Joshua Woods

Title
Seismic Retrofit of Deficient Reinforced Concrete Shear Walls using Fibre-reinforced Polymer Sheets: Experimental Study and Anchor Design

Abstract
Modern design standards allow engineers to design shear wall structures to resist lateral loads induced by major earthquakes by ensuring the structures have adequate strength, ductility and energy dissipation capacity to prevent loss of life. However, despite the advances in earthquake resistant design, there is still a large existing stock of shear wall structures designed according to older less stringent design standards (ACI 318-68; CSA A23.3-77) which are potentially at risk of suffering severe damage under moderate to large earthquakes. The common deficiencies in old shear wall structures include insufficient in-plane stiffness, shear strength and ductility. There are many existing techniques to retrofit and strengthen deficient structures to enhance their safety and improve their seismic performance. An attractive alternative to conventional retrofitting techniques is the use of externally-bonded fiber-reinforced polymer (FRP) sheets. Previous studies have demonstrated the feasibility of using externally bonded FRP sheets as a retrofitting strategy for enhancing the flexural strength of reinforced concrete shear walls. In this study, the effectiveness of applying FRP sheets to enhance the seismic performance of deficient reinforced concrete shear walls is evaluated. These walls exhibit brittle shear behaviour due to insufficient shear reinforcement and poor confinement of the boundary elements in their design, leading to poor seismic performance. The shear wall specimens are either strengthened or repaired using FRP sheets and then cyclically tested to failure. A crucial component of this FRP retrofitting system is an innovative tube anchor system. The performance objective of this anchoring system is to ensure that the load carried by the vertical FRP sheet(s) is efficiently transferred to adjacent supporting structural elements and premature failure of the FRP sheet due to FRP-concrete debonding is prevented. Finite-element studies conducted to investigate the performance characteristics of the tube anchor system and to develop an optimized design procedure are presented in this thesis. Experimental results obtained from testing FRP-strengthened deficient reinforced concrete shear walls with the new tube anchor system are compared and correlated with the analytical predictions by the finite element models. Experimental results confirm the ability of the FRP retrofitting system to increase in-plane stiffness, flexural strength, ductility and energy dissipation capacity in shear deficient wall specimens. The system is also capable of recovering the initial stiffness in severely damaged shear wall specimens.

Degree Masters of Applied Science
Date of Completion September 2014
Supervisor Professor David T. Lau