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Microstructural properties of hardened cement paste blended with coal fly ash, sugar mill lime sludge and rice hull ash

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Abstract. The synergistic interactions of supplementary cementitious materials (SCMs) with ordinary portland cement (OPC) in multi-blended systems could enhance the mechanical and durability properties of concrete and increase the amount of cement that can be replaced. In this study, the characteristics of the hydration products as well as paste microstructure of blended cement containing 20% coal fly ash, 10% rice hull ash and 10% sugar mill lime sludge in quaternary blended system was investigated. Portlandite content, hydration products, compressive strength, pore size distribution and microstructural architecture of hydrated blended cement pastes were examined. The quaternary blended cement paste showed lower compressive strength, reduced amount of Portlandite phases, and higher porosity compared to plain hardened cement paste. The interaction of SCMs with OPC influenced the hydration products, resulting to the formation of ettringite and monocarboaluminate phases. The blended cement paste also showed extensive calcium silicate hydrates and calcium aluminate silicate hydrates but unrefined compared to plain cement paste. In overall, the expected synergistic reaction was significantly hindered due to the low quality of supplementary cementitious materials used. Hence, pre-treatments of SCMs must be considered to enhance their reactivity as good quality SCMs can become limited in the future.

Keywords: quaternary blended cement; synergistic interactions; multi-blended systems; supplementary cementitious materials; coal fly ash; rice hull ash; sugar mill lime sludge

1. Introduction

The use of supplementary cementitious materials (SCMs) such as coal fly ash (CFA), limestone powder, steel slag, silica fume, meta-kaolin clay and biomass ashes in the production of cement and as partial replacement to cement in concrete has received considerable attention nowadays. This is because the utilization of SCMs could significantly lessen the environmental impact of cement and concrete production by providing alternative solution to the disposal problems of SCMs and by reducing CO_2 emissions (Juenger and Siddique 2015). Moreover, SCMs can

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mixing ratio of fly ash, and curing temperature on pozzolanic reaction of fly ash in cement paste", *Cement Concrete Res*., **31**(1), 31-39.

Juenger, M.C. and Siddique, R. (2015), "Recent advances in understanding the role of supplementary", *Cement Concrete Res*., **78**, 71-80.

Kathirvel, P., Saraswathy, V., Karthik, S.P. and Sekar, A.S. (2013), "Strength and durability properties of quaternary cement concrete made with fly ash, rice husk ash and limestone powder", *Arab. J. Sci. Eng*., **38**(3), 589-598.

Kroehong, W., Sinsiri, T., Jaturapitakkul, C. and Chindaprasirt, P. (2011), "Effect of palm oil fuel ash fineness on the microstructure of blended cement paste", *Constr. Build. Mater*., **25**(11), 4095-4104.

Lothenbach, B., Scrivener, K. and Hooton, R. (2011), "Supplementary cementitious materials", *Cement Concrete Res*., **41**(12), 1244-1256.

Madandoust, R., Ranjbar, M., Moghadam, H. and Mousavi, S. (2011), "Mechanical properties and durability assessment of rice husk ash concrete", *Biosyst. Eng*., **110**(2), 144-152.

Menendez, G. and Bonavetti, V. (2003), "Strength development of ternary blended cement with limestone filler", *Cement Concrete Compos*., **25**(1), 61-67.

Nadeem, A., Memon, S.A. and Lo, T. (2013), "Mechanical performance, durability, qualitative", *Constr. Build. Mater*., **38**, 338-347.

Panda, K.C. and Prusty, S.D. (2015), "Influence of silpozz and rice husk ash on enhancement of concrete strength", *Adv. Concrete Constr*., **3**(3), 203-221.

Pandey, S.P. and Sharma, R.L. (2000), "The influence of mineral additives on the strength and porosity of OPC mortar", *Cement Concrete Res*., **30**, 19-23.

Ramezanianpour, A. (2014), *Cement Replacement Materials*, Springer-Verlag Berlin Heidelberg, New Delhi, India.

Wang, X.Y. (2017), "Modeling of hydration, compressive strength, and carbonation of portland-limestone cement (plc) concrete", *Mater*., **10**(2), 115.

Winter, N.B. (2012), *The Fast Star User-friendly Insight into Cement Production, Cement Hydration and Cement and Concrete Chemistry*, WHD Microanalysis Consultants Ltd., U.K.

Wong, H.S. and Buenfeld, N.R. (2009), "Determining the water-cement ratio, cement content, water content and degree of hydration of hardened cement paste: Method development and validation on paste samples", *Cement Concrete Res*., **39**(10), 957-965.

Zeng, Q., Li, K., Fen-Chong, T. and Dangla, P. (2012), "Pore structure characterization of cement pastes blended with high-volume fly-ash", *Cement Concrete Res*., **42**(1), 194-204.

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