INTEGRATING GREEN AND RESILIENT BUILDING DESIGN FOR ENHANCED DISASTER RECOVERY

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Motivation – Christchurch Central Recovery Plan

“Improved resilience is a key theme across many of the environmental issues facing the City.”

www.theaustralian.com.au
Motivation – Christchurch City Three Year Plan

“The rebuild will undoubtedly stretch the city’s resources and capacity.”
Objective

Create a framework that

• identifies building characteristics jointly affecting building environmental impact & hazard vulnerability and

• assesses tradeoffs and opportunities in building design & performance
Green-Resilience Framework

Stage 1: Design

Framework Introduction
Green-Resilience Framework
Green-Resilience Framework

Stage 1: Design

Stage 2: Analysis
- Structural Analysis
- Loss Estimation
- Environmental Analysis

Framework Introduction
Green-Resilience Framework
Green-Resilience Framework

Stage 1: Design

Stage 2: Analysis

Stage 3: Assessment

Stage 4: Adoption
- Design Revision
- Construction
- Policy Change
Stage 1: Design

Initial Design 4-Story RC commercial building in southern Los Angeles

Comparison addition of shallow green roof

Control Model

Green Roof Model
Stage 2: Analysis—*Structural*

Model

- 2D, 3-bay building
- nonlinear, dynamic seismic analysis
Stage 2: Analysis—*Structural*

Observations

- interstory drift ratios increased with greater seismic intensity
- stiff green roof model resulted in lower interstory drifts

![Graph showing base shear vs. roof drift ratio comparing Control and Green Roof models.](image-url)
Stage 2: Analysis—*Loss Estimation*

**Process** quantify potential repair needs & economic cost of post-earthquake reconstruction.

*Analysis* Performance Assessment Calculation Tool (PACT)

Damage $\rightarrow$ Materials

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Stage 2: Analysis—Loss Estimation
Stage 2: Analysis—Environmental

Metrics: climate change potential & fossil fuel consumption

Life Cycle: extraction, manufacturing, material transportation, construction, operations and maintenance (O&M)

Assumptions: no material deterioration over life cycle; post-hazard repairs added to O&M stage
Stage 2: Analysis—Environmental

Case Study 1: Green Roof
Stage 3: Assessment

• What are tradeoffs/consequences of design choices?
• What are strengths/opportunities over life cycle?
• What is the overall building performance?
Stage 3: Assessment—Integration
Stage 3: Assessment—Integration

Control Model

- Partition Damage
- Repair Cost
- Fossil Fuel Consumption
- Climate Change Potential

Legend:
- Good Performance
- Poor Performance

Colors:
- Green
- Blue
- Yellow
- Red
Stage 3: Assessment—Integration

Control Model

Green Roof Model
Stage 1: Design

Case Study 2 new hospital construction in Christchurch, New Zealand

Features 4 Star Green Star Rating & PREcast Seismic Structural System (PRESS)
Stage 2: Analysis

**Structural**
- assess performance under extreme loading

**Loss Estimation**
- quantify losses to innovative seismic systems and green building features

**Environmental**
- life cycle performance of solar power, smart lighting, heat recovery system, energy building management
Stage 2: Analysis

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• assess performance under extreme loading

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Environmental
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http://architecturenow.co.nz/articles/seismic-firsts/
Stage 2: Analysis

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http://www.stuff.co.nz/the-press
Stage 3: Assessment

Possible Outcomes

• develop Christchurch as “green city” with “stronger built identity”

• integrate disaster reduction & long-term environmental health

• assess life cycle economic, social, environmental tradeoffs and opportunities
Stage 4: Adoption

- Evaluate opportunities & tradeoffs
- Improve & revise design
- Establish disaster risk policies
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