BUILDING PERFORMANCE

EPB Guidance Consultation:

Webinar #2 for Engineers

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2

Purpose of this webinar

- Help you engage with the ongoing **EPB Guidance** consultation – closes 4 Dec 2026
- Provide an overview of the new EPB System – **focus on technical aspects** of interest to engineers
- Webinar is **NOT** technical training on application of the EPB Guidance and Annexes.
  - Some technical guidance documents still under development.



Scan this to go to consultation page!

3

How the EPB system fits together

Different documents play different roles but work as one system.

BUILDING ACT 2004 — LEGAL FRAMEWORK
Establishes the statutory framework for identifying, managing and remediating earthquake-prone buildings.

EPB METHODOLOGY — REQUIREMENTS + PROCESS
Defines which buildings are in the EPB system and sets the requirements for identifying, evaluating and remediating them.

TECHNICAL ANNEXES — TECHNICAL DETAIL
Set out detailed criteria, evaluation procedures and performance requirements.

EPB GUIDANCE — PUTTING IT INTO PRACTICE
Explains how TAs, owners and engineers can apply the Act and methodology in real situations.

Other parts of the system

- **REGULATIONS** — Set supporting requirements, including exemption criteria.
- **EPB REGISTER** — Provides the national public record of designated EPBs.
- **ENGINEERING DOCUMENTS** — Support seismic assessment and retrofit design.

- ✓ **The Act says what the law requires**
- ✓ **The Methodology says what must be done**
- ✓ **The Annexes provide the technical detail**
- ✓ **The Guidance shows how to apply it**

4

Outline

- Background
- New system overview
- URM
  - Definitions
  - Mitigation requirements

Webinar #1

Scan this to go to page with recording!

- 3+ storeys of heavy (concrete) construction
  - Definitions
  - High-Risk Deficiencies
  - Mitigation requirements

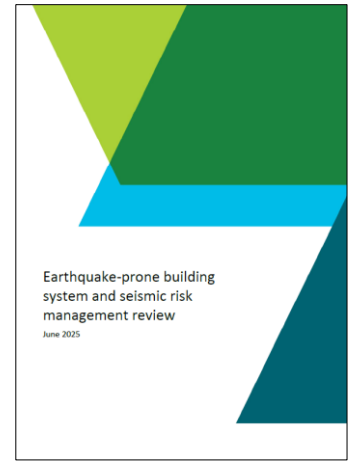
Webinar #2 (Today)

5

Brief outline of Seismic Review findings

Despite some 1,500 earthquake prone buildings (EPBs) being strengthened or demolished, problems with 2017 EPB system have emerged:

- Remediation is often **uneconomic or unaffordable** for many owners
- Many **lower risk buildings** becoming EPBs
- **Insurer preferences** for more resilient buildings can drive up costs and make getting remediation finance more difficult
- **%NBS** causing confusion; differing engineering assessments
- **Heritage restrictions** posing barriers to remediation
- Impractical **enforcement tools** for territorial authorities



6

International lessons



QuakeCoRE
NZ Centre for Earthquake Resilience
Te Hiranga Rū

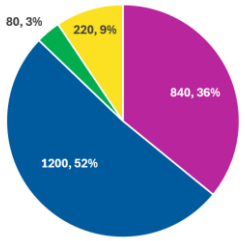
Olga Filippova
Jason Ingham
John Hopkins

7

Risk-targeted mitigation requirements

Mitigation requirements based on:

- Building vulnerability (building type)
- Human exposure (size and location)



Approx. distribution of mitigation requirements for current EPBs

LOCATION	BUILDING TYPE: Unreinforced masonry buildings – 1-2 storey	BUILDING TYPE: Unreinforced masonry buildings – 3+ storey	BUILDING TYPE: 3+ storey high risk heavy construction (eg concrete) buildings
Not Urban Area	Register and EPB sign	Façade risk mitigation	Targeted retrofit
Urban Area	Façade risk mitigation	Targeted retrofit	







8

Mitigation requirements

Section 133AD(2):

(a) **facade risk mitigation**, which mitigates the risk of injury or death posed by an earthquake causing building elements that are built of, or supported by, unreinforced masonry to fall onto an area outside the building by requiring the building's owner to carry out seismic work on or in relation to some or all of those elements:

(b) a **targeted retrofit**, which mitigates the risk of injury or death posed by an earthquake causing a building to fully or partially collapse by requiring the building's owner to carry out seismic work on or in relation to some or all of the structural deficiencies of the building that give rise to that risk.

High-Risk Deficiencies





9

EPB Lifecycle



Territorial authority decides if a building becomes or remains an EPB.

Different for:
- **Existing EPBs**
- New EPBs in coastal Otago prior to July 2032
- New EPBs after statutory time frames

The **owner** can provide **territorial authority** with new information impacting its identification.

Includes **High-Risk Deficiency** review.

Building owner has seismic work done to meet the *remediation requirement* (façade risk mitigation, targeted retrofit or demolition).

Territorial authority removes the building from the EPB Register and informs the **owner** that they may remove the *EPB sign*.

10

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Category B – Tall buildings, built using heavy materials



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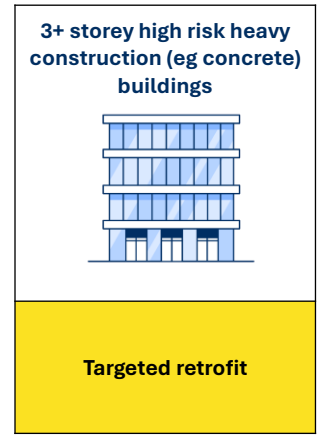
11

Outline

- Defining Category B Buildings
- High-Risk Deficiencies (HRDs)
  - *Background to concept*
  - *HRD Reviews*
- Targeted Retrofit (Category B)



12

Definition of Category B

Methodology requirements

A building is a Category B building if it—
(a) has 3 or more storeys or is 12 metres or more in height; and
(b) is built using heavy materials.



Heavy materials:

- Floors or roofs constructed substantially in reinforced or unreinforced concrete (including composite construction or construction incorporating masonry)

  or

- Framing that supports and braces the building constructed in reinforced or unreinforced concrete, RC masonry or concrete encased structural steel

13

Definition of Category B

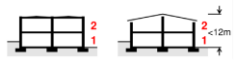
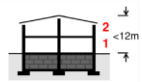
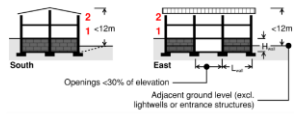
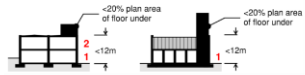
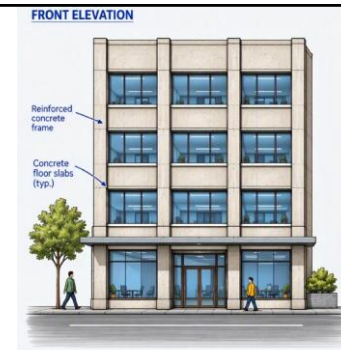
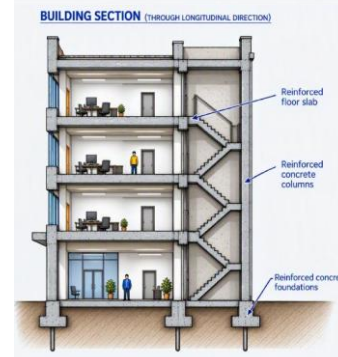
Example	Figure	Outcome
Three *storeys*, on a level or sloping site, including partially embedded storeys.		Category B
Two *storeys*, less than 12m in height.		Not Category B
Two *storeys* above a basement that is fully below *ground level*, less than 12m in height.		Not Category B
Two *storeys* above a partially embedded storey that is effectively enclosed, less than 12m in height.		Not Category B
One or two *storeys* and less than 12m high, excluding towers or rooftop structures that are <20% of the floor area supporting them).		Not Category B

Table 7: Examples of counting *storeys* for *Category B* buildings





14

Only *high-risk* Category B buildings can be EPB

IDENTIFY → VALIDATE → MITIGATE → REMOVE

A high-risk building, is a building possessing one or more high-risk deficiencies

15

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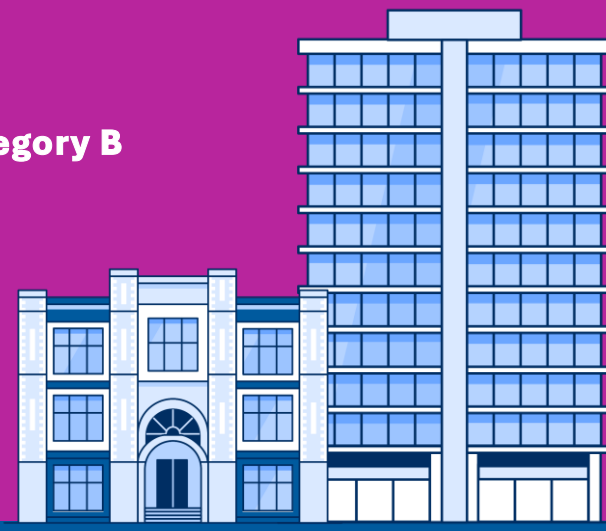
High-Risk Deficiencies in Category B Buildings

Background to the concept



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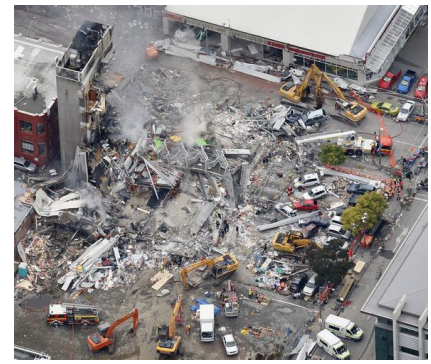
16

Why is an identification tool needed?

Non-URM buildings tend to be less vulnerable than URM buildings… but…

- In larger buildings the consequence of failure is higher (similar risk)
- There is large variation in the vulnerability of concrete buildings…
  - …not all older concrete buildings are vulnerable, or high-risk

How to evaluate collapse potential in older concrete buildings?



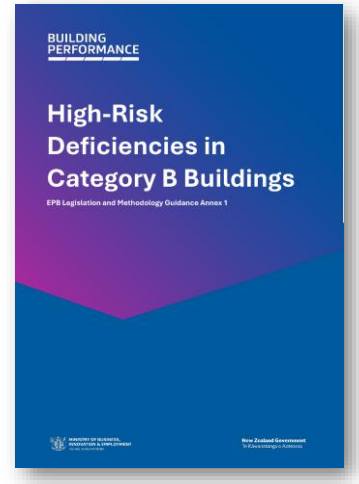
Example: High number of fatalities from a single building collapse

17

Why is an identification tool needed?

Need an identification tool to identify highest-risk buildings

- Previously (currently), engineering assessments (and %NBS) used to identify EPB
  - Comprehensive, application has helped quantify performance and drive retrofit
  - However, has not consistently performed as an effective method to identify highest collapse potential
- Now limited to specifically defined high-risk deficiencies…



18

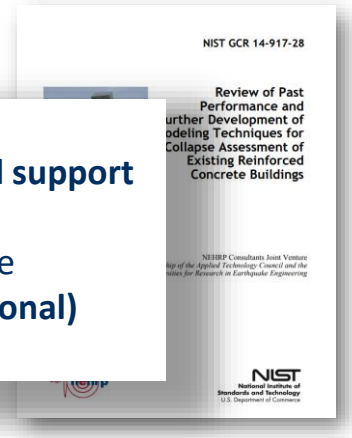
Buildings with higher collapse potential

Table 2-15 Frequency of Most Common Design and Construction Characteristics Found Within the Group of Six Buildings that Collapsed

Level	Category								
Global	Vertical load system								
	Vertical load system								
	System strength								
	Load path								
	Plan irregularities								
	Vertical irregularities								
	Vertical irregularities								
	Vertical irregularities								
	Load path								
Component	Joints (beam-col. or slab-col.)								
	Columns								
	Beams/flat slabs								
	Shear walls								
	Columns								
	Joints (beam-col. or slab-col.)	Interior (concrete on four sides)	Likely	Likely	Likely	Unknown	Unknown	Unknown	50%
	Shear walls	Discontinuity of wall	Likely	Unlikely	N/A	N/A	Likely	Possible	50%
	Infills	Interference with frame action	Likely	Possible	N/A	Possible	N/A	N/A	50%

Key Conclusions:

1. Collapse due to **loss of gravity load support** (with or without lateral instability).
2. Typically collapsed buildings include **combination of global (configurational) AND component deficiencies**.



19

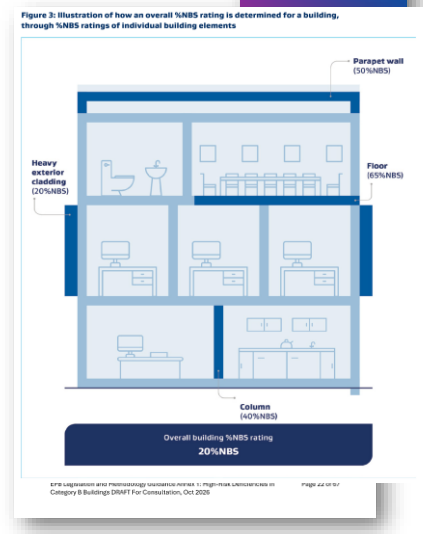
What is a high-risk deficiency?



An HRD is a prescriptive list of specific building construction features in heavy, larger buildings, that cause those buildings to be a higher risk.

Important differences to engineering assessment (*%NBS*):

- A simpler (more prescriptive) evaluation of whether or not the listed features exist.
- More direct link to building failure evidence (from past earthquakes)
- HRD definitions allows consequence of part/component failure to be considered directly



20

What is a high-risk deficiency?

Section 133AD(2):

(a) **facade risk mitigation**, which mitigates the risk of injury or death posed by an earthquake causing building elements that are built of, or supported by, unreinforced masonry to fall onto an area outside the building by requiring the building's owner to carry out seismic work on or in relation to some or all of those elements:

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21

Criteria for defining high-risk deficiencies

Engineering criteria

- High vulnerability – often compounding issues (not just one thing, but several)
- High physical consequence and exposure – (full or partial building or storey collapse)

Non-engineering criteria

- Administrative workability – identify the worst problem areas in buildings, but with less burdensome assessment and calculation
- Value for money – Cost effectiveness relative to risk reduction

Drawing heavily on evidence from real earthquakes

22

Why use the HRD concept?

Improve risk-focus

- Simpler/coarser identification does not necessarily mean less accurate at a system level.
- Evidence-based, deficiency-focused approach should improve focus.

Facilitates targeted retrofit

- Focus on remediation of HRDs
- In many cases, this can reduce the cost of retrofit. Significantly in some cases.

23

Deficiency-based approaches
International Precedent



Has this been done before?

The specifics are new, but similar 'deficiency-based' approaches are used internationally (or are in development). Some notable examples:

- Weak storey retrofits (Taiwan)
- San Francisco Concrete Building Safety Programme (2025)
- Some West Coast USA mandatory retrofit programs (e.g. West Hollywood, LA)
- Several others…



24

For example..

San Francisco Concrete Building Safety Program 2025



Table A6.4-1: Engineering Criteria Options

Option (a)	Comply with all of the following:
	1. ASCE 41 with a performance objective of Structural Collapse Prevention (S-5) with the BSE-1E earthquake hazard level.
	2. For each seismic deficiency in Table A6.4-2, demonstrate that the deficiency is not present, or address it by retrofitting. In a bulletin, the Department shall specify requirements for identifying, evaluating, and retrofitting the seismic deficiencies listed in Table A6.4-2.
	3. For all unreinforced masonry elements, ASCE 41 with a performance objective of Nonstr

Similar concept to HRDs

Table A6.4-2: Seismic deficiencies to be addressed by Engineering Criteria Option (a)

Weak story: The structure includes one or more stories having lateral strength less above.
Lateral-force-resisting-element irregularity: The lateral force-resisting system includ concrete walls or frames that are not continuous to the foundation.
Non-ductile moment frame: The main lateral-force-resisting-system includes concrete frames that do not satisfy strong-column-weak-beam requirements or that have shear-gove or beams.
Shear-governed concrete column or wall pier: The structure includes one or more co or wall piers that are shear-governed and susceptible to failure resulting in loss of gravity
Punching shear in concrete slab: One or more concrete floor or roof slabs are supporte more columns without beams framing into the column and is susceptible to loss of gravity following punching shear failure.
Weak connection of concrete wall to flexible diaphragm: The structure includes one

25

Deficiency-based approaches
International Precedent



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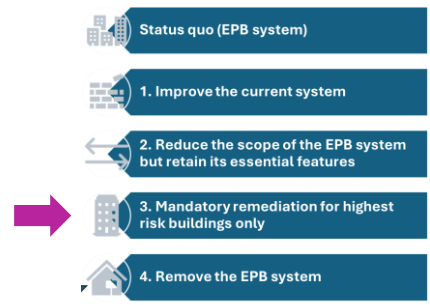
How/why is the proposed NZ approach different?

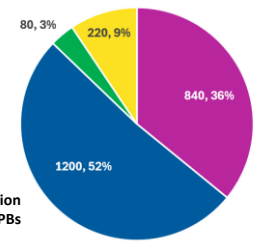
- US/Californian 'non-ductile concrete' programs are generally more expansive
- As deadlines approach, they are facing similar problems (to NZ's current system)
- New Zealand has a highly variable building inventory (c.w. Taiwan, for example)
- Different starting point (NZ is part way through an expansive EPB regime)

26

What the HRD concept aims to achieve

- **Risk tolerance**
  - c.w. current system, only address significant building vulnerabilities that can lead to building collapse
- **Fewer Category B EPBs** with remediation requirements (only highest risk)
- **Cost to remediate**
  - Targeted retrofit: A modest average reduction (c.w. status quo) but wide variability.





Approx. distribution of mitigation requirements for current EPBs

27

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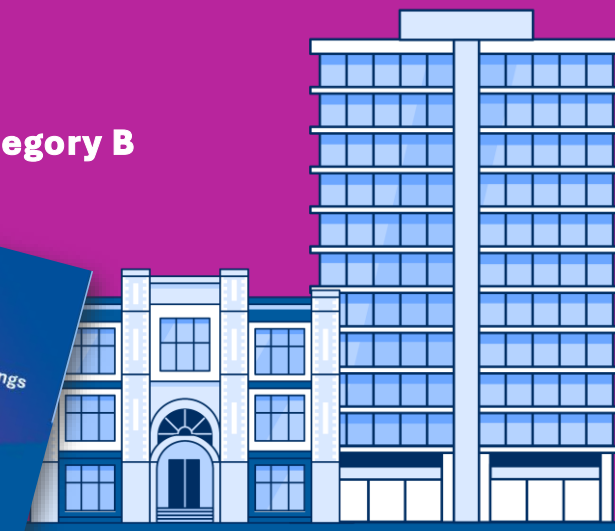
High-Risk Deficiencies in Category B Buildings

HRD Reviews





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28

HRD Review Process

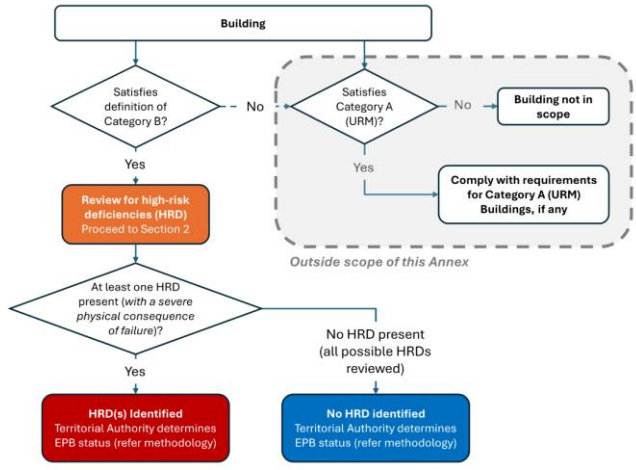


Figure 1: Process for using an HRD review to determine whether a Category B building could be Earthquake-prone

29

HRD Review Process

New, simple prioritisation tools replace detailed engineering assessment

Fundamental to the new approach

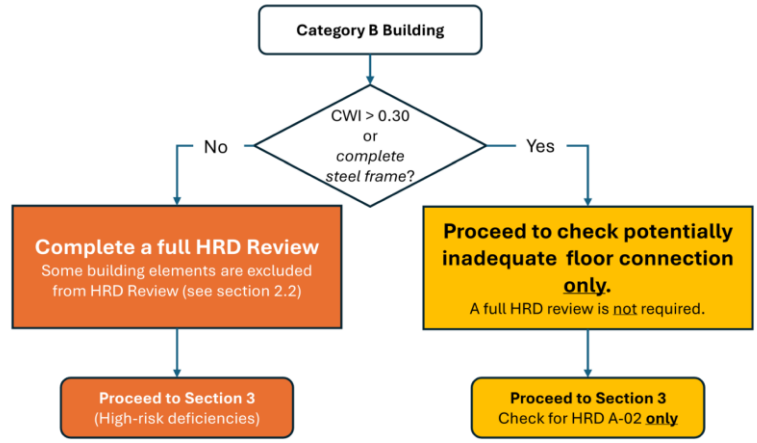


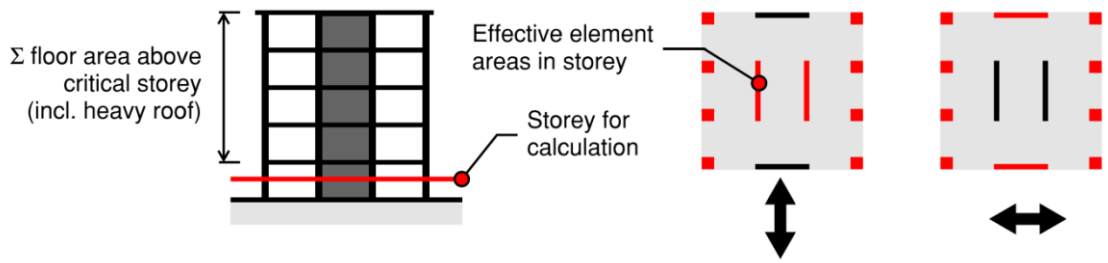
Figure 2: Determining whether or not an HRD review is required

30

Area-based indices used in HRD review

Column-Wall Index

Ratio of effective cross-sectional area of vertical structure within a storey (columns, walls, and braces) to the total gross floor area supported above.



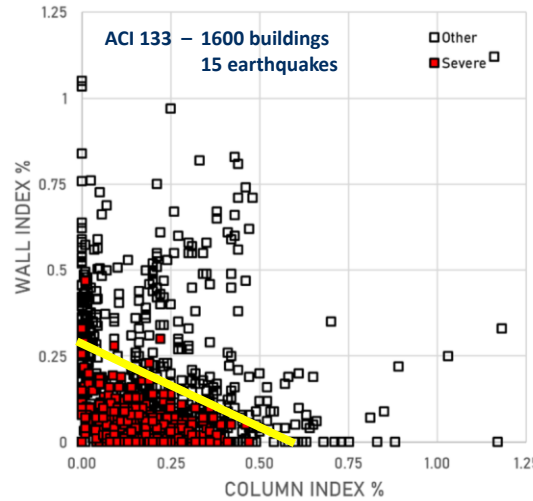
31

Area-based indices used in HRD review

Column-Wall Index

A significant body of post-earthquake reconnaissance data correlating this index with observations of building performance.

A simpler, evidence-based approach to prioritising buildings with highest collapse potential.



32

Area-based indices used in HRD review

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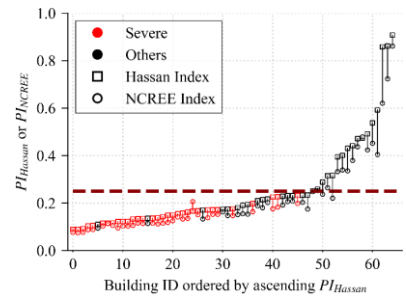


Hualien Earthquake damage distribution

$$CI = \frac{\sum(c_j A_{RC_{col},j})}{\sum A_{floor}}$$

$$WI = \frac{\sum A_{RCwall} + 0.5\sum A_{RCMwall} + 0.1\sum A_{Masonrywall}}{\sum A_{floor}}$$

Column-Wall Index (CWI) = WI + CI

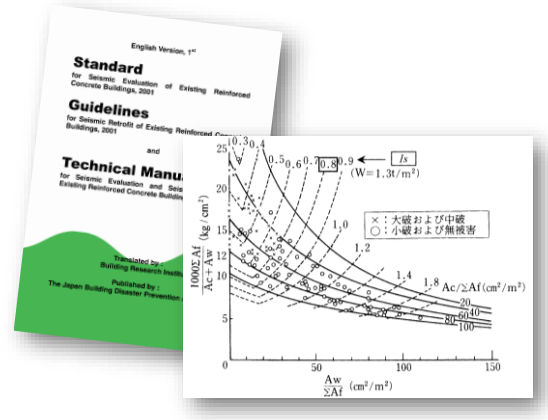
33

Area-based indices used in HRD review

Column-Wall Index

Usage as a prioritisation index is similar to:

- I_s Index used by Japan (Shiga map)
- NCREE Index used by Taiwanese seismic safety programs
- Some adaptions for New Zealand's inventory

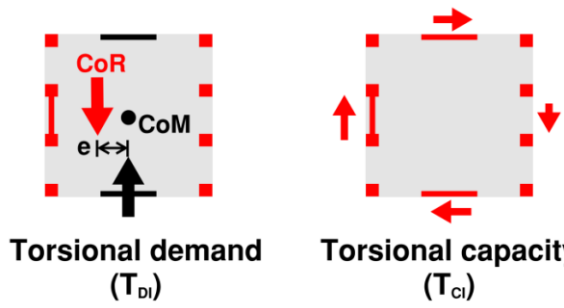


34

Area-based indices used in HRD review

Torsional strength index

A relative measure of how much torsional strength a building has to provide stability when, loaded through the CoM, it reaches its translational strength in a given direction.



Torsional strength index

$$TSI = \frac{T_{DI}}{T_{CI}}$$

35

HRD Review Process

Buildings with a column wall index > 0.3% do **not** require full HRD review.

That is, they **cannot** have an HRD, other than A-02.

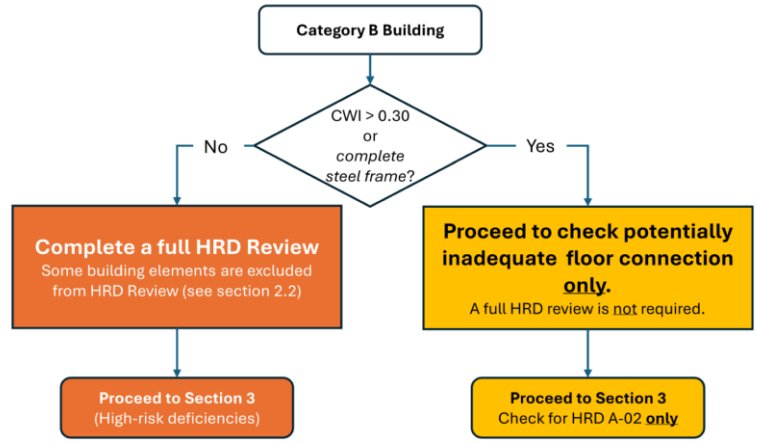


Figure 2: Determining whether or not an HRD review is required

36

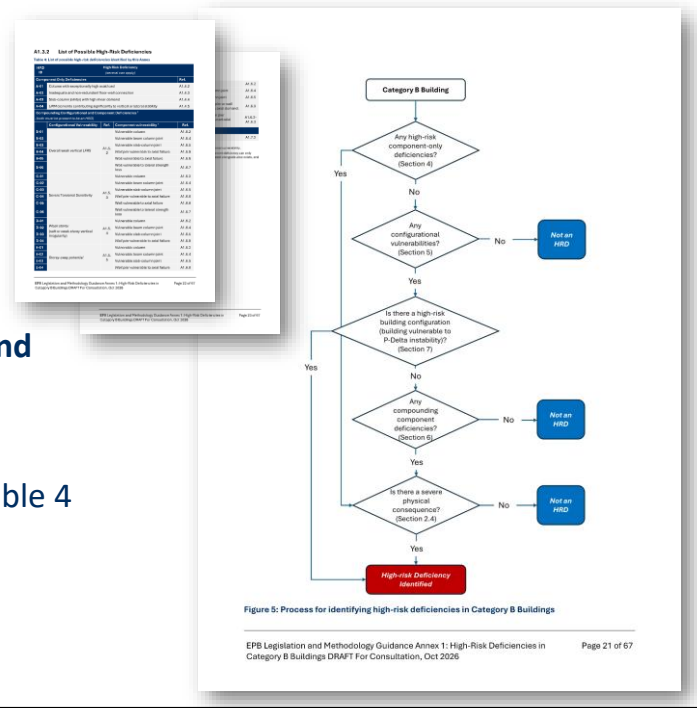
HRD Review Process

Three types of potential HRD:

- **Component only**
- **Compounding component and configurational**
- **Configuration**

Only those listed in Annex 1, Table 4 are potential HRDs

Must be a severe physical consequence!



37

Severe physical consequence

Either of the following

- **Gravity**: Loss of support of a significant area of heavy floor (full bay)
- **Lateral:** Loss of significant proportion of lateral building stability

Applies throughout the process

If no severe physical consequence, no HRD!

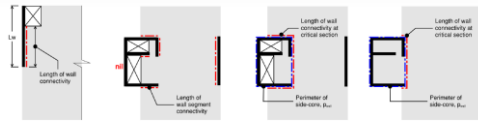
38

HRD Review Process

Component only deficiencies

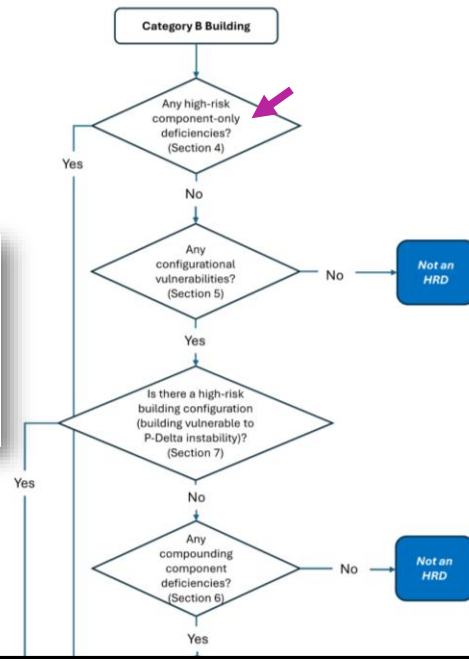
Table 4: List of possible *high-risk deficiencies* identified by this Annex

HRD ID	High Risk Deficiency *(several can apply)*	
Component Only Deficiencies		**Ref.**
A-01	Column with exceptionally high axial load	A1.4.2
A-02	Inadequate and non-redundant floor-wall connection	A1.4.3
A-03	Slab-column joint(s) with high shear demand	A1.4.4
A-04	*URM* elements contributing significantly to vertical or lateral stability	A1.4.5



Connectivity of wall segments

Connectivity of side core



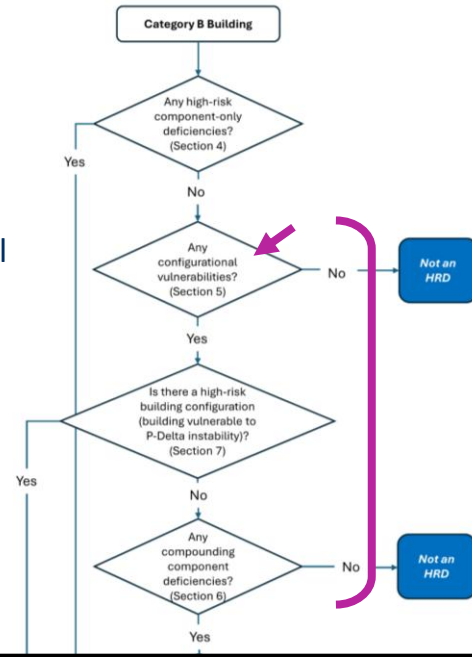
39

HRD Review Process

Compounding component and configurational vulnerabilities

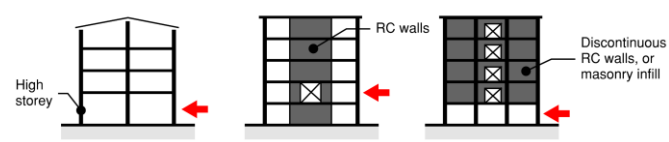
First, identify if one or more configurational vulnerabilities are present

- Defined in Annex 1, Section 5
  - Overall weak LFRS (CWI ≤ 0.15%)
  - Severe torsional sensitivity
  - Weak storey
  - Storey-sway potential
  - Slender LFRS w/ poor founding
  - Discontinuous wall or braced frame



40

HRD Review Process



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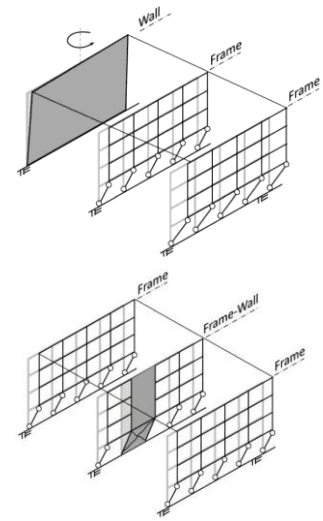
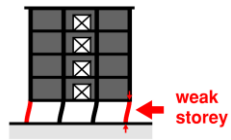


41

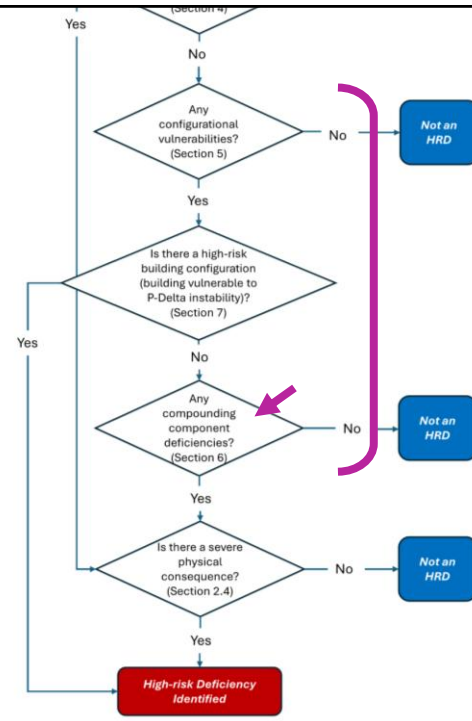
HRD Review Process

Compounding component and configurational vulnerabilities

- Configurational deficiency?
- Any *vulnerable component(s)* affected by the configurational deficiency?
  - For example:



- If so, is there a severe physical consequence?

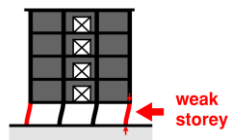


42

HRD Review Process

Compounding component and configurational vulnerabilities

- Configurational deficiency?
- Any *vulnerable component(s)* affected by the configurational deficiency?
  - For example:



- If so, is there a severe physical consequence?

Compounding Configurational and Component Deficiencies [2]
(both must be present to be an HRD)

	Configurational Vulnerability	Ref.	Component vulnerability [1]	Ref.
B-01	Overall weak *vertical LFRS*	A1.5.2	Vulnerable column	A1.6.2
B-02			Vulnerable beam column joint	A1.6.4
B-03			Vulnerable slab-column joint	A1.6.5
B-04			*Wall pier* vulnerable to axial failure	A1.6.8
B-05			Wall vulnerable to axial failure	A1.6.6
B-06			Wall vulnerable to lateral strength loss	A1.6.7
C-01	Severe Torsional Sensitivity	A1.5.3	Vulnerable column	A1.6.2
C-02			Vulnerable beam column joint	A1.6.4
C-03			Vulnerable slab-column joint	A1.6.5
C-04			*Wall pier* vulnerable to axial failure	A1.6.8
C-05			Wall vulnerable to axial failure	A1.6.6
C-06			Wall vulnerable to lateral strength loss	A1.6.7
D-01	*Weak storey* (soft or *weak storey* vertical irregularity)	A1.5.4	Vulnerable column	A1.6.2
D-02			Vulnerable beam column joint	A1.6.4
D-03			Vulnerable slab-column joint	A1.6.5
D-04			*Wall pier* vulnerable to axial failure	A1.6.8
E-01	*Storey-sway potential*	A1.5.5	Vulnerable column	A1.6.2
E-02			Vulnerable beam column joint	A1.6.4
E-03			Vulnerable slab-column joint	A1.6.5
E-04			*Wall pier* vulnerable to axial failure	A1.6.8

43

HRD Review Process

High-risk building configuration

Exceptionally weak frame (vulnerable to P-Delta instability)

Applies to frames with:

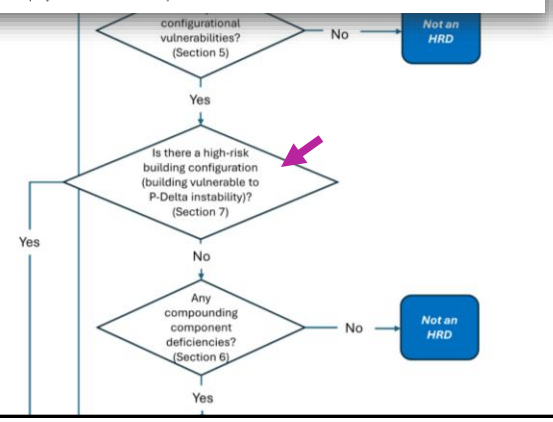
- Weak storey (or storey-sway potential); **and,**
- CWI < 0.08% or TSI > 0.8 (i.e. exceptionally weak or torsional)

F-01	Slender *vertical LFRS* with poor founding conditions	A1.5.6	Vulnerable column	A1.6.2
F-02			Vulnerable beam column joint	A1.6.4
F-03			Vulnerable slab-column joint	A1.6.5
G-01	Discontinuous wall or braced frame (horizontal offset or vertical discontinuity irregularity)	A1.5.7	A supporting column, pier or wall overlap with excessive axial demand.	A1.6.3
G-02			A supporting column or pier vulnerable to drift-induced axial failure.	A1.6.2-A1.6.3
High-risk building Configurations				
H-01	Exceptionally weak frames (vulnerable to P-Delta instability)			A1.7.2

Notes:

[1] Applies only to components that are within the influence of the configurational vulnerability.

[2] For compounding configurational and component deficiencies, the component deficiency can only classify as an *HRD* where the compounding configurational vulnerability listed alongside *also* exists, and would amplify demands on the component.



44

Templates to guide this process

Table 9: Example Only - Component-only deficiencies

Component Deficiency					Severe Physical Consequence				HRD Identified?	
Component deficiency	Criteria		Y/N	Comment	Criteria	Value	Y/N	Comment	Y/N	HRD ID
Columns with exceptionally high axial load		$\frac{N_G}{A_g f'_c} > 0.4$	☒	Example only	Loss of support of significant area of heavy floor		☒	Example only	☒	A-01
Vulnerable and non-redundant floor-wall (or braced frame) connection	At significant transfer diaphragm(s)	Significant transfer diaphragm *And,* Non-ductile floor reinforcing at critical section, or low connectivity (<50% L_w) *And,* Absence of integral (continuously reinforced) collector beam	☐ ☐ ☐		*Column wall index* CWI excluding all such walls[2] ≤ 0.15% Or *Torsional strength index* TSI excluding any single such bracing element or wall assemblage[2] ≥ 0.8	State value (%) or "*not computed*" State TSI or "*not computed*"	☐		☐	A-02
	At general Floors	Exterior walls or side core *And,* Non-ductile floor reinforcing at critical section, or low connectivity to floor slab (<50% L_w for wall segments, <50% p_{wall} for *side-core*) *And,* Absence of integral (continuously reinforced) collector beam sufficiently restrained to floor plate	☒ ☐ ☐	Example only	*Column wall index* CWI excluding exterior walls[2] ≤ 0.15% Or *Torsional strength index* TSI excluding any single exterior bracing element or wall assemblage[2] ≥ 0.8	State value (%) or "*not computed*" State TSI or "*not computed*"	☐ ☐			
Slab-column joint(s) with high shear demand	Where joints contribute significant lateral resistance [1]	For any joints, where $V_g/V_p > 0.4$ Absence of continuous bottom reinforcement in each direction meeting: $A_{s,bottom} > 0.6\,V_g/f_y$ And, $V_g/V_p > 0.2$	☐ ☐ ☐		Where joints contribute significant lateral resistance[1]		☐		☐	A-03
	Any slab-column joint	Absence of continuous bottom reinforcement in each direction meeting: $A_{s,bottom} > 0.6\,V_g/f_y$ And,	☐		Loss of support of significant area of heavy floor		☐			

45

Templates to guide this process

Table 10: Example Only - Configurational vulnerabilities

Configurational Deficiency	Criteria		Value X	Value Y	Criteria Satisfied?		Comment	Outcome
Overall Weak LFRS	*Column Wall Index* CWI ≤ 0.15%		0.23%	0.21%	☐	☐ B_	Example only	ny configurational vulnerability has been identified, Go to Table 11
Severe Torsional Sensitivity	*Torsional strength index*, TSI $T_{D}/T_{\square}$>0.4 (in a storey with CWI ≤ 0.30%) *And* *Torsional displacement index*[1], TDI>1.4 *(at vulnerable component)* or for walls, where the majority of lateral and torsional resistance is provided by a single core.		0.13 1.13	0.13 1.18	☐ ☐	☐ C_	Example only	
Weak storey	*Storey strength index* < 90% of storey over[2] *And* *Column Wall Index* CWI ≤ 0.30% in the storey (and direction) under consideration		≥100% 0.23%	≥100% 0.21%	☐ ☒	☐ D_	Example only	
Storey-sway potential	Either of the following identified *(in conjunction with low CWI, as defined below)*	Identified based on comparison of storey-sway and beam/mixed sway mechanism strengths; or, Identified based on the sway index method for frames	☒ ☐	☐ ☐	☒	☒ E_	Example only	
	Column Wall Index CWI ≤ 0.30% in the storey (and direction) under consideration[5].		0.23%	0.21%	☒			
Slender vertical LFRS with poor founding conditions	One of the following structural types that are vulnerable to differential settlement or tilting effects *(in conjunction with poor founding conditions, as defined below)*	Buildings with isolated shallow foundations under frame columns[3] *And* Overall aspect ratio[4] H/B > 1.5 More than 60% lateral resistance (based on CWI) is from isolated bracing elements (cantilevered wall, core or braced frame). *And* Overall aspect ratio[4] of lateral system is H/B > 2.0 *And* Potentially vulnerable frame components are founded on separate footings	State H/B value *(or n/a)* State H/B value *(or n/a)*	... ...	☐ ☐ ☐ ☐ ☐ ☐	☐ ☐	☐ F_	
	Poor founding conditions should be assumed for NZS 1170.5:2004 site subsoil class is C, D or E, but does not include situations where the lateral system piles extend to found on rock. *Poor founding conditions* need not apply where specific foundation assessment information		NZS 1170.5:2004 Site Class C		☒	☒	Example only	

46

Templates to guide this process

Table 11: Example Only - Compounding component and configurational deficiencies (columns, joints and wall piers)

Component Deficiency								Severe Physical Consequence			HRD Identified ?
					Component Vulnerability						
Component Deficiency	Criteria		Y/N	Comment	Vuln. to Axial (Gravity) Failure	Vuln. to Loss in Lateral strength	Affected by config. vulnerability?	Criteria	Y/N	Comment	
Vulnerable column(s) (For columns supporting discontinuous walls, use $N^*_{\square}$ instead of $N_{\square}$)	Shear-limited(s): $V_r/V_{\square Colb}$≥0.7	Any shear-limited column	☒	Example only		☒	☐ B_ *Overall weak LFRS* ☐ C_ Severe tors. sens. ☐ D_ *Weak storey* ☒ E_ *Storey-sway potential* ☐ F_ *Slender LFRS w/ poor founding* ☐ G_ *Disc. Wall/Braced Frame (in conjunction with B, D or E)*	Loss of support of significant area of heavy floor *Or* Loss of significant proportion of lateral building stability	☒ ☐	Example only	☐ B-01 ☐ C-01 ☐ D-01 ☒ E-01 ☐ F-01 ☐ G-02
		$\frac{N_G}{A_g \alpha_{v,col} \rho_t f_{yt}} > 5$	☒	Example only	☒						
	Any column	$\frac{N_G}{A_g f'_c} > 0.2$ *And,* *lightly confined*, meaning either: Tie spacing, s > h/2, *or* $\rho_t < 0.2\%$, or $A_g/A_{\square} > 1.5$	☐ ☐ ☐ ☐		☐						
Vulnerable beam-column joint(s)	Ext. joints vulnerable to shear failure	Hoop spacing > $h_{\square}$ / 2 *Or* Joint aspect ratio $h_{\square}$ / $h_{\square}$ >1 and *poor hook anchorage*[1]	☐ ☐			☐	☐ B_ *Overall weak LFRS* ☐ C_ Severe tors. sens. ☐ D_ *Weak storey* ☐ E_ *Storey-sway potential* ☐ F_ *Slender LFRS w/ poor founding*	Loss of support of significant area of heavy floor *Or* Loss of significant proportion of lateral building stability	☐ ☐		☐ B-02 ☐ C-02 ☐ D-02 ☐ E-02 ☐ F-02
	Ext. joints vulnerable to axial failure	Vulnerable to shear failure (as above), also having both $\frac{N_G}{A_j f'_c} > 0.3$ *And* lightly confined[1].	☐ ☐ ☐		☐						
	Absence of continuous bottom reinforcing in each direction passing		☐				☐ B_ *Overall weak LFRS* ☐ C_ Severe tors. sens.				☐ B-03

47

Templates to guide this process

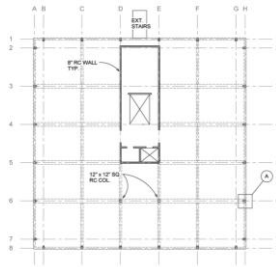
Table 12: Example Only - High-risk configurational deficiencies (exceptionally weak frames susceptible to P-Delta instability)

Configurational Deficiency									Severe Physical Consequence	HRD Identified?
	Susceptibility to P-Delta					Configurational Vulnerability				
	Criteria		Value	Y/N	Comment	Criteria *(See Table 10)*		Comment		
Exceptionally weak frames susceptible to P-Delta instability	Either of the following in storeys affected by weak storey or storey-sway potential *(in the direction under consideration)*	Exceptionally weak frames: *Column wall index* ≤ 0.08%	X Dir: _ Y Dir: _	☐ ☐	☐ Examples only	Frames having either of the following: (in the direction under consideration)	☐ D_ *Weak storey* ☒ E_ *Storey-sway potential*	Example only	A severe physical consequence (lateral sway failure) is deemed to exist if this configuration is identified.	☐ H-01
		Severe torsional sensitivity: *Torsional strength index* T_{Di}/T_{Ci} > 0.8	X Dir: _ Y Dir: _	☐ ☐						

48

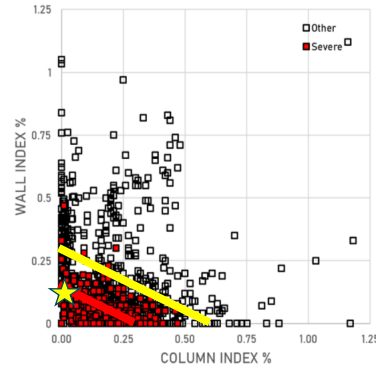
PGC









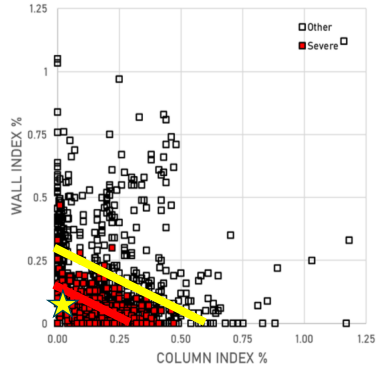


HRDs Identified		
	B-01 B-02	**Overall weak building, with vulnerable columns and beam-column joints**
	B-05 B-06	**Overall weak building, with walls vulnerable to axial failure** Multiplanar wall vulnerable to axial instability failure. Also vulnerable to lateral failure due to light vertical reinforcement.

49

CTV







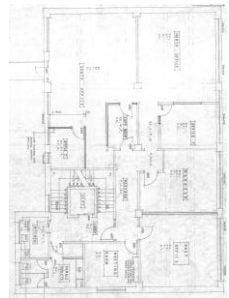


HRDs Identified	**A-02**	**Non-redundant and inadequate floor-wall collectors** Poor connectivity to northern core. South wall also vulnerable (mesh floors and collector beam not restrained to floor plate).
	B-01 **C-01**	**Severely torsionally sensitive building (E-W) and overall weak (N-S), with columns vulnerable to axial failure** Columns have high axial load ratios, very low confinement, and flexure shear-limited
	B-05 **C-05**	**Severely torsionally sensitive building (E-W) and overall weak (N-S), with walls vulnerable to axial failure** Orange as not calculated in full. Several north wall segments likely to be vulnerable.

50

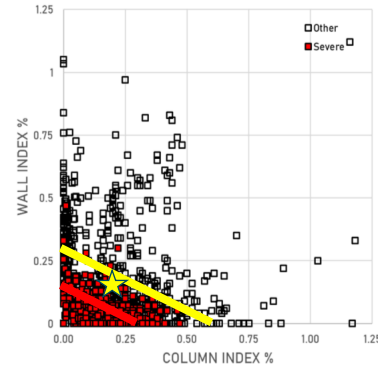
TVNZ











HRDs Identified	-	**None**

51

What's involved in an HRD review?

Predominantly based on building features

- Geometric info uplifted for CWI and TSI/TDI
- Estimate gravity loads on components, uplift detailing, section analysis.
- Structural analysis? Possibly, but limited/simplified.
  - Could be convenient for estimating N_G (instead of hand methods)
  - In some cases, EQ action needed (*benchmark seismic hazard*)
  - Help test for *severe physical consequence*, if not obvious.
- If there is an existing assessment, much of the necessary information will be readily available.

…all depending on how far you need to go before ruling out HRDs.

52



Reminding the situations in which an HRD review might take place…

Existing EPBs after 1 July 2027:	New EPBs in coastal Otago (prior to 1 July 2032):	New EPBs after statutory timeframes:

• For an existing EPB that is Category B
  • *Can choose to undertake HRD review to validate EPB status at any time (prior to remediation deadline)*
	• Identify if building is Category B1 (pre-76)
	  • *Similar to current identify process*
	• Validate: Owner has 12 months to provide HRD review
		• If Category B1 was missed during statutory timeframes
		• If Category B2 building (**with HRD**) is brought to attention of TA
		→ *Needs MBIE approval*

53

Residual Risks

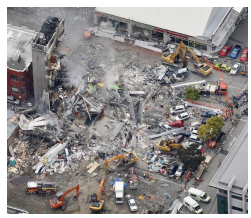
…some notable examples

Not included in HRDs:

- Secondary and non-structural elements (where they previously required addressing as a *significant life safety hazard*)
- Potentially vulnerable precast floor and diaphragm configurations
- Most structural steel issues
- Heavy facades (e.g. precast panels) with high exposure to people
- Lack of load path

54

Outcomes expected to classify as HRDs








55

Outcomes not intended to qualify as HRDs



56

BUILDING PERFORMANCE

Remediating Category B Buildings

Targeted Retrofit



MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

New Zealand Government
Te Kāwanatanga o Aotearoa

57

Targeted Retrofit

(b) a **targeted retrofit**, which mitigates the risk of injury or death posed by an earthquake causing a building to fully or partially collapse by requiring the building's owner to carry out seismic work on or in relation to some or all of the structural deficiencies of the building that give rise to that risk.

High-Risk Deficiencies



Targeted retrofit must mitigate the collapse hazards associated with HRDs

Targeted retrofit for Category B buildings is not required to address other hazards not associated with HRDs.

An HRD review is a pre-requisite to remediation of Category B building that is EPB

- If no HRD review yet available, it is the first step



58

Targeted Retrofit: Pathways

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 *vulnerable component(s)*, 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 *HRDs*, each by following either of the following pathways		
A	Address the *HRD* as part of retrofit	Address the *HRD* by complying with Table 7 (A2.5.4.5); and, Validate that the capacity of *vulnerable component(s)* (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 *vulnerable component(s)* are sufficiently protected	Demonstrate that the capacity of *vulnerable component(s)* (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).

59

Targeted Retrofit

Performance

- Scope boundary for targeted retrofit
  - Limited to remediating the HRD to the required performance
  - But avoid introducing new vulnerabilities
- Earthquake demands (one third of *benchmark seismic hazard*)
- Capacity of existing, retrofitted and new elements
  - By reference to assessment guidelines (Part C)
  - Risk Factor F_R applies (unless HRD fully addressed)

60

Targeted Retrofit: Pathways

Explained by way of analogy (not a Category A/B building!):

If remediating a hazardous chimney, one could:

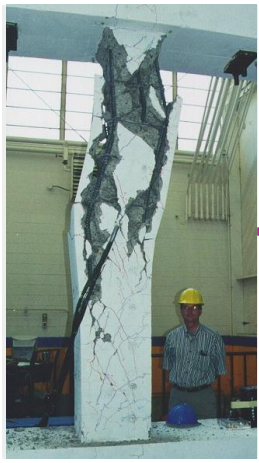
- **Remove** the chimney
  - Fully address the issue!
- **Strengthen** the chimney
  - Must define performance required (demand, capacity)

Not an EPB!



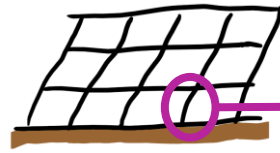
61

Targeted Retrofit: Pathways



A

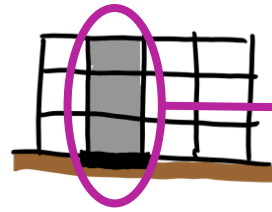
Enhance the ductility of columns so they can tolerate high building movements.
Addresses the high-risk feature





B

Strengthen the building so that the building doesn't move as much
columns are still vulnerable





62

Why two pathways?

A technical reason, and a practical reason

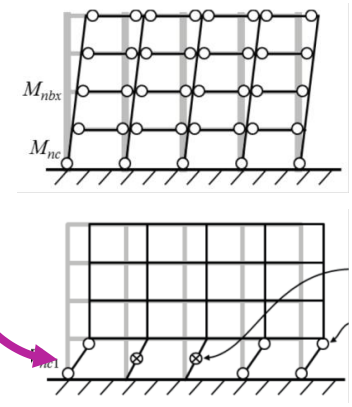
- Account for higher-risk, if the high-risk feature not fully addressed
- Retrofitting existing buildings is complex, extensive technical guidelines can be overwhelming
  - Clear focus on the deficiency improves chance of effective retrofit

63

Accounting for higher risk in Pathway B

Why an adjustment is required

- The high-risk feature is retained: most are a combination of
  - Vulnerable building element
  - A building feature which amplifies demand
- Actual collapse risk is higher in these cases (for the same calculated capacity), and is significant
  - Therefore, an adjustment is required when calculating the capacity of these elements

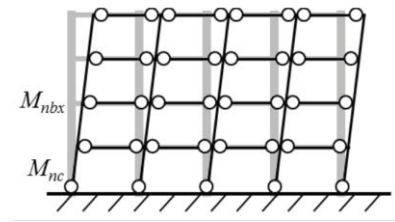


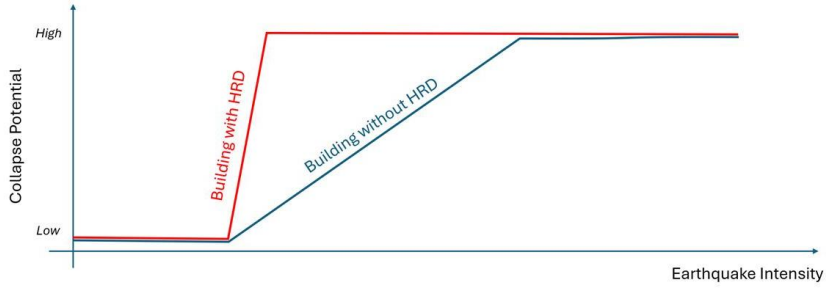
64

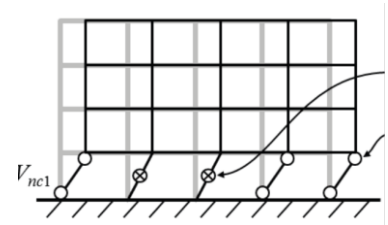
Accounting for higher risk in Pathway B

Why an adjustment (F_R) is required for B

- The high-risk feature is retained:
- Actual collapse risk is higher in these cases (for the same calculated capacity), and is significant





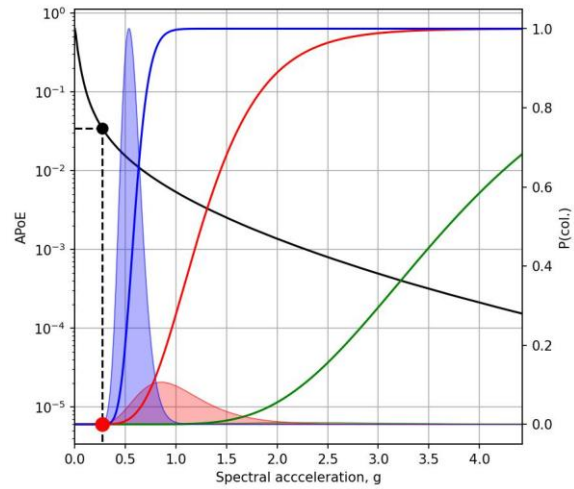


65

Accounting for HRD brittle failure modes

- Collapse risk for modern building →
- Minimum tolerable collapse risk for existing building →
- Collapse risk for HRD building →
  - Significantly higher than minimum acceptable risk

How to retrofit to achieve "minimum acceptable risk"?



66

Retrofit options

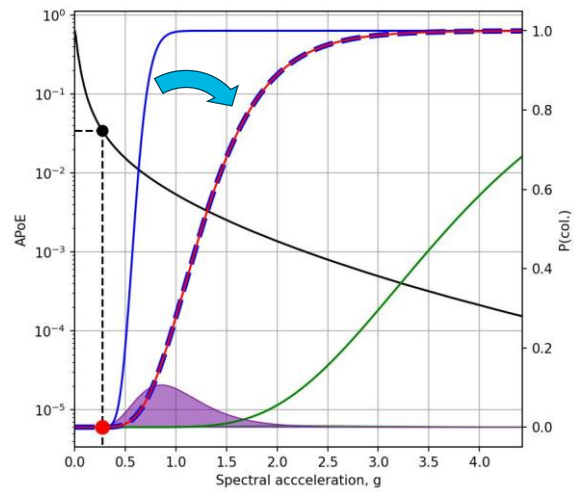
How to retrofit to achieve "minimum acceptable risk"?

A - Remove HRD (brittle modes)

→ i.e. Flatten the fragility



Keller et al. (2026)



67

Retrofit options

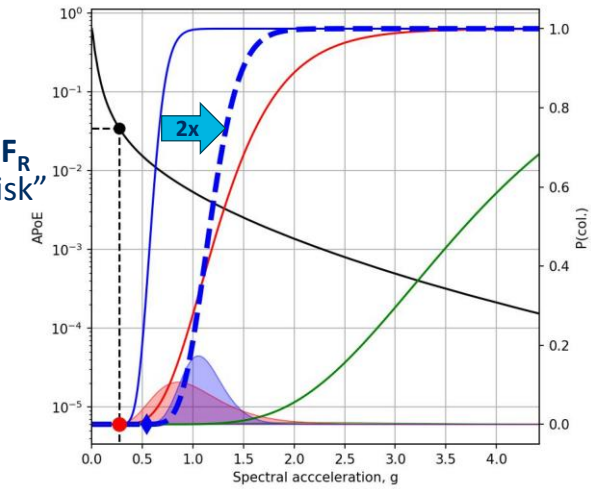
How to retrofit to achieve "minimum acceptable risk"?

B - Reduce the drift

→ i.e. Shift the fragility by **risk factor F_R** to achieve "minimum acceptable risk"



Barker Hall (UCB) (PEER 2006/01)



68

Precedent example

San Francisco SFEBC (2025)

One of the most rece
Californian ordinance

- Similar two pathwa
  - Slightly different
    (still all-of-buildir
- They have put mos
  the practical outco
  introducing this sp

Standards for (voluntary) retrofit of Concrete buildings

SFEBC Appendix A6

Requirements	Relative level
Option (a) Structural Collapse Prevention at the BSE-1E level (225-year earthquake motions), **AND** eliminate specific deficiencies (or show they do not exist)	Approximately 54%(+) of BPOE structural objective (plus deficiency check)

Advantages of providing options

- **Retrofit efficiency.** Two options improves the chances of an efficient retrofit. Expect most engineers will consider both options and do the less expensive one.
- **Retrofit effectiveness.** Option (a) starts with a focus on deficiencies. ASCE 41 can be a learning curve (615 pages) for engineers who are not familiar with it; starting with a focus on deficiencies improves the chances of an effective retrofit.



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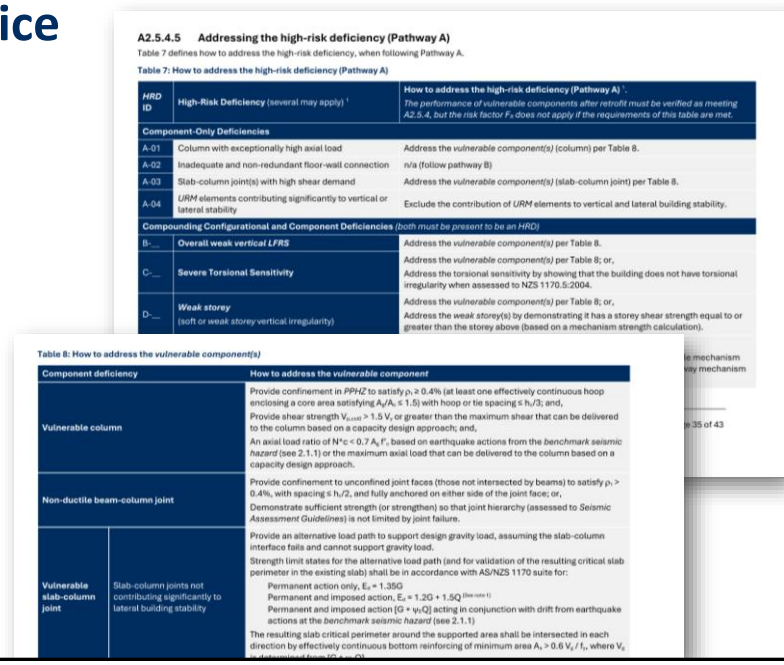
69

Pathway A in practice

Annex 2 stipulates how to address the HRD…



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]. *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.*
Component-Only Deficiencies		
A-01	Column with exceptionally high axial load	Address the *vulnerable component(s)* (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 *vulnerable component(s)* (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 *vulnerable component(s)* per Table 8.
C-__	**Severe Torsional Sensitivity**	Address the *vulnerable component(s)* 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 *weak storey* vertical irregularity)	Address the *vulnerable component(s)* per Table 8; or, Address the *weak storey*(s) by demonstrating it has a storey shear strength equal to or greater than the storey above (based on a mechanism strength calculation).

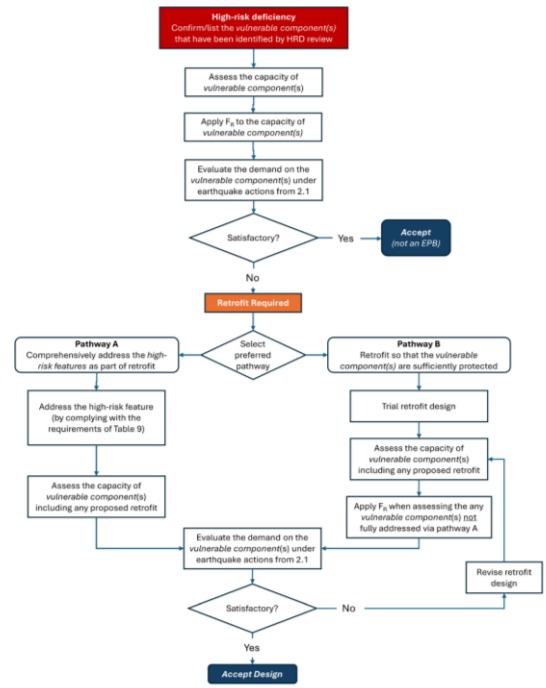
Table 8: How to address the *vulnerable component(s)*

Component deficiency		How to address the *vulnerable component*
Vulnerable column		Provide confinement in *PPHZ* to satisfy $\rho_s \geq 0.4\%$ (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 $V_{n,exist} > 1.5\,V_e$ 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 *benchmark seismic hazard* (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 $\rho_s > 0.4\%$, 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 *Seismic Assessment Guidelines*) 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 $[G + \psi_2 Q]$ acting in conjunction with drift from earthquake actions at the *benchmark seismic hazard* (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 $A_s > 0.6\,V_e / f_y$, where V_e

70

Process Overview…

Meeting EPB requirements for Category B Buildings:



71

BUILDING PERFORMANCE

Category B Buildings in Summary

HRD Reviews, and Targeted Retrofit



MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

New Zealand Government
Te Kāwanatanga o Aotearoa

72

A simpler, risk-informed tool to validate status of Category B EPBs…

Significant change in focus

- For Category B buildings currently on the EPB register:
  - Can undertake HRD review to confirm if they need to remain EPB
  - Draw on existing assessment information, if present
- For other buildings not yet identified:
  - HRD review offers a simpler, more risk-focused identification tool
- For buildings that do not have HRDs, and are confirmed as non-EPB
  - Owner decides whether/how to manage residual risk

73

A new philosophy to get used to

Altered risk settings, and some new tools/terminology (for EPB)…

…But otherwise?



Where to focus (HRDs)
Defines scope of remediation and performance required



Incorporated by reference, remain the engineering basis to prove out retrofitted performance
(Note the version referencing in Annexes, and expect a new front cover!)

Retrofit guidelines and case examples

In preparation

Guidelines to aid/clarify application

74

Additional Engineering Documents

Incorporated by reference in Methodology Annex

- Seismic Assessment Guidelines — **Consultation in Q1-Q2 2027**
  - Used within HRD review and retrofit design
- Standardised Securing Handbook — **Consultation in Q1-Q2 2027**
  - Used for Standardised Securing of 1-2 storey URM

Guidance Documents

- Retrofit Guidance and Case Studies
  - Section 112 and 115 retrofit guidance
  - SED guidance for Façade Risk Mitigation and Targeted Retrofit
  - EPB retrofit case studies
- Retrofit Techniques for Concrete Buildings (to be published by BRiDGE)

75

Consultation: what we need from you

REAL BUILDINGS
REAL SITUATIONS

Help us test how the methodology will work in practice.

1 Is it clear?
Can you follow the methodology and understand the role of the engineer?

2 Is it workable?
Can the requirements be applied consistently to real buildings and sites?

3 Are there gaps?
Are any building types, configurations or scenarios unclear or missing?

4 Is the scope of retrofit clear?
Does it provide enough information to support implementation of cost-effective retrofits?

Test the drafts against your experience

EPB GUIDANCE	ANNEX ONE - HRDs	ANNEX TWO - REMEDIATION REQUIREMENTS
Building classification	High-Risk Deficiencies Definitions	Retrofit scope
Façade Definitions	Component Vulnerabilities	Façade Risk Mitigation
Storey Definitions	Configurational Vulnerabilities	Targeted Retrofit (URM)
Public spaces	Severe Physical Consequence Test	Targeted Retrofit (Heavy)
Setbacks		

BRING US THE DIFFICULT EXAMPLES — **Tell us what is unclear, what scenario causes the difficulty, and what would make the methodology easier to apply consistently.**

76

Consultation: what we need from you

How to make a submission

How to provide feedback on the Earthquake-prone buildings methodology guidance

All interested parties are invited to provide feedback on any part of the proposed EPB methodology and guidance using the submission form below and email it to building@mbie.govt.nz by Friday 4 December at 5pm.

Submission form - EPB Legislation and Methodology and Guidance Consultation [DOCX, 179KB]

How to provide feedback on the Earthquake-prone buildings technical annexes

While the EPB annexes are mostly intended to support engineers with providing advice and designing solutions for earthquake-prone buildings, all interested parties are invited to provide feedback on any part of the proposed annexes and the high-risk deficiencies (HRD) review template. Submitters may either use the submission form below for general feedback, or download the spreadsheet to provide more detailed and specific technical feedback, and email it to building@mbie.govt.nz by Friday 4 December at 5pm.

Submission form - EPB Annexes Consultation [DOCX, 172KB]

EPB Annexes Consultation Feedback Spreadsheet [XLSX, 12KB]



77

Questions and Reminders

- Upcoming in-person seminars for engineers:
  - Wellington – 11 Nov
  - Dunedin – 18 Nov
  - Christchurch – 19 Nov
- NZSEE developing FAQs
- Submit comments by 4 Dec!
  - building@mbie.govt.nz
  - NZSEE/SESOC/NZGS also helping to coordinate feedback

Registration for seminars will be available here!

78