Does Height Matter? The Embodied Impacts of Tallness, Slab Thickness, Building Code, and Design Tranches

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Pre-print: https://www.researchsquare.com/article/rs-6001700/v1

Summary

While it is widely believed that taller buildings are worse for sustainability – a sense that aligns with historical suspicion of tall buildings – this research challenges that assumption and identifies more impactful design strategies for reducing embodied carbon. The work compares the impact of building height to slab thickness, building code choices, and design tranches (the number of floors that have the same structural design) for concrete buildings from 5 to 20 storeys tall. The embodied GHG is evaluated holding the total floor area the same. Accordingly, the equivalent of one 20-storey building is two 10-storey buildings or four 5-storey buildings.

This study evaluates the embodied GHG emissions of 128 reinforced concrete buildings. Using structural design calculations, we assess the quantity of structural materials needed and associated with embodied GHG. Across the 128 studied buildings, we vary height, slab thickness, and design tranches. We evaluate both Canadian and American design codes finding the same overall conclusions for both.

Key Takeaways:

1) **Height has a minimal impact on emissions** – Increasing building height does slightly raise emissions per square meter (~1% per storey), but the effect is small compared to other design choices. The savings from minimizing height are offset by other needed services for additional buildings (e.g. four 5-storey buildings rather than one 20-storey building), such as longer roads and water pipes and more elevators.

2) **Slab thickness is a major driver of embodied carbon** – A 25 mm reduction in slab thickness is equivalent to, on average, removing eight storeys from a building.

3) **Optimizing design tranches significantly reduces emissions** – Designing structural elements floor-by-floor rather than using uniform designs every 10 to 15 storeys can cut embodied emissions by up to 14%.

4) **Building codes influence emissions** – Recent changes in the American concrete design code (2014 vs 2019) caused a noticeable jump in required steel reinforcement for shear compared to the Canadian code, increasing slab rebar emissions by 15 to 45%.

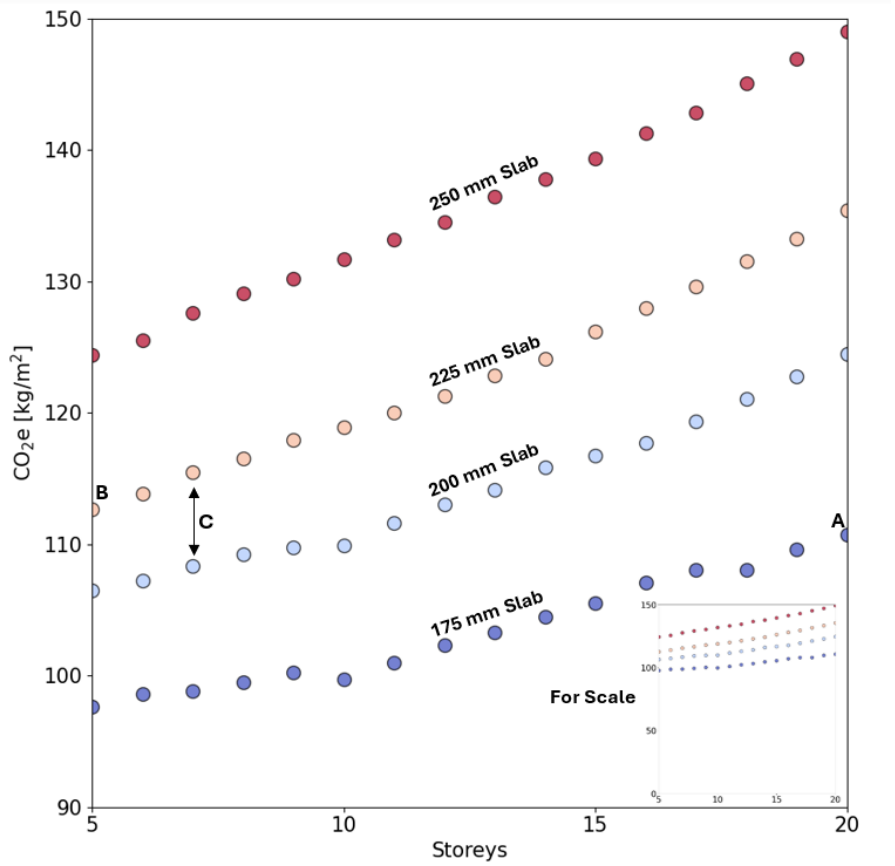

Figure 1: *Global Warming Potential in CO_2 equivalents as the number of storeys increases for 4 different slab thicknesses.*

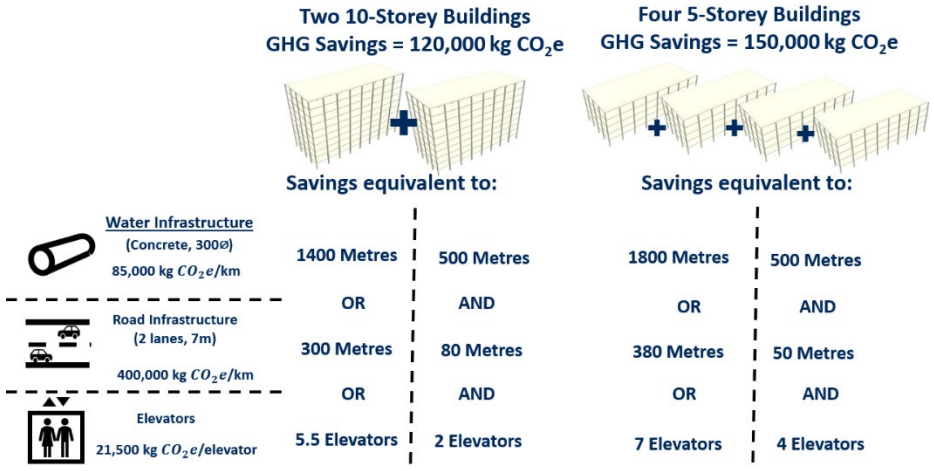

Figure 2: *Comparison of reducing height from one 20-storey building to two 10-storey and four 5-storey buildings in terms of required services.*