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Title : ENHANCEMENT OF AUTONOMOUS HEALING MORTAR THROUGH ENCAPSULATED BACTERIA BIOMINERALISATION

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The autonomous healing by Microbially Induced Calcite Precipitation (MICP) mechanism has become significant interest in a sustainable approach to concrete repair and maintenance. Previous research works reported that *Bacillus pasteurii* and *Bacillus sphaericus* are the most common bacterial species used in concrete associated with bacteria. However, there is limited information on other types of bacteria species as MICP agent in concrete. The vegetative cells of *Geobacillus stearothermophilus* introduced in this study. First, an experimental work was conducted directly incorporating bacteria to assess the improvement that can be made by bacteria without encapsulating it. The results confirmed that direct incorporation increased compressive strength and flexural strength up to 24 % while decreased water absorption rate as compared to control specimens. For further improvement, secondly, vegetative cells of *Geobacillus stearothermophilus* were encapsulated into alginate-hydrogel prior incorporation into the mortar. The urease activity, viability, swelling and water retention properties of the bacterial *Geobacillus stearothermophilus* cell encapsulated in alginate hydrogel were examined. Also, the performance of alginate-encapsulated *Geobacillus stearothermophilus* (AE-GS) in mortar mix as a self-healing agent measured regarding compressive strength, flexural strength, water absorption and crack healing efficiency. The precipitation of calcium carbonate (CaCO_3) of AE-GS mortar was confirmed using Thermogravimetric Analysis (TGA). Maximum crack healed at the percentage of 100 % (corresponding to the

initial crack width) in average achieved by incorporating 15 % AE-GS (replacement of total weight of mortar) at 60 days of age. However, the lower result of compressive strength and flexural strength, along with higher absorption rate portrayed by the mortar specimens that contained 15 % of AE-GS replacement as compared to control mortar (AE-R) and with those of AE-GS replacement level at 3 % and 9 %. Healing efficiency observed by the whitish precipitation as a crack filling material confirmed by TGA analysis and Scanning Electron Microscopy (SEM) microstructure examination. The optimisation process was conducted using Response Surface Methodology (RSM) to obtain a relationship between factors of bacterial concentration (BC, cfu/ml) and alginate encapsulation (AE, %). Using the RSM evaluation and analysis, the prediction based on the desirability function to achieve higher results of compressive strength, flexural strength and healing efficiency along with lower water absorption rate for BC and AE were 10×10^{10} cfu/ml and 5.37 %, respectively. The establishment of alginate-encapsulated *Geobacillus stearothermophilus* (AE-GS) mortar would give insight on varying the utilisation of bacteria as a repair material. It also would benefit by adopting natural and sustainable approach towards concrete structure crack remediation method.