Having Our Concrete and Eating it Too: A Carbon Reduction Success Story

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**CARBON FOOTPRINT OF BUILDINGS AND CONCRETE**

1 - According to the US Energy Information Agency in 2012 total US carbon dioxide emissions were about 2360 Million Metric Tons (MMT).

2 - Of that number about 45% was contributed by the operation of buildings (heating, cooling, lighting, and plug loads).

3 - Worldwide at least 7% of the collective carbon footprint comes from the manufacture of portland cement concrete alone. There are two reasons for this: (1) concrete is the 2nd most used material on the planet next to water and (2) it is very energy intensive to produce, requiring the burning of limestone at high temperatures.

Fixing the carbon footprint of concrete, then could take a huge chunk out of climate change. The problem needs to be approached from two angles: (1) looking for a less energy/carbon intensive concrete and (2) finding ways to use concrete in buildings in ways that save energy/carbon.

**CONCRETE R&D AT THE UNIVERSITY OF NORTH CAROLINA CHARLOTTE**

Architects and engineers at UNCC have been working on just such a solution.

4 - As part of the architecture curriculum and through Professor Thomas Gentry’s lab, The Laboratory for Innovative housing, state of the art building science and a practical understanding of the concrete manufacturing and construction industry are being applied to the problem of how to build more energy efficient building envelopes.

5 - Through this work, an innovative wall system has been developed using a continuously insulated precast concrete assembly. The wall can be thought of as having four distinct “thermal zones”. The concrete on the inside of the insulation stores and moves heat using both embedded hydronic tubing connected to heat exchangers and solar thermal collectors and phase change materials (PCMs) to turn the concrete into an efficient heating and cooling system.

6 - In Professor Brett Tempest’s Materials Science lab, a new class of concrete that uses geopolymer cements is being developed. Compared to portland cement concretes (OPCC), geopolymer cement concretes (GCC) have a fraction of the carbon footprint (up to 75% less) of OPCC, yet can be manufactured to have equivalent physical properties.

7 - Professors Tempest and Gentry have been working together for a number of years to bring these two technologies together. The result is a high performance wall system that incorporates GCC instead of OPCC. In this photo the zoned temperature sensors for a test panel outfitted with integrated hydronics can be seen before concrete was poured.

8 - In 2011, UNCC was awarded entry into the US DOE’s Solar Decathlon competition. The mandate is to design, build, deliver, and operate a state of the art, marketable, comfortable, innovative house that is completely powered by the sun. UNCC’s team of students and faculty decided to utilize the GCC wall system already under development as the central innovation of the project. PCI and local partner precast manufacturer Metromont assisted as the students went from experimenting with surface treatments for small GCC samples they poured in the lab to full size test panels with complex facade patterns designed through parametric computer modeling.

9 - In Spring of 2013, the team succeeded in pouring the wall system for the house. The walls were constructed with professional and student labor using mostly existing infrastructure at Metromont’s Charlotte precast plant. In this photo, the walls are being erected on the UNCC campus as part of the complete construction of the house for commissioning before being sent to Irvine, CA for the competition in the Fall of 2013.


11 - UNCC’s 2013 entry was the first building ever constructed using GCC as an architectural component, an accomplishment acknowledged by a third place finish in the Engineering competition. The house also won the coveted People’s Choice award showing that this new technology can be utilized as part of a marketable package.

This project was the culmination of a number of years of research targeted at finding a better concrete and a better way to use concrete in buildings. The process was by no means perfect, but the deliverable does make a point. In this case, academia, industry, and government worked together to create a prototype building system and material innovation that if implemented widely could make a real difference in climate change mitigation. Neither industry initiative nor consumer demand could have accomplished this alone. It took this partnership to jumpstart this process.

There is still much work to be done, but forward thinking industrial manufacturers could take up this product today and start producing a concrete with a massively lower carbon footprint in a building envelope that delivers lower heating and cooling loads.

**OUT OF THE LAB ONTO THE STREET**

**GOVERNMENT INVOLVEMENT IN INNOVATION: THE FULL CIRCLE**