Sustainable nano-modified seawater concrete with enhanced service life (NanoSeaCon)

Proposal ID no: 534718

Name and surname of the Applicant (Principal Investigator): Sundar Rathnarajan

Name of the Host Institution: West Pomeranian University of Technology in Szczecin, Poland

Abstract:

Freshwater resources comprise only 3% of the total water available on our planet. Based on the estimate made by World Wildlife Organization, two-thirds of the world's population may face water shortages by 2025. Agriculture and industry are the two primary water-consuming occupations across the globe. The share of concrete production stands at 9% of the global industrial freshwater withdrawals. Moreover, 75% of such water demand for concrete production could occur in regions expected to experience severe water stress. Water stressed nations face shortages of freshwater resources even for the basic needs of all the life on the planet. Countries that aim at significant industrial growth need to produce more concretes in upcoming decades to create new jobs and build facilities for their booming population. They face an existential threat due to shrinking freshwater sources amid the need for development. Hence, any attempts to reduce the water withdrawals for concrete production can be a lifeline to such nations.

Alternate water sources for concrete production are a challenging topic in recent days for researchers in concrete technology. Romans successfully used lime, seawater, and volcanic ash to produce concrete for seawalls that have been standing stronger for more than 2000 years, resisting the aggressive sea waves. However, seawater usage in concretes is restricted by several national standards for producing reinforced concrete owing to the higher concentration of chloride ions in seawater. The reinforced concrete could experience pitting corrosion due to the presence of more chlorides at the level of steel in concrete.

This project aims at developing durable reinforced concrete with seawater. With freshwater conservation in mind, seawater concretes (SWC) could be developed with the addition of pozzolanic materials and nanoparticles. Like volcanic ash used by Romans, blast furnace slag from steel production, fly ash from thermal power plant production can be used in concretes to make it denser due to pozzolanic reaction that enables reactive silica in these materials to react with hydrated cement products. The addition of nano-SiO_2 in concrete makes concrete impenetrable due to its ability to enhance the cement hydration reaction rate and make the concrete much denser. Free chlorides present in the cement matrix are responsible for reinforcement corrosion. The addition of nano-Al_2O_3 can bind these free chlorides and reduce the available chlorides near steel reinforcement.

The synergetic effect of reactive SCMs and nanoparticles addition in concrete can be a sustainable solution for mitigating the looming freshwater crisis. This study assesses the feasibility of producing this novel concrete through the project ***NanoSeaCon***. The holistic assessment of this concrete includes the evaluation of hydration, fresh/flow, mechanical, and durability properties of nano-modified SWC. In addition, the electrochemical characteristics of embedded steel in nano-modified SWC will be studied to understand the influence of chloride binding on mitigating corrosion initiation. The success of NanoSeaCon could instill confidence in the construction industry to process their most used material, concrete, to future needs. The enhanced service life of these concretes can create opportunities to make the concrete industry more sustainable than ever.