Abstract

Post-tensioned timber frames are an emerging concept in timber engineering with great potential for the creation of high-performance and cost-efficient structures. (Palermo, Pampanin, Buchanan, & Newcombe, 2005). Since existing research show that post-tensioned timber frames provide favorable seismic performance (Newcombe, Pampanin, Buchanan, & Palermo, 2008b; Smith et al., 2012), it is evaluated whether they can be used for seismic retrofit of structures. The suitability as a retrofit concept is evaluated on a case study that is part of the *ProGETonE* research program, which aims to provide innovative, and cost-efficient strengthening concepts for existing buildings in seismic hazard regions. The case study deals with unreinforced masonry structures in the Netherlands, which suffer from earthquakes induced by gas extraction in the Groningen gas fields. In the course of the research program, a strengthening concept with steel frames has been developed. This thesis investigates if an optimized strengthening concept is feasible with post-tensioned timber frames. Thereby, possible optimization regards aspects of costs and constructability, seismic performance, and sustainability. Detailed research on the structural behavior of post-tensioned timber frame is provided, for example, by publications from University of Canterbury in New Zealand and ETH Zurich in Switzerland (Newcombe, 2011; Wanninger & Frangi, 2014a, 2016). Simplified numerical modelling approaches have been developed and verified for accuracy with experimental testing (Newcombe, 2011; Ponzo et al., 2012; Wanninger & Frangi, 2014b). A common approach is the representation of the post-tensioned connections with rotational springs. The springs exhibit non-linear moment-rotation relations and can be implemented into numerical models to perform structural analysis. However, existing research focuses on the application of glue-laminated timber (glulam) and Laminated Veneer Lumber (LVL). In addition to glulam timber frames this thesis also considers potential application of cross-laminated timber products (x-lam). The seismic performance of multiple design variants is studied and differences between multiple frame designs are evaluated. Therefore, a simplified modelling approach by Wanninger and Frangi (2014a) is adapted and modified for the use of cross-laminated timber. Moreover, the impact of different design properties on the capacity of post-tensioned timber frames is evaluated in the course of a parameter study. Thereby, common methods in seismic design such as pushover analysis are applied. The findings indicate distinct differences in the performance of the variants. It is found that the x-lam frames provide stiff connections but exhibit rather soft, global deformation behavior, resulting in large horizontal displacement. The results also show that the potential of the post-tensioned timber frames strongly depends on the available construction space. For reasons of limited construction space, it is found that a post-tensioned timber frame with glue-laminated timber is not feasible for the Groningen area. A finalized design concept with x-lam is developed and connection details and construction processes are discussed. The results indicate that post-tensioned timber frames generally possess potential for seismic retrofit, but the developed design concept fail to provide sufficient resistance against bending stresses. Therefore, additional modification is required that, however, depends on results from further research and testing with cross-laminated timber.