Thermal Performance and Environmental Impact of Sustainable Concrete

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THE PROBLEM

Sustainable development involves maintaining our current rate of development while leaving suitable resources for later generations to continue developing. The production of ordinary Portland cement (OPC) is a resource- and energy-intensive process consuming approximately **1.5 ton of raw materials and producing approximately 1 ton of carbon dioxide (CO2) fo**

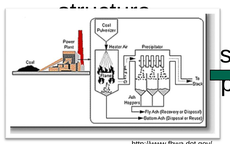
Globally, the production of OPC accounts for approximately between **5 to 7% of CO2 emissions** into the atmosphere.
There are three main reasons to use fly ash as a substitute ingredient in concrete:

- First, the reduction of disposal into landfills of the coal combustion products such as fly ash.
- Second, it creates significant environmental benefits
- Third, it improves the quality of the finished product in terms of its properties.

THE PROJECT

The purpose of this project is to evaluate the thermal performance of green concrete based on benchmark developments related to this material. By measuring the thermal resistance of concrete panels with different percentages of fly ash, gathering, and analyzing the data, we will be able to determine the thermal efficiency of each panel and the contribution of this ingredient. With that data, specifications can be made to better inform the use of fly-ash in concrete. The project is comprised of 3 stages:

1. Retrofit an existing structure for testing the panels.
2. Assemble and configure data-logging equipment for



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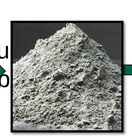

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Courtesy UC/CITRIS

DESIGN

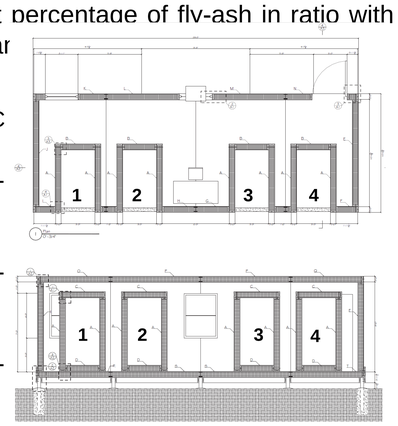
The structure is designed built as a large room with 4 identical compartments. Each one of these compartments hold a Green Concrete slab each with a different percentage of fly-ash in ratio with Ordinary Portlar

Panel 1: 0%FA-100%OPC

Panel 2: 25%FA-75%OPC

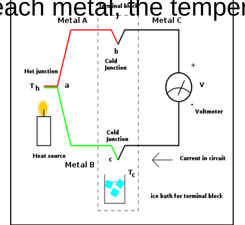
Panel 3: 50%FA-50%OPC

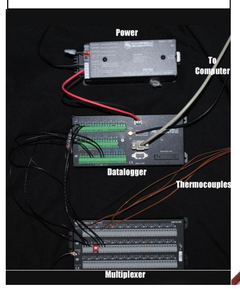
Panel 4: 75%FA-25%OPC



The Compartments are designed to separate each panel into its own thermal zone. Since the entire inside will provide a control temperature that will effect each compartment the same way, the only surface that will be influenced individually will be the concrete panel. The main room will be kept at a constant temperature using a window AC unit. It is constructed with a door and two typical windows in order to imitate a typical dwelling.

The structure is outfitted with thermocouples. Thermocouples are a wired pair of different metals that, due to the different conductivities in each metal, the temperature can be calculated.





Type T: Thermocouple (copper–constantan)

These thermocouples will attach to a multiplexer, this allows for many thermocouples to be run. The multiplexer is run to the data logger which gathers the information produced from the thermocouples and sends it back to the computer. Once the data is gathered in the computer it is calculated and put into graphs that make it easier to read as well as organize.

BUILT ENVIRONMENT

The Structure was made out of Structurally-Insulated-Panels (SIPS) which made design and building more efficient. After erecting, the

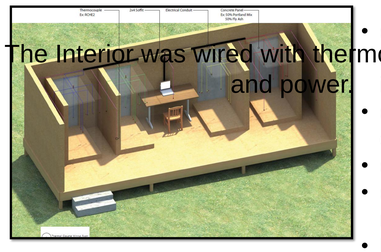
same concrete panels are interchangeable for any future experiments. Temporary appendages were built until further pieces could be done. From there the final construction sequence began.

1. Weather barriers were applied; house-wrap and tar paper.
2. Roof profile was thickened and pitched.
3. Gutter was installed recessed as to not be seen.
4. Cedar rain screen installed.

The cedar rain screen performs multiple tasks.

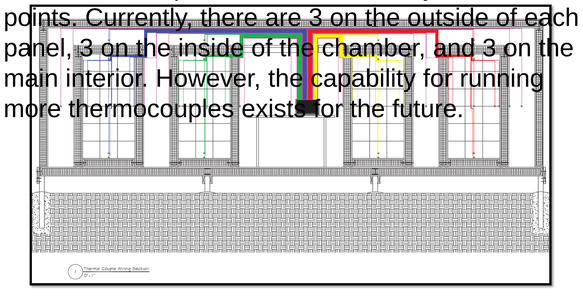
- Provides a ventilation cavity for evaporation
- Provides a insulation cavity.
- Provides depth to an otherwise planar façade.

The Interior was wired with thermocouples, lighting, and power.



- (2) Standard fluorescent lights for interior space.
- (2) Standard 120V outlets
- (1) Specialty AC outlet
- (27) thermocouple runs
- Powered by external Troy-Bilt 7000 watt generator.

The thermocouples are wired an many different points. Currently, there are 3 on the outside of each panel, 3 on the inside of the chamber, and 3 on the main interior. However, the capability for running more thermocouples exists for the future.

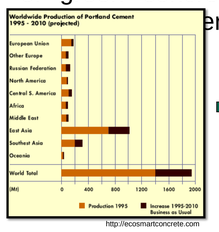


SUSTAINABILITY

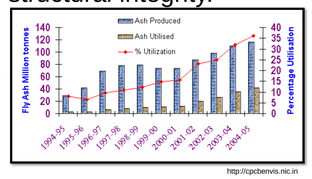
This investigation and its product has significant relevance to sustainability. The information, design, and lessons learned will be disseminated to a broad ranging audience.
The experimental building itself as an interface with the public will stand as a demonstration and example for the appreciation of fly ash as a waste by-product.

- The building is designed and built in a cost effective, sustainable, and appealing way in emphasizing the sustainable built environment
- The data gathered will demonstrate the reduced impact on the natural systems.
- The results obtained from this research will indicate the recommendation guidelines related to best practice of mix and application of green concrete for lesser environmental

erved structural integrity.



http://ecosmartconcrete.com



http://cpcbenvis.nic.in

THE FUTURE

This Project provides an environment to cater to similar future investigations. Now, any sample panel may be placed in and data gathered. Future investigations may include:

- Fiber-reinforced fly-ash concrete
- Aerated fly-ash Concrete
- Insulated Panel with fly-ash concrete

The information from these experiments can make headway in implementing fly-ash in concrete for the future. With the thermal data on fly-ash concrete the restraints of structure vs. thermal can be refined. By narrowing those restraints we can eliminate waste. It takes being informed about a product to make the most accurate decision. By providing this information we may increase the implementation and use of fly-ash therefore resulting in less waste, less pollution due OPC production, and a better environment.

This poster was prepared in partial fulfillment of SUST 4103 Sustainability Capstone