Economical Thermal-Mechanical Precast Concrete Systems Comprised of a Polymerized Sandwich Structure

Dr. Thomas Attard, University of Alabama at Birmingham, 205 - 934 - 8436, thoma1@uab.edu

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Abstract/Objectives: The objective of this project is to design thermal-mechanical multi-functional precast concrete systems for (1) debris-impact resistance; (2) reduction of thermal bridging (R-value); and (3) flexural capacity. The proof-of-concept study will seek to develop full-composite action in sandwich panels and beams comprised of reinforced concrete (R/C) and a Carbon-fiber reinforced Hybrid Matrix Composite (CHMC) using low-cost carbon produced from textile grade PAN precursors; the study will also examine the viability of using relatively inexpensive glass fiber in the hybrid matrix. The CHMC system, developed by Dr. Thomas Attard (UAB), has the potential to streamline fabrication and increase performance of precast sandwich panels. Because of its high shear resistance, CHMC may eliminate the need for transverse reinforcement to create composite action between the outer concrete layers. Supplanting the foam insulation used in typical sandwich panel construction with CHMC may produce an insulation-mechanical R/C-CHMC system (fig 1a) that can enhance manufacturing and performance efficiency. CHMC, which minimizes the carbon footprint with respect to traditional carbon-fiber reinforced polymer systems (CFRP), is formulated using an epoxy (resin/hardener)/polymer (EP) reaction that: (a) dissipates energy through interfacial mobility at the EP interface; and (b) improves the R-value to a suggested R-28 (hr-ft²-F/Btu) for about ½-in panel, vs R-5 per inch for XPS and about R-4 per inch for EPS. For a standard 3-2-3 sandwich panel (3-in conc x 2-in foam insulation barrier x 3-in conc), ASHRAE reports a maximum R-value of 9, where Kosny et al.2, after supplanting the 2-in insulation with concrete to illustrate the significance of the foam insulation, showed a 45% reduction in R-value. Conversely, PCI reports show that high-performance precast prestressed insulated sandwich panels have R-values ranging from 12 and 20 in, where an increase of 5 in R-value can reduce energy costs by 5% - 20%. However, preliminary tests conducted by Dr. Attard in 2010 showed that microspores in polyurea may improve thermal resistance with comparable thickness to an R-value of 28.