The Effects of Non-Biodegradable Waste Materials and Glass Microspheres on Cement

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Research

Title: The Effects of Non-Biodegradable Waste Materials and Glass Microspheres on Cement
This research was aimed at developing a low density, high strength, environmentally friendly cement composite that incorporates non-biodegradable waste. There were two primary goals in mind for the cement composites: 1) develop cement that is environmentally friendly by incorporating the waste materials of human hair and coal fly ash and 2) create a syntactic foam structure that optimizes durability and strength in the cement while minimizing the density through use of glass microspheres and Class F fly ash. To achieve these goals, cement-based composites were created using various percentages of fly ash, human hair, and glass microspheres. The research was aimed at determining the impact of these materials in the composite mixture and to determine a suitable proportion of materials based on a high strength to density ratio. In using human hair and fly ash, we showcase how non-biodegradable waste materials can be repurposed and reused. The purpose of incorporating the glass microspheres into the matrix was to lower the density of the cement even further while increasing its compressive strength. The fly ash also helps to reduce the density and has a positive impact on compressive strength. The human hair aims to reinforce the strength of the cement and to reduce plastic shrinkage and cracking. Using quasi-static compressive testing yielded insight into the stress-strain optimization of these composites. The use of glass microspheres and Class F fly ash reduced the density of the cement by about 50%, however the peak stress of the cement composites was also reduced by about 80% compared to pure cement. The impacts of the human hair on the cement were inconclusive and seemed to have no effect on the compressive strength of the samples. Further testing using a larger sample size could be conducted in the future and yield more accurate data.

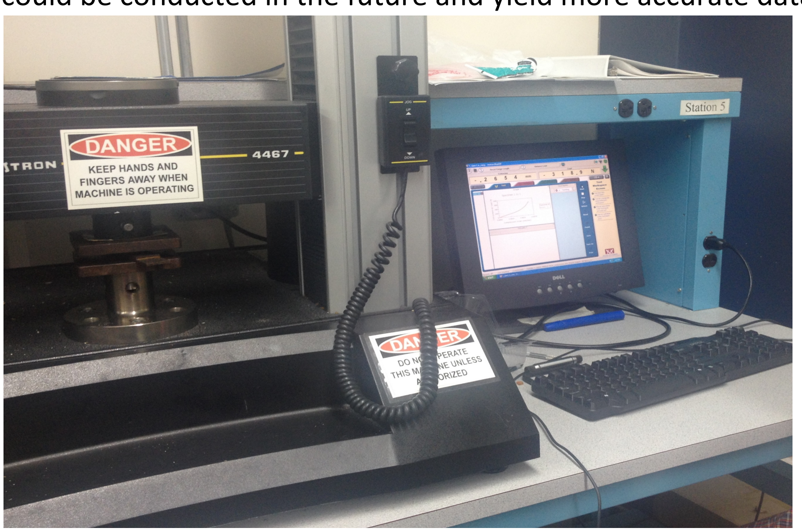

Figure: Quasi-static compressive testing

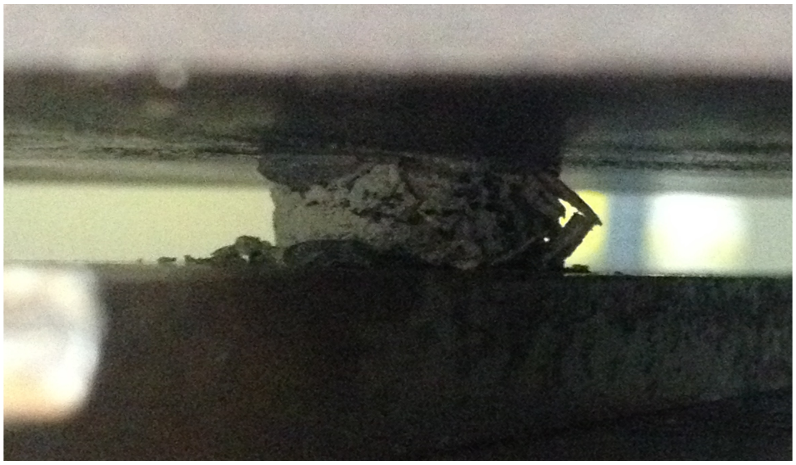

Figure: Cement composite specimen being compressed

Lesson Plan

Title: When Should I Drink my Hot Chocolate?

The students complete two separate, but interconnected, tasks using a microcontroller temperature sensor to collect data. In part 1 of the activity, students conduct an experiment to explore the cooling rate of a cup of hot chocolate. Students collect and graph the data to create a mathematical model representing the cooling rate. Using an exponential decay regression, students determine how long one should wait to drink the cup of hot chocolate at an optimal temperature. In part 2 of the activity, students investigate the specific heat capacity of the cup of hot chocolate. They determine how much energy is needed to heat the hot chocolate back up to an optimal temperature after it has cooled to room temperature. The concepts of heat exchange and cooling rates are applicable to a wide range of engineering fields including heating and cooling systems, microprocessors, internal combustion engines, and food engineering to name a few. For example, knowledge of the heat capacity and cooling rates of chocolate is required for engineers to design production machinery, storage equipment, and determining processing times for the production of chocolate. Because physical properties and conditions vary greatly, engineers must also make mathematical models that predict the effects of changes on the systems. Like engineers, students apply the concepts of cooling rates and heat capacity to hot chocolate as they determine the time to reach optimal drinking temperature and the energy needed to heat the hot chocolate to optimal temperature.

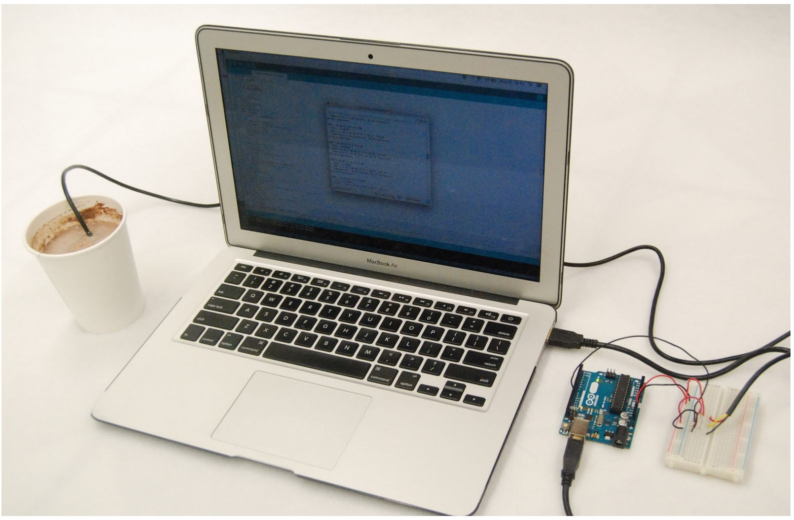

Figure: Classroom activity of hot chocolate with the temperature sensor