Monitoring modern timber structures and connections

Hugh Morris[1], Margaret Worth[2], Piotr Omenzetter[3]

Abstract Long term laboratory experiments have been set up to measure the time dependant performance of multi-nailed connections. Deformations are recorded from dial gauges and strain-gauge based deformation gauges previously used in short term applications. These devices are cost effective but long term drift and creep may need compensation.
A 3 storey building in New Zealand has frames and energy dissipating rocking shear walls constructed from laminated veneer lumber (LVL). Wall post tension, wall shortening, deformation of the energy dissipating devices, floor dynamics, moment rotations and mid span deformations are remotely monitored. Preliminary dynamic performance has been tested and verified the operation of the installed accelerometers and allowed the initial dynamic modes to be identified.

Keywords monitoring, instrumentation, modern structures, LVL, connections

1. INTRODUCTION

The long term performance of moment nail plate connections is being monitored as these will creep at a different rate to the structural timber and could cause moment redistribution in a structural frame with significant serviceability and possibly strength implications. Long term laboratory experiments have been set up to measure the time dependant performance of multi-nailed connections and the instrumentation to measure small deformation changes is outlined in section 2.

The Nelson Marlborough Institute of Technology (NMIT) in New Zealand includes a three storey building with gravity frames and novel energy dissipating rocking shear walls constructed from laminated veneer lumber (LVL). Over 90 channels of data are being collected from this building.

2. INSTRUMENTATION

2.1. Long term tests and use of strain gauge deformation device

A test connection has been constructed to evaluate the moment rotation of a portal frame connection. A datalogger records from strain-gauge based deformation gauges previously used in short term applications. As shown in figure 1 the strain-gauges are bonded to stainless spring steel to give a strain to deformation relationship that is linear and precise over a small range. These are cost effective systems but compensation may need to be made for the long term drift and creep of the strain-gauges.

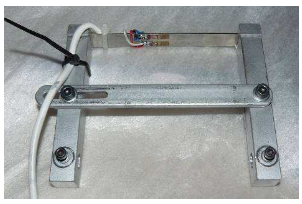

Figure 1 – Stain gauge based deformation device.

[1] Hugh Morris, Department of Civil & Environmental Engineering The University of Auckland, New Zealand, hw.morris@auckland.ac.nz
[2] Margaret Worth, Dept of Civil & Env Eng., Uni of Auckland, NZ, mwor012@aucklanduni.ac.nz
[3] Piotr Omenzetter, Dept of Civil & Env Eng., Uni of Auckland, NZ, p.omenzetter@auckland.ac.nz

2.2. Monitoring systems in the innovative LVL building in Nelson

Two related sets of instrumentation are installed in the arts building at NMIT as shown in figure 2. Wall post tensioning, wall shortening, deformation of the energy dissipating devices, floor dynamics, moment rotations and mid span deformations are to be remotely monitored.

Figure 2a – The NMIT arts building with shear walls at both ends, and along the middle

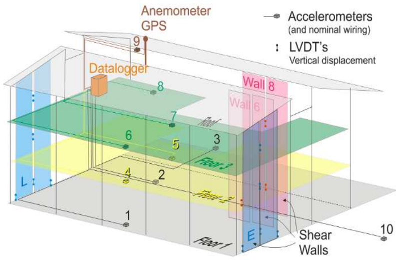

Figure 2b – Schematic of Dynamic layout including accelerometers, LVDTs for lateral monitoring

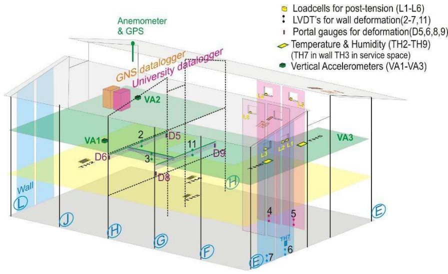

Figure 2c – Schematic of long term layout, with devices for deformation, load, temperature and humidity

Wind or earthquake response is dynamically monitored real time at 200Hz for shear wall deformations and for accelerations at 9 locations. The seismic uplift at the base of the coupled rocking shear walls and deformation of the energy dissipating devices is measured with LVDT's as shown in figure 3.

Long term instrumentation monitors the LVL shear walls for loss of pre-tension in the rods and axial compressive creep. The deformation of several beams and a portal frame are monitored using a wire baseline system. Temperature and humidity, floor vertical accelerations, and deformation at beam column interface are monitored, as well as moment frame deformations in an attached building.

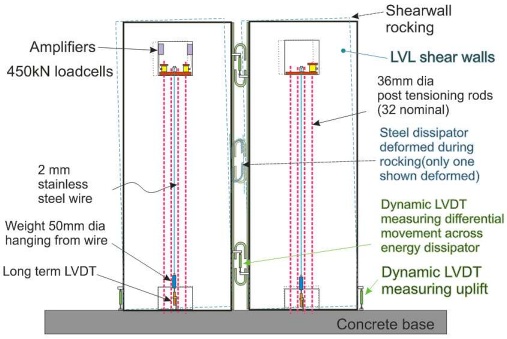

Figure 3 – Shearwall instrumentation schematic

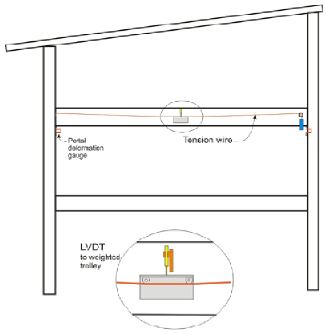

Figure 4 – Floor beams long term monitoring

The long term floor sag is monitored using a baseline system for the measurement reference. As shown in figure 4 a catenary wire is hung over a pulley in between the beam members with a 40kg mass to maintain constant tension and provide a measurement reference.

3. DYNAMIC TESTING

In-situ ambient and forced vibration dynamic tests of the Arts building were performed to analyse the design parameters and identify natural frequencies, damping ratios and mode shapes at various stages of construction. Forced vibration tests were used for updating an FEM model of the building. Initial comparisons with the installed dynamic accelerometers gave good agreement.

4. RESULTS AND CONCLUSIONS

Preliminary results from the forced vibration test series have indicated the response modes and insitu dynamic design parameters and damping of this building at serviceability accelerations. Forced vibration testing proved more reliable than ambient tests for determining the dynamic modal response. Low cost deformation gauges have been used in two long term applications. Monitoring of modern timber structures contributes important design information and this comprehensive system will provide a wealth of data for future studies and is an example that can be used for future comparisons.