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Properties of concrete with eggshell powder: A review

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ABSTRACT

Sustainable concrete is currently a widely studied topic in order to reduce the environmental impact of cement. Substitute materials are usually industrial and municipal wastes. Eggshell powder as cement replacement is a viable option to produce green concrete. At the same time, it improves the disposal of eggshell, which is thrown away as household waste and mostly ends up in the landfill. This paper reviews the constituents, production techniques and properties of eggshell concrete (ESC). The paper presents the chemical compound of eggshell and the suitability of the waste as cement replacement. This is followed by a discussion of the fresh, hardened and durability properties based on a variety of previous studies. At the optimal content of 10%, ESC has various advantages compared to conventional concrete. The advantages are associated with the high calcium content and good filling effect of eggshell powder. This includes improved hardened properties, reduced setting time, and increased resistance to water penetration and carbonation. Eggshell is also an accelerator to the hydration process. However, ESC shows weakness in chloride and sulphate environment due to the vulnerability of eggshell to these compounds. While studies on the material are available significantly, researches on durability properties of ESC should be enhanced.

1. Introduction

Concrete is a construction material composed of cement, fine aggregates (sand) and coarse aggregates mixed with water which hardens with time. Concrete is the most-used material in the construction industry today. Global cement production has reached 4 billion tonnes with about half of which being consumed to produce concrete for construction needs (Naqi and Jang, 2019). Cement is the most-used building material due to its myriads of strength, such as economical, durable, fire and water resistance, and more. However, the negative environmental impact of concrete is increasingly being highlighted across the world. The cement industry is the among the largest contributors of greenhouse gas. About 7% of global CO_2 emission comes from the industry, with 900 kg CO_2 emitted to the atmosphere for producing one ton of cement (Benhelal et al., 2013). Apart from being a large contributor of greenhouse gas, the cement industry is also responsible for major air pollution through the release of particulate matter (PM), oxides of nitrogen (NO_x), carbon monoxide (CO), sulphur dioxide (SO_2) and volatile organic compounds (Adeyanju and Okeke, 2019). The dust particles are usually in the size range from about 1 to 100 μm in diameter. The pollutants lumped together to form smog and posts a great risk to the environment and human health (Edalati and Namdari, 2014). To adhere to the Sustainable Development Goal, many studies and initiatives had been done to evolve the concrete technology to satisfy the need of the civilization (Naik and Moriconi, 2005). Solid waste management is one of the leading environmental problem in Malaysia. The recycling rate of Malaysia is below 20%, which is mediocre compared to modern countries such as Japan, Germany, and Sweden. Currently, about 23,000 tons of waste is being produced daily, and the number is expected to reach 30,000 tons by the year 2020. Food waste and organic waste is the majority of the waste generated by Malaysian (JeremeSiwar and Alam, 2014). One of the methods to promote recycling rate is to introduce new ideas of reusing waste products. The study of green concrete with waste products has great potential as it solves problem with the waste while saving up on the usual material required for conventional concrete. Thus far, various wastes had been discovered to has the potential to product concrete with acceptable or even superior properties, such as demolition waste (Teara et al., 2018), sewage slug (Amminudin et al., 2020), rice husk ash (Putra Jaya et al., 2018) and so on. Another potential waste material to be used is eggshell. Eggshell is a waste that is disposed in

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