UNIVERSITI TEKNOLOGI MARA

UTILIZATION OF NANO WPSA AS SUPPLEMENTARY CEMENTITIOUS MATERIAL IN ENHANCING PROPERTIES OF SELF-CONSOLIDATING HIGH-PERFORMANCE CONCRETE

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ABSTRACT

Self-consolidating high-performance concrete (SCHPC) has been extensively studied, but the incorporation of nano waste elements remains largely unexplored. This research aims to innovate SCHPC by introducing Nano Waste Paper Sludge Ash (NaWPSA) as a Supplementary Cementitious Material (SCM), a novel material. Experimental investigations assess the properties and performance enhancements of SCHPC with NaWPSA. The study's objectives include producing and analyzing NaWPSA properties, developing an optimal SCHPC mix, incorporating varying percentages of NaWPSA, and measuring the resulting mechanical, chemical, and durability properties. The final objective involves evaluating NaWPSA's effects on SCHPC using software analysis. Findings indicate that NaWPSA, primarily composed of CaCO3 and CaO, has a particle size of 5.615 nm and smooth, rounded surfaces. The optimal SCHPC mix was determined to contain 1000 kg/m³ cement with a 0.2 water-to-cement ratio. The best compressive strength and flow were achieved with a 1% NaWPSA replacement. This mix also exhibited the highest splitting tensile strength and no visible carbonation after one year. SEM analysis revealed NaWPSA's role in forming ettringite needles and WPSA flakes. Additionally, NaWPSA SCHPC outperformed others in flexural strength and deflection tests. Mathematical models confirmed a clear correlation between compressive and splitting tensile strengths. This research enhances the understanding of SCHPC, WPSA, and nano materials, offering valuable insights for future studies and practical applications in high-performance concrete.

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CHAPTER ONE
INTRODUCTION

1.1 Research Background

Construction industry in Malaysia nowadays has just stepping to the verge of sustainable development by the implementing environmental-friendly element in their construction project. The construction industry now focuses on improving the performance of concrete by implementing waste byproduct to reduce the usage of cement and at the same time reduce the construction cost. Since concrete is the main material used in construction industry, it requires a high amount of cement to produce high performance concrete which is not environmentally friendly and not in line with sustainable development. Due to this high demand of cement, innovation and ideas are required as alternative to produce better performance, eco-friendly and economical.

Over the years, concrete has been utilized with mineral additives in search to reduce the usage of cement powder. Numerous researchers have conducted researches on the alternatives to cement powder such as Palm Oil Fuel Ash (POFA) (Hamada et *al*., 2018; Mujah, 2016; Sooraj VM, 2013), Rice Husk Ash (RHA) (Chao-Lung et *al*., 2011; Chindaprasirt et *al.*, 2014; Van Tuan et al., 2011), and Waste Paper Sludge Ash (WPSA) (Azmi et al., 2016; Mohd Sani et al., 2011; Saman, 2012). Based on this research, the utilization of mineral additives from wastes tends to improve the properties of concrete.

Paper has become the most used material and at the same time produces the most abundant waste in the world. Malaysian Newsprint Industry (MNI) is a local paper producer, produce incinerated waste paper sludge ash (WPSA) up to 80 tons per day in 2011 (Mohd Sani et *al*., 2011). On the other hand, Europe produces around 11 million tonnes of Paper wastes in 2005 (Monte, et *al.*, 2009). Whereas, Italy generates around 600 tonnes of sludge yearly, where every 1000kg of the sludge can produced up to 60kg of ash (Fava, at *al*. 2011). The waste is undeniably a lot that even landfilling is not ideal anymore.

WPSA is a byproduct recycling paper in paper mill. Recycled paper undergoes a few processes before a final usable product is produced. However, during the process of recycling, an unwanted byproduct is eliminated called waste paper sludge. It is then