Cement and Concrete Research 41 (2011) 373–379

Contents lists available at ScienceDirect

Cement and Concrete Research

journal homepage: http://ees.elsevier.com/CEMCON/default.asp

Influence of bentonite clay on the rheological behaviour of fresh mortars

A. Kaci [a], M. Chaouche [b,*], P-A. Andréani [c]

[a] Université de Cergy-Pontoise, L2MGC, EA 4114, F – 95000 Cergy-Pontoise, France
[b] Laboratoire de Mécanique et Technologie — Cachan (ENS Cachan/CNRS UMR8535/UPMC/PRES UniverSud Paris), 61, av. du Président Wilson F-94230 Cachan, France
[c] Centre d'Innovation de ParexLanko, BP 5 — 38, rue du Montmurier, ZI Parc des Chesnes 38291 Saint Quentin Fallavier Lyon, France

ARTICLE INFO

Article history:
Received 22 March 2010
Accepted 12 January 2011

Keywords:
Fresh mortars (A,E)
Bentonite clay
Rheology (A)
Creep (c)
Thixotropy

ABSTRACT

Fine mineral additives are often used in the formulation of ready-mix mortars as thickeners and thixotropic agents. Yet, these attributed fresh state properties are not clearly defined from the rheological point of view. In the present study, we consider the influence of bentonite (montmorillonite-based clay mineral) on the rheological behaviour of mortars, including in particular creep and thixotropy. The mortar pastes are subjected to different shear-rates and then allowed to creep under fixed shear stresses until reaching steady state, which corresponds to either rest if the applied stress is smaller than the yield stress or permanent flow otherwise. The evolution of the creep strain is investigated depending on shear history for different contents of bentonite. The microstructure rebuilding kinetics after shear (thixotropy) is considered by analysing the temporal evolution of the creep strain for different applied shear stresses (lower than the yield stress). As expected, bentonite is found to enhance the mortar creep (or sag) resistance. This enhancement consists of both an increase of the yield stress recovered after shear, and a diminution of the characteristic time for yield stress recovery (related to microstructure rebuilding).

1. Introduction

Ready-mix mortars, including among others tile adhesives, rendering and repairing mortars, are often characterised by a highly complex formulation. In particular different types of organic and mineral admixtures are included in their mix-design in order to meet a number of requirements related to their placement processing (pumpability, workability, sag-resistance, etc.), their hardening properties (open-time, cracking-resistance, etc.) and their long-time behaviour (water-proofing, mechanical properties, durability, etc.).

Ready-mix mortars are generally provided to the construction site in a dry power form. A given dosage rate of water is then added and the mix is kneaded to obtain a homogeneous mortar paste that can be mechanically or handily placed on vertical or horizontal supports. The rheological behaviour of the mortar paste will clearly determine its placement properties. Yet, the relationship between the rheological properties of these materials and their on-site placement behaviour are far to be clearly established [1,2]. Most of the rheological studies devoted to fresh mortars, which are usually assumed to behave as Bingham fluids, have focused essentially on two rheological parameters, namely the yield stress and the plastic viscosity [3,4]. These investigations are related in particular to the self-compacting/self-levelling issue. The transient rheological properties of cementitious materials, including mortars, are much less considered [5–7]. Moreover these investigations are mostly related to the practical issue of successive concreting and pressure on formworks. Paiva et al. [8,9] reported some rheological studies concerning specifically render mortars, considering in particular the influence of water-retaining agents [8], without however considering the issue of thixotropy.

When dealing with the problem of pumpability, as in the present study, a more extensive rheological characterisation is required since in such a process the material experiences a highly complex flow. During a machinery application process the mortar is sheared under varying rates, leading to an irreversible evolution of its microstructure, and subsequently its rheological properties. The crucial practical question is then: Does the mortar have enough thixotropy to recover a sufficient yield stress once on the support to avoid creeping under its own weight?

In the present study, to reproduce approximately the pumping process from the rheological point of view, the mortars are subjected to different shear-rates in a rheometer and let to creep under a given applied shear stress. This stress may correspond in practise to the one exerted by gravity, which intensity can be estimated as (one assumes a vertical wall): $\rho g a$, where ρ is the mortar density, a the applied layer thickness and g the acceleration of gravity. Once on the wall the material must quickly recover a yield stress higher than the gravity stress in order to avoid sagging. For a typical render mortar application ($\rho = 1800$ kg/m^3, $a = 2$ cm, $g = 10$ m/s^2), the yield stress must exceed 360 Pa once on the wall in order to avoid sagging.

We consider both the level of the yield stress recovered after shear and the dynamics of the microstructure recovering (thixotropy). We focus in particular on the influence of a bentonite clay mineral on these rheological properties.

* Corresponding author.
E-mail address: chaouche@lmt.ens-cachan.fr (M. Chaouche).

0008-8846/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.cemconres.2011.01.002