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Properties of Portland cement pastes enriched with addition of calcined marl

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Abstract

Increasing global production of Portland cement and the necessity to reduce CO_2 emissions have resulted in the need to increase the production and application of blended cements enriched with supplementary cementitious materials (SCMs). Recently, polymineral clays, which are abundantly available across the globe, have gained attention as promising raw materials for the production of SCMs. In this study, the effect of marl on the properties of hardened Portland cement was investigated. The Portland cement pastes enriched with marl (5–20%) calcined at 400–800 °C and ground up to 250–800 m^2/kg showed better physical-mechanical properties than those enriched with metakaolin. This study demonstrates the potential of calcined marl to be used as an effective pozzolan additive for Portland cement.

Keywords: Portland cement, Cement paste, Pozzolane, Compressive strength, Fineness

Introduction

One of the ways to reduce the amount of CO_2 emitted into the environment during the production of Portland cement is to reduce the consumption of Portland clinker. This can be done by replacing Portland clinker with supplementary cementitious materials (SCMs) [1].

A wide range of SCMs are known today. The commonly used SCMs such as ground granulated blast furnace slag and fly ash are not easily available. This limits their widespread use. Hence, SCMs containing natural pozzolans and calcined clays (glinites) are preferred [2]. Clay is abundantly available across the globe and is a cheap raw material for the production of pozzolans. Thermally activated clays are known as artificial pozzolans (EN 197-1-2000). Metakaolin (MK), which is an artificial pozzolan, is obtained by calcining clays and has been used to improve the physical-technical performance of Portland cement-based materials over the past few decades [3,7]. However, the raw materials required for the production of MK are kaolin clays. These clays are scarcely available and are expensive. This limits the large-scale production and widespread use of MK.

Thereby the studies concerning the pozzolanic activity and efficiency of application of calcined clays based on wide spread polymineral clays with different content of kaolin and clays without kaolins are being renewed last decades [3, 8–10]. Similar studies were carried out in the USSR on the pozzolanic activity of these polymineral clays. Out of the 207 clays that were studied, only 11% were found to be unsuitable for production of SCMs with enough pozzolanic activity [11]. Out of the 12 calcined clays that showed the highest pozzolanic activity nine were rich in marl and only three were rich in kaolin. Earlier studies revealed that demonstration of higher pozzolanic activity compared to MK of calcined at certain temperatures and ground to certain fineness of the polymineral clays with different content of kaolin and without [10, 12–14]. Finely dispersed carbonate mineral additives, which influence the properties of Portland cement, have been were systematically studied in the USSR and other countries [15–18] and are widely used nowadays. Blended Portland cements enriched with carbonate additives are widely used in Denmark, Norway, Canada, USA, France and various other countries. Portland cement containing 5–25% of carbonate additives constitutes more than 30% of the total production of cement in France. Many studies have reported that the incorporation of carbonate materials improves the properties of Portland cement. Even though contradictory in terms of level of