DESIGN AND CONSTRUCTION OF TALL WOOD BUILDINGS: A GUIDE FOR FIRE-SAFETY DESIGN

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ABSTRACT: A technical guide has been developed in Canada to aid in the design and construction of tall wood buildings. In this paper, a design methodology is described whereby a tall mass building can be demonstrated to provide the same level of fire safety as a code-compliant tall building of non-combustible construction. Under the objective-based building code in Canada and under performance-based codes elsewhere, the tall wood alternative is therefore permitted.

KEYWORDS: Fire safety design, mass timber construction, acceptable solutions, alternative solutions.

1 INTRODUCTION

A Technical Guide for the Design and Construction of Canadian Tall Wood Buildings [1] has been prepared by experts under the supervision of FPInnovations. This paper outlines the strategies in Chapter 5 Fire Safety and Protection of the Guide that address concerns about fire safety often thought to be impediments to the use of wood elements in tall buildings. The Chapter outlines a path for developing an alternative solution that demonstrates that a tall mass timber building can meet or exceed the level of fire performance provided by the National Building Code of Canada (NBCC) [2] acceptable solutions for tall buildings of non-combustible construction.

2 CANADIAN BUILDING REGULATIONS

2.1 ACCEPTABLE SOLUTIONS: FIRE SAFETY

Historically the acceptable solutions of the NBCC have restricted the use of combustible construction to 2, 3 or 4 storeys due in part to concerns about fire safety. These acceptable solutions anticipate combustible construction with the lowest level of fire performance: light-frame wood construction. The treatment of mass timber construction is therefore very conservative. Furthermore, as the acceptable solutions are largely prescriptive, they do not reflect state-of-the-art fire engineering methodologies. Consequently the NBCC effectively penalises the superior performance of mass timber construction.

2.2 ALTERNATIVE SOLUTIONS: FIRE SAFETY

The objective-based NBCC permits a designer to adopt an acceptable solution or implement an alternative solution that demonstrates an equivalent level of performance in the areas identified by objectives and functional statements attributed to the acceptable solution it is replacing.

To demonstrate compliance with the fire safety provisions of the NBCC using an alternative solution, one must carry out a qualitative or quantitative fire risk assessment to establish the level of fire risk associated with the acceptable solution, and then carry out the same assessment for the alternative solution, so that the level of performance between the two designs can be compared.

3 DEVELOPING AN ALTERNATIVE SOLUTION

3.1 THE ACCEPTABLE SOLUTION

The prescriptive (acceptable) fire safety solution for a tall building can be quite complex. For the purposes of the Guide, it is assumed that the proposed tall wood building will comply with most of the prescriptive requirements. The most significant alternative is that the structural elements will be of 2-hour rated mass timber construction as opposed to 2-hour rated non-combustible construction.

3.2 ENCAPSULATION

While non-combustible construction is prescribed, an alternative could be to encapsulate combustible structural elements. Encapsulation is a fundamental approach to fire protection of all structural materials. Steel is traditionally protected in large buildings by fibrous or cement coatings,
gypsum board or intumescent paints. Encapsulation initially delays the onset of a contents fire affecting the structural elements, and delays the combustible structural elements from contributing to the fire. The guide considers the pros and cons of three levels of encapsulation: complete, limited and fully exposed (no encapsulation).

### 3.3 Smoke Movement

Naturally, there may be a desire to leave some elements of the wood construction exposed. However, in tall stair, elevator and service shafts, it is recommended that wood construction be lined. The goal is twofold. First, because the joints between panels (such as CLT) may not be as tight as concrete or framed assemblies, shafts constructed of exposed wood panels may be subject to greater risk of smoke migration. Second, exposed wood panels in a tall shaft could pose the risk of rapid flame spread within the shaft. Consequently, it is recommended, unless further analysis, testing or modelling demonstrates otherwise, that shafts be lined with non-combustible material, such as sheet steel, or with a layer of gypsum board.

### 3.4 Fire Resistance

For tall buildings in Canada, a 2-hour fire-resistance rating is prescribed for structural elements. Chapter 5 describes methods for calculating the fire resistance ratings of mass timber elements whether they are exposed or encapsulated. Also addressed is the protection of connections. The fire-resistance integrity of fire separations is also given much attention. This includes discussion of the methods for the protection of joints between panels and of through penetrations (i.e. service penetrations).

Of particular importance is the contribution of layers of fire-rated gypsum board to augment the fire-resistance ratings of structural elements and fire separations.

### 3.5 Concealed Spaces

In developing an alternative solution, it is essential to acknowledge that void spaces will occur, and establish a methodology to address the risk. The concern with concealed spaces is simply that these spaces may allow for fire growth, or may contribute to fire spread through a building, possibly bypassing fire separations. The premise of the approach in the Chapter is that all exposed timber within concealed spaces must be protected unless it is shown that protection is not required in the alternative solution. Protection could entail encapsulation, but other alternatives are also discussed.

### 3.6 Spatial Separation

A fire in a building can pose a threat to neighbouring buildings. Flames issuing through windows or unprotected openings in the exterior wall can cause combustible materials on a nearby building to ignite by direct flame impingement or through excessive thermal radiation.

For sprinklered tall-wood buildings in which complete encapsulation has been employed, it is assumed that the building will perform as well as if it were a sprinklered building of non-combustible construction for all fire protection considerations including those related to spatial separation and exposure protection requirements. If partial encapsulation is employed, the fire intensity will not likely be greater than in a non-combustible building, but the potential fire duration could be longer, and water supply duration available for controlling exposures should be increased. Again a properly designed automatic sprinkler system will significantly mitigate this concern.

### 3.7 Fire Safety During Construction

In recent years there have been a number of serious fires in wood-frame or mass timber buildings that have received much negative press. The Chapter provides a very detailed explanation of how to ensure fire safety during the construction of a tall mass timber building.

### 4 Conclusions

Development of sound alternative solutions for a tall mass timber building is feasible and practical given the current knowledge of mass timber buildings and fire science. At a most conservative level, complete encapsulation of all mass timber elements provides an equal or better level of fire performance than that provided by concrete or steel buildings. A lesser level of encapsulation, and exposure of certain mass timber elements, can also be demonstrated as providing an equivalent level of safety as a traditional steel or concrete building. It is essential, however, to pay attention to the details.

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### References
