Technical report

Flexural Behaviour of Reinforced Lightweight Concrete Beams Made with Oil Palm Shell (OPS)

Delsye C. L. Teo[1], Md. Abdul Mannan[2] and John V. Kurian[3]

Received 3 May 2006, accepted 11 August 2006

Abstract

This paper presents an investigation on the flexural behaviour of reinforced concrete beams produced from oil palm shell (OPS) aggregates. Utilising OPS in concrete production not only solves the problem of disposing this solid waste but also helps conserve natural resources. A total of 6 under-reinforced beams with varying reinforcement ratios (0.52% to 3.90%) were fabricated and tested. Data presented include the deflection characteristics, cracking behaviour, ductility indices and end-rotations. The investigation revealed that the flexural behaviour of reinforced OPS concrete beams was comparable to that of other lightweight concretes and the experimental results compare reasonably well with the current Codes of Practice. It was observed that beams with low reinforcement ratios satisfied all the serviceability requirements as per BS 8110.

1. Introduction

Malaysia is currently producing more than half of the world's total output of palm oil, planted over 4.05 million hectares of land, yielding about 18.88 tonnes/hectare of fresh fruit bunch (FFB) (MPOB 2006). At the mills where the FFB are processed and oil extraction takes place, solid residues and liquid wastes are generated. These wastes include empty fruit bunches, fibre, shell and effluent. In general, the fresh fruit bunches (FFB) contains about 5.5 % shell (Ma *et al*., 1999) and consequently, over 4 million tonnes of oil palm shell (OPS) solid waste is produced annually. This waste is normally disposed through incineration and at times, the shell is left to rot in huge mounds as shown in **Fig. 1**. This will ultimately cause pollution and is harmful to the ecosystem. Environmental regulations have also become more stringent, causing this waste to become increasingly expensive to dispose. Therefore, exploitation of this waste material as sustainable building material in the construction industry helps preserve the natural resources and also helps maintain the ecological balance. In addition, once the service life of OPS concrete is reached, it may also be possible for reuse as aggregates in the production of recycled aggregate concrete. However, further investigations are required to confirm this on OPS concrete.

OPS is hard in nature and does not deteriorate easily once bound in concrete and therefore, it does not contaminate or leach to produce toxic substances (Basri *et al*. 1999). Unlike artificially produced aggregates or industrial by-products, OPS does not need to be processed or require any chemical pre-treatment before it is used. The bulk density of OPS is about 500 to 600 kg/m^3, producing concretes of about 1900 kg/m^3 in density, which makes them lightweight. It has been found that OPS concrete easily attains the strength of more than 17 MPa (Mannan and Ganapathy 2004), which is a requirement for structural lightweight concrete as per ASTM C330. More recently, compressive strengths of up to 28 MPa have been achieved (Teo *et al*. 2005). The durability of OPS concrete has also been studied previously. When cured in water, it was found that OPS concrete have water absorption and water permeability of about 11% and 6.4 x 10^{-10} cm/s respectively at an age of 28 day (Teo *et al*. 2006), which is comparable to other lightweight concretes such as those made from pumice aggregates (Güdüz and Uğur 2005; Hossain 2004).

Fig. 1 Oil palm shell (OPS) being left at palm oil mill area.

[1]Research Associate, Civil Engineering Program, School of Engineering and Information Technology, Universiti Malaysia Sabah, Malaysia.
[2]Associate Professor, Civil Engineering Program, School of Engineering and Information Technology, Universiti Malaysia Sabah, Malaysia.
E-mail: mannan@ums.edu.my
[3]Associate Professor, Civil Engineering Program, School of Engineering and Information Technology, Universiti Malaysia Sabah, Malaysia.