Universidade do Minho

Escola de Engenharia

Semana da Escola de Engenharia
October 24 - 27, 2011

ECO-EFFICIENT CONCRETE USING SINERGETIC EFFECTS OF INDUSTRIAL WASTES AND POZZOLANS IN CONCRETE

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KEYWORDS
Eco-efficient concrete, pozzolan, industrial waste, metakaolin.

ABSTRACT

Concrete is one of the most widely used construction materials in the world. However, the production of Portland cement as the essential constituent of concrete requires a considerable energy level and also releases a significant amount of chemical carbon dioxide emissions and other greenhouse gases (GHGs) into the atmosphere. In the next 40 years portland cement demand will be twice as needed now reaching 6000 million tons/year. Thus, seeking an eco-efficient and sustainable concrete may be one of the main roles that construction industry should play in sustainable construction. With this viea, partial replacement of Portland cement by pozzolanic admixtures leads to carbon dioxide emissions reductions as a major issue in the current climate change context. It also reduces landfill disposal and enhances the durability of concrete structures.

This research project is striving to make the concrete more eco-efficient and sustainable by using the synergetic effect of industrial wastes and pozzolanic materials with following specific objectives: To investigate the reactivity of different types of Schist stone dusts and ceramic waste powders; to assess the potentiality of using schist/slate stone dust and ceramic waste powder, per se, and in synergy with other pozzolanic materials such as fly ash or metakaolin in concrete; to seek an accelerated test method for distinguishing pozzolanic materials; to evaluate the durability of concrete using the above mentioned byproducts; to assess the sustainability and eco-efficiency of concrete containing Schist and ceramic waste in a quantitative approach and comparing with conventional concrete; and to apply Life Cycle Cost Analysis and improving cost of concrete.

Achiving the objectives of this project can lead to following outcomes: Protecting of the natural environment by minimizing the GHG signature of concrete by maximizing the replacement of Portland cement in the concrete mixtures by byproducts and wastes; minimizing resource consumption and reducing the industrial waste materials, while minimizing land-fill disposal; improving the sustainability and eco-efficiency of concrete to create a more healthy and non-toxic environment; enhancing the quality of concrete using the synergetic effect of highly reactive pozzolans and less reactive wastes and industrial by-products; developing a reliable and quick method for estimating the pozzolanic reactivity of materials in concrete and improving the durability of eco-efficient concretes by rational mixture of locally available reactive/less reactive additions.

The first phase of the research was carried out within two main parts: firstly, a complementary literature review was done to bring this work up to date with performed and current studies on this topic. The research was in the area of using by-products and wastes and SCM in concrete focusing on ceramic waste, schist and metakaolin. Secondly, available studies and statistics on local resources of proposed alternative materials were reviewed as well as a survey research to find different types of schist and ceramic waste from different sources, mines or raw materials. Four types of sanitary ceramic, tile ceramic, red roof tile and white roof tile were selected for ceramic wastes and three types of schist/slate, Valongo, Arouca and Solicel, were found and considered as schist waste. The selection was according to the reactivity of the types, amounts of production and availability and homogeneity of production. this application.

As in implemention phase, via some series of laboratry experiments, the degree of pozzolanic reaction of different ceramic wastes and stone dusts in cement pasts was quantitatively determined by evaluation of mechanical properties. Subsequently, optimum

percentage of metakaolin in concrete was determined to reach the maximum compressive strength. At last, using Response Surface Methodology, various mixtures were designed to be implemented in next series of lab works for making a numerical model of properties of the project aimed concrete. In following paragraphs upcoming tasks and activities are explained briefly.

1- Determination of Optimum percentage of ceramic wastes and schist powders (and applying RSM): Trial mix approach may be the best procedure to select mix proportioning in order to achieve a set of critical properties; however, due to large amount of variables in this research, Response Surface Methodology (RSM) apparently will be the more adequate procedure. Mechanical properties and durability of hardened concrete will be assessed according to relevant standards and norms such as ASTM and EN. Based on the results of the primary tests, new mixtures will be selected for assessment and the effect of constituent proportions will be evaluated. Relevant properties such of shrinkage, workability, and heat of hydration will be determined in fresh concrete, as well as, compressive strength, tensile strength and modulus of elasticity in hardened concrete.

2- Evaluation of concrete durability: In the experimental phase, the durability of concrete samples is assessed by three durability tests covering the main mechanisms related to concrete deterioration: First, water sorptivity test involves the uni-directional absorption of water into one face of a preconditioned concrete sample. The lower the water sorptivity index, the better is the potential durability of the concrete. Second, oxygen permeability test for which a method can be applied that uses a falling-head permeameter measuring pressure decay with time as oxygen permeates through concrete. And the third test is chloride conductivity test for which Nordtest method NT Built 492 is used. In this method an external electrical potential is applied axially across the specimen and forces the chloride ions outside to migrate into the specimen. After certain test duration, the specimen is axially split and a silver nitrate solution is sprayed on the surface of the freshly split sections. The chloride penetration depth can then be measured from the visible white silver chloride precipitation, after which the chloride migration coefficient can be calculated from this penetration depth.

3-Sustainability assessment: Firstly, the concrete will be considered in a functional unit such as one frame with a slab. Based on LCA approach and following guidance in Eco-indicator 99 and ISO 14040 standard for LCA, we lead to an environmental score and an environmental profile of the functional unit. However For every process in the life cycle of these concrete functions, data on environmental inputs (e.g. raw materials; energy) and outputs (e.g. emissions to air, water and soil; solid waste) will be collected. Economic performance will be separately measured using the ASTM International standard life-cycle cost (LCC) approach. This project aims to improve available assessment tools such as EcoConcrete, ECO-it and ECO-edit according to this application.

AUTHOR'S BIOGRAPHY

ARMAN SHASAVANDI was born in Esfahan, Iran and went to the BIHE University, where he studied civil engineering and obtained his degree in 2002. He worked for a couple of years for Sazeh Consultants Company besides teaching as TA, CTA and instructor in BIHE. Now he is doing his PhD in civil engineering, construction materials, at university of Minho.