Construction and Building Materials 139 (2017) 403–418

Contents lists available at ScienceDirect

Construction and Building Materials

journal homepage: www.elsevier.com/locate/conbuildmat

Review

Overview of supplementary cementitious materials usage in lightweight aggregate concrete

Kim Hung Mo [a,*], Tung-Chai Ling [b], U. Johnson Alengaram [a], Soon Poh Yap [a], Choon Wah Yuen [a]

[a] Department of Civil Engineering, Faculty of Engineering, University of Malaya, Kuala Lumpur 50603, Malaysia
[b] College of Civil Engineering, Hunan University, Changsha, Hunan 410082, China

HIGHLIGHTS

- Summary of effect of SCM on fresh, hardened and durability properties of LWAC.
- Silica fume is the most effective SCM for enhancing properties of LWAC.
- Inclusion of fly ash and GGBS give good performance of LWAC.
- Further investigation required for SCM of more porous nature such as RHA and POFA.

ARTICLE INFO

Article history:
Received 22 December 2016
Received in revised form 15 February 2017
Accepted 16 February 2017

Keywords:
Supplementary cementitious materials
Lightweight aggregate concrete
Silica fume
Fly ash
Blast furnace slag
Mechanical properties
Durability properties

ABSTRACT

The decrease in density of lightweight aggregate concrete (LWAC) leads to the economic savings in terms of structural design, transportation and handling costs. LWAC exhibits better insulation properties and resistance towards earthquake effects as compared to normal concrete. However, the use of higher content and better quality of cement paste in LWAC may increase the overall cost of production. Therefore, the possibility of utilizing supplementary cementitious material (SCM), especially at higher volume is desirable to reduce the cement consumption and carbon footprint. This review summarizes previous findings on the utilization of different types of SCM (such as silica fume, fly ash, ground granulated blast furnace slag, metakaolin, etc.) in LWAC as well as the effects on the resulting concrete performances, namely the fresh, mechanical and durability properties. In general, the silica fume is the most effective SCM for performance enhancement of LWAC, and the use of fly ash and ground granulated blast furnace slag are also feasible if lower cost and higher cement replacement levels are desired. On the other hand, literatures are relatively limited for the case of utilization of SCM which are porous in nature such as rice husk ash, palm oil fuel ash, pumice powder, volcanic ash and more, and hence further research works are required to fully understand their effects on LWAC.

Contents

* Corresponding author.
E-mail addresses: khmo@um.edu.my, khmo890815@gmail.com (K.H. Mo).

http://dx.doi.org/10.1016/j.conbuildmat.2017.02.081

1. Introduction

Lightweight aggregate concrete (LWAC) is a type of lightweight concrete produced by introducing lightweight materials as conventional coarse or fine aggregate substitute. There are different categories of lightweight aggregates used in LWAC, namely natural and artificial lightweight aggregates. Artificial lightweight aggregates include expanded clay, expanded shale and sintered fly ash, among others whereas natural lightweight aggregates consist of pumice, oil palm shell, coconut shell and more [1]. Typically, the density of LWAC is below 2000 kg/m^3 as compared to the density of 2400 kg/m^3 for normal weight concrete (NWC). The reduced density of LWAC induces lower dead load to concrete structures, consequently saving on transportation and handling costs. In addition, the lower density of LWAC exhibits superior heat and thermal insulation, as well as reducing risk of earthquake damage.

However, there are certain drawbacks associated with LWAC mixes. For instance, for a given mix with lightweight aggregate as aggregate substitute, the strength properties of the LWAC are typically low due to the weaker and more porous nature of the lightweight aggregate. As such, safety factor are usually adopted in codes of practices for the strength properties in the design of LWAC, such as mechanical performance, steel-concrete bond properties [2] and shear strength. In addition, for a given compressive strength, LWAC requires better paste quality and lower volume of aggregates [3], which results in higher demand of cement content as compared to NWC. The higher usage of cement content in LWAC has in turn increased the cost and carbon footprint, as well as higher

Table 1
Summary of chemical composition and properties of SF used in LWAC.

Composition (%)	Literature							
	[12,19]	[14–16]	[20]	[24]	[26]	[27]	[3,25]	[23]
SiO_2	80.9	85–95	81.4	94.31	94.48	91.0	94.0	94.0
Al_2O_3	0.34	1.0–3.0	4.47	–	0.27	0.58	–	–
Fe_2O_3	0.55	0.5–1.0	1.40	0.03	0.87	0.24	–	–
MgO	5.23	1.0–2.0	1.48	0.41	0.91	0.33	–	–
K_2O	4.50	–	–	–	–	–	–	–
CaO	0.44	0.8–1.2	0.82	2.13	0.54	0.71	3.38	–
Na_2O	0.35	–	–	–	–	–	–	–
SO_3	–	–	1.35	–	–	–	–	–
Loss on ignition (%)	2.70	0.5–1.0	7.26	–	1.90	1.84	3.70	–
Specific surface area (m^2/kg)	–	–	–	–	20,000	–	–	20,300 (BET)
Specific gravity	–	–	2.32	2.01	–	2.2	2.25	–
Pozzolanic activity index at 28 days (%)	–	–	122	–	–	–	106.7	–