DEVELOPMENT OF SYNTHETIC-OIL PALM HYBRID FIBER REINFORCED MORTAR

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DEVELOPMENT OF SYNTHETIC-OIL PALM HYBRID FIBER REINFORCED MORTAR

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ABSTRACT

This research use oil palm fibre (OPF) as a natural fiber, crumb rubber aggregate, superplasticizer, and synthetic fiber to study the physical and mechanical strength reinforced mortar. The mechanical properties of mortar were identified with addition 0.6% cement by weight for oil palm fiber and synthetic fiber, 5%, 10% and 15% fine aggregate partial replacement by weight for rubber crumb, and 0.4%, 0.6% and 0.8% of superplasticizer. The composite mixtures were subjected to the compression strength test, split tensile strength test and flexural strength tests. A total of 13 mix proposition has been done for this research. There were 117 sample for compression strength, 117 sample for split tensile test and 117 sample for flexural strength has been done in this research with the total of 351 sample. The result was then analysed to identify the effect of crumb rubber, oil-palm fiber and synthetic fiber to the mortar matrix. Addition of fiber and crumb rubber in the mortar matrix significantly decrease the workability of the mix. The strength of the mortar also shown to be directly proportional to the crumb rubber and fiber content. The addition of 0.6% synthetic fiber to the composite was found to improve the split tensile strength of the mortar composites.

ABSTRAK

PEMBANGUNAN MORTAR BERTETULANG MENGGUNAKAN GENTIAN HIBRID ANTARA GENTIAN SINTETIK DAN GENTIAN KELAPA SAWIT

Penyelidikan ini menggunakan gentian kelapa sawit (OPF) sebagai gentian asli, agregat getah serbuk, superplasticizer dan gentian sintetik untuk mengkaji mortar bertetulang kekuatan fizikal dan mekanikal. Sifat mekanikal mortar dikenal pasti dengan penambahan 0.6% simen mengikut berat untuk gentian kelapa sawit dan gentian sintetik, 5%, 10% dan 15% penggantian separa agregat halus mengikut berat untuk serbuk getah, dan 0.4%, 0.6% dan 0.8% daripada superplasticizer. Campuran komposit telah tertakluk kepada ujian kekuatan mampatan, ujian kekuatan tegangan pecahan dan ujian kekuatan lentur. Sebanyak 13 proposisi campuran telah dilakukan untuk penyelidikan ini. Terdapat 117 sampel untuk kekuatan mampatan, 117 sampel untuk ujian tegangan pecah dan 117 sampel untuk kekuatan lentur telah dilakukan dalam penyelidikan ini dengan jumlah sampel sebanyak 351. Hasilnya kemudian dianalisis untuk mengenal pasti kesan getah serbuk, gentian kelapa sawit dan gentian sintetik terhadap matriks mortar. Penambahan gentian dan getah serbuk dalam matriks mortar dengan ketara mengurangkan kebolehkerjaan campuran. Kekuatan mortar juga ditunjukkan berkadar terus dengan getah serbuk dan kandungan gentian. Penambahan gentian sintetik 0.6% pada komposit didapati dapat meningkatkan kekuatan tegangan pecahan komposit mortar.

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LIST OF ABBREVIATION

ASTM - American Society of Testing and Material

CLC - Cellular Lightweight Concrete

CR - Crumb Rubber

EFB - Empty Fruit Bunch

EFBF - Empty Fruit Bunch Fibres

FRC - Fiber Reinforced Concrete

FRM - Fiber Reinforced Mortar

GF - Glass Fiber

GFRC - Glass Fibre Reinforced Concrete

GHG - Greenhouse Gas

HRWRA- High Range Water Reducing Admixture

LECA - Lightweight Expanded Clay Aggregate

NaCl - Sodim Chloride

NaOH - Soduim Hydroxide

NF - Natural Fiber

NFRC - Natural Fibre Reinforced Concrete

OPC - Ordinary Portland Cement

OPF - Oil Palm Fibres

OPFF - Oil Palm Frond Fibres

OPMF - Pressed Fruit (Or Mesocarp) Fibres

OPTF - Oil Palm Trunk Fibres

PE - polyethylene

PP - Polypropylene

PVA - polyvinyl alcohol

RC	-	Reinforced Concrete
SCC	-	Self-Consolidating Concrete
SFRC	-	Steel Fibre Reinforced Concrete
SNFRC	-	Synthetic Fibre Reinforced Concrete
ST	-	Steel
UMS	-	Universiti Malaysia Sabah

CHAPTER 1

INTRODUCTION

1.1 Research Background

One of the century's primary tasks is to accept a path of sustainable development that balances environmental, social, and economic concerns for current and future generations (Elkington, 1998). In this backdrop, the civil construction sector is at a crossroads in terms of meeting the triple bottom line sustainability standards (Ding, 2008; Myers, 2005). When it comes to the environment, the construction sector consumes half of all raw materials and industrial waste, 40% of world energy consumption (Marinkovi et al., 2017), and between 40% and 50% of greenhouse gas (GHG) emissions (Khasreen et al., 2009; Petek Gursel et al., 2014). Because conventional concrete is one of the most widely used building materials today, developing procedures that result in a less energy-intensive product will have a large worldwide effect. Additionally, the sector contributes to additional environmental consequences such as ecosystem deterioration, soil, water, and air pollution (Vieira et al., 2016).

Thus, underdeveloped nations have a technical difficulty in producing a durable and low-cost fibre reinforced mortar for building construction. Currently, steel, glass, synthetic, and natural fibres are utilised. Economic considerations have limited the commercial use of carbon fibres in cementitious composites due to their nonecofriendly properties. Natural fibres may be utilised as reinforcement to compensate for the inherent shortcomings of cementitious materials.

Natural fibres were often used in old mortars. Ancient Greece made extensive use of wood and straw fibres to promote volume stability (V. Pachta el.,2014). Jute and straw were also utilised to strengthen bonds and minimise fissures in Indo-Muslim building (P. Thiroumalini el., 2013). Typically, fibres are employed to reduce breaking caused by plastic and drying shrinkage, as well as to boost tensile strength, toughness, and durability. Their usefulness is determined by their geometry (length, diameter, and shape), concentration, interaction with the binder, and orientation and dispersion within the mixture (P.K. Mehta el.,2006). Natural fibres were gradually supplanted by contemporary materials such as polypropylene, steel, glass, and carbon fibres as technology progressed. Fiber Reinforced Concrete (FRC) is classified into four categories by the American Concrete Institute Committee 544 based on the fibre material used. These are SFRC for steel fibre reinforced concrete; GFRC for glass fibre reinforced concrete; SNFRC for synthetic fibre reinforced concrete, including carbon fibres; and NFRC for natural fibre reinforced concrete (R.F. Zollo,1997). Fibers added to a concrete mix increase the concrete's tensile strength while also providing post-crack strength by bridging and joining cracks. Because fibres act as a flow barrier in their natural condition, admixture should be added to optimise both fresh and mechanical properties.

The accumulation of waste rubber, particularly vehicle tyres, causes long-term environmental problems due to polymers' inability to degrade efficiently. Typically, when materials are disposed of in landfills or stacked, issues such as landfill instability and chemical leeching into groundwater develop. Tyres may collect water and create a breeding ground for insects such as mosquitos, posing a hazard of fire. Globally, this significant problem is being addressed, with the United States recycling 3.824 million tonnes of waste rubber in 2013. (Sienkiewicz et al., 2017). Over the past decade, research into the use of recycled crumb rubber (CR) aggregates as a substitute for conventional natural aggregates in concrete has increased in response to the rising demand to discover meaningful uses for rubber waste (Huang et al., 2013; Dong et al., 2013).

The production of Crumb Rubber (CR) is relatively inexpensive and provides material for a variety of applications, including athletic track surfaces. The incorporation of waste tires into concrete is a feasible alternative for waste tyre utilisation since it reduces the weight of the concrete, resulting in reduced dead loads and therefore less stress on a building's foundations, so enhancing the overall structural efficiency. Several efforts have been undertaken over the last two decades to integrate waste tire particles in the form of coarse, fine, and a mix of both in concretes and mortars, most recently as ash. The composite has shown increased efficiency in terms of density, thermal conductivity, electrical resistivity, and ductility, among other properties. The use of waste tire particles as a substitute for cement has shown significant promise in terms of toughness, ductility, and energy dissipation capability (Marques A el.,2013). Increased waste tire content might reduce the density of concrete to as little as 75% of its typical weight (Khatib and Bayomy,1999). However, past research has shown that the addition of rubber particles to concrete reduces compressive split tensile strength and flexural strength while increasing strain at failure.

1.2 Problem Statement

Malaysia's massive oil palm industry creates 4 million tonnes of waste oil palm each year. At the moment, our nation is having difficulty managing garbage created by oil palm planting and processing. The great majority of fibre is stored in open spaces, which may lead to contamination of the air, water, and land. Because no fiber-reinforced concrete has ideal mechanical qualities, Walton and Majumdar created hybridization by combining organic and inorganic fibres. Hybridization may be used depending on the fibre type. For instance, steel fibres are sometimes combined with synthetic fibres (Parkravn et al., 2017).

With the number of automobiles on the road rising year after year, tyres have become one of our country's greatest and most serious wastes. Without an economical disposal method, old tyres would be tossed haphazardly around, providing breeding grounds for mosquitoes and vermin. Recycled crumb rubber is made by crushing and shredding old tyres. There is no question that the growing stacks of tyres are a source of worry for the environment. The viability of efficiently employing recycled tyres in the concrete industry has been intensively researched during the last two decades. The objective has been to give an option for a significant amount of this waste material to be reused, so preventing the buildup of millions of scrap tyres and the related environmental concerns throughout the globe (J. Yadav and S. Tiwari, 2017).

Increased water content improves the workability of mortar but decreases its strength. As a result, superplasticizer is used to minimise the amount of water required while also improving the workability and strength of mortar. Other than that, adding crumb rubber and fiber into the mortar mix is known to reduce the workability. Thus, superplasticizer added to improve workability. Furthermore, natural fiber degrades in alkaline environment. Thus, synthetic fiber will be used to resist the alkaline environment.

Therefore, this experimental research will be done and carried out to monitor the effect of using rubber crumb aggregate, synthetic fibers, oil palm fiber and superplasticizer in the mortar mixes on the strength development of mortar in term of compressive, flexure and tensile strength properties of the hardened mortar.

1.3 Objective of Study

The main objective of this research study is to investigate the performance of synthetic-oil palm hybrid fiber reinforced mortar. To achieve the main objective, the research study has been divided into three specific objectives as follows:

a) To observe the effect in workability and mechanical properties of the hybrid fibers mortar when superplasticizer added in by 0.4%, 0.6% and 0.8%.
b) To observe the effects on mechanical properties of the mortar when sand in the hybrid fiber mortar was partially replaced with rubber crumbs aggregate by 5%, 10% and 15%.
c) To observe the strength development of mortar in term of compressive, tensile, and flexural strength at 3-, 7- and 28-days curing age when two different types of fiber which is synthetic fiber called as FORTA ferro fiber and natural oil palm fiber combined.

1.4 Significance of the Project

The Ninth Malaysian Plan (RMK-9) was announced in 2007, with one of its key goals being to strengthen the country's biotechnology sector. One of the key government agendas under this strategy is to produce massive volumes of agricultural goods to be sent internationally. The palm oil sector is one of the key commodities that have been listed. It is projected that the expansion of palm oil output would be substantial. As the production of palm oil increases, so will the by-products of this business, which are generally disposed of as garbage. Palm oil fibre is a byproduct of fibre and husk crushing.

The most beneficial potential for the use of industrial by-products is the environmental values, which can be achieved by using recycled materials as fibre reinforced materials. These efforts will not only benefit the government by reducing the amount of land available for disposal, but will also boost economic growth in various sectors, particularly the construction industry. By replacing certain amounts of OPC, we will significantly reduce our reliance on large amounts of it, and thus our emissions of CO2 or greenhouse gases will be reduced as well.

Fibre composites have been used in building and construction materials for many decades, with synthetic materials leading the way owing to their superior mechanical properties. Natural fibres (NFs) are increasingly being researched as a means of achieving sustainability. The effective incorporation of NFs into cement-based composites has the potential to minimise the production of other non-natural fibres.

Fibers improved mechanical characteristics, particularly fatigue and tensile stresses, as well as cracking, ductility, and impact resistance. The fibre strengthening mechanism includes stress transmission from the matrix to the fibre through interfacial shear or interlock between the fibre and the matrix. According to Singh, incorporating fibres into concrete enhances engineering features such as static flexural strength, impact strength, tensile strength, durability, and flexural toughness. Palm oil fibres will boost load capacity against flexural and tensile splitting stress; however, compressive strength may or may not improve. The toughness is the most distinct attribute. Toughness is defined as the area under the load-deflection curve. The fibre in the concrete matrix will prevent the fracture from dispersing continually.

Hybrid fibres have been shown to enhance the fresh and hardened characteristics of concrete. Although Self-Consolidating Concrete (SCC) integrating steel fibres has received a lot of attention, few studies have looked into the hybridization of synthetic fibres with varied diameters in SCC. The experimental data and created models provided in this study will aid in understanding the effects of fibre type, size, and volume fraction hybridization on concrete behaviour, providing insights into material design.