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The influence of chosen factors on the rheological properties of cement paste

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Abstract

Rheological investigations were conducted into cement paste made of various cement types (CEM I 42.5 R, CEM II/B-S 42.5 R, CEM III/A 32.5 N LH/HSR/NA), with and without superplasticizer. The tests were performed at 15ºC, 20ºC and 25ºC, for one hour. Rheological parameters (yield value and plastic viscosity) were designated according to the Bingham model. The influences of hydration time, the presence of superplasticizer and of temperature on the occurrence of the thixotropy phenomenon in cement paste were identified. The thixotropy was analysed by measuring hysteresis loops surfaces using a numerical integral method.

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Keywords: cement paste; rheological; superplasticizer; thixotropy

1. Introduction

Due to the size of cement grains, cement pastes should be included in dispersion systems. Research into the rheological properties of cement pastes shows that these properties depend on many factors, including water cement ratio (w/c), the specific surface area of the cement, grain composition of the cement, mineral composition, conditions and methods of measurement, and also the presence of chemical admixtures and mineral additives

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[1,2,3].

The rheological properties of cement pastes in the initial stage of hydration depend on the type and quantity of products produced from the hydration of C_3A and C_3S. The complexity of the cement-water system causes great difficulty in the interpretation of rheological research results. This is mainly due to the non-Newtonian characteristics of cement pates and changes in the phase composition of cement pastes during the hydration process progress. These factors mean that the results of rheological measurement are dependent on the method of conducting the experiment, i.e. the methods used for sample preparation, the intensity and time of mixing, conditions of shear etc. [4,5,6].

Cement pastes can exhibit different rheological properties, such as the Newtonian fluids, pseudoplatic, plastic and dilatant fluids. The flow curves of cement pastes may be reversible or may exhibit hysteresis (being thixotropic or anti-thixotropic). The presence of thixotropy and antithixotropy, during the shear stress of cement suspension, indicates the strong influence of time in shaping the rheological properties of cement pastes [7].

Quantitative measurement of thixotropy is not an easy task, because material exhibiting thixotropic properties is sensitive to shear rate gradient changes and the rheological history of the sample.

Many methods for the research of fluids with thixotropic properties are described in the literature, among them the "area of hysteresis" [8,9]. Non of the methods demonstrate a clear rheological characteristics of these fluids. One method for thixotropic fluid is that proposed by Kembłowski and Petera, based on the determination of equilibrium flow curves, which gives results independent of the method of conducting the experiment [10].

This paper presents the rheological research results of cement pastes with and without the addition of superplasticizer in different temperatures. The analysis paid particular attention to the thixotropy of cement suspensions. Quantitative measurements of thixotropy were made by measuring the surface area of the hysteresis loop of flow curves. Future research plans involve applying the method recommended by Kembłowski and Petera.

Nomenclature

τ_0	yield stress (Pa)
η	plastic viscosity (Pa·s)
S	surface area of hysteresis loop (Pa/s)

2. Materials

The experimental investigation was carried out on various cement pastes prepared from different types of cements: CEM I 42.5 R (CEM I), CEM II/B-S 42.5 R (CEM II) and CEM III/A 32.5 N LH/HSR/NA (CEM III). The chemical composition of cements is described in Table 1. The specific surface area (Blaine) of CEM I is 379 m^2/kg, CEM II - 417 m^2/kg and CEM III - 419 m^2/kg.

Table 1.Chemical composition of cement and the corresponding clinker.

Cement	Characteristics (% by mass)							
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Cl^-	Na_2O_{eq}	SO_3
CEM I	17.9	5.8	2.9	63.1	1.2	0.01	0.7	2.1
CEM II	22.2	6.2	2.6	59.6	2.4	0.02	0.8	2.6
CEM III	30.2	7.7	1.6	50.1	5.7	0.02	0.7	2.0
Clinker	20.2	6.5	3.4	65.0	1.5	0.01	0.7	0.7