



## Seismic

All buildings must be capable of resisting lateral forces. Wind and earthquake forces are the main lateral loads that need to be considered in New Zealand. Wind forces occur frequently and occur from positive and negative pressures acting on the walls and roof. Earthquake ground motion, which arises infrequently, induces horizontal forces in a building. Earthquake induced inertial forces increase as the weight of the building increases as well as when the stiffness of the structure increases. The earthquake design forces also depend on the level of structural ductility considered by the designer.

A wall bracing element is a length of wall with a bracing function and a known bracing performance. The load resistance of wall bracing element is normally determined experimentally and expressed as a "Bracing Unit" (BU)-rating. BUs quantify the forces that act on the building and the resistance that the structure provides; in simple terms, a 1 kN force is equivalent to 20BUs. The total resistance of the structure is the sum of all individual wall bracing element ratings (BUs achieved), which should be equal to, or exceed, the wind and earthquake forces applied to the building.

According to BRANZ<sup>1</sup>, 84% of veneer clad houses constructed in New Zealand are clad with clay bricks, while 16% are clad with concrete bricks. Clay brick veneer houses are also the dominant form of construction in Australia and are commonly used in areas of low seismicity in USA. Generally, design Standards<sup>2</sup> regard the brick veneer walls as non-structural components and require the walls to only support their own self weight. These Standards provide prescriptive construction requirements such as brick tie spacings to be used with timber and/or steel studs, with little regard to the complex interaction between the frame and veneer walls under dynamic loads.

Following concerns that the small-scale tests given in AS/NZS 2699.1<sup>3</sup> are not entirely appropriate for light steel framing, together with the fact that none of the seismic testing conducted in the northern hemisphere used high-strength thin-walled steel that is unique to New Zealand, an international research programme was undertaken in 2009 under the direction of the National Association of Steel-framed Housing (NASH)<sup>4</sup>. The research was conducted as a partnership between the University of Melbourne, University of Auckland, BRANZ, NASH (NZ) and NASH (Australia). In the investigation a full-scale 2.6 m wide × 2.8 m long × 2.4 m high test house was constructed on the shaking table at the University of Melbourne. To provide the most severe case, the test house was subjected to in-plane loading (which has the potential to weaken the veneer/tie/stud system), prior to subjecting it to out-of-plane earthquake loading. The test house reflected typical New Zealand light steel framed construction with 0.75 mm thick lipped C-section studs rolled from grade G550 steel supplied according to AS1397<sup>5</sup>. The exterior veneer consisted of standard 70 Series bricks with Type B brick ties fixed to the steel studs. The internal lining was plasterboard. A roof slab weighing 1500 kg was placed at the top and was supported by the frame to simulate the equivalent mass from a house roof. The result was that the test house exhibited the same dynamic characteristics as those of a typical full-scale single-storey brick veneer house.

To assess the performance of the Test House against specific design performance criteria, a design earthquake was selected as input excitation into the shaking table. The selected excitation was the 1940 El-Centro earthquake record having a Peak Ground Acceleration (PGA) of 0.349g; this selected earthquake record is consistent with the New Zealand Earthquake loading Standard

<sup>1</sup> Thurston, S.J. and Beattie G.J. Seismic Performance of Brick Veneer Houses, BRANZ Study Report 190, 2008

<sup>2</sup> NZS 3604 Light Timber Framed Buildings. Standards New Zealand, Wellington, New Zealand.

<sup>3</sup> AS/NZS 2699.1 Built-in components for masonry construction - Wall ties, Standards Australia/Standards New Zealand, Sydney/Wellington, Australia/New Zealand

<sup>4</sup> Paton-Cole, V.-P., Gad, E.F., Clifton, C., Lam, N., Davies, C. and Hicks, S.: Out-of-plane performance of a brick veneer steel-framed house subjected to seismic loads, Construction and Building Materials, 28, 2012, pp. 779-790.

<sup>5</sup> AS 1397 Continuous hot-dip metallic coated steel sheet and strip - Coatings of zinc and zinc alloyed with aluminium and magnesium, Standards Australia, Sydney

NZS 1170.5<sup>6</sup> and is widely used for benchmark testing by researchers worldwide since it has a good distribution of energy over a broad range of frequencies, thereby providing the absolute worst design case. The earthquake record was scaled to generate design earthquake loading for Serviceability Limit State (SLS), Ultimate Limit State (ULS) and Maximum Considered Earthquake (MCE).



*Test house on shaking table prior to test.*

The Test House was subjected to 9 earthquake tests with increasingly severe levels of shaking intensity ranging from moderate SLS ground motion, to excitation well beyond the design MCE for New Zealand. Up to the eighth shake, which was equivalent to 1.51 times MCE (2.6 times El Centro), the Test House did not suffer serious damage with no bricks being lost from the out-of-plane walls. The testing was terminated after the final ninth shake of 1.57 times MCE (2.7 times El Centro) because the capacity of the shaking table had been reached. The results from this international research programme demonstrated the excellent seismic performance of light steel framing even under the most onerous New Zealand design load conditions.

The benefits of light steel framing in relation to seismic performance are summarised below.

- Ductility of steel as a material.
- Many possible ductile mechanisms in steel elements and their connections.
- More reliable seismic behaviour than those using other materials, due to guaranteed material strength as a result of controlled production and consistent geometrical properties.

<sup>6</sup> NZS 1170.5 Structural Design Actions Part 5: Earthquake actions. Standards New Zealand, Wellington, New Zealand.