MECHANICAL PROPERTIES OF NORMAL STRENGTH CONCRETE CONTAINING OIL PALM SHELL AS PARTIAL AGGREGATE REPLACEMENT

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor Degree of Civil Engineering

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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

Tempurung kelapa sawit (TKS) merupakan salah satu daripada sisa besar yang terhasil daripada proses pengekstrakkan kelapa sawit. Tempurung kelapa sawit yang bersaiz semulajadi didapati sesuai untuk menggantikan batu dalam pembinaan konkrit memandangkan terdapat kajian terdahulu yang mendapati bahawa tempurung kelapa sawit adalah agregat organik yang mempunyai rintangan kesan yang lebih baik berbanding dengan agregat biasa. Tujuan penyelidikan ini dijalankan adalah untuk mengkaji peratusan optimum tempurung kelapa sawit sebagai pengganti agregat kasar dan untuk menentukan sifat mekanik konkrit tempurung kelapa sawit (TKS) dari segi kekuatan mampatan, pemisahan tegangan, lenturan dan modulus keanjalan. Satu set ujian makmal dilakukan pada konkrit biasa yang dibuat oleh agregat kasar sebagai sampel kawalan dan konkrit TKS dengan 50% dan 100% peratusan tempurung kelapa sawit sebagai pengganti agregat kasar separa. Keputusan ujian menunjukkan bahawa konkrit TKS dengan kekuatan mampatan dalam julat 16.56 - 60.1 MPa mempunyai julat kekuatan tegangan sebanyak 1.05 - 3.31 MPa, julat kekuatan lenturan 3.61 - 8.95 MPa dan julat keanjalan modulus 5.32 - 39.35 GPa. Kesemua kekuatan mampatan, kekuatan lenturan, kekuatan tegangan dan modulus keanjalan, menunjukkan trend menurun secara dramatik apabila pengganti TKS meningkat. Ini menunjukkan bahawa apabila TKS berkuantiti tinggi digunakan dalam reka bentuk campuran konkrit, ia mempunyai kesan ke atas sifat basah iaitu kebolehkerjaan dan ia berpotensi dapat mengurangkan semua sifat kekuatan konkrit. Walauabagaimanpun, konkrit TKS berkekuatan normal G30 boleh dihasilkan sekiranya 50% daripada kuantiti aggregate kasar digantikan dengan TKS.

ABSTRACT

Palm oil shell is a one of the huge waste producing from oil palm extraction process. The oil palm shell (OPS) which have natural sized seems to be ideal for substituting aggregates in concrete construction because previous study found that oil palm shells was the organic aggregate which is better impact resistance compared to normal weight aggregate. The purpose of this research is to investigate the optimum percentage of oil palm shell as a partially coarse aggregate replacement and to determine the mechanical properties of oil palm shell concrete such as compressive strength, splitting tensile, flexural and modulus of elasticity. A set of laboratory tests were conducted on normal weight concrete made by coarse aggregate as control sample and OPS concrete with 50% and 100% percentage of OPS as a partial coarse aggregate replacement. The test results showed that OPS concrete with a compressive strength in the range of 16.56 - 60.1 MPa has a splitting tensile strength range of 1.05 – 3.31 MPa, flexural strength range of 3.61 – 8.95 MPa and modulus of elasticity range of 5.32 – 39.35 GPa. Similarly, for compressive strength, flexural strength, splitting tensile strength and modulus of elasticity, the trends of those tests decreases dramatically as the OPS replacement were increased. This indicated that when the high quantity of OPS is used in concrete mix design, it has an impact on wet properties which is workability and it can potentially reduce all the strength properties of concrete. However, the normal strength G30 OPS concrete can be produced with the 50% of partially coarse aggregate replacement in concrete.

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W_{below}	The total mass of the aggregate within the sieves below the current sieve, not including the current Sieve's aggregate
Wt_{otal}	The total mass of all of the aggregate in the sample
P	Ultimate load
A	Surface area of a cube
fcf	Flexural strength
F	Maximum load
L	Distance between supporting rollers
$d_1 \, x \, d_2$	The lateral dimensions of the specimens
λ	Stress/strain

LIST OF ABBREVIATIONS

OPS	Oil palm shell
GGBFS	Granulated blast furnace slag
OPSC	Oil palm shell concrete
OPS LWAC	Oil palm shell lightweight aggregate concrete
OPKS	Oil palm kernel shell
CS	Cockleshell
LWAC	Lightweight aggregate concrete
OPSLWC	Oil palm shell lightweight concrete
POFA	Palm oil fuel ash
HPOCP	High strength palm oil clinker powder
HPOC	High strength palm oil cylinder
POCP	Palm oil clinker powder
MOE	Modulus of elasticity
PKSC	Palm kernel shell concrete
LWA	Lightweight aggregate
OPC	Ordinary Portland cement
SSD	Surface dry condition

CHAPTER 1

INTRODUCTION

1.1 Background

The utilization of industrial and agricultural waste materials can be a breakthrough to make the industry more environmentally-friendly and sustainable. It has led to green and sustainable construction to improve the environmental friendliness of concrete by reducing the cost of construction materials and waste management. The utilization of waste materials, such as natural pumice, vermiculite, shale, slate, oil palm shell (OPS), fly ash, ground granulated blast furnace slag (GGBFS), silica fume, recycled concrete, recycled tyres, and recycled plastics, have been successfully used in concrete (Yew et al., 2015).

Khankhaje et al. (2017) stated that the effective management of by-product waste materials plays an important role in increasing environmental sustainability. One of the strategies in waste management is the utilisation of byproduct waste materials in the construction industry to reduce the landfill of waste materials. Moreover, with the application of waste materials, more sustainable, clean and green construction could be achieved due to the decrease of cost.

In a past studies, the enhancement of mechanical properties of OPSC is dependent on the density, aggregate content, crushed or uncrushed particle size of OPS and heat treatment on OPS aggregate. Other factors include water-cement ratio and incorporation of cementitious materials (silica fume, fly ash and ground granulated blast furnace slag). The influence of density on the compressive strength of OPSC can be observed from previous studies (Yew et al., 2015).

1.2 Problem Statement

Palm oil industry is recognized as one of the major agriculture contributions to the abundant production of oil palm solid wastes. These include empty fruit bunches, palm kernel shell, mesocarp fiber, oil palm frond, and oil palm trunk, which were obtained from plantation and milling activities. In terms of increasing the economic value and solving environmental problems, the use of these wastes as an alternative fuel is very important.

Waste materials are a major environmental problem, which is a threat to the environment. It is important to reuse these materials and dispose of them. Waste can be used in the construction industry in two ways: by reusing (reuse components) and recycling (processing waste into raw materials used in the production of building materials).

Waste materials are usually discarded on-site after the palm oil extraction process and this resulted in unnecessary piling of wastes in the vicinity of factories and posed serious land pollution. As such, there is a great prospect to utilize waste materials from the palm oil industry such as oil palm shell (OPS) as replacement for conventional materials in the production of concrete.

So, the innovative use of OPS in concrete could improve the sustainability of the environment since it reduces the dependency of non-renewable gravel and at the same time encourages the re- use of waste OPS. This is motivated not only by the environmental protection, but also by the conservation of natural aggregate resources, the shortage of waste disposal land, and the increasing cost of waste treatment prior to disposal.

The outcome of this research is to achieve the most optimum performance in terms of the sustainability of the oil palm shell concrete and improve the compressive strength of oil palm shell concrete.

1.3 Objectives of the Study

The most important properties that need to be considered when designing a concrete structure are the strength of the concrete. The objectives of this project are as below;

i) To investigate the optimum percentage of oil palm shell as a partially coarse aggregate replacement.

ii) To investigate the fresh and harden mechanical properties of oil palm shell concrete such as compressive strength, splitting tensile, flexural and shrinkage tests.

1.4 Scope of Study

The experimental work includes the common preferred test for concrete and few other tests will be conducted in conjunction with the original aim of the study.

To test the material of the oil palm shell, fine aggregate and coarse aggregate, the sieve analysis test must be conducted. Also, slump test is important to get the workability of a fresh concrete.

For mechanical properties, the tests that need to be conducted are compressive strength test, splitting tensile test, flexural test and modulus of elasticity test as accordance to BS 1881: part 116: 1983, ASTM Designation C490, ASTM C78 and ASTM C469 respectively. The targeted for compressive strength is 30 N/mm^2.

The percentage of course aggregate replacement to be used for normal strength concrete in this project are 0%, 50% and 100% of oil palm shell.

Water curing process will be done for a duration of 7 and 28 days.

REFERENCES

Abutaha, F., Abdul Razak, H., Ibrahim, H.A. & Hamad Ghayeb, H. (2018). Adopting particle-packing method to develop high strength palm oil clinker concrete. *Resources, Conservation & Recycling*, 247-258.

Ahmmad, R. Jumaat, M.Z., Alengaram, U.J., Bahri, S., Muhamad Abdur Rahman & Hashim, H. (2016). Performance evaluation of palm oil clinker as coarse aggregate in high strength lightweight concrete. *Journal of Cleaner Production*, 566-574.

Alengaram, U.J., Mahmud, H. & Jumaat, M.Z. (2011). Enhancement and prediction of modulus of elasticity of palm kernel shell concrete. *Materials and Design*, 2143–2148.

Alsaman, A., Dang, C.N., Prinz, G.S. & Hale, W.M. (2017). Evaluation of modulus of elasticity of ultra-high performance concrete. Construction and Bulding Materials, 918–928.

Aydin, H., Gravina, R.J. & Visintin, P. (2018). A partial-interaction approach for extracting FRP-to-concrete bond characteristics from environmentally loaded flexural test. *Composites Part B*, 214-228.

Bilir, T. (2016). Investigation of performances of some empirical and composite models for predicting the modulus of elasticity of high strength concretes incorporating ground pumice and silica fume. *Construction and Building Materials*, 850–860.

Gerges, N.N., Issa, C.A. & Fawaz, S. (2015). Effect of construction joints on the splitting tensile strength of concrete. *Case Studies in Construction Materials*, 84-91.

Hama, S.M. (2017). Improving mechanical properties of lightweight Porcelanite aggregate concrete using different waste material. *International Journal of Sustainable Built Environment*, 82-90.

Hefni, Y., Abd El Zaher, Y. &Abdel Wahab, M. (2018). Influence of activation of fly ash on the mechanical properties of concrete. *Construction and Building Materials*, 728-734.

Islam, M.M.U., Mo, K.H., Alengaram, U.J. & Jumaat, M.Z. (2015). Mechanical and fresh properties of sustainable oil palm shell. *Journal of Cleaner Production*, 308-314.

Khankhaje, E., Rafieizonooz, M., Salim, M.R., Mirza, J. & Salmiati, Hussin, M.W. (2017). Comparing the effects of oil palm kernel shell and cockle shell on properties of pervious concrete pavement. *International Journal of Pavement Research and Technology*, 383-392.

Khankhaje, E., Salim, M.R., Mirza, J., Salmiati, Hussin, M.W., Khan, R. & Rafieizonooz, M. (2017). Properties of quiet pervious concrete containing oil palm kernel shell and cockleshell. *Applied Acoustics*, 113-120.

Mannan, M.A, Alexander, J., Ganapathy, C. & Teo, D.C.L. (2006). Quality improvement of oil palm shell (OPS) as coarse aggregate in lightweight concrete. *Building and Environment*, 1239-1242.

Mo, K.H. & Alengaram, U.J. (2015). Compressive behaviour of lightweight oil palm shell concrete incorporating slag. *Construction and Building Materials*, 263-269.

Mo, K.H., Yeoh, K.H., Ibnul Bashar, I., Alengaram, U.J. & Jumaat, M.Z. (2017). Shear behaviour and mechanical properties of steel fibre-reinforced cement-based and geopolymer oil palm shell lightweight aggregate concrete. *Construction and Building Materials*, 370-375.

Muthusamy, K., Zamri, N., Zubir, M.A, Kusbiantoro, A. & Wan Ahmad, S. (2015). Effect of mixing ingredient on compressive strength of oil palm shell lightweight aggregate concrete containing palm oil fuel ash. *Procedia Engineering*, 805-810.

Ni, P., Mangalathu, S., Mei, G. & Zhao, Y. (2017). Compressive and flexural behaviour of reinforced concrete permeable. *Engineering Structures*, 317-327.

Rashid, K., Razzaq, A., Ahmad, M., Rashid, T. & Tariq, S. (2017). Experimental and analytical selection of sustainable recycled concrete with ceramic waste aggregate. *Construction and Building Materials*, 830-840.

Raut, A.N. & Gomez, C.P. (2016). Thermal and mechanical performance of oil palm fibre reinforced mortar utilizing palm oil fly ash as a complementary binder. *Construction and Building Materials*, 476-483.

Sata, V., Jaturapitakkul, C., Kiattikomol, K. (2007). Influence of pozzolan from various by-product materials on mechanical properties of high-strength concrete. *Construction and Building Materials*, 1589-1598.

Shafigh, P. & Alengaram, U.J. (2013). Engineering properties of oil palm shell lightweight concrete containing fly ash. *Materials and Design*, 613-621.

Shafigh, P., Jumaat, M.Z., Mahmud, H. & Anjang Abd Hamid, N. (2012). Lightweight concrete made from crushed oil palm shell: Tensile strength and effect of initial curing on compressive strength. *Construction and Building Materials*, 252-258.

Silva, R.V., Brito, J.d. & Dhir, R.K. (2016). Establishing a relationship between modulus of elasticity and compressive strength of recycled aggregate concrete. *Journal of Cleaner Production*, 2171-2186.

Traore, Y.B., Messan, A., Hannawi, K., Gerard, J., Prince & W. Tsobnang, F. (2017). Effect of oil palm shell treatment on the physical and mechanical properties of lightweight concrete. *Construction and Building Materials,* 453-460.

Yew, M.K., Mahmud, H., Ang, B.C & Yew, M.C. (2015). Influence of different types of polypropylene fibre on the mechanical. *Construction and Building Materials*, 37-43.

Ziatol Ihazair, M.A.K. & Yahya, K. (2016). The Effect of Concrete with Replacement of Oil Palm Shell as Course. 122-135.