Project F4.3

Seismic loss assessment to motivate high performance building solutions

Project Leader:	Tim Sullivan
Assistant Leaders:	Rajesh Dhakal
	Ken Elwood
	Quincy Ma
Postdoc:	Trevor Yeow
PhD Student:	Shreehar Khakurel

Key Objectives

1. Demonstrate how loss assessment could be an effective means of quantifying the benefits of innovative construction technologies

2. Test and develop options for simplified loss-assessment appropriate for preliminary design phase

3. Identify and develop loss functions for non-structural elements for NZ usage

4. Identify functions from literature suitable for NZ construction, and develop fragility functions for components unique to NZ.

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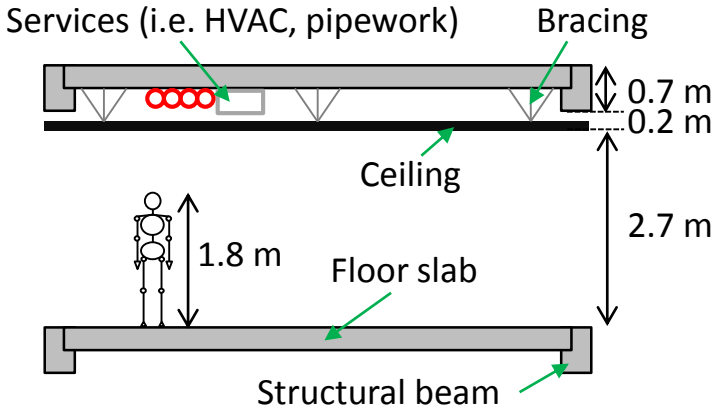
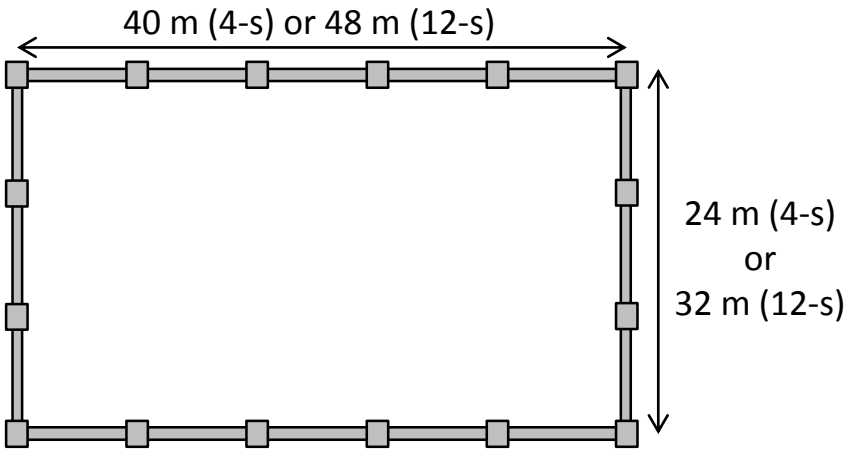
Objective 1 – Loss assessment of case study buildings

- **Stage 1: Develop case study building layouts**
- Stage 2: Obtain information required to estimate damage and losses (overlaps objectives 3 and 4)
- Stage 3: Design buildings featuring innovative construction technologies
- Stage 4: Apply loss assessment methodologies to assess benefits of using innovative technologies

Case Study Buildings – May Update

- First case to be examined:
  - 4 storey office building
  - 24 m by 40 m rectangular plan
  - New construction
- 12 storey office and 4 storey residential to follow





Case Study Buildings – May Update

- Stage 1: Identified newly constructed buildings that is similar to desired case study building

109 Cashel Street

161 Cashel Street

293 Durham Street

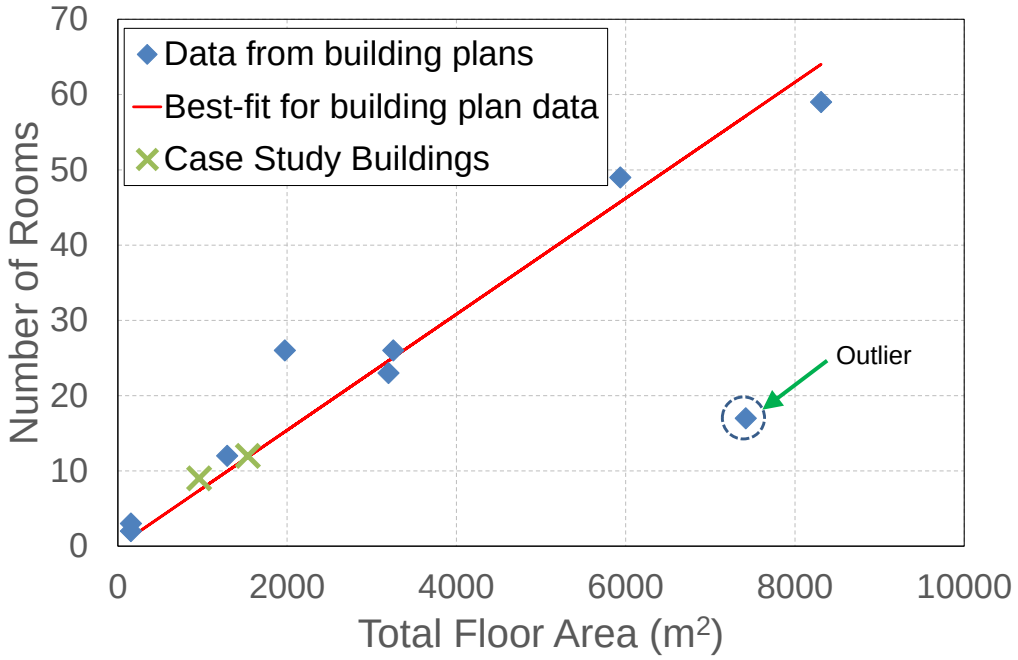
71 Gloucester Street

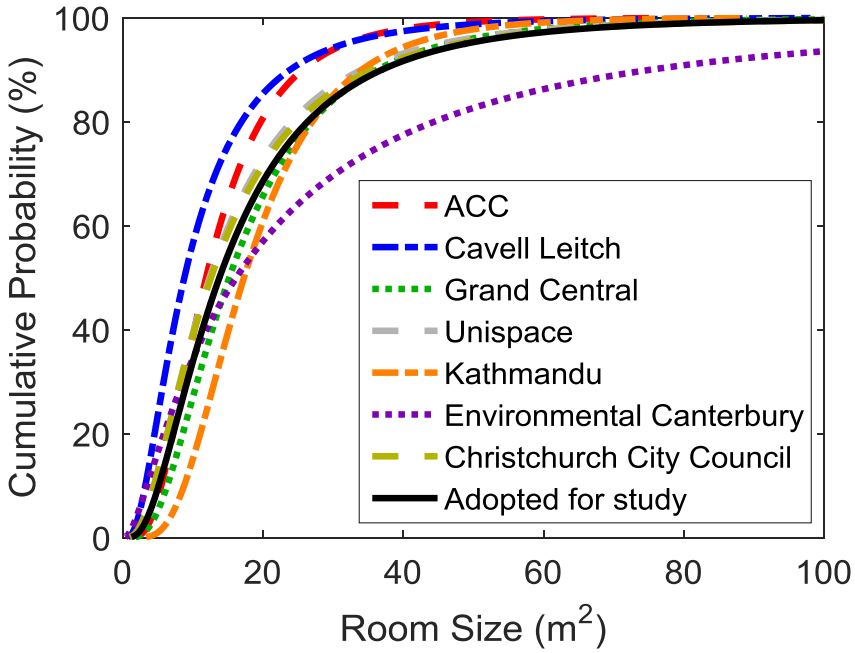
200 Tuam Street

229 Tuam Street

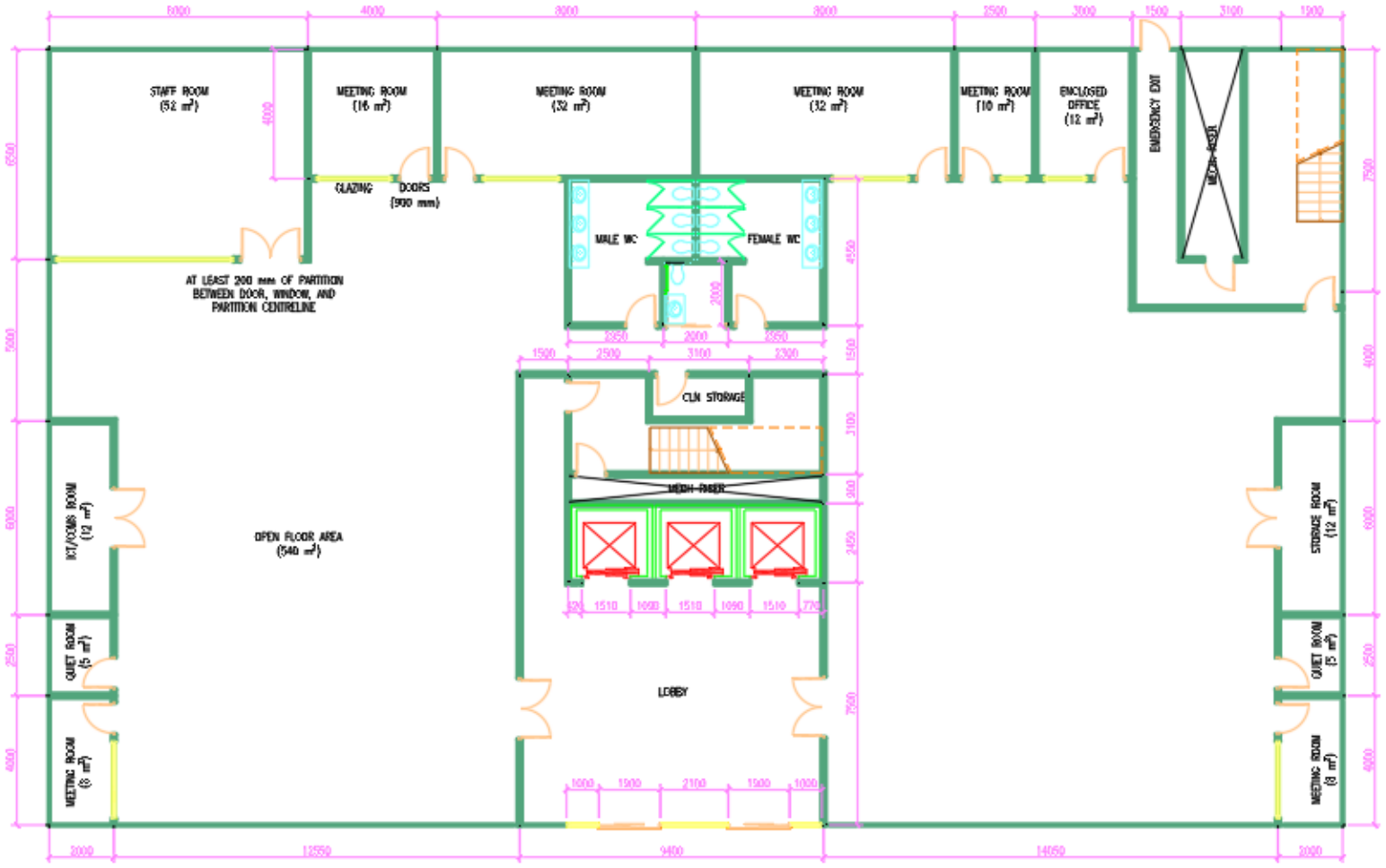
Case Study Buildings – May Update

- Stage 1: Use building plans to estimate details of a "typical" building layout
  - Report to be uploaded to QuakeCore wiki page



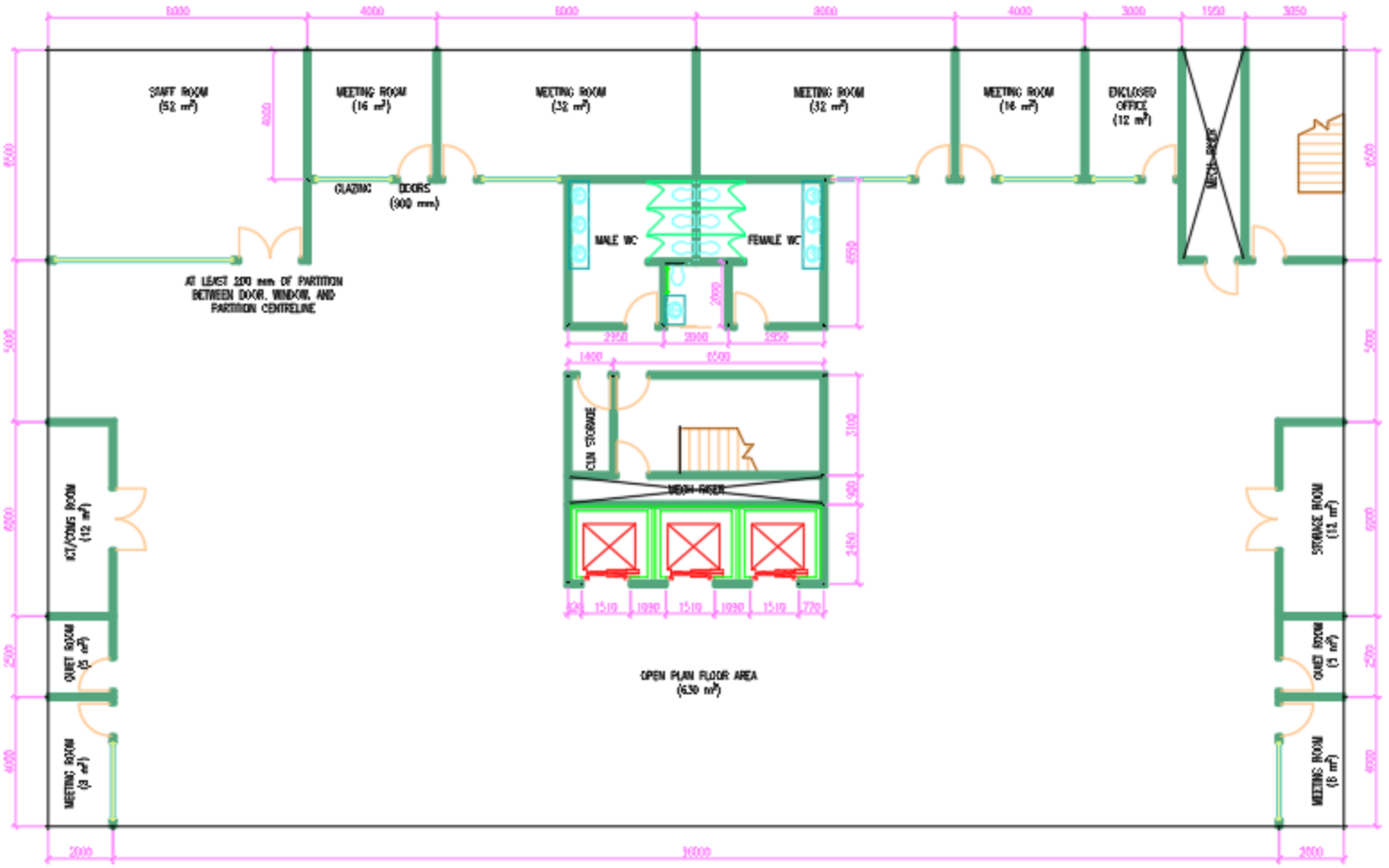


Case Study Buildings – May Update



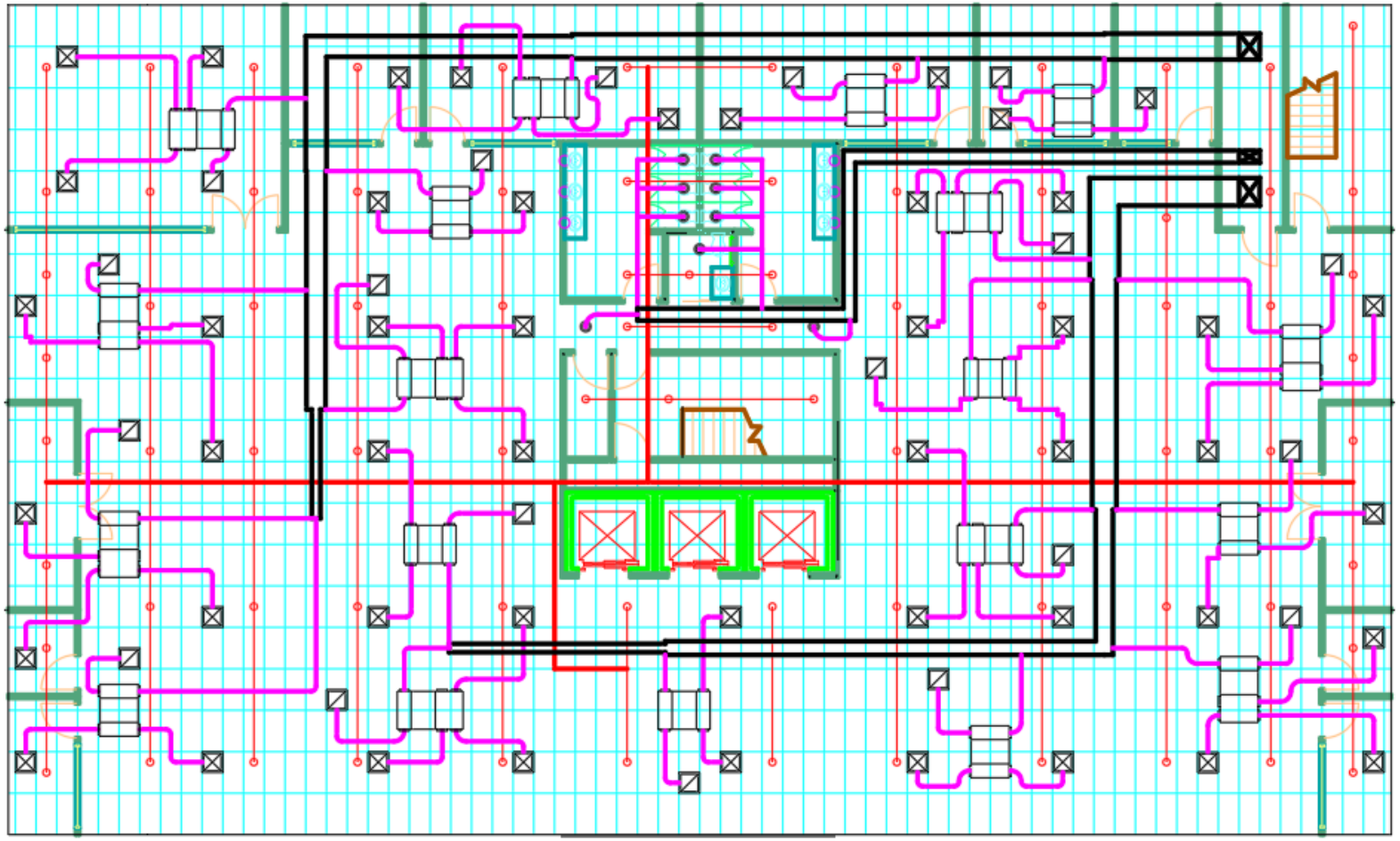
Room layout – ground floor

Case Study Buildings – May Update



Room layout – upper floors

Case Study Buildings – May Update



Sprinkler and HVAC duct layout

Case Study Buildings – May Update

Project FP4.3 - Usage of seismic loss assessment to motivate high performance building solutions

Created by Trevor Yeow, last modified on May 05, 2017

Project Title

Usage of Seismic Loss Assessment to Motivate High Performance Building Solutions

Research Team

- Project Leader - Tim Sullivan
- Assistant Leaders - Rajesh Dhakal, Ken Elwood, Quincy Ma
- Postdoc - Trevor Yeow
- PhD students - Shreedhar Khakurel

Project Description

To achieve widespread implementation of low-damage systems, the economic benefits of such systems must be demonstrated. This requires a long term outlook and an assessment of life-cycle costs. To address this need, this strategic project will firstly highlight the potential benefits of adopting a life-cycle costing framework. By applying an assessment framework that permits comparison of both up-front and long-term costs, including future losses from earthquakes, to a selection of case study buildings realized with different design alternatives, it can be demonstrated that life-cycle cost analysis could be used to effectively quantify the improved performance offered by low-damage construction technologies.

Secondly, in order to assist the NZ engineering profession make a smooth transition towards such probabilistic seismic loss assessment, the project proposes to test and develop different simplified loss assessment methods.

Finally, recognizing that the accuracy of any loss assessment will depend on the quality of the inputs used, the project will identify and develop loss and fragility functions for elements typical of NZ construction practice.

Key Objectives

The main objectives of this project are as follows:

1. Demonstrate, via loss-assessment of a selection of case study buildings, how loss assessment could be an effective means of quantifying the benefits of innovative construction technologies.
2. Test and develop options for simplified loss-assessment appropriate for preliminary design phase, thus assisting the NZ engineering profession make a smooth transition towards probabilistic seismic loss assessment.
3. Identify and develop loss functions for non-structural elements that will assist with the application of loss assessment in New Zealand.
4. Review procedures for the definition of fragility functions, identify functions from literature suitable for NZ construction, and develop fragility functions for components unique to NZ buildings.

Case Study Building Plans

Most up-to-date version of the case study building plans are provided below. Past versions will be added if superseded.

Four-Storey Office Building

Ground floor

Floor Plan (no dimensions provided)

Upper floors

Floor Plan (no dimensions provided)

All drawings will be made available via QuakeCore wiki

Objective 1 – Loss assessment of case study buildings

- Stage 1: Develop case study building layouts
- **Stage 2: Obtain information required to estimate damage and losses (also part of objective 4)**
- Stage 3: Design buildings featuring innovative construction technologies
- Stage 4: Apply loss assessment methodologies to case studies

Objective 1 – Loss assessment of case study buildings

- Stage 2: Identify typical components used in newly constructed buildings (excluding main structural elements)

Category	Component		Quantity x	Quantity y	Fragility Function	Consequence Function
Structural	Floor slabs	- Hollow core units	?	?	×/?	×/?
		- Double tee units	?	?	×/?	×/?
		- Comfloor units	?	?	×/?	×/?
	Stairs		1	1	×/?	×/?
Structural/non-structural	Cladding	- Precast panels	-	48 m	OBJECTIVE 3	
		- Glazing	80 m	-		
Non-structural	Partitions	- Full height	?	?	✓	✓
		- Partial height, braced at top	?	?	×/?	×/?
		- Glazing	15 m	4.5 m	×/?	×/?
	Ceilings		?	?	✓	✓
	HVAC		?	?	×/?	×/?
	Heavy plant on roof		?	?	×/?	×/?
	Sprinklers		?	?	×/?	×/?
	Elevators		3		✓	✓

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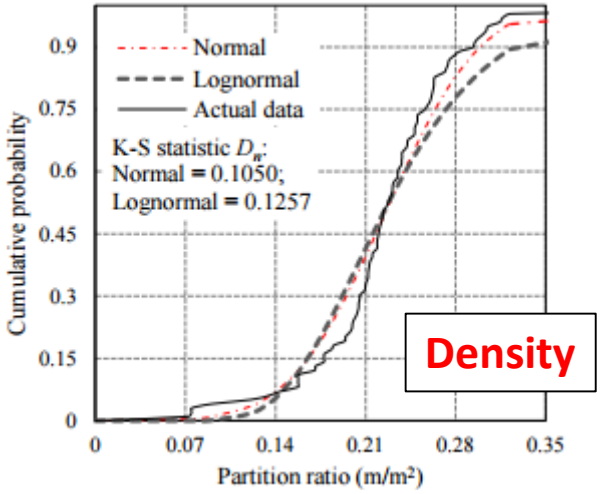
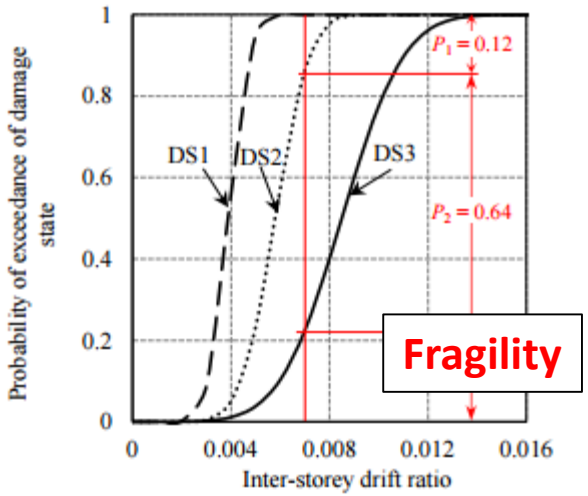
Loss Functions - Cladding

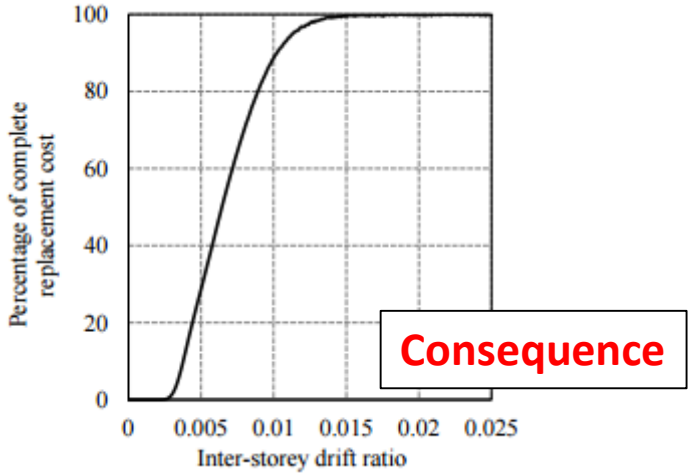
Aim:

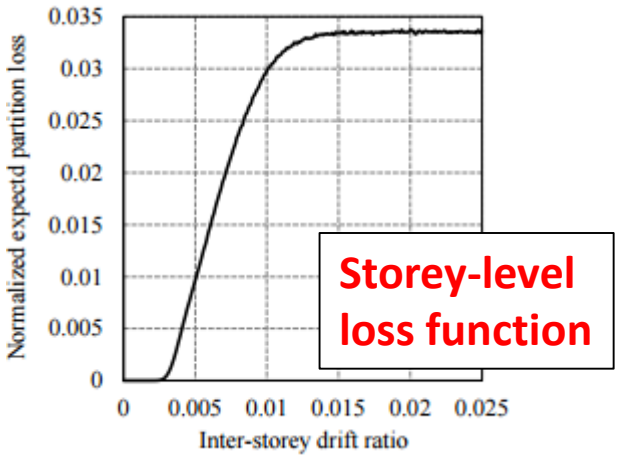
- Developing storey-level normalized loss functions for use in simplified loss estimation approaches





Example for partitions (Dhakal et al. 2016)





Loss Functions - Cladding

Aim:

- Developing storey-level normalized loss functions for use in simplified loss estimation approaches
- Steps:
  - **Familiarize with the types of cladding using in New Zealand**
  - **Survey buildings in Christchurch to identify which is most commonly used**
  - **Use data to obtain typical density of cladding elements**
  - Survey engineers and contractors involved in repair work following the 2010-2011 Canterbury earthquakes to obtain damage-loss relationships
  - Obtain fragility functions for the most commonly used cladding types
  - Perform Monte Carlo simulations to obtain EDP-normalized Loss relationships at a storey-specific level

Loss Functions - Cladding

Building Survey

- Building usage
- Total exterior surface area
- Type of cladding
- Percentage of exterior surface area covered by given cladding type (for building front, sides, and back)

"all dimensions in meter

Building	Area	Building ID	address	Type	Storey	Dimension		Useage	Types of cladding													
						Length	Width		Curtain Wall			stick curtain			Double skin			Frameless glazing			monolithic cladding		
									F	B	$	F	B	$	F	B	$	F	B	$	F	B	$
Turners Auction		1	6 Detriut Pl	Commercial	2	45	20	Car seller										10	10	40			
Vision College Christchurch Campus		2	48 Hazelden Rd	Commercial	4	70	35	CarPark												8			
Hunter Furnituer		3	221 Moorhouse Ave	Commercial	3	100	60	Warehouse										9					
Briscoes Homefare		4	196 Salisbury Street	Commercial	3	55	40	Warehouse							30	50	30	20	10				
Commercial Building (Selling)		5	113 Machester Street	Commercial	5	60	30	Commercial Building				20	30	30	4			8	8	5			
Office Products Depot		6	46 Bath Street	Commercial	1	20	30	Car parts										10		20	10		10
AA Insurance		7	8 Hawdon Street	Commercial	2	30	30	Car Testing							5	5			7				
Post Shop	750	8	54 Cashel Street	Commercial	1	30	25	Post shop							12	12	18	8	8	7			
Ganellen construction(Firstfloor)	1300	9	253 Monstreal Street	Commercial	1	50	28	Commercial										50	50	28			
Ganellen construction	1300	10	253 Monstreal Street	Commercial	2	50	28	Commercial										10	10	8			
Under construction	400	11	245 Montreal Street	Commercial	2	20	20	Commercial				15	15	15									
Storage House	625	12	6 Hawdon street	Commercial	1	25	25	Commercial										2					
Miles Continental	1296	13	60 Tuan street	Commercial	1	36	36	Car dealer										33		20			
Audis	528	14	32 Tuan Street	Commercial	1	22	24	Car dealer				20			2	22	24						
Audis(Second floor)	528	15	32 Tuan Street	Commercial	1	22	24	Car dealer							17	22	24	5					
Archibalds	1215	16	28 Tuan Street	Commercial	1	24	41	Commercial										28	0	35			
Archibalds(Second floor)	1215	17	28 Tuan Street	Commercial	1	24	41	Commercial				24	0	40				24	0	0			
Wilson	140	18	189 Antigua Street	Commercial	1	10	14	Commercial										8			0	10	14
Canterbury Medical Research Fondation	400	19	195 Antigua Street	Commercial	1	20	20	Research										20					
Canterbury Medical Research Fondation	400	20	195 Antigua Street	Commercial	1	20	20	Research										20		20	3	22	1
Electrolux Sales abd Service	484	21	210 Antigua Street	Commercial	1	22	22	Service										20			3		1
Lifetime	320	22	192 Moorhouse Avenue	Commercial	1	20	16	Service							10	10	15	10	10	15			
Lifetime	320	23	192 Moorhouse Avenue	Commercial	1	20	16	Service							10	10	15	10	10	15			
ENGEO	240	24	120 Montreal street	Commercial	1	12	20	Construction										16	2				
ENGEO(Second foor)	240	25	120 Montreal street	Commercial	1	12	20	Construction															
Deal	600	26	118 Montreal street	Commercial	1	15	60	Construction										15					
Deal(Other side)	300	27	118 Montreal street	Commercial	1	15	40	Construction															
Active	300	28	113 Montreal Steet	Commercial	1	30	30	Seller										20	20				
Active(second floor)	300	29	113 Montreal Steet	Commercial	1	15	20																

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