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Toward Durable Structures: Novel Design and Advanced Material Characterization

Adil Al-Mayah
Associate Professor
Civil & Environmental Engineering/ Mechanical and Mechatronics Engineering (cross appointment)/ Centre for Bioengineering and Biotechnology
University of Waterloo

Abstract - Materials research is at the heart of advances in a broad range of seemingly disparate applications, spanning structures, pavement, automotive and emerging biomedical technologies. For example, Canada's aging infrastructure is deteriorating at a rate that requires immediate repair or renewal, placing a huge strain on our economy and highlighting a critical need for innovative design, materials, and methods to evaluate and delay structural materials failure.

Innovative design and material theme of our research focuses on the advancement of structural applications of composite materials of different forms, such as circular rods and plates, for repair, strengthening and new construction. This aspect has been materialized by the successful designs of various anchorage systems that are compact, epoxy free, reusable, user friendly, and high load-carrying capacity. Different fibre reinforced polymer (FRP) materials were investigated for prestressed concrete applications including carbon FRP (CFRP), glass FRP (GFRP), and basalt FRP (BFRB) rods, in addition to CFRP plates, as prestressing materials. These systems efficiently enable structural engineers to fully utilize the high strength of FRP rods and plates by eliminating unwanted stress concentrations and slippage.

The material characterization research program advances concrete material characterization from the conventional 'overall' evaluation to a 'components-based' characterization. The role of void contents, cracks propagation, corrosion micromechanics and repair schemes on material performance will be investigated. This innovative approach provides detailed image-based stress distribution and deformation maps to identify failure initiation and propagation. As the program grows, the scope of potential new research directions can expand to include fracture mechanics, steel welding, asphalt, and biomaterials.