

Understanding the chloride-binding behaviour in cementitious and alkali-activated seawater-mixed binder systems to improve durability (DuraSeaCon)

Abstract for general public.

In arid regions, an increase in water demand for industrial purposes can impact sustainable water supply for domestic purposes. Even in our lifetime, we have seen cities like Capetown ran out of water for domestic supply and local government had to introduce severe restrictions on per capita water supply. This scenario is affecting the UN-Sustainable Development Goal of providing “Clean water and Sanitation” for people. Often these water-stressed regions are situated in developed and developing countries which is the home for two-thirds of the global population. Concrete is one of the industrial products these countries need for improving their infrastructure and thus, posing a constant threat to potable water supply.

Conventional concretes are produced by mixing the cement and aggregates with potable water from the nearest source. Several international and national codes of practice for producing reinforced concrete had recommended limits on the total solids in the mixing water for concretes. More stringent measures are emphasized for reinforced concretes with carbon steel for mitigating the risk of pitting corrosion at higher free Cl ions at the steel-cementitious (S-C) interface and it restricts usage of seawater with high chloride content in concrete mixing.

The advances in concrete technology over past five decades enabled us developing high-resistive binder compositions over ordinary Portland cement and alternative materials for replacing the conventional steel reinforcement. Fiber-reinforced polymer (FRP), epoxy-coated, and galvanized rebars are the alternatives to the steel rebars that can negate the negative effect of chlorides present in seawater used for concrete mixing. However, the higher initial cost of these alternative rebars is a significant challenge to be tackled by the researchers for producing seawater-mixed concretes. Hence, the inclusion of supplementary cementitious materials (SCMs) as a partial replacement and complete replacement of cement can solve this problem.

The addition of SCMs in concrete reduces global artificial CO₂ emissions by replacing the clinker production which is an energy intensive process. Also, the inclusion of SCMs in concrete can refine the pore structure of cementitious matrix to produce high resistance against the ingress of harmful ions that affect the durability of concrete. Furthermore, SCMs such as slag and metakaolin (with high volume Al₂O₃) bind the free chlorides in the concrete and improve the resistance against corrosion initiation in reinforced concrete structures by reducing the availability of free Cl ions at the steel-cementitious interface. More research is needed to understand this phenomenon in SW-mixed concretes produced with partial and complete substitution of SCMs and DuraSeaCon aims to fill this knowledge gap.

Project DuraSeaCon consists of research tasks leading to the fundamental understanding of this chloride binding effect in cementitious and alkali-activated cementitious systems. Outcomes of these research tasks can enable us to develop SW-mixed concretes with an ideal binder composition suitable for extending the service life of the concrete. Roman concretes standing on the coast of Italy is a standing example of seawater-mixed concrete with local materials of that age. Our research is trying to mimic that success with novel sustainable binder systems of modern age and produce concretes with improved durability through fundamental understanding of chloride binding and its effect on engineering properties of concrete.