

Remediating Earthquake-Prone Buildings

EPB Legislation and Methodology Guidance Annex 2



Ministry of Business, Innovation and Employment (MBIE) Hīkina Whakatutuki – Lifting to make successful

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A2.1 Overview: Remediating Earthquake-Prone Buildings

A2.1.1 Pathways for Removal of EPB Status

This Annex defines how to remove Earthquake-prone Building (EPB) status other than by demolishing the building, by either:

- Remediating according to the appropriate pathway (*façade risk mitigation*, *targeted retrofit* or an alternative verification); or,
- Demonstrating the required performance without retrofit.

The available pathways are listed in Table 1.

Table 1: Retrofit Pathways

Pathway		Reference
Conventional	<i>Façade Risk Mitigation of Category A buildings</i>	Refer to section A2.3
	<i>Targeted retrofit of Category A buildings</i>	Refer to section A2.4
	<i>Targeted retrofit of high-risk Category B buildings (buildings possessing high-risk deficiencies (HRDs))</i>	Refer to section A2.5
Alternative Verification	Alternative Verification via ASCE 41 for <i>Category B buildings</i>	Refer to section A2.6
Demonstrate the required performance without retrofit		See A2.1.2

A2.1.2 Demonstrating that no retrofit is required to meet the remediation requirement

It is permitted to demonstrate by evaluating the building against the performance requirements described herein (Table 1, and sections A2.3, A2.4, A2.5 or A2.6 as applicable) that no retrofit is required to meet the required performance. Assessments can account for any prior retrofit work that may be present.

This can occur where assessment finds significant mitigating factors that improve the expected performance of the building, compared to other *Category A buildings* or *Category B buildings* with *HRDs*. It is more likely where prior historic mitigation/retrofit exists, has been installed properly, and is assessed to be effective.

A2.1.3 Complying with other Rules and Regulations when Undertaking Remediation Work

This Annex sets out the technical requirements that remediation work on *EPBs* shall meet under the *EPB Methodology*. In undertaking remediation work, owners must comply with all other applicable laws and regulations.

Considerations include:

Other aspects of the Building Act that remain in effect.

Rules for alterations, other than those addressed specifically by the Building (Earthquake-prone Buildings) Amendment Act 2026 and the EPB Methodology.

Heritage rules.

Town planning and resource consent.

Title and land use rights, especially where undertaking remediation work outside of property title boundaries (such as providing/enhancing protective structures).

A2.1.4 Terminology and Notation

A2.1.4.1 Defined Terms and Acronyms

Table 2: Defined terms and acronyms used in this Annex

Term	Definition
APoE	Annual probability of exceedance
Benchmark seismic hazard	The reference level of earthquake shaking set out in A2.2.1.1 and used by this Annex to set earthquake loads for the design of seismic remediation work.
Category A building	An unreinforced masonry (URM) building that either has at least one <i>façade requiring risk mitigation</i> or has three or more storeys and is in an urban centre. See the <i>EPB Methodology</i> .
Category B building	A Category B1 or B2 building, as defined in the <i>EPB Methodology</i> .
Column Wall Index, CWI	The ratio of effective cross-sectional area of vertical structure within a storey (columns, walls, and braces) to the total gross floor area supported above. Details are defined specifically in section 8.1 of Annex 1. The CWI is computed along each building axis and at sufficient storeys to confirm the critical (lowest) value for each direction and the building as a whole.
Configurational vulnerability	A feature of a building's configuration that causes the building components within its influence to be more vulnerable (because it locally amplifies earthquake demands).
Design capacity	As defined by the applicable standard referenced under B1/VM1 for ultimate limit state design. See also <i>probable capacity</i> .
EPB	Earthquake-prone building: as defined in the <i>EPB Methodology</i> .

EPB Methodology	The methodology to identify, evaluate and remediate earthquake-prone buildings, set by MBIE's Chief Executive under section 133AZ of the Building (Earthquake-prone Buildings) Amendment Act 2026.
Façade	An exterior wall of a URM building. (refer to the <i>EPB Methodology</i>)
Façade element	Any part of a <i>façade</i> , or anything attached to or supported by it, including parapets, pediments, ornaments, chimneys, towers, gables, piers, spandrels and cornices, and elements of any material supported by <i>URM</i> , such as balconies, canopies, verandahs and signage. (refer to the <i>EPB Methodology</i>)
Façade requiring risk mitigation	A <i>façade</i> containing <i>URM</i> materials that faces onto a <i>public space</i> , where the horizontal distance to that area is less than the height of its uppermost <i>façade element</i> above adjacent ground level. (refer to the <i>EPB Methodology</i>)
Gravity system	The structural elements that support gravity loads from other building elements, such as floors, roofs, beams, columns and load-bearing walls, including elements that also form part of the <i>LFRS</i> .
Heavy floors	Floors or floor areas constructed substantially in reinforced or unreinforced concrete (including as part of composite floor construction and floor construction incorporating masonry elements of any type).
Heavy materials	Means floors or roofs constructed substantially in reinforced or unreinforced concrete (including as part of composite floor construction and floor construction incorporating masonry elements of any type); or framing elements supporting and bracing the building (such as walls, columns, beams or braces) constructed in reinforced or unreinforced concrete.
High-risk deficiency	See <i>HRD</i> .
High-risk feature	A term describing features of <i>Category A</i> or <i>B</i> buildings with elevated risk, and where the <i>risk factor</i> F_R is applied in evaluating their capacity. It applies to: ▪ <i>URM façade elements</i> that are part of a <i>façade requiring risk mitigation</i> and their immediate connections to existing supporting structure (refer A2.3.4.2.4 and A2.4.4.1); and, ▪ Building features forming part of <i>high-risk deficiencies</i> (refer A2.5.4.4).
HRD	High-risk deficiency: a specific building feature of a <i>Category B building</i> (or combination of features) that causes elevated risk of partial or full building collapse in earthquake.
HRD review	High-risk deficiency review: as defined in the <i>EPB Methodology</i> , carried out in accordance with Annex 1.
LFRS	Lateral force resisting system: an assembly of structural members that act together to resist lateral actions in the direction of loading under consideration, including vertical systems, diaphragms and foundation systems that transfer lateral actions to the ground.

Liquefaction hazard map	The most recent and detailed map published by the relevant territorial authority following MBIE planning and engineering guidance ¹ and which meets the minimum requirements stated in Section A2.2.3.
PPHZ	Potential plastic hinge zone
Probable capacity	As defined by the <i>Seismic Assessment Guidelines</i> . The expected or estimated mean capacity (strength and deformation) of a member, an element, a structure as a whole, or foundation soils.
Public space	A public road, footpath or other thoroughfare, or a place where people congregate. As defined in the <i>EPB Methodology</i> .
Remediation requirement	As defined in the <i>EPB Methodology</i> .
Risk factor, F_R	A factor applied to the capacity of <i>high-risk features</i> of buildings in this Annex, recognising the combination of high vulnerability, low predictability (or rapid onset of failure), and consequence of failure. It is explained in section A2.2.2.2 and defined within the sections describing each <i>remediation requirement</i> .
Secondary element	An element that is not part of the <i>LFRS</i> and does not support gravity loads from other building elements, such as a parapet, chimney, ornament or canopy. (refer Table 6)
SED	Specific engineering design: design specific to the building, carried out in place of a <i>standardised solution</i> .
Seismic Assessment Guidelines	The <i>Seismic Assessment of Existing Buildings: Technical Guidelines for Engineering Assessments</i>
Severe structural weakness	As defined in the <i>Seismic Assessment Guidelines</i> .
Standardised securing handbook	The <i>Standardised securing handbook for URM 1-2 storey EPB Retrofit</i> .
Standardised solution	A solution for façade risk mitigation that uses the details and procedures in the <i>Standardised securing guidelines</i> , within the scope of application set out in those guidelines.
Storey-sway potential	Where the strength hierarchy in a structure allows the potential for storey-sway mechanism to form in earthquake shaking, irrespective of whether a <i>weak storey</i> vertical irregularity is present. For the purposes of this Annex, <i>storey-sway potential</i> is defined in section 5.5 of Annex 1. See also <i>weak storey</i> .
Structural weakness	As defined by the <i>Seismic Assessment Guidelines</i> .
Ultimate capacity	As defined by the <i>Seismic Assessment Guidelines</i> .

¹ Ministry of Business, Innovation and Employment, Ministry for the Environment, & Earthquake Commission. (2017). Planning and engineering guidance for potentially liquefaction-prone land: Resource Management Act and Building Act aspects.

URM	Unreinforced masonry
URM building	A building with <i>URM</i> materials in or on at least one of its <i>façades</i> . (refer to the <i>EPB Methodology</i>)
Vertical LFRS	Vertical or near <i>vertical LFRS</i> , such as moment-resisting frames, braced frames, structural walls and coupled walls.
Vulnerability	In non-italicised usage within this Annex, this is a common term used to describe features of buildings that can be vulnerable to poorer performance in earthquake shaking (compared with modern well-configured buildings).
Vulnerable component	The italicised usage of this term has a specific meaning in this Annex. It is a component that contributes to the existence of an <i>HRD</i>, either ▪ Due solely to its own characteristics (as specifically defined in section 4 of Annex 1), or ▪ Due to its characteristics and because it is within the influence of a <i>configurational vulnerability</i> (as specifically defined in sections 5, 6 and 7 of Annex 1).
Vulnerable to lateral failure (describing a vulnerable component)	In this Annex, an element vulnerable to loss in lateral capacity <i>only</i> (should be assumed to continue to carry gravity loads after loss of lateral capacity).
Vulnerable to gravity failure (describing a vulnerable component)	In this Annex, an element vulnerable to loss in both lateral capacity <i>and</i> vertical (gravity) carrying capacity. Interchangeably referred to as axial failure for columns and walls.
Wall Index, WI	See <i>Column Wall Index, CWI</i>
Wall pier	A vertical wall segment within a structural wall, bounded horizontally by two openings or by an opening and an edge, with a ratio of clear height to horizontal length greater than 1.0, and either: ▪ singly reinforced; or, ▪ (where doubly reinforced) having a ratio of horizontal length to wall thickness greater than or equal to 4. This includes <i>wall piers</i> incorporating columns/pilasters to the interior or to one end only of their section.
Weak storey	A <i>weak storey</i> vertical irregularity, where the storey shear strength is notably lower than that of the storey above. For the purposes of this Annex, <i>weak storey</i> is defined in section 5.4 of Annex 1. See also <i>storey-sway potential</i>.

A2.1.4.2 Notation

A_c	Area of concrete core of section measured to outside of peripheral spiral or hoop, mm ² .
A_g	Gross area of column cross section, mm ²

A_s	For slab-column joints, the area of bottom reinforcing steel that is effectively continuous through the joint in one direction, mm ² .
f'_c	Probable strength of concrete, as given by the <i>Seismic Assessment Guidelines</i> section 2025-C5.4.2.2, MPa.
E_u	Earthquake actions at <i>benchmark seismic hazard</i> , as defined in section A2.2.1 of this Annex.
E_{EPB}	Earthquake design actions for earthquake-prone buildings, as defined in section A2.2.1 of this Annex.
f_y	Probable yield strength of steel reinforcement, MPa.
F_R	<i>Risk factor</i> applied to the capacity of <i>high-risk features</i> of buildings (in their assessment as part of meeting <i>remediation requirements</i>). Explained in section A2.2.2.2 and defined within the sections describing each <i>remediation requirement</i> .
M_p	Probable flexural strength of an element, calculated in accordance with the Seismic Assessment Guidelines section 2025-C5.5.2.2, Nmm.
V_g	Perimeter shear demand acting on the critical perimeter section of a slab-column joint under N_G , N.
V_p	Probable shear strength at the critical perimeter section of a slab-column joint (determined in accordance with NZS 3101:2006 and the Seismic Assessment Guidelines section 2025-C5.5.4.5), N.
$V_{p,col0}$	The undegraded shear strength of a column, determined in accordance with the Seismic Assessment Guidelines section 2025-C5.5.5.2., N.
V_y	The shear demand coincident with flexural yielding, V_y , based on the development of flexural hinges with strength M_p at both ends of the column's clear span, N.
ρ_t	Transverse reinforcing ratio $A_v / (b_c s)$.

A2.1.5 Document References

Normative document references (by section or clause references within this annex) include the following documents:

- *Seismic Assessment Guidelines* which refers to the *Technical Guidelines for Engineering Assessments, Part C: Detailed Seismic Assessment* (2027 Edition).
- NZS 1170.5:2004 *Structural design actions Part 5: Earthquake actions – New Zealand* as adopted and amended by B1/VM1 as at the date of commencement of the Building (Earthquake-prone Buildings) Amendment Act 2026.
- *Standardised securing handbook for URM 1-2 storey EPB Retrofit*
- NZS 3101:2006 Inc. Amd. 1-3 *Concrete Structures Standard*.
- ASCE 41-23 *Seismic Evaluation and Retrofit of Existing Buildings*.

Other document references are informative.

Future released versions of the Seismic Assessment Guidelines should not be used for remediation of EPBs unless explicitly incorporated by reference into the EPB Methodology (by a future update to the EPB Methodology).

The following versions are assumed and are the basis for document and clause references made within:

C1-2025

C2-2025

C3-2025

C4-2027 (not yet released)

C5-2025

C6-2027

C7-2025

C8-2027 (not yet released)

C9-2017

C10-2017

C11-2027 (not yet released)

A2.2 General Criteria that Apply to All Remediation Requirements

A2.2.1 Earthquake Demands for Remediating Earthquake-prone Buildings

A2.2.1.1 Benchmark seismic hazard

The *benchmark seismic hazard* E_u is a reference level of earthquake shaking used by this Annex, and shall be as given by NZS 1170.5:2004, as adopted (and amended) by B1/VM1 as at the date of commencement of the Building (Earthquake-prone Buildings) Amendment Act 2026, for an annual probability of exceedance (APoE) of 1/500.

Review of risk settings based on present day understanding of earthquake hazard has been undertaken when setting the benchmark seismic hazard in this Annex. Comparison to other loadings standards, if made, require benchmarking for comparable risk.

For example, should owners and/or engineers wish to compare the benchmark seismic hazard with SNZ TS 1170.5:2025, an annual probability of exceedance (APoE) of 1/250 gives comparable outcomes to the objective. Unless revised in the future, use of SNZ TS 1170.5:2025 is not a compliance option under the EPB Methodology. This comment is made for information only.

A2.2.1.2 Earthquake actions for remediation of earthquake-prone buildings

For structural aspects

For the design of façade securing or targeted retrofit works including assessment/verification of existing aspects, where required, the elastic site spectrum for horizontal earthquake loading shall be one third of *benchmark seismic hazard* unless otherwise stated in sections A2.3 to A2.6 of this Annex.

For protective structures used as part of façade risk mitigation, requirements are given in section A2.3.5: Overhead Protection.

For geotechnical aspects

Where geotechnical assessment is required as part of *façade securing* or *targeted retrofit*, use NZS 1170.5:2004 C(0). The shaking hazard to be applied in geotechnical assessment (if required) shall use the *benchmark seismic hazard*, proportioned by one third. A geotechnical step change factor shall be applied where appropriate in accordance with the *Seismic Assessment Guidelines* (see A2.2.2.1).

A2.2.2 Capacity of Existing, Retrofitted and New Elements

A2.2.2.1 Capacity of existing elements

The design of remediation work will typically require several aspects of the existing structure's capacity to be verified, as part of demonstrating that the building meets its *remediation requirement* once retrofitted.

For earthquake actions, the *probable capacity*, S_{prob} , of existing elements shall be used, determined using the *Seismic Assessment Guidelines*, subject to section A2.2.2.2 which modifies the probable capacity of *high-risk features* by the *risk factor*, F_R .

For geotechnical aspects, the *probable capacity* shall be reduced as appropriate in accounting for geotechnical step change, as given by the *Seismic Assessment Guidelines* section 2027-C4.7.

A2.2.2.2 Risk factor (adjusting the capacity of high-risk building features)

The *EPB Methodology* focuses on the identification and management or remediation of higher risk buildings. These buildings have high-risk construction features that tend to arise from a combination of:

- a) High vulnerability.
- b) Low predictability (or rapid onset of complete failure once their capacity is reached).
- c) High consequence of failure.

These are termed *high-risk features*. They include several aspects of *URM* construction, and the building features resulting in the identification of *HRDs*. When assessing their capacity as part of applying the *remediation requirements* (following this Annex) a *risk factor*, F_R must be applied. This accounts for higher risk, and ensures that remediated buildings achieve the required level of performance.

The *risk factor* does not apply if the retrofit removes the *high-risk features*.

Sections A2.3 to A2.5 describe the specific *remediation requirements* for façade securing and targeted retrofit. They define the values for F_R and explain where it applies.

Severe structural weaknesses and geotechnical step change

Wherever the *risk factor* applies (according to this Annex) it replaces any capacity reduction that may apply according to the *Seismic Assessment Guidelines* if:

1. The affected element is also defined as a *severe structural weakness* by the *Seismic Assessment Guidelines*; or,
2. The affected element is affected by geotechnical step change as given by the *Seismic Assessment Guidelines* section 2027-C4.7.

A2.2.2.3 Capacity and detailing of retrofitted elements and new work

A2.2.2.3.1 General

For earthquake actions, capacities of retrofitted elements (and new elements associated with the retrofit) should be determined based on the following:

For element behaviours within the scope of Part C and with quantifiable and dependable inelastic capacity:

1. *Probable capacity*, S_{prob} , (strength and deformation) as defined by Part C of the *Seismic Assessment Guidelines* (for components included within the scope of Part C). For structural aspects, this is determined using probable material strengths, and no strength reduction factor should be used ($\phi = 1$).

For any other element behaviours (including those with low or negligible inelastic capacity)

2. *Design capacity*, as defined by the applicable standard referenced under the New Zealand Building Code verification method B1/VM1, using nominal strengths and appropriate strength reduction factors; or,
3. As determined from a rational procedure supported by experimental evidence and accepted engineering principles, or an appropriate referenced standard or guideline. Reliability should be consistent with the definition of *design capacity* for the purposes of Ultimate Limit State seismic design.

The capacity of the retrofitted elements and the structure as a whole shall account for deformation compatibility between the existing and new elements.

A2.2.2.3.2 Deformation capacity

Deformation capacities for ultimate limit state design should be determined based on:

- *Probable capacity* (for deformation), as determined by Part C of the *Seismic Assessment Guidelines* (for components included within the scope of Part C); or,
- As defined by a standard referenced by New Zealand Building Code verification method B1/VM1 (for the purposes of ultimate limit state design); or
- A rational procedure supported by experimental evidence and accepted engineering principles, or an appropriate referenced standard or guideline. Reliability should be consistent with the definition of probable capacity for the purposes of Ultimate Limit State seismic design and assessment.

Deformation capacities should be applied based on loss of lateral capacity, or loss of gravity carrying capacity as appropriate to analysis assumptions and the function of the component.

A2.2.2.3.3 Detailing of new elements

Detailing of *new elements* should generally follow the requirements of B1/VM1 (or equivalent alternative solution) where applicable. Where not applicable, or where it is impractical or unreasonably onerous to do so due to existing structure interfaces, detailing requirements shall be determined on a rational basis. A rational basis should be supported by experimental evidence and accepted engineering principles, or an appropriate referenced standard or guideline, in order to demonstrate that the following requirements can be met:

1. The required strength can be achieved either as shown by rational calculation to accepted engineering principles (or verified via test); and either:
 1. Sufficient inelastic displacement capacity post-yield exists to resist the demands (including under earthquake demands greater than the ULS as adjusted for the retrofit level); or,
 2. It can be demonstrated that the strength hierarchy is such that the component is unlikely to yield, irrespective of the level of earthquake demand.

The following situations describe cases where B1/VM1 detailing requirements cannot easily be followed in the design of remediation work:

- *The combination of existing and new construction makes the requirements inapplicable.*
- *It is impractical (or unreasonably onerous) to comply with the detailing requirements due to the constraints of existing building elements.*
- *The retrofit technique is novel and/or not included within the scope of B1/VM1.*

In these circumstances, established/reputable guidelines on retrofit techniques are a source of information that can be used to meet the requirements of this Annex, by informing appropriate detailing approaches.

A2.2.3 Geotechnical Considerations

Table 3 indicates the extent of specific geotechnical foundation design or assessment required in meeting the minimum remediation requirements.

Table 3: Highlighting where specific geotechnical considerations are required

Bldg Cat.	No. Storeys	Remediation requirement	Building elements	Need specific foundation assessment or design?
A (URM)	1-2	Façade securing	Existing elements	No
			Foundations of new bracing elements (walls or frames)	Yes, as typical for new foundation design
	3+ (See note 1)	Façade securing	Existing elements supporting a <i>façade requiring risk mitigation</i>	Only where liquefaction or known geotechnical hazards are present ²
			Foundations of new bracing elements (walls or frames)	Yes, as typical for new foundation design
			Other elements (not supporting a <i>façade requiring risk mitigation</i>)	No
	3+	Targeted retrofit	Existing elements providing building stability overall or supporting a <i>façade requiring risk mitigation</i>	Only where liquefaction or known geotechnical issues are present ²
			Foundations of new bracing elements (walls or frames)	Yes, as typical for new foundation design
B	Per EPB Meth.	Targeted retrofit	Existing elements requiring direct evaluation as part of HRD (i.e. HRD F-_)	Yes
			Existing or new foundation elements forming part of vertical LFRS improvements, required to ensure that effectiveness of HRD retrofit	Yes
			Other elements	No

Notes:

- [1] Or any structures with unusual/larger features (e.g. tall storeys, high-volume open spaces or localised areas with larger number of storeys that are excluded from storey count).

When to review existing foundations due to liquefaction or other known hazards

Specific assessment of existing foundations for liquefaction or known geotechnical issues (where indicated in Table 4 for Category A buildings) is required in the following circumstances:

1. **For liquefaction**, only sites other than where *liquefaction hazard maps* indicate the risk, vulnerability, likelihood or susceptibility to liquefaction is ‘low’ or ‘less severe’. *Liquefaction hazard maps* means the most recent and most detailed liquefaction maps available on the relevant territorial authorities’ websites.
- 2.
3. **For known geotechnical issues**, where known factors (such as those documented in any readily available previous assessments of the building, or other documented information specific to the building site) indicate founding conditions which could materially compromise the ability of the *façade securing* or *targeted retrofit* to perform as intended. Specific assessment is not required in the absence of such information.

Specific assessment in these cases can be qualitative or desktop, but shall be in sufficient detail to indicate whether or not founding conditions exist which could compromise the ability of the façade securing or targeted retrofit to perform as intended.

A2.3 Façade Risk Mitigation for Category A (URM) Buildings

A2.3.1 Applicability

This section applies to *Category A buildings* where the *remediation requirement* is façade risk mitigation.

This section also applies to register only *EPBs*, where the owner chooses to undertake façade risk mitigation to remove *EPB* status.

A2.3.2 Objective of Façade Risk Mitigation

The objective of façade risk mitigation is to mitigate the risk of injury or death posed by an earthquake causing building elements that are built of, or supported by, *URM* to fall onto a *public space*.

This reflects the objectives in the *Building (Earthquake-prone Buildings) Amendment Act 2026*.

A2.3.3 Approaches for Façade Risk Mitigation

A2.3.3.1 General

Façade risks can be mitigated by one or a combination of the following:

- Façade securing (described in section A2.3.4).
- In certain circumstances, by overhead protection (described in section A2.3.5).
- Removal of potentially hazardous elements.

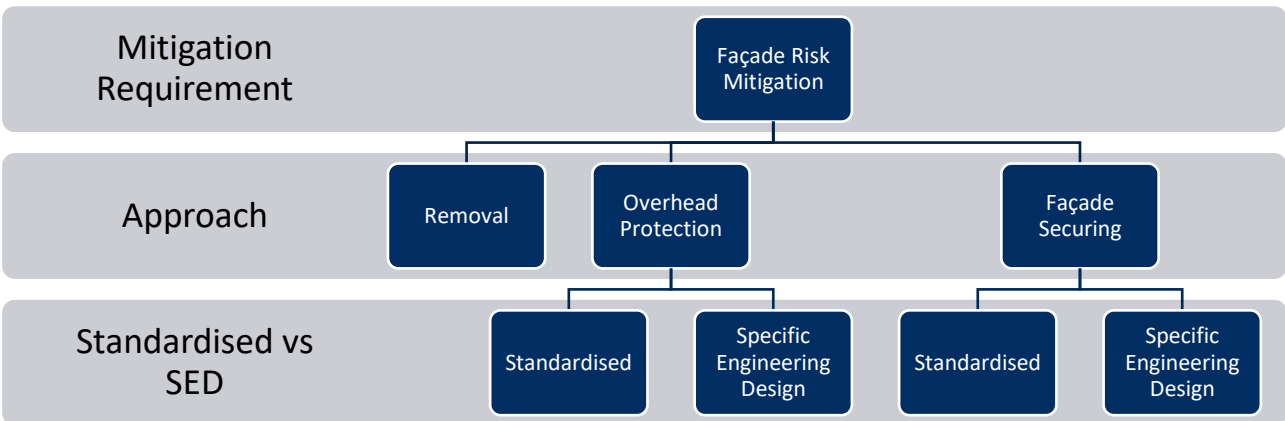


Figure 1: Approaches for façade risk mitigation

Façade securing aims to mitigate the likelihood of potentially hazardous *façade elements* (or sections of *façade*) from falling off the building.

Overhead protection does not aim to prevent *façade* failure or falling *façade elements*, but requires the consequences to be substantially reduced by a form of overhead protection structure that protects those in the *public space* from falling *façade elements*.

A2.3.3.2 Removal of existing elements

Where appropriate (and with reference to A2.1.3), *façade elements* may be removed as part of meeting the remediation requirement. The extent could comprise:

1. Complete removal of *façade elements* that would otherwise require intervention; or,
2. Partial removal (e.g. reduction in height of a parapet or chimney), such that the remaining *façade elements* are evaluated with enough capacity (and a complete load path) to resist earthquake loads as prescribed by section A2.2, and thus requiring no further mitigation or protective structure; or;
3. Partial removal, to reduce the extent and weight of vulnerable *façade elements* to facilitate a more practical, cost-effective protective structure. For example, the reduction in height of a parapet such that it fits within the parameters for selecting standardised securing techniques (see A2.3.4.3.3).

Review the effect of removal

The effect of any proposed element removal shall be reviewed, with additional ‘make-good’ work undertaken, if necessary, to either:

- Ensure that the affected elements continue to comply with the Building Code if they did so before; or,
- Such that building performance overall (including seismic aspects) is not clearly worsened by removing the element(s).

A2.3.4 Façade Securing

A2.3.4.1 Functional requirements for façade securing

Façade securing should secure the *façade elements* of each *façade requiring risk mitigation*, such that there is a sufficiently low likelihood of their failure leading to full or partial collapse of the *façade* in earthquake.

Façade securing does not require any intentional mitigation of the following (and therefore risks may remain present):

Full or partial building collapse (except secured portion of façade).

Full or partial façade collapse in an earthquake which causes loading higher than the earthquake actions defined in 2.1.2.

Strengthening of the façade in-plane.

Masonry or non-URM elements falling into areas that are not a public space, including neighbouring properties.

Risk to occupants of the building, including from internal load-bearing walls and partitions, chimneys, exterior walls that are not façades requiring risk mitigation, and from non-URM elements.

Failure (in-plane, out-of-plane or gravity) of any element that neither forms part of nor supports a façade requiring risk mitigation.

Pounding effects.

Excessive foundation deformations including but not limited to deformations occurring as a result of liquefaction and lateral spread.

Failure of secondary elements (such as chimneys, parapets, partitions and veneers), except where they form part of a façade requiring risk mitigation.

Façade securing does not necessarily result in the reduction of damage to a building following an earthquake.

A2.3.4.2 Performance requirements for façade securing

A2.3.4.2.1 General Requirements

Design of façade securing work shall address the following (in relation to *façade elements* of a *façade* requiring risk mitigation):

- Stability of masonry *façade elements* (or other *façade elements* supported by masonry) by either their modification, enhancement, provision of additional restraining structure, or removal.
- Connection of *façade elements* to the building elements that provide stability to the *façade*, such as floors, roofs and return walls.
- Provision of a tied load path from the restrained *façade* to the foundation, meaning:
- Identification of the load path for forces restraining the *façade elements* to the foundation, enhanced as necessary (see A2.3.4.2.2); and,
- Tying of elements providing bracing stability to the secured façade as part of that load path (see A2.3.4.2.3).

1.

4. In achieving all of the above, consider the condition of elements.

Figure 2 shows the areas that require addressing as part of façade securing, described above:

Façade elements of a façade requiring risk mitigation.

Part of the return walls and internal supporting structures (such as floor and roof diaphragms), as required to ensure a complete load path to ground for stability under seismic loads.

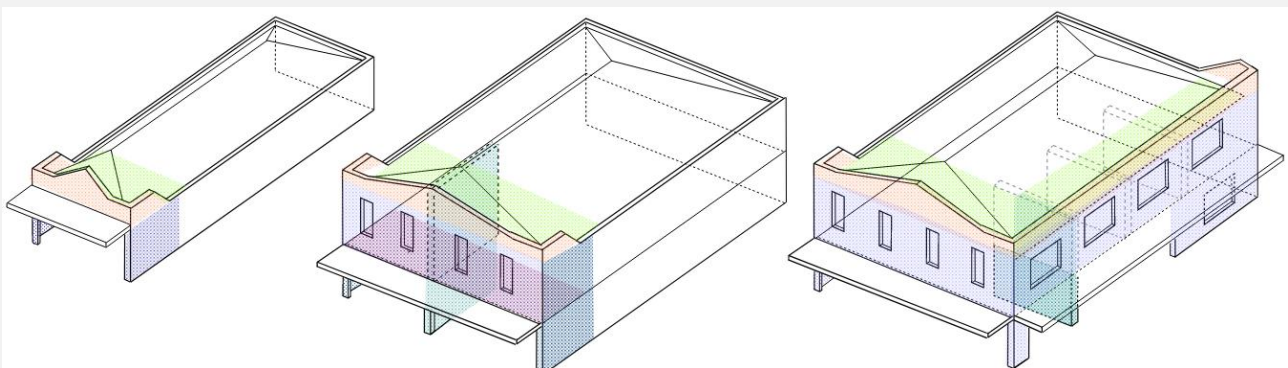


Figure 2: Example of areas (shown shaded) required to be addressed by façade securing.

Façade securing needs to address both URM elements and non-URM elements supported by masonry. This can include canopies, balconies, verandahs, signage, and plant or equipment. Other seismic vulnerabilities present within the building are not required to be specifically addressed (for retrofits that meet only the minimum requirements of the EPB Methodology).

A2.3.4.2.2 Load path (addressing elements required to support the secured façade)

A load path shall be provided for forces associated with the out-of-plane restraint of *façades requiring mitigation* in earthquake (actions out-of-plane to the *façade* being secured).

The load path shall provide the capacity required by section A2.2, resolved to the top of the foundation. For *façade risk mitigation*, existing foundations can be assumed to be adequate unless there is exceptional evidence to the contrary.

Where complete load paths cannot be established via existing elements or have insufficient capacity, enhancement shall be provided having due regard for deformation compatibility. Where new or enhanced vertical bracing elements are provided (*vertical LFRS*) the new or existing foundations supporting them should be checked.

A complete load path includes connections between elements of the façade and the elements providing direct support to the façade, such as existing/enhanced floor or roof diaphragms or other restraining structures like waler beams and strongbacks. It further includes the connection of these elements to a sufficient length of return wall (or other element) providing bracing stability to the secured façade as a whole. See Figure 2 for illustration.

The purpose of providing a complete load path is to avoid the outwards separation and failure of large sections of secured façade at or below the required level of performance. New or enhanced vertical LFRS, if required, could include timber shear walls, steel braced frames, or reinforced concrete/block walls, sufficiently well-connected to complete the load path.

Regarding existing foundation adequacy, ‘exceptional’ circumstances includes only where foundation conditions have degraded substantially since the original construction, such as by a leaking drain washing out the fines, or alterations removing or undermining foundation elements. Otherwise foundations should be assumed to have adequate capacity as they rarely have a significant influence on performance at the levels relating to the façade risk mitigation objectives.

Façade securing of buildings with three or more storeys, tall storeys, high volume open spaces or URM façade elements taller than 10m are likely to require extended scope of intervention in meeting the requirements for load path, and in the tying of elements providing bracing stability to the secured façade.

A2.3.4.2.3 Tying of elements providing bracing stability to the secured façade

Elements forming part of the load path in A2.3.4.2.2 to restrain the secured *façade* (such as sections of return walls) require:

1. Verification of their own out-of-plane stability, spanning vertically or horizontally between points of restraint; and,
2. Tying connections to floors and roof diaphragms.

This so that they themselves have reduced vulnerability and can be relied on to be present and stabilise secured *façades*.

Tying shall have capacity required by section A2.2 to resist earthquake actions acting in their own out-of-plane direction. These tying forces need only be resolved into the floor and roof diaphragms (they do not need to be resolved to the foundation).

Beyond the tying requirement, building stability in the parallel-to-façade direction does not generally require consideration nor a complete load path to ground. The exception is where adjoining perpendicular façades are both a façade requiring risk mitigation.

For these cases the in-plane capacity of each façade to act as a return wall to complete the load path for face-loaded elements to the foundation needs to be considered. This situation will typically occur in corner buildings (Figure 3)—and may require the addition of new vertical LFRS.

This includes verification of the out-of-plane stability of the existing return walls themselves, spanning vertically or horizontally between points of restraint.

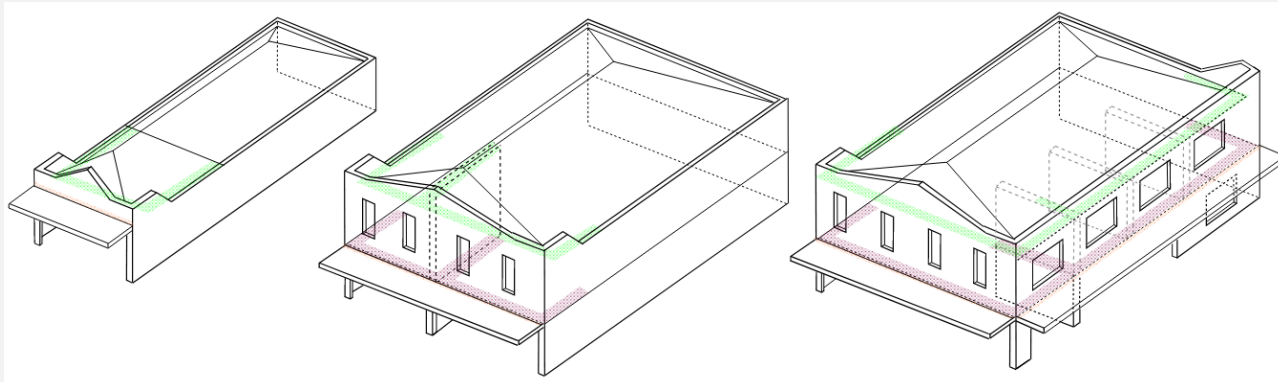


Figure 3: Diagram indicating the connections that require design for OOP actions to meet the tying requirements.

A2.3.4.2.4 Risk factor for high-risk URM features

The *risk factor*, F_R , adjusts the capacity of high-risk building features, and is explained in section A2.2.2.2. Specific building elements and the corresponding value for F_R are defined in Table 4. For URM features, F_R applies to the *probable capacity* of elements, S_{prob} as determined by the *Seismic Assessment Guidelines*).

Table 4: Risk factors applicable to URM building elements (applied to probable capacities of elements)

Building or connection element	Risk factor, F_R	Examples (non-exclusive)
Existing <i>façade</i> elements (on <i>façade</i> being secured) and direct connection to restraining elements	0.7	- Rocking capacity of parapet. - Rocking capacity of street-facing wall. - Existing floor to <i>façade</i> wall connection capacity. - Existing roof to <i>façade</i> wall connection capacity. <i>Façade</i> wall braced by strongback. - Parapet braced by new roof brace. - Connections to masonry in older pre-existing retrofits of unknown quality.
Existing building elements not located on <i>façade</i> being secured	1.0	- In-plane and out-of-plane capacity of return wall. - Capacity of floor or roof diaphragm.
New bracing elements (or enhancement to existing bracing elements) and their foundations.	1.0	- New steel strongbacks, walers, tie beams etc. and their fixings to masonry. - New timber shear overlay bracing to existing return wall. - New bracing wall and foundation.

Building or connection element	Risk factor, F_R	Examples (non-exclusive)
Existing building elements required for the support of overhead protection (to section A2.3.5).	0.7	- Existing shopfront lintel with improved canopy providing overhead protection. - Existing canopy posts, lateral capacity.

The risk factor, F_R , applies only to the elements given $F_R = 0.7$ in Table 3. It reflects the lack of redundancy in façade failure mechanisms, where collapse occurs immediately upon reaching the instability deflection.

A2.3.4.3 Design Pathways for Façade Securing

A2.3.4.3.1 General

Façade securing can be specified by the following pathways:

- Based on standardised design solutions** as referenced by A2.3.4.3.3.
Such solutions are deemed to meet the *remediation requirements* of façade securing (and section A2.3.4) when applied within their limits of applicability.
- Developed by specific engineering design (SED)** to the requirements of section A2.3.4.
The presence of any building characteristics listed in Table 5 will require *SED* for that particular aspect of the structure. Façade securing can continue to use *standardised solutions* for the remaining areas that are within the limits of their applicability.

Buildings with specific characteristics listed in Table 5 are required to use the *SED* pathway to meet their *remediation requirements*.

Table 5: Characteristics of buildings that require façade securing by specific engineering design.

Building characteristics requiring <i>SED</i> :	
1	3+ storeys
2	Gross Floor Area (GFA) greater than 600m ² per floor or greater than 1000m ²
3	Span between return walls greater than 8m (high seismicity), 12m (medium seismicity)
4	Floor height greater than 4.5m or localised area of building greater than 15m ² with a height greater than 4.5m.
5	Voids in mid floor and/or roof within 4m of the <i>façade</i> with a size greater than 15m ² or 6m length in any one direction
6	Pitched roof greater than 45 degrees
7	When a void/window in the <i>façade</i> crosses through the floor level or roof level of the building.
8	Row buildings greater than 1 storey and where: One or more buildings has a different number of storeys to the remainder, or;

Building characteristics requiring SED:	
	- The floor levels are at a different height (greater than 0.6m different) between the different buildings/section of buildings, or; - There are significant differences in <i>façade</i> openings between buildings
9	Buildings with two or more perpendicular <i>façades</i> requiring <i>façade</i> risk mitigation.
10	Significant pediments, large chimneys, unusual concentrated mass beyond those covered by the <i>standardised solutions</i> that are present within the <i>public space</i> . This category applies only to items above roof level.
11	Stone rubble/cobble masonry/unreinforced concrete block masonry (not brick masonry or ashlar stone with parallel horizontal mortar beds)
12	Buildings with <i>URM façades</i> laterally supported by non-URM systems (capacity of non-URM resisting elements will need to be derived through specific engineering assessment).
13	Buildings with <i>URM façades</i> laterally supported by a concrete diaphragm

Whilst the presence of one or several of the characteristics listed in Table 5 requires SED (by a suitably qualified engineering professional), it is anticipated that many aspects of the suggested standardised solutions will remain applicable. Specification of some of the standard details (subject to engineering review) and use of similar approaches is encouraged.

In addition to the above characteristics, individual existing elements of a building may require SED, if their size exceeds the parameters given in the standardised solutions in the Standardised securing guidelines. The Standardised securing guidelines will signal the need for SED to users. These cases are expected to be uncommon.

A2.3.4.3.2 Incorporating pre-existing retrofit

The incorporation of any pre-existing seismic strengthening into *façade* securing requires specific assessment of its performance including installation condition against the requirements of section A2.3.4.

A2.3.4.3.3 Standardised solutions for *façade* securing

The *standardised securing handbook* contains standardised retrofit details which can be applied to common building configurations, and which satisfy the requirements of *façade* securing. The scope of applicability for each of the specific details is defined in the Guidelines.

A2.3.5 Overhead Protection

A2.3.5.1 Functional requirements for overhead protection

Façade risk mitigation by overhead protection shall substantially reduce the likelihood of falling *façade elements* (or sections of *façade*) striking people or vehicles in the *public space*, where those elements are vulnerable to outwards failure in earthquake.

This should be achieved by utilising a form of protective structure that is adequately proportioned and sufficiently robust to arrest and contain the falling materials.

Overhead protection does not address façade failure itself, and only seeks to minimise the consequence of vulnerable façade element failures in the public space. Nor does overhead protection address risks of full or partial building collapse of masonry buildings. Therefore those risks remain present (for example, to building occupants, or to adjacent properties and spaces which are not the focus of the remediation/mitigation measures). In addition, damage to the building in an earthquake is not addressed by overhead protection.

A2.3.5.2 Performance requirements for overhead protection

A2.3.5.2.1 General Requirements

Protective structures shall protect all *public spaces* exposed to fall hazards from *façade elements* that do not comply with Section A2.3.4.2. Any existing building element relied upon by the protective structure, including supports and attachments, shall comply with Section A2.3.4.2 or be strengthened accordingly.

Complying protective structures can utilise existing building elements (for example an existing canopy, enhanced as required to meet the requirements) or by the provision of new protective structures. Where an existing canopy is used, the portion of the existing URM structure to which the canopy is attached and by which it is supported needs to remain effective (i.e. should not itself be vulnerable to failure from earthquake).

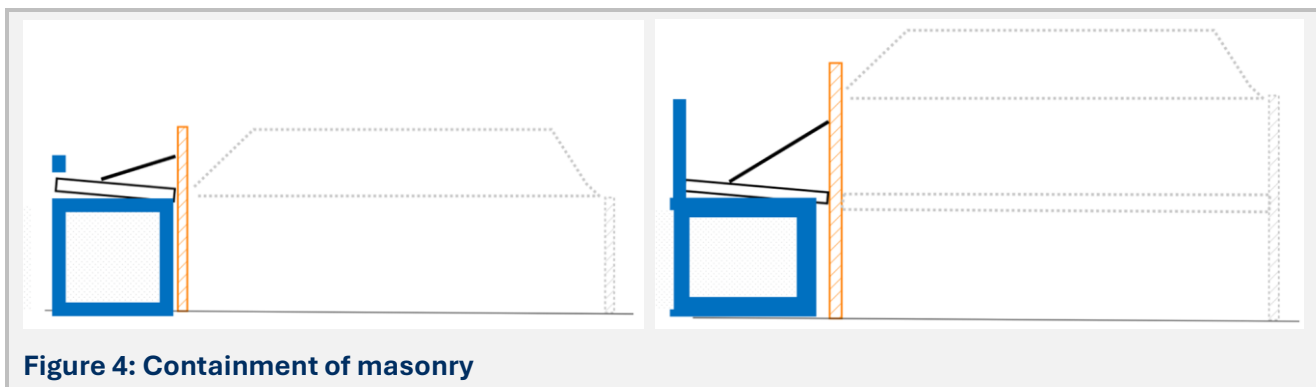
A2.3.5.2.2 Demands, and design methods for protective structures

Protective structures, including enhanced existing elements, shall be designed to arrest and contain falling *façade elements* based on the full unreduced fall energy from their height on the building.

For their own stability, new structures should be design in accordance with the Building Code as for ordinary new building work. Elements of the existing structure that support protective structures (including connections and load paths for restraint and stability) shall comply with section A2.3.4.2.

A2.3.5.2.3 Containment of fallen masonry

Overhead protection shall arrest and contain falling masonry, including associated horizontal momentum, and prevent its ejection from the protected area.



A2.3.5.3 Design pathways for overhead protection

A2.3.5.3.1 General

There are two pathways to achieve overhead protection:

1. **Specification of a standardised system** for enhancement of existing canopies for one-storey buildings
2. **Specific engineering design (SED)** for all other overhead protection structures.

A2.3.5.3.2 A standardised solution for canopy enhancement

The *standardised securing handbook* contains a standardised solution that meets the requirements of A2.3.3. It is suitable for parapets of one-storey buildings that meet criteria, using an existing propped canopy and ensuring the remaining structure is sufficiently secured.

A2.3.5.3.3 Specific engineering design for overhead protection

Buildings which cannot exclusively use *standardised solutions* (referenced by A2.3.5.3.2) require *SED* by a *suitably qualified engineering professional*.

A2.4 Targeted Retrofit of Category A (URM) Buildings

A2.4.1 Applicability

This section applies to *Category A buildings* where the *remediation requirement* is *targeted retrofit*.

A2.4.2 Objective of Targeted Retrofit for Category A Buildings

The objective of targeted retrofit for *Category A buildings* is to mitigate the risk of injury or death posed by an earthquake causing a *URM building* to fully or partially collapse.

Targeted retrofit must also fulfil the objective of *façade risk mitigation* (Section A2.3.2), which is to mitigate the risk of injury or death posed by an earthquake causing building elements that are built of, or supported by, *URM* to fall onto a *public space*.

This reflects the objectives in the *Building (Earthquake-prone Buildings) Amendment Act 2026*.

A2.4.3 Functional Requirements for Targeted Retrofit for Category A Buildings

Targeted retrofit for *Category A buildings* should improve the building such that there is a sufficiently low likelihood of failure of the *LFRS* or *gravity system* leading to full or partial collapse of the building in earthquake.

In addition, targeted retrofit for Category A buildings should mitigate against the risk of full or partial outwards collapse of *façades requirement risk mitigation* (i.e. *façades facing a public space*).

Targeted retrofit for Category A buildings does not require mitigation of the following (and therefore risks may remain present):

Partial or total collapse of the structure under levels than that provided for by Section A2.4.4: Performance.

Collapse and/or ejection of façade elements that are not part of a façade requiring risk mitigation (except where these elements provide lateral and/or vertical stability to the building overall).

Failure of secondary elements (such as chimneys, parapets, partitions and veneers), except where they form part of a façade requiring risk mitigation. These elements should be accounted for as part of the building's seismic mass, but themselves are not required to be addressed (for retrofits meeting the minimum requirements of the EPB Methodology).

Local hazards or building stability risks arising from pounding effects between adjacent buildings.

Excessive foundation deformations, such as those arising from liquefaction and/or lateral spreading (to existing elements of the structure).

Damage or loss of function to means of escape from the building.

Horizontally adjoining structures (extensions, annexes, lean-to structures and the like) are not required to be considered, other than for loads imparted by these structures on the URM building.

Targeted retrofit for Category A buildings does not necessarily result in the reduction of damage to a building following an earthquake.

A2.4.4 Performance Requirements for Targeted Retrofit for Category A Buildings

A2.4.4.1 General requirements

For *Category A buildings*, targeted retrofit should mitigate the collapse hazards associated with higher-risk features of *URM* buildings, by the following:

- Provide adequate tying between building structural elements, giving improved predictability of structural behaviour in earthquake, and a complete load path for primary seismic actions that is proportionate and sufficiently dependable; and,
- Ensure elements of the *LFRS* and *gravity* system have sufficient strength and stability (and are retrofitted where necessary) to meet the performance required by section A2.2; and,
- Meet the requirements of A2.3.4 (façade securing), that is, ensure that other *façade elements* not contributing to overall building stability, but which form part of a *façade requiring risk mitigation*, are sufficiently restrained.
- In achieving all of the above, consider the condition of elements.

*In targeted retrofit, the first objective is to enhance the tying between elements such that a **predictable, box-like behaviour** can be achieved in the building overall. Improved predictability in overall building behaviour is a prerequisite to any further strength enhancement.*

Predictability in behaviour is improved by:

Improvement of material condition (repointing, repair and replacement of deteriorated elements, durability improvement, etc).

Provision of robust (intentional and proportionate) connections between primary structural elements and a complete load path to ground.

Box-like behaviour is improved by:

Identifying the vertical LFRS (the “sides” of the box).

Improvement and connecting of floor and roof diaphragms (the “lids” of the box).

Existing retrofit work can be integrated into any further targeted retrofit work, where it can be shown by assessment that the totality of the new and existing work is structurally compatible and achieves the required performance.

It is permitted to demonstrate (by evaluation of the building using the Seismic Assessment Guidelines, and accounting for any prior retrofit that may be present) that no retrofit is required to meet the required performance. This may occur where there are found, on assessment, to be significant (atypical) mitigating factors that improve the expected performance of the building, or where prior historic mitigation/retrofit exists and is assessed to be effective.

A2.4.4.2 Scope boundary for targeted retrofit for Category A buildings

A targeted retrofit design for *Category A buildings* should:

- For any *façade* that is a *façade requiring risk mitigation*, comply with the full *façade* securing requirements of section A2.3.4.
- For other *façades*, secure *façade elements* that are part of the *LFRS* or *gravity system*, in accordance with section A2.3.4.
- Evaluate the seismic mass of the building (including *façade* loads and loads imparted by adjoining structures), and assign this mass to elements of the *LFRS*. Assess against the performance required by section A2.2, providing additional bracing or strengthening to the *LFRS* including connections where needed, and ensuring that there is a complete load path to the foundation.
- Ensure that displacement compatibility is maintained for elements supporting vertical loading, such that these elements maintain a low probability of full or partial collapse.

A2.5 Targeted Retrofit of Category B Buildings

A2.5.1 Applicability

This section applies to *Category B buildings* that have been confirmed as *EPBs*, where the *remediation requirement* is targeted retrofit.

A *high-risk deficiency* (HRD) review (following Annex 1) is required to apply this section. Targeted retrofit focuses on the remediation of *HRDs* only. All *HRDs* in a building need to be known so that the scope of the minimum *remediation requirement* can be determined.

A2.5.2 Objective of Targeted Retrofit for Category B Buildings

The objective of targeted retrofit for *Category B buildings* is to mitigate the risk of injury or death posed by an earthquake causing a building to fully or partially collapse.

This reflects the objectives in the Building (Earthquake-prone Buildings) Amendment Act 2026.

A2.5.3 Functional Requirements for Targeted Retrofit for Category B Buildings

Targeted retrofit for *Category B buildings* shall mitigate (in accordance with sections A2.5.4 to A2.5.5) the collapse hazards associated with *HRDs* (defined in accordance with Annex 1).

Each *HRD* should either be addressed (Pathway A), or the building strengthened such that there is a sufficiently low likelihood of failure of the deficient component(s) leading to full or partial collapse of the building in earthquake (Pathway B).

Targeted retrofit for *Category B buildings* is not required to address other hazards not associated with *HRDs* listed in Annex 1.

Targeted retrofit for Category B buildings does not require any intentional mitigation of vulnerabilities that are not HRDs (and therefore risks may remain present). Some examples include:

Secondary structural and non-structural elements, including stairs, façade panels (including heavy RC panels) and façade infill masonry, interior heavy partitions.

As a general category, elements of the primary gravity system and vertical LFRS that are not HRDs (several notable potential vulnerabilities that are not HRDs are listed below).

Shear controlled and/or lightly reinforced columns, but in stockier buildings with lower axial load.

Partially grouted reinforced concrete masonry walls.

In-plane strength of general floor diaphragm areas, other than the specific areas included as part of HRD (for vulnerable and non-redundant floor-wall connection).

Precast floor units with vulnerable support characteristics and configurations.

Other heavy elements and portions of a structure that are not HRDs, for example concrete elements supporting lightweight roofs, heavy cantilevered walls, parapets or gables extending above the uppermost heavy floor and poorly restrained.

Detailing vulnerabilities in structural steel vertical LFRS.

Detailing vulnerabilities in lightweight roof structures, or lightweight storey additions built on buildings of heavy construction.

Restraint of precast concrete wall panels to large, long-span industrial or retail buildings (rigid wall flexible diaphragm buildings).

Targeted retrofit for Category B buildings does not necessarily result in the reduction of damage to a building following an earthquake.

A2.5.4 Performance Requirements for Targeted Retrofit for Category B Buildings

A2.5.4.1 General requirements

To meet the *remediation requirements*, one of the compliance pathways in Table 6 shall be met. The process is illustrated in Figure 5.

Table 6: Compliance options for Category B Earthquake-prone Buildings

Demonstrate no retrofit required		
	Demonstrate that the building, without retrofit, meets the required performance.	Evaluate the building and demonstrate that the capacity of <i>vulnerable component(s)</i> , reduced by F_R , is sufficient to resist the earthquake demands (prescribed in A2.5.4.3 and A2.5.4.4).
Targeted retrofit of the <i>HRDs</i> , each by following either of the following pathways		
A	Address the <i>HRD</i> as part of retrofit	Address the <i>HRD</i> by complying with Table 7 (A2.5.4.5); and, Validate that the capacity of <i>vulnerable component(s)</i> (including any proposed retrofit), is sufficient to resist the earthquake demands (prescribed in A2.5.4.3); and, Consider the effect of the retrofit on other building elements (A2.5.5).
B	Retrofit so that the <i>vulnerable component(s)</i> are sufficiently protected	Demonstrate that the capacity of <i>vulnerable component(s)</i> (including any proposed retrofit), reduced by F_R , is sufficient to resist the earthquake demands (prescribed in A2.5.4.3 and A2.5.4.4); and, Consider the effect of the retrofit on other building elements (A2.5.5).

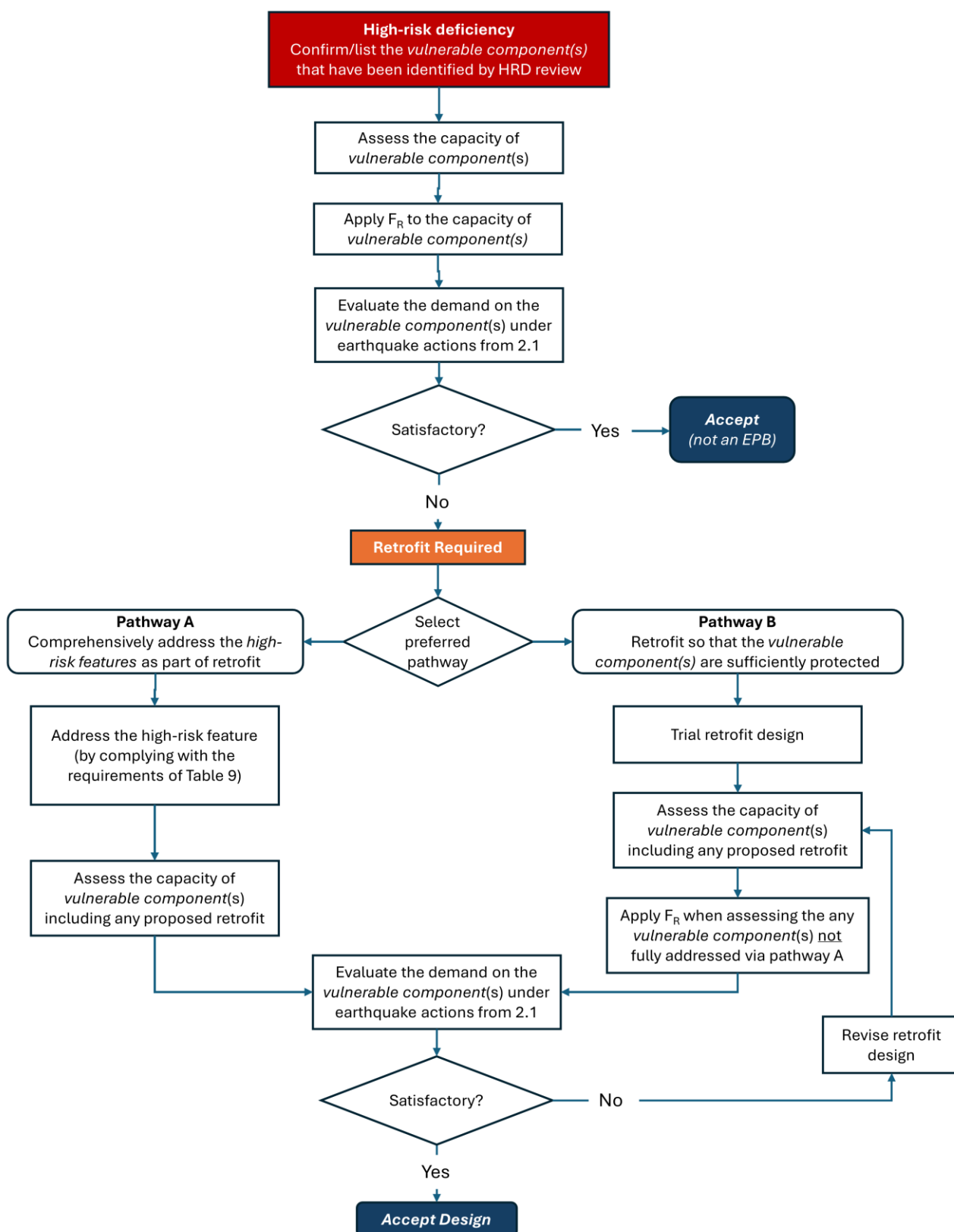


Figure 5: Process for meeting remediation requirement for Category B buildings

A2.5.4.2 Scope boundary for targeted retrofit for Category B buildings

Scope objective for HRD retrofit

The scope objective for *HRD* retrofit is limited to the remediation of *vulnerable component(s)* forming part of *HRD(s)*. For compounding configurational and component vulnerabilities, this means the component(s) whose demands are amplified by the *configurational vulnerability*.

Other vulnerabilities are not required to be specifically addressed (for retrofits that meet only the minimum requirements of this Annex) except insofar as may be required to:

- Ensure the effectiveness of the *HRD* retrofit (sufficient to verify adequate performance of the *vulnerable components*); and/or,
- Avoid worsening the performance of other vulnerabilities (or introducing new ones) by complying with section A2.5.5.

Scope of assessment for verifying the performance of vulnerable component(s)

Assessment should be in accordance with provisions for detailed seismic assessment in the *Seismic Assessment Guidelines* (see A2.2.2), but limited to the verification of *vulnerable component(s)*. *Vulnerable component(s)* are those associated with *HRDs*.

An assessment should consider the following, but only insofar as is necessary to evaluate the performance of vulnerable components.

Establish the likely behaviour and strength hierarchy of the building's LFRS.

Using an appropriate analysis procedure, evaluate the probable capacity of the building overall at the point where the vulnerable component(s) reach their capacity.

Completeness of load path for lateral force resisting system enhancements

For new or enhanced *vertical LFRS* that are introduced to limit demands on non-ductile components, the anchorages of new components to existing and the performance of other existing elements that are required to be effective for the intervention to work as intended shall be verified to meet the required performance.

For LFRS enhancements that are intended to reduce or remove some building irregularity types and are not otherwise intended to intentionally increase overall base shear or overturning resistance, this can be localised to the anchorage of the retrofit to existing elements.

Examples of LFRS enhancements that may be intended only to reduce or remove a building irregularity could include:

An infill frame to address a weak storey.

A spine wall to address storey-sway potential.

Reviewing the effect of the retrofit on the resulting building

The requirement to avoid material detriment to the performance of other aspects of the building can affect the scope of retrofit or the approach used. These requirements are determined by section A2.5.5 (Reviewing the effect of the retrofit on the building).

A2.5.4.3 Earthquake loads, and capacity of existing, retrofitted and new elements

Refer to section A2.2.

Design actions (horizontal design response spectrum and/or design coefficient) shall be determined from the elastic site spectrum as appropriate to the method of analysis, in accordance with the *Seismic Assessment Guidelines*. Where the *HRD* is not addressed (removed), the minimum value of S_p shall be 0.9.

A2.5.4.4 Risk factor for vulnerable components forming part of high-risk deficiencies

The *risk factor*, F_R , adjusts the capacity of high-risk building features, and is explained in section A2.2.2.2. For category B buildings, these are the *HRDs*.

In the evaluation of *vulnerable component(s)* that form part of *HRDs*, the *probable capacity* of the building overall (considering the *vulnerable component(s)*) shall be reduced by a *risk factor* $F_R = 0.5$. Expressed in relative terms, this means the earthquake shaking resisted by the building when the *vulnerable component(s)* reach their probable capacity S_{prob} (strength and deformation).

The risk factor F_R only applies to assessment of the *vulnerable component(s)*.

Where the retrofit addresses an *HRD* by Pathway A (5.4.5), the *risk factor* F_R does not apply to assessment of those *vulnerable component(s)* in any further retrofit design validation.

All other cases follow Pathway B, and the *risk factor* shall continue to apply to the assessment of *vulnerable component(s)*.

A2.5.4.5 Addressing the high-risk deficiency (Pathway A)

Table 7 defines how to address the high-risk deficiency, when following Pathway A.

Table 7: How to address the high-risk deficiency (Pathway A)

HRD ID	High-Risk Deficiency (several may apply) ¹	How to address the high-risk deficiency (Pathway A) ¹. <i>The performance of vulnerable components after retrofit must be verified as meeting A2.5.4, but the risk factor F_R does not apply if the requirements of this table are met.</i>
Component-Only Deficiencies		
A-01	Column with exceptionally high axial load	Address the <i>vulnerable component(s)</i> (column) per Table 8.
A-02	Inadequate and non-redundant floor-wall connection	n/a (follow pathway B)
A-03	Slab-column joint(s) with high shear demand	Address the <i>vulnerable component(s)</i> (slab-column joint) per Table 8.
A-04	URM elements contributing significantly to vertical or lateral stability	Exclude the contribution of URM elements to vertical and lateral building stability.
Compounding Configurational and Component Deficiencies (both must be present to be an HRD)		
B-__	Overall weak vertical LFRS	Address the <i>vulnerable component(s)</i> per Table 8.
C-__	Severe Torsional Sensitivity	Address the <i>vulnerable component(s)</i> per Table 8; or, Address the torsional sensitivity by showing that the building does not have torsional irregularity when assessed to NZS 1170.5:2004.
D-__	Weak storey (soft or <i>weak storey</i> vertical irregularity)	Address the <i>vulnerable component(s)</i> per Table 8; or, Address the <i>weak storey(s)</i> by demonstrating it has a storey shear strength equal to or greater than the storey above (based on a mechanism strength calculation).
E-__	Storey-sway potential	Address the <i>vulnerable component(s)</i> per Table 8; or, By comparison of storey-shear strengths, demonstrate that the probable mechanism strength of a <i>weak storey-sway</i> mechanism is greater than the beam-sway mechanism strength computed at overstrength ² .

F-__	Slender vertical LFRS with poor founding conditions	Address the <i>vulnerable component(s)</i> per Table 8; or, Demonstrate by geotechnical assessment that <i>poor founding conditions</i> do not exist (see Annex 1, Section A1.9.4).
G-__	Discontinuous wall or braced frame (horizontal offset or vertical discontinuity irregularity)	Address (remove) the discontinuity by the introduction of a suitably designed reinforced concrete wall that encompasses (as a minimum) the full cross-section of the existing wall over, has equal or greater quantities of vertical and horizontal reinforcing, and equal or lesser spacing of vertical reinforcing ³ .
High-Risk Building Configurations (Vulnerable to P-Delta Instability)		
H-__	Exceptionally weak frame (vulnerable to P-Delta instability)	n/a (must follow pathway B)

Notes:

- [1] If multiple *HRDs* are present in a building, and only some are addressed via pathway A, the *risk factor* must be included for *HRDs* which are not fully addressed in accordance with the above requirements (that is, follow pathway B for any *HRDs* where the requirements of this table are not met).
- [2] This requirement need not be applied to all levels; however any level where storey-sway behaviour is not suppressed in accordance with this requirement shall retain the application of the *risk factor* in its evaluation.
- [3] Addition of a braced frame in the plane of a wall can be a suitable means to reduce configurational irregularity such as potential weak storey; however, it does not address the wall discontinuity, so the *risk factor* still applies.

Table 8: How to address the *vulnerable component(s)*

Component deficiency		How to address the <i>vulnerable component</i>
Vulnerable column		Provide confinement in <i>PPHZ</i> to satisfy $\rho_t \geq 0.4\%$ (at least one effectively continuous hoop enclosing a core area satisfying $A_g/A_c \leq 1.5$) with hoop or tie spacing $\leq h_c/3$; and, Provide shear strength $V_{p,col0} > 1.5 V_y$ or greater than the maximum shear that can be delivered to the column based on a capacity design approach; and, An axial load ratio of $N^*c < 0.7 A_g f'_c$ based on earthquake actions from the <i>benchmark seismic hazard</i> (see 2.1.1) or the maximum axial load that can be delivered to the column based on a capacity design approach.
Non-ductile beam-column joint		Provide confinement to unconfined joint faces (those not intersected by beams) to satisfy $\rho_t > 0.4\%$, with spacing $\leq h_c/2$, and fully anchored on either side of the joint face; or, Demonstrate sufficient strength (or strengthen) so that joint hierarchy (assessed to <i>Seismic Assessment Guidelines</i>) is not limited by joint failure.
Vulnerable slab-column joint	Slab-column joints not contributing significantly to lateral building stability	Provide an alternative load path to support design gravity load, assuming the slab-column interface fails and cannot support gravity load. Strength limit states for the alternative load path (and for validation of the resulting critical slab perimeter in the existing slab) shall be in accordance with AS/NZS 1170 suite for: - Permanent action only, $E_d = 1.35G$ - Permanent and imposed action, $E_d = 1.2G + 1.5Q$ [See note 1] - Permanent and imposed action $[G + \psi_E Q]$ acting in conjunction with drift from earthquake actions at the <i>benchmark seismic hazard</i> (see 2.1.1) The resulting slab critical perimeter around the supported area shall be intersected in each direction by effectively continuous bottom reinforcing of minimum area $A_s > 0.6 V_g / f_y$, where V_g is determined from $[G + \psi_E Q]$.
Wall vulnerable to axial failure	Susceptibility to through-the-thickness axial failure	Enhance the wall so that it no longer classifies as susceptible to through-the-thickness axial failure (per Annex 1); Or, Address the physical consequence of failure so that it no longer classifies as severe (Annex 1).

Component deficiency		How to address the <i>vulnerable component</i>
	Multi-planar walls susceptible to axial instability failure	Address concentration of wide cracking, as for lightly vertically reinforced walls (below in table).
Wall vulnerable to loss in lateral strength	Walls acting out-of-plane	Exclude the contribution of walls acting out-of-plane in demonstrating that satisfactory performance is met.
	Slender singly reinforced walls susceptible to concentration of deformation in a single crack	Provide enhanced boundary zone ² to <i>PPHZ</i> and verify its curtailment does not relocate the potential yielding region.
	Slender walls that are lightly vertically reinforced	Provide enhanced boundary zone ² to <i>PPHZ</i> and verify its curtailment does not relocate the potential yielding region nor result in shear-controlled behaviour.
	Slender walls that are lightly horizontally reinforced	Enhance the wall shear capacity such that wall strength is limited by flexure ³ .
	Walls with a lack of reinforcing anchorage in <i>PPHZ</i>	Remediate to provide fully developed anchorage of wall reinforcing, and ensure the probable strength of the wall anchorage configuration is capable of transmitting demands arising from the lesser of a) or b): The wall overstrength section strength at the critical section computed assuming full anchorage of all wall reinforcing. The overstrength tension capacity of the supporting element (or in the case of shallow foundations, the capacity to resist uplift).

Notes:

- [1] $1.5\psi_{EQ}$ can be used in lieu of $1.5Q$ for areas that are not egress routes.
- [2] Addressing by enhanced boundary zone: Enhance boundary zone in order that it meets the dimensional limitations of NZS 3101:2006 A3 Cl. 11.4.3 and end zone reinforcing content requirements of NZS 3101 Cl. 11.4.4 for limited ductile plastic regions. It is important to ensure that the addition of flexural strength by boundary zone improvement does not relocate the *PPHZ* to a potentially non-ductile region (including the wall segments over, or anchorage to the foundation).
- [3] This can be demonstrated by methods of assessing behaviour hierarchy in the *Seismic Assessment Guidelines* (for example Appendix 2025-C2A: SL_{MA}), or by satisfying a shear force envelope from a rational capacity-design approach such as Appendix CD4 of NZS 3101:2006 A3. The dynamic shear magnification factor in NZS 3101 Appendix CD4 need not apply.

A2.5.5 Reviewing the Effect of the Retrofit on the Building

A2.5.5.1 General

For targeted retrofit that addresses or improves only the *HRDs*, the effect of the retrofit on the performance of the remainder of the building shall be considered. This consideration should take a holistic view of the building overall in order to ensure that the requirements of section 112 of the Building Act² are met in relation to structure. This involves consideration of the building configuration (A2.5.5.2) and individual elements that are impacted by modified *LFRS* or mechanisms (A2.5.5.3 and A2.5.5.4).

The retrofit must not introduce features that would result in the creation of an *HRD* (as defined by Annex 1).

In most cases it is not anticipated that a comprehensive analysis of the whole structure is needed to verify that the building overall will not perform worse than before. By addressing the identified HRDs, the building should clearly perform better than before, subject to the checks in 5.5.2, 5.5.3 and 5.5.4 to verify that other potentially significant seismic vulnerabilities are not being inadvertently introduced.

A2.5.5.2 Building Configuration (and the introduction or worsening of irregularities)

If the retrofit introduces (or clearly worsens) a building configuration irregularity consisting of any of:

- Storey-sway potential; or,
- Weak storey; or,
- Vertical irregularity; or,
- Torsional irregularity,

Then the following requirements shall apply to any elements whose demands could be reasonably impacted (i.e. clearly worsened) by the introduction of the irregularity:

- Show their *ultimate capacity* (strength and deformation) equals or exceeds demands at the *benchmark seismic hazard* (section A2.2.1.1); or,
- Mitigate by further retrofit intervention and demonstrate that the seismic performance of the affected element(s) in terms of their *ultimate capacity* (strength and deformation), is not worsened.

The purpose of this requirement is to preclude the introduction of a significant additional source of potential seismic vulnerability (by introducing irregularities that can concentrate demands) because of attempts to address another.

A2.5.5.3 Reviewing for Increased Gravity Demand on Existing Elements

The seismic retrofit measures shall not increase the gravity load demands on existing structural elements and foundations by more than 5% nor reduce the capacity of existing structural elements or

² Building Act s. 112(1)(b) *continue to comply with the provisions of the building code to at least the same extent as before the alteration.*

foundations to resist gravity loads without demonstrating that the affected component(s) comply with the requirements of B1/VM1 for gravity loads at the ultimate limit state.

A2.5.5.4 Reviewing for Increased Seismic Demands on Existing Elements

If the retrofit of an *HRD* increases seismic demands on any existing structural element, connection or foundations by more than 10% because of added seismic mass, an increase in building strength or a change in seismic load path, then such elements should be reviewed as follows and remediation scope adapted as necessary:

- Show their *ultimate capacity* (strength and deformation) is enough to withstand demands at the *benchmark seismic hazard* (section A2.2.1.1); or,
- Mitigate by further retrofit intervention and demonstrate that the seismic performance of the affected element(s) in terms of their *ultimate capacity* (strength and deformation) is not worsened.

A2.6 Alternative Remediation Pathways

A2.6.1 Verification of targeted retrofit using ASCE 41 Tier 3 assessment

A2.6.1.1 Applicability

Where the remediation requirement is targeted retrofit, it shall be permitted to apply an alternative verification following ASCE 41 Tier 3 assessment, to either:

- verify the performance of *targeted retrofit*; or,
- demonstrate that no retrofit is required to meet the necessary performance.

A2.6.1.2 Performance objective for ASCE 41 Tier 3

For alternative verification to ASCE 41 tier 3, the performance objective shall be as defined in Table 1.

Table 9: Performance objective for alternative verification of targeted retrofit following ASCE 41 Tier 3 assessment

Building Category	Performance objective	
Category A (URM)	1. Structural collapse prevention (S-5) with earthquake hazard level as given by NZS 1170.5:2004 for a 1/250 APoE; and, 2. Comply with all remediation requirements for <i>façade risk mitigation</i> (refer section A2.3).	
Category B	Select either (a) or (b)	
	Option (a)	Structural collapse prevention (S-5) with earthquake hazard level as given by NZS 1170.5:2004 for a 1/250 APoE; and, For each <i>HRD</i> identified by Annex 1, demonstrate that the <i>HRD</i> is addressed in accordance with section A2.5.4.5 (Table 7) or address it as part of the retrofit.
	Option (b)	Structural collapse prevention (S-5) with earthquake hazard level as given by NZS 1170.5:2004 for a 1/1000 APoE.

Scope of targeted retrofit

For verification of targeted retrofit to ASCE 41 Tier 3, the scope of assessment and retrofit shall be defined by meeting the performance level prescribed in Table 9 for the building as a whole. The scope boundary described in sections A2.4 and A2.5 for targeted retrofit of Category A and B buildings respectively does not apply.



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