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Concrete apartment tower in Los Angeles reimagined in mass timber

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ABSTRACT

This study explores the seismic performance advantages and disadvantages of mass timber construction over reinforced concrete construction for high-rise buildings in high seismic regions. In a side-by-side comparison of a 20-story reinforced concrete tower and a corresponding mass timber tower, the timber tower is demonstrated to have roughly half the mass and twice the flexibility of the reinforced concrete tower. Building code minimum for acceleration and maximum for drift govern the lateral design of the theoretical mass timber tower, whereas code minimum acceleration and strength govern the reinforced concrete tower. The study demonstrates that mass timber provides a viable alternative to reinforced concrete construction in high seismic regions.

1. Introduction

The market for mass timber high-rise construction is growing in the United States. The development of large scale engineered wood products such as cross laminated timber (CLT) has allowed mass timber to compete with steel and concrete in tall building construction with respect to cost and schedule. In addition, mass timber structures offer sustainable advantages over steel and concrete because wood is a naturally renewable resource with relatively low embodied energy. Federal funding, proposed legislation in support of mass timber market growth, and code developments are all facilitating the rise of the construction type.

Compared to steel and concrete, relatively little is known about the structural performance of high-rise mass timber buildings, particularly in regions of high seismic activity. This study presents the design of a code-compliant, high-rise mass timber apartment tower in the seismically active city of Los Angeles. Using the existing cast-in-place (CIP) reinforced concrete Museum Tower Apartment building in downtown Los Angeles as a basis, the study demonstrates structural performance improvements and tradeoffs of the mass timber design compared to the reinforced concrete design.

2. Architectural design

The existing 20-story Museum Tower Apartment building is constructed using a reinforced concrete perimeter moment frame with a beamless interior supported by post-tensioned concrete slabs. Cladding is painted structural concrete and window wall glazing. No additional fireproofing is added to the concrete structure.

Before beginning design of the mass timber tower, the CIP tower baseline model was simplified to allow for easy comparison of the structural performance and architectural expression of the CIP and mass timber towers. The three podium floors were replaced with the typical tower footprint and basement floors, mezzanine and penthouse were eliminated. This resulted in the baseline CIP tower with twenty floors of identical footprint. Using this same footprint, the 20-story mass timber tower was designed.

While maintaining the same floor plate and massing of the CIP tower, the theoretical mass timber tower finds architectural expression by exposing the wood structure, recessed balconies, a vertically continuous window walls expression, and the streamlining and modernizing of interior floor plans and unit amenities. The mass timber tower uses steel buckling-restrained brace frames, glulam columns, and beamless composite concrete cross laminated timber floor slabs. Cladding is weather-coated mass timber and window wall glazing (see Fig. 1).

2.1. Floor plan layout

The CIP tower floor plan includes four studios, four one-bedrooms and four two-bedrooms laid out among eight interior columns, and thirty-two perimeter moment frame columns. While maintaining the number and size of the units of the CIP tower, the mass timber tower floor plan is completely redesigned to accommodate the fewer number of columns (thirty-two overall) and the braced frames of the mass timber structure. See Fig. 2 for the CIP tower floor plan and Fig. 3 for

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Fig. 1. Perspective view of existing museum tower apartment tower and mass timber apartment tower.

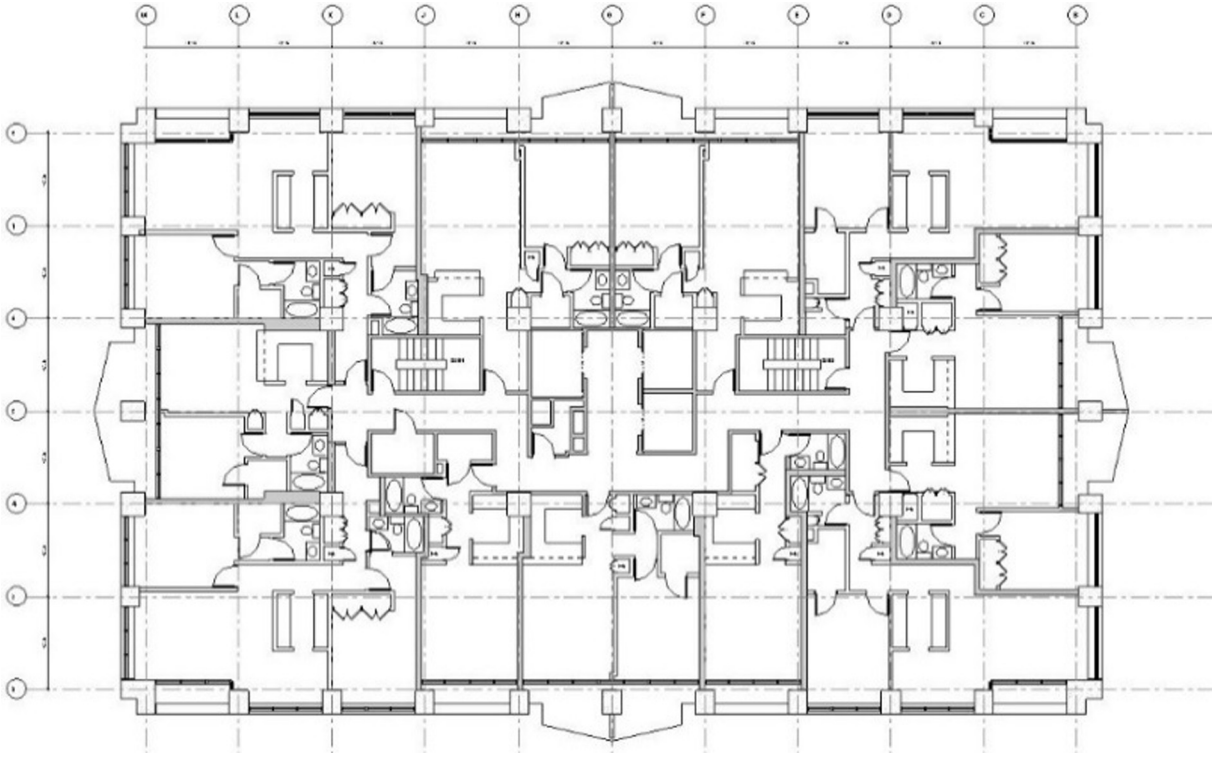

Fig. 2. Floor plan view of existing museum tower apartment tower.

the mass timber tower floor plan.

2.2. Beamless floor design and building height

To achieve a competitive building height with the CIP tower, the mass timber tower has a beamless floor design and a matching 8′–0″ (2.438 m) floor-to-ceiling height. While the CIP post tensioned slab thickness is 8″ (203 mm), the mass timber slab has two thicknesses, the thickest of which is 12 1/8″ (308 mm). Hence the mass timber tower is typically 4 1/8″ (105 mm) taller per floor than the CIP tower; typical floor-to-floor height is 8′–8″ (2.642 m) for the CIP tower and 9′–0 1/8″ (2.746 m) for the mass timber tower. On floors 1–4 and 19 and 20, the mass timber floor-to-floor and the CIP floor-to-floor have been set equal as follows: 1: 14′–3″ (4.343 m), 2–4: 10′-6″ (3.200 m), 19: 11′-0″ (3.353 m), 20: 12′–0″ (3.658 m). The CIP tower is 190′–1″ (57.937 m) and the mass timber tower is 194′–10¾“ (59.404 m).