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Influence of Mineral Admixtures on the Short and Long-term Performance of Steam-cured Concrete

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Abstract

In view of sustainable development, it is imperative that mineral admixtures be used to replace cement in the concrete industry. This paper presents a laboratory study on the performance of steam cured concrete by adding mineral admixtures. Performance of the concrete mixes was determined with short and long-term tests, which include compressive strength, dry shrinkage, anti-chloride permeability and pore structure. The test results, in general, showed that mineral admixtures improved the performance of concretes. Ground granular blast furnace slag (GGBS) contributed to both short and long-term properties of concrete, whereas Fly ash (FA) shows its beneficial effect in a relatively longer time. Adding of both GGBS and FA significantly improved the microstructure of steam cured concrete, and contributed more to the improvement of transport properties of concretes.

keywords: Steam cured concrete; Mineral admixtures; Microstructure; Performance

1. Introduction

All human activity results in some degree of environmental degradation. For the civil engineering community, in view of sustainable development, mineral admixtures such as, fly ash, ground granulated blast furnace slag (slag) and silica fume have been commonly used to replace part of cement in concrete as supplementary cementitious materials[1,2].

Precast concrete elements are mainly adopted steam-cured concrete in industrial manufacturing. Due to high cement content, the elements of ordinary steam-cured concrete are poor durability, such as high

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shrinkage s and easy to crack etc [3,4]. Many researchers [5,6]have reported that under steam curing condition the quality of concrete with mineral admixtures is better than that of the pure cement concrete. However the research on the short and long term performance of steam cured concrete with mineral admixtures is very limited. This work is intended to improve our understanding of the mechanism by which mineral admixtures interact with concrete and to shed light on the effectiveness of mineral admixtures in improving the properties of hardened concrete under steam curing procedures and conditions.

2. Experimental procedure

2.1 Materials and mix proportions

The cement used was reference Portland cement with grade P.O 42.5 provided by china building material research institute. Fly ash (FA) was supplied by Xiangtan Power Plant, and its surface area is 512m^2/kg. Ground granular blast furnace slag (GGBS) came from a commercial producer in Xiangtan city, and its surface area is 470m^2/kg. Xiangjiang river sand is used as fine aggregate, and its fineness modulus is 2.71. Coarse aggregates are crushed lime stones. A superplasticizer of sulfated naphthalene formaldehyde base made in Zhuzhou Bridge Chemical Plant is used in the mix, which is commercially named as TQN. Mixing water is tap water. Experimental proportion and related parameters of samples are shown in tables 1and 2.

Table 1 Chemical compositions(by mass) of P.O 42.5, FA, GGBS and SF

Material	w/ %						
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	IL
P.O. 42.5	24.3	4.8	3.8	55.3	4.2	2.2	2.4
FA	52.7	25.8	9.7	3.7	1.2	0.2	3.0
GGBS	34.18	13.8	15.3	26.6	8.14	-	-

Table 2 Mix proportions of samples

Sample	Cement /kg/m^3	Fly ash /kg/m^3	GGBS /kg/m^3	Sand /kg/m^3	Limestone /kg/m^3	Water /binder	TQN /%
C-1	450	—	—	700	1240	0.27	1
C-2	315	135	—	670	1210	0.27	1
C-3	315	90	45	670	1210	0.27	1

2.2 Preparation of specimens

Concrete samples were prepared in the laboratory using a mixer, and then vibrated for 3 min. Samples were cast from each batch of concrete. After casting, some specimens were covered with water-saturated burlap and left in the casting room at 20±2℃ for 24h. They were then demoulded and transferred to standard curing rooms. The other specimens were placed in steam room to cure according to following steam-curing regime after cast. The steam curing treatment had a total duration of 13h, including preheating duration of 2h, heating duration of 2h, the treatment duration of 8h with constant temperature of 60℃, and the cooling duration of 1h. After 13h steam curing, the specimens were demoulded and then treated according to standard curing conditions.