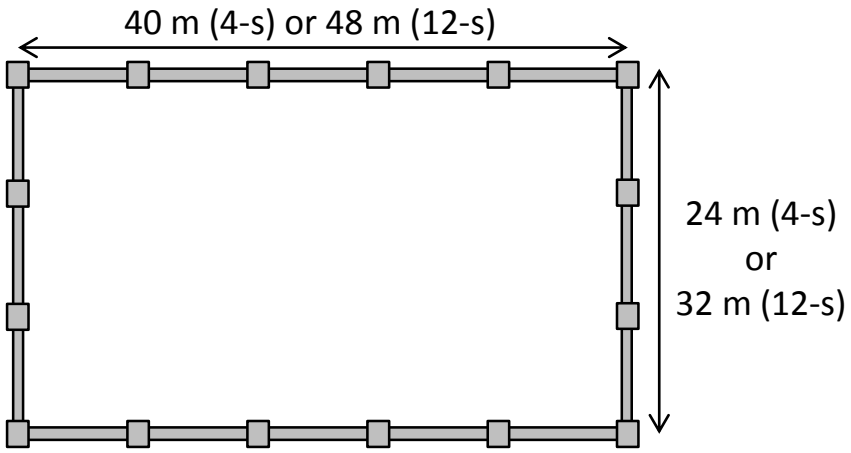
Loss Assessment Studies

- Objective
  - Provides typical building layouts for use in seismic loss assessment studies for quantifying the relative performance of structural systems (e.g. low damage systems)
- Requires
  - Building geometry and mass for building design
  - Building component layout and density
  - Component detailing and construction cost
  - Others (e.g. repair method, cost, and duration)

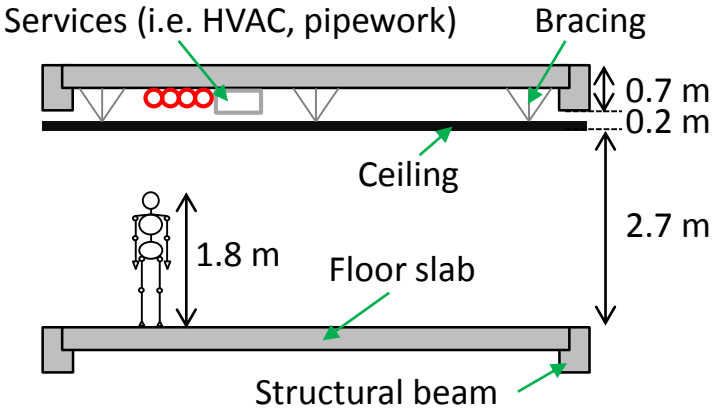
Case study buildings

- Building type and geometry
  - 4 storey residential
  - 4 storey office building
  - 12 storey office building

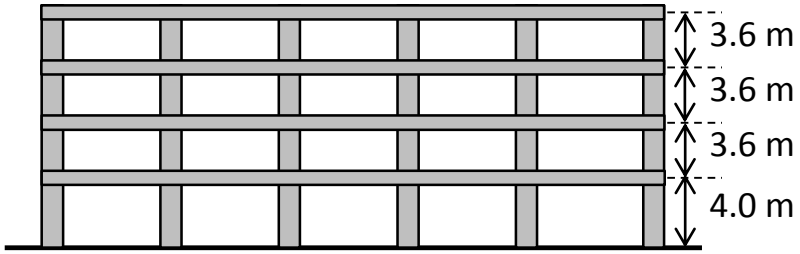


Plan view

(Structural layout not fixed)



Floor level cross section



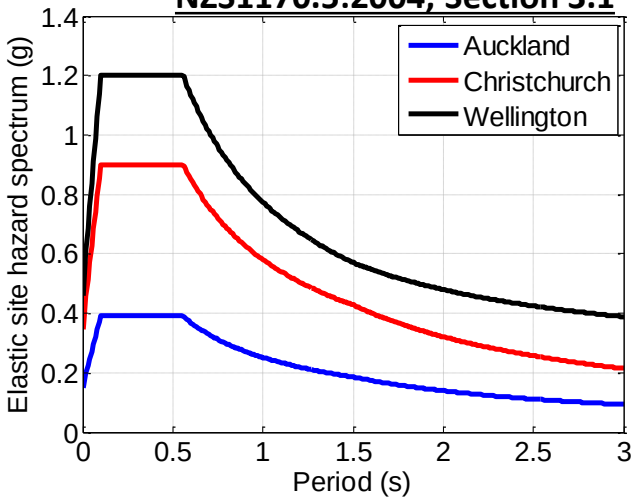
Front Elevation

(Structural layout not fixed)

Case study buildings

- Building location
  - Auckland, Christchurch, and Wellington
  - Ductility detailing
    - Nominally ductile for Auckland
  - Beam span
    - 8 m grid for Wgtn/Chch
    - 12 m grid for Auckland

NZS1170.5:2004, Section 3.1



NZS3101:2006, Table 2.5

Type of structure	Reinforced concrete	Prestressed concrete with bonded non-prestressed reinforcement
1. Nominally ductile structures	1.25	1.25
2. Structures of limited ductility		
(a) Moment resisting frame	3	3
(b) Walls	3	3
(c) Cantilever face loaded walls (single storey only)	2	2
3. Ductile structures		
(a) Moment resisting frame	6	5
(b) Wall		
(i) Two or more cantilevered	$\frac{5}{\beta_a}$	As for reinforced concrete
(ii) Two or more coupled	$\frac{5}{\beta_a} \le \frac{3A+4}{\beta_a} \le \frac{6}{\beta_a}$	As for reinforced concrete
(iii) Single cantilever	$\frac{4}{\beta_a}$	As for reinforced concrete

NOTE –

(1) The ductility factor is a measure of the anticipated overall structural ductility demand which is a function of the appropriate magnitude of earthquake design forces.

(2) In the above table

$1.0 < \beta_a = 2.5 - 0.5A_r < 2.0$

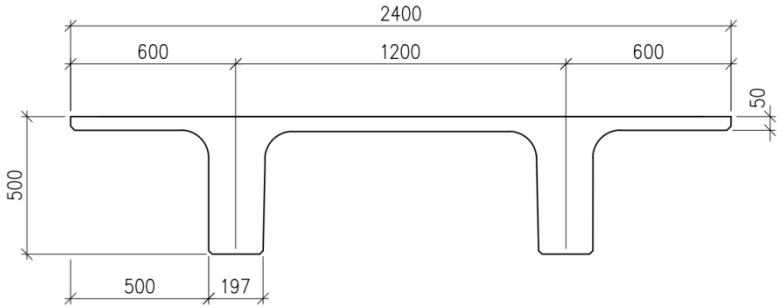
and

$\frac{1}{3} \le A = \frac{T_w L'}{M_{ow}} \le \frac{2}{3}$

Case study buildings

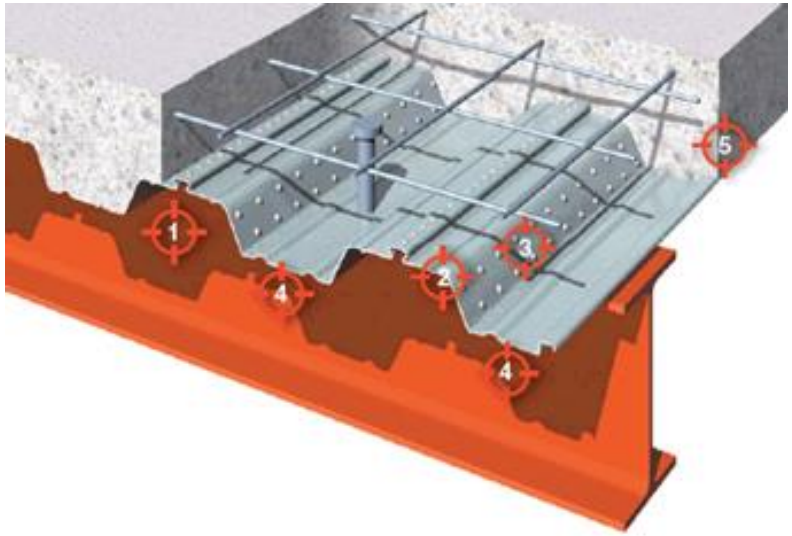
- Building Components
  - Flooring

Retrieved from www.stahlton.co.nz on 26/02/2017)



500 Double Tee Typical Section

Retrieved from www.comflor.co.nz on 26/02/2017)



Composite flooring:

- Steel buildings if not exposed

Retrieved from www.bancrete.com on 26/02/2017)

Double Tee flooring:

- Reinforced concrete buildings
- Steel buildings if exposed

Case study buildings

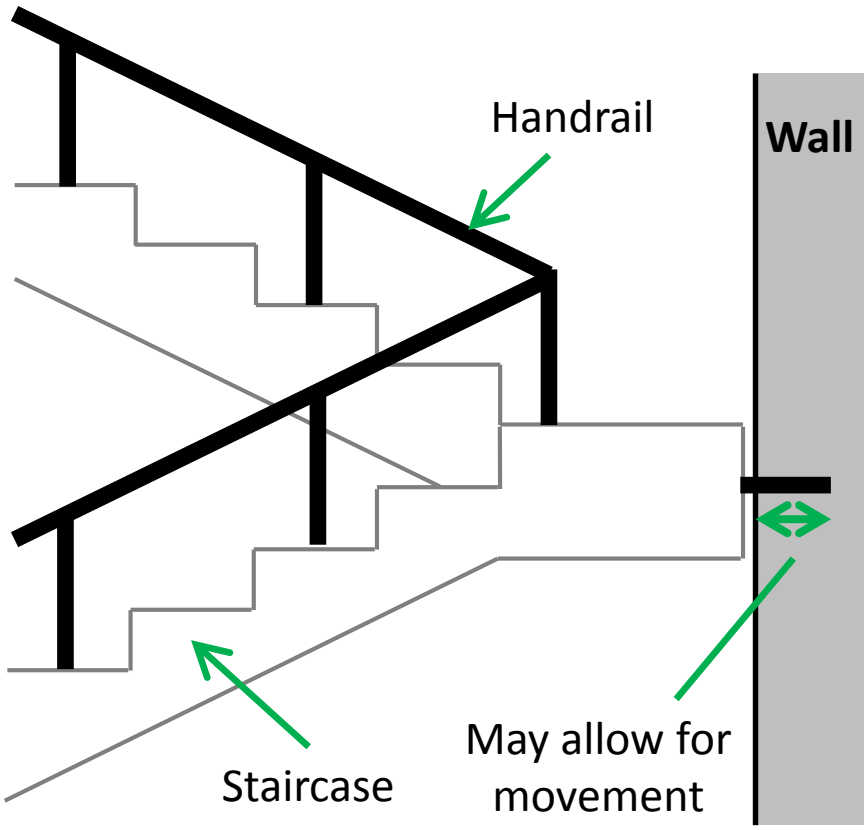
- Building Components (façade)
  - Precast cladding
    - E.g. Ballantynes, Eastgate
    - Connections designed by engineer
    - **Input from Rajesh?**
  - Glass curtain wall
    - Top hung, bottom free to slide
    - Example of supplier – Thermosash, Miller Design
  - Timber wall, plywood membrane
    - E.g. Ngai Tahu building
    - **Not commonly used so exclude?**

Retrieved from www.wilcoprecast.co.nz on 26/02/2017

Retrieved from www.thermosash.co.nz on 26/02/2017

Case study buildings

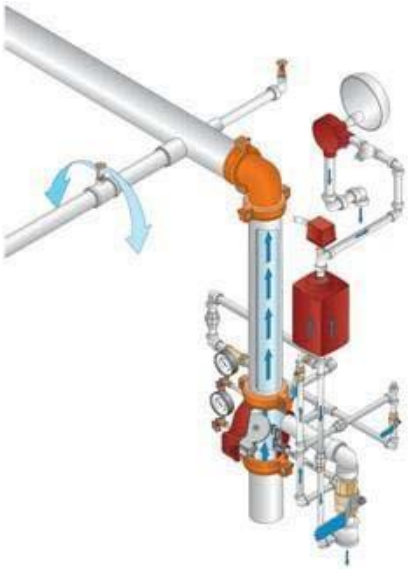
- Building Components (stairs)
  - Staircase
    - Fixed at top
    - Free to move at half-landing or bottom



Case study buildings

- Building Components
  - Sprinklers
    - **Input from mechanical engineers?**
  - Elevator
    - Otis lift (http://www.otis.com/site/nz/)
    - US fragility functions should be applicable
  - Heavy plant
    - Air conditioning units
    - Electrical control panels fixed to walls
    - Server rooms

Retrived from http://www.argusfire.co.nz on 26/02/2017



Retrived from www.airtech.co.nz on 26/02/2017

Case study buildings

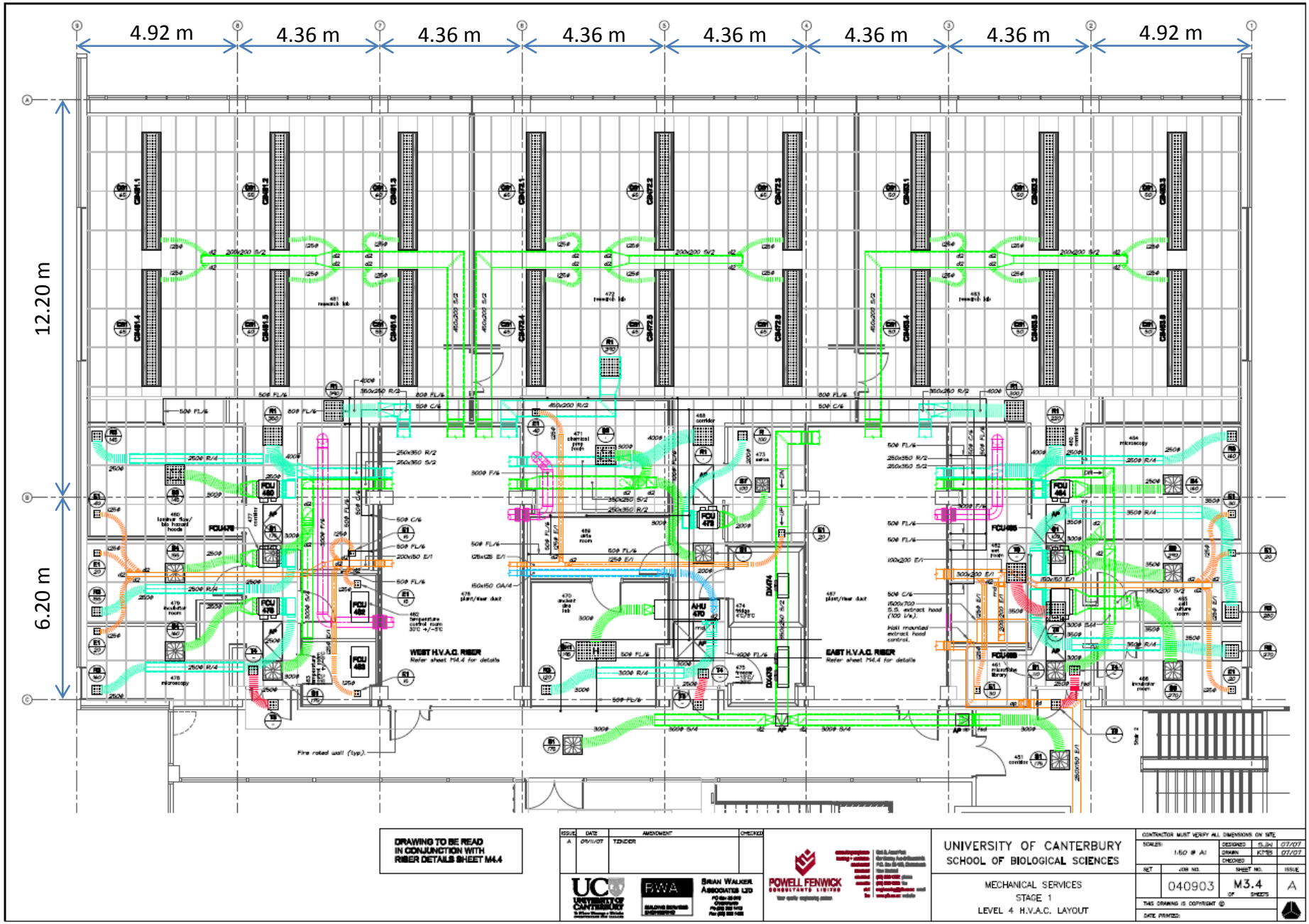
- Building Components
  - Partitions: mainly GIB
    - Example of supplier – RONDO®
    - GIB guidelines
  - Ceilings
    - Example of supplier – RONDO®
    - **Input from Rajesh/Atefeh?**

Retrieved from www.gib.co.nz on 26/02/2017

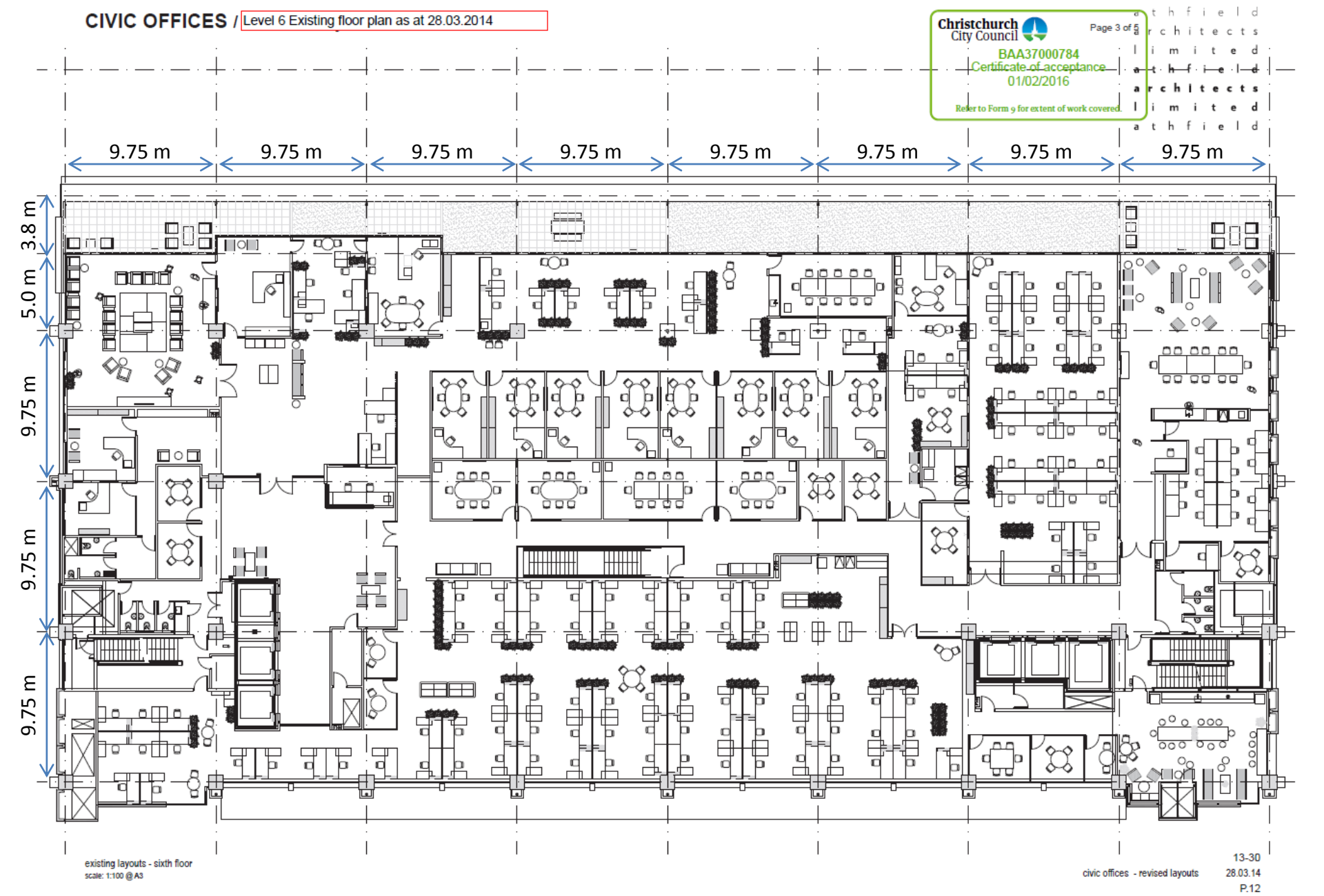
Retrieved from www.cbsgroup.co.nz on 26/02/2017

Case study buildings

- “Typical” layout
  - Collaborators
    - Architects
    - Engineers
  - Building plans
    - Modern buildings (i.e. constructed or refurbished after 2004)
    - Commercial building plans obtained from City Councils
    - **Flagship 3 for residential buildings?**



University of Canterbury Biological Sciences (New Part) – HVAC details

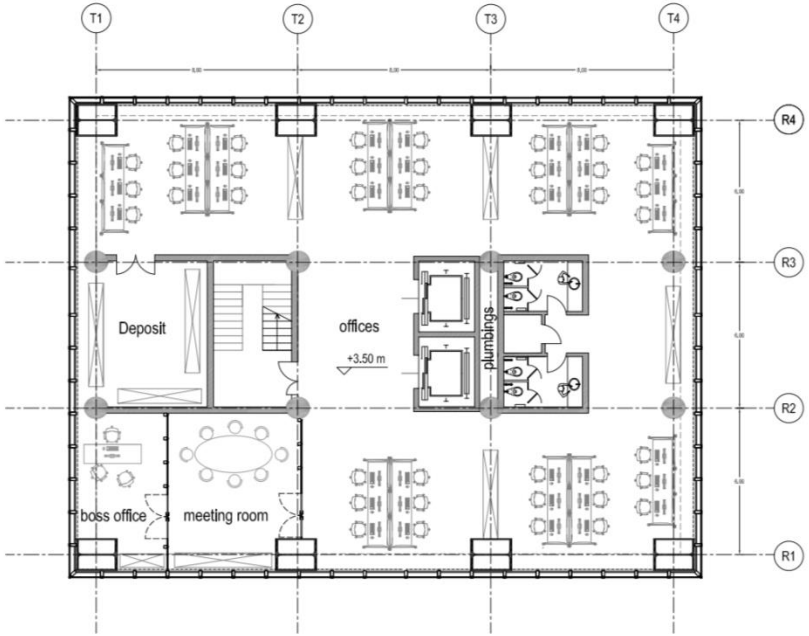


Christchurch City Council Building (53 Hereford Street) – Level 6 details

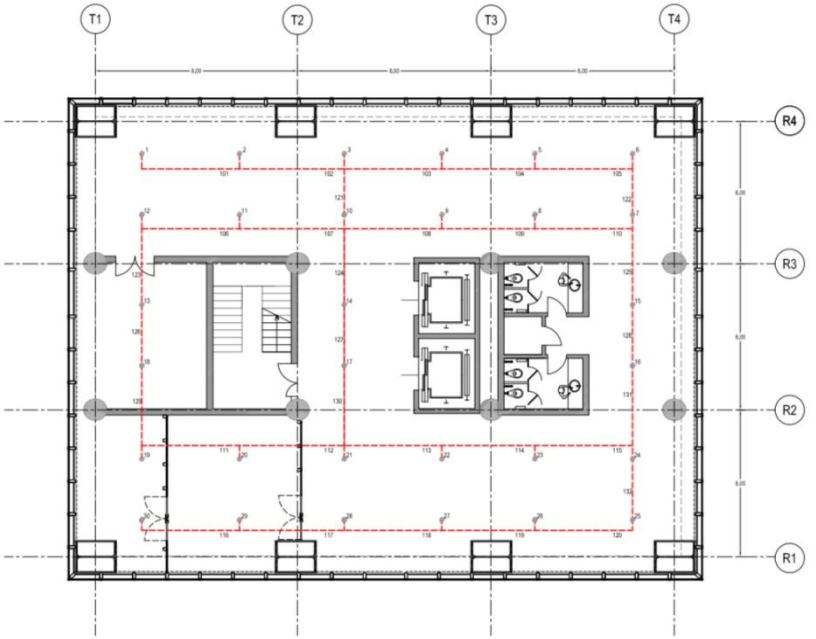
Case study buildings

- "Typical" layout
  - Findings will be used to propose several sample building layouts

Sample residential plan layout



Sample office plan layout

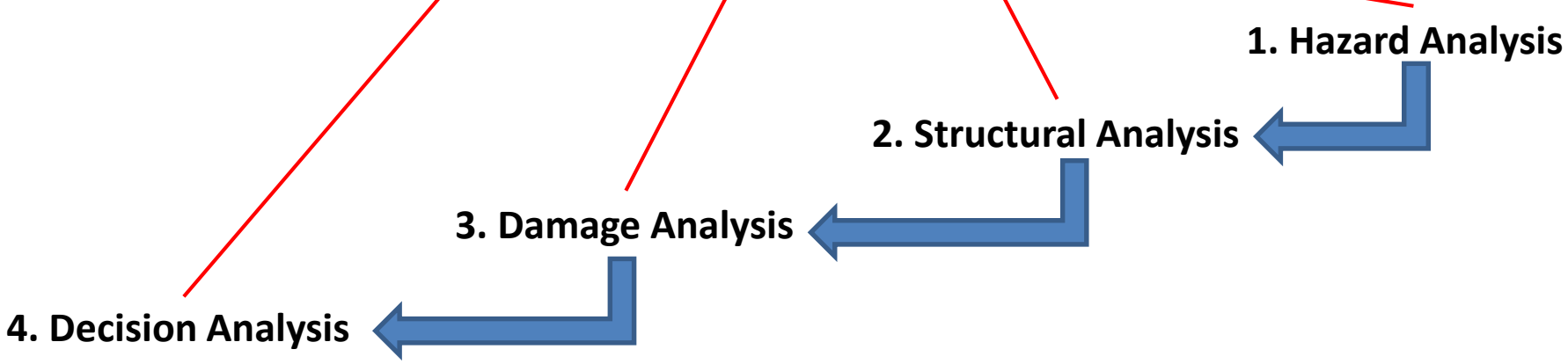


Sample office sprinkler layout

Loss Assessment Studies

- Seismic loss assessment steps
  - PEER PBEE framework (Porter 2003, Deierlein 2004)

$$\lambda[DV \mid D] = \iiint p[DV \mid DM]\, p[DM \mid EDP]\, p[EDP \mid IM]\, \lambda[IM]\, dIM dEDP dDM$$



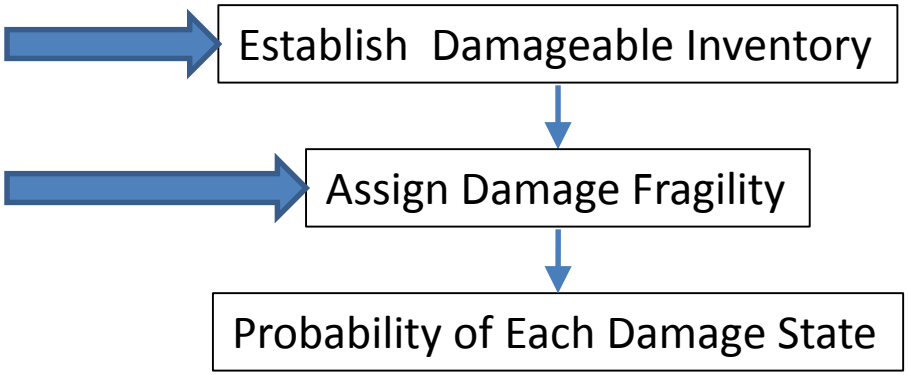
  - Step 1: Use site-specific ground motions (**Flagship 1?**)
  - Step 2: Design and analyse buildings based on **proposed geometry and layout** (i.e. floor mass)

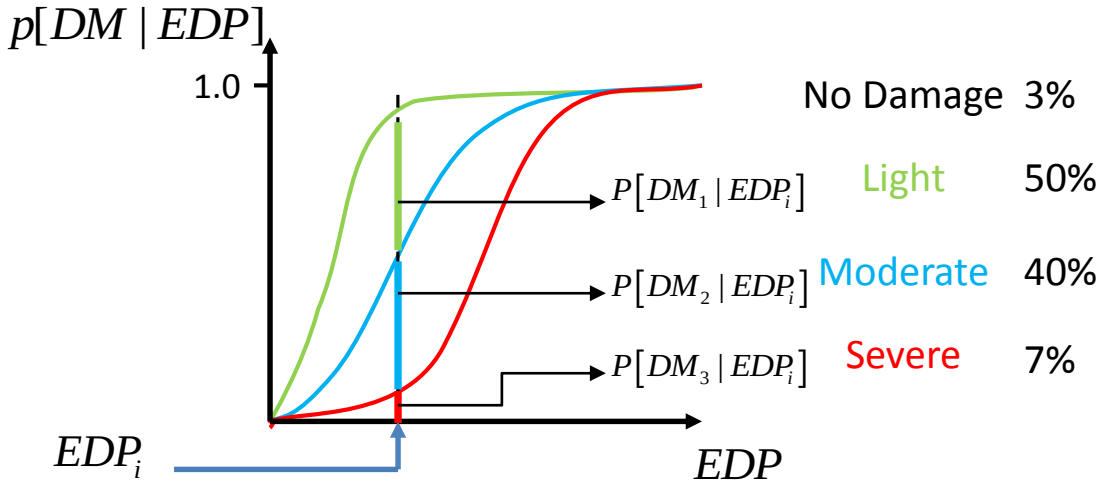
Loss Assessment Studies

- Step 3: damage analysis

Typical building layouts

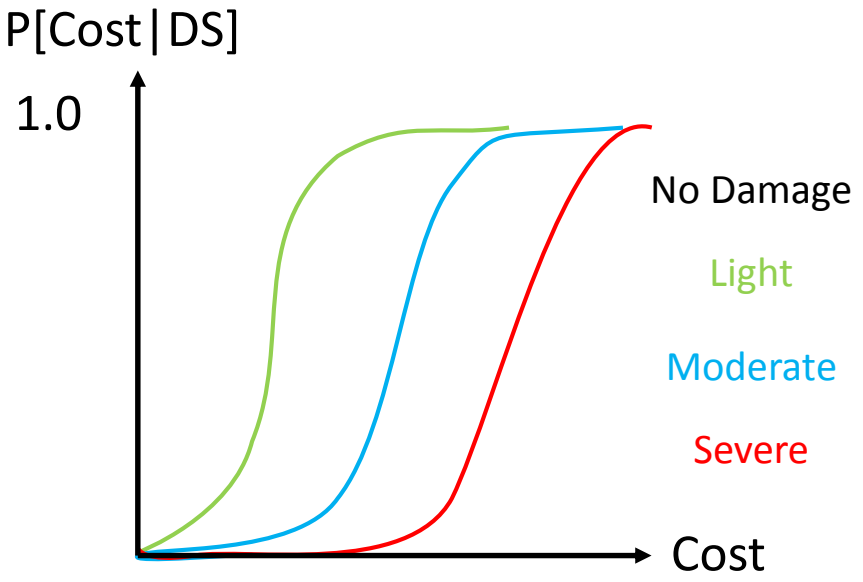
Typical construction practice and detailing





Loss Assessment Studies

- Step 4: decision analysis
  - Direct damage-repair costs: component repairs, demolition, site clean-up
  - Indirect costs: downtime, injuries/fatalities
  - Direct damage-repair costs estimated based on:
    - **Repair methods**
    - **Material costs**
    - **Labour hours and availability**



Loss Assessment Studies

×/?/✓ indicates the immediate availability and quality of data for NZ-specific usage (from poor to great) based on subjectivity

Building component	Fragility	Consequence
Structural beam/column/walls	✓	?
Floor slabs	✓	?
Stairs	×/?	?
Façade	?	?
Partitions	×/?	?
Ceiling	✓	✓
Heavy Plant	×/?	?
Sprinklers	×/?	?
Elevators	✓	✓