INTERNATIONAL CONFERENCE
SUSTAINABLE PRODUCTION AND USE OF CEMENT AND CONCRETE

Calculating apparent activation energy of Portland cement blended with dehydrated cement by isothermal calorimetry

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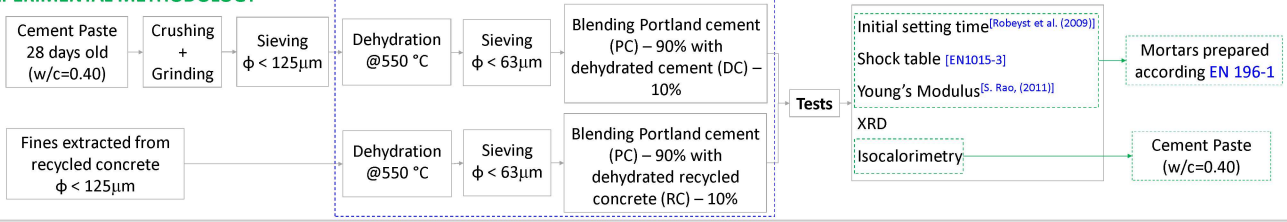
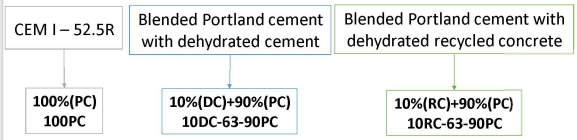
In 2012 alone, the production of cement was approximately responsible for 8% of the annual anthropogenic CO_2 emissions. As a consequence, the cement industry worldwide is facing growing challenges in conserving material and energy resources, as well as reducing its CO_2 emissions[Miller et al. (2016)]. The recycling of end-of-life concrete structures to lower CO_2 emission, protect natural resources and reduce environmental pollution is of special importance. A key priority for cement industry remains the reduction of the clinker factor. A previous study on the characterization of fines from recycled concrete showed that the highest ratio of hydrated cement can be recovered from fractions below 125 µm. Thus, in this work, two different types of blended cement were tested: Portland cement blended with dehydrated cement paste and Portland cement blended with dehydrated recycled concrete recovered from fines below 125 µm. The mineralogical composition and physical properties as consistency, initial setting time and Young's Modulus were compared. The hydration heat of the studied blends has also been measured by isothermal calorimetry for different temperatures, from which the apparent activation energy was determined.

EXPERIMENTAL METHODOLOGY



MATERIALS



Physical Properties	100PC	10DC–63–90PC	10RC–63–90PC
Density (kg/m³)	3120	3216	3174
Blaine surface (m²/kg)	540	-	-
Initial setting time /min	122	144	131
Slump value /mm	103	100	101
Shock value/mm	152.5	145.5	153

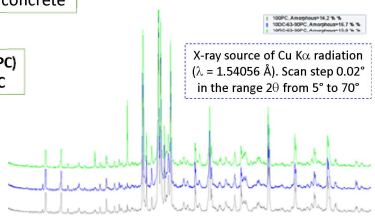


Figure 1: XRD pattern comparison of raw materials.

Mineralogical composition	100 PC	10DC–63–90PC	10RC–63–90PC
C_3S monoclinic (%)	59.59	55.76	53.27
C_2S beta (%)	17.28	20.57	17.09
C_2S gamma (%)	-	1.07	-
C_3A cubic (%)	5.45	5.35	4.98
C_4AF (%)	10.07	9.57	8.80
Bassanite (%)	2.06	2.47	1.82
Gypsum (%)	0.26	0.23	0.08
Periclase (%)	0.79	0.68	0.65
Portlandite (%)	1.71	2.11	1.06
Quartz (%)	0.55	0.50	3.46
Dolomite (%)	1.70	2.34	2.31
Anhydrite (%)	0.54	0.44	0.31
Lime (%)	-	0.42	-
Calcite (%)	-	1.57	6.17

RESULTS

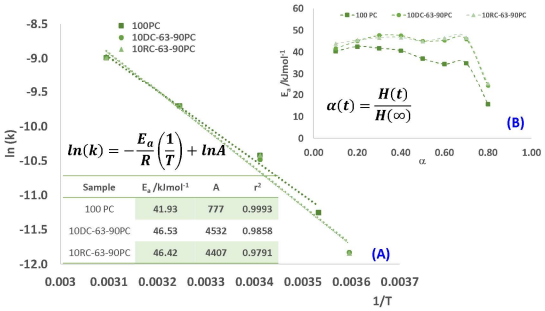


Figure 2: Determination of apparent activation Energy from the plot of ln (k) versus 1/T, according Arrhenius equation **(A)**; activation energy at various degrees of hydration α(t) **(B)**.

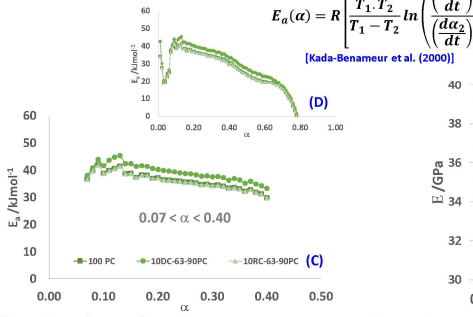


Figure 3: Evolution of apparent activation energy according Kada-Benameur et al. (2000) model for the range of temperature (20°C–35°C) in the stabilized parts (0.07<α<0.40) **(C)**; activation energy at various degrees of hydration α(t) **(D)**.

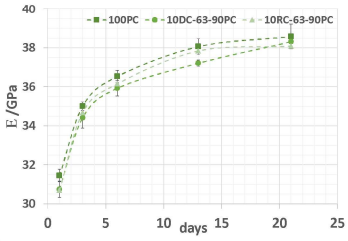


Figure 4: Young's Modulus[S. Rao, (2011)] of the samples at different curing days.

CONCLUSIONS

The proportion of recycled materials in the cement mix is very limited, thus the physical properties and mineral composition are very close to pure Portland cement. As a consequence the Young's Modulus and apparent activation energy are very similar.

The higher setting time of mortar 10DC-63-90PC is a consequence of its dry consistence.

Although the mineralogical composition of samples originated from recycled concrete (10RC-63-90PC) is similar to 100PC, it is important to notice the quantities of quartz and calcite in the raw material.

Calcite presence in sample 10DC-63-90PC may result from carbonation during the dehydrated cement paste preparation.

The mechanical tests showed promising results for the replacement of clinker by recycled concrete up to 10 wt% there only small differences between the properties of pure Portland cement and recycled containing concrete.

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