Understanding Efficiency of the New Method for Strengthening and Repairing Structures Using Eco-Repair Material (Eco-Jacket)

This project aims to demonstrate a new strengthening and repairing techniques with the advantages of eco-friendly, eco-costly with improved bonding agents. Casting a new layer of concrete (overlay) over substrate is a common method for strengthening and repairing structures. Two major concerns are identified in this approach as: (i) higher price and CO_2 emissions of the overlay and (ii) lower effective bending length. Based on that through this research for the overlay a new generation for ultra-high performance fiber reinforced concrete by replacement of cement by spent catalyst from petrochemical refinery and recycled steel fibers from end life tires are proposed. For increasing the effectiveness of the bonding agent as a pioneer one flexible polymer adhesive is proposed since the effectiveness of the bonding agent by this adhesive was proven in the literature for bonding ONLY fiber reinforced polymer on the substrates. Total system is in this project nominated as Eco-Jacket.

This proposed research will employ multiple research methods including experimental, numerical, analytical and parametric studies in 4 working packages (WPs) with the duration of 36 month to explain the efficiency of Eco-Jacket for strengthening different structural elements such as concrete slabs, beams, columns, and masonry walls. For the waste material the XRF technique will be used to collect the cement and Ecat compositions whereas SEM-EDS will be used to study the morphology and elemental composition of raw materials and recycled steel fiber. The heat flow, rheology, shrinkage and compressive and flexural strengths of cement pastes will be determined with calorimetry, mini-slump, shrinkage, and crushing and bending tests via the universal testing machine instrument (WP1). For evaluating mechanical properties of flexible polymer joints, direct tensile tests using universal testing machines will be employed using dog-bone specimens. The surface of the specimens will be roughened using a mechanical grinder to remove the surface laitance and expose the coarse aggregate. Direct pull-off automated testing machines will be used for bond interface strength. Universal testing machines by fixing specimens and applying the force on Eco-UHPFRC will be used for measuring bond strength and effective bonding length. The two-dimensional digital image correlation, as a non-interferometric image processing metrology method, will be used to measure the strain field on the side surface of the specimens during the loading (WP2). Eco-Jacket is going to be applied on different substrates with quite small size to understand the working mechanism of our system in improving bearing capacity of damaged and undamaged substrates. All specimens including columns, slabs, walls can be tested under a universal testing machine choosing the right load-cell capacity to minimize the error of the testing (WP3). Finally, the proposed numerical and theoretical solutions in the previous tasks will be calibrated using full-scale samples (WP4).

This research topic in this proposal is broad and involves the fields of materials science and chemistry. The host institution will be Wroclaw University of Science and Technology (WUST) in Poland. The research team in this research will be 2 graduated students, 1 PhD student, 1 technician. The graduated students will be to help in conducting measurements, analyzing results, etc in WP2 and WP3. The PhD student will mainly focus on the analysis of the results, implementing numerical modelling and performing theoretical and analytical approaches. The specialist will be the assistant, skilled in handling sophisticated instruments and dealing with the construction of samples and their corresponding data storage and analyses. I will pay special attention to the promotion of the project and its findings among many different recipients from outside their own university and country. This project assumes close cooperation with Professor Lucas da Silva from the Department of Mechanic at the Porto university (FEUP), who will co-supervise this project.