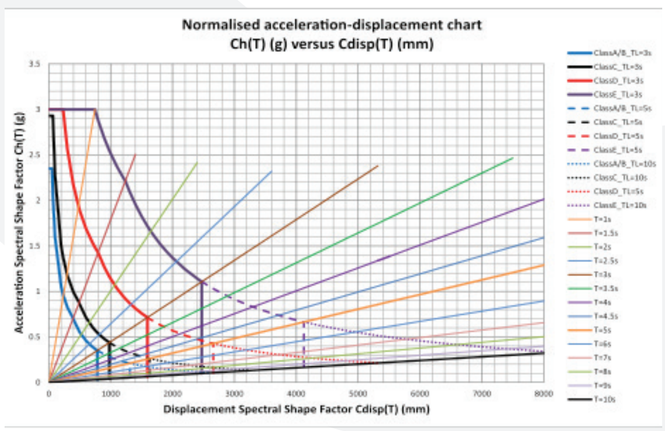
NZS 1170.5 design parameters, such as Structural Performance Factor Sp, design ductility factor μ (and kμ) for isolated buildings, are given for each isolated building type.

Preliminary analysis for all isolated building types would typically start with single degree of freedom analysis of a rigid building on a flexible isolation layer, followed by more detailed analysis using equivalent static, modal response spectrum or nonlinear time history analysis, depending on the type and complexity of the building.

Isolator property variability (upper and lower bound) must be considered in addition to nominal isolator system properties. Upper bound properties lead to maximum force demands on the structure, and lower bound properties lead to maximum displacement demands on the isolators.

Flow charts are provided for each building type and separately address performance design of the isolated building overall, performance at the isolators, adjacent stability structure, rattle space, substructure and superstructure.

Guidance is provided for parameters to carry over to the materials standards for design of foundation, substructure and superstructure.



Seismic isolation system capacity and ADRS demand curves

A minimum level of ductile detailing and capacity design will generally be required in the superstructure to allow for unexpected inelastic demands.

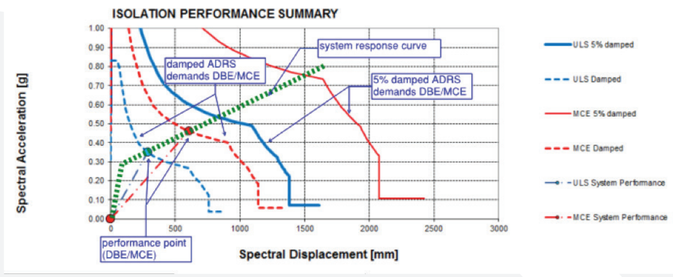
Procurement of isolators

Guidance is provided for performance-based specification of the isolation system and isolator devices based on international standards from the US (ASCE) and Europe (EN 15129). A sample specification is also provided. Designers are recommended to select the type and number of isolators to be provided and to prepare a performance-based specification giving the combinations of design forces and displacements that isolators are to be supplied for. It is strongly recommended that actual design of the isolators is left to the supplier in accordance with an approved international standard. Qualification, prototype and production testing sequences and acceptance criteria are to be specified. Full-scale testing of isolators or similar prototypes is generally required.

International peer review

Three international peer reviewers (from USA, Europe and Japan) have been approached to review the document.

Progress



Seismic isolation system capacity and ADRS demand curves

As at November 2016, all sections of the guideline have been drafted and technical editing is proceeding. The document will now be sent to international peer reviewers for a first review, before being finalised by the project team and reviewed again. Industry trialling and review will also be sought. A working guideline is expected to be available in early 2017.

Project management

The project has a Governance Group comprising representatives of the Funders, UCQC and the project leaders. UCQC is providing the project management.

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Acknowledgements

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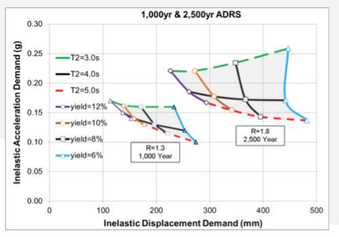
Awly– new isolated building in Christchurch

Christchurch Art Gallery – retrofitted with isolation

Transmission Gully Bridges to be isolated



Inelastic demand Acceleration and Displacement Spectra for Christchurch to NZS 1170.5

(Whittaker and Jones 2014)

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