The Next Frontier – Improving the Seismic Resilience of Non-Structural Components.

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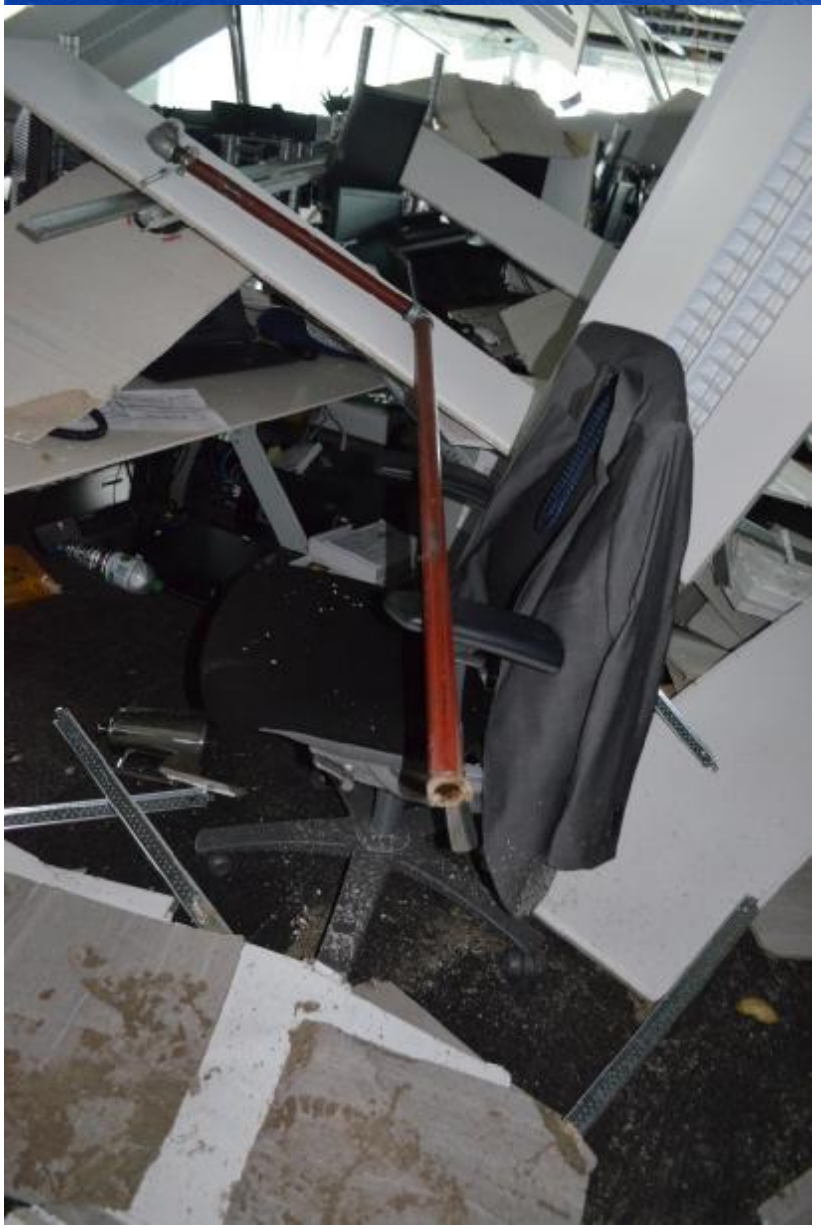
Recent NZ earthquakes



NZ Design standards for Non-structural components

New Zealand

- NZS1170.5 – Parts and Components
  - ULS – risk to life safety
  - SLS – risk to operational continuity
- NZS4219 – Seismic Performance of Engineering Systems in Buildings
- AS/NZS2785 – Suspended Ceilings – Design and Installation

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California Hospital Performance

Northridge Hospital Performance

Performance of all Buildings at 23 Hospital Sites with One or More Yellow or Red Tagged Buildings		
Type of Damage	Number (%) of Buildings	
	Pre Act	Post Act
Structural Damage		
Red tagged	12 (24%)	0 (0%)
Yellow tagged	17 (33%)	1 (3%)
Green tagged	22 (43%)	30 (97%)
Nonstructural Damage		
Major	31 (61%)	7 (23%)
Minor	20 (39%)	24 (77%)
Total Buildings	51	31

From "Seismic Vulnerability of Hospitals based on Historical Performance in California"; 8th National Conference on Earthquake Engineering, by William T Holmes and Lawrence Burkett.

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Issues with NZ Current Practice

Why are seismic restraints not being installed in NZ?

- Cost
- “Just in Time” Design Timing
- Procurement
- Construction Process and Programme
- Engagement of Consultants
- Existing Buildings
- Code compliance

EERI Industry Survey of Issues

Figure 4.1.11 Reasons for Noncompliance and Their Relative Importance; Summary from All Respondent Groups

Answer	%
No one is adequately trained to make sure the standards are complied with.	44%
There is little regulatory enforcement of compliance with the standards.	42%
No one knows who is ultimately responsible for compliance.	40%
There is a communication breakdown between everyone involved in constructing the building that contributes to noncompliance.	35%
It is too expensive to comply with the standards.	35%
Compliance just falls through the cracks.	33%
Everyone just assumes someone else will make sure that compliance occurs.	31%
Everyone passes the buck to someone else, so compliance doesn't occur.	28%
The standards are too difficult to understand.	25%
There is little incentive to comply with the standards.	23%
Penalties for noncompliance aren't severe enough to make compliance a high priority.	20%
It is too time consuming to comply with these standards.	17%
There is a lack of compensation for oversight compliance.	15%
There are liability concerns that prevent compliance.	2%

(Note: Respondents can select and rank more than one choice.)

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There is little regulatory enforcement of compliance with the standards	42%
No one knows who is ultimately responsible for compliance	40%

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Suggested Approaches to Improve the Situation

1. **Make clear the design and inspection requirements for bracing of non-structural components**

Example - St Louis “Seismic Block”

MECHANICAL AND PLUMBING EQUIPMENT COMPONENTS
EARTHQUAKE LOAD RESISTANCE

Occupancy Category ( ) **Seismic Design Category ( )**

LISTING OF EQUIPMENT AND SYSTEM COMPONENTS	ANCHORAGE TO FLOORS, ROOFS, ETC. (See Note 1 below)		SWAY BRACING (See Note 1 below)		LOCATION OF PROFESSIONALLY SEALED ANCHORAGE AND SWAY BRACING DETAILS			COMMENTS
					ON CONST. DOCUMENTS	SUBSEQUENT SUBMITTAL (See Note 2 below)		
	Not Provided For Project	Provided For Project	Not Provided For Project	Provided For Project	Drawing No. or Spec. Section	Shop Drawings	Separate Permit & Plans	
FIRE PROTECTION, DETECTION & ALARM EQUIPMENT & SYSTEM COMPONENTS: * See Chapter 4, Table 4.1 (List items such as: fire sprinkler system equipment & system components, smoke control & evacuation equipment & system components)								
HAZARDOUS EQUIPMENT & SYSTEM COMPONENTS: * See Chapter 4, Table 4.1 (List items such as: gas piping, piping containing flammable, combustible liquids & gasses or toxic chemicals. Include items such as flammable & combustible tanks, vats & other industrial equipment containing hazardous or toxic liquids, gasses, chemicals, etc.)								
OTHER EQUIPMENT & SYSTEM COMPONENTS NEEDED FOR CONTINUED OPERATION OF OCCUPANCY CATEGORY IV FACILITIES OR WHOSE FAILURE COULD IMPAIR THEIR CONTINUED OPERATION * See Chapter 4, Table 4.1 (List items)								
OTHER GENERAL EQUIPMENT & SYSTEM COMPONENTS (List items such as: boilers, furnaces, AHU's, tanks, heat exchangers and pressure vessels, suspended piping, water heaters, VAV boxes, HVAC ducts, drain, waste & vent piping, pumps, etc.)								

Notes:
1. It is the basic intent of this Code Block to declare whether or not anchorage and sway bracing is being provided on the project, if so, to declare whether or not the details are shown on the plans or will be shown on a subsequent submission. If seismic restraint of a component is not required by code this should be stated in comments. If seismic restraint, which is not required by code, is being provided due to owner/designer requirements this should also be stated in the comments.
2. Shop drawings need to be submitted to the County a minimum of two weeks prior to the planned installation to allow for plan review and distribution to the inspector. Additional time may be needed if such submissions are deficient.

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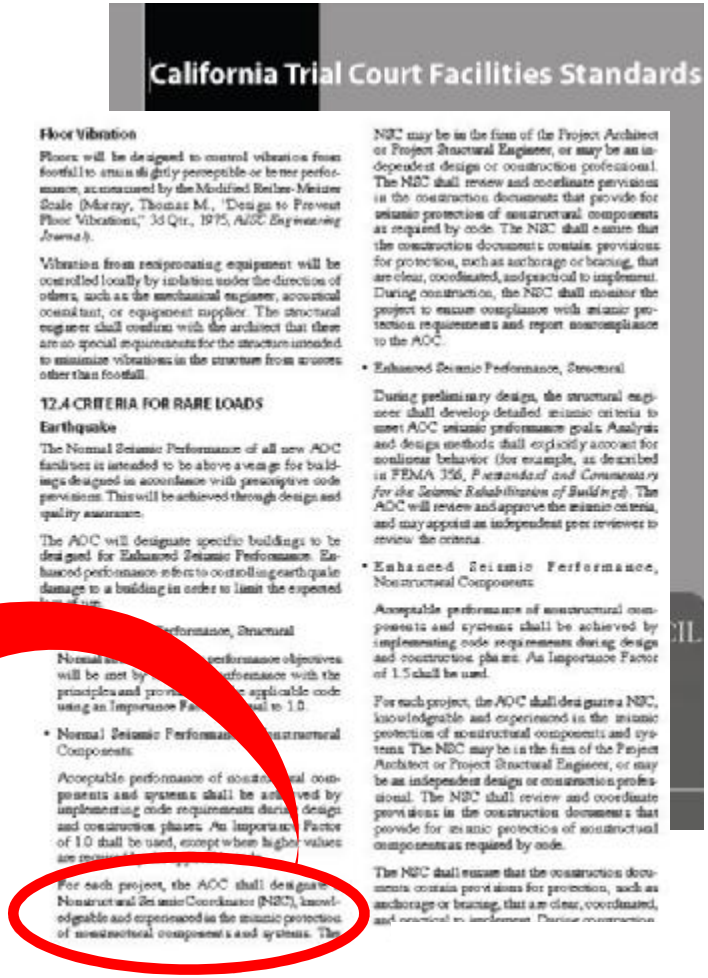
Suggested Approaches to Improve the Situation

2. Add a role to the design team - someone responsible for considering the seismic protection of non-structural components

Example – Non-Structural Seismic Coordinator

- The University of California introduced the role for Stanley Hall,
- The role is now a codified requirement for courts projects in California


California Trial Court Facilities Standards

Floor Vibration

Floors will be designed to control vibration from footfall to ensure slightly perceptible or better performance, as measured by the Modified Reiher-Meister Scale (Murray, Thomas M., "Design to Prevent Floor Vibrations," 3d Qtr., 1975, *AISC Engineering Journal*).

Vibration from reciprocating equipment will be controlled locally by isolation under the direction of others, such as the mechanical engineer, acoustical consultant, or equipment supplier. The structural engineer shall confirm with the architect that there are no special requirements for the structure intended to minimize vibrations in the structure from sources other than footfall.

12.4 CRITERIA FOR RARE LOADS

Earthquake

The Normal Seismic Performance of all new AOC facilities is intended to be above average for buildings designed in accordance with prescriptive code provisions. This will be achieved through design and quality assurance.

The AOC will designate specific buildings to be designed for Enhanced Seismic Performance. Enhanced performance refers to controlling earthquake damage to a building in order to limit the expected

NBC may be in the firm of the Project Architect or Project Structural Engineer, or may be an independent design or construction professional. The NBC shall review and coordinate provisions in the construction documents that provide for seismic protection of nonstructural components as required by code. The NBC shall ensure that the construction documents contain provisions for protection, such as anchorage or bracing, that are clear, coordinated, and practical to implement. During construction, the NBC shall monitor the project to ensure compliance with seismic protection requirements and report noncompliance to the AOC.

- Enhanced Seismic Performance, Structural

During preliminary design, the structural engineer shall develop detailed seismic criteria to meet AOC seismic performance goals. Analysis and design methods shall explicitly account for nonlinear behavior (for example, as described in FEMA 356, *Prestandard and Commentary for the Seismic Rehabilitation of Buildings*). The AOC will review and approve the seismic criteria, and may appoint an independent peer reviewers to review the criteria.

- Enhanced Seismic Performance, Nonstructural Components

Acceptable performance of nonstructural components and systems shall be achieved by implementing code requirements during design and construction phases. An Importance Factor of 1.5 shall be used.

For each project, the AOC shall designate a NBC, knowledgeable and experienced in the seismic protection of nonstructural components and systems. The NBC may be in the firm of the Project Architect or Project Structural Engineer, or may be an independent design or construction professional. The NBC shall review and coordinate provisions in the construction documents that provide for seismic protection of nonstructural components as required by code.

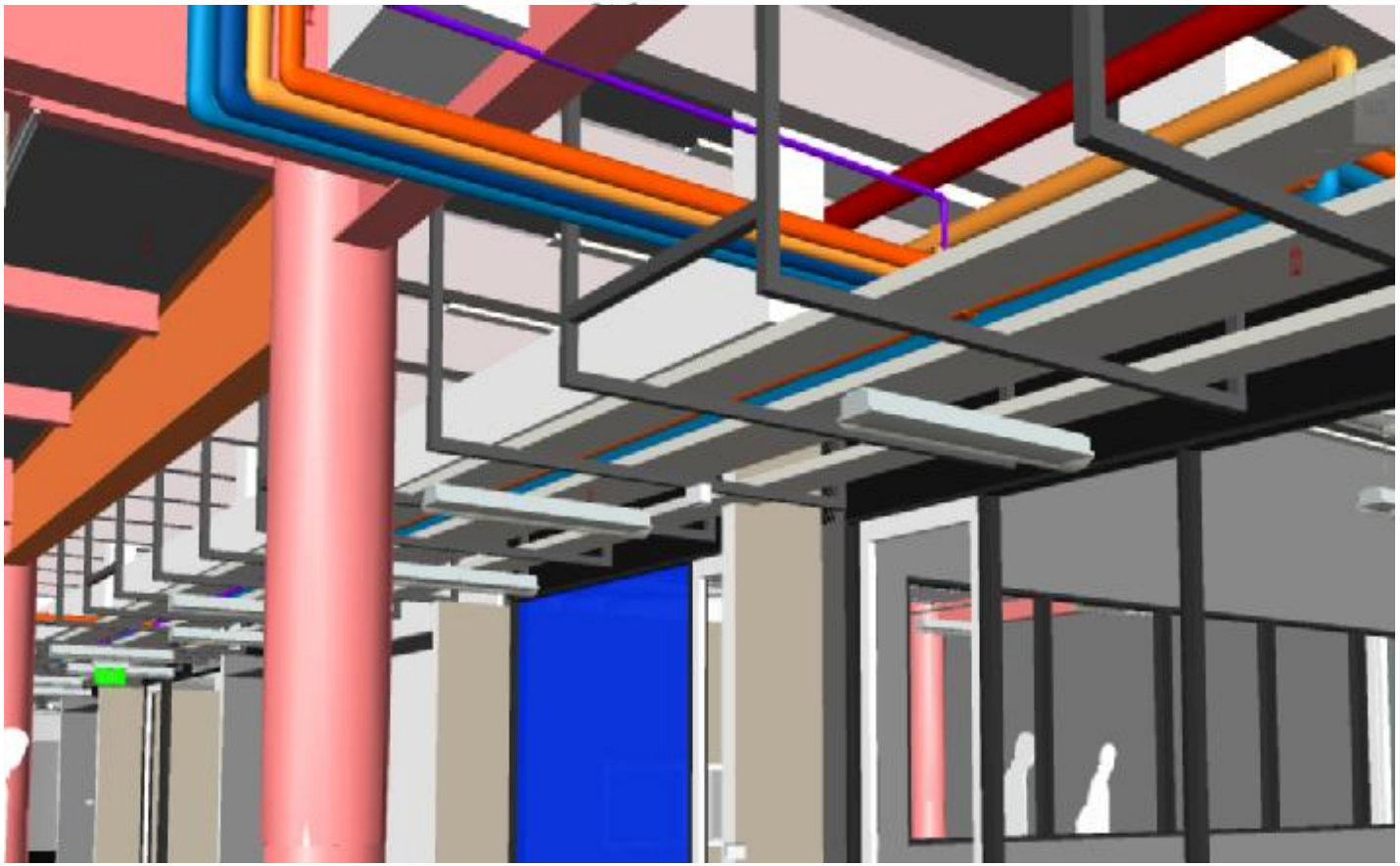
The NBC shall ensure that the construction documents contain provisions for protection, such as anchorage or bracing, that are clear, coordinated,

For each project, the AOC shall designate a Nonstructural Seismic Coordinator, knowledgeable and experienced in the seismic protection of non-structural components and systems …….

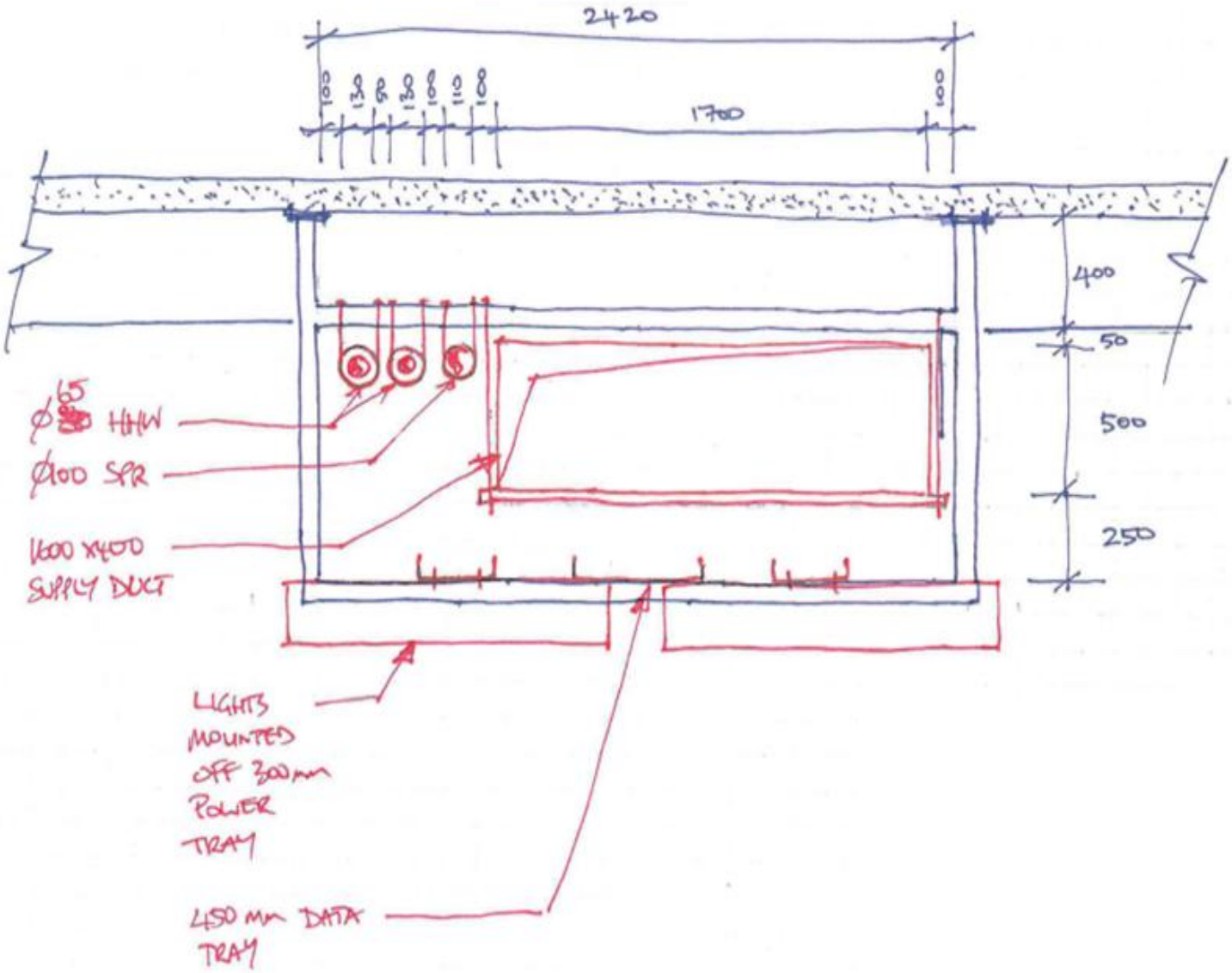
Suggested Approaches to Improve the Situation

3. Include seismic restraint of non structural components as part of a Holistic Design Approach

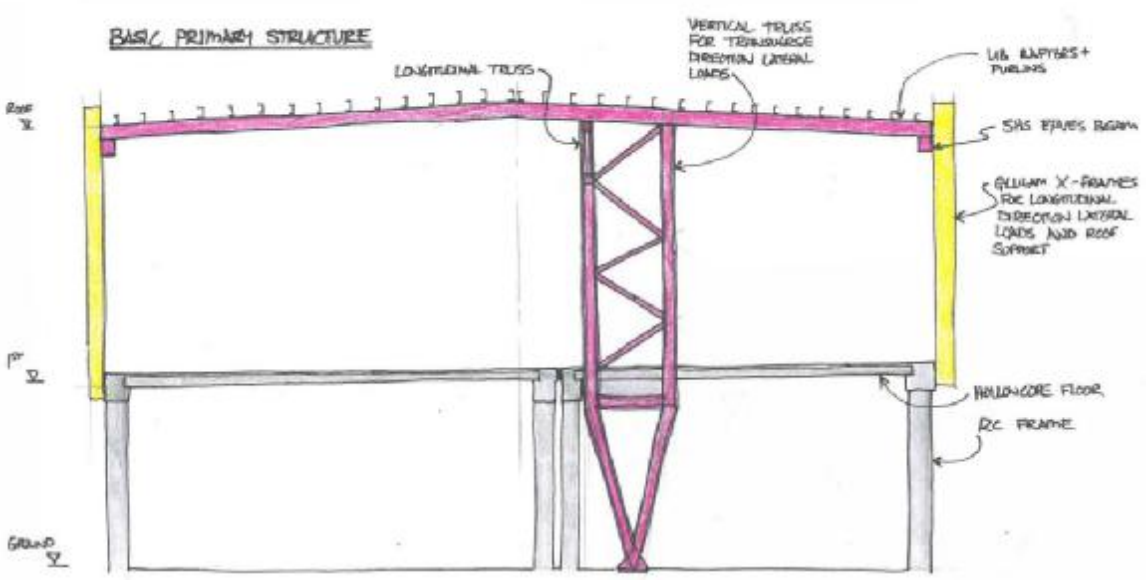
Example – AUT ETD Services Racetrack



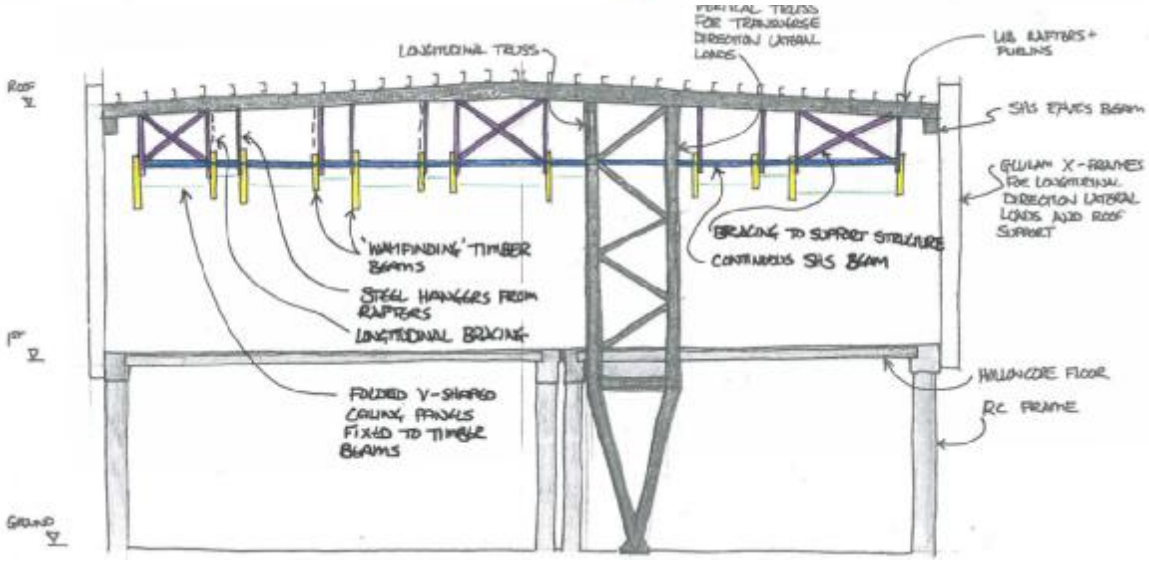
AUT ETD - Service Support Frames



Wellington International Airport



Primary structure



Primary structure plus secondary structure to support non structural components

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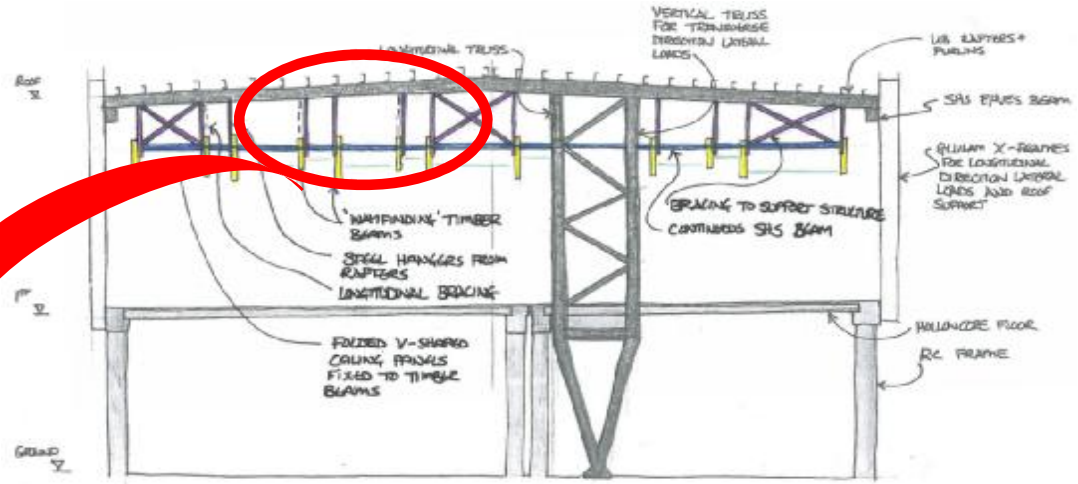
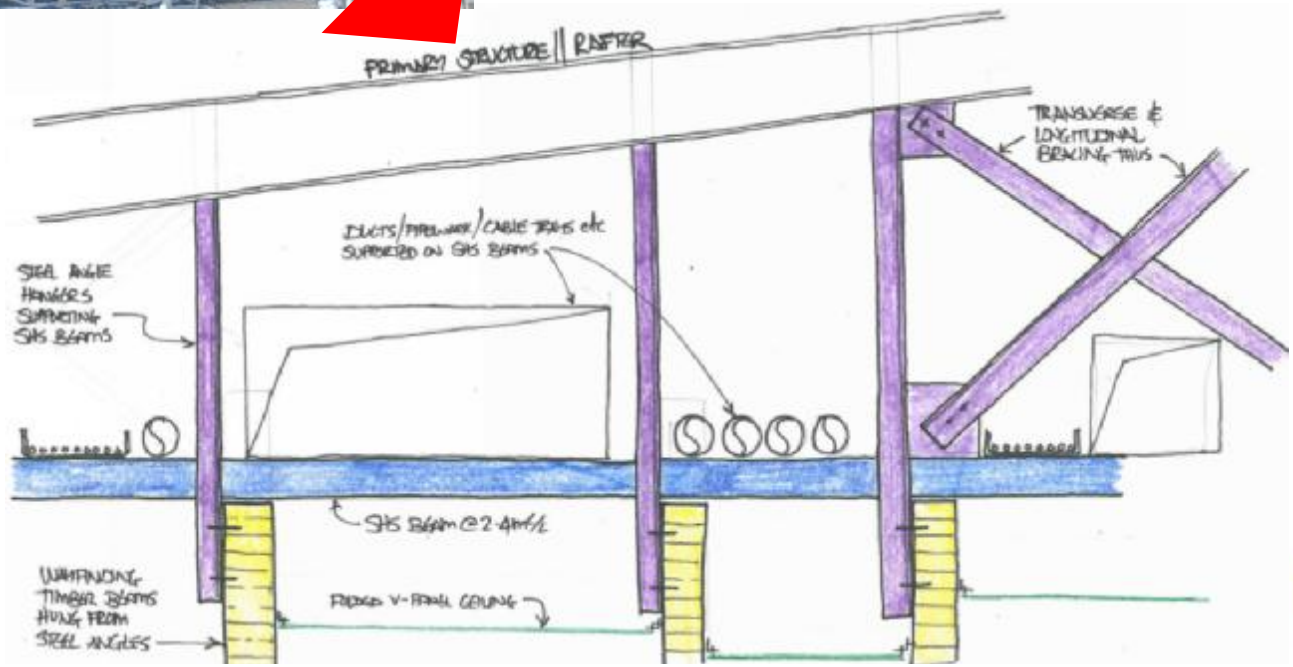
Wellington International Airport





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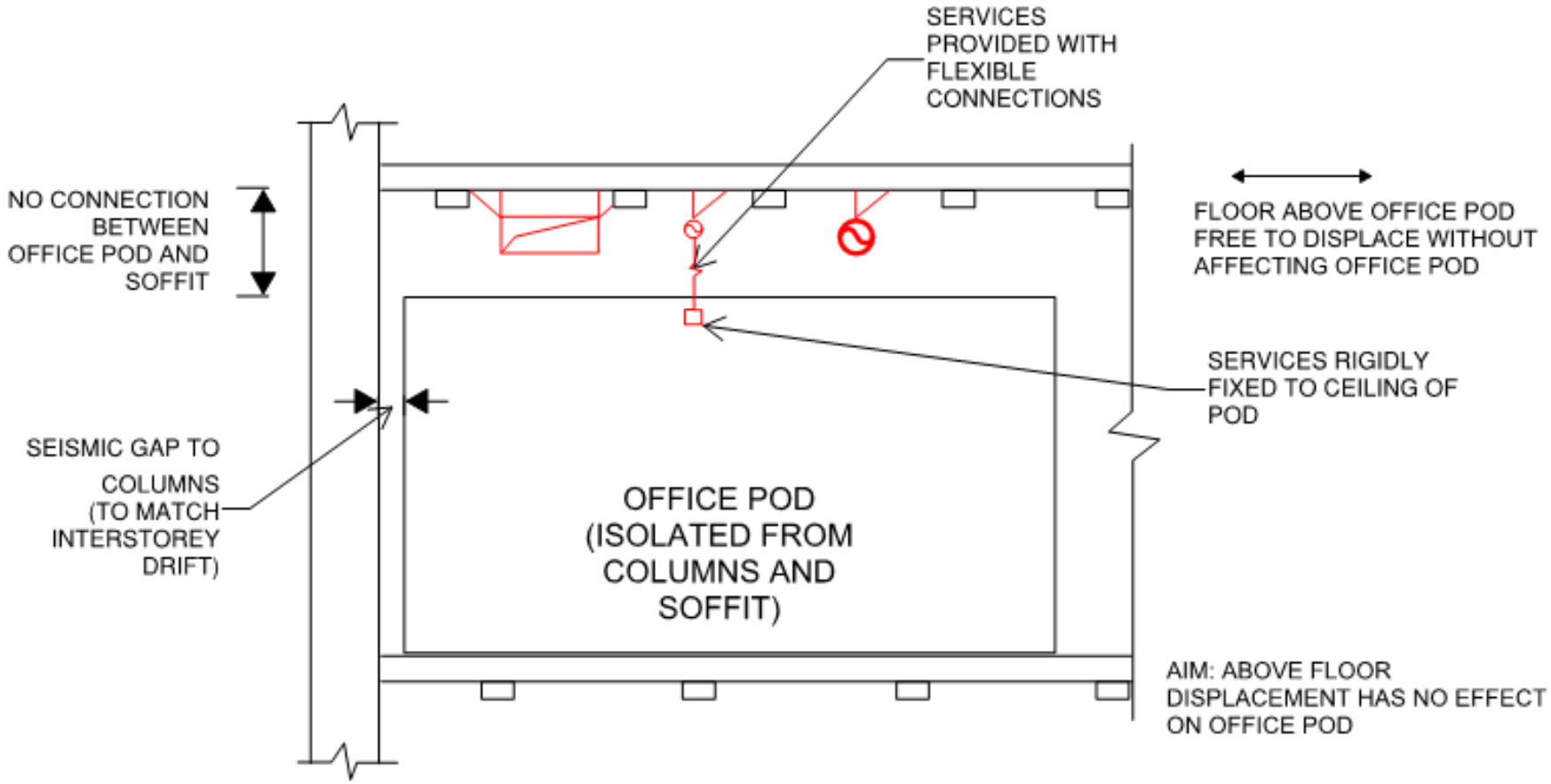
Victoria University Faculty of Architecture Refurbishment



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Conclusions

- Generally implementation of non structural seismic protection is poor in New Zealand
- Change is possible
- Improvements can be made by assigning responsibility and by designing buildings in a holistic manner including considering non structural components from the early stages in design
- Costs of design and construction will inevitably rise; but
- Damage and economic losses caused from non structural damage in earthquakes will fall.

Thank you

- Helen Ferner, Technical Director Structural Engineering

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