Journal of Cleaner Production 127 (2016) 183–194

Contents lists available at ScienceDirect

Journal of Cleaner Production

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

Drying shrinkage behaviour of structural lightweight aggregate concrete containing blended oil palm bio-products

Muhammad Aslam [a], Payam Shafigh [b], Mohd Zamin Jumaat [a, *]

[a] *Department of Civil Engineering, Faculty of Engineering, University of Malaya, 50603, Kuala Lumpur, Malaysia*
[b] *Department of Building Surveying, Faculty of Built Environment, University of Malaya, 50603, Kuala Lumpur, Malaysia*

ARTICLE INFO

Article history:
Received 16 December 2015
Received in revised form
29 March 2016
Accepted 29 March 2016
Available online 9 April 2016

Keywords:
Oil palm shell
Clinker
Structural lightweight concrete
High strength lightweight aggregate concrete
Efficiency factor
Shrinkage

ABSTRACT

Oil palm shell (or palm kernel shell) and oil-palm-boiler clinker are two solid wastes from palm oil industry in tropical region. They can be used as aggregate in concrete mixture. Lightweight aggregate concrete with high strength was successfully produced using oil palm shell as coarse lightweight aggregate. However, lightweight concretes containing oil palm shell with normal and high strengths have relatively high drying shrinkage at early and later ages. This study is an effort to reduce drying shrinkage of oil palm shell lightweight concrete. It was found from previous studies that increasing the volume of oil palm shell in concrete increased its drying shrinkage. Therefore, one method to reduce the drying shrinkage is the reduction of oil palm shell volume by substituting this aggregate with another type of aggregate. For this purpose, comprehensive experimental study was carried out to investigate the effect of partial replacement of oil palm shell with oil-palm-boiler clinker aggregate on the shrinkage behaviour of this type of lightweight concrete. Two sets of concrete mixes were designed in this study. In the first set, oil palm shell was replaced with oil-palm-boiler clinker from 0 to 50% with interval of 10% in oil palm shell concrete with a constant water to cement ratio of 0.36. In the second set, the replacement of oil palm shell with oil-palm-boiler clinker was 30–50% with reduced water to cement ratios from 0.36 to 0.295. The influence of curing conditions on drying shrinkage of concretes was also considered. The test results indicated that partially substitutions of oil palm shell with oil-palm-boiler clinker could significantly reduce long term drying shrinkage of concrete. Contribution of oil-palm-boiler clinker in oil palm shell concrete in the range of 30–50% significantly increased the slump of control oil palm shell concrete. Therefore, it was possible to reduce the water content of these concretes to achieve the same workability of the control mix. Reduction on water content further reduced the drying shrinkage of the concrete. Concrete specimens under 7-day moist curing showed higher drying shrinkage compared to air drying condition.

© 2016 Elsevier Ltd. All rights reserved.

1. Introduction

The increase in shrinkage increases proportionally with the age of concrete. It shrinks when it is exposed to a drying environment which causes an increase in tensile stress leading to cracking and external deflection, before the concrete is subjected to loading (Day, 2003). The shrinkage of a concrete is influenced by the amount of mixing, time after addition of water, temperature fluctuation, placement, and curing (McKeen and Ledbetter, 1969). The higher the amount of water present in the fresh concrete the highly drying shrinkage will be affected (Day, 2003). The makeup of concrete is very important because each ingredients have distinctive characteristics which contribute to the shrinkage of concrete. Drying shrinkage can occur in beams, slabs, columns, foundations and causes stress loss in prestressed members and failure of joints (Shafigh et al., 2013).

In the case of lightweight aggregate concrete (LWAC), the drying shrinkage is greater than conventional concrete and is mostly affected by the properties and the amount of aggregates (Satish and Berntsson, 2003). The fact is that the shrinkage of concrete is essentially governed by the cement paste due to its contraction. Because the water inside C–S–H is removed in the drying condition. Wongkeo et al. (2012) reported that when small capillary pores (pores less than 50 nm) losses the water, it

---

* Corresponding author. Tel.: +60 379675203; fax: +60379675318.
E-mail addresses: bhanbhroma@gmail.com (M. Aslam), pshafigh@gmail.com (P. Shafigh), zamin@um.edu.my (M.Z. Jumaat).

http://dx.doi.org/10.1016/j.jclepro.2016.03.165
0959-6526/© 2016 Elsevier Ltd. All rights reserved.

significantly affect the change in volume of concrete. The degree of hydration or change in volume of concrete affects the drying shrinkage strain of concrete (Basma and Jawad, 1995). One of the main source to oppose this contraction is by the addition of the aggregates to restrain the shrinkage of Portland cement paste to a point that the concrete becomes a practical material (CEB/FIP, 1977). Since structural LWAC is modified at these two factors, it is expected that its behaviour differs from that observed in normal weight concrete (NWC). Firstly, the use of less rigid porous aggregates decreases the restriction effect on paste deformation (Zhang et al., 2005). Secondly, either for strength purposes or for reasons of workability and stability of the mixtures, lightweight concrete (LWC) is usually characterized by larger volumes of better quality paste and lower volume of coarse aggregates (Bogas, 2011; Holm and Bremner, 2000). Therefore, the long-term shrinkage of lightweight concrete should be higher than that of NWC of the same grade. On the other hand, it should be noted that water absorbed by lightweight aggregate (LWA) is released later into the paste due to internal curing, which compensates for the initial water lost by drying and self-desiccation. Because of the internal curing and the continued hydration of the paste, the deformation resistance of the matrix is higher and therefore less water is available for evaporation (Selih and Bremner, 1996). The combination of all these affecting factors together with different variability of lightweight aggregates, the higher shrinkage in LWAC compared to NWC was reported (Coquillat, 1986; Hossain and Lachemi, 2007; Shafigh et al., 2014a). However, some reports showed that shrinkage in LWAC is less than or similar to shrinkage of NWC (Shafigh et al., 2014a; Wegen and Bijen, 1985). For general design work, it was suggested that the shrinkage of LWAC is between 1.4 and 2 times that of NWC (Clarke, 2002). The drying shrinkage values for structural lightweight concrete may vary between 0.04% and 0.15% (Lamond, 2006).

Since last two decades, oil palm shell (OPS) or palm kernel shell (PKS) has been used as a LWA for producing structural LWAC with a density of 20–25% lower than NWC (Shafigh et al., 2012a). There is a little information in the literature concerning the shrinkage of OPS concrete. The drying shrinkage of OPS concrete was first investigated by Abdullah (1997), who reported that OPS concrete showed about 5 times higher drying shrinkage than the NWC. Mannan and Ganapathy (2002) investigated the drying shrinkage of OPS concrete and NWC up to 90 days age. They reported that the drying shrinkage of both the concretes was increased with age but OPS concrete showed higher increment. The OPS concrete showed 14% higher drying shrinkage compared to NWC at the age of 90 days. Alengaram (2009) measured the drying shrinkage of several types of OPS lightweight concrete without any initial moist curing. The specimens were exposed to laboratory environment immediately after demoulding with average humidity of 75% and temperature of 30 °C. The cement content, total binder content (cement + fly ash + silica fume), water to binder ratio and 28-day compressive strength varied between 500 and 560 kg/m^3, 560–595 kg/m^3, 0.30–0.35 and 22–38 MPa, respectively. He reported that drying shrinkage of OPS concrete at 28, 56 and 90 days is in the range of 160–520, 300–990 and 540–1300 microstrain, respectively. He reported that structural lightweight OPS concrete has high drying shrinkage due to high cement and OPS (as coarse aggregate) contents. Shafigh et al. (2013, 2014b) studied the drying shrinkage of OPS concretes with the substitution of fly ash with cement and normal sand with oil-palm-boiler clinker (OPBC) sand. They reported that the use of 10% fly ash in OPS high strength concrete did not affect the drying shrinkage of the concrete. However, generally, for higher percentage replacement levels of 30% and 50%, the drying shrinkage increased but was not significant. The substitution of normal sand with OPBC sand in OPS concrete does not influence the drying shrinkage (Shafigh et al., 2014b). However, they further conducted a comparative study of OPS and expanded clay lightweight concretes (Shafigh et al., 2014a). The investigations showed that, although the OPS concrete had a better engineering properties and greater efficiency factor (compressive strength to density ratio) but it showed twice the amount of drying shrinkage at early ages. However this ratio reduces significantly at later ages. Recently, Mo et al. (2016) investigated the durability properties of a sustainable concrete by using OPS as coarse and manufactured sand as fine aggregates. The GGBFS was used as partial cement replacement at 20, 40 and 60% levels in the OPS concrete. They reported the drying shrinkage values of about 740–760 microstrain at GGBFS replacement levels of 20% and 40%, it was closer to that of the control OPS concrete. However, the substitution of 60% GGBFS increased the shrinkage values by about 20% compared to control OPS concrete.

Previous studies (Mannan et al., 2006; Teo et al., 2007) revealed that OPS concrete has good mechanical properties and durability performance. However, this concrete has some drawbacks which needs to be solved before it is used in practice. One of the drawbacks is its high drying shrinkage compared to artificial lightweight concretes and also normal weight concrete. The main objective of this study is to resolve the high drying shrinkage problem of OPS concrete. Shafigh et al. (2013) reported that the main reason for high drying shrinkage of OPS concrete is due to high cement content and OPS (as coarse) contents. Therefore, it seems that one way to reduce the drying shrinkage of this concrete is to reduce the volume of coarse OPS in concrete mixture. For this purpose oil-palm-boiler clinker (OPBC) as lightweight aggregate was selected to be used as partially replacement with OPS. The reason for choosing the incorporation of OPBC aggregates in OPS concrete is that OPBC is a solid waste and lightweight material produced from burning of solid wastes in the boiler combustion process in palm oil mills. It is like a porous stone, grey in colour, flaky and irregular in shape (Ahmad et al., 2007). Previous studies (Ahmad et al., 2008; Chan and Robani, 2005; Zakaria, 1986) have shown that OPBC can be used as coarse lightweight aggregate in concrete. The density and the 28-day compressive strength of OPBC concrete fulfil the requirements of structural LWAC. Therefore, in this study, two types of waste originated from the palm oil industry, namely OPS and OPBC, were used as coarse aggregates. The optimum substitution level of OPBC in OPS concrete to reduce drying shrinkage of OPS concrete was identified.

2. Experimental program

2.1. Materials used

Ordinary Portland cement (OPC), having 3-, 7- and 28-day compressive strength of 26, 36 and 48 MPa, respectively was used as binder conforming to MS522, part-1:2003. The specific gravity and Blaine specific surface area of the cement were 3.14 and 3510 cm^2/g, respectively. A Sika viscocrete containing total chloride ion content of ≤0.1 and compatible with all type of cements according to BS-5075 was used as super plasticizer (SP). The local mining sand with a fineness modulus of 2.89, specific gravity of 2.68 and maximum grain size of 4.75 mm was used as fine aggregate. The OPS and OPBC were collected from a local palm oil mill. They were used as coarse aggregate. The OPS aggregates were placed in open air for 6 months to remove fibres from the surface and then washed (Shafigh et al., 2011). While the OPBC aggregates were crushed using a crushing machine. After washing and crushing, both aggregates were sieved to get the same grading of

Download English Version:

https://daneshyari.com/en/article/1744077

Download Persian Version:

https://daneshyari.com/article/1744077

Daneshyari.com