Evaluation of Existing Buildings

August 2013

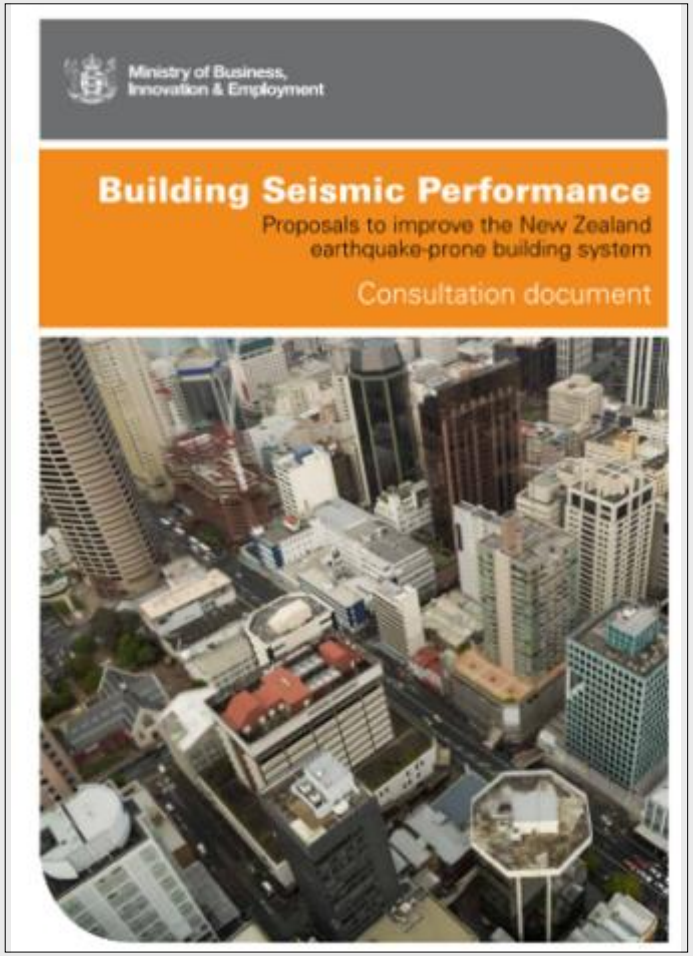
Outline

- Where the EPB legislation is now
- A run through of the SESOC EPB submission, outlining some of the concepts and ideas presented
- A summary of where the NZSEE "Assessment and Improvement of the Performance of Buildings in Earthquake" is headed
- Outcomes of the Royal Commission, with discussion of key points
- Aspects of the building assessment process


Earthquake
Prone
Buildings

NZ Wide – Earthquake Prone Buildings

- Consultation process underway following CERC report
- Dilemma
  - %NBS?
  - Or something else?



Revisions to EPB policy

- MBIE discussion document
  - Submissions closed March 2013
  - Policy announced August 7 2013
  - Law….?

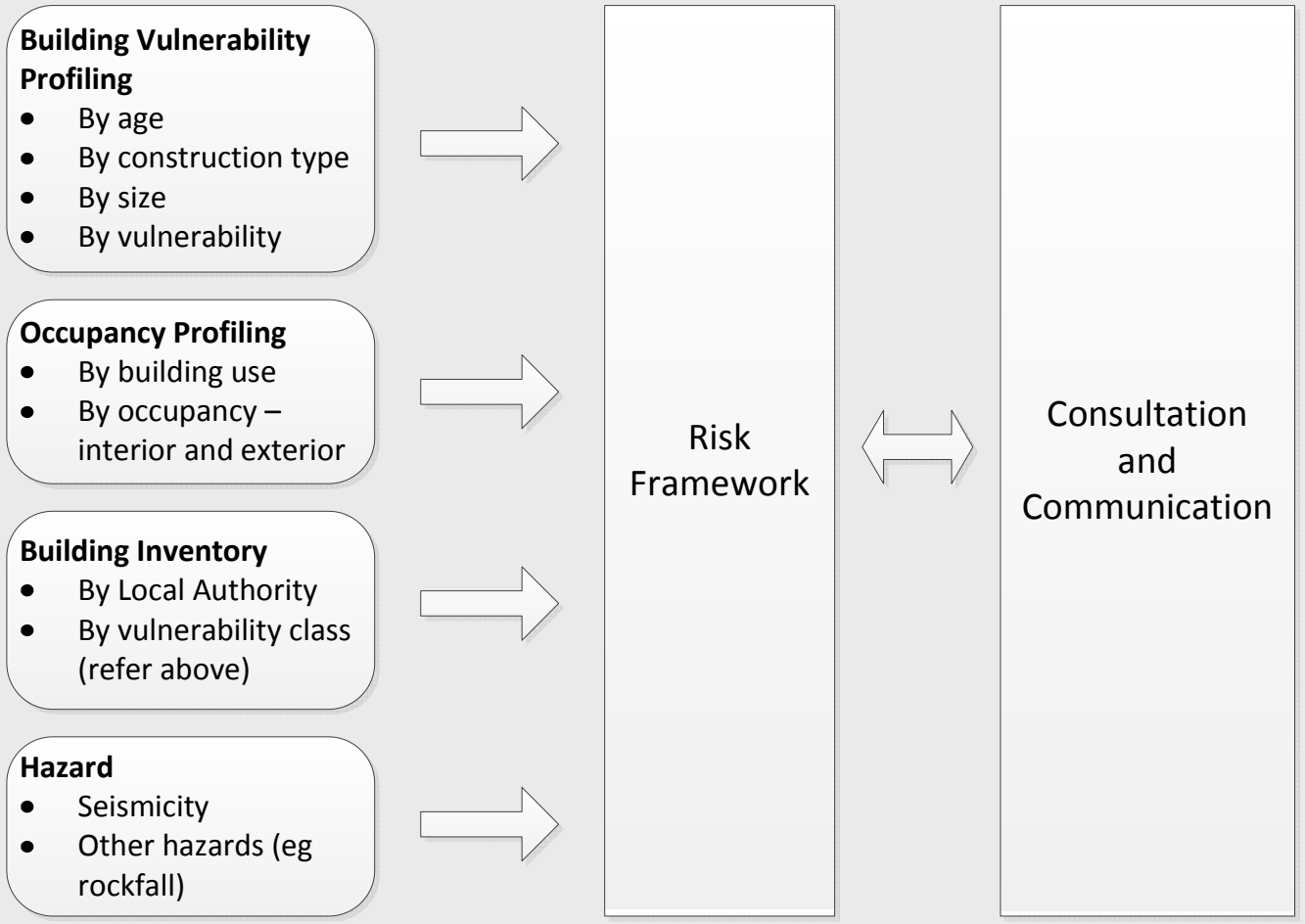
SESOC Summary points

1. Supported the Tony Taig recommendations – to develop a comprehensive Risk Assessment framework.
2. A new definition of EPB is recommended to include high risk buildings not currently considered EPBs
3. Once Risk Assessment process is completed, prioritise

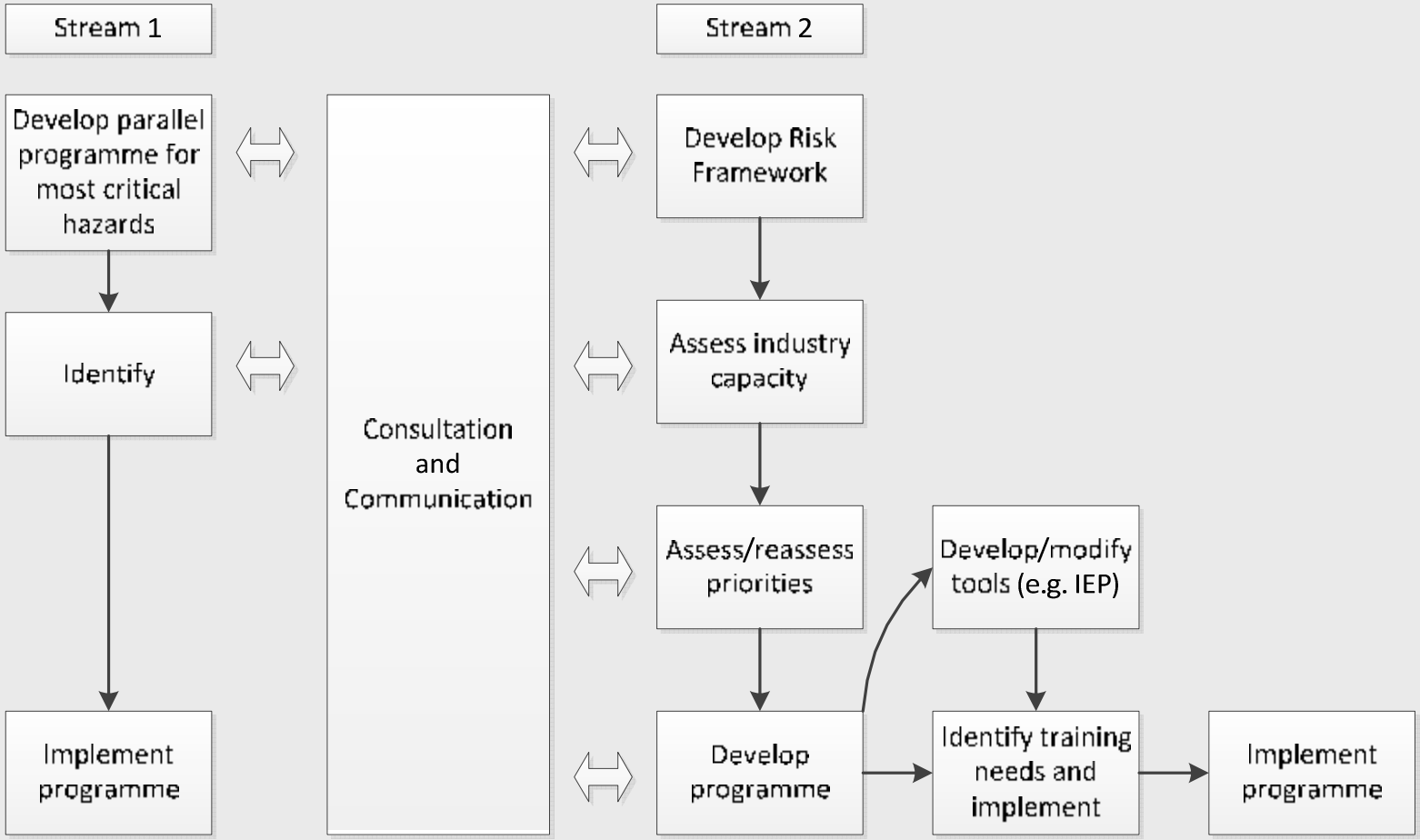
SESOC Summary points

4. MBIE to engage with IPENZ and societies to develop a programme that focuses on most dangerous buildings, and effective risk reduction methods
5. Training and communication critical:
    1. For professionals involved in assessment and retrofit
    2. For public, in understanding and management of risk

Risk Management framework



Proposed programme development



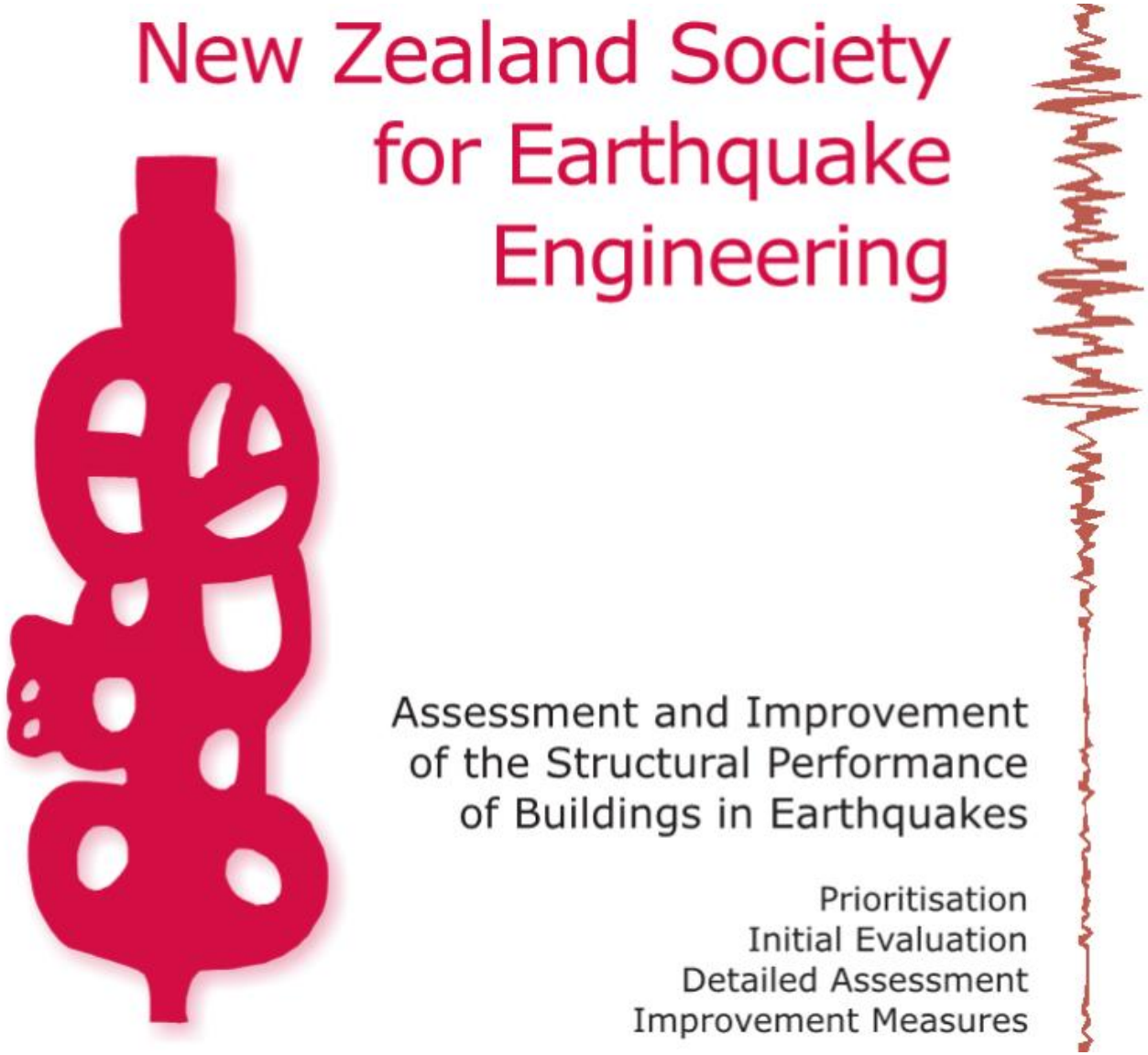
Policy announcement 7 Aug

- 33% NBS still the threshold
- 5 years to complete assessments (TAs)
- Further 15 years to upgrade or demolish
- A national register to be established
- Some buildings to be prioritised
  - Buildings causing significant safety hazard
  - Strategically important buildings
- Low risk buildings may apply for exemptions on timeframe
- Cat 1 historic buildings may get up to 10 years exemption

What Next?

- Detail!!!!
- MBIE still to address buildings with critical vulnerabilities
- MBIE preparing guidelines for building owners and employers on overlap between Building Act and Health & Safety in Employment Act

Red Book Review



Red Book review

- Red Book*
  - Known errors being corrected, to be uploaded to NZSEE website
  - IEP section being updated
  - URM section being re-written to incorporate URM Guidelines
- URM Guidelines#
  - Updated for out-of-plane actions
  - Calibrated to match Red Book
  - Undergoing Peer review and verification
- Future
  - Alignment of Red Book and ASCE41 under consideration

* Assessment and Improvement of the Structural Performance of Buildings in Earthquakes. NZSEE, June 2006

Assessment and Improvement of Unreinforced Masonry Buildings for Earthquake Resistance. NZSEE, Draft 2011

Red Book review

- Governance
  - EQC
  - MBIE
  - NZSEE
  - SESOC
  - WCC

Canterbury Earthquakes Royal Commission

Canterbury Earthquakes Royal Commission (CERC)

- April 2011 – November 2012
- Seven volumes of report, covering:
  - Seismicity and soils
  - Performance of CBD buildings
  - Low damage design technology
  - Earthquake Prone Buildings
  - Summary and recommendations
  - CTV collapse
  - Roles and responsibilities
- 189 Recommendations

Summary

- Existing Buildings
- Communication
- Collaboration
- Compliance
- Design
- Building Safety Evaluation

Existing Buildings

73.	The Ministry of Business, Innovation and Employment should review the New Zealand Society of Earthquake Engineering Recommendations entitled *Assessment and Improvement of the Structural Performance of Buildings in Earthquakes* and, in conjunction with engineering practitioners, establish appropriate practice standards or methods for evaluating existing buildings These practice standards or methods should have regulatory standing, and be monitored by the Ministry of Business, Innovation and Employment for consistency of application
82.	The Building Act 2004 should be amended to require and authorise territorial authorities to ensure completed assessments of all unreinforced masonry buildings within their districts within two years from enactment of the Amendment, and of all other potentially earthquake-prone buildings within five years from enactment.
83.	The legislation should be further amended to require unreinforced masonry buildings to be strengthened to 34% ULS within seven years from enactment of the Amendment and, in the case of all other buildings that are earthquake- prone, within 15 years of enactment.

A Myth – Capacity Matters

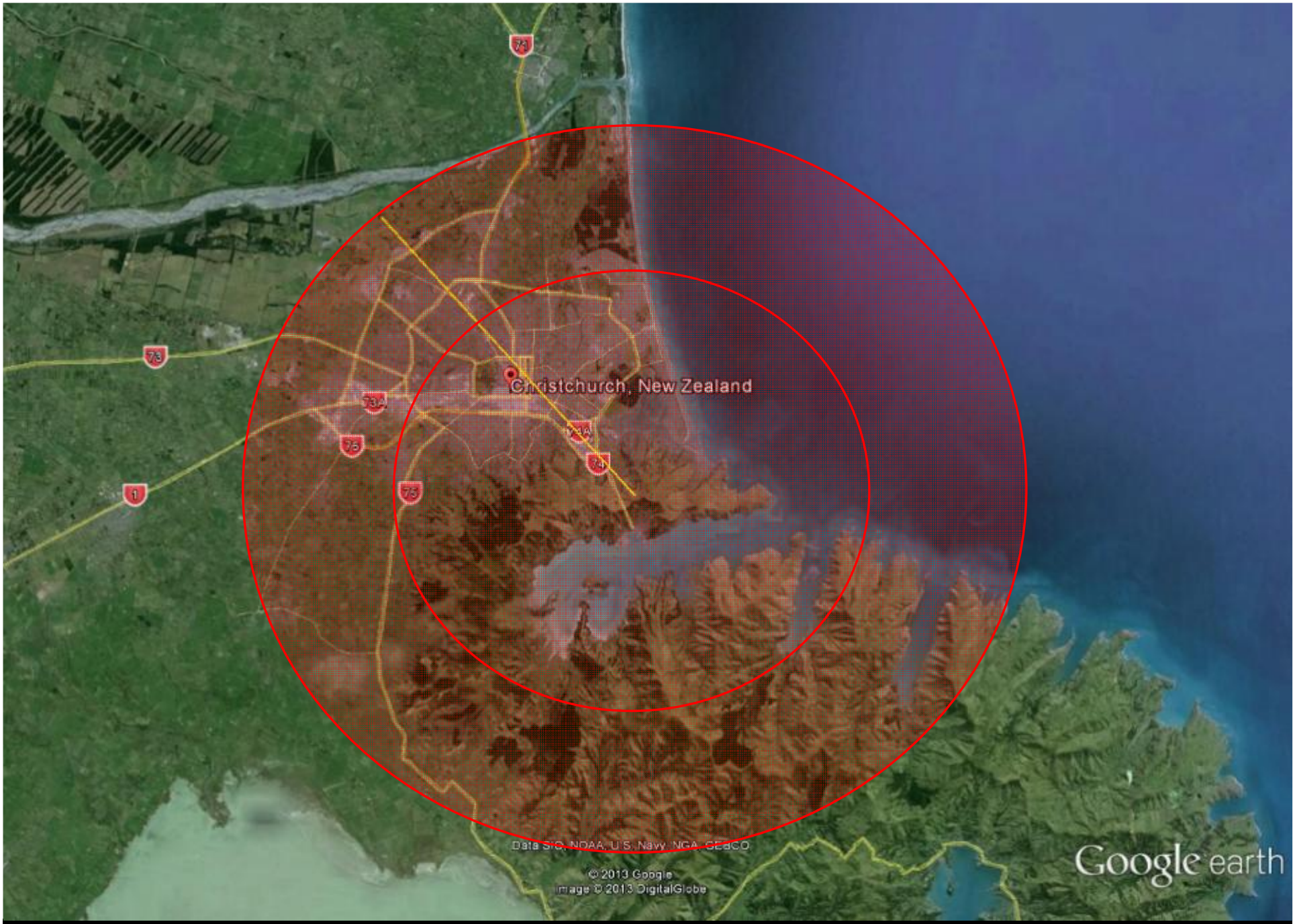
- Current criteria for EPB – 33%NBS
- Is that understood?
- But what causes failure of buildings in earthquake?
  - Refer DEEs and IEPs….
  - Non-EPBs 133 vs. EPBs 42

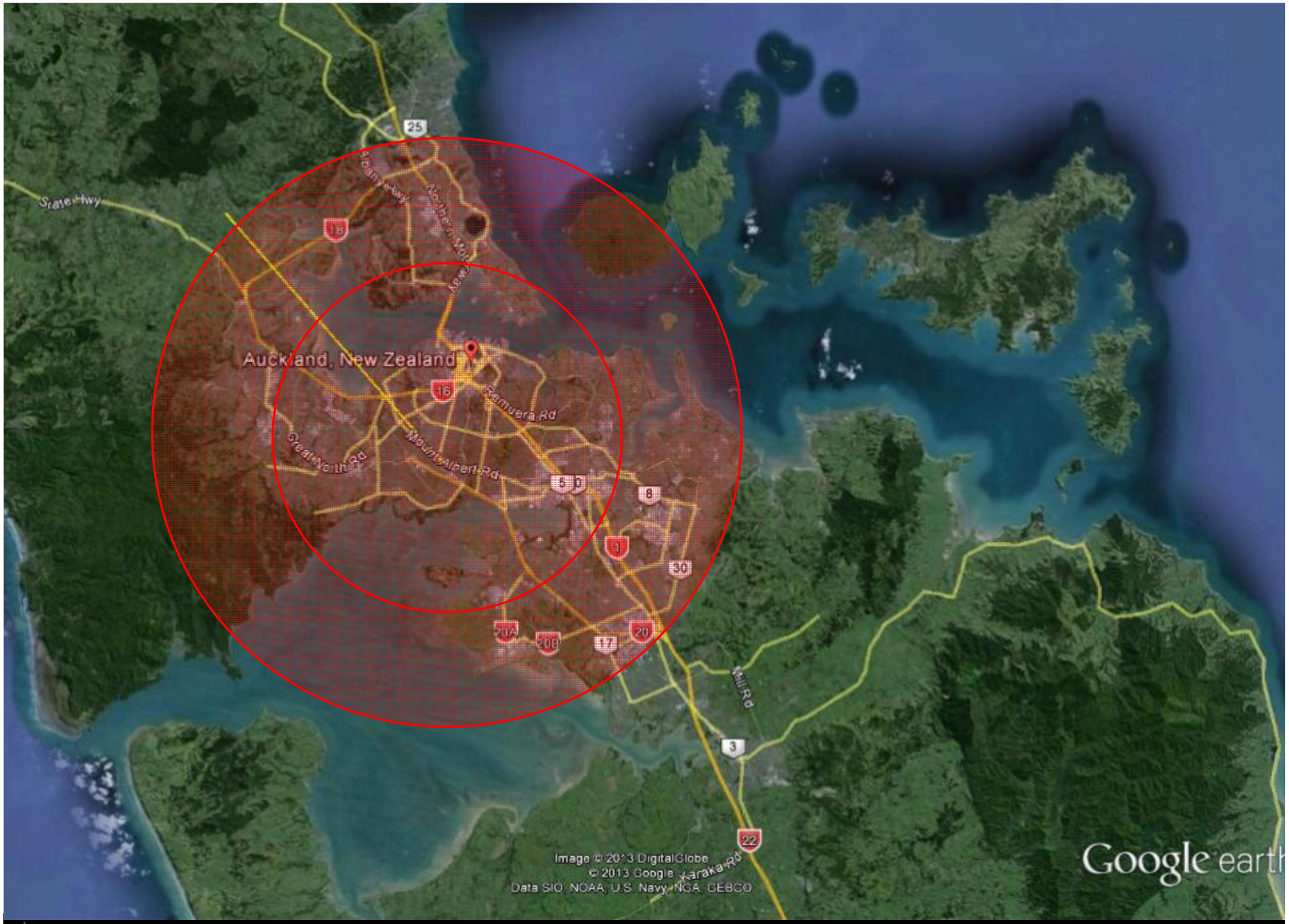
Guess some scores

Guess some scores

What about Auckland?

- NZS1170.5
  - Minimum earthquake design actions: C3.1.4
  - 84%ile shaking from M6.5 at 20km

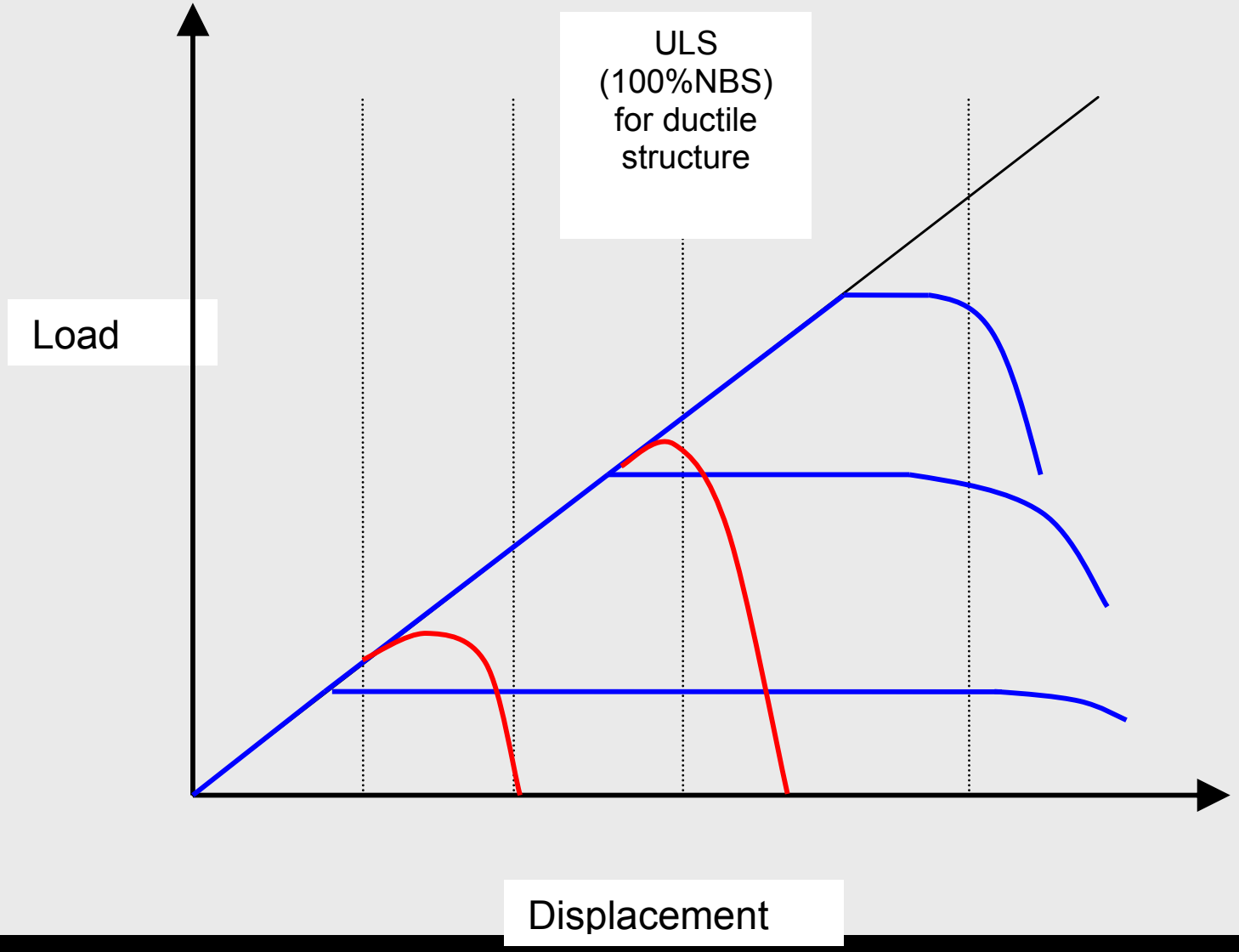

Christchurch, New Zealand
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2013 Google
Image © 2013 DigitalGlobe
Google earth


Auckland, New Zealand
State Hwy
Northern Motorway
Remuera Rd
Great North Rd
Mount Albert Rd
Mill Rd
Karaka Rd
Image © 2013 DigitalGlobe
© 2013 Google
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google earth

SESOC Proposed Definition of EPB

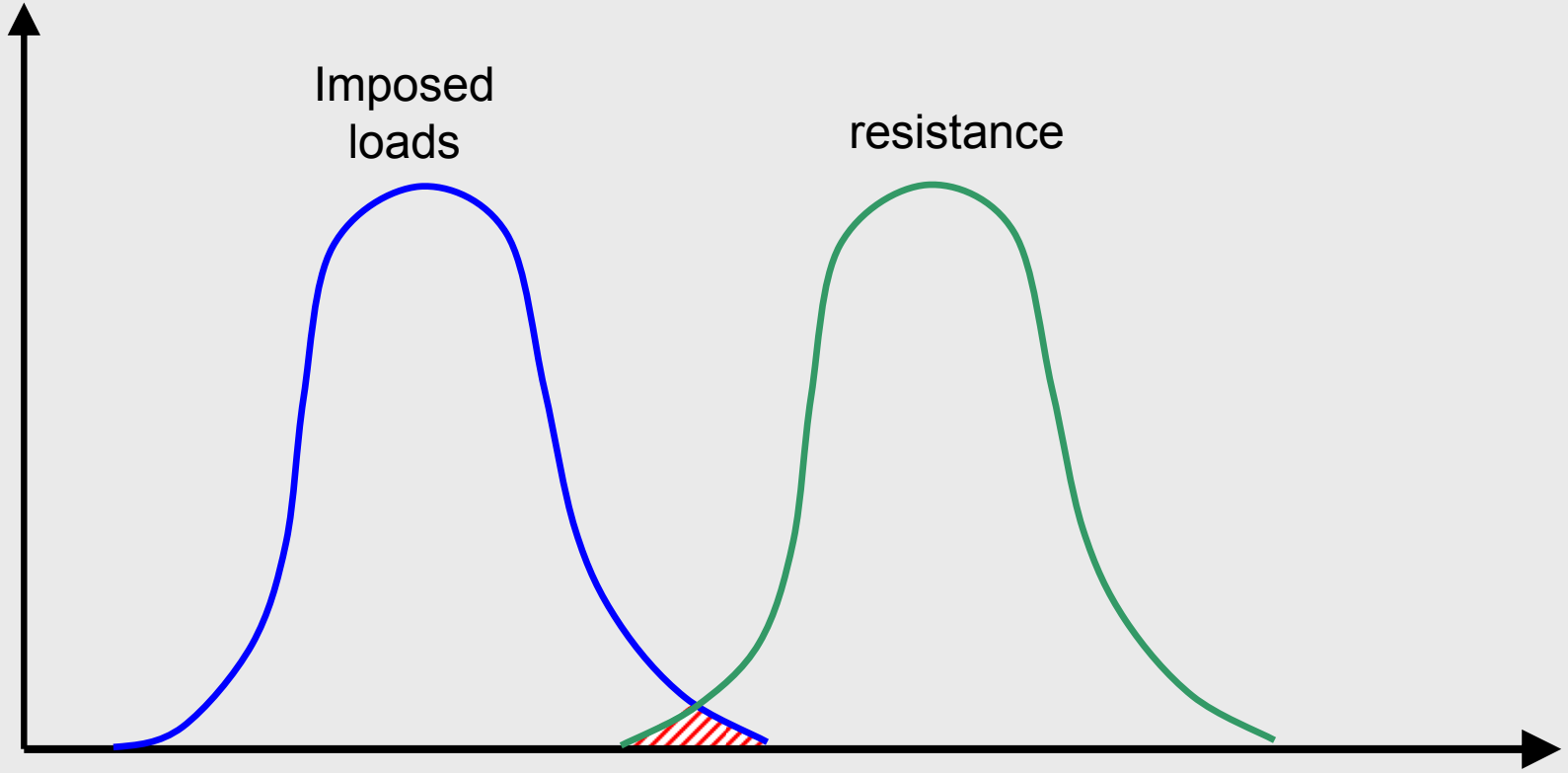
- An earthquake prone building is a building that either:
  - Is likely to have its ultimate capacity exceeded in a moderate earthquake, either wholly or in part, in a way that may lead to death or injury to persons within or outside the property; or
  - Has significant critical vulnerabilities that could result in catastrophic collapse in a major earthquake

Seismic Design 101

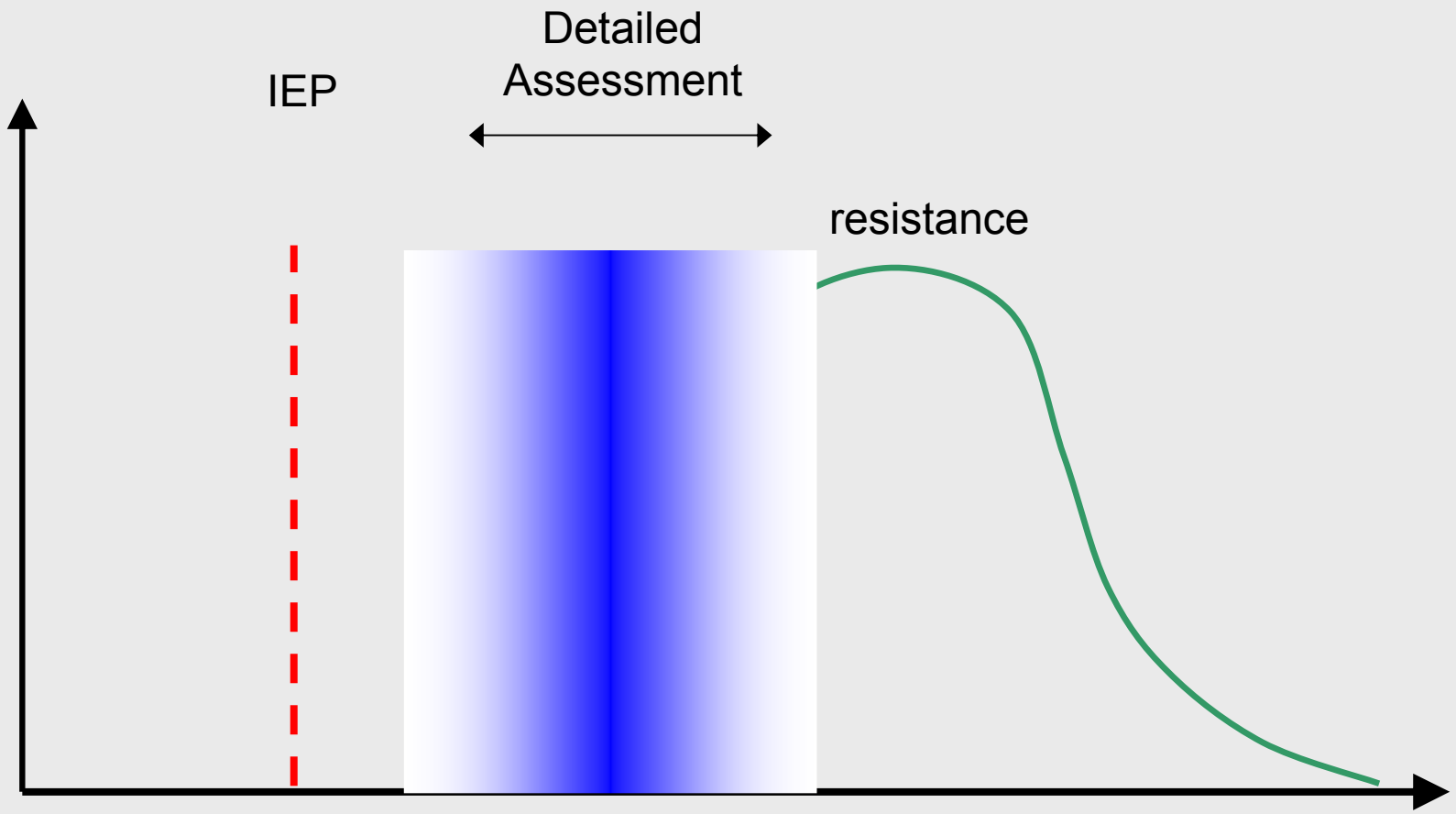


ULS Design (eng 102)

$$S^* \leq \phi S_n$$



Accuracy of Assessment



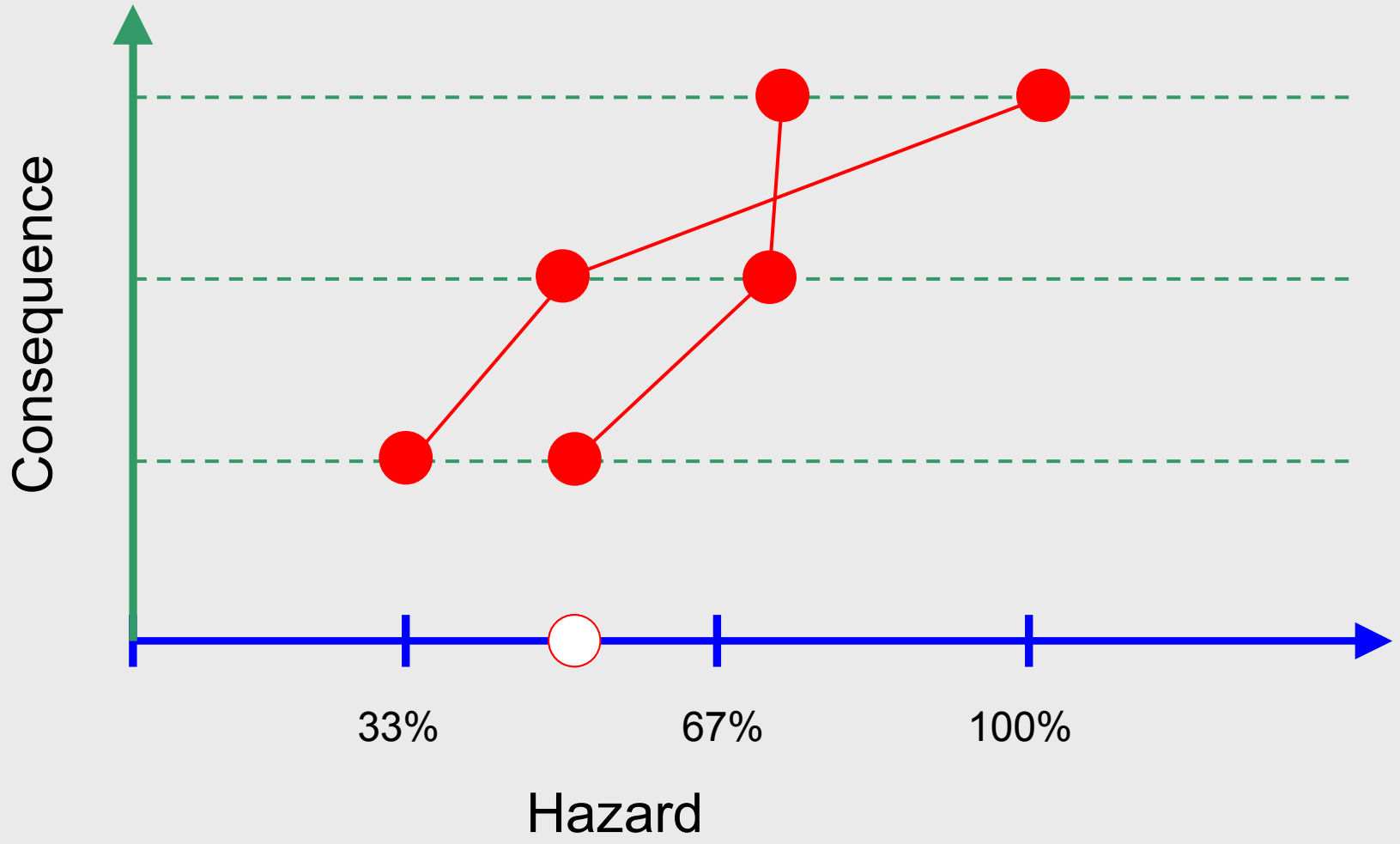
Assessment methods

- IEP = Initial Assessment Procedure - developed to sift buildings, ie identify which buildings MIGHT be earthquake prone ✗
- DEE = Detailed Engineering Evaluation – procedure for methodically identifying and assessing damage, may include IEP or more detailed assessment ≈
- Detailed Assessment – quantitative assessment using recognised methodology ✓

~~Guess~~ Calculate some scores

Conclusion

- Vulnerabilities are more critical than strength assessment
- To focus only on capacity is inappropriate
- We need to find a new measure.
- It is not so easy in low seismicity areas such as Auckland

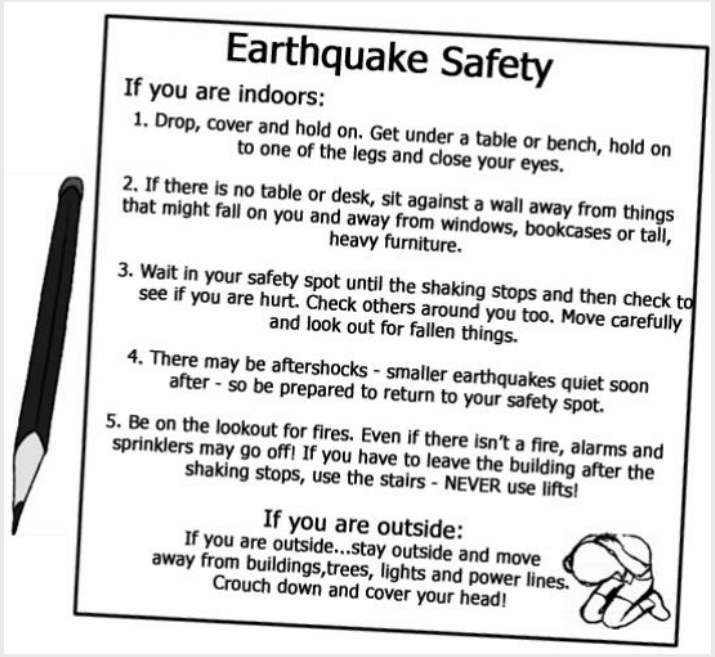

Consequence
33%
67%
100%
Hazard

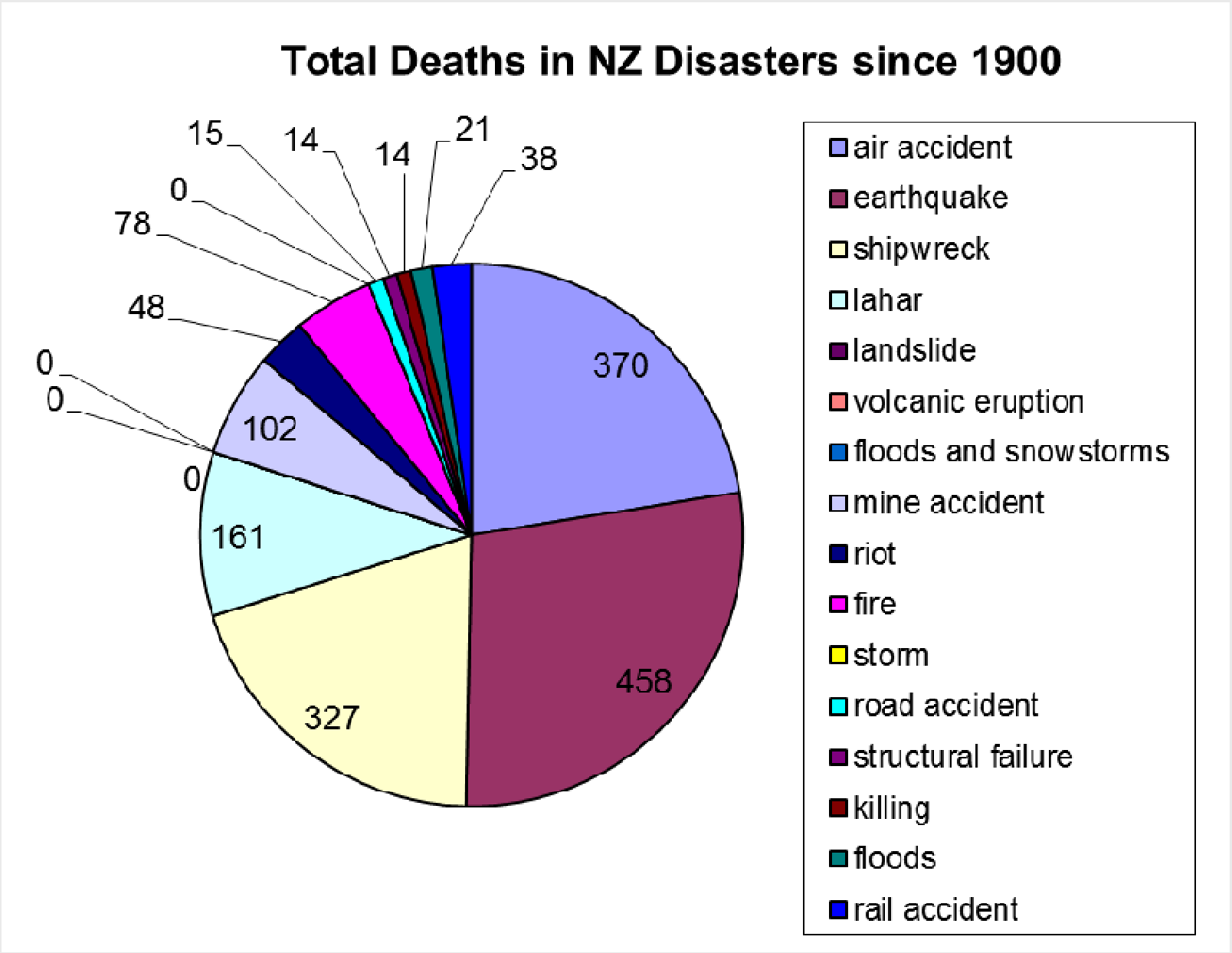
Communication

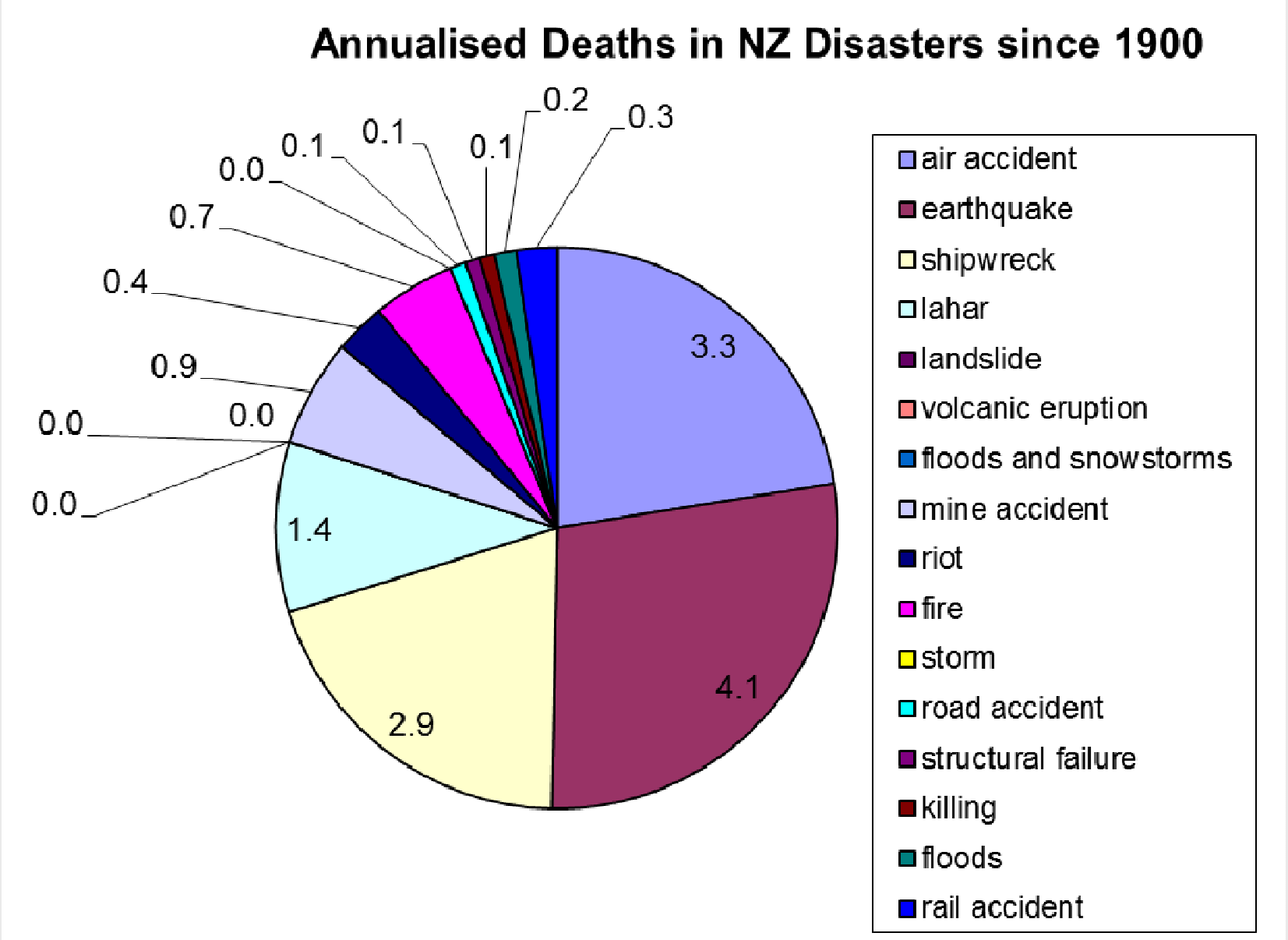
72.	The Ministry of Business, Innovation and Employment should work with territorial authorities, building owners, the New Zealand Society of Earthquake Engineering and other interested parties to develop a grading system for existing buildings that is able to be understood by the general public and adequately describes the seismic performance of a building.
94.	Section 32(4) of the Earthquake Commission Act 1993 should be amended to allow for disclosure of information that may affect personal safety. A suggested wording is set out in section 4.25.4.3 of this Volume.
95.	Legislation should provide for: a. duty to disclose information that a building is in a dangerous or potentially dangerous condition to the relevant territorial authority and any affected neighbouring occupier; b. the above duty to be applied to statutory bodies, engineers and other professional persons who have become aware of the information; c. a similar duty on building owners in respect of their own tenants and neighbouring occupiers; and d. the protection of those carrying out these duties in good faith from civil or other liability or allegations of professional misconduct.
102.	The Ministry of Business, Innovation and Employment should review the best ways to make information about the risk buildings pose in earthquakes available to the public and should undertake appropriate educational activities to develop public understanding about such buildings
103.	The engineering and scientific communities should do more to communicate to the public the risk buildings pose in earthquakes, what an assessment of building strength means, and the likelihood of an earthquake.
104.	Industry participants, such as insurers, valuers, and property managers, should ensure that they are aware of earthquake risks and the requirements for earthquake- prone buildings in undertaking their roles, and in their advice to building owners.

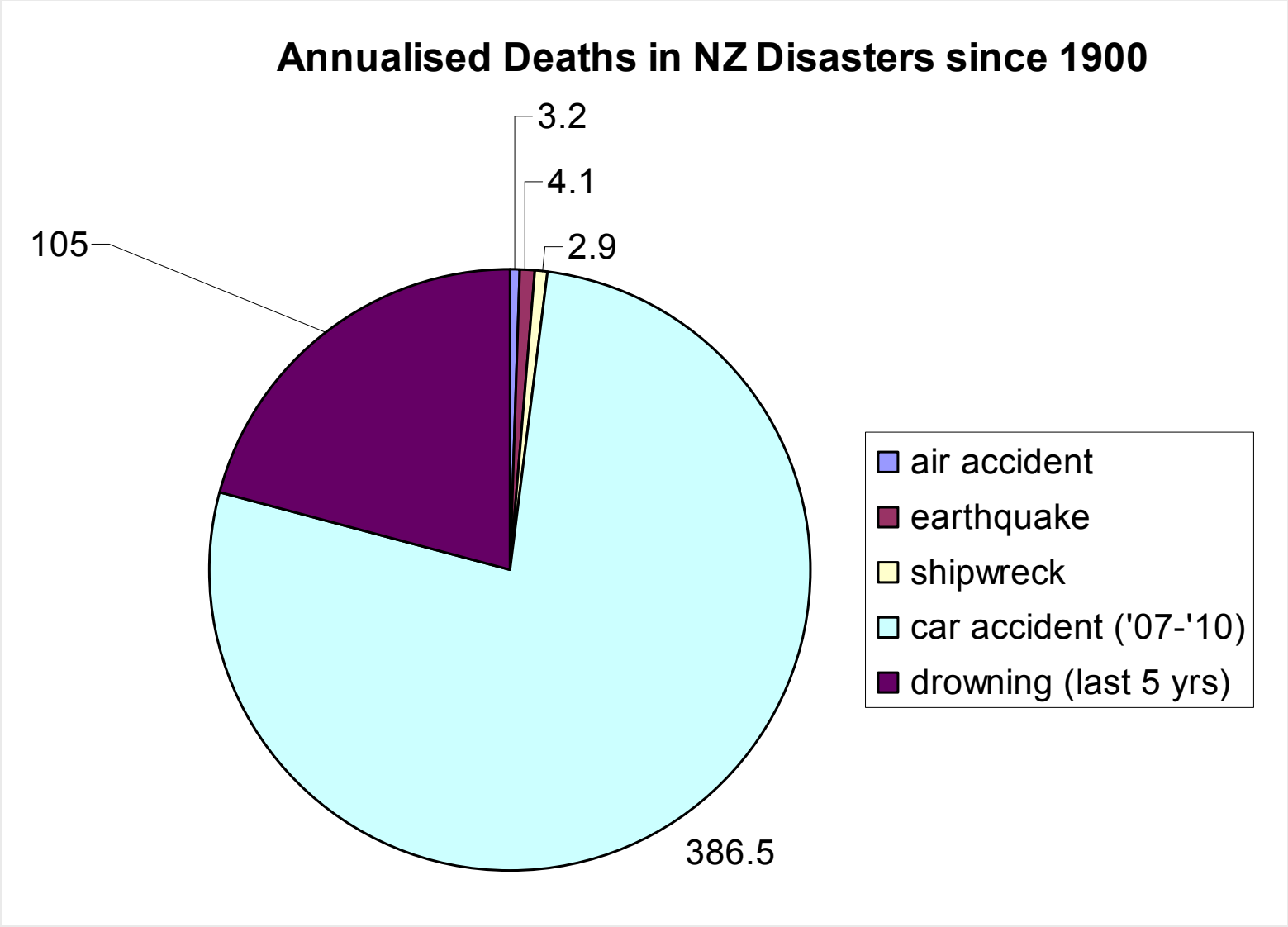
Another Myth – ‘Safe’

- There is no such thing as absolute safety.
- There could always be a bigger earthquake
- Its all about the context




Total Deaths in NZ Disasters since 1900
15
14
14
21
38
0
78
48
0
0
370
102
0
161
458
327
air accident
earthquake
shipwreck
lahar
landslide
volcanic eruption
floods and snowstorms
mine accident
riot
fire
storm
road accident
structural failure
killing
floods
rail accident

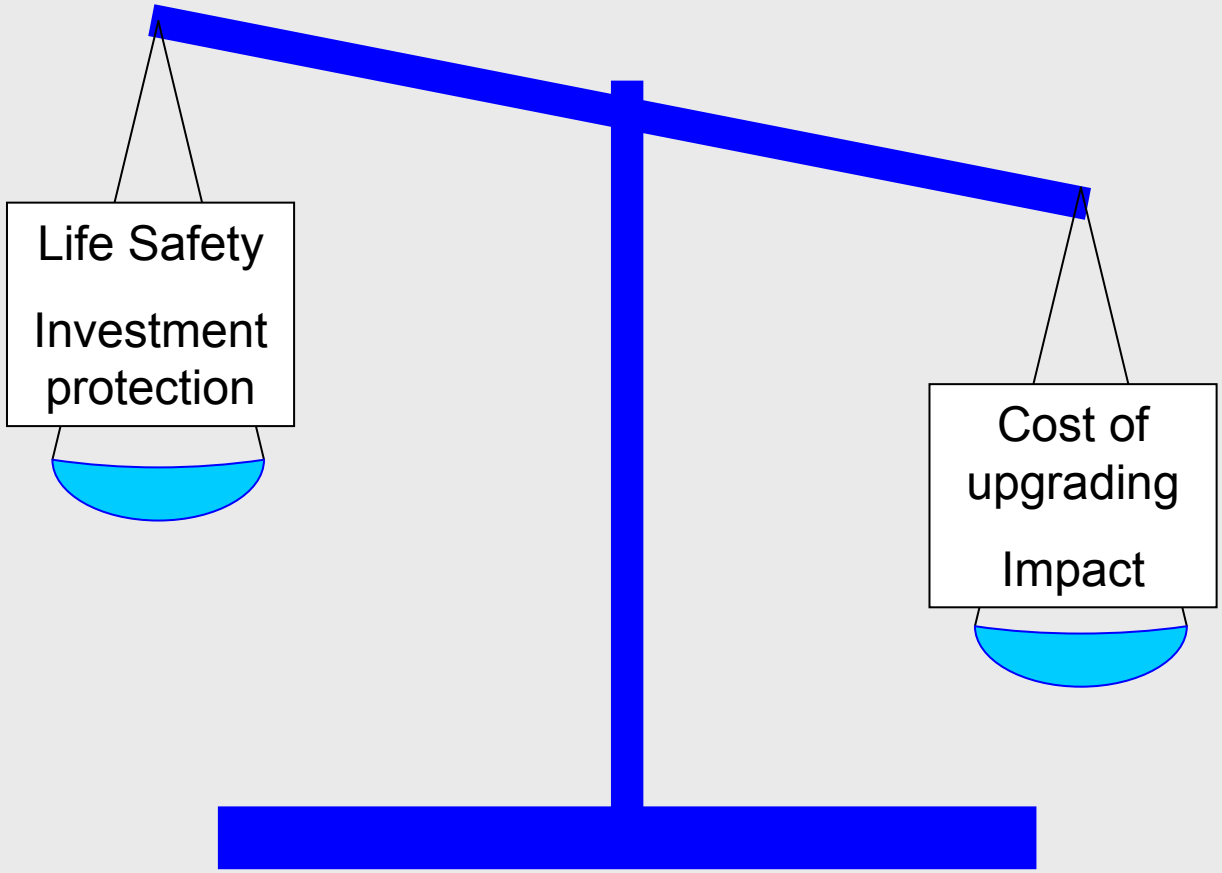

Annualised Deaths in NZ Disasters since 1900
3.3
4.1
2.9
1.4
0.0
0.0
0.9
0.4
0.7
0.0
0.1
0.1
0.1
0.2
0.3
air accident
earthquake
shipwreck
lahar
landslide
volcanic eruption
floods and snowstorms
mine accident
riot
fire
storm
road accident
structural failure
killing
floods
rail accident


Annualised Deaths in NZ Disasters since 1900
3.2
4.1
2.9
105
386.5
air accident
earthquake
shipwreck
car accident ('07-'10)
drowning (last 5 yrs)

Question – how to communicate risk?

- Damaging return period?
- Likelihood of exceedence?
- Capacity relative to code?
- Likelihood of death?
- Relativity to lotto?
- Building Safety Rating – Quakestar?

A Fine Balance



Conclusions

- We need to communicate risk more effectively
- We must not allow people to think that risk can be eliminated.
- We should be careful not to over-react to risk

Compliance

162.	Building consent applications for: • buildings in importance levels 3, 4 and 5 in Table 3.2 of AS/NZS 1170.0:2002; • commercial buildings comprising three or more storeys; and • residential buildings comprising three or more household units should be accompanied by a Structural Design Features Report, which describes the key elements of the design, including the foundations and gravity and lateral load resisting elements.
164.	After consideration of the Structural Design Features Report, the building consent authority should decide whether or not the structure should be regarded as complex.
165.	The Ministry of Business, Innovation and Employment should develop criteria to be applied in determining whether a structure is complex, in consultation with the Structural Engineering Society New Zealand, the New Zealand Society for Earthquake Engineering, the New Zealand Geotechnical Society and other relevant groups, including building consent authorities. When developed, the criteria should be given regulatory force.
167.	If the structure is determined to be complex, a Recognised Structural Engineer should be required to certify the structural integrity of the design
168.	On receipt of the building consent application, the building consent authority should decide: a. whether it has the staff with the appropriate competency (qualifications and experience) to process the application in-house (including any decision as to whether the structure is complex and whether any additional peer review certified by a Recognised Structural Engineer should be required); or b. whether it needs to refer the application to another building consent authority that has the staff with the appropriate competency (qualifications and experience) to process the application

Compliance

- Is this really the big issue that some think it is?
- Christchurch DEEs show significant number of non-compliant buildings – so, YES.
- Why then?
- Internal checking and review
- Competence of designers
- Lack of validation of design – compliance review

A Poor Analogy

- A doctor
  - Works on one patient at a time
  - Has immediate feedback
- A pilot
  - Flies the same plane day after day
  - Has an experienced co-pilot
- An engineer
  - Works on many projects at once, all different
  - Designs for events that rarely happen

What to do?

- Compliance reviews should be more than checking boxes
- Need to consider how to achieve better design and construction WITHOUT increasing costs disproportionately
  - More guidance to designers, reviewers and builders
  - More effective consent review
  - More effective construction review
- Risk based consenting?

A Proposed Model

1. Pre-application (facilitative)
   - Early engagement to indentify potential issues
   - Alignment of procedures
   - External high-level peer input
2. Application (regulatory)
   - Pre-determined consent review
   - Independent peer review if required
   - Approved reviewers
   - External secondment
   - External high-level review
3. Special Inspections
   - Independent support to construction monitoring

Design

54.	Designers should define load paths to ensure that the details have sufficient strength and ductility to enable them to perform as required.
55.	Structural engineers should assess the validity of basic assumptions made in their analyses.
63.	The principles of protecting life beyond ultimate limit state design should be applied to all elements of a building that may be a risk to life if they fail in an earthquake.
64.	In designing a building, the overall structure, including the ancillary structures, should be considered by a person with an understanding of how that building is likely to behave in an earthquake.
65.	Building elements considered to pose a life- safety issue if they fail should only be installed by a suitably qualified and experienced person, or under the supervision of such a person. The Department of Building and Housing should give consideration to the necessary regulatory framework for this.

Design

- The Outcome:
  - **With one exception, all modern buildings in Christchurch met the basic life safety objective of the NZ Building Code**

- The Conclusion?
  - **That wholesale change to the Building Code would not be nearly as effective as properly applying the one that we already have**

Advanced Design

67.	The Department of Building and Housing should work with researchers, engineering design specialists and industry product providers to ensure evidence-based information is easily available to designers and building consent authorities to enable low-damage technologies to proceed more readily through the building consent process as alternative solutions.

But first of all, lets make sure that the proposed new systems meet the performance expectations required of them, that the R&D is complete, and that these systems are subject to through review

Let's not create tomorrow's problems, today.

Building Safety Evaluation after Earthquake

114.	The Ministry of Business, Innovation and Employment should progress its proposals to incorporate new emergency risk management provisions into the Building Act 2004 to: • make the Ministry of Business, Innovation and Employment responsible for the development and maintenance of New Zealand's building safety evaluation process; • make territorial authorities responsible for delivering a building safety evaluation operation; and • give the Ministry of Business, Innovation and Employment a formal role within national civil defence and emergency planning arrangements.
122.	The liability waiver for building safety evaluators should be aligned with the building safety evaluation process instead of being restricted to an operation carried out in a state of emergency.
147.	Information management systems should be developed as part of planning for New Zealand's building safety evaluation process.
148.	The Ministry of Business, Innovation and Employment should work with territorial authorities and other relevant agencies to develop a way for territorial authority building records to be electronically recorded and stored off-site.

Building Safety Evaluation after Earthquake

- Chch revealed serious issues with information management
- Building Safety Evaluation guidelines under review
- Recommend data sheets as a means of briefing safety inspectors
- Need better TA records

Building Data Sheet

Building:	Engineering House
Address:	123 Quake Street
Year of design:	1982
Number of stories:	18
Occupancy:	Commercial/Office
Assessed by:	An Engineer

Structural System

The building consists of 18 floors above ground level, including a 3 storey podium. Parking is provided in a 3 level basement.

The gravity load resisting system comprises a reinforced concrete frame supporting precast double tee flooring spanning in an east-west direction. The tees are flange hung with an insitu topping reinforced with hard drawn wire mesh that forms the structural diaphragm.

Lateral loads are resisted by the perimeter ductile reinforced concrete moment resisting frames, constructed of insitu concrete columns and precast beams.

The east and west frames use conventional ductile frame detailing, with diagonal reinforcement provided on the north and south frames. The internal gravity frames do not have ductile detailing.

The stairs are not fixed at the landings and seating lengths of 75mm are provided. The rear of the tower is clad with precast concrete panels. The panels are fixed from floor to floor with a sliding detail at the top of the panels.

Foundations and Soil Conditions

The site comprises 5-10m of medium dense to dense sands and silts overlying dense gravels. Ground water level is at 3.5m bgl.

The building is founded on driven concrete piles, founded at 8m – 12m depth.

Typical Floor Plan

Photograph

Seismic Evaluation

Overall capacity:	70% NBS
CSW capacity:	30% NBS
Date of assessment:	2012
Evaluated against:	NZS1170.5:2004
Zone factor:	0.3
Importance level:	2
Ductility, μ :	4 (both directions)

Expected Building Performance

A linear response spectrum analysis was carried out to establish the capacity of the building.

The perimeter concrete MRF's were found to have sufficient capacity and detailing to resist loads in excess of 100% NBS.

The overall performance of the building is limited by the deformation capacity of the internal gravity frames which are expected to sustain column shear failures at 70% NBS.

The stair detailing was found to comprise a critical structural weakness with collapse possible at loads exceeding 60% current code (equivalent to 30% NBS as a CSW).

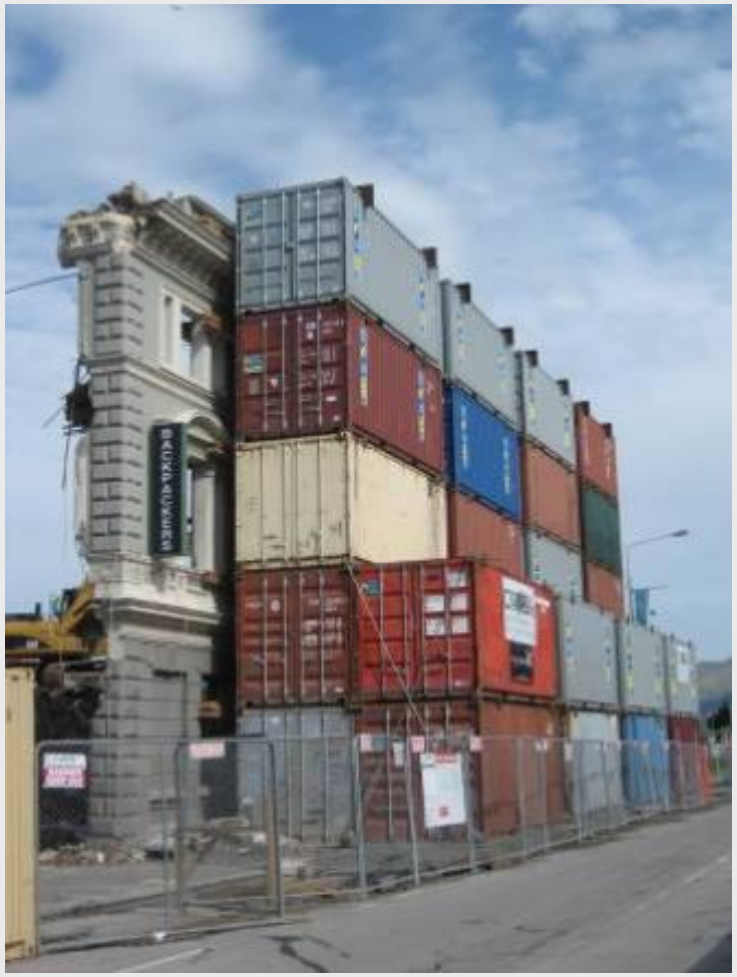
Critical Elements to Inspect

Stair seatings
Flange hung double tees
Internal gravity columns
North and south perimeter frames


Building
Evaluation

Building Evaluation & Repair

- Detailed Engineering Evaluations
  - For all non-residential structures
  - Approx 2000 submitted, 1000 approved
- Temporary stability concerns
- Strengthening design loads



Alphabet Soup!

Alphabet Soup

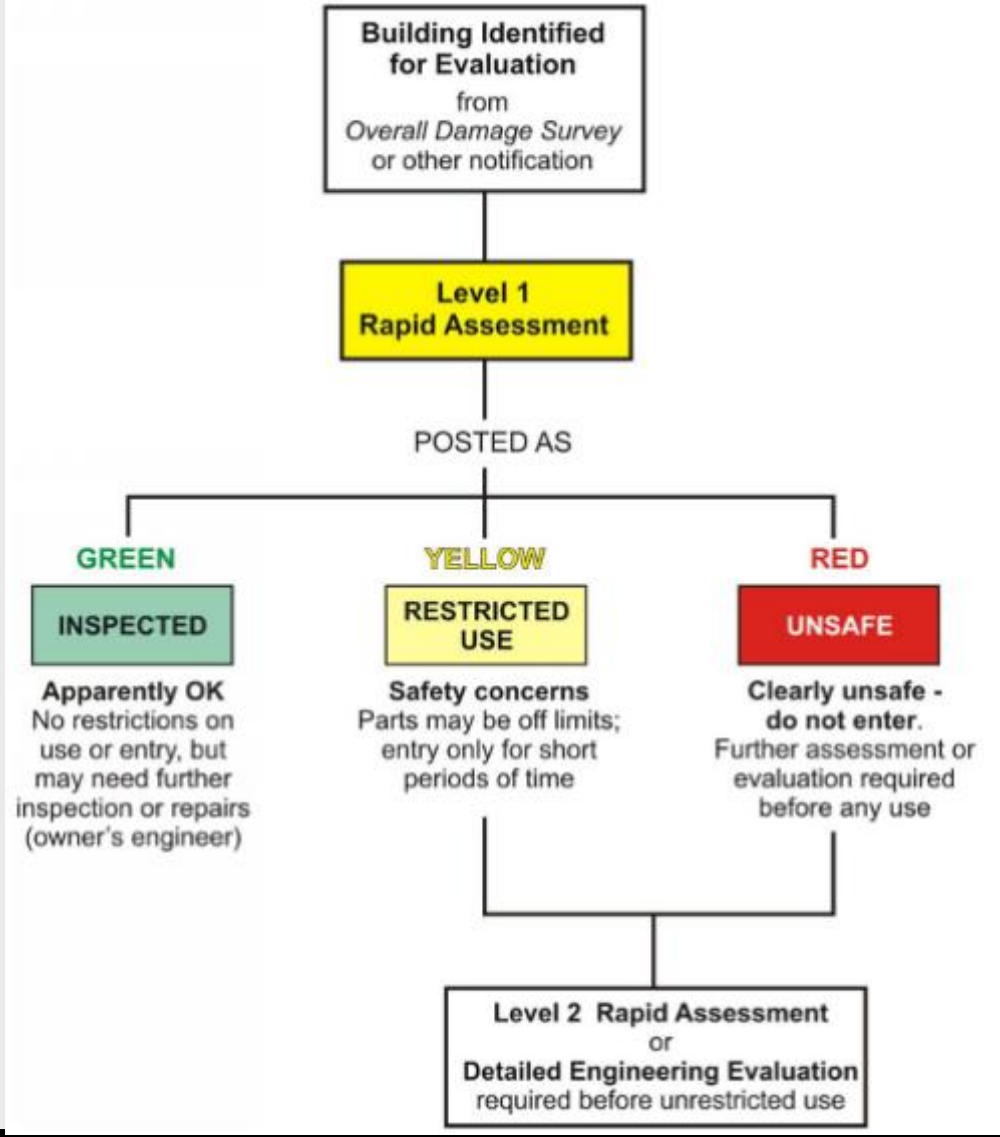
- EPB = Earthquake Prone Building – refer legal definition
- ERB = Earthquake Risk Building, ie less than 67%NBS
- IEP = Initial Evaluation Procedure
- IUE = Initial Use Evaluation
- DSA(DA) = Detailed Seismic Assessment
- DEE = Detailed Engineering Evaluation

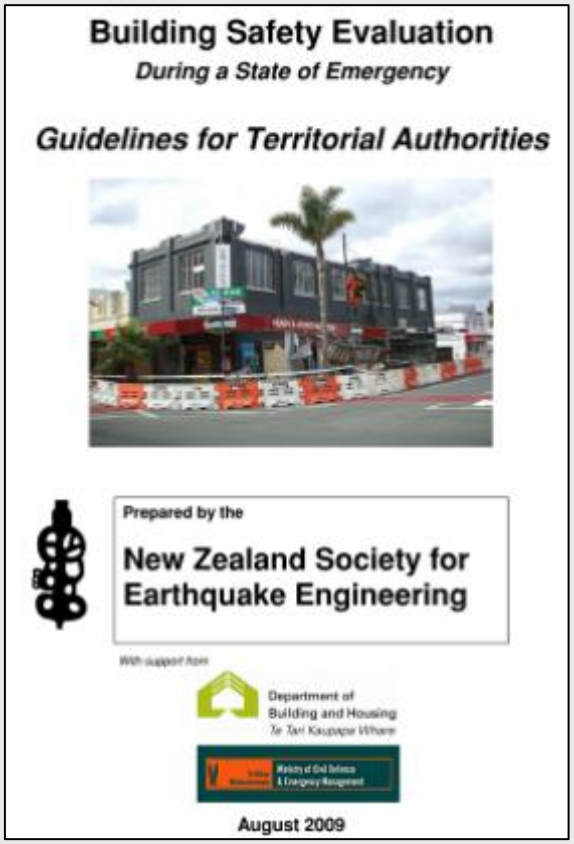
Assessment methods

- IEP = Initial Assessment Procedure - developed to sift buildings, ie identify which buildings MIGHT be earthquake prone ✗
- DEE = Detailed Engineering Evaluation – procedure for methodically identifying and assessing damage, may include IEP or more detailed assessment ≈
- Detailed Assessment – quantitative assessment using recognised methodology ✓

Building Safety Evaluation

General Procedure





Rapid Safety Evaluation

To NZSEE Guidelines for Territorial Authorities, August 2009

Level 1

- Visual inspection, exterior only
- Superficial, basic triage
- Develop view of overall scale and extent of damage

Level 2

- Visual inspection, exterior and interior
- Less superficial, but still non-invasive

The focus of the building safety evaluation process is on immediate public safety, not the provision of an engineering assessment service to building owners

What next?

Green = Safe,
right?

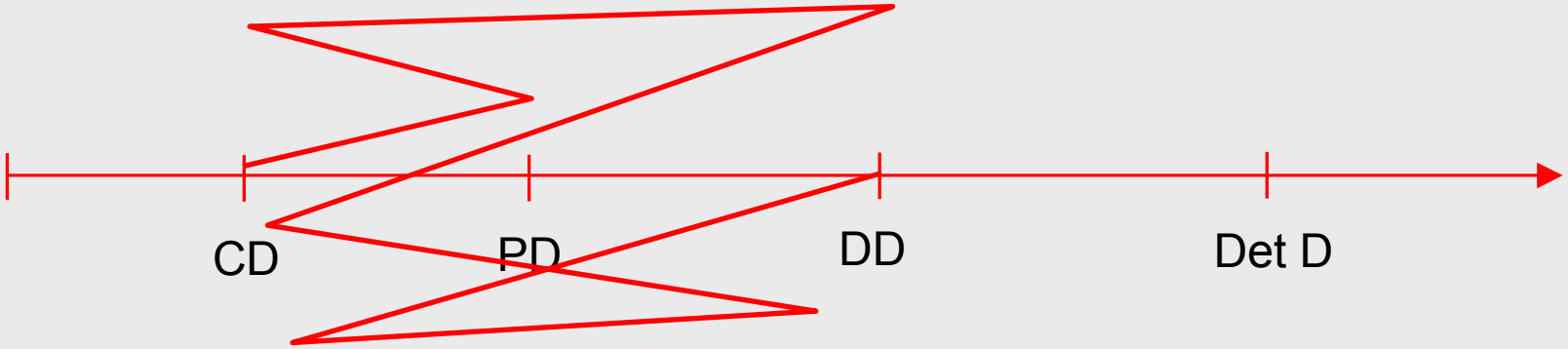
What next?

What next?

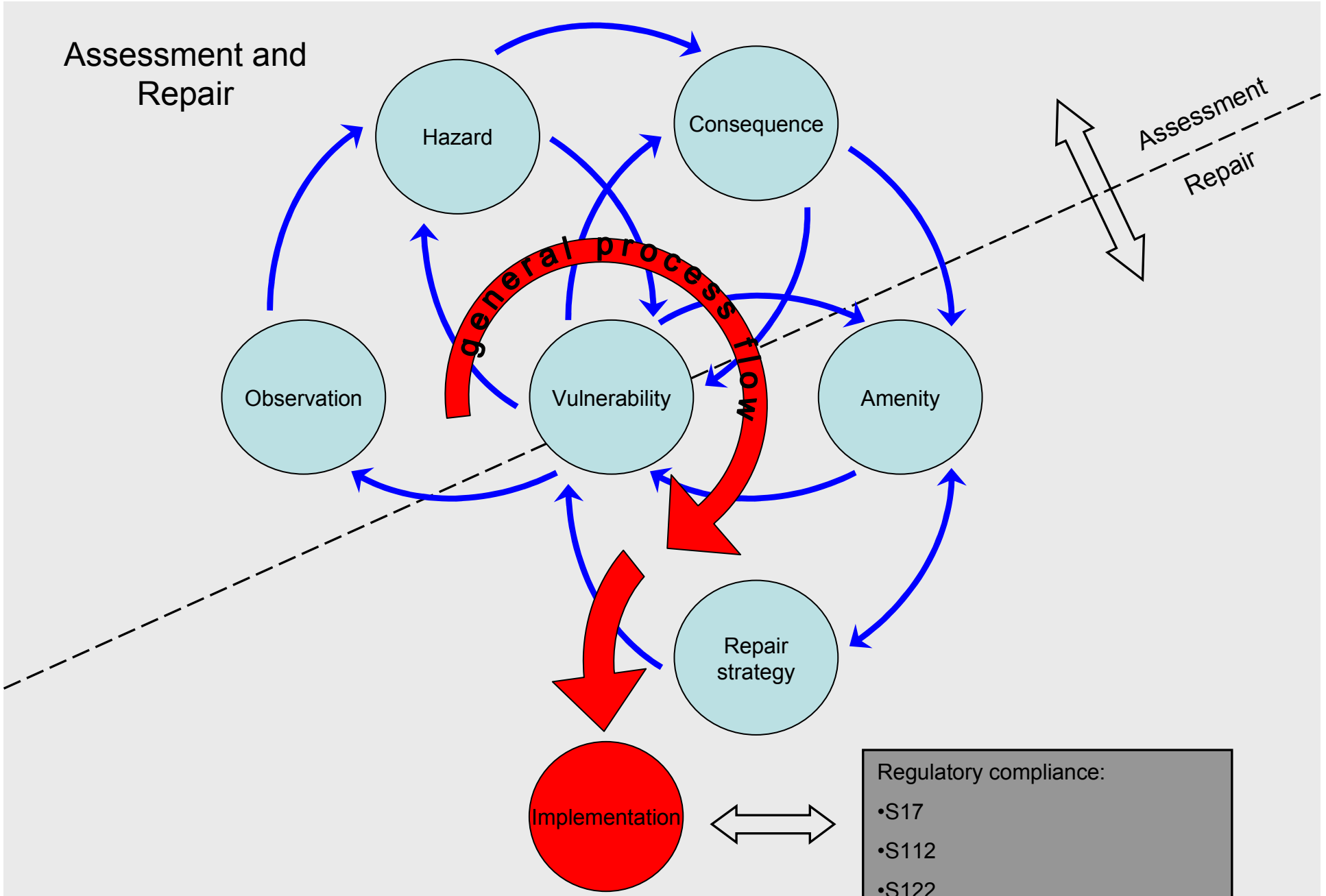
Green =

NO OBVIOUS DAMAGE

Design



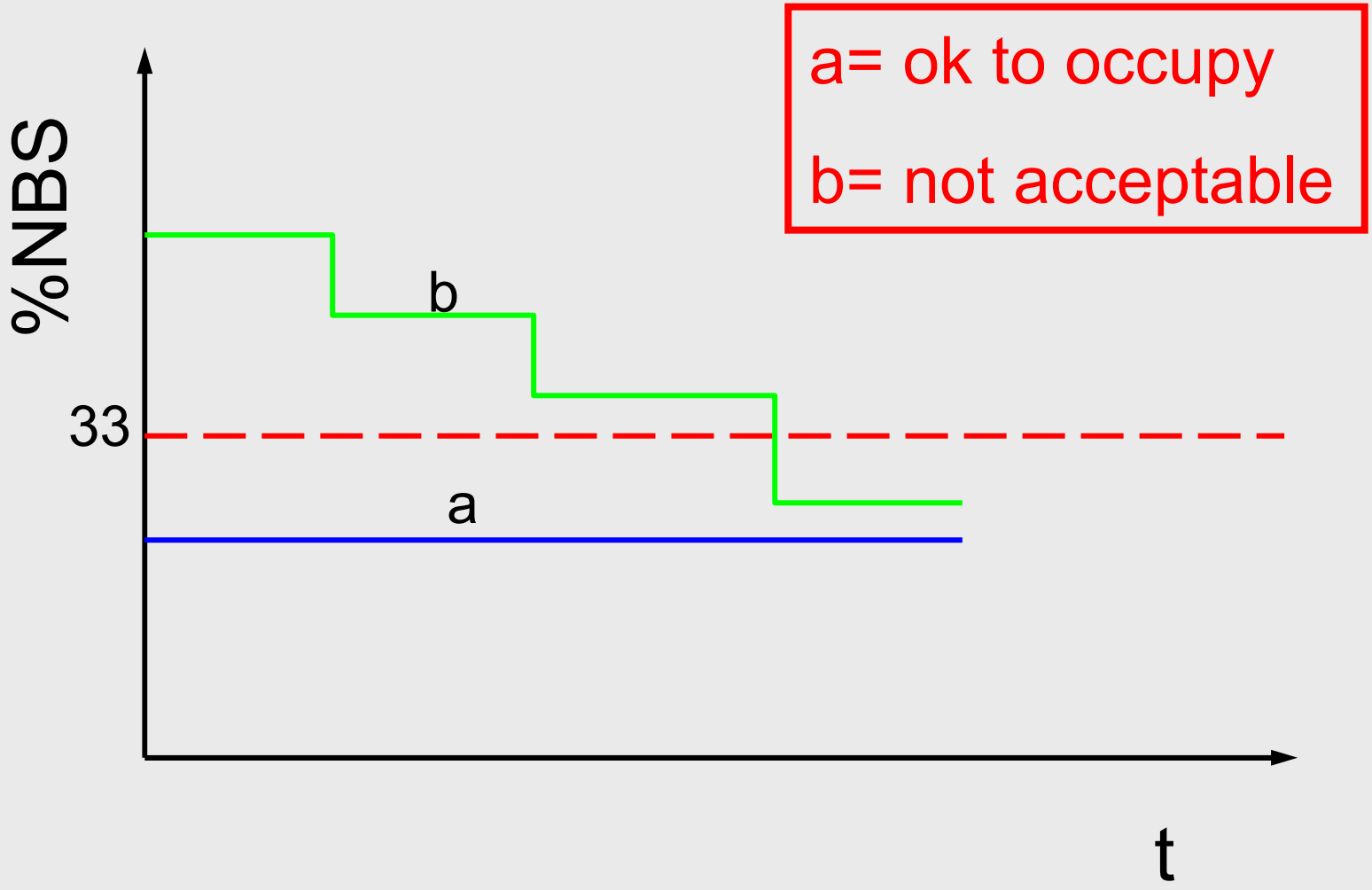
Assessment and Repair



Occupancy Review – Key Messages

- Owners are responsible for determining the ongoing occupancy of their buildings (subject to CERA or Council notices)
- Owners should obtain advice from suitably qualified and experienced CPEngs
- Building owners should not wait for CCC or CERA to take action
- Decisions to vacate or strengthen should be based on suitable evaluation – not IEP!

Building Status



Interim Use Assessment

- Similar to Level 2, but:
- Level 2 – Damage only
  - Refer NZSEE Guidelines
- Qualitative review:
  - Identify damage
  - MUST sight/understand load path
  - MUST determine damage/no damage
    - Intrusive investigation if necessary – eg cracked walls
  - Identify CSWs

Overall Assessment Process

- Must look at the capacity of systems, not simply elements – recognise redundancy
- If IEPs, use judgement on ALL matters – but explain your assumptions
- Cannot ignore issues - %NBS is the lowest value, but explore upgrade potential.
- Nowhere in the DEE process does it say “Suspend engineering judgement!!!!”

Overall Assessment Process

- If there is already another engineer's IEP out there – talk! (Mawhera House)
- IEP may be iterative process – as more information comes to hand, or further assessment is completed
- NOTE: IEP assumes that building was compliant at time of design. If not, must consider impact of non-compliance

DEE – General Feedback

- Don't overcomplicate reporting
  - Subject to insurance/owner overlay, don't need to report issues to CERA which are not relevant eg more about earthquakes…..
- Just:
  - Demonstrate:
    - Understanding of behaviour – load paths
    - Completeness of damage review
    - Recognition of vulnerabilities
  - Capacity assessment
  - Recommendations for action

DEE – General Feedback

- Guidance on reporting %NBS
  - Report minimum value for building system, irrespective of whether it is for the system or a secondary element
    - Still earthquake prone if any part < 33%NBS
  - Primary system strength can allow for redistribution for elements ‘in parallel’, provided load paths exists.
    - eg walls in a system – overall capacity
  - Secondary elements should be weakest component
    - eg capacity of precast panel connection, seating for stair

DEE – General Feedback

- Timber buildings
  - IEP not generally appropriate
  - Use Bracing unit analysis if appropriate
  - Or use Red Book

Questions?