

論文の内容の要旨

論文題目

A study on multi-storey timber residential building in Japan –
Contemporary applications and potential opportunities
(日本における多層木造集合住宅の研究 – 応用の現状と潜在する可能性)

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Climate change and global warming are causing a growing number of countries to seek strategies for reducing the use of fossil fuels for energy and the resulting emission of CO₂. In the construction industry, wood has low production energy requirements compared with concrete and steel building materials, and wood building materials have capacity for long-term carbon storage. The processing of by-products for biofuels can replace the use of fossil fuels. Using sustainably managed forests for timber production enhances capacity of forests to absorb CO₂ from the atmosphere, as mature trees are replaced by young trees. Therefore, timber is gradually becoming accepted as the most suitable building material to be integrated with strategies for addressing climate change. In a number of countries, this recognition has helped to revise building codes and provide new options to timber construction in segments, which were prohibited in the past, while also boosting the development of new technologies for engineered timber products and construction methods for new building applications, including multi-storey timber construction.

The advantages of multi-storey timber construction are in expanding timber construction from low-rise buildings to multi-storey buildings, while providing the option of replacing construction methods, which cause heavier loads on the environment. In addition, the fact that multi-storey timber construction requires different structural and technical solutions than low-rise timber buildings creates national economic opportunities as a by-product of the construction itself. Often, countries that have recognised both the national environmental and economic opportunities strive to expand timber construction to the segment of multi-storey buildings.

The overall purpose of this dissertation is to understand how multi-storey timber building could better be developed in order to expand its use in Japan. The study focuses on residential building because this merges environmental and economic opportunities of timber construction. In multi-storey construction, the residential segment has the largest

share of the construction industry. Consequently, promoting multi-storey timber residential building offers the largest growth potential for multi-storey timber construction. To maximise Japan's full opportunities from the promotion of multi-storey timber construction, the larger segment of residential construction needs to be well progressed.

While promoting multi-storey timber construction, it is important to demonstrate that timber material has both advantages as a construction material and several disadvantages; it burns, has low density and low ductility that can cause acoustic and earthquake resistance problems, and as a biological material it changes and can decay. Modern construction, however, as a result of extensive research works demonstrates that, with correct use of technical solutions, safety and quality requirements can be addressed and multi-storey timber building can achieve high building performances, equal to any other modern building. In other words, for multi-storey timber construction, building performances should not be a reason for hindering expansion.

This study examines the progress of multi-storey timber residential building in Japan. The methodology includes reviewing and analysing constructed buildings and the motives driving construction in the country. This study compared Japan with several European countries, which, like Japan, have a relatively short history of construction in this segment. The results show that in Europe, multi-storey timber residential projects are built in large housing markets, and have similar or larger built floor area and construction budgets to non-timber housing projects. They often have better building performances compared with common reinforced concrete buildings and high architecture value, due to design competitions. In general, the segment enjoys a good image among decision-makers and the general public. New technological developments of engineered-timber products, structures and construction methods were invented. Projects are built by financially sound mid-size or large construction companies. Clients are from the public and private sectors, even though the buildings are about 10% more expensive than conventional buildings. Several specific downsides were also found, but while they need to be addressed, they are not critical obstacles for further expansion.

The study found that that the segment has made good and steadily progress as a result of numerous, usually closely co-ordinated, supportive measures undertaken by three groups of key players: the government, research institutes and forest industries, which see a construction segment with large growth potential.

In Japan, the review and analysis of multi-storey timber residential building found that there has been little progress since construction was permitted by Building Standard Law in 2000. The study found that construction is limited in several ways: nationwide expansion is narrow; the segment occupies a narrow market niche of low-grade one-room rental apartment projects; and only small number of buildings has been built. Moreover,

building performance has not achieved the sound insulation target grade, the number of available construction methods and the type of construction companies are limited; and there are no public clients, which could influence the type of projects built. Cost effectiveness motivates the segment's construction. All multi-storey timber residential apartment projects built in the period examined in this study, used timber-frame construction, which costs about 20% less than equivalent concrete buildings. The method was developed as a cost-effective construction method and it was shaped by the needs of its current market niche.

A review of the activities, conditions, and approaches of the three groups of key players, namely, the forest and construction industries, national and large construction companies' research institutes, and the government found that relatively little has been done to promote multi-storey timber residential construction in Japan. Two timber housing builders associations, most importantly the Japan 2x4 Home Builders Association, are behind efforts to move the segment forward. However, the associations' limited capability and wherewithal, due to the size and types of member firms, hinder significant progress.

The opportunities for Japan in promoting multi-storey timber building are in forest economy and health; national economy in cumulative ways; and environment. Compared with a few years ago, there is greater recognition today of the opportunities in expanding multi-storey timber construction in Japan. This study concludes that a clear policy is required with defined objectives aimed at large-scale expansion. In addition, the government, research institutes, and industries need to provide strong and well-coordinated supportive measures. As a by-product of this process, timber residential building would be promoted because of its large share in construction industry, which cannot be ignored. A strong and expanding multi-storey timber construction industry could achieve full economic and environmental opportunities for Japan.