UNIVERSITI TEKNOLOGI MARA

DYNAMIC BEHAVIOUR OF FINE RECYCLED AGGREGATE MORTAR REINFORCED WITH HYBRID FIBRE

MOHAMMAD ASRI BIN ABD HAMID

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ABSTRACT

The recycling of concrete waste into recycled aggregate (RA) by crushing and reprocessing concrete lumps into small particles has recently become a viable solution to the shortage of natural aggregate sources in different parts of the world. However, the inferior qualities of RAs compared with those of natural aggregates have resulted in limited commercial use of RA concrete/mortar, especially for structural application. Aggregates play a vital role in impact-resistant concrete/mortar composite because they serve as barriers to crack propagation. The low-impact strength of RAs tends to weaken the concrete/mortar at this aggregate particle when subjected with high-impact loads. In addition to safety concerns, understanding the behaviour of concrete/mortar under impact loading is important because its behaviour differs from that under quasi-static loading. This study aims to enhance the understanding of the inclusion effect of hybrid fibre on fine RA mortar (FRAM) subjected with quasi-static and high strain-rate load. Quasi-static test was conducted using an axial torsion universal testing machine, and impact load tests was applied using a 12 mm-diameter Split Hopkinson Pressure Bar (SHPB). Scanning electron microscopy (SEM) was also conducted. Two types of microfibre, namely, polypropylene and nylon, were respectively added in single and hybrid form in FRAM production, in which the number of microfibres was maintained at a volumetric fraction of 0.6%. The effects of fibres on failure mode, strain–strain curve, compressive strength and dynamic increase factor (DIF) were analysed and discussed. Experimental results showed that the hybrid fibres reinforced with FRAM exhibited large quasi-static and dynamic compressive strengths compared with those of normal mortar. The hybridisation fibre at the volume fraction of 0.3% polypropylene + 0.3% nylon (H3) yielded the most promising effective result with the improved dynamic compressive strength of FRAM with resulted higher reading for stress-strain rate average of 40 MPa. By contrast, the effect of hybrid fibre-reinforced FRAM exhibited higher DIF values than those of the reference mortar, especially under high strain-rate loading. Meanwhile, SEM observations indicated that fibre reinforcement at the microscale prohibits the initiation and growth of cracks, thus improving the impact resistance of the mortar matrix.

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CHAPTER ONE
INTRODUCTION

1.1 Introduction

Construction and demolition (C&D) waste has become an important issue in Malaysia due to its rapid development. Substantial C&D waste has been generated from the construction industry due to "lack of special handling to reuse and recycle C&D waste" (Ismail et al., 2017). Many researchers have studied new methods, such as reusing concrete waste in construction materials to reduce C&D waste, which has an impact to the environment. Fan et al. (2016) mentioned that the replacement of natural aggregate (NA) with aggregate produced by crushing concrete waste in manufacturing concrete can aid in conserving natural resources and promoting a sustainable infrastructure.

Guo et al. (2018) stated that recycled aggregate (RA) produced from C&D waste is suitable for partial or full replacement of virgin natural aggregate to make a new concrete. Ismail et al. (2013) revealed that reusing and recycling C&D waste is an effective method for simultaneously reducing the volume of C&D waste, size of landfill areas and consumption of raw material, thereby leading to sustainable development. Recent research on replacing NA with RA in concrete has led to positive results. Khatib (2005) stated that compressive strength remains constant when 25% NA is replaced with RA, which indicates that the replacement of material in concrete has no effect.

Reusing and recycling of C&D waste exhibit positive environmental and economic influences. Xiao et al. (2012) reported that using C&D waste as RA in concrete could save approximately 60% of limestone resources, and 15%–20% carbon emission could be reduced. Concrete debris is a main portion in C&D waste that can be broken into small particles to become recycled concrete aggregate (RCA), which can be used to replace NA in producing new concrete. Fine particle fraction is indirectly generated by producing coarse RCAs (CRCAs). Fine RAs (FRAs) are composed of cement mortars and possess high absorption characteristics. FRAs are highly difficult to combine with concrete or mortar than the CRCA. Restuccia et al. (2016) mentioned that most international standards prohibit the use of FRAs in concrete due to difficulty in incorporating them with mortar or concrete. However, Cuenca-Moyano et al. (2014)