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Structural Systems for Mass Timber Buildings

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1 Abstract

This paper investigates the design of lateral force resisting systems (LFRS) for multi-story mass timber structures in Boston, MA. Structural and environmental tradeoffs of replacing conventional concrete cores or steel braced frames with glue-laminated timber (GLT) braced frames are evaluated through numerical analyses of 8-, 12-, and 18-story building prototypes. Finding an optimal timber gravity system configuration is followed by examining lateral resistance of the prototypes. The resulting designs demonstrate a practical approach to assist designers in selecting a lateral system during the early stages of conceptual design. This research was conducted in parallel with a related study for implementation of mass timber in affordable housing in Boston, enabling a comparison between composite systems and all-timber structures.

Keywords: Mass timber, braced frames, affordable housing, sustainability, embodied carbon

2 Introduction

Carbon dioxide (CO_2) comprises approximately 81.6% of the greenhouse gasses (GHGs) released into the atmosphere, and 49% of this CO_2 is generated by building construction and operation [1]. By expressing the weight of carbon dioxide equivalent (CO_2e) of all GHG emissions from producing the embodied energy of a building, designers can estimate the Global Warming Potential (GWP, measured in kg_{CO2e}) of a built structure [2]. Production of steel, concrete, and timber entails GHG emissions, however timber uniquely stores (sequesters) atmospheric CO_2 by converting it into biomass through photosynthesis. Storage of CO_2 is especially important when considering the permanence of embodied carbon, contrary to the operational carbon, which can be reduced during the lifetime of a building through retrofit. In addition, for reasons including redevelopment, obsolescence, and lack of maintenance of non-structural elements, actual service life of buildings is often shorter than their design lifespan [3]. With increasing urban densities, sustainable use of materials within typical building lifespans will require innovative solutions for structural systems in order to reduce the carbon footprint of multi-story structures.

In January 2019, new provisions were approved for the 2021 International Building Code (IBC) allowing mass timber construction of up to 18 stories or 270 feet above grade. While the new code amendments make way for wider adoption of timber structures, recently completed mass timber projects (e.g., T3 in Minneapolis, Carbon 12 in Portland, and Brock Commons in Vancouver) demonstrate creative

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