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New Technologies in Steel Buildings

Review of material presented by Dr G Charles Clifton

Canterbury Earthquakes Royal Commission
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Why move to low damage steel buildings

• Design Focus	Previously Life Safety, not building continuity
• Current Practice	Member design for between 1/6 and 1/3 of the expected earthquake. Ductility = damage.
• Structural damage	Not addressed in design. Damage = repair
• Non structural damage	Need to limit drifts, keep ductility low
• Code Compliance	Doesn't control or limit 'damage'
• Reality	Some damage / demolition / repair / losses?
• Owner perception	Need to gain some certainty on asset performance?
• Cost	1 - 4% additional capital cost
• Steel structures	Few buildings built with 'damage' mitigation features
• Solution	Change philosophy to apply latest research

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Cast Study – Low Damage Design of Te Puni Student Village

- Victoria University of Wellington – requested inclusion of damage mitigation design in new student accommodation project.
- Three Buildings, up to 11 storeys in height
- Structural system consists of steel frame construction with concrete floors, clad in a lightweight-façade with lightweight roofs
- Lateral bracing systems consist of ‘Moment frames in longitudinal direction’ and ‘Coupled Concentric braced frames in transverse direction’

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The building during construction

- Tower Building (foreground) and Edge Building

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Project goals

Drivers for low damage selection:

- Facility to function as a disaster administration centre with nominal repair
- Suitability to multi storey steel buildings
- Speed of construction / buildability
- Economy of damage mitigation system
- Limit primary structural member damage
- Availability of components
- Sustainability for the future

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Research: Basis of innovative ideas

- University of Auckland, University of Canterbury – research papers
- Moment Frames - Sliding Hinge Joints
- Rocking Steel Frames - CBFs – A tension limited hinge
- Coupled in plane concentric Braced Frames
- Localised and controlled damage in joints rather than in primary members

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The innovation

We developed and refined a new system for damage mitigation system for multi storey steel framed buildings, including:

- Transverse (short direction system) Bracing System (Innovation 1)

  Rocking coupled concentrically braced steel frames (CBF's) with a tension limited foundation hinge, consisting of prestressed Ringfeder Springs and friction plates.

- Longitudinal (long direction) bracing System (Innovation 2 & 3)

  Steel Moment Resisting Frames (MRFs) with sliding hinge joints, a new vertically orientated friction plate joints to provide base column hinge protection.

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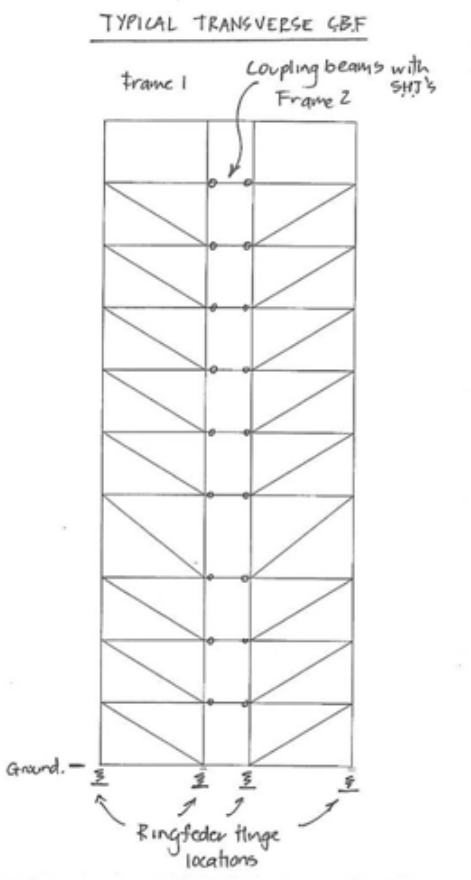
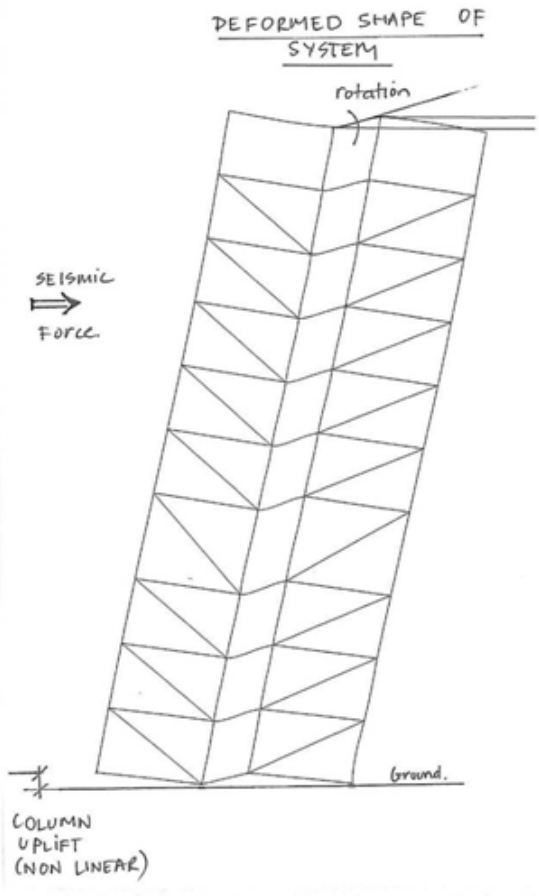
Innovation 1: Transverse Bracing System

Before/After



During



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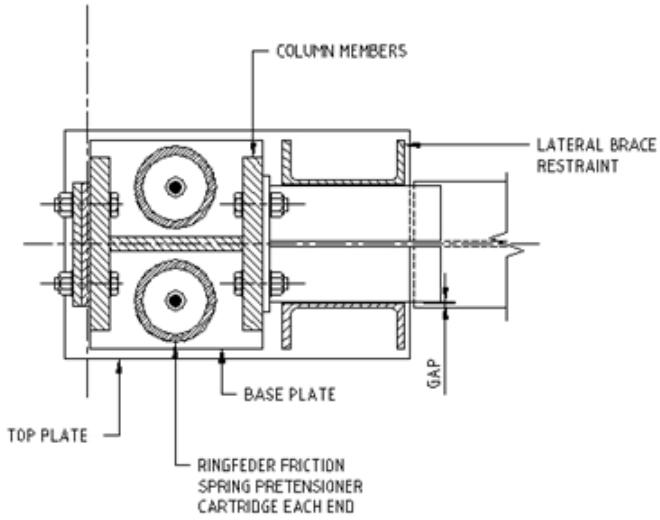
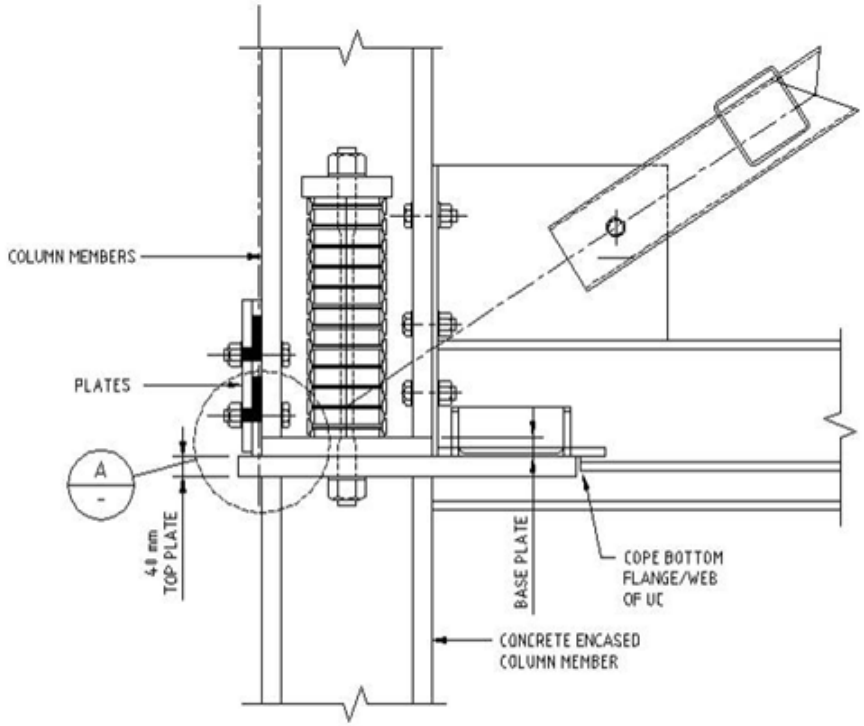
Innovation 1: Ringfeder / Friction Plate Hinge



PLAN ON INTERNAL COLUMN WITH RINGFEDER SPRING & SHJ'S



INTERNAL CBF WITH RINGFEDER SPRING & VERTICALLY ORIENTATED SHJ

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Site photo

- Coupled CBF Frames with central SHJ

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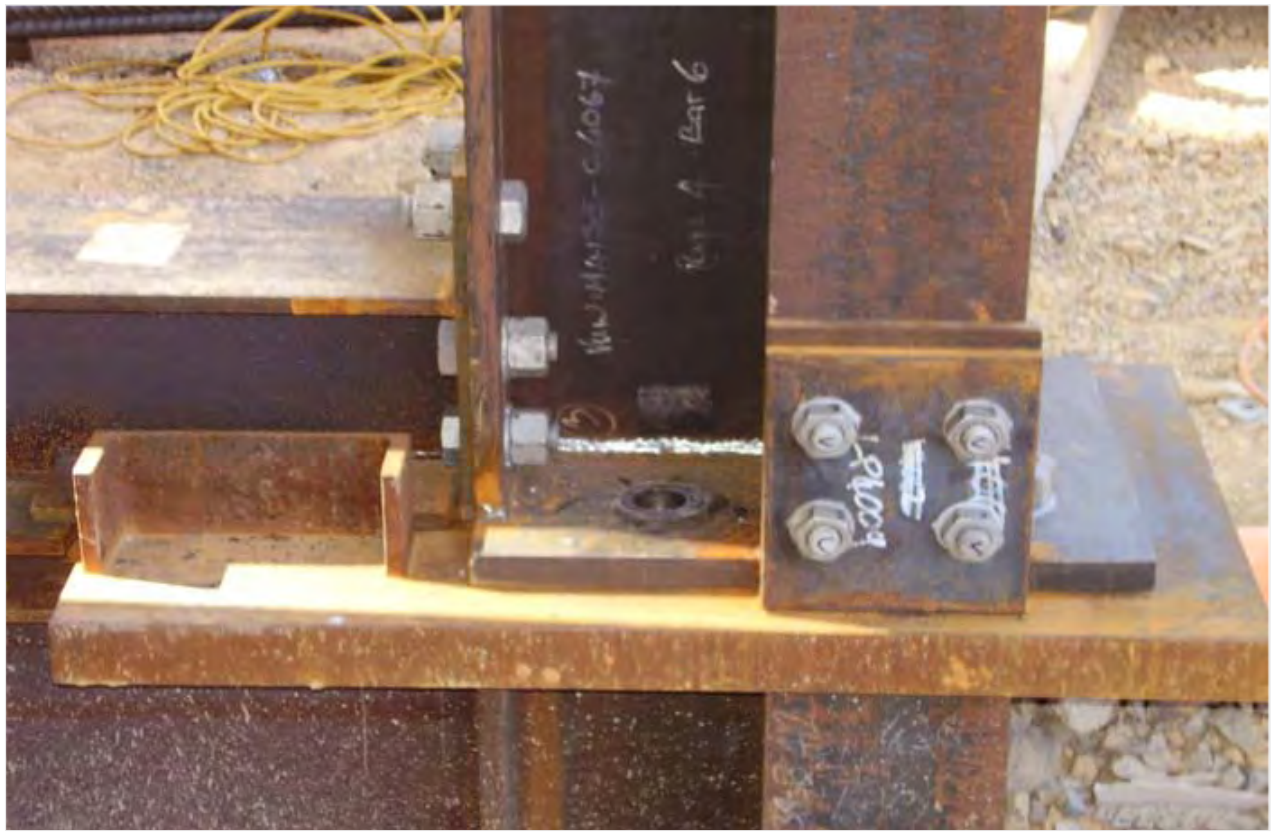
Site photo



- CBF Frame / Ringfeder Housing at foundation connections

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Site photo

- Installed Ringfeder Springs – work in progress

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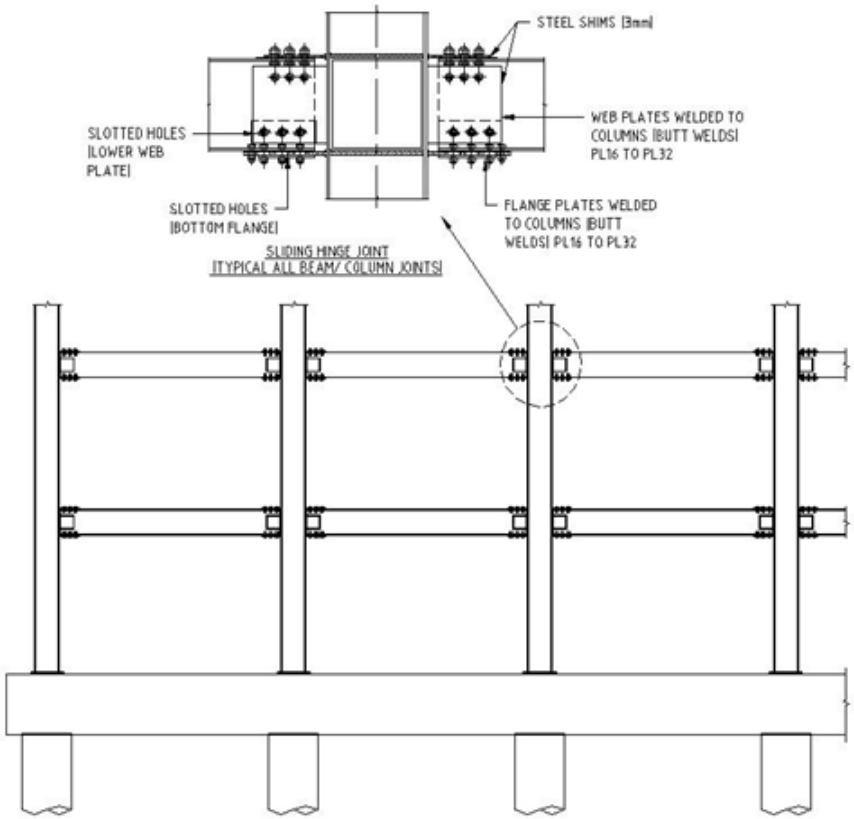
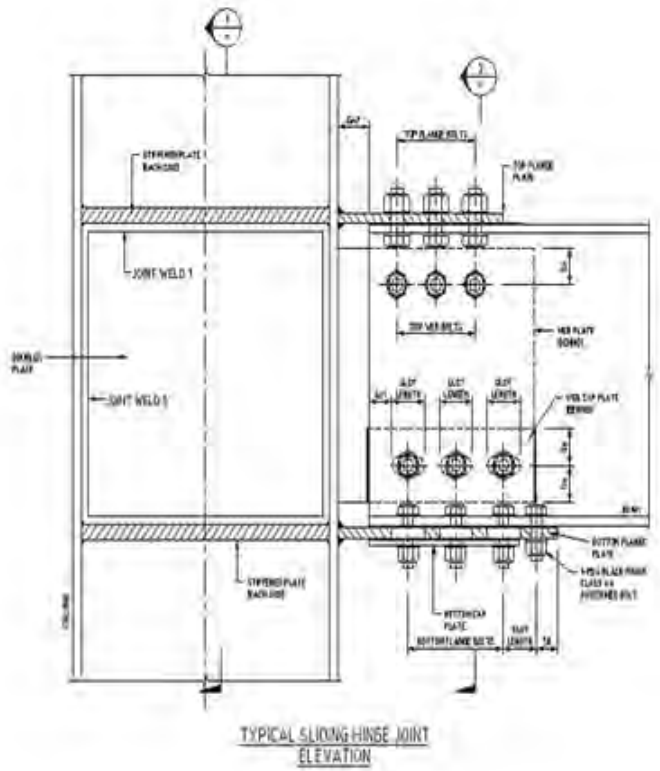
Innovation 2: Longitudinal Bracing System – Sliding Hinge Joints



- Moment Frame with Sliding Hinge Joints



- Sliding Hinge Joint

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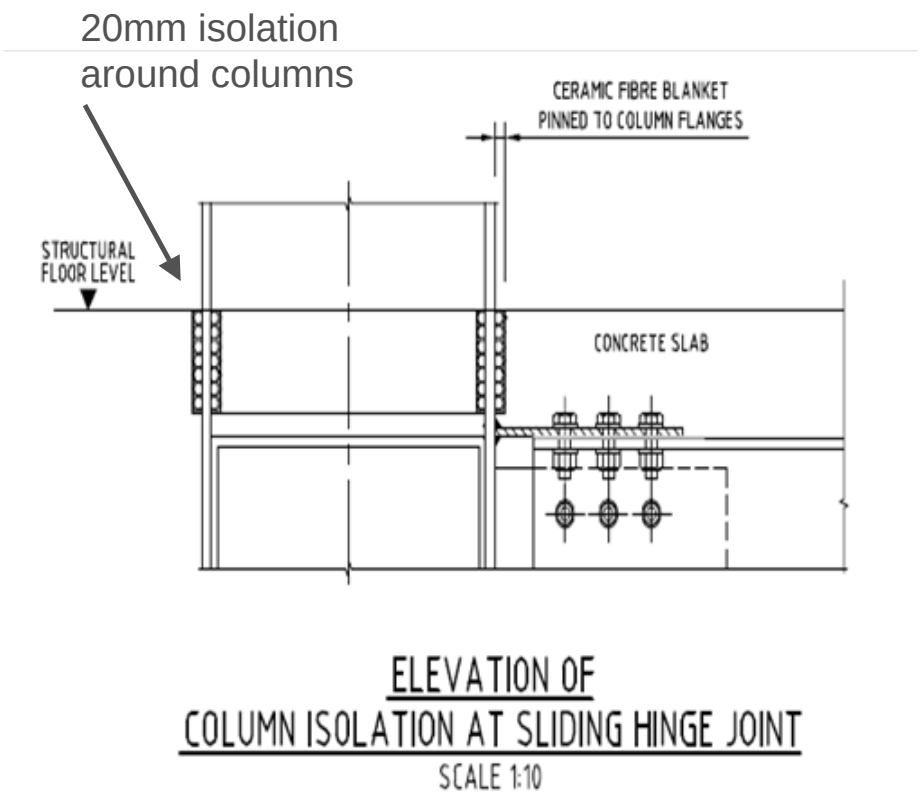
Sliding hinge joints – Limits floor slab from damage

- Sliding Hinge Joints – Invented by Dr Charles Clifton(UOA) – whilst at HERA
- Pivots at flange/beam connection via gap
- Isolates frame movement from cracking concrete floors
- Reduces foundation uplift loads
- Tendency to self-center after design earthquake



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Site photo

- Moment Resisting Frame Column with Sliding Hinge Joint

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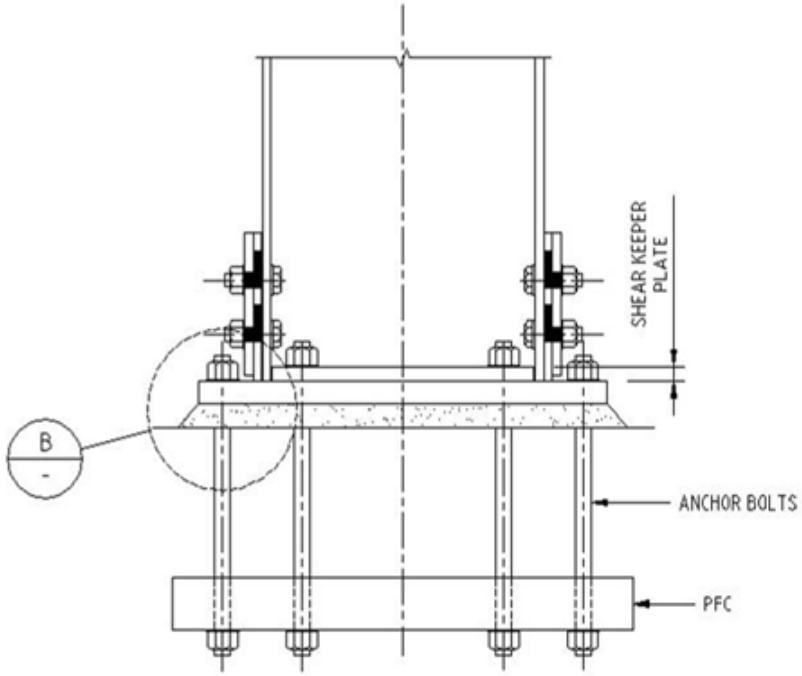
Innovation 3: Longitudinal Bracing System – Column Protection Feature



COLUMN BASE
VERTICALLY ORIENTATED SHJ'S

- Column Hinge Protection in MRF's Columns

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Photos

Photos

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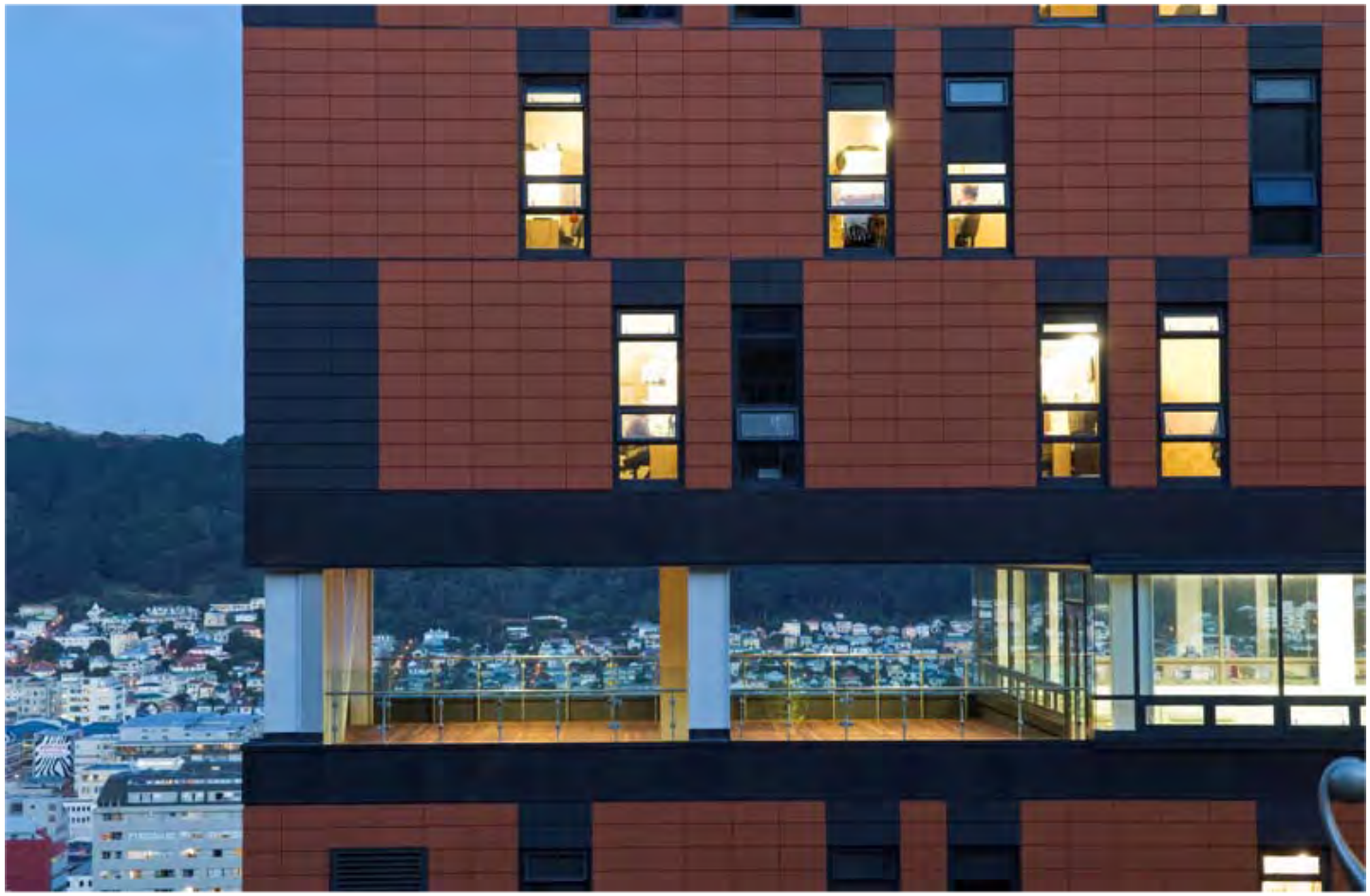
Photos



Photos

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