



Sustainable Zero-Cement Repairing Agent for Climate-Resilient Infrastructure

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To support global decarbonization and climate resilient infrastructure targets, this study experimentally investigates the bond performance of a sustainable, economic zero-cement alkali activated system produced from industrial and agricultural byproducts. The proposed alkali activated system utilizes blast furnace slag and rice husk ash, thereby reducing reliance on carbon intensive Portland cement while promoting circular use of waste materials and lowering environmental footprints.

The effectiveness of alkali activated system as a concrete repairing agent for ageing and climate exposed infrastructure is governed primarily by both strength of the repairing agent and its bonding behaviour with existing concrete. The bonding behaviour plays a critical role in the long term performance of repaired systems under sustained load, moisture ingress, and thermal variability associated with climate change. Accordingly, a comprehensive experimental program has been prepared to evaluate bonding behaviour under various stress states, including pure tension, pure shear, and combined shear and compression.

The combined contribution of blast furnace slag and rice husk ash for development of interfacial strength and cracking pattern of the alkali activated system has been investigated through controlled laboratory testing and compared with that of conventional Portland cement based concrete. The results demonstrate that the blast furnace slag and rice husk ash based alkali activated system exhibits superior bonding performance compared with conventional cement based repair mortars, indicating improved resistance to debonding, cracking and moisture induced deterioration.

By enabling durable, low carbon repair solutions that extend the service life of existing structures while reducing raw material consumption and greenhouse gas emissions, this study highlights how material technologies that are aligned with Nature-based Solutions can contribute to sustainable and resilient adaptation of the built environment under a changing climate.