FP4.1 - Exploration of Lower-Damage Modifications to Conventional Reinforced Concrete Walls

Project Title

Exploration of Lower-Damage Modifications to Conventional Reinforced Concrete Walls

Research Team

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Project Description

Previous research into lowdamage structural systems has focused on innovative methods to either eliminate damage completely or isolate damage to easily replaceable components (structural fuses). For concrete structures, research and practice has primarily focused on posttensioned rocking components with additional energy dissipating devices (Henry et al. 2012, Holden et al. 2003, Kurama et al. 2008, Marriott et al. 2008, Perez et al. 2013, Priestley et al. 1999, Restrepo et al. 2007, Sritharan et al 2015). This focus has resulted in two distinct classes of solutions, hightech lowdamage rocking systems and conventional ductile systems, with few alternatives in between. A 2016 QuakeCoRE FP4 funded project titled “Residual capacity of repaired reinforced concrete walls and lowerdamage modifications” investigated the repair of heavily damaged conventional reinforced concrete walls. Although the walls were successfully repaired to reinstate their Ultimate Limit State (ULS) strength and ductility, the repairs were extensive and costly. This project aims to fill the gap between conventional and lowdamage systems by exploring a range of modifications to conventional wall designs that might result in faster and cheaper postearthquake repairs. This is intended to be an extension of the 2016 QuakeCoRE wall repair project which conceptualised possible lower damage modifications for concrete walls, including the use of armouring or high performance concretes to prevent spalling and crushing of concrete in the compression toe, debonding of reinforcement to reduce the plastic strains, and selective weakening to encourage increased secondary cracking. The focus is on modifications to conventional reinforced concrete walls (i.e. continuous reinforcement and plastic hinge formation in the wall) as opposed to post tensioned rocking (jointed) walls.

Alternative lowdamage concepts that don’t necessarily rely on posttensioned rocking components have been previously developed and tested for concrete frames and bridge piers. A lowerdamage slotted beam design that modified the reinforcement detailing of a conventional plastic hinge to minimise the beam elongation and potential tearing of the floor diaphragm has been extensively tested (Muir et al. 2012). The concept of “controlled damage” or “damagetolerant” plastic hinges has been investigated for bridge piers designed for accelerated bridge construction. Ideas to reduce damage in the plastic hinge region of bridge priers have included debonding longitudinal reinforcement, replacing conventional confined concrete with energy dissipaters armoured within a sacrificial compression region (White and Palermo 2015, Mashal et al. 2016), steelreinforced elastomeric bearings restrained against shear deformation (Motaref et al. 2010), and engineered cementitious composite (ECC) reinforced with shape memory alloy (SMA) bars for recentering (Saiidi and Wang 2006, Saiidi et al. 2009, Varela and Saiidi 2014). Several of these bridge pier solutions could easily be adapted to concrete walls. In particular, the concept of developing a range of solutions that suit different performance objectives and economic considerations has been successful for bridges and such a diverse range of solutions does not yet exist for walls.

Despite the development of lowdamage structural systems intended to simplify postearthquake repair, few studies have actually implemented repairs on tested lowdamage systems. Tests on controlled damage bridge piers have demonstrated that repaired specimens can achieve similar performance to undamaged specimens if the connection is properly detailed (White and Palermo 2015). In addition to verifying the seismic behaviour of the asbuilt wall systems, it is considered important to show the availability of viable options for repair (if required) and that the structural integrity can be successfully reinstated.

Key Objectives

The main objectives of this project are as follows:

1. Experimentally verify lowerdamage modifications to conventional reinforced concrete walls that were conceptually developed during previously funded QuakeCoRE wall repair project. Selected solutions will cover a range of different complexity and expected damage levels.
2. Assess the reparability and residual capacity of the tested alternative wall solutions in comparison to the response of the conventional walls tested, repaired and retested as part of previous QuakeCoRE and MBIE funded research.
3. Verify existing numerical modelling techniques