DESIGN OF A 6-STOREY LIGHT-FRAME TIMBER BUILDING IN QUEBEC CITY

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ABSTRACT: This paper presents the structural design of a case study, a 6-storey timber building in Quebec City, showing the feasibility of using light-frame wood construction in this context. Specific hotspots of the design are discussed, such as appropriate design specifications, vertical resistance, vertical deformation due to loading and shrinkage, fire performance and global lateral resistance and deformation. It highlights specific considerations which need to be addressed in order to insure successful realisations in this specific context.

KEYWORDS: mid-rise timber building, structural design, light-frame construction, vertical movement, lateral resistance, shearwall, diaphragm, hold-downs.

1 INTRODUCTION

Wood light frame structure has been used successfully for a long time in Canada for the construction of residential buildings up to three storeys. Apart from performance based-design, wood constructions are allowed up to 4 storey by Canadian Regulation [1]. Since July 2013, Quebec Government consents the construction of wooden residential buildings up to 6 storeys, when designed following specific guidelines [2].

Cecobois is presently developing a technical guide to support practitioners in the design of these 5- and 6-storey residential buildings. In this process, a design example was developed to highlight the hotspots of such a construction, in this specific context. A team of architects and engineers was involved in the design process to insure the development of a realistic case study.

The design and construction of a 4- 5- or 6-storey building require specific attention. Even when using the same light-frame construction system, the design and construction of these buildings are in many aspects different than low-rise building, specifically in terms of the lateral resistance system and details to control the vertical movement.

2 OBJECTIVES

The objective of this paper is to discuss the differences in structural design between midrise buildings and traditional 3-storey light frame timber buildings.

3 METHODOLOGY

The specific aspects of the structural design of light-frame midrise buildings are studied using a typical case study. Building codes, technical guidelines, manufacturer’s data as well as discussion with specialised engineers and architects were used to elaborate possible solutions and identify the design hotspots.

3.1 CASE STUDY

The paper presents the structural design of a case study in Quebec City. The residential building is a 6-storey wood light-frame construction (platform frame system) (Figure 1).

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Figure 1: Southern elevation of the case study

The building has a floor area of 1100 m² (19.5 m x 57 m) and a height of 18.3 m (from the ground) with the elevation of the highest floor from the ground at 14 m.

3.2 LATERAL FORCE RESISTING SYSTEM (LFRS)

The case study uses only nailed shearwalls and diaphragms with wood panels, such as OSB or plywood, for the lateral force resisting system.

Figure 2 presents the positioning of the lateral force resisting system (green and red lines). In the N-S direction, the shearwalls (green lines) are located mainly between the apartments. In the E-W direction, the corridor walls are used as shearwalls (red lines), due to many openings in the exterior walls. In CSA O86 [3], only shearwall segments without openings can be considered as a shearwall. However, with shearwalls located in the corridor only, diaphragm is acting as a cantilever beam. Some verification will have to be done regarding the deflection of the diaphragm and the sensitivity to torsion. Floor joists are oriented E-W to minimize gravity loads on façade walls.

Figure 2: Floor plan with shearwalls

4 KEY-FINDINGS

4.1 CANTILEVER DIAPHRAGM

The analysis of a cantilever diaphragm is complex and demand care and attention from the designer. Most examples in handbooks show calculation of diaphragms supported at each end. To calculate the loads distribution on shearwalls, we need to consider a rigid diaphragm. In this case study, this assumption looks acceptable since the cantilever is much deeper than the length of the cantilever. However, this assumption needs to be verified according to the definition of a rigid diaphragm. In CSA-O86 Standards, formula presented for deflection is only for diaphragms supported at each end as a simple beam. There is no guideline regarding a cantilever diaphragm. Designer may adjust the basic deflection formula based on a simple beam to a cantilever beam, or use structural software to make this verification.

4.2 INTER-STOREY FLOOR DETAILS

Inter-storey floor details are very important and may affect the vertical movement of the building, as well as the horizontal displacement, the horizontal shear connections, the fire detail and the cost. The figure 3 shown details the most used.

Figure 3: Inter-storey floor junction

5 CONCLUSIONS

Designing a 6-storey building is feasible with light wood framing system. But some considerations need to be respected. A 6-storey building is a mid-rise construction and has to be designed according to the part 4 of the NBCC. Wood light framing structure can be used for the construction of a 6-storey building as long as there are enough shearwalls with adequate lengths. Short shearwall segments could have enough resistance but may be not stiff enough in term of horizontal deflection. Care should be brought also to inter-storey floor details, especially to reduce vertical movement.

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REFERENCES

