Seismic Low Damage Technologies for Bridges in New Zealand
From Research to Practice

Sam White
Opus International Consultants

Peter Routledge
Opus International Consultants

Alessandro Palermo
University of Canterbury
Presentation Outline

• Introduction to low damage connections for bridge substructures

• Research at the University of Canterbury

• Application to a bridge in Christchurch, New Zealand
Conventional approach

Ductile plastic hinging in concrete
- Economical
- Good ductility
- Damage and residual deformation in large seismic events
- Post-earthquake inspection, assessment and repair

Focus is shifting towards:
- Accelerating bridge construction
- Improving seismic performance
- Reducing post-earthquake costs associated with repair
Innovations in bridge design and construction → Research at UC → Application to a bridge

Dissipative Controlled Rocking (DCR) / Hybrid Connections

Monolithic System vs. Hybrid System

EQ1 record (Loma Prieta, 1989)

Base pier-to-foundation section

Residual drift

Residual rotation

Sam White, Peter Routledge, Alessandro Palermo
Innovations in bridge design and construction → Research at UC → Application to a bridge

Dissipative Controlled Rocking / Hybrid Connections

Moment contributions
- $M_{PT}$ - Post Tensioning
- $M_N$ - Gravity Load
- $M_E$ - Energy Dissipation

Recentering ratio
$$\lambda = \frac{M_{PT} + M_N}{M_E}$$

**Unbonded Post-Tensioned Tendons or Bars**

Energy dissipaters

**Hysteresis response for recentering components**

**Hysteresis response for dissipating components**

**Resulting flag-shaped hysteresis response**
Innovations in bridge design and construction $\rightarrow$ Research at UC $\rightarrow$ Application to a bridge

Research at the University of Canterbury

- Cost-effective, pre-determined repair methodologies
- Minimise the need for post-earthquake assessment of residual strength and ductility
Could cut this slide and just jump straight into the range of low damage connections we tested. No need to talk about emulative here.

Sam White, 6/18/2016
Testing of Low Damage Connections
Testing of Low Damage Connections

Innovations in bridge design and construction → Research at UC → Application to a bridge

Sam White, Peter Routledge, Alessandro Palermo
Innovations in bridge design and construction → Research at UC → Application to a bridge

Wigram-Magdala Bridge

1525mm deep Super-tee beams with 200mm thick slab

In-situ pier headstocks

Concrete plinths

1500mm dia. steel cased columns with low damage connections

900mm dia piles

60 degree skew
Low-Damage Joint Detail
Low-Damage Joint Detail

- Post-tensioned Macalloy bar
- Steel cased column
- Dissipater anchorage
- Rocking interface
- Energy dissipater
- Dissipater anchorage
- Macalloy anchorage

15.9m

In-situ headstock
1500mm dia. cased column
Concrete plinth

Low damage rocking connections

Innovations in bridge design and construction → Research at UC → Application to a bridge

Sam White, Peter Routledge, Alessandro Palermo
Innovations in bridge design and construction  ➔  Research at UC  ➔  Application to a bridge

Construction Photos

Sam White, Peter Routledge, Alessandro Palermo
Innovations in bridge design and construction → Research at UC → Application to a bridge

Construction Photos

Sam White, Peter Routledge, Alessandro Palermo
Innovations in bridge design and construction → Research at UC → Application to a bridge

Construction Photos
Conclusion

• Testing and application of low damage connections highlighted a number of issues and challenges

• Low damage connections will continue to improve with further testing and application

• It is expected that low damage connections will offer a competitive alternative to conventional methods of construction
Thank you for your attention

Any questions?
Innovations in bridge design and construction → Research at UC → Application to a bridge

Energy Dissipaters

‘Mini Buckling Restrained Brace (BRB)’

Grooved Dissipaters

Sam White, Peter Routledge, Alessandro Palermo
Could cut this slide and just jump straight into the range of low damage connections we tested. No need to talk about emulative here.

Sam White, 6/18/2016