SPECIFIC DESIGN OF LIGHT TIMBER FRAMED MULTI-STOREY BUILDINGS FOR NEW ZEALAND

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ABSTRACT: This paper outlines a research project currently underway to develop methods for providing structural engineers with a basis for verifying the compliance of light timber framed buildings that fall outside the scope of New Zealand Standard (NZS) 3604:2011 \cite{1} and yet maintain the serviceability and safety performance requirements of the New Zealand Building Code. Light timber framing is used widely for the construction of one- and two-storey structures, but the prescriptive standard, NZS 3604:2011 limits the building size to 2½ storeys. Hotel, office and multi-unit residential structures are often of a form that requires the use of many small compartments, which lend themselves to using light timber framing as the main structural system. This project aims to provide guidance documents for the design of light timber framed structures beyond the height or storey limits of NZS 3604:2011, which would allow for greater usage of domestically available timber resources within New Zealand building construction.

KEYWORDS: Light Timber Framing, Multi-storey Timber Buildings, Earthquake Engineering

1 INTRODUCTION AND BACKGROUND

In New Zealand, Australia and around the world there is continued interest in pushing forward with new types of timber structures so that this renewable building material that can be used in simple systems using a range of connectors and skill levels will be used more and for larger buildings, including multi-storey structures beyond the range of most international building codes for timber.

There are various reasons for this move towards increased use of timber in larger buildings, but for this paper, of most interest are situations around New Zealand and Australia where locally sourced materials can be utilised. Increased steel prices have been cited as contributing to the surge in timber interest \cite{2} but it was also mentioned that timber industries may find it difficult to replace steel for non-residential applications without improving their manufacturing methods and finding more support from engineering and quantity surveying sectors. Maclaren \cite{3} used the Nelson Marlborough Institute of Technology Arts and Media Building in Nelson, New Zealand as an example of extensive use of timber in multi-storey buildings and provided numerous reasons for why this type of construction is attractive to designers, builders and users. Buchanan \cite{4} provides an extensive list of benefits derived from utilising timber in larger buildings including economic, environmental, aesthetic and structural performance in earthquakes, while also providing historic examples from around the world supporting the increased use of timber in multi-storey buildings.

Design and construction of light timber framed (LTF) buildings in New Zealand are specified primarily by either prescriptive means using NZS 3604:2011 \textit{Timber-framed buildings} \cite{1}, or for timber structural solutions requiring specific engineering design (SED) using NZS 3603:1993 \textit{Timber Structures Standard} \cite{5}. NZS 3604 is intended to be used 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 is more for use by qualified professional design engineers with a knowledge of timber structures for the design of timber building components that fall outside the scope of NZS 3604, but contains very little information relating to LTF construction methods.

Due to the prescriptive nature of the standard, NZS 3604 specifically defines the limitations on buildings that can be built or designed using these methods. The most relevant limitations for the current research are that the total height from ground level to the highest point on the roof cannot exceed 10 m, and while two-storey structures are allowed, in the event of a three-storey building there are limits that only two of the stories can be supported on timber framing and one of the stories must be a part storey in a roof space, thereby effectively limiting the number of stories to 2.5, with additional stipulations on the lower storey walls that include the use of concrete and/or masonry. Also included in NZS 3604 is a flowchart and schematic drawings for determining the applicability of the standard for a particular building. Testing methods for bracing units used
for buildings designed using NZS 3604 limit their applicability to modest sized timber buildings which incorporate structural elements that are well distributed, but it is mentioned that they could potentially be used for buildings beyond the scope of NZS 3604, but would require appropriate engineering judgement [6]. While the majority of construction methods provided in NZS 3604 are adequate for the scope of buildings allowed by the standard and should also be acceptable for taller buildings, additional design and construction techniques are needed for increased LTF building heights, especially when considering foundations, subfloors, walls and diaphragms. Within these parts of the buildings there are certain components that can likely be constructed using NZS 3604 while others will require more detailed consideration and alteration.

2 RESEARCH METHODS

Throughout the world there have been numerous projects aimed at quantifying the behaviour of LTF buildings. These have included testing programmes on materials, components, assemblies and full-scale structures, and have included monotonic, cyclic and shake table test regimes. One of the largest testing programmes on the behaviour of LTF buildings in the United States has been the NEESWood project, which was a collaboration among several universities and researchers aimed at developing a performance based design philosophy that would allow for safely increasing heights in LTF buildings in high seismic zones while also mitigating damage in these buildings following significant seismic events [7]. In Canada, less stringent restrictions on timber construction have allowed for the design of larger LTF buildings and in recent years the province of British Columbia has altered the provincial building code to allow for LTF buildings up to 6 storeys [8]. The increase in allowable heights has made it necessary to consider alternative design options for vertical and horizontal load resistance in LTF structures.

Because this current New Zealand based research work has a focus similar to other LTF building projects around the world, the methods employed include an exhaustive investigation into the literature generated from the previously mentioned projects, particularly those from North America, where building systems are similar to those used in New Zealand and Australia. Investigations are being conducted to determine the limitations of structural components that are likely to require additional strength or stiffness in order to accommodate increased loads due to higher walls and additional stories. Components such as bottom plates, bottom plate connectors, wall and end stud hold-downs, top plates, top plate connectors (to trusses, rafters, etc.) and shear wall sheathing fasteners will be scrutinised. It will also be necessary to consider the overall performance of typically constructed shear walls, which in New Zealand most often rely on gypsum plasterboard to provide lateral loading resistance in LTF buildings and this is likely to be inadequate for more than 4 storeys [4].

3 PROJECTED OUTCOMES

The aim of this project is to develop a Design Guide that provides structural engineers with a basis for verifying the compliance of light timber framed buildings that fall outside the scope of NZS 3604 and yet fulfil the serviceability and safety performance requirements of Clause B1 of the New Zealand Building Code. While this document would contain methods for designing and constructing LTF buildings within New Zealand and utilising resources found there, the information would draw on many international sources and methods that have been proven effective in other parts of the world.

4 CONCLUSIONS

This paper presents the development of verification methods for the design of light timber frame buildings in New Zealand that currently exceed the scope of the prescriptive timber frame building code. While incorporating methods used around the world, this work also provides a framework for continued development of similar reference documents in parts of the world where light timber framing has the potential for use in multi-storey buildings exceeding 2 storeys.

REFERENCES