Sustainable use of palm oil fuel ash as a supplementary cementitious material: A comprehensive review

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ABSTRACT

Cement concrete has been popularly used as a construction material with an approximate annual consumption of 10 billion tons. Increase in urbanization and industrialization increased the demand of concrete materials at recent days. It has been estimated that the cement industry alone generates approximately 6–7% of the total CO_2 emissions. These environmental concerns demand the use of alternative renewable and sustainable materials to produce green concrete. Meanwhile, a large amount of agricultural waste, especially palm oil waste is disposed into the open area and landfills, causing serious environmental problems. An estimated 12 million tons of palm oil fuel ash (POFA) is generated in the world per annum. To minimize the passive effects of concrete production using traditional Portland cement, it was recommended by many researchers to adopt the palm oil waste fall-outs as a supplementary cementitious material. It may be considered a suitable and reliable source for better solutions to magnify the sustainability of the construction industry. This paper reviews the potential utilization of POFA as an alternative cementitious material in concrete. The impact of POFA on the fresh, hardened and durability properties of concrete are deliberated, providing a brief of the current knowing about a suitable utilization of POFA as SCM to promote a sustainable environment in the construction industry. The grinding treatment of raw POFA particles significantly enhances the quality of POFA in terms of compressive strength, resistance against aggressive environments and assist in reducing the drying shrinkage of concrete, although there is a tendency to increase the water absorption and delay the hydration heat of cement mortar. The high quantity of SiO_2 in POFA enables pozzolanic reaction and delays the setting times with the addition of CaO to produce further C–S–H gels. The utilization of POFA (20%), ultrafine POFA and nano POFA (30%) can produce high strength and durable concrete, proving to be a promising contribution towards the sustainability of the construction industry.

KEYWORDS
Sustainability; Cement concrete; Agricultural waste; Environmental hazards; Palm oil fuel Ash (POFA); Supplementary cementitious materials

REFERENCES

1. C. Meyer
   The greening of the concrete industry
   Cement Concr. Compos., 31 (2009), pp. 601-605

2. P. Monteiro
   Concrete: Microstructure, Properties, and Materials
   McGraw-Hill Publishing (2006)

3. V. Malhotra
   Role of supplementary cementing materials in reducing greenhouse gas emissions
   Infrastructure Regeneration and Rehabilitation Improving the Quality of Life through Better Construction: a Vision for the Next Millennium (Sheffield, 28 June-2 July 1999) (1999), pp. 27-42

4. S.-B. Park, M. Tia
   An experimental study on the water-purification properties of porous concrete
   Cement Concr. Res., 34 (2004), pp. 177-184

5. N.M. Altwair, M.M. Johari, S.S. Hashim
   Flexural performance of green engineered cementitious composites containing high volume of palm oil fuel ash
   Construct. Build. Mater., 37 (2012), pp. 518-525