# MIT's 2011 Concrete Industry Day

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The Massachusetts Institute of Technology's (MIT's) Concrete Sustainability Hub, which is sponsored by the Portland Cement Association and the National Ready Mix Concrete Association (NRMCA), hosted its annual Concrete Industry Day in conjunction with NRMCA's Concrete Sustainability Conference on August 11, 2011, in Cambridge, Mass.

In the morning plenary session, researchers presented overviews of their work in two areas: life cycle assessment (LCA) and green concrete. Three reports,[1–3] all posted on the Concrete Sustainability Hub website that day, present the findings on the LCA so far. The two that pertain to the precast/prestressed concrete industry are summarized below.

PCI's Jim Toscas and Dean Frank attended the afternoon session of more detailed presentations of the LCA work, and Rachel Detwiler attended the afternoon session on green concrete. The MIT researchers are studying concrete from the nano (atomic) scale and larger to gain a fundamental understanding of it. This work is at a very early stage; only preliminary findings were presented.

## Life cycle assessment on buildings

MIT's Concrete Sustainability Hub has released its LCA on buildings.[1] The report compares concrete (insulated concrete forms) with wood for the cases of single-family and multifamily residential construction and cast-in-place concrete with steel for the case of a large office building. Only the latter will be discussed in this summary because of its relevance to the precast concrete industry. The entire report is available for free download online.

The methodology takes into account a comprehensive life cycle, including materials, construction, operation, maintenance, and end of life. The building used is a 12-story Department of Energy benchmark office building with 498,590 ft$^2$ (46,321 m$^2$) of usable space. The facade comprises 40% glazing and 60% aluminum rainscreen panels. Interior finishes, assumed to be the same for both steel and concrete, are not included in the LCA model but are included in the energy model.

The building is analyzed for its global warming potential (GWP) for the climates of Phoenix, Ariz., and Chicago, Ill. The LCA covers a 60-year lifetime but provides annual operating data to permit extrapolation to longer or shorter lifetimes. The end-of-life phase assumes complete demolition of the building, with recycling of nearly all of the steel and aluminum and half of the concrete; the remainder of the material is assumed to be sent to a landfill.

Operating GWP of the exposed concrete building is 9% and 7% less than the steel building in Chicago and Phoenix, respectively. However, because the embodied GWP of concrete is higher, the total GWP for concrete is about 3% less in both climates. Interior finishes reduce this savings to 2% because the thermal mass of the concrete is no longer exposed. A comparison of the GWPs over a 60-year life span shows the total emissions for the two building materials to be essentially the same.

The use of supplementary cementitious materials to reduce the portland cement content would decrease the embodied GWP of the concrete by a few percent. However, over a 60-year life span the operating GWP is much more significant. For example, replacing 25% of the portland cement with fly ash would lower the embodied GWP of the concrete by 4.3%, but over a 60-year service life the reduction in total GWP would be only 0.18% in Chicago or 0.25% in Phoenix. On the other hand, the potential reduction in GWP by passive use of the thermal mass of concrete is estimated to be 5% to 15%; thermo-active building systems, which circulate water in pipes in the concrete, offer much greater potential for reductions in GWP.

## Taking variable inflation rates into account for LCCA

Life cycle cost analyses (LCCA) are frequently based on the implicit assumption that the prices of construction materials move in lockstep with general inflation. In the marketplace, however, the relative prices of concrete, asphalt, and steel can vary enough to affect the choice of material for a project.

MIT researchers[2] used the Monte Carlo simulation of price variations based on the Bureau of Labor Statistics' Producer Price Index from 1977 through 2010. They found that for a representative highway project, real concrete prices would fall in 86% of the simulations, while asphalt prices would likely outstrip inflation. That is, an LCCA that did not take into account the differences in relative prices would give asphalt an unfair advantage.

The researchers then used stochastic simulation of price variations over a 50-year period for four construction materials: concrete, steel, asphalt, and timber. This method aids in quantifying risks associated with cost estimates. Their report describes how to use a Microsoft Excel spreadsheet to compare the costs of different alternatives by incorporating the latest inflation data and stochastic simulation for more accurate comparisons among different materials.

## References

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