Analytical modelling of controlled rocking connections in post-tensioned timber frames under combined seismic and gravity loading

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Abstract

The Modified Monolithic Beam Analogy (MMBA) is a method for the analytical modelling of controlled rocking connections by establishing a displacement equivalence between the rocking member and an equivalent monolithic member. As member displacement is a function of the applied loads, the MBA must formulated for each loading scenario. The MMBA is extended to loadings scenarios with simultaneous seismic and gravity actions. This formulation can be used to analyse and design controlled rocking connections under combined seismic-gravity actions. The difference in connection response between seismic-only and combined seismic-gravity loadings is exemplified and the design implications for frames under this combined loading case is discussed.

Keywords: post-tensioning, timber, seismic, low-damage design

1 Introduction

Recent earthquake events, such as Christchurch, New Zealand 2010 and 2011 seismic sequences, have illustrated that buildings designed using conventional plastic hinge design principles met life safety objectives but sustained significant damage. Conventional plastic hinge design principles, which have facilitated the design of ductile structures, assert that energy dissipation occurs through plastic hinges forming in members at designated locations (often at column bases and at beam ends). These plastic hinges can undergo large deformations and rotations and the material in these regions enters its plastic state. Effectively, the formation of plastic hinges implies damage to parts of the structural system.

As the materials of the plastic hinge enter plastic states, and are effectively damaged, this material must often be replaced, in order to restore the lateral load resisting system to full performance or alternate strengthening measures employed. The replacement, repair and strengthening process is often complex, expensive, takes significant time to both plan and execute and often requires the tenants to vacate. More often, it can be more efficient from the insurer's perspective to settle for a new structure or lump sum rather than repair the existing damaged building. In this case, the building and land is unproductive until a new building is designed and constructed.

Challenges with reinstating conventional structures after earthquakes has created a demand for low-damage structures – structures which experience much less or no damage in seismic events. These low-damage structures have many advantages over conventional structures including that they can be reoccupied sooner after seismic events, damage to building contents is less repairs or reinstatement, if any is required, are less and

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