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ASSESSING THE FULL IMPACT OF BUILDINGS

MIT REPORT: METHODS, IMPACTS, AND OPPORTUNITIES IN THE CONCRETE BUILDING LIFE CYCLE

Key Findings

Methodology

- Identified key requirements for transparent buildings LCA
- Established comprehensive system boundaries

Single-Family Residential LCA

- Concrete homes produce 5% to 8% lower greenhouse gas emissions than best practice wood-frame homes and exceed code requirements
- Concrete homes use 8% to 11% less energy than code compliant wood-frame construction
- Study offers cost effective strategies to improve environmental performance of ICF systems

Commercial Building LCA

- Study isolates the environmental impacts of a concrete structural frame compared to a steel structural frame
- Commercial office buildings built with concrete produce slightly lower greenhouse gas emissions over a 60-year service life than a steel structure
- Concrete structural frame results in a 2% energy savings during operation

The heating, cooling, and general operations of buildings and homes in the United States accounts for approximately 70% of national energy consumption each year and more than 40% of CO_2 emissions generated in the U.S. Buildings create more CO_2 emissions than either transportation or industrial sources.

The need to decrease energy usage and subsequent emissions from the building sector has been at the forefront of U.S. green movement. Not only has energy reduction been viewed as a step for improving the environment, it has financial benefits for companies and homeowners.

Concrete, essential for the construction of buildings and homes, has largely been chosen as a building material for its structural properties rather than its energy-saving properties. Although the thermal mass attributes of concrete are known to significantly reduce heating and cooling needs, the energy consumption required to produce its key ingredient, cement, has raised questions about its environmental viability.

To address this, researchers at the Massachusetts Institute of Technology's (MIT) Concrete Sustainability Hub conducted a life-cycle assessment (LCA) study to evaluate and improve the environmental impact and study how the "dual use" aspect of concrete – its ability to offer a durable structure while providing thermal mass benefits for energy loads – impacts the environmental footprint of the structure.

Methods, Impacts, and Opportunities in the Concrete Building Life Cycle, an MIT report released in August 2011, provides a comprehensive analysis that advances three key areas relevant to the buildings LCA field: methodology, benchmarking, and impact reduction opportunities.

The study is a major development for construction-related life-cycle assessment because it thoroughly examines *all* phases of the complete life-cycle of a building – from acquisition of materials to construction, the use of the building, and finally demolition and end of life. Most environmental assessments done today do not move beyond the construction phase and only provide a partial picture of the full impact a particular material can have on a building.

A Study of Two Buildings

Assuming a 60-year lifetime, MIT researchers compared the environmental impacts of code-compliant buildings and homes in a heating climate (Chicago) and a cooling climate (Phoenix).

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The Building Life-cycle

Materials
- Extraction
- Production
- Transportation

Construction
- Equipment
- Temporary structures
- Transportation

Use
- Plug loads
- Lighting
- HV AC systems
- Thermal mass
- Routine maintence

End of Life
- Demolition
- Landfilling
- Recycling/reuse
- Transportation

In its environmental assessment, MIT researchers found concrete homes produce lower greenhouse gas emissions than current best practice code – compliant wood frame residences throughout a 60-year service life.

Concrete homes did have a higher embodied global warming potential (GWP) associated with the pre-use phase of LCA when raw materials are harvested and turned into construction materials, transported to the site, and assembled into the finished home. But this phase accounts for only about 2% to 12% of the overall global warming potential for the life of the home. For the 60-year period of the study, ICF houses have 5% to 8% lower GWP than current code compliant light frame wood houses, based on greater thermal mass and higher R-values. Similar results were found when evaluating multifamily residences.

Commercial office buildings built with a concrete structural frame produce slightly less greenhouse gas emissions over a 60-year service life than commercial structures built with steel frames, based on the results of the comprehensive MIT assessment.

MIT researchers then evaluated strategies to lower a concrete buildings's carbon footprint and overall environmental impact. A major advancement was the incorporation of a cost-impact analysis to determine whether or not a given environmental reduction strategy made economic sense. Among the strategies evaluated, the two that reduced embodied emissions – increased fly ash and reducing the thickness of ICF walls from a six-inch to a four-inch concrete core – were found to be both economical and effective ways to reduce emissions.

More information

The research presented here is part of an ongoing project by the LCA team at the MIT Concrete Sustainability Hub. More information, including the full report *Methods, Impacts, and Opportunities in the Concrete Pavement Life Cycle,* can be found online at http://web.mit.edu/cshub.

About the Hub

Established in 2009 in collaboration with PCA and the Ready Mixed Concrete (RMC) Research and Education Foundation, MIT's Concrete Sustainability Hub is a collaborative effort to integrate the best science on concrete into industry practices. The MIT Sustainability Hub includes researchers from MIT's School of Engineering and School of Architecture and Planning.

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0020-11-105

0020-11-105