Guiding multi-storey timber buildings

The demand for multi-level light timber-frame buildings is increasing, but New Zealand lacks specific design guidelines. The good news is that a BRANZ research project is developing the necessary guide to fill the gap.

IN NEW ZEALAND, as elsewhere, there is interest in pushing forward with new types of timber structures to allow this renewable resource material to be used in simple structural systems for larger buildings, including multi-storey structures.

Growing demand for light timber frames

There are various reasons for increased use of timber in buildings, with environmental and economic advantages at the forefront. Increased steel prices have been cited as contributing to the surge of interest in timber in 2008. However, it was noted then that the timber industries would find it difficult to replace steel for non-residential applications without improving their manufacturing methods and gaining more support from the engineering and quantity surveying sectors.

Along with renewed interest in timber structures is great interest in developing methods for designing and building light timber-frame (LTF) buildings that are larger, taller and have applications in the non-residential market.

LTF buildings tend to be simple to design and are built with locally sourced materials. Additionally, because of the widespread history of use, this system is familiar to many New Zealand builders and designers.

Current standards

The design and construction of LTF buildings in New Zealand are described primarily by prescriptive means using NZS 3604:2011 Timber-framed buildings or, for timber structural solutions requiring specific engineering design (SED), using NZS 3603:1993 Timber structures standard.

NZS 3604:2011

NZS 3604:2011 is intended for use by builders, architects, engineers and designers and provides detailed guidelines for the design and construction of LTF buildings within a limited scope of building types.

NZS 3603:1993

NZS 3603:1993 is more for use by qualified professional design engineers with knowledge of timber structures for the design of timber buildings and components that fall outside the scope of NZS 3604:2011. It is approved as a Verification Method for New Zealand Building Code compliance.

Height limitations for NZS 3604

NZS 3604:2011 very specifically limits the buildings that can be built or designed using LTF— the total height from ground level to the highest point on the roof cannot exceed 10 m.

Two-storey structures are allowed. Three-storey buildings can only have two of the storeys supported on timber framing, and one must be a part storey in a roof space, effectively limiting the number of storeys to 2.5, with additional stipulations on the lower storey walls including the use of concrete or masonry.

Broadening the scope

Testing methods for establishing available bracing units for buildings designed using NZS 3604:2011 limits their use to modest-sized timber buildings that incorporate well distributed structural elements. Although it could potentially be used for buildings beyond the scope of NZS 3604:2011, this would require appropriate engineering judgement.

While the majority of construction methods provided in NZS 3604:2011 should also be acceptable for taller buildings,
additional techniques are needed for foundations, subfloors, walls and diaphragms when building heights are increased.

Other documents are available for New Zealand designers wanting guidance on designs of larger LTF buildings, including the Timber design guide and The multi-storey timber buildings manual.

While these documents provide guidance on the design of larger LTF buildings, none provides prescriptive methods, and some are based on older building codes and standards that have been replaced.

Up to 6 storeys in British Columbia
Standards from other parts of the world provide requirements and limitations on larger LTF buildings, but due to differences in design and building practices, these are only good for ideas - they do not provide specific solutions that can be used in New Zealand. It is worth noting that, in British Columbia, a seismic region in Canada, they have increased allowable heights of LTF buildings up to 6 storeys.

Observations following the 2010 and 2011 Canterbury earthquakes have provided ample evidence that LTF construction provides more than adequate resistance to earthquake loading. This suggests that LTF has great potential for the Christchurch rebuild as well as for the increasing demand for multi-family residential buildings in Auckland.

BRANZ developing a design guide
In New Zealand, BRANZ has a research project Specific design of light timber-framed buildings under way to develop a BRANZ design guide for designers with simple methods for developing LTF buildings beyond the scope of NZS 3604:2011.

This will provide structural engineers with a basis for verifying the compliance of LTF buildings that fall outside the scope of NZS 3604:2011 with the serviceability and safety performance requirements of clause B1 of the New Zealand Building Code.

Issues that will be considered using a combination of previous research, analytical and experimental assessments include:

- strength of bottom plate and rafter/truss/top plate/stud connections
- requirements for end restraints for bracing panels
- effects of vertical misalignment of bracing walls
- effects of torsional response of typical eccentric plan elements
- shear wall resistance when a significant axial load is present - for example, lower floors of multi-storey apartment blocks
- determining the limits that need to be applied to ensure vertical continuity of stacked shear walls.

It is important to remember that, beyond the structural capacity of the various components and the building as a whole, other issues driving the design and construction of larger timber buildings include floor vibrations, acoustic transmission through floors and fire resistance, so these factors must also be considered.

Looking overseas for application here
Currently, the project has included a detailed analysis of how larger timber buildings are being designed and constructed around the world and how these various methods can be applied to buildings using the techniques and materials available in New Zealand.

Testing has been conducted on bottom plate connections, and a testing plan is being developed for 2014 that includes lateral bracing elements and bracing panel end restraints for longer and taller walls.

Delivery in 2016
The project is scheduled for completion in 2016 and will include development of computer models that have been calibrated by means of tests on full-size assemblies of selected systems and include parameters that can be changed easily to suit changing needs.

Development of practical solutions and subjecting these to testing and analysis to prove compliance with the criteria will provide the necessary information for a recognised guidance document that gives engineers the means of easily designing light timber-framed buildings beyond the scope of NZS 3604:2011.