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Study of magnetically driven concrete

Ju Chen *, Jun Wang, Wei-liang Jin

Department of Civil Engineering, Zhejiang University, China

HIGHLIGHTS

- Magnetic force was used to drive and vibrate concrete containing steel slag aggregate.
- Magnetic force is able to drive concrete to move in plastic tube.
- The magnetic vibration method is able to vibrate the concrete as well as the shanking table method.

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ABSTRACT

This paper focuses on the study of magnetically driven concrete. Magnetic force was used to drive and vibrate concrete containing steel slag aggregate. A test program containing 120 concrete specimens was conducted. Three series of concrete with different portions of aggregate replaced by steel slag were tested. Each series of concrete was vibrated by two methods – the magnetic vibration method and the shanking table method. The compressive strengths, splitting strengths and flexural strengths of concrete vibrated by the two methods were compared. Additionally, the porosities of concrete were also compared. It is shown that the magnetic vibration method is able to vibrate the concrete as well as the shanking table method.

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1. Introduction

In the history of concrete, concrete has been driven by gravity or mechanical force, but never by magnetic force. In this study, magnetic force was used to drive and vibrate concrete. In the magnetically driven concrete, the aggregate was replaced by steel slag as the magnetic force carrier. Aggregate, which makes up approximately 70% of the concrete volume, is one of the main constituent materials in concrete. If the aggregate could be driven by magnetic force, whole concrete could be driven by the magnetic force. Steel slag is a by-product obtained from steel manufacturing plants. Research on the use of steel slag as a coarse and fine aggregate of concrete has been reported in several papers [1–7]. The use of steel slag to replace natural aggregate in concrete is initially based on the availability of natural resources and the good characteristics of steel slag [6]. Although steel slag contains hydratable oxides that can result in volumetric instability, it could still be used with appropriate steel slag aging and quality control. In this study, steel slag is used in concrete because it could be driven by magnetic force, as the steel slag contains magnetic iron oxide. Compared to gravity, which is limited by gravitational acceleration, the magnetic force could be applied from any direction and has no limitations of acceleration. Compared to mechanical force, the magnetic force could be applied uniformly and without noise. It also provides a new way to control the movement of aggregate in concrete.

The magnetic drive concrete could be used where concrete is unable to flow under its own weight, such as in horizontal structural members or connections. Completely filling formwork and achieving full compaction could be assured by the magnetic drive force. In addition, the magnetic drive concrete could be vibrated uniformly without mechanical vibrations. It also has no special requirement of good deformability and high segregation resistance as self-compacting concrete.

2. Experimental details

2.1. Materials and mix designs

A normal P.O Type 42.5 Portland cement was used throughout this study. The chemical composition and associated properties provided by the cement manufacturer are as follows: SiO_2 – 25.23%, Al_2O_3 – 4.87%, Fe_2O_3 – 3.04%, CaO –

* Corresponding author at: A613 Anzhong Building, 338 Yuhangtang Road, Zhejiang University, Hangzhou 310058, China.
E-mail address: cecj@zju.edu.cn (J. Chen).

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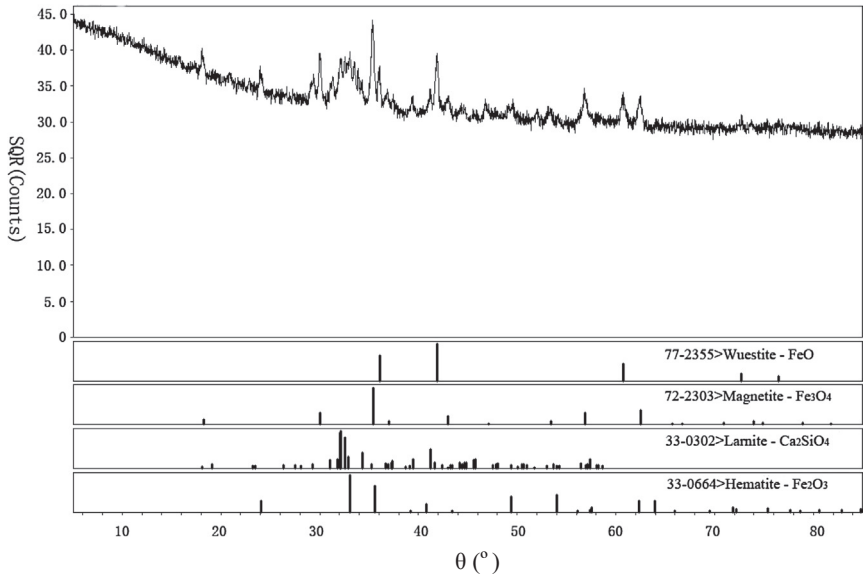
Table 1
Physical properties of natural aggregate and steel slag.

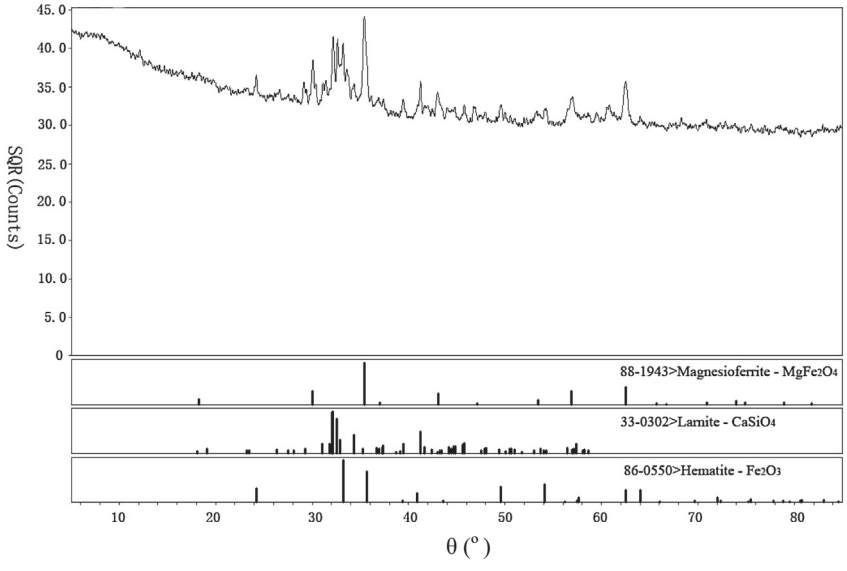
	Coarse aggregate	Sand	Coarse steel slag	Fine steel slag
Bulk density (kg/m^3)	1448	2069	1834	1806
Relative density (kg/m^3)	2810	2305	3888	3788
Water absorption (%)	1.9	3.4	5.4	6.5
Dust content (%)	3.3	0.5	8.4	0.4
Void ratio (%)	48.5		52.8	
Water content (%)	2.1	3.2	2.6	3.9
Shape	Angular	Round		
Surface texture	Rough	Smooth		

Table 2
Chemical composition of steel slag.

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	P_2O_3	FeO	MnO_2	S	C	Other
11.2	2.81	5.90	25.5	3.64	1.12	42.56	3.78	0.04	0.48	2.97



(a) Coarse steel slag



(b) Fine steel slag

Fig. 1. XRD test results of steel slag.

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