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WATER ABSORPTION AND ACID RESISTANCE OF OIL PALM SHELL LIGHTWEIGHT AGGREGATE CONCRETE CONTAINING FLY ASH AS PARTIAL CEMENT REPLACEMENT

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Penggunaan agregat secara besar-besaran dalam industri konkrit menyebabkan pengurangan sumber alam seperti batu kelikir dan granit. Lebihan simen dalam industri pembinaan menyebabkan banyak masalah alam sekitar. Bagi meringankan kesan terhadap alam sekitar, kajian semakin tertumpu kepada penggunaan bahan dan proses berasaskan tumbuhan alternatif seperti cengkerang kelapa sawit (OPS) dan abu terbang (FA) sebagai pengganti simen separa. Kajian ini dijalankan untuk menentukan ketahanan konkrit kelapa sawit dari segi keliangan, penyerapan air dan rintangan asid dalam konkrit yang mengandungi abu terbang. Semua spesimen disediakan dan tertakluk kepada pengawetan sehingga 60 hari. Keadaan pengawetan yang digunakan adalah pengawetan udara. Keputusan menunjukkan bahawa konkrit dengan FA mempunyai kekuatan mampatan yang lebih rendah. Keliangan dan penyerapan air meningkat apabila kandungan FA digunakan bertambah. Konkrit yang mengandungi jumlah FA yang lebih besar menunjukkan lebih banyak kehilangan jisim dan kemerosotan kekuatan selepas direndam dalam larutan asid sulfurik. Secara keseluruhannya, ketahanan OPS konkrit berkurang apabila jumlah FA yang lebih besar digunakan.

ABSTRACT

The massive use of aggregates in concrete industry leads to depletion of natural stone such as gravel and granite. The overuse of cement in construction industry causes many environmental problems. In light of environmental impact, the discussion has increasingly focused on using alternative plant-based material and processes such as oil palm shell (OPS) and fly ash (FA) as partial cement replacement. This research is conducted to determine the durability of oil palm shell concrete in terms of porosity, water absorption and acid resistance in concrete containing fly ash. All the specimens were prepared and subjected to curing until 60 days. The condition of curing employed is air curing. The results demonstrate that the concrete with FA have lower compressive strength. The porosity and water absorption of concrete increase when content of FA used is increased. Concrete containing larger amount of FA exhibit higher mass loss and strength deterioration after immersed in sulphuric acid solution. Conclusively, the durability of OPS concrete reduces as larger amount of FA is used.

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LIST OF SYMBOLS

%	Percentage
Kg	Kilograms
Kg/m^3	Kilograms per metre cubes
m	Metre
m^3	Metre cubes
mm	Millimetre
MPa	Mega Pascal
w/c	Water content

LIST OF ABBREVIATIONS

Al_2O_3	Aluminium
ASTM	American Society for Testing and Materials
BS	British Standard
BS EN	British Standard European Norm
CaO	Calcium
CI	Chloride
CO_2	Carbon dioxide
C-S-H gel	Calcium Silicate Hydrate gel
FA	Fly Ash
Fe_2O_3	Iron
K_2O	Potassium
LWAC	Lightweight Aggregate Concrete
MgO	Magnesium
Mil ha	Million hectares
MOE	Modulus of Elasticity
N	Nitrogen
Na_2O	Sodium
OPC	Ordinary Portland Cement
OPS	Oil Palm Shell
S	Sulphur
SiO_2	Silica
SO_2	Sulphur dioxide

CHAPTER 1

INTRODUCTION

1.1 Introduction

Basically, concrete is one of the most essential materials used in the construction industry. Ever since the ancient day, concrete has been widely used in construction in many numbers of structures. The continuing advancements and research of concrete have resulted in the development of several kinds of concrete. Each of the concrete has its own properties fulfilling the industries requirement. Lightweight aggregates concrete (LWAC) is one of the concretes that currently has a higher demand in the construction industry. Concrete with a density range between 1600 kg/m^3 until 2000 kg/m^3 is classify as lightweight aggregate concrete (LWAC) (Newman et al. 2003). Lightweight aggregates concrete (LWAC) can reduce the weight of the structure. It allows the reduction size of the load bearing elements such as columns and foundations. Therefore, the demand of lightweight aggregates concrete has been growing for the past few years.

In Malaysia, oil palm shell (OPS) is an agricultural solid waste of lightweight aggregates to produce lightweight aggregates concrete that has been known for the past twenty years (Payam Shafigh et al. 2013). Oil palm shell (OPS) consists of small particles comes in different shapes and sizes that can be used as aggregate in concrete. The use of oil palm shell as an aggregate in concrete will produce lightweight aggregates concrete (LWAC). Fly ash (FA) is one of the pozzolanic material. It is a product of burning crushed coal in an electric generating station. Precisely, it is an unburned excess that comes from the burning zone in the boiler. Fly ash usually benefits on the strength and durability of concrete at later ages (Xu & Shi, 2018). Many studies have been conducted in the replacement level of fly ash in concrete that varies from 15% to 30%. Fly ash (FA) will be used as partial cement replacement in this research to gain a better reaction in the cementitious paste.

1.2 Problem Statement

The massive use of aggregates in the concrete industry leads to huge depletion of natural stone such as gravel and granite. The aggressive consumption will reduce the non-renewable aggregate resources if there are no control measures to be implemented (Ismail et al. 2013). In the meantime, Malaysia is one of the major producers and exporter countries of palm oil and palm oil products. For about 80 million tonnes of solid biomass waste were yielded in 2010 by the oil palm industry in Malaysia and is expected to increase to 85-110 million tonnes by 2020 (National Biomass Strategy 2020, 2015). These wastes are being dumped near the palm oil mill thus resulting in environmental pollution issues (Arunima & Sreelekshmi, 2016). At the same time, disposal of fly ash by coal power plant causes pollutions such as air pollution, water pollution, noise pollution and land degradation (Nawaz, 2013).

1.3 Objective of the Study

There are three objectives of this research. The objectives are as follows;

a) To determine the compressive strength of OPS LWAC containing fly ash as partial cement replacement.
b) To determine the acid resistance of OPS LWAC containing fly ash as partial cement replacement.
c) To determine the water absorption and porosity of OPS LWAC containing fly ash as partial cement replacement

1.4 Scope of the Study

This study is to determine the durability properties of oil palm shell lightweight aggregates (LWAC) concrete containing fly ash (FA) as partial cement replacement. The coarse aggregates inside the concrete are replaced with OPS. The OPS in this study are obtained from Kilang Sawit Panching, Pahang. 0,10,20,30 and 40 % of fly ash added in the concrete as partial cement replacement. The sample size of the concrete used in this study is 100 x 100 x 100mm cube. The hardened concretes were cured by air curing up to 60 days. There are four tests that conducted in this study; compressive strength, water absorption, acid resistance and porosity in concrete.

1.5 Significance of Research

The efficient used in this waste materials can prevent or helps in depletion of natural aggregates such as gravel and granite. Other than that, the usage of oil palm shell in the concrete can reduce the amount of abundant waste material and contribute toward a greener environment. Use of fly ash can reduce the use of landfill for dumping and creates a cleaner environment.

1.6 Layout of the Thesis

In this thesis, chapter one describes the introduction part that consists of the problem statement, the objective of the study, the scope of research and layout of the thesis. Summary of literature review of oil palm shell (OPS) lightweight aggregates concrete (LWAC) and fly ash (FA) is discussed in chapter two of the thesis. In the literature review, the utilization of oil palm shell is elaborate further in terms of the method to treat the oil palm shell based on the previous study. It also includes the description on each of the material used in the concrete such as fly ash, cement, sand, and superplasticizer.

Chapter three basically describe the methodology part of the research that consists of apparatus used, preparation of material and sample, the method used and laboratory test of a sample. Chapter four presents result and data on the durability properties of the oil palm shell (OPS) lightweight aggregates concrete (LWAC). Finally, chapter five concludes the whole research based on the objects that has been listed. Several recommendations are included for future research.

REFERENCES

Agensi Inovasi Malaysia. (2015). National Biomass Strategy 2020 for Malaysia v2.0, (September), 47.

Arunima, V. R., & Sreelekshmi, S. (2016). Study on Fresh Concrete Properties Using Palm Oil Clinker as Fine Aggregate Replacement Material, *7*(6), 315–319. https://doi.org/10.1021/JF070893F

ASTM C-267, American Society for Testing Materials, Volume 04.05, 1997.

British Standard 1881: Part 122 (2011). Method for determination of Water Absorption. London, British Standard Institution

British Standard. (2009). 12390-3: 2009. Testing hardened concrete. Compressive strength of test specimens, 12390-5

Coal-Fired Power Plants in Malaysia. (2010). *Gallery*. Retrieved from http://www.industcards.com/st-coal-malaysia.htm

Curiosity Zone. (2016). Experiment with Pumice – Experiment Exchange. Retrieved April 5, 2019, from http://experimentexchange.com/earth-space/experiment-with-pumice/

Ehsan, T., Bank, R. H. B., Zhang, Y. R., Liu, M. H., Xie, H. B., Wang, Y. F., … Meyer, C. (2009). The greening of the concrete industry. *Cement and Concrete Composites*, *31*(8), 601–605. https://doi.org/10.1016/j.cemconcomp.2008.12.010

Hamad Mohammed, J., & Hamad, A. J. (2014). Materials, properties and application review of lightweight concrete. *Revista Tecnica de La Facultad de Ingenieria Universidad Del Zulia*, *37*(2), 10–15. https://doi.org/10.12720/ijmse.2.2.152-157

Hamada, H. M., Jokhio, G. A., Yahaya, F. M., Humada, A. M., & Gul, Y. (2018). The present state of the use of palm oil fuel ash (POFA) in concrete. *Construction and Building Materials*, *175*, 26–40. https://doi.org/10.1016/j.conbuildmat.2018.03.227

Hemalatha, T., & Ramaswamy, A. (2017). A review on fly ash characteristics – Towards promoting high volume utilization in developing sustainable concrete. *Journal of Cleaner Production*, *147*, 546–559. https://doi.org/10.1016/j.jclepro.2017.01.114

Holm, T. A., & Ries, J. P. (2007). Physical Properties of Structural Lightweight Concrete. *Reference Manual for the Properties and Applications of Expanded Shale, Clay and Slate Lighweight Aggregate*, *84117*(April), 6–3 to 6–36.

Huda, M. N., Jumat, M. Z. Bin, & Islam, A. B. M. S. (2016). Flexural performance of reinforced oil palm shell & palm oil clinker concrete (PSCC) beam. *Construction and Building Materials*, *127*, 18–25. https://doi.org/10.1016/j.conbuildmat.2016.09.106

International Energy Agency, & IEA. (2014). Cement Technology Roadmap 2009: Carbon emissions reductions up to 2050. *Cement Sustainability Initiative, World Business Council for Sustainable Development (WBCSD)*, 36. https://doi.org/978-3-940388-47-6

Ismail, S., Hoe, K. W., & Ramli, M. (2013). Sustainable Aggregates: The Potential and Challenge for Natural Resources Conservation. *Procedia - Social and Behavioral Sciences*, *101*, 100–109. https://doi.org/10.1016/j.sbspro.2013.07.183

J. Marchand, Ivan Odler, J. P. S. (2003). *Sulfate Attack on Concrete - J. Marchand, Ivan Odler, Jan P. Skalny - Google Books*. New York: Spon Press. Retrieved from https://books.google.com.my/books?id=0ZN-z35qV1sC&pg=PA6&source=gbs_selected_pages&cad=2#v=onepage&q&f=false

Mahlia, T. M. I., Abdulmuin, M. Z., Alamsyah, T. M. I., & Mukhlishien, D. (2001). An alternative energy source from palm wastes industry for Malaysia and Indonesia. *Energy Conversion and Management*, *42*(18), 2109–2118. https://doi.org/10.1016/S0196-8904(00)00166-7

Malhotra, V. M. (1990). Durability of concrete incorporating high-volume of low-calcium (ASTM Class F) fly ash. *Cement and Concrete Composites*, *12*(4), 271–277. https://doi.org/10.1016/0958-9465(90)90006-J

Mannan, M. A., & Ganapathy, C. (2004). Concrete from an agricultural waste-oil palm shell (OPS). *Building and Environment*, *39*(4), 441–448. https://doi.org/10.1016/j.buildenv.2003.10.007

Medhat. (2000). The effect of fly ash composition on the expansion of concrete due to alkali silica reaction. *Cem. Conr*, 30.

Mishra, S., & Siddiqui, N. (2014). A Review On Environmental and Health Impacts Of Cement Manufacturing Emissions. *International Journal of Geology, Agriculture and Environmental Sciences*, *2*(6), 26–31.

Mo, K. H., Alengaram, U. J., & Jumaat, M. Z. (2016). Bond properties of lightweight concrete - A review. *Construction and Building Materials*, *112*, 478–496. https://doi.org/10.1016/j.conbuildmat.2016.02.125

Mo, K. H., Johnson Alengaram, U., Jumaat, M. Z., & Yap, S. P. (2015). Feasibility study of high volume slag as cement replacement for sustainable structural lightweight oil palm shell concrete. *Journal of Cleaner Production*, *91*, 297–304. https://doi.org/10.1016/j.jclepro.2014.12.021

Mousa, A., Mahgoub, M., & Hussein, M. (2018). Lightweight concrete in America: presence and challenges. *Sustainable Production and Consumption*, *15*, 131–144. https://doi.org/10.1016/j.spc.2018.06.007

MPOB (Malaysian Palm Oil Board). (2007). Malaysian Palm Oil Statistics. Retrieved from http://econ.mpob.gov.my/economy/overview07.htm

Nawaz, I. (2013). Disposal and Utilization of Fly Ash to Protect the Environment. *International Journal of Innovative Research in Science, Engineering and Technology*, *2*(10), 5259–5266.

Newman, J. (John B., & Choo, B. S. (2003). *Advanced concrete technology : constituent materials*. Butterworth-Heinemann.

Nordin, N., Abdullah, M. M. A. B., Tahir, M. F. M., Sandu, A. V., & Hussin, K. (2016). Utilization of Fly Ash Waste As Construction Material. *International Journal of Conservation Science*, *7*(1), 161–166. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=vth&AN=113480308&lang=es&site=ehost-live

Okafor, F. O. (1988). Palm kernel shell as a lightweight aggregate for concrete. *Cement and Concrete Research*, *18*(6), 901–910. https://doi.org/10.1016/0008-8846(88)90026-9

Ole, H. (1996). Disposal strategies for municipal solid waste incineration residues. *Journal of Hazardous Materials*, *47*(1–3), 345–368. https://doi.org/10.1016/0304-3894(95)00111-5

Potgieter, J. H. (2012). An Overview of Cement production: How "green" and sustainable is the industry? *Environmental Management and Sustainable Development*, *1*(2), 14–37. https://doi.org/10.5296/emsd.v1i2.1872

Şahmaran, M., & Li, V. C. (2009). Durability properties of micro-cracked ECC containing high volumes fly ash. *Cement and Concrete Research*, *39*(11), 1033–1043. https://doi.org/10.1016/j.cemconres.2009.07.009

Sayer, J., Ghazoul, J., Nelson, P., & Klintuni Boedhihartono, A. (2012). Oil palm expansion transforms tropical landscapes and livelihoods. *Global Food Security*, *1*(2), 114–119. https://doi.org/10.1016/j.gfs.2012.10.003

Scoria - Igneous Rocks. (n.d.). Retrieved May 22, 2019, from https://www.sandatlas.org/scoria/

Shafie, S. M., Mahlia, T. M. I., Masjuki, H. H., & Ahmad-Yazid, A. (2012). A review on electricity generation based on biomass residue in Malaysia. *Renewable and Sustainable Energy Reviews*, *16*(8), 5879–5889. https://doi.org/10.1016/j.rser.2012.06.031

Shafigh, P, Jumaat, M. Z., & Mahmud, H. (2010). Mix design and mechanical properties of oil

palm shell lightweight aggregate concrete: A review. *International Journal of the Physical Sciences*, *5*(14), 2127–2134. Retrieved from http://www.scopus.com/inward/record.url?eid=2-s2.0-78650983523&partnerID=40&md5=0a17068230083cc72bc2ce76fba8228c%5Cnwww.academicjournals.org/ijps/pdf/pdf2010/4 Nov/Shafigh et al.pdf

Shafigh, Payam, Johnson Alengaram, U., Mahmud, H. Bin, & Jumaat, M. Z. (2013). Engineering properties of oil palm shell lightweight concrete containing fly ash. *Materials and Design*, *49*, 613–621. https://doi.org/10.1016/j.matdes.2013.02.004

Shafigh, Payam, Jumaat, M. Z., & Mahmud, H. (2011). Oil palm shell as a lightweight aggregate for production high strength lightweight concrete. *Construction and Building Materials*, *25*(4), 1848–1853. https://doi.org/10.1016/j.conbuildmat.2010.11.075

Shen, J., & Xu, Q. (2019). Effect of moisture content and porosity on compressive strength of concrete during drying at 105 °C. *Construction and Building Materials*. https://doi.org/10.1016/j.conbuildmat.2018.11.046

Simeh, A., & Tengku Ahmad, T. M. A. (2001). The Case Study on the Malaysian Palm Oil. *Regional Workshop on Commodity Export Diversification and Poverty REduction in South and South-East Asia*, 1–15.

Teo, D. C.L., Mannan, M. A., Kurian, V. J., & Ganapathy, C. (2007). Lightweight concrete made from oil palm shell (OPS): Structural bond and durability properties. *Building and Environment*, *42*(7), 2614–2621. https://doi.org/10.1016/j.buildenv.2006.06.013

Teo, D C L, Mannan, M. A., Kurian, V. J., & Program, C. E. (2006). Structural Concrete Using Oil Palm Shell (OPS) as Lightweight, *30*, 251–257.

Teo, Delsye C. L., Mannan, M. A., & Kurian, J. V. (2006). Flexural Behaviour of Reinforced Lightweight Concrete Beams Made with Oil Palm Shell (OPS). *Journal of Advanced Concrete Technology*, *4*(3), 459–468. https://doi.org/10.3151/jact.4.459

Traore, Y. B., Messan, A., Hannawi, K., Gerard, J., Prince, W., & Tsobnang, F. (2018). Effect of oil palm shell treatment on the physical and mechanical properties of lightweight concrete. *Construction and Building Materials*, *161*, 452–460. https://doi.org/10.1016/j.conbuildmat.2017.11.155

Tuff - Igneous Rocks. (n.d.). Retrieved May 22, 2019, from https://www.sandatlas.org/tuff/

US Environmental Protection Agency EPA (2017). (n.d.). Overview of Greenhouse Gases. Retrieved from https://www.epa.gov/ghgemissions/overview-greenhouse-gases

Valley, B. (1999). Introduction, 552–557.

Wilson, H. S., & Malhotra, V. M. (1988). Development of high strength lightweight concrete for structural applications. *International Journal of Cement Composites and Lightweight Concrete*, *10*(2), 79–90. https://doi.org/10.1016/0262-5075(88)90034-6

Xu, G., & Shi, X. (2018). Characteristics and applications of fly ash as a sustainable construction material: A state-of-the-art review. *Resources, Conservation and Recycling*, *136*(August 2017), 95–109. https://doi.org/10.1016/j.resconrec.2018.04.010