National Institute of Technology Rourkela

Departmental Seminar

Seminar Title	: Mimicking the Cementitious Mechanism of Ancient Roman Concrete Using Lime Based Binder Incorporating Pumice and Calcined Clay
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Venue	: CE Seminar Hall
Date and Time	: 17 Jul 2025 (10:30 AM)
Abstract	: Cement production is a major contributor to global carbon dioxide (CO2) emissions. In contrast, Roman concrete not only lowers the carbon footprint but also reduces long-term costs due to its sustainable characteristics. Roman concrete structures have endured for nearly 2000 years. This study proposes a method for creating long-lasting and environmentally friendly seawater concrete by replicating the cementation process utilized in ancient Roman concrete. Pumice, calcined clay, hydrated lime and seawater were used to produce the binder mixtures. The hydration products of the samples, which were mixed and cured in seawater, were analysed for up to 56 days using X-ray diffraction (XRD), field emission scanning electron microscopy-Energy Dispersive X-ray Analysis (FESEM-EDAX), and differential scanning calorimetry (DSC). The high alkalinity of seawater activates the pozzolanic reaction of hydrated lime with natural Pozzolans, which eliminates the need for additional alkali activators. The results reveal that calcined clay exhibits higher pozzolanic reactivity than pumice in the early stages of hydration, leading to enhanced compressive strength at an early age. However, over the course of time, there is a notable enhancement in compressive strength for the specimen with a higher proportion of pumice. Blends with a higher proportion of hydrated lime demonstrated superior compressive strengths, reaching about 8.46, 10.2, 14.1, 18.8, and 21.74 MPa at 3, 7, 28, 56, and 90 days. The presence of hydrated lime and natural pozzolona, i.e. calcined clay and pumice, attributed to the formation of strength and durability-enhancing phases like Calcium Silicate Hydrate (C-S-H) and Calcium-Aluminum-Silicate Hydrate (C-A-S-H) gels. Additionally, the use of seawater promoted alkali activation, leading to the formation of N-A-S-H and C-A-S-H phases, which improved long-term strength and durability. The DTG analysis of the hydrated samples containing a high proportion of calcined clay after 28 days revealed significant dehydration of C-S-H, C-A-S-H, and Afm phases. Keywords: Pumice, Calcined Clay (CC), Seawater, Roman Concrete, X-ray diffraction (XRD), Field Emission Scanning Electron Microscopy-Energy Dispersive X-ray Analysis (FESEM-EDAX), and Differential Scanning Calorimetry (DSC)