College of Creative Arts

A New Zealand 'world first' – post tensioned LVL beams & columns / pre-cambered LVL / precast slabs

Post tensioned LVL beams & columns – A World First

Part 1
Design phase – documenting and testing the theory

- Massey University brief
- Architectural competition
- Unique design post tensioned LVL
- Early trade tendering
- Peer review of DT structural design
- Production testing of LVL/composite floor slabs/Unitised Curtainwall

POST TENSIONED LVL BEAMS & COLUMNS – A WORLD FIRST

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Part 2
Construction - delivering the vision

- Prefabrication strategies s
- Bracing –"a house of cards"
- Hoisting / scaffolding
- Speed of production
- Cost / Benefits

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POST TENSIONED LVL BEAMS & COLUMNS – A WORLD FIRST

Basic Building Statistics

- Alistair Cattanach in response to a question regarding the basis of the seismic design for the College of Creative Arts building. Based on a1 in 500 year event as required by code. Events like a 8.1 on the Wiarapa Fault or 7.5-7.8 on the Wellington Fault - would withstand a Christchurch event even with the same peak accelerations.
- Building materials – sustainable where possible
- Stories – various in our case five levels
- Typical LVL building – 3.6m floor to floor x 3 floors – 10.8 metres overall. approximately 3m to the bottom of the LVL beam / corbel
- Typical Grid – 7.2m. Column spacing's approximately 9m (long span) and 6m (short span).
- AC – Passive Ventilation – 247 Window Actuators BMS driven – Double glazing throughout
- Heating –a combination of low radiators + under floor heating

DESIGN MANAGEMENT – HISTORICAL CONTEXT

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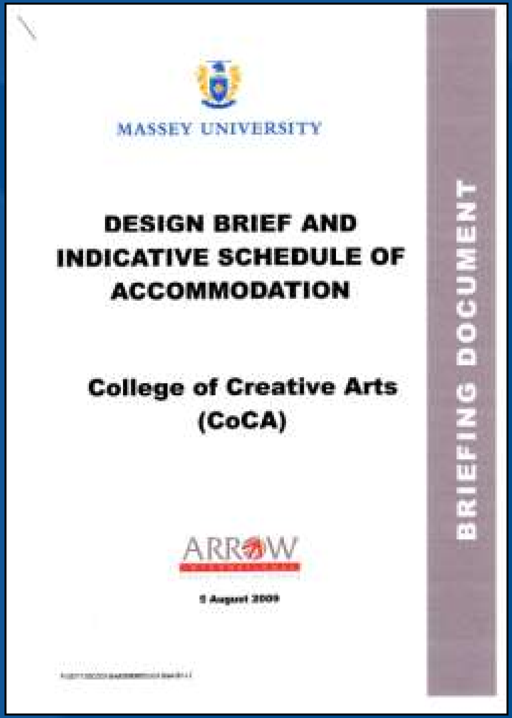
The Massey University Brief – Key Principals

1. World class facility operating in a global market
2. Open flexible teaching spaces and studios
3. Inspire and respond to users
4. Visual inspirational experiences
5. Sustainability and response to the natural environment
6. Energy efficiency
7. Flexible building services
8. Draft Schedule of Accommodation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DESIGN BRIEF AND INDICATIVE SCHEDULE OF ACCOMMODATION

College of Creative Arts (CoCA)

ARROW

5 August 2009

BRIEFING DOCUMENT

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Design Management – Historical Context

The Architectural Design Competition

1. 35 registrations of interest
2. 4 firms shortlisted
3. Athfield entry responded most closely to the brief including the budget criteria

July 2009

July 2012

WHY POST TENSIONED LVL ?

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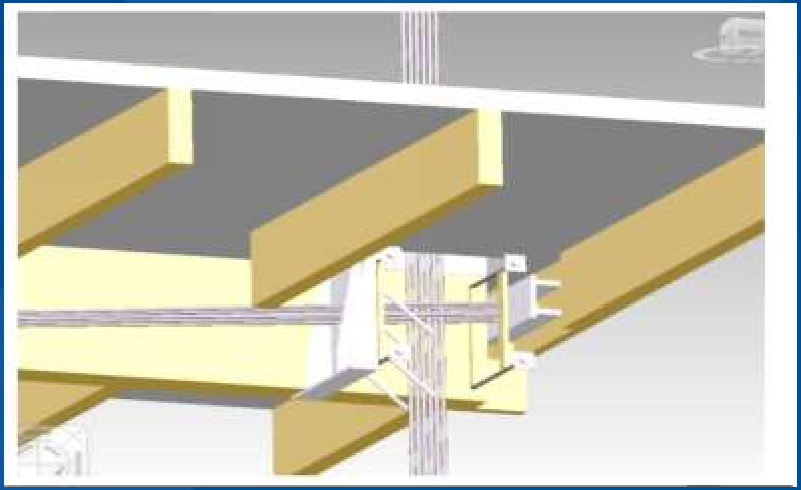
Why take the risk (real or perceived) to take the next step ?

- Response to the competition brief
- Seismic performance in a significant earthquake
- Historical context – NMIT



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Design Management – Early Trade Tendering

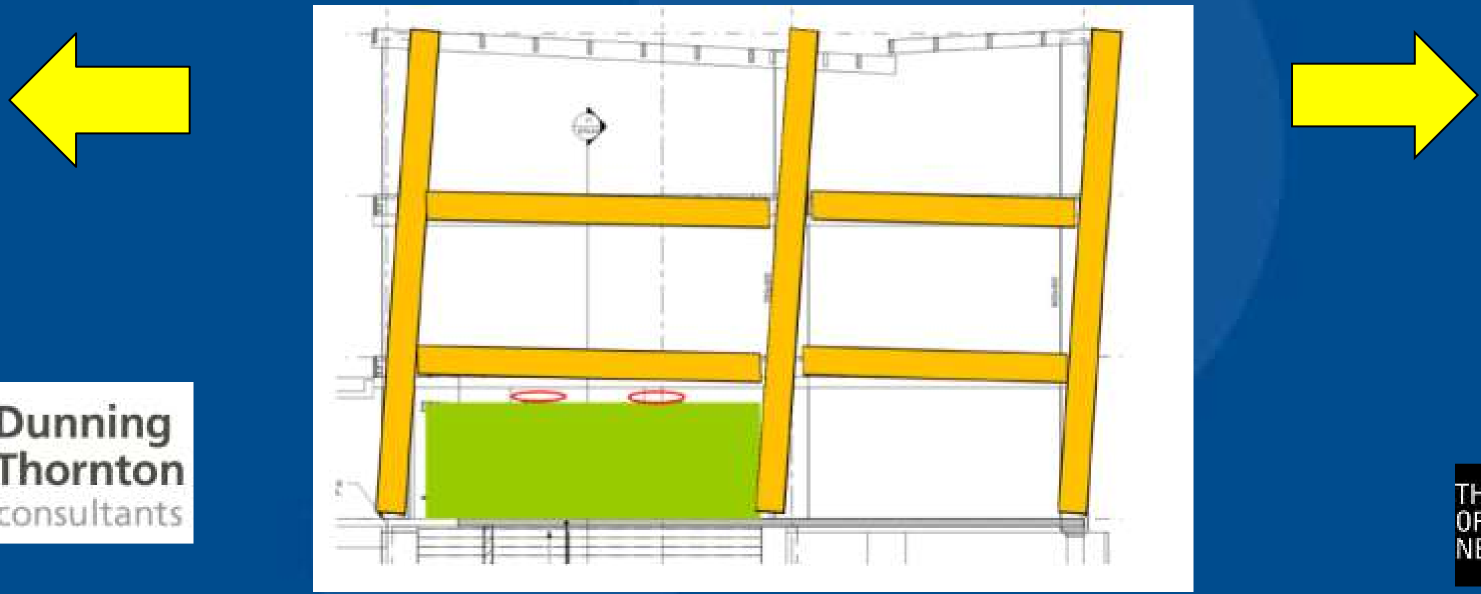
Eliminating / mitigating technology risk

- Alternatives considered by design / QS team
- Early trade tendering – early June 2010 – four months prior to the completion of design
- Production testing / prototypes
    1. Post tensioned LVL / beam column joint
    2. Precambered composite floor slabs
    3. Unitised Curtainwall

Post Tensioned LVL Beam/Column Design Concept

LVL beam / column superstructure frame

- Designed to 2.5% - 250mm (at the top of a 10m high column) . Curtainwall follows in East / West event and can slide in head / sill sub-frames in a North / South event
- Post Tensioning Loads (Beams 120kN x 6 = 72Tonnes) – 100 year life
- Post Tensioning Loads (Columns 116kN x 6 = 70Tonnes)
- Post Tensioning Loads (Precast Shear Walls 80kN x 17 = 135Tonnes)



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DESIGN MANAGEMENT

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Testing of the beam / column / shear block assembly

- Canterbury University – early approval and testing during developed design (Professor Andy Buchanan, Associate Professor, Stefano Pampinin, Doctorial students)
- Test results – tested at 4% - code is 2%
- Peer review of the structural design – part of Building Consent process

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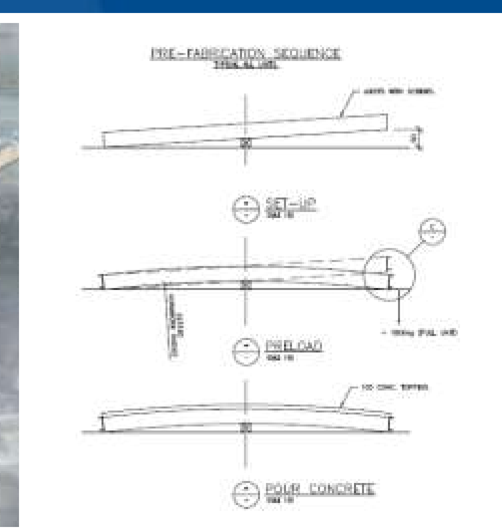
Design Management

Composite floor slabs – production testing of prototypes

- Steel mould - commitment to only two prototype slabs – one mould
- Pre-camber pour / screed – 5mm drop out of mould
- 28 day cure – in 1 yr. should be flat!



Design Management

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Curtainwall prototype

- Included as part of an early tender – Major Australia and New Zealand suppliers / subcontractors
- Early June 2010 tender – 4 months to assist with Developed Design

- Double glazing
- Europan Natura exterior – prefabricated – low maintenance – 50 yr. life
- Echo Panel Interior – site installed
- Actuators - installed with cabling within the mullions
- Weather tightness - testing regime

Post Tensioned LVL Beams & Columns – A World First

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Part 2
Construction - delivering the vision

- College of Creative Arts - structural design / site geometry
- Programme - speed of production – keeping up with the LVL
- Prefabrication strategies – four key elements
- Bracing –*"a house of cards"*
- Cost / benefits of LVL
- Lessons
- Questions

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CONSTRUCTION – THE DESIGN AND THEORY

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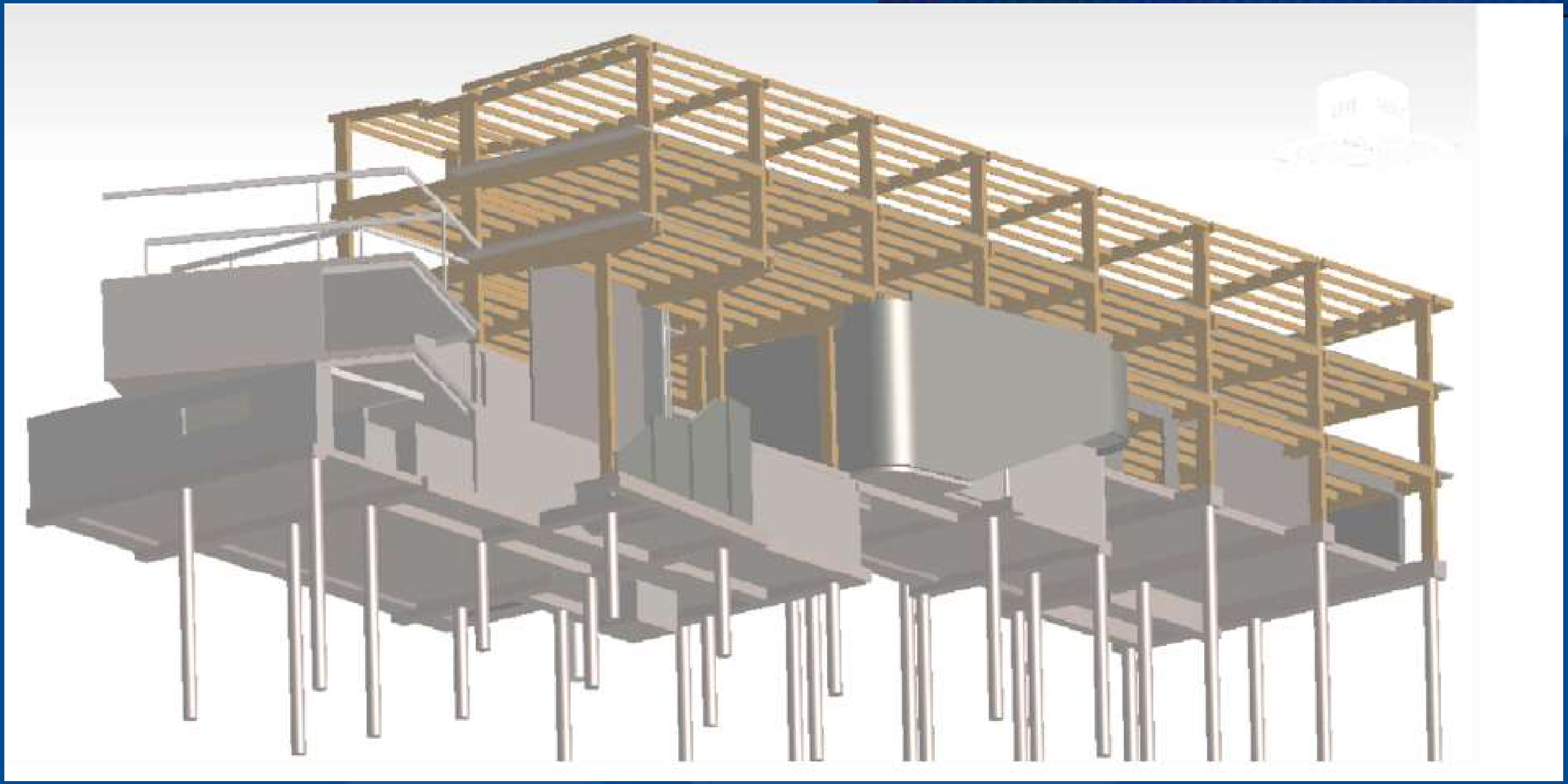
Basic Structural Design



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CONSTRUCTION – THE SHARP END

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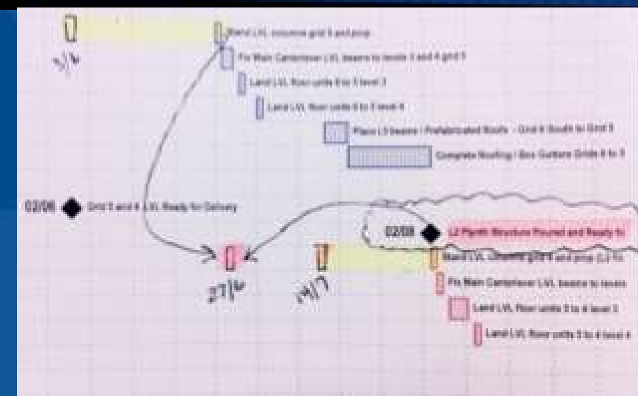
Site Geometry

- 8.5m steep wall excavation
- Multiple work faces



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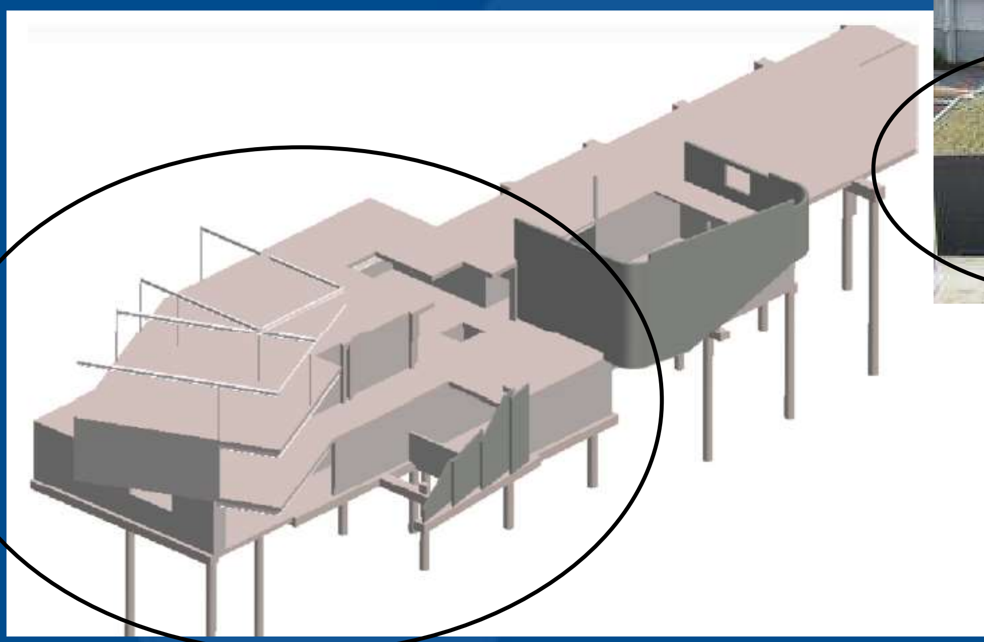
Site Geometry – Ground Conditions

CONSTRUCTION – THE DESIGN AND THEORY

Plinth Structure: Basement to Level 2

- Ridged robust structure
- Traditional materials - concrete, precast, blockwork and steel
- Structural design had to respond not only the new building but also the buildings above in an earthquake



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CONSTRUCTION – THE DESIGN AND THEORY

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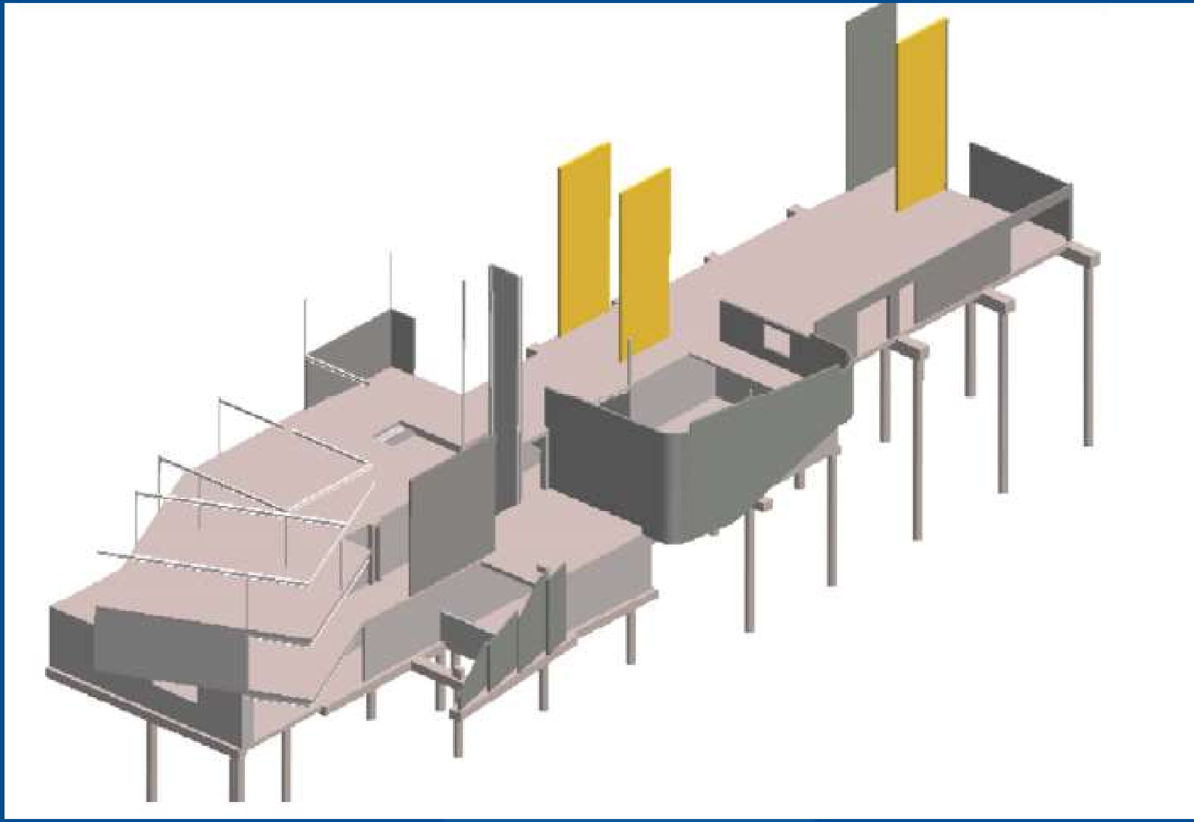
Main Upper Floor Bracing Walls

- North / South – post tensioned shear walls



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Construction – The Design & Theory of the LVL Frame

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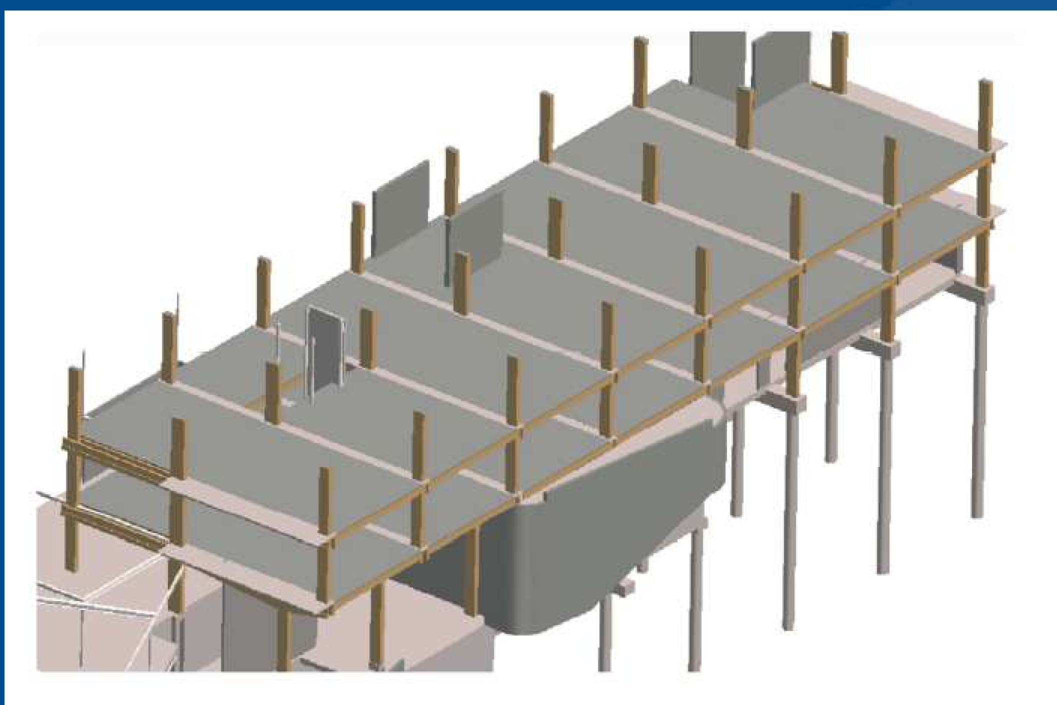
Typical Upper Floor

- Post tensioned LVL beams and columns
- Composite floor slabs
- Insitu stitch joints



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CONSTRUCTION – THE LVL FRAME

Placing / erecting the worlds first post tensioned LVL columns / beams and pre-cambered composite slabs

- No mechanical connections at the beams/column joints – designed to move!

26 May 2012

25 August 2012

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CONSTRUCTION – THE LVL FRAME

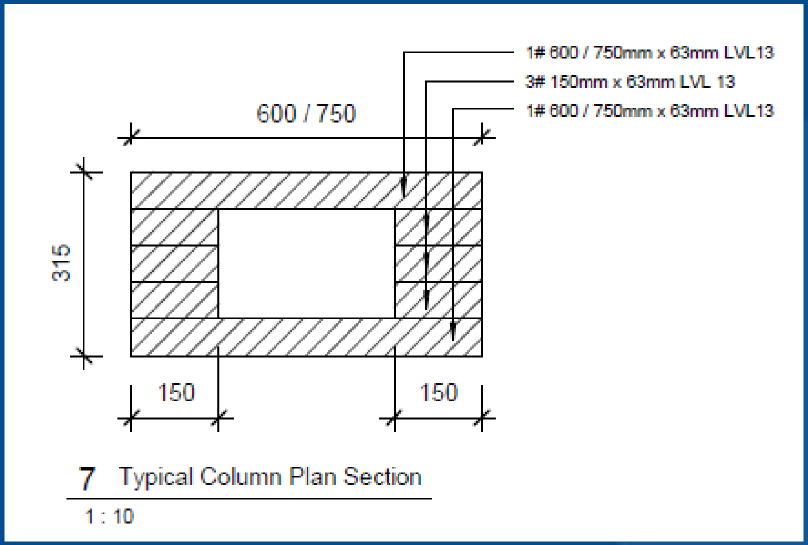
Placing / erecting the worlds first post tensioned LVL columns / beams and pre-cambered composite slabs

- Sequence of operations

CONSTRUCTION – THE LVL FRAME

LVL Columns, deviator assemblies and beams

- Typical Columns – 63mm billet sizes

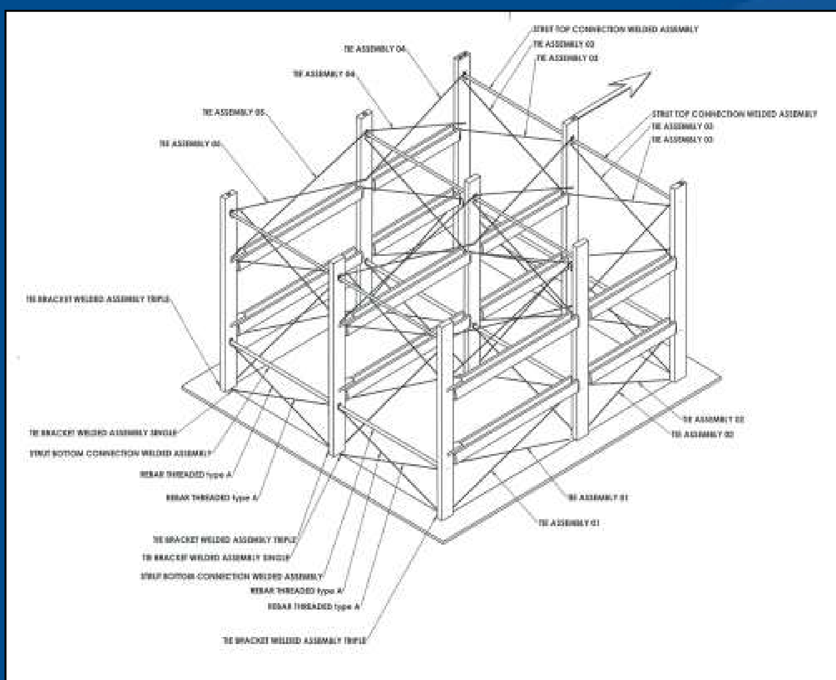


- 1.2 T, light weight
- Two locator pins – some shear capacity
- Designed to avoid “walking” at the base

CONSTRUCTION – THE LVL FRAME

Bracing / propping the LVL column / beam frame

- Threaded rebar ties – tension braces
- Steel struts – compression braces
- Props, ropes & straps



CONSTRUCTION – THE LV FRAME

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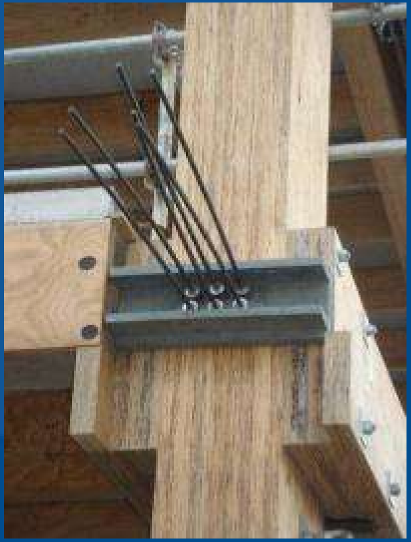
Bracing / propping the LVL column / beam frame



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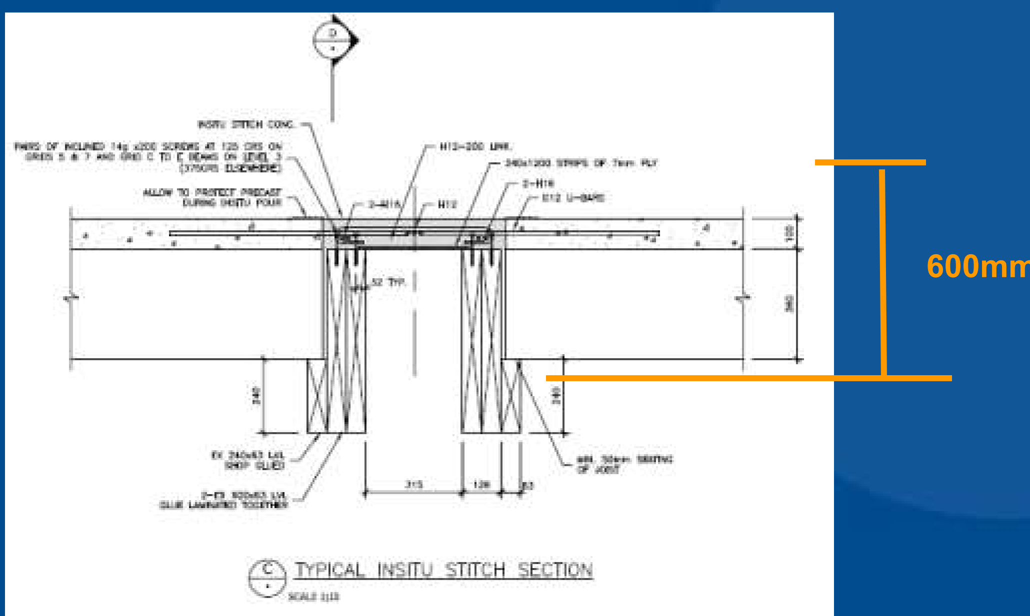
CONSTRUCTION – THE LVL FRAME

Wet trade – Stitch Joints

- programming constraint but alternative available in the future
- Tight tolerances – plane off 1mm to slip in!
- Matching finishes / levels



CONSTRUCTION – THE LVL FRAME

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Transfer Beams and Exposed Columns

- H3.1 with Dryden's Wood Oil
- Trimmer beam cover
- BRANZ visit!

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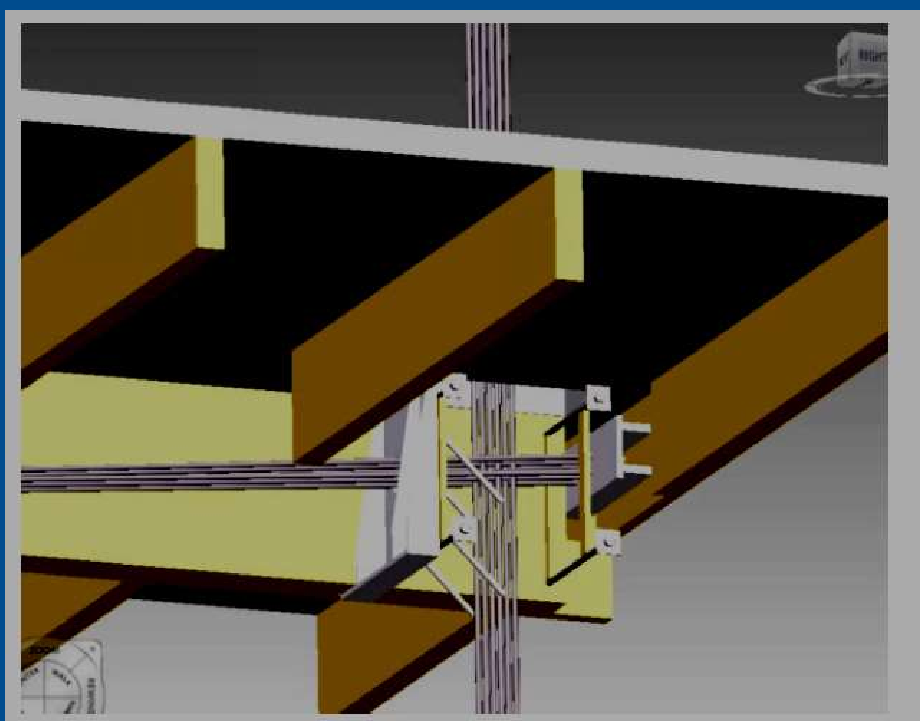
Construction – the design & theory and the sharp end

Post Tensioned Seismic Frames

- The guts of the design – the beam column joint (inside and out)



CONSTRUCTION – THE DESIGN & THEORY AND THE SHARP END

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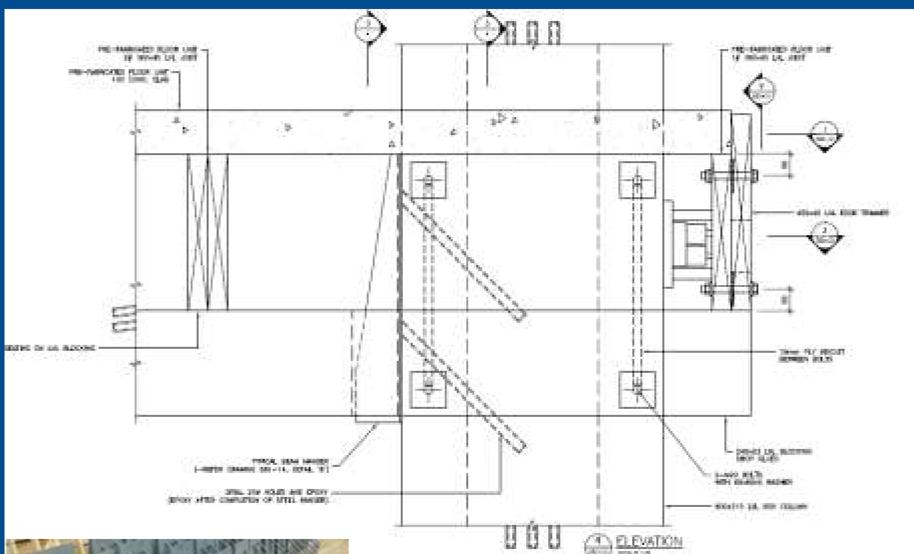
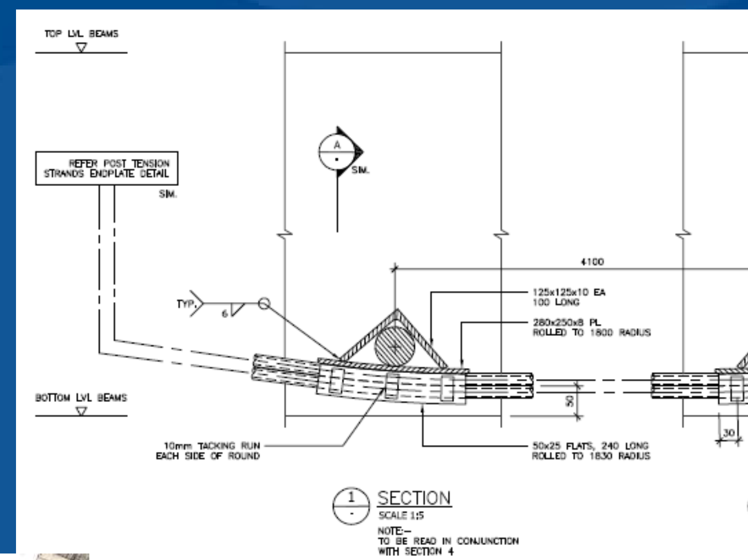
Post Tensioned Seismic Frames

- Beam / Column Joint
- Deviator pins & assemblies





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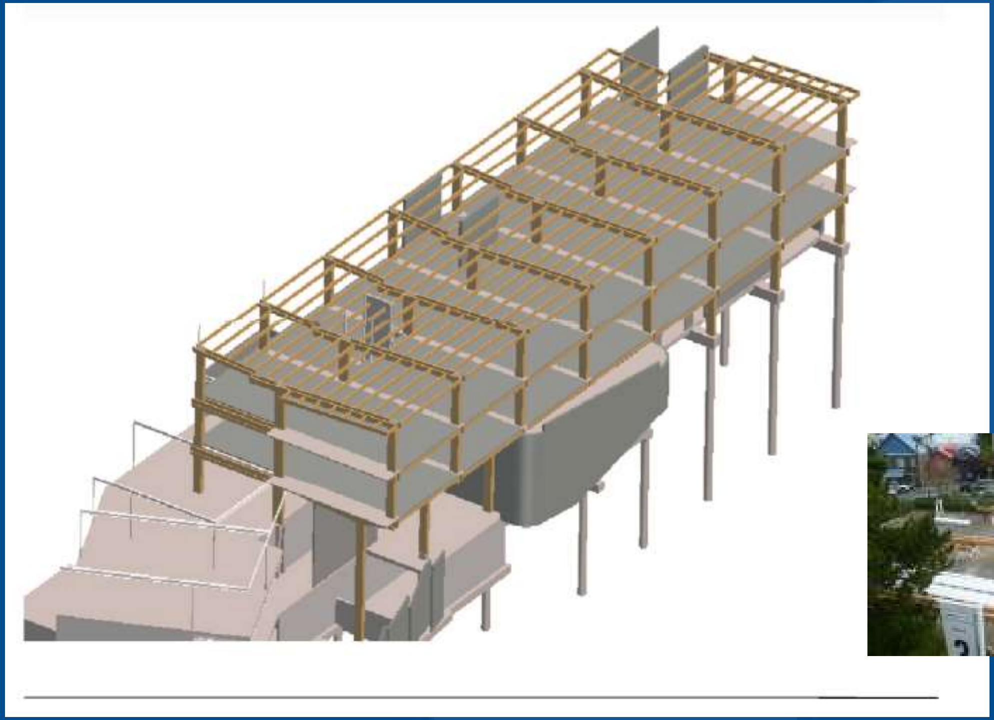
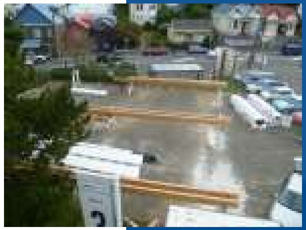
CONSTRUCTION – THE LVL ROOF AND PLY CEILINGS

Roof Structure

- Keeping up with the frame and prefabricate the roof





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CONSTRUCTION – THE LVL ROOF AND PLY CEILING

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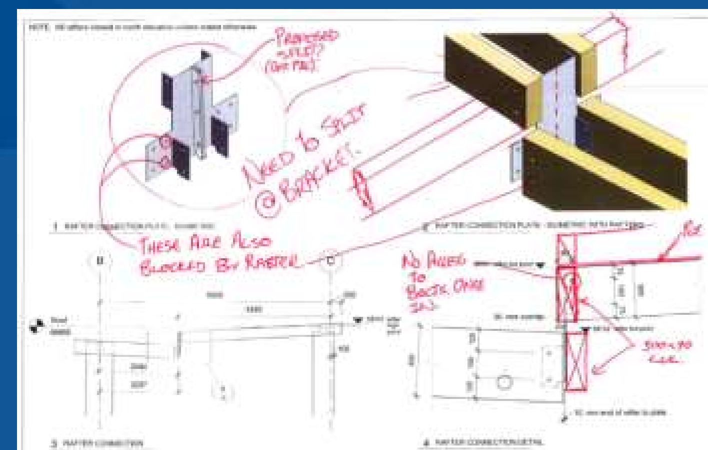
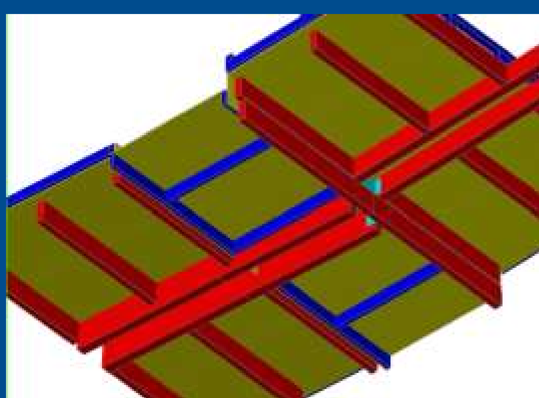
Roof Structure

- Finished ply ceiling included in each section.



CAD Modelling



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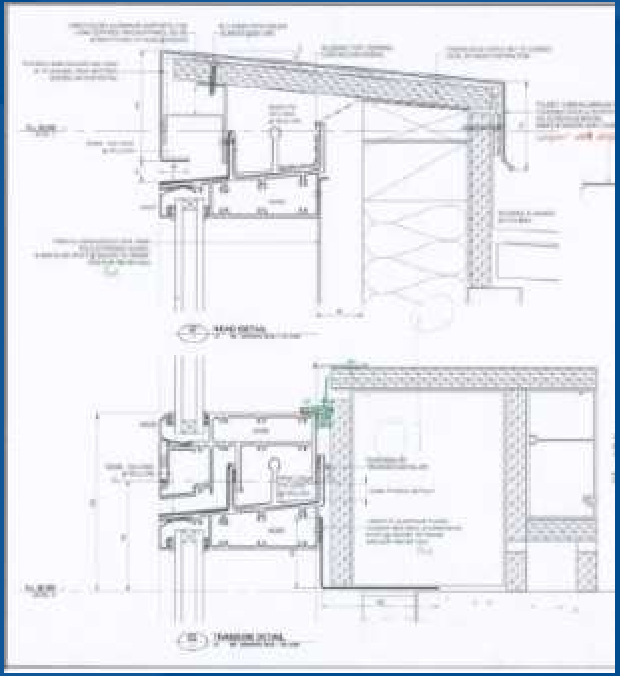
Construction – Attaching the Unitised Curtainwall

Unitised Curtainwall



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Some Lessons and Suggestions

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Post tensioned LVL beams / columns and composite LVL / precast slabs - lessons

- On-site and off-site observation are equally important
- Shop drawings and shop drawing reviews are critical
- QA records must meet very high standards
- Temporary protection of LVL needs be considered carefully
- Inclusion of metalwork components and factory installation is recommended for QA
- Early contractor / subcontractor involvement
- Stitch joints and curing constraints need to be re-thought (wet trades)
- Better bracing planning and temporary beam / column mechanical fixing should be considered in the future
- The next stage is likely to be very efficient even when compared to steel

Cost / Benefit Review

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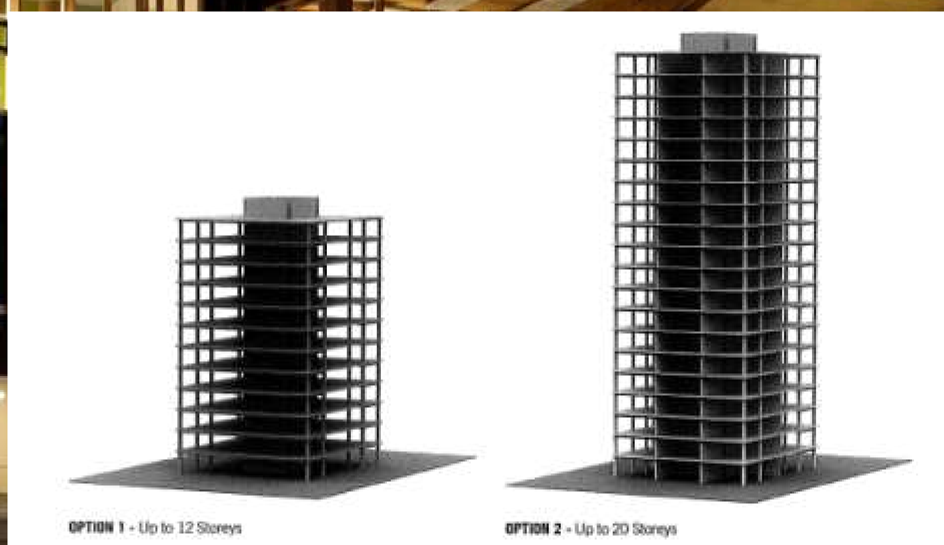
Cost/Revenue Benefits – 'Poor mans base isolcation'

- Minor cost premium over alternatives for significantly improved seismic performance
- Environmentally Sustainable Design (ESD) – use of New Zealand raw materials fully recyclable
- Structure intact and usable after an earthquake and aftershocks – damage avoidance design
- Reduced insurance premiums ?
- Increased rental rates ?
- Increased tenancy terms ?
- Reduced loss of business impacts
- Refer NMIT study and *"A Case for Tall Wood Buildings"* (Energy consumption benefits, reduced GWP, etc.)

THE FUTURE?

Directions

- New combinations of technologies used on NMIT and the College of Creative Arts
- Multi story wood buildings



Windows

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Green Roof

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Studio Space and Ventilation & Light Shaft

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Interior

Upper Access

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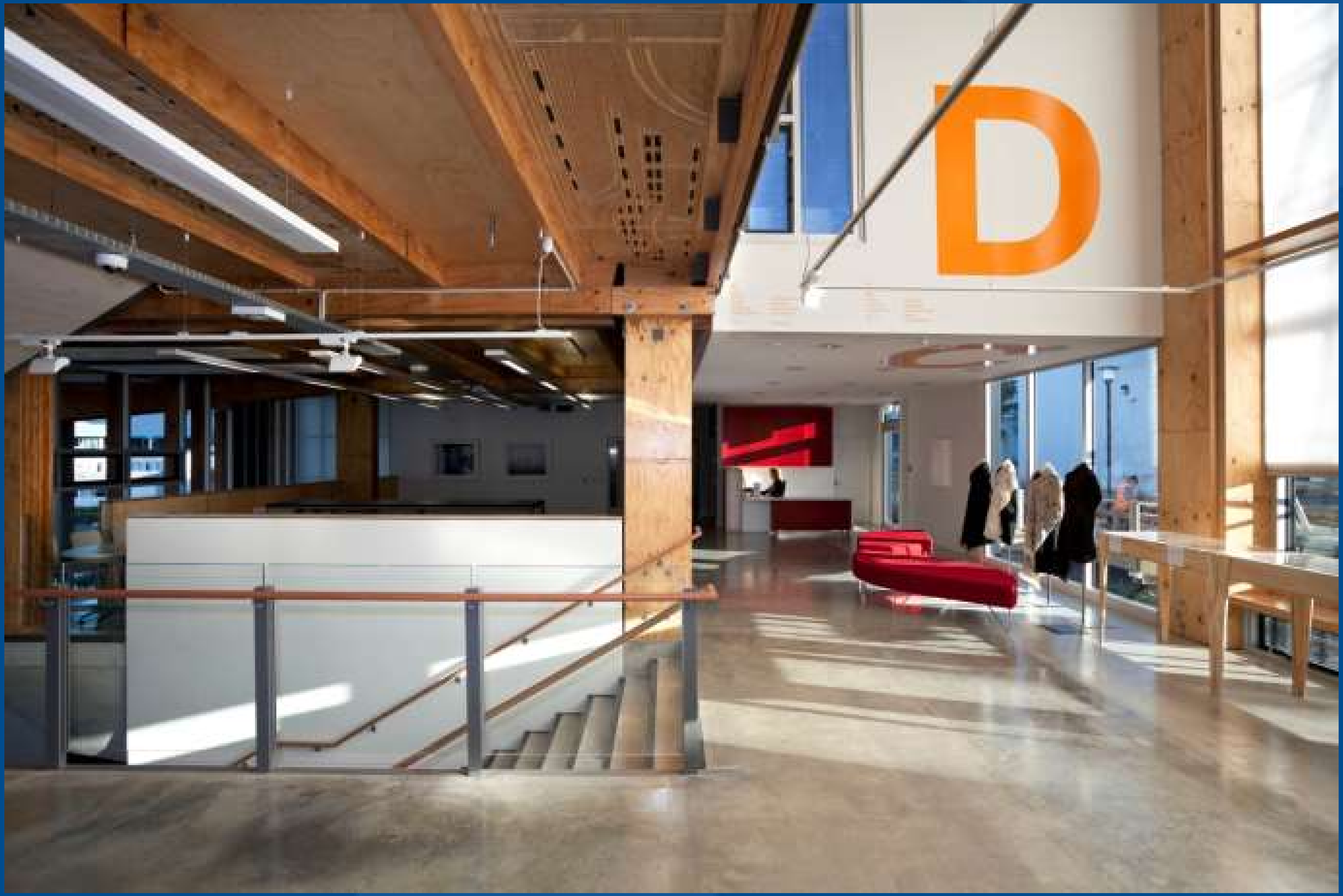
Interior



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Te Aro Hihiko

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DAY AND NIGHT

THE ENGINE
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