Embodied Carbon in Structures and Cities

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1. Abstract

Beyond LEED and other evaluation techniques that largely consider carbon emissions from building operations, a basis for design must be established to account for the embodied carbon in a structure. Minimum acceptable goals must be created to encourage a responsible approach to environmental design—one that accounts for carbon emissions from groundbreaking through the building's service life.

An advanced methodology and tool termed the Environmental Analysis Tool™ has been published that evaluates embodied carbon in buildings. The method is capable of considering the embodied carbon at the time of construction through the expected service life. Considerations are made for material, construction, and probabilistic seismic damage based on specific site conditions.

An evaluation of embodied carbon in over 200 built structures has revealed trends and correlations among common design parameters such as building height, occupancy type, seismic and wind conditions. Correlations of embodied carbon with building height and lateral system type are observed. Results such as this can be utilized by designers to set design goals, and to form a basis for incentive programs and future codification.

Topics: Embodied Carbon, LCA, Carbon Limits, Construction, Seismic Damage

2. Introduction

The environment is at risk. The structural engineering design profession needs to carefully reconsider design approaches to structures. Embodied carbon of structural systems in buildings has been established to be considerable and detrimental the environmental impact of the buildings. Structural materials use mostly natural resources. Large amounts of carbon are emitted into the atmosphere during the extraction, refinement, and installation of structural materials such as steel, concrete, wood, CMU, and cold-formed metal framing. The combination of reducing material supplies and increased demands require the built environment be built with less, but provide more.

Furthermore, damage resulting from a seismic event requires repair. In many cases, complete demolition and replacement of the structure is required, thereby requiring further use of natural resources and emitting of additional carbon. If minimizing the built environment's impact on the natural environment is a goal of the structural engineering profession, then using less materials, low carbon-impact materials, and mitigating seismic damage should all be at the center of the profession's goals.

One could imagine that in the near future, international building codes will not only address safety, but they will also address life-cycle performance, perhaps imposing limits on carbon emissions attributable to building construction and use. One could also argue that structural engineers are among those who can have the most significant impact on reducing carbon emissions into the environment since material and structural system performance decisions are theirs. As a profession, we need to create great awareness of potentially damaging carbon emissions resulting in global warming.

3. Environmental Analysis Tool™

Up until now, most of the efforts made in calculating the carbon footprint are associated with the operations of buildings with little or no focus on the structure at the time of construction and over its

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