This document includes the presentation slides shown during the Seismic Design Seminar/Webinar on 15 April 2024.

The information presented in this document represents current planning only and will be subject to extensive change as the Seismic Risk Working Group continues its work through the year.

BUILDING
PERFORMANCE

B1/VM1 Project Stage 2

Ken Elwood

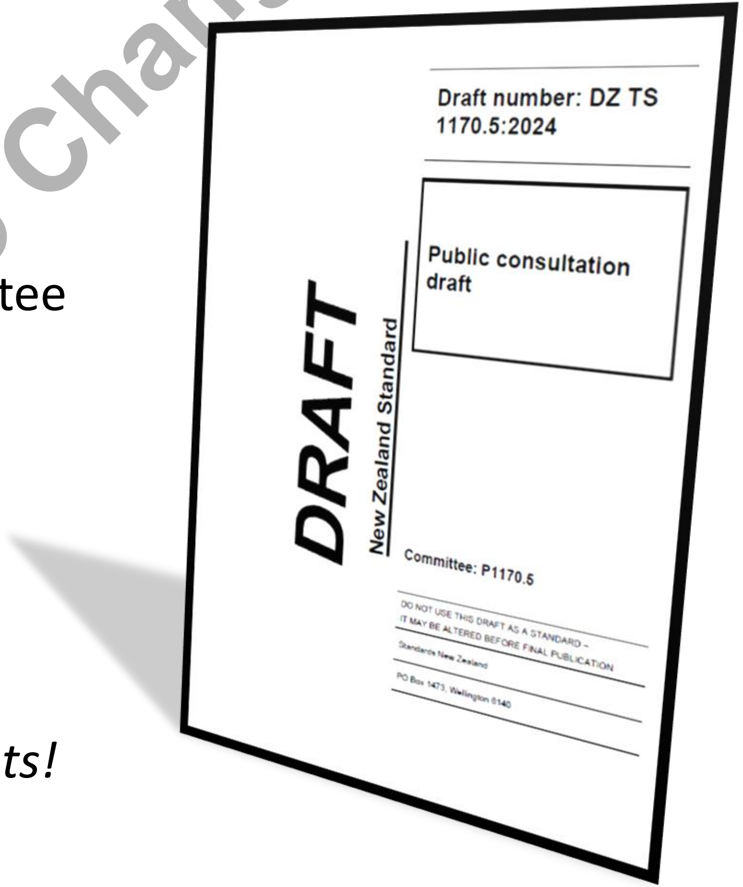
MBIE-EQC Chief Engineer
(Building Resilience)

Draft TS 1170.5

- 600+ public comments – thank you!
- All comments to be considered by TS Committee (per SNZ process)
- Premature to estimate a publication date for TS 1170.5
- Cost-Benefit Analysis is underway
- **Reminders:**

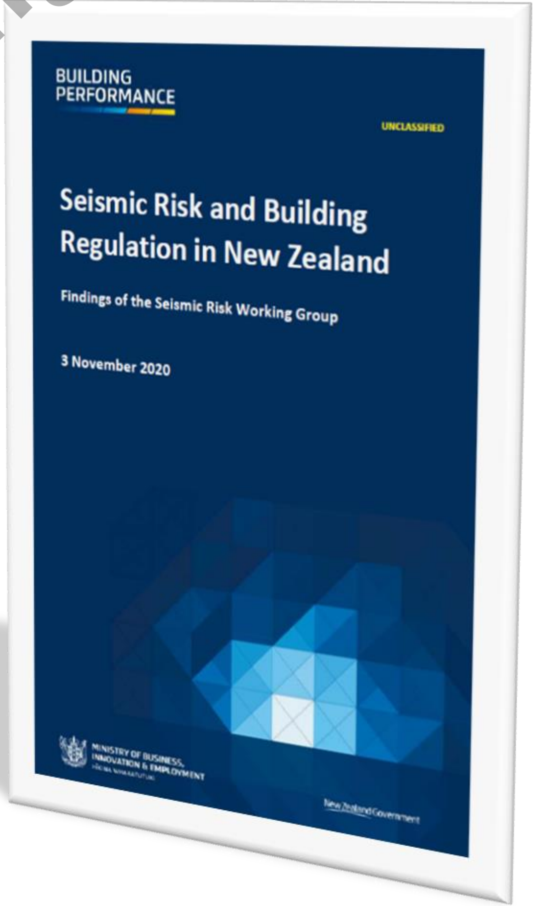
  Do not use the DRAFT TS 1170.5 for design!

  Do not use TS 1170.5 for seismic assessments!



History

- 2019 – MBIE/EQC started GNS contract to update National Seismic Hazard Model (NSHM)
- 2020 – MBIE contracted ENZ to convene Seismic Risk Working Group (SRWG) to advise on how the updated NSHM could be applied within the Building Code.
  - Key recommendations related to:
    - Seismic loading provisions, considering the uncertain nature of earthquakes;
    - Geotechnical considerations; and
    - Seismic design process and analysis.



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Seismic Risk Work Programme: B1/VM1 Project

- Contracted with ENZ in March 2022
- Stage 1: Minimum Viable Product
  "immediate work required to enable the output of the NSHM … to be integrated into the existing framework, as soon as and in the simplest way possible"
  → Draft TS 1170.5
- Stage 2: Further updates to design and analysis provisions
  "to develop a seismic design approach for buildings which provides better outcomes for society from our built environment in earthquakes, recognising cost and sustainability"

Key issues with current system to be considered in Stage 2

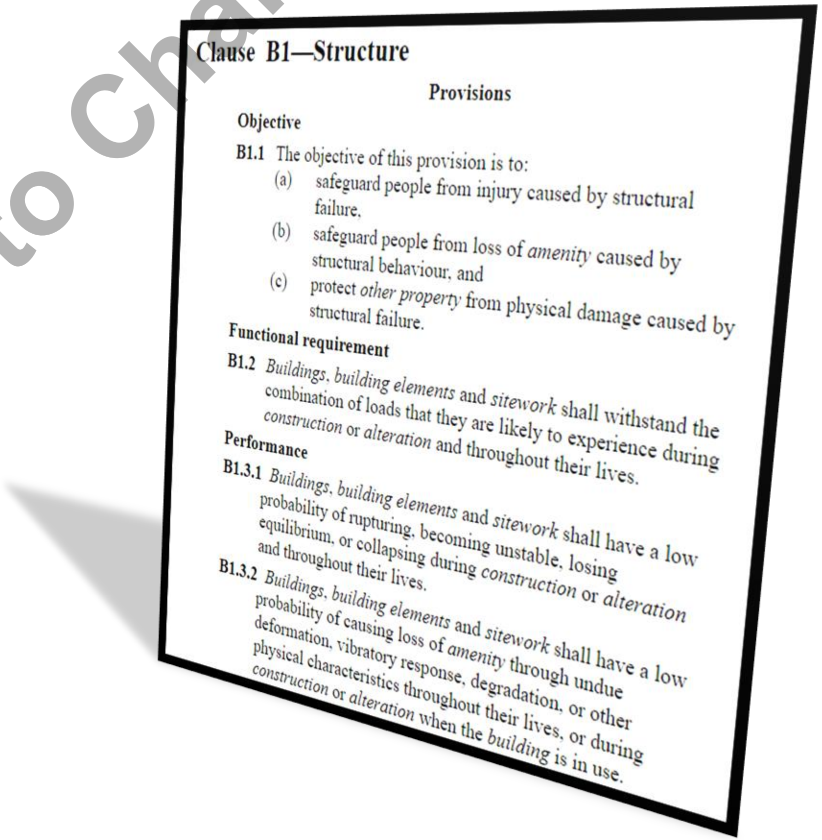
- **Importance Level** structure confuses amenity and life safety performance objectives.
- **Design process** does not facilitate a focus on controlling damage in buildings.
- Critical role of **irregularities** in driving building damage is not fully recognised.
- **Analysis** provisions are out of date leading to uncertainty in estimated local demands and global response.
- Compliance framework does not adequately address **geotechnical considerations**.
- Inconsistent alignment between 1170.5 and **external standards**, including capacity design requirements.

BUILDING PERFORMANCE

Performance objectives

- SRWG considers the objectives and performance requirements in B1 (amenity and life safety) are generally fit for purpose at this time.

- Stage 2 includes a focus on how the design approach addresses the amenity objective, in addition to life safety.



Clause B1—Structure

Provisions

Objective

B1.1 The objective of this provision is to:

(a) safeguard people from injury caused by structural failure,

(b) safeguard people from loss of *amenity* caused by structural behaviour, and

(c) protect *other property* from physical damage caused by structural failure.

Functional requirement

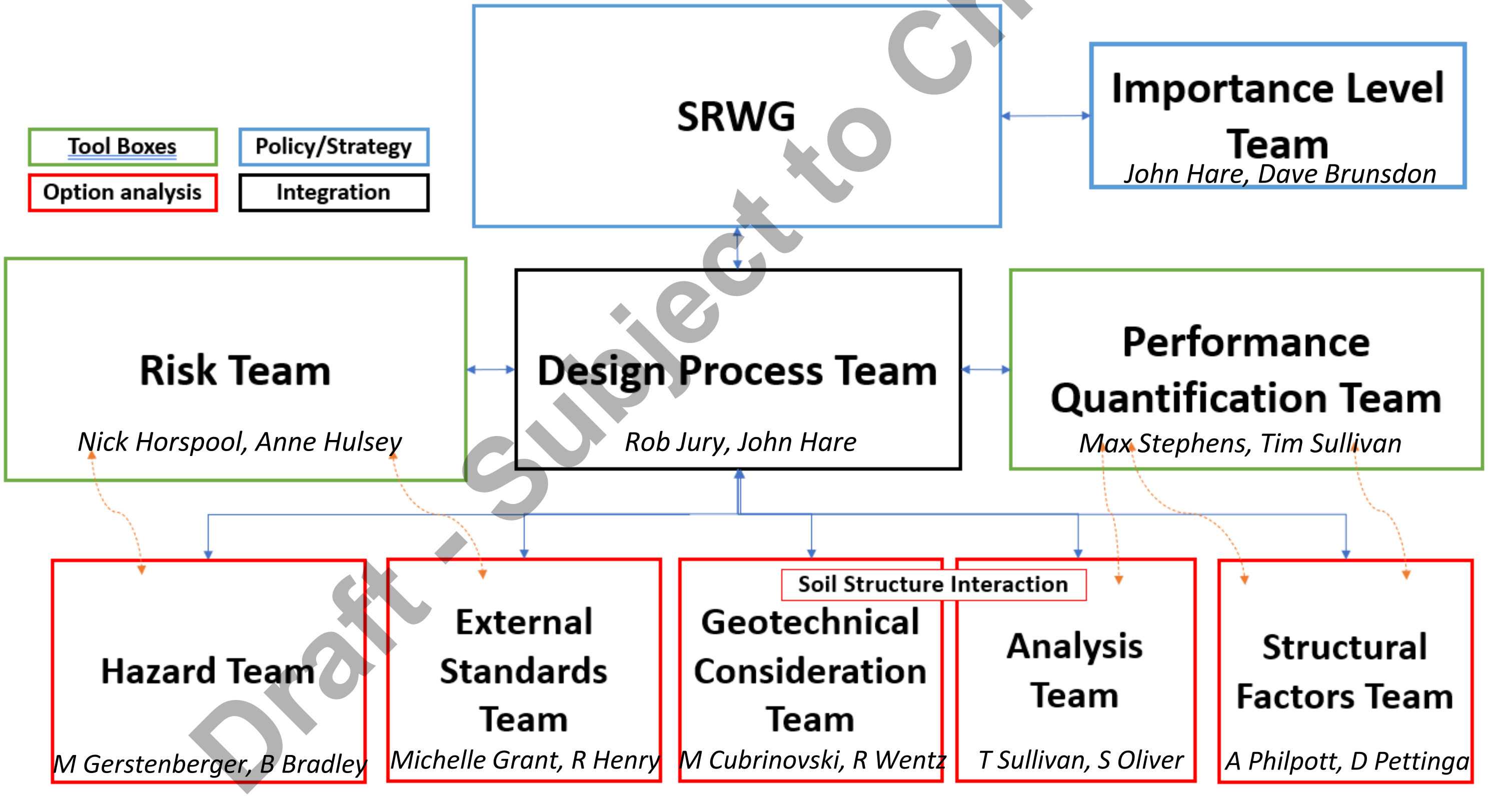
B1.2 *Buildings, building elements* and *sitework* shall withstand the combination of loads that they are likely to experience during *construction* or *alteration* and throughout their lives.

Performance

B1.3.1 *Buildings, building elements* and *sitework* shall have a low probability of rupturing, becoming unstable, losing equilibrium, or collapsing during *construction* or *alteration* and throughout their lives.

B1.3.2 *Buildings, building elements* and *sitework* shall have a low probability of causing loss of *amenity* through undue deformation, vibratory response, degradation, or other physical characteristics throughout their lives, or during *construction* or *alteration* when the *building* is in use.

Organisational structure



BUILDING PERFORMANCE

Outputs and timeline

- Key deliverables:
  - Proposed updates to TS 1170.5 (including commentary)
  - Proposed framework for Importance Levels
  - Report summarising other actions needed beyond TS 1170.5

- Tentative Timeline:
  - 2024-2025: Develop and ballot proposals through SRWG
  - Late 2025: Deliverables to MBIE
  - 2026: SNZ Committee to consider proposed updates
  - 2027?: Updated 1170.5 released

Outline

- John Hare: Importance Levels and Design Process
- Michelle Grant: External Standards, Structural Factors, Analysis
- Rick Wentz: Geotechnical Considerations
- Q&A

Please note:

We are very early in this process!

What is eventually achieved may vary from what is described here today.

Thank you.

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Te Kāwanatanga o Aotearoa
New Zealand Government

IMPORTANCE LEVELS AND DESIGN PROCESS

SRWG Stage 2

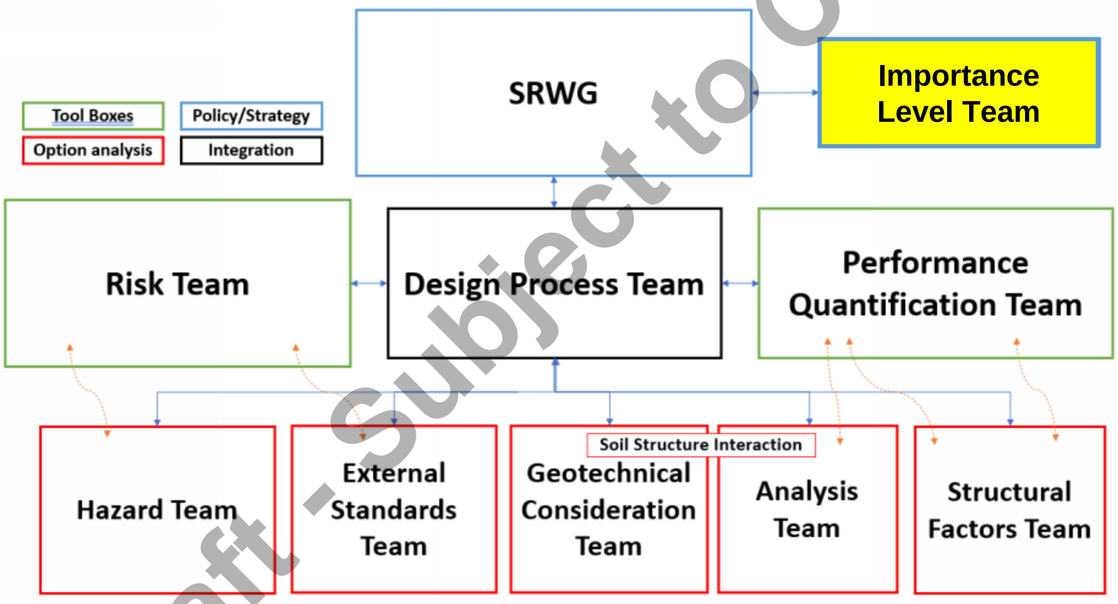

Figure 6. Organisational Structure for Stage 2

John Hare (L)
Ken Elwood
Dave Brunsdon
Kaley Crawford-Flett

Importance Levels

- Starting at Objectives – Clause B1.1:
  a) Life Safety – ULS
  b) Amenity
- Consider RBP (and others)
  - Life safety expectations are generally met
  - Amenity (and protection of property) expectations

16 *Building Regulations 1992* 1992/150

FIRST SCHEDULE—*continued*

Clause B1—STRUCTURE

Provisions	**Limits on application**
OBJECTIVE **B1.1** The objective of this provision is to: (a) Safeguard people from injury caused by structural failure, (b) Safeguard people from loss of *amenity* caused by structural behaviour, and (c) Protect *other property* from physical damage caused by structural failure.	

Importance Levels

TABLE 3.1

CONSEQUENCES OF FAILURE FOR IMPORTANCE LEVELS

Consequences of failure	**Description**	**Importance level**	**Comment**
Low	**Low** consequence for loss of human life, *or* **small or moderate** economic, social or environmental consequences	1	Minor structures (failure not likely to endanger human life)
Ordinary	**Medium** consequence for loss of human life, *or* **considerable** economic, social or environmental consequences	2	Normal structures and structures not falling into other levels
High	**High** consequence for loss of human life, *or* **very great** economic, social or environmental consequences	3	Major structures (affecting crowds)
		4	Post-disaster structures (post disaster functions or dangerous activities)
Exceptional	Circumstances where reliability must be set on a case by case basis	5	Exceptional structures

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Importance Levels

- Inconsistencies in threshold numbers
- Needs updating for new uses
- Are the underlying assumptions valid?
  - Non-ambulatory
  - Confined
- Needs clarity on what 'post-disaster' means

TABLE 3.2

IMPORTANCE LEVELS FOR BUILDING TYPES—NEW ZEALAND STRUCTURES

Importance level	Comment	Examples
1	Structures presenting a low degree of hazard to life and other property	Structures with a total floor area of <30 m^2 Farm buildings, isolated structures, towers in rural situations Fences, masts, walls, in-ground swimming pools
2	Normal structures and structures not in other importance levels	Buildings not included in Importance Levels 1, 3 or 4 Single family dwellings Car parking buildings
3	Structures that as a whole may contain people in crowds or contents of high value to the community or pose risks to people in crowds	Buildings and facilities as follows: (a) Where more than 300 people can congregate in one area (b) Day care facilities with a capacity greater than 150 (c) Primary school or secondary school facilities with a capacity greater than 250 (d) Colleges or adult education facilities with a capacity greater than 500 (e) Health care facilities with a capacity of 50 or more resident patients but not having surgery or emergency treatment facilities (f) Airport terminals, principal railway stations with a capacity greater than 250 (g) Correctional institutions (h) Multi-occupancy residential, commercial (including shops), industrial, office and retailing buildings designed to accommodate more than 5000 people and with a gross area greater than 10 000 m^2 (i) Public assembly buildings, theatres and cinemas of greater than 1000 m^2 Emergency medical and other emergency facilities not designated as post-disaster Power-generating facilities, water treatment and waste water treatment facilities and other public utilities not designated as post-disaster Buildings and facilities not designated as post-disaster containing hazardous materials capable of causing hazardous conditions that do not extend beyond the property boundaries
4	Structures with special post-disaster functions	Buildings and facilities designated as essential facilities Buildings and facilities with special post-disaster function Medical emergency or surgical facilities

SRG

Menu of Options

Revision 13 March 2024

Item	Problem Statement	Solution Options		
		Basic Clarifications *(Fundamental but with minimal impact)*	**Additional Enhancements** *(with potential impact)*	**Desired Changes** *(Aspirational with potentially significant impact)*
1	ILs are **defined in two separate places** (NZBC A3 for Fire and B1/VM1 through citing of AS/NZS1170.0 for structure), and slightly differently	Clarify the relationship between the two sets of ILs Clarify use of 'average occupancy' values and how to determine	Develop alternative approaches to create 'single point of truth'	Bring the two sets of IL definitions together within the same Building Code clause (preferably B1 Structure)
2	**Life safety as primary focus** - ILs are defined as a single value for each individual building, regardless of the load case being considered. The 'Importance' aspects of ILs is also overstated in practice (ex-7)	Introduce further measures for functionality (amenity)	Spilt ILs into two parts	Rename 'Importance'
3	**Listed building uses are limited and dated** - current ILs are based on defined building types and usages from the 70's or earlier and need updated for the modern context.	Amend Table 3.2 and add sector-based clarifications[1]	Integrate Tables 3.1 and 3.2 into an aligned and navigable table	Create a clearer navigational framework
4	There are apparent **occupancy anomalies** in the number of occupants that trigger IL3			Amend to create a more rational continuum
5	There are **no established risk measures in place to assess amenity performance**	Develop risk metrics for amenity		Develop new risk metrics for all performance objectives
6	**Hazards beyond the scope of the subject building** and property are not addressed under current ILs	Clarify the relationship with B1.1(c)		Introduce provisions requiring owners of adjacent sites to address potentially imposed risk

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Split Importance Levels

Why?

- Allows amenity and life safety to be addressed separately

Split:

- Occupancy Category – number of people exposed to risk
- Use Category – a measure of amenity

Occupancy Category

- Review numbers exposed to risk
- Two levels or more?
- Purpose:
  - Adjust demand to increase reliability – current IL approach

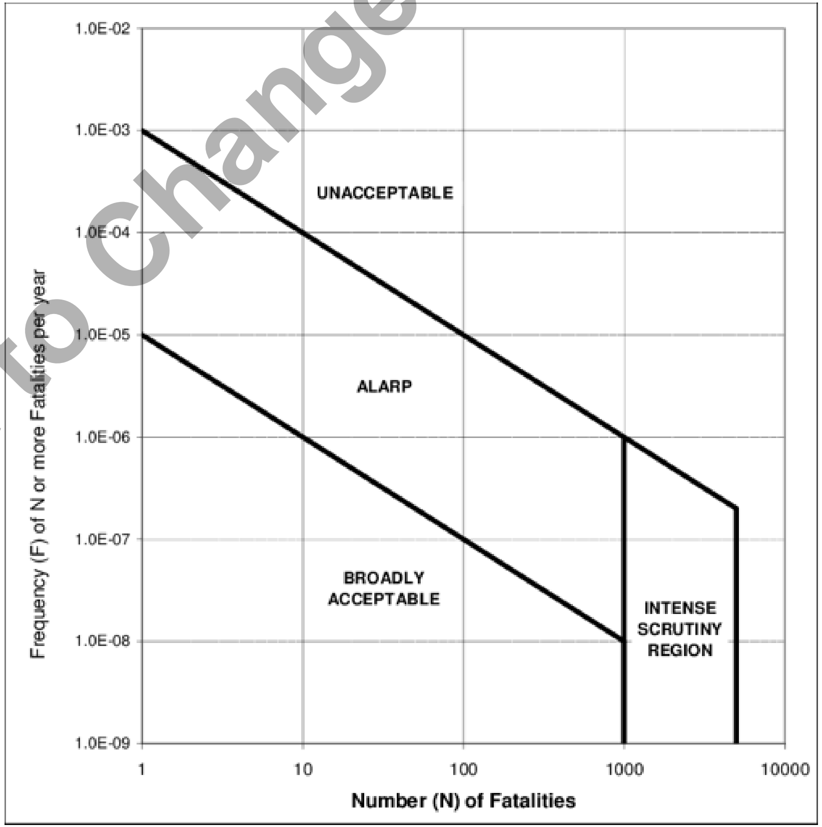

Figure 1: F-N curve for nuclear hazards (Kendall et al, 1977)

Use Category

- Considering amenity
  - Emergency services
    - Without redundancy
    - With local redundancy? Possible reduction if alternatives exist?
  - Enhanced performance required
    - Other recovery purposes – per Resilient Buildings Study, eg Food distribution, community wellbeing
    - Shelter-in-place
    - Cultural significance
  - Everything else (current IL2)
- Amenity risk metrics required ➔Risk Team

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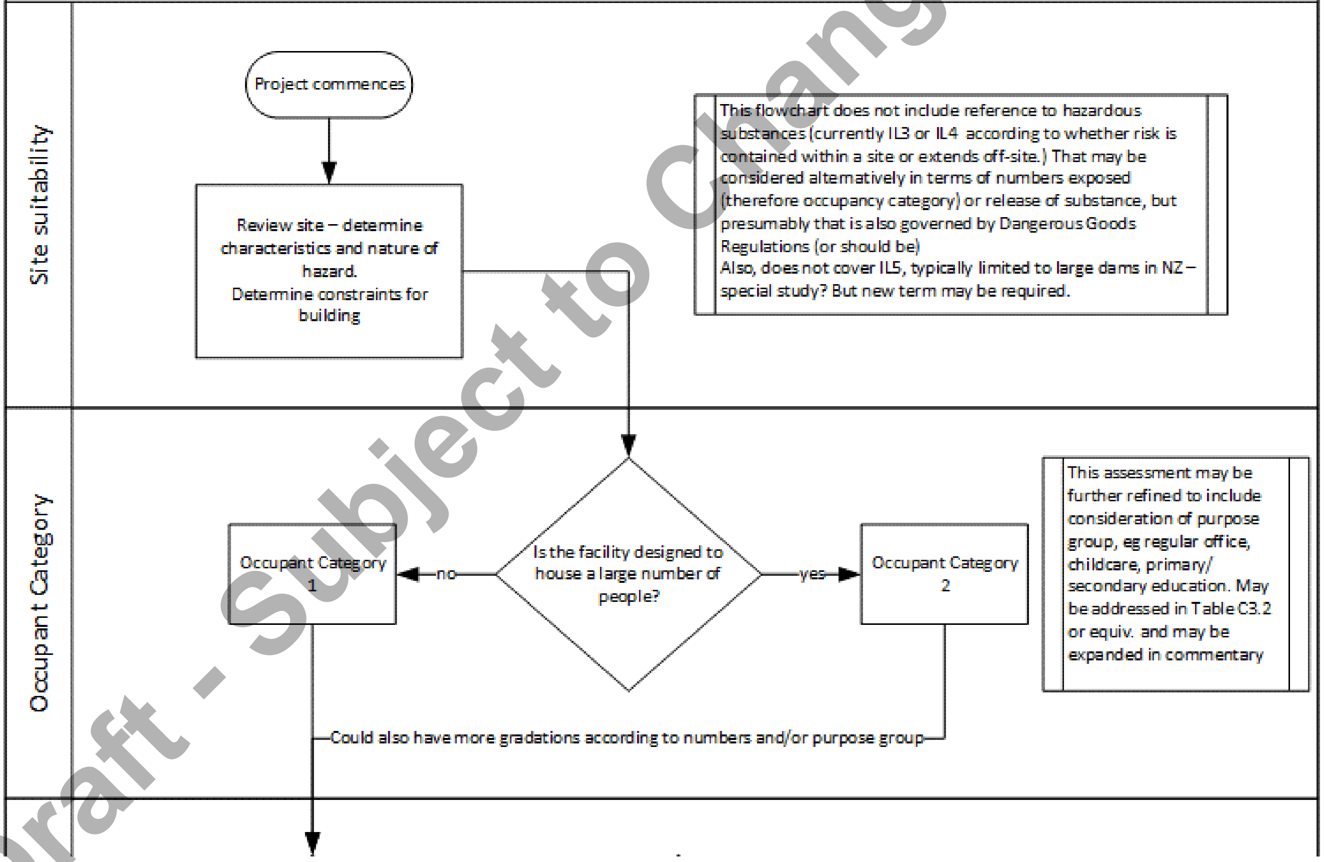
Purpose of Use Category

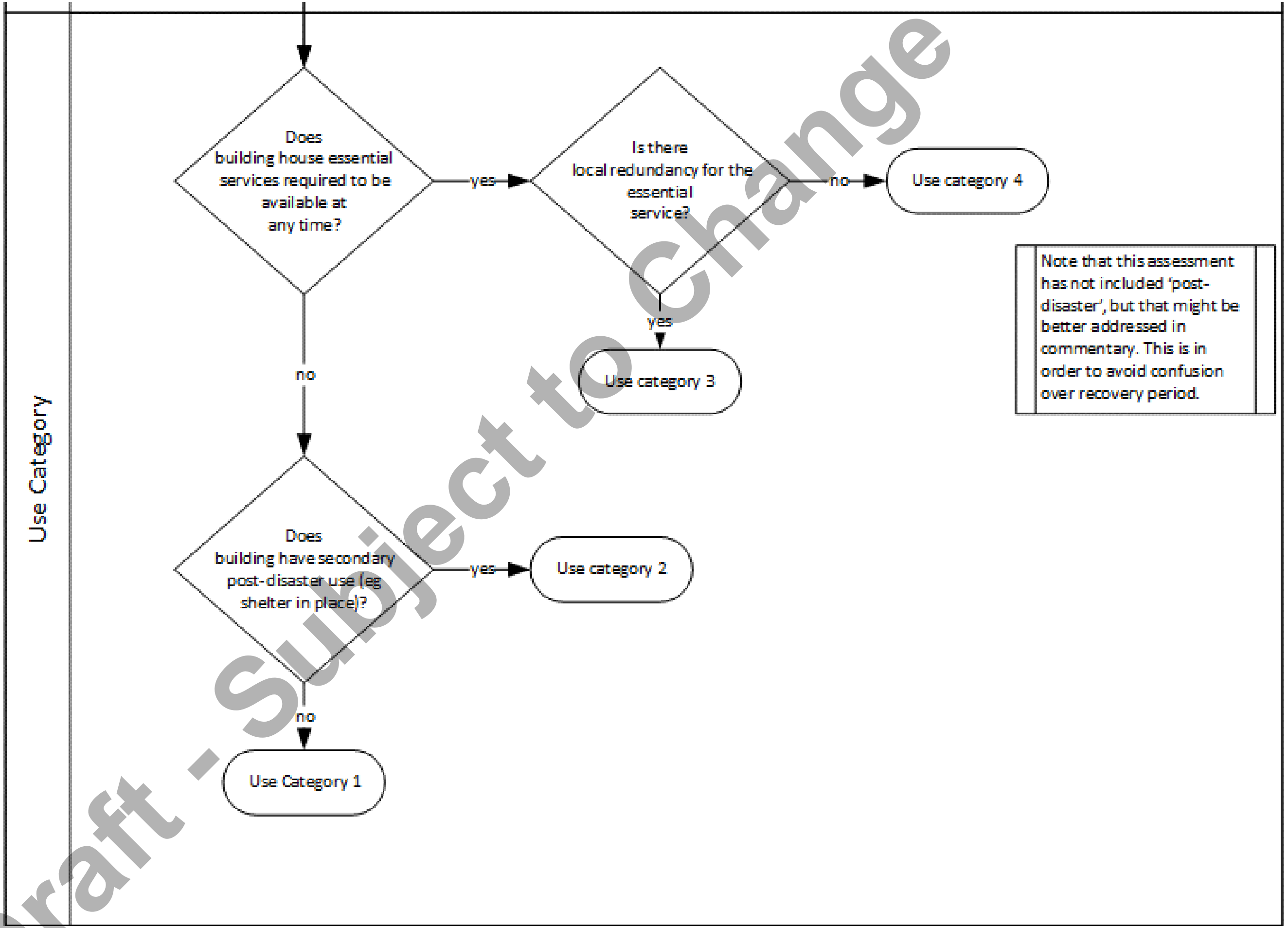
- Identify constraints on use for site/buildings?
- Allow evaluation of non-load related design elements
  - Set limits and thresholds for different UC levels
  - Restrict use of some building typologies, or require greater evaluation

Alternative to current IL structure

19 March 2024

Importance Level Issues Group




Use Category
Does building house essential services required to be available at any time?
yes
Is there local redundancy for the essential service?
no
Use category 4
yes
Use category 3
no
Does building have secondary post-disaster use (eg shelter in place)?
yes
Use category 2
no
Use Category 1
Note that this assessment has not included 'post-disaster', but that might be better addressed in commentary. This is in order to avoid confusion over recovery period.

SRWG Stage 2

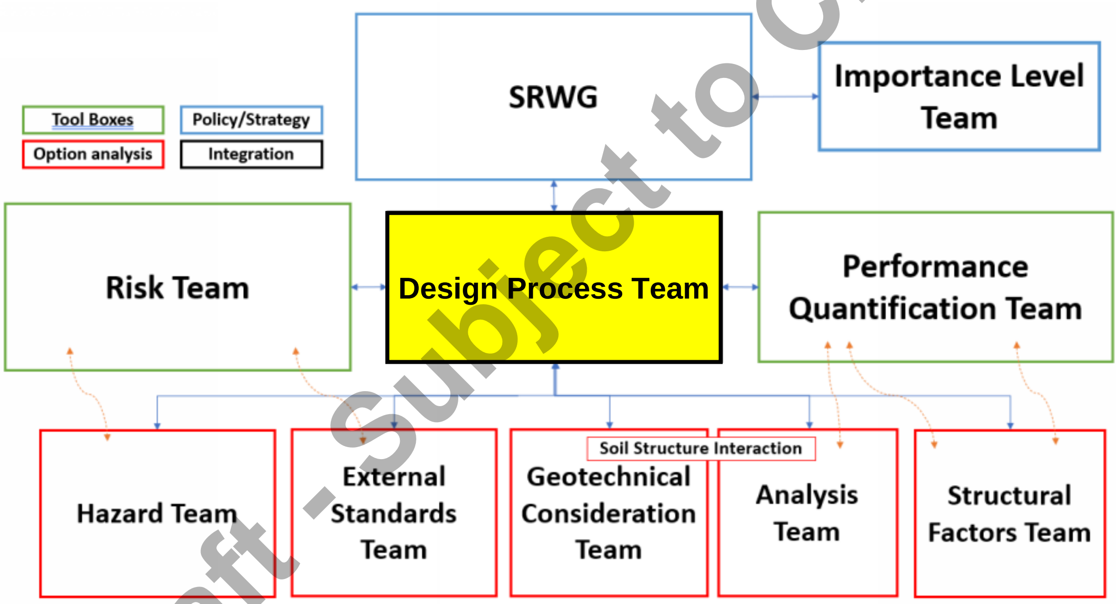
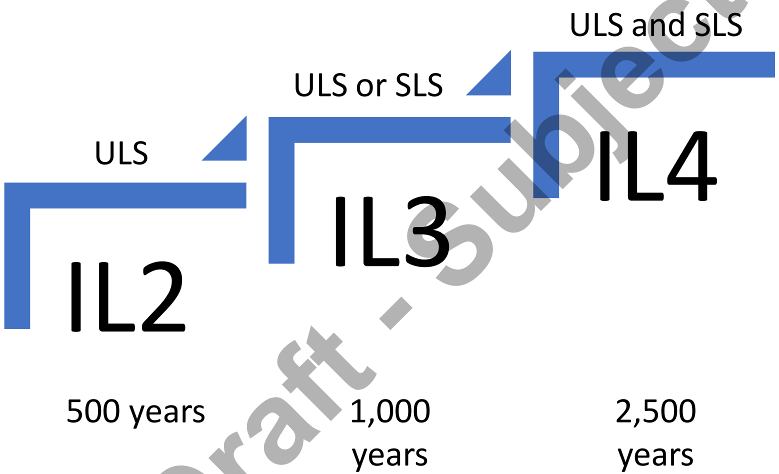
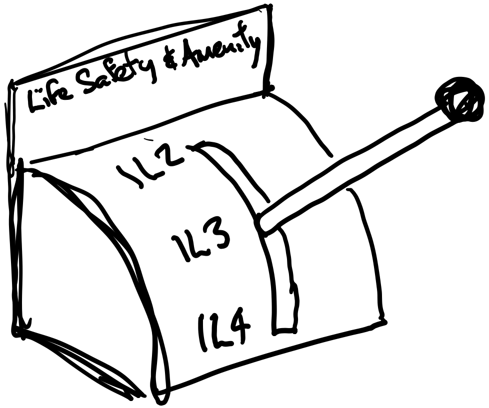


Figure 6. Organisational Structure for Stage 2

Current Approach

Determine Importance Level → Assume a ductility → Derive design actions → Size for stiffness → Design for strength → Check conditions → Capacity design → Parts and Components

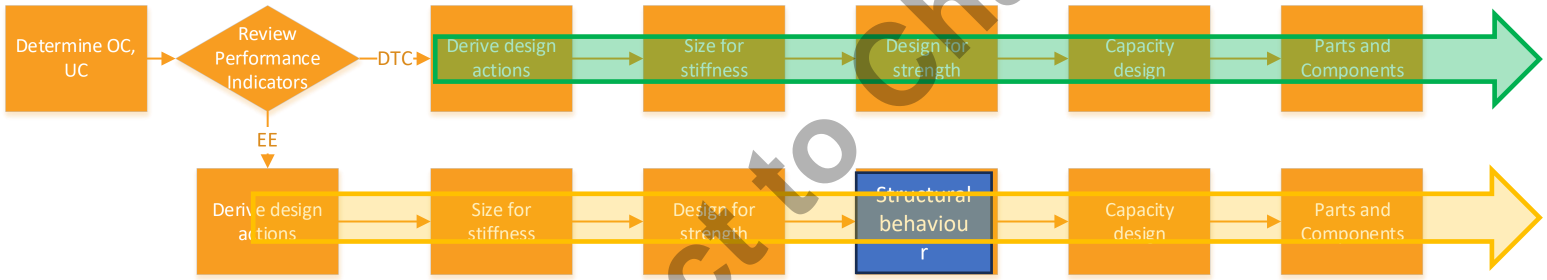


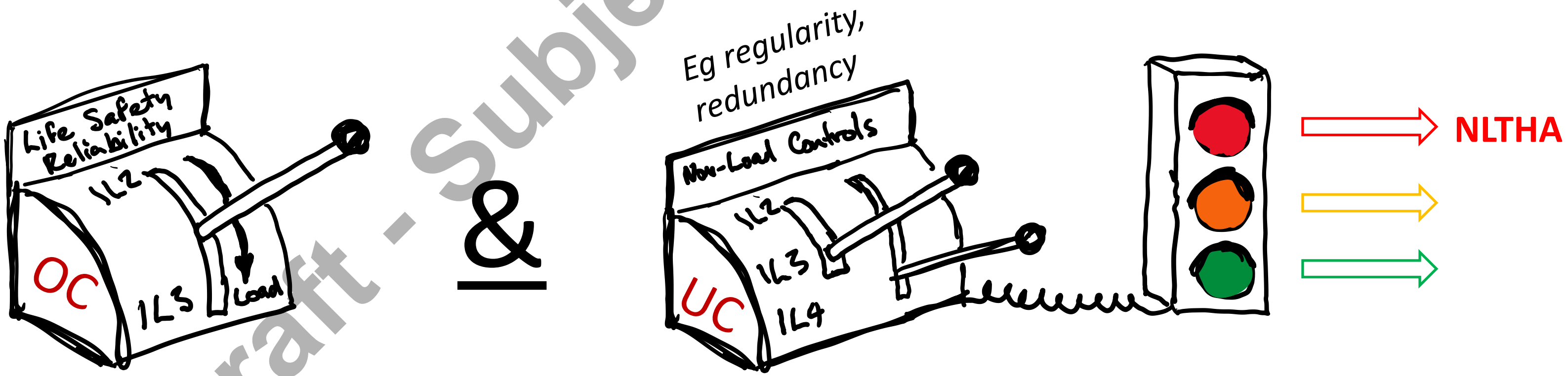


All x 1.5 collapse prevention →

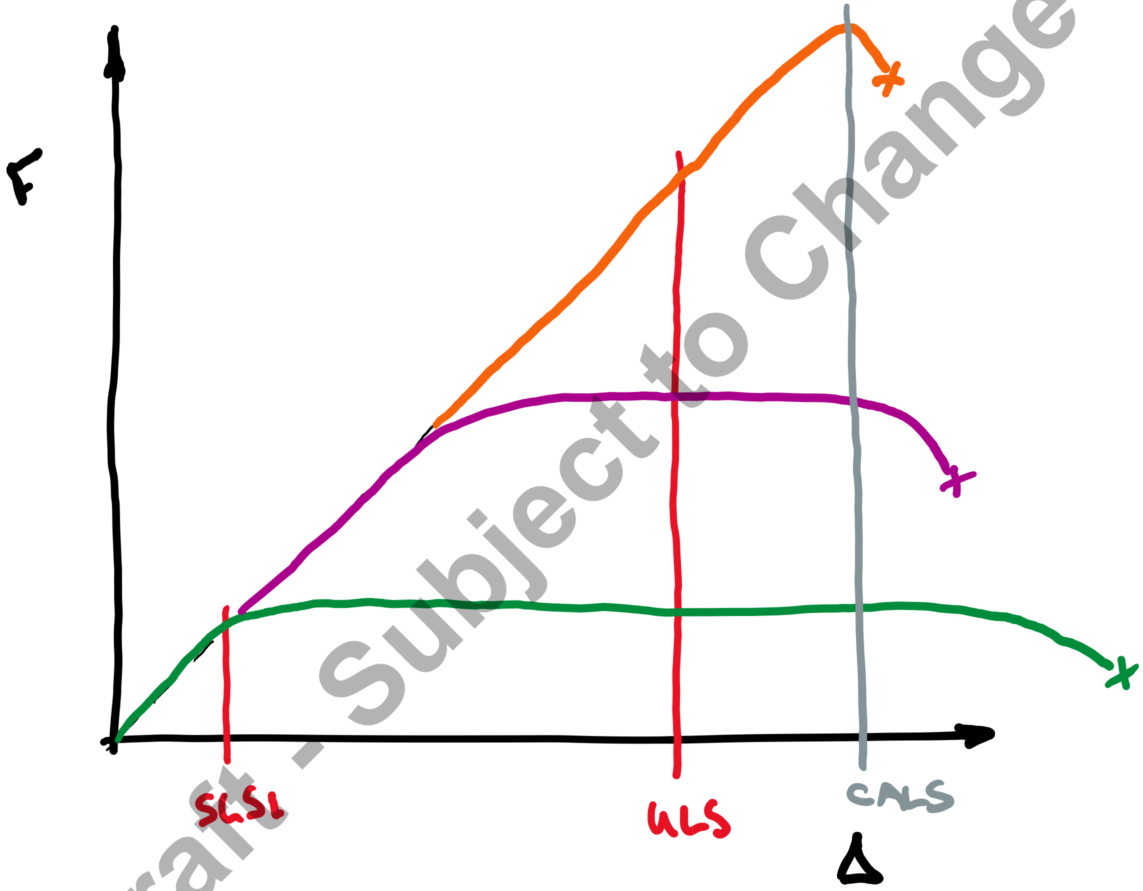
?

Future Approach?

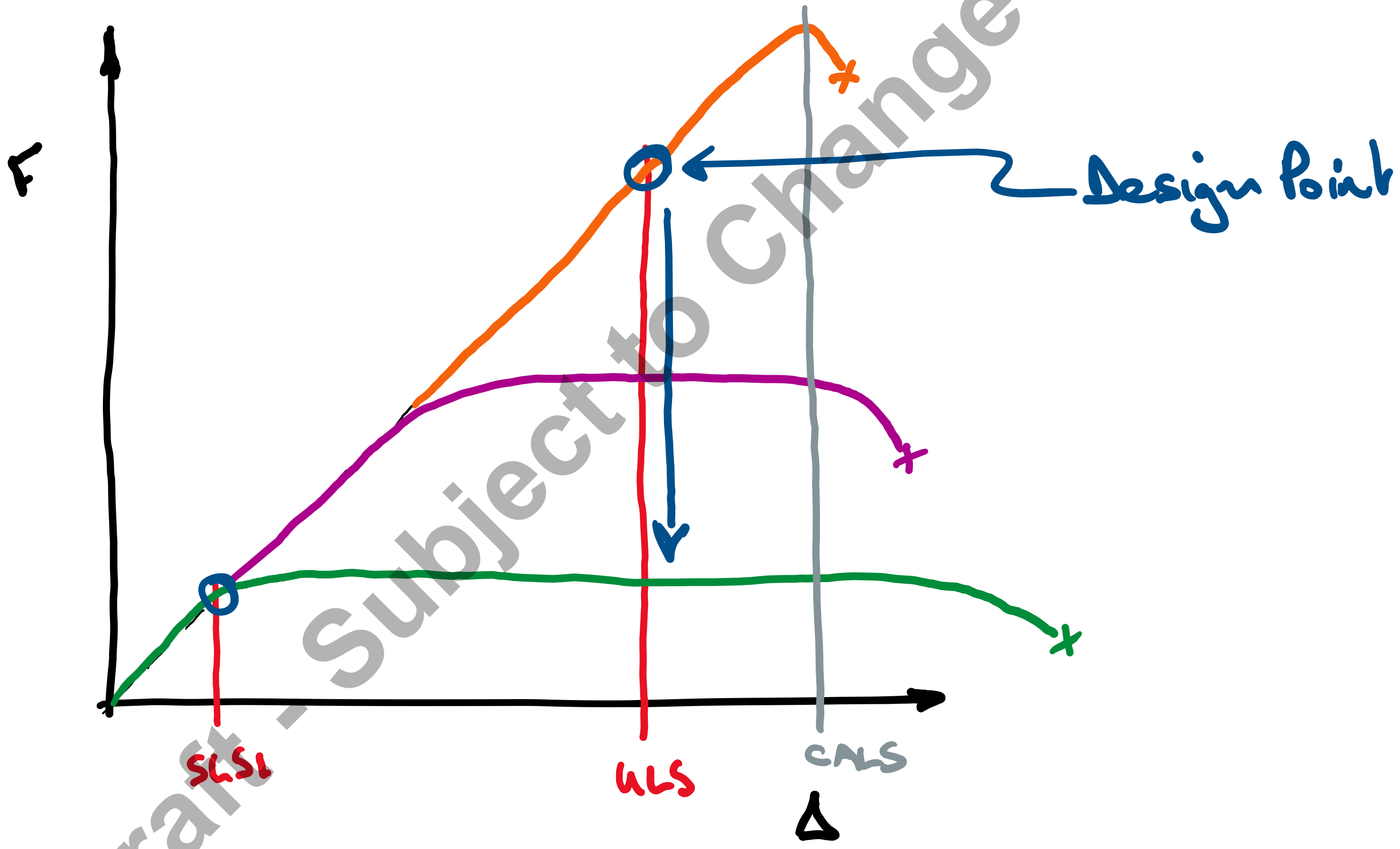




Now



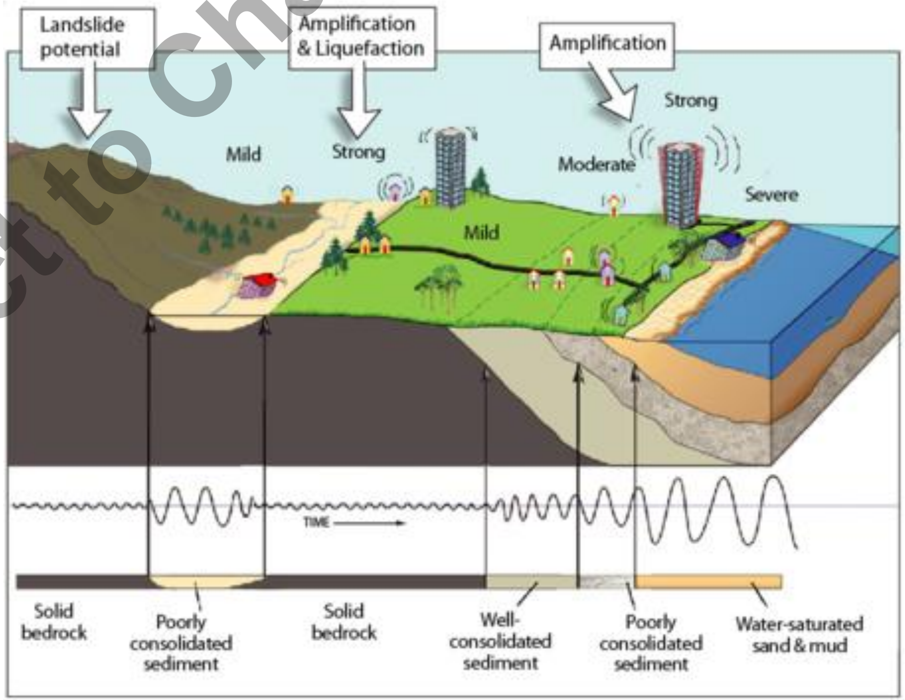
Now



Factors Influencing Building Performance

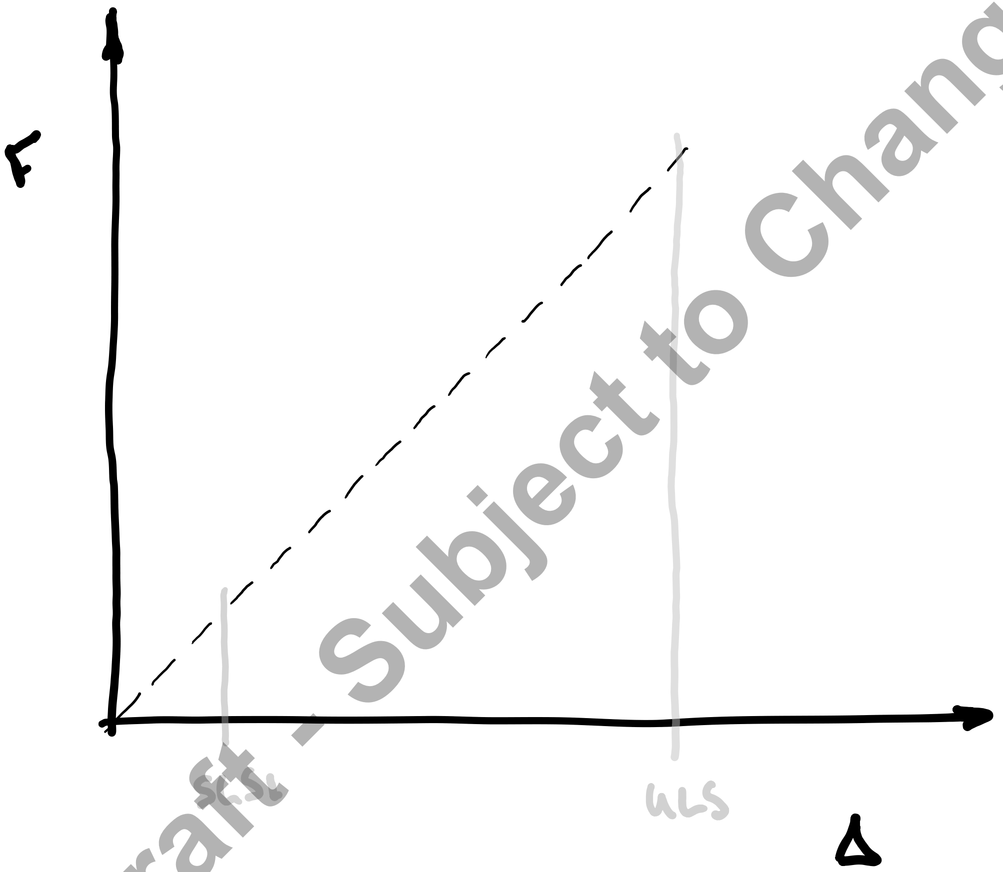
- Siting
- Load paths
- Regularity
- Redundancy
- Ductility – add, don't subtract…
- Construction quality
- Post-construction maintenance
- Alterations

- Oh yes – design loading… (SLS2)

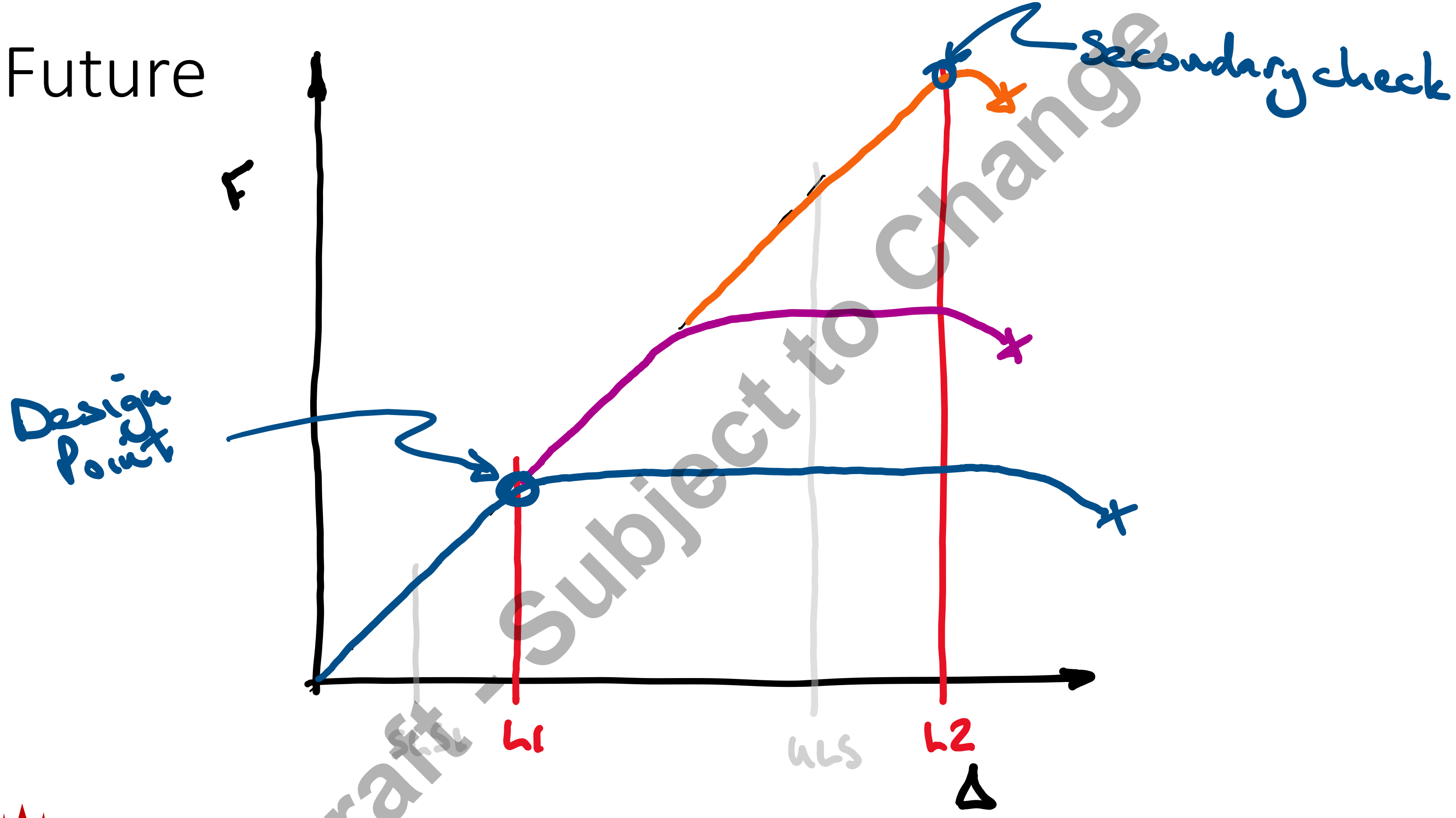


Source: Science Education Resource Center at Carleton College

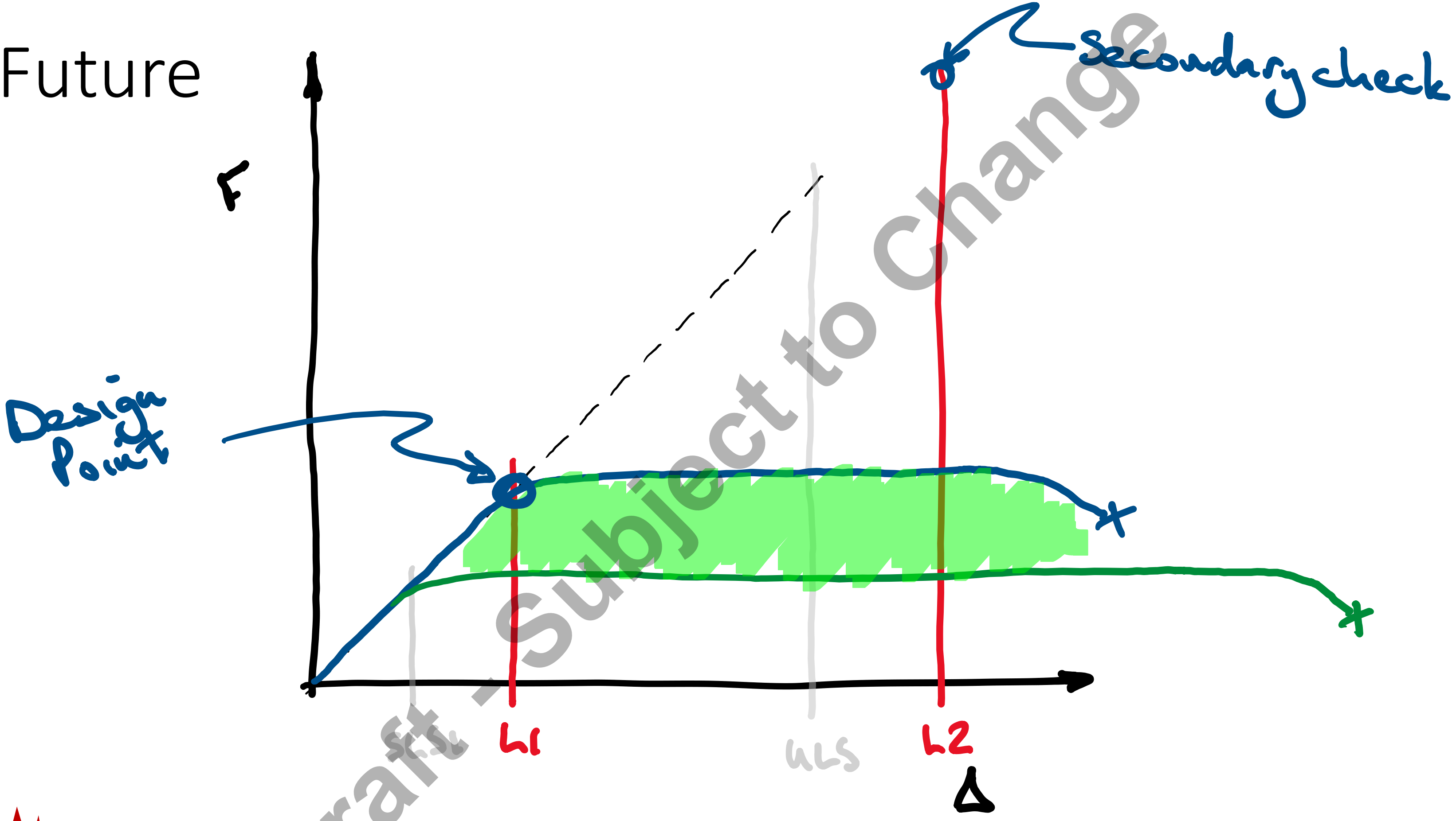
Future



Future



Future



Use Categories in Action

Use Category / Feature	UC1 (current IL2)		UC2		etc…	
	DTC	EE	DTC	EE	DTC	EE
Vertical irregularity	index< x_1	x_1≤index<y_1	index< x_2	x_2≤index<y_2		
Horizontal irregularity	index< m_1	m_1≤index<n_1	index< m_2	m_2≤index<n_2		
etc…						

Notes:

1. DTC = limit to be applied for designer to follow deemed to comply design approach.
2. EE = range with hard limit (if deemed necessary) for explicit evaluation, using any design approach.

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Why?

- Uniform hazard vs uniform risk
- Potential for change in design approach to mitigate possible outcome of reducing hazard
  - e.g. maintain target AIFR, but reduce hazard level, by eliminating lower end of distribution.
  - But only allow where non-load factors are optimised for performance
- How?

  → Risk Team

  → Structural Factors Team

  → Analysis Team

Structural Analysis
Structural Factors
External Factors

SRWG Phase 2

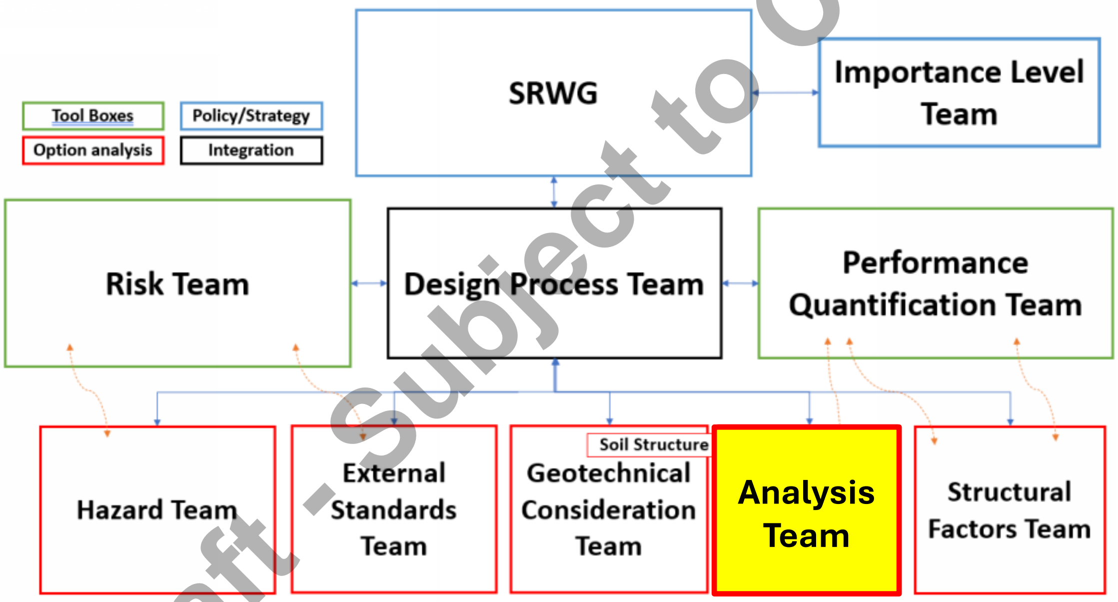
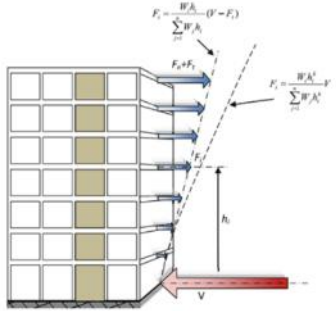


Figure 6. Organisational Structure for Stage 2

Analysis Team



Members
Tim Sullivan
Stuart Oliver
Nic Brooke
Tom Francis
Kieran Haymes
Arun Puthanpurayil
Reagan Chandramohan
Maxim Millen

Goal

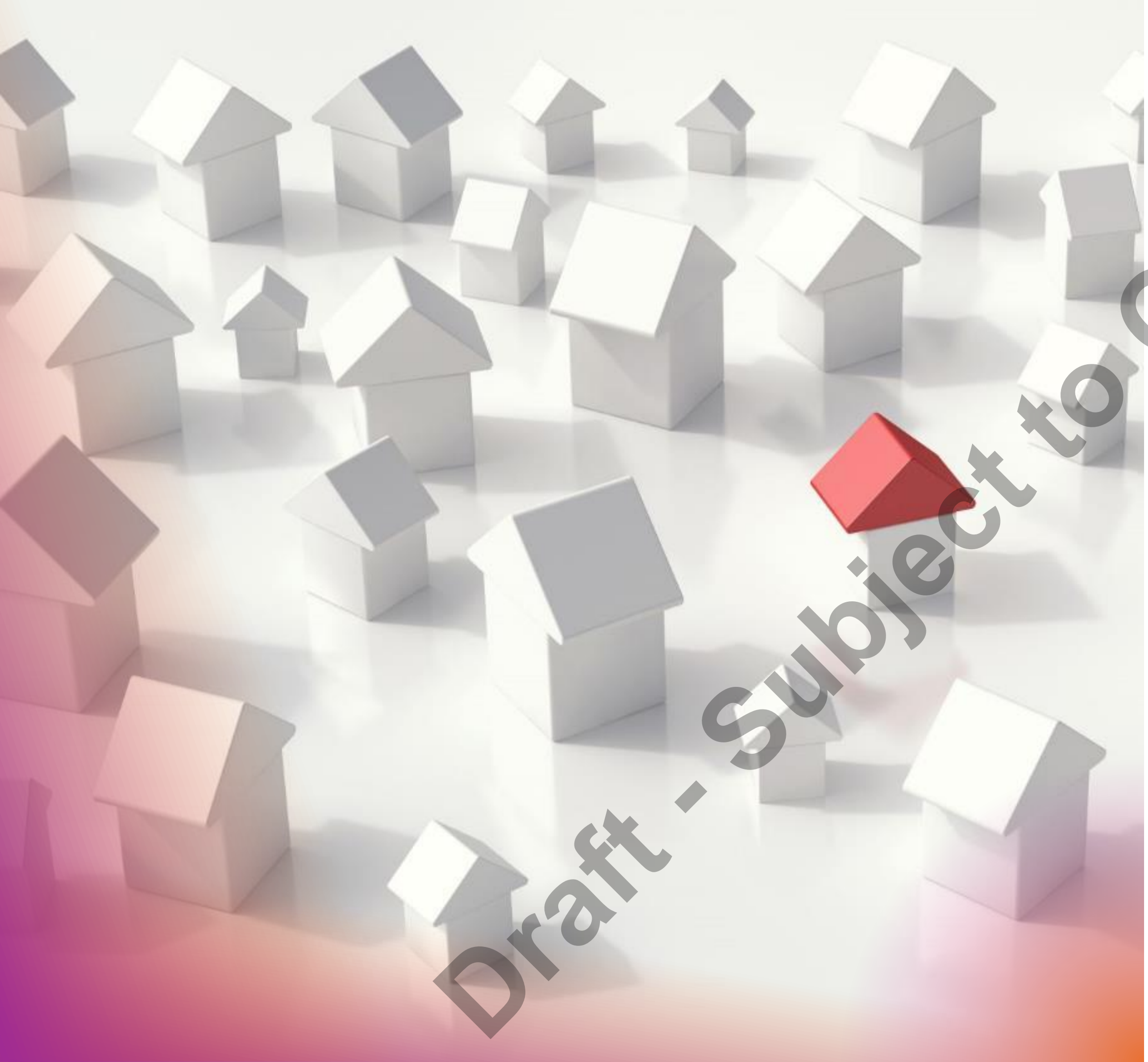
Set provisions for structural analysis that limit risk to acceptable levels, whilst enabling efficient design

Analysis Team

- Identify what updates and restrictions should be introduced for structural analysis to effectively achieve the life safety objectives of the Building Code
- Consider how soil structure interaction should be addressed as part of the structural analysis process

Analysis Team

- Restrictions & improvements to elastic analysis methods
  - Equivalent static & Modal response spectrum methods
- Potential update to NLTHA methods
- Consider a pushover analysis option
- Review the analysis provisions relating to capacity design
- Analysis provisions for floor diaphragms
- Considerations of SSI as part of structural analysis



Aim

- Similar buildings should get similar results from the different methods of analysis
- Analysis provisions should lead to similar risks and therefore performance

SRWG Phase 2

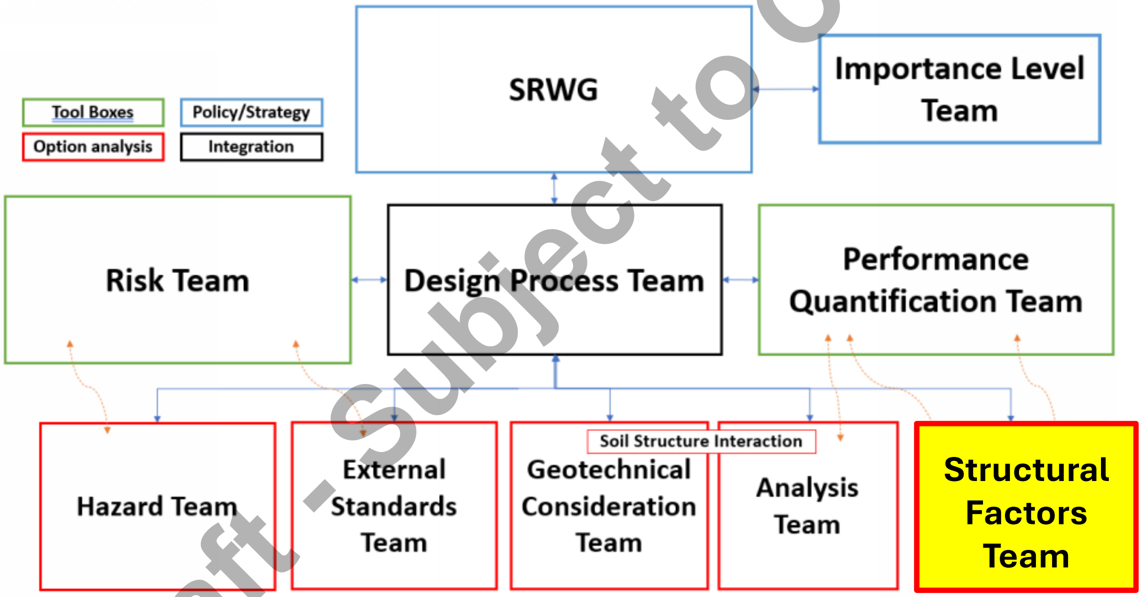


Figure 6. Organisational Structure for Stage 2

Structural Factors Team

Members

Anna Philpot

Didier Pettinga

Rowan Ballagh

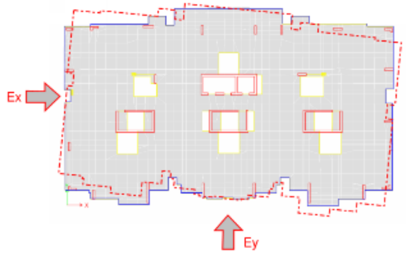
Greg Macrae

Dion Marriott

Max Stephens

Goal

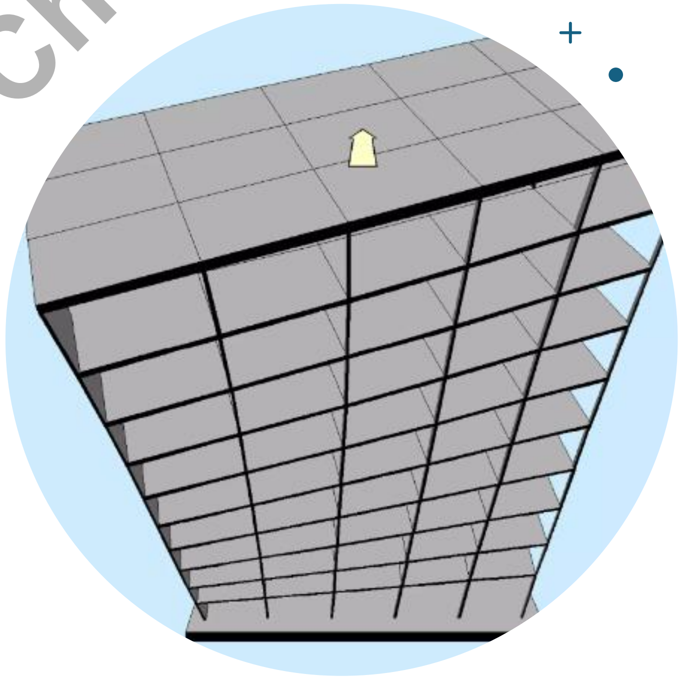
Recognise the impact structural configuration has on building behaviour and develop design provisions to reflect this.



Scope

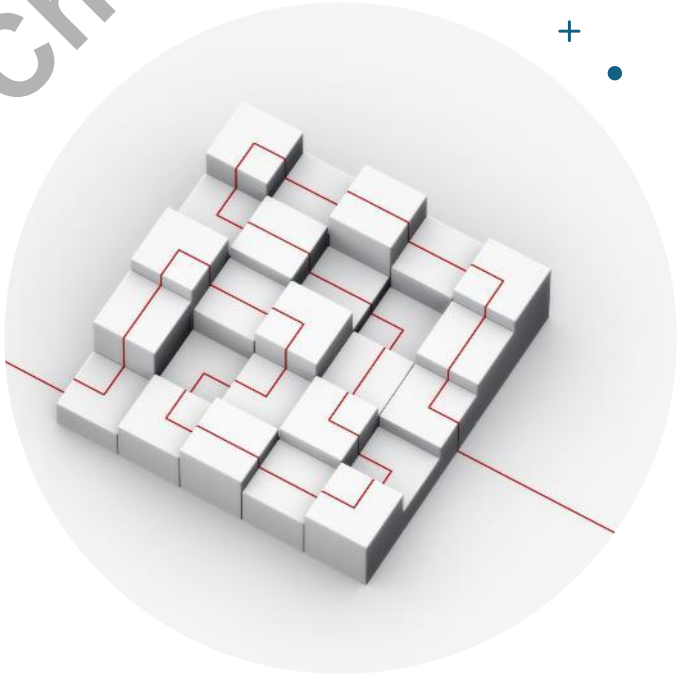
More complex aspects of structural behaviour including

- Behaviour driven by irregularities
- Behaviour driven by p-delta, non-linear torsion, ratcheting (including interaction with irregularities)



Aim

- Promote adoption of well configured structures through simpler design approaches and/or reduced design loads (or no load penalties).
- Develop practical design requirements, including simplified methods or deemed to comply when certain structural configurations are satisfied.



SRWG Phase 2

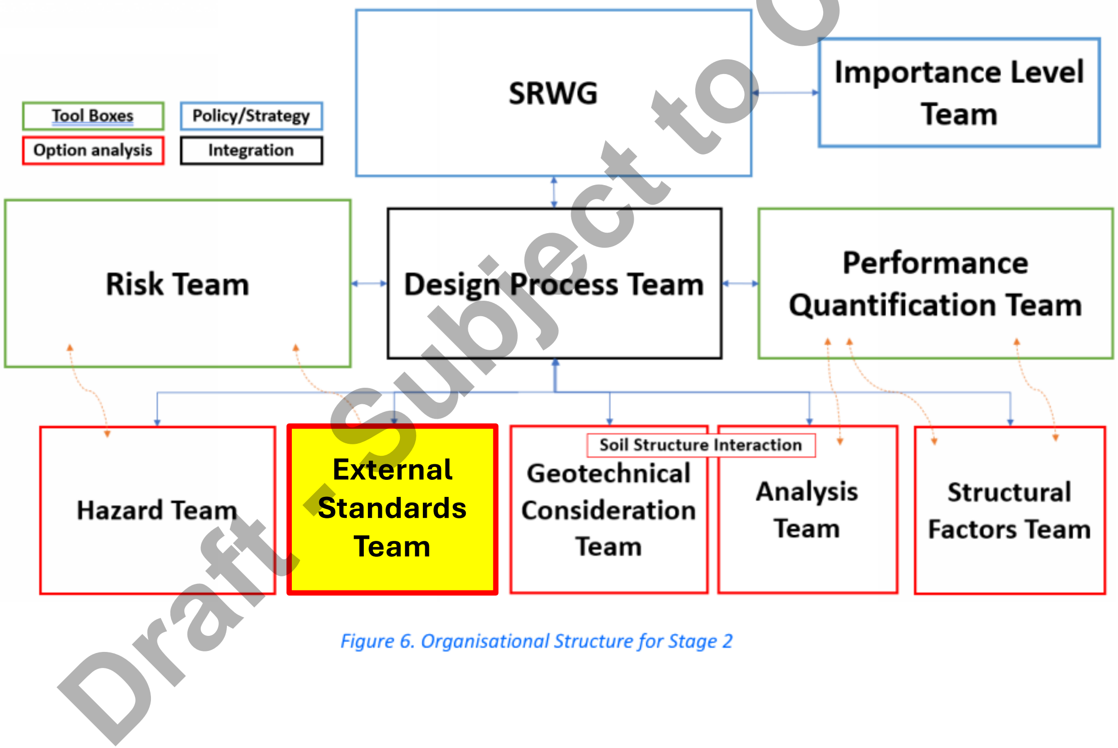


Figure 6. Organisational Structure for Stage 2

External Standards Team

Team Members

Michelle Grant

Rick Henry

Glenn Houston

Jaimie Whitehead

Jan Stanway

Tim Shannon

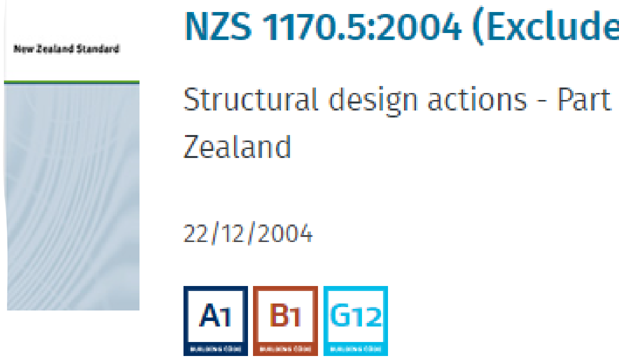
AS/NZS1170.5 Appendix D aims to identify *'the linkages that are required between the material design Standards and this Standard for earthquake design.'*

Goal

External Standards team goal is to prepare an updated Appendix D for the new 1170.5

Scope

- Review how the existing external standards respond to the current instructions in 1170.5 (concrete, steel, timber, masonry, NSE)
- Inconsistencies, gaps, what needs to be addressed but isn't
- Review some case study buildings through the lens of how the design to the Material Standard meets (or otherwise) the objectives of 1170.5



Scope

- Nominally ductile provisions
- Low rise design instructions
- Outcomes we are getting with our designs and if these are aligned with the performance objectives of the building code

Aim

- Clear articulation of what is required by the External Standards to achieve the intent of the updated 1170.5 Loading Standard.
- A reasonably comprehensive briefing/background summary to allow interpretation for external Standards
- Clear requirements for low-rise and mixed system buildings (to extent deemed necessary to achieve performance objectives).

Performance Quantification

SRWG Phase 2

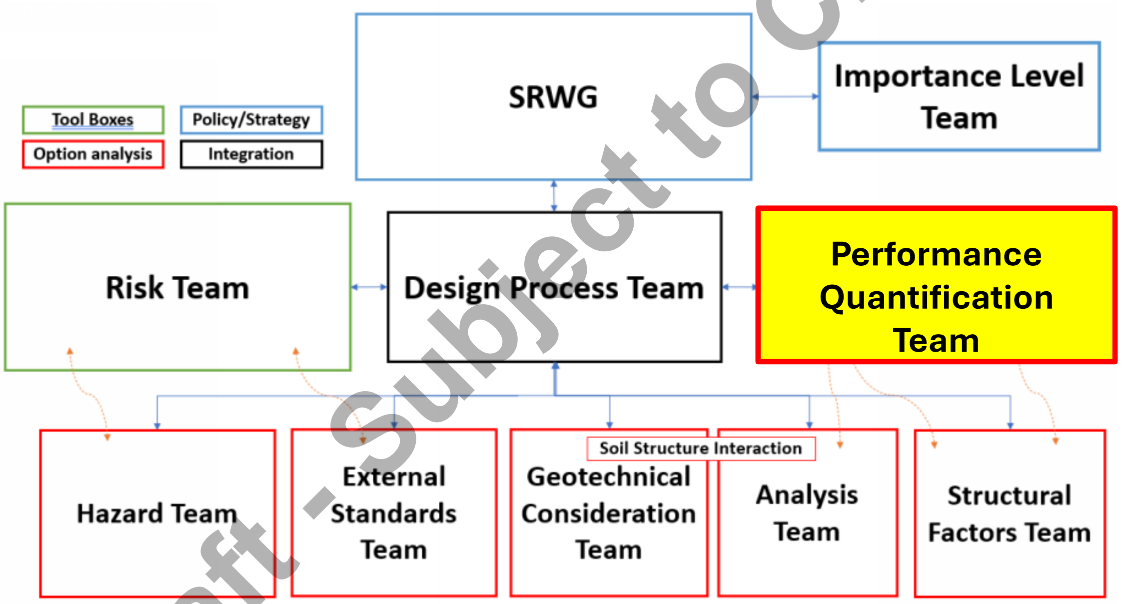
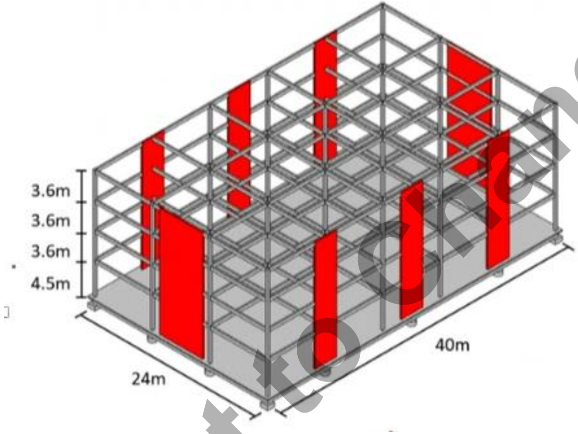
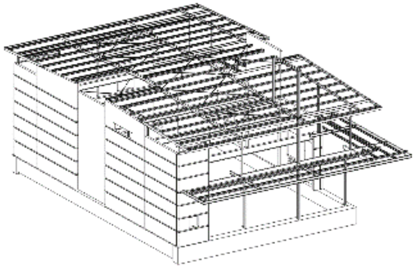


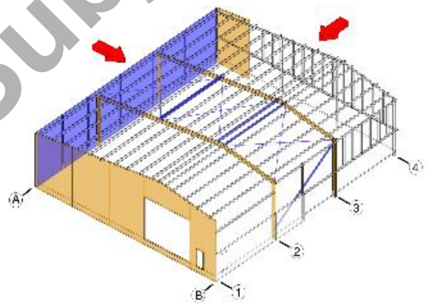
Figure 6. Organisational Structure for Stage 2

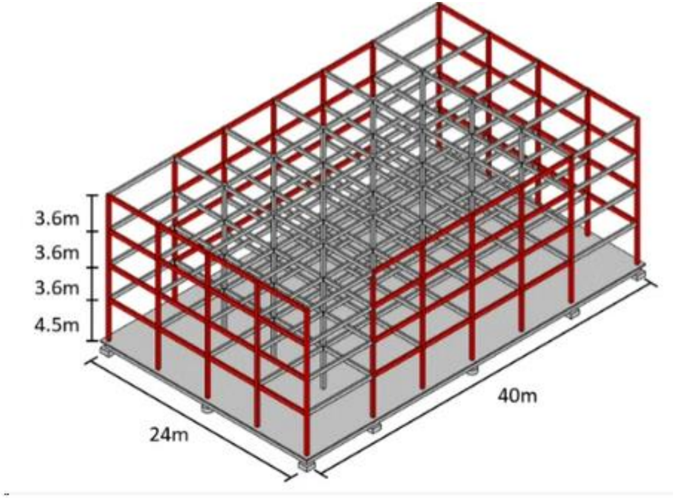
Case Study Buildings

- Used to make sure the proposed provisions are practical
- Some will be modelled by the Performance Quantification Team to explore the impact of the proposed changes on performance metrics









Case Study Buildings

Case Study Building	No. Storeys	Vertical Lateral System - X (longitudinal)	Vertical Lateral System - Y (transverse)	Diaphragms
A	1	"3604 bracing walls"	Steel MRF/portal frame and "3604 bracing walls"	3604 "ceiling diaphragms"
B	3	SED bracing walls lower level, "3604 bracing walls" upper	SED bracing walls and Steel MRF lower level, "3604 bracing walls" upper	SED ply diaphragms
C	3	Plywood bracing shear walls	Steel moment frames	SED ply diaphragms
D	1	RC walls	Steel moment/portal frame	Mix of RC and steel bracing
E	1	Cantilever (out of plane RC panel)	Cantilever (out of plane RC panel)	Steel bracing
F	1.5	CBF/Tension bracing	Steel portal frame	Steel bracing
G	Mid to high rise	RC walls	RC walls	RC diaphragm
H		Steel moment frame	Steel moment frame	RC diaphragm
J		EBF	EBF	RC diaphragm
K		RC Wall	Steel moment frame	RC diaphragm
L		RC wall and steel MRF dual system	RC wall and steel MRF dual system	RC diaphragm
M		BRB frame and possibly steel MRF	BRB frame and possibly steel MRF	RC diaphragm

Still being refined!

+CLT walls & core?

+Timber portal frame?

+??

BUILDING PERFORMANCE

Key issues with current system to be considered in Stage 2

- Critical role of **irregularities** in driving building damage is not fully recognised.
- **Analysis** provisions are out of date leading to uncertainty in estimated local demands and global response.
- Inconsistent alignment between 1170.5 and **external standards**, including capacity design requirements.

SEISMIC RISK WORKING GROUP B1/VM1
Project Stage 2 - Geotechnical Issues

- Background and context to the development of the Geotechnical Issues Team
- Brief presentation of the five primary issues identified to date

15 April 2024

Geotechnical Issues - Background and context

Stage 1 of the B1/VM1 project introduced a consideration of geotechnical issues into the Technical Specification (TS 1170.5)

- Not enough time to fully incorporate all geotechnical considerations
- Completely new content – hence a 'soft introduction' of geotechnical considerations was deemed important

Key objectives:

- Succinct provision of minimum requirements in Section 2 (Verification)
- Provide commentary to highlight important issues and references to the NZGS modules and selected other guidance / standards that might be useful
- Set out the seismic hazard parameters / values to be used for geotechnical assessment / design

Geotechnical Issues - Background and context

Stage 2 of the B1/VM1 project aims to incorporate geotechnical considerations in the design process.

- Five primary items have been identified for the scope of the project.
- Each item is intended to address a specific gap in the current design process/considerations.

The specific outputs are not yet fully developed, but anticipated to include:

- Framework and concepts for incorporating geotechnical inputs in the design process
- Methodologies for specific aspects of the design process
- Incorporation in the next version of the TS – both normative and commentary – likely development of a new ‘geotechnical’ section
- Highlight areas where new or additional guidance may be needed (external to the TS)

Geotechnical Issues to be addressed

(1) Design load limits accounting for nonlinear soil behaviour

Objective: examine and possibly modify high-frequency design load values (PGA and Sa) from NSHM2022 to account for effects of nonlinear soil response.

- Will be coordinated with geotechnical industry group currently looking into this issue

Geotechnical Issues to be addressed

(2) Step-change behaviour

Objective: Develop concepts and methodology for consideration of step-change behaviour in the design process.

- Identify engineering problems involving SCB
- Characterize SCB and its effects on a problem-specific basis
- Quantify key characteristics of response and thresholds
- Develop methodology for consideration of SCB in design

Geotechnical Issues to be addressed

(3) Treatment of settlement and bearing capacity in design

Objective: Define philosophy, principles, criteria and hierarchy in design of foundations by considering (S) and (BC) in the context of the performance of the soil-foundation-building system.

- Review International codes / standards
- Develop design philosophy/principles, objectives and criteria
- Consider gravity vs seismic loads
- Consider the role of (S) and (BC) in design calculations and checks

Geotechnical Issues to be addressed

(4) Soil-Structure Interaction

Objective: Develop geotechnical guidance / input to inform structural design for SSI / analysis.

- Review recent SSI guidance and International codes / standards
- Concepts (models) for consideration of soil flexibility in SSI models / analyses
- Determination of soil springs for various levels of nonlinearity
- Consideration of equivalent-static analysis and dynamic SSI
- Combining inertial and kinematic loads

Geotechnical Issues to be addressed

(5) Liquefaction and lateral spreading considerations in design

Objective: Develop specific guidance (possibly specific methodology, assessment/design approaches) for consideration of liq / lateral spreading in design process.

- Liquefaction-induced building settlement
- Loads / effects of lateral spreading

Thank you

Thank you.

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