ASSESSMENT OF THE STRENGTH AND DURABILITY OF GEO-POLYMER CONCRETE CURED IN LAGOON WATER

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ABSTRACT

Geopolymer Concrete (GPC) presents a suitable alternative to Portland Cement Concrete (PCC) in infrastructure projects due to its friendly production effect to the environment. The production of Portland Cement (PC) contributes significantly to greenhouse gas emissions, and its poor performance in aggressive environment. This study investigated the strength and durability of GPC in Lagoon water with the target strength of 50 MPa. The GPC comprises fine and coarse aggregates, metakaolin with ground granulated blast furnace slag acting as the binders; sodium hydroxide (NaOH) and sodium silicate (Na_2SiO_3) which provided the alkaline media. Reinforced GPC 100 × 100 × 600 mm beams, 100 × 100 x 100 mm cubes and 100 × 200 mm cylinders were prepared for flexural, compressive and split tensile tests, respectively. Two specimens were prepared; the main specimen was cured in lagoon water (GPCW), while the control specimen was cured at ambient temperature (GPCD), for 28, 90, 180, 270 and 365 days. A finite element program ANSYS was used to simulate the mechanical properties of both specimens. Scanning Electron Microscopy and Energy Dispersive X-ray Spectroscopy were used to determine the microstructural and elemental composition of the specimens, respectively. Results showed an increase (111.31 to 146.22 MPa) in compressive, flexural and splitting tensile on an average of 38.8% from 28 to 180 days, with a decrease of 23.6% (205.25 to 146.22 MPa) by the 365th day for the GPCD samples. The GPCW showed a reduced strength of 11% (45.02 to 40.01MPa) from 28 to 365days; 43% when compared with GPCD. Deflection of the reinforced beams indicated a steady increase from 28 to 365 days, mirroring the general deflection behaviour of conventional concrete's linear elasticity. The SEM revealed differences in GPCD and GPCW with the latter displaying less dense structures having larger voids, consistent with the reduction in compressive strength over time. Conversely, GPCD samples had a denser

microstructure, resulting in higher strength. Unreacted Metakoalin with particles were visible in SEM images, indicating incomplete geopolymerisation in certain areas of the GPCW. The XRD analysis highlighted a stable calcium-to-silicon ratio in GPCW, with variations in the silicon-to-aluminum ratios between GPCW and GPCD specimens. Efflorescence substance was observed in the GPCD samples after 180 days. The presence of calcium oxide and iron oxide revealed the reduction in strength after 180 days. The simulation of both GPC samples revealed the elastic strain, normal stress and the deformation generated within the concrete samples during the experiment. Statistical analysis showed the difference between the experimental and simulation strength results to have $p \leq 0.05$. Overall, the convergence of laboratory testing, microstructural analysis, and simulation results confirms that geopolymer concrete demonstrates commendable mechanical and durability properties. GPCD cured in ambient temperature performed better overall than in lagoon water (GPCW), but both exhibited potential for structural applications. These findings support the viability of geopolymer concrete as a sustainable alternative to Portland cement, particularly in aggressive environments.