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Effect of windscreen glass waste (WGW) as sand replacement on water absorption of mortar

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ABSTRACT

Recently most developing countries are having problems of shortage of waste landfill sites. Due to this constraint, it is proposed to regenerate the glass waste and use it as a sand substitute in the production of concrete to minimize the environmental pollution This study investigates and analyzes the effect of the windscreen glass waste on replacement of sand into the mortar mixture on water absorption test. The mix design proportion of the mortar is 1:3 and with water cement ratio of 0.5 and with the partial replacement of 10%, 20%, 30% of sand to windscreen glass waste, taken at age 7 days, 14 days and 28 days of curing session. From this study, it found that mortar with replacement with windscreen glass waste produced a better result as compared to control sample. In term of water absorption, 30% replacement of windscreen glass waste at 28 days curing has produced the lowest water absorption level.

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Introduction

Windscreen glass waste has contributes to a large sum of solid wastes found on disposal site (Anisah et al., 2020; Meyer, 2009; Jani & Hogland, 2014). Car accidents and disposal of cars are major contributors to the windscreen glass waste (Ngah et al., 2021; Islam et al., 2017). Windscreen glasses are typically disposed to the landfill sites and recycle centres (Bhandari & Tajne, 2013; Vasudevan & Pillay, 2013; Adaway & Wang, 2015). The processes of recovering and recycling the windscreen glass waste involves crushing, melting and cooling processes. (Anisah et al., 2020; Harrison et al., 2020; Shi & Zheng, 2007). However, these processes call for a huge amount of money (Bentchikou et al., 2017; Rashad, 2014). Furthermore, it is inefficient since not all types of windscreen are recyclable (Bhandari & Tajne, 2013; Aliabdo et al., 2016). But, if all the wastes are just being disposed without recycled, the massive amount of waste will demand for an enormous size of disposal site (Meyer, 2009; Harrison et al., 2020; Oliveira et al., 2012). As a result, this scenario affects the environent in the most unpleseant way (Bentchikou et al., 2017; Park et al., 2004; Zidol et al., 2017).

Little knows that windscreen glass waste shares similar characterics to natural sand as a contruction material (Shao et al., 2000; Nassar & Soroushian, 2011; Topçu & Canbaz, 2004). However, the windscreen glass waste needs to be transformed into windscreen glass waste (WGW) before being used as a construction material (Ngah et al., 2021). (WGW) also contains silica that works as natural sand on chemical composition (Vasudevan &

Pillay, 2013; Neville, 2011). Silica produce pozzolanic materials. Hence can be used to substitute the natural sand that possesses similar property (Du & Tan, 2014; Omoniyi et al., 2014; Taha & Nounu, 2008).

Malaysia is developing rapidly. This results to the increasing amount of sand production that affected to environment unpleasantly (Bentchikou et al., 2017; Poon et al., 2007; Ling, 2012). There are many construction sites all around the country that call for a massive amount of construction materials to satisfy the demand (Department of Standards Malaysia, 2007). In sand mining, erosion is inevitable especially in some risky places. This indirectly results to undesirable impact to the local environment including human and wildlife (Meyer, 2009; Poon et al., 2007; Cheng et al., 2018). Supporting this, Bentchikou et al (2017), predicted that tonnes of trash glasses will be produced annually all around the world as a result to fast population expansion and urbanisation.

Therefore, it is vital to look for other options to substitute sand as construction (Harrison et al., 2020; Jani & Hogland, 2014; Rashad, 2014). Hence, this study looked into the potention of the chemical and physical properties of WGW as a part construction material (Ngah et al., 2021). This study was carried out to investigate the ability of WGW in substituting the sand in the mortar. With the hope to uphold sustainability of natural resources, this study aims to explore this issue. The objective of this study is determine the water absorption of the mortar with partial replacement of glass waste in a given mix proportions and identify the optimum percentage of the windscreen glass waste used in the mortar in terms of degree of water absorption Ngah et al., (2018).

Glass waste is one of the common materials found in any dumping areas (Bhandari & Tajne, 2013). The glass wastes can be categorized by their different chemical compositions and the physical properties. Different types of glasses result to different element of the glass waste. Then, different types of glass wastes possess their own exclusive behaviour in reacting to the mixture. Typically, the glass wastes are sorted by their types and colours. Vasudevan & Pillay (2013) highlighted that, during the recycle process or at the disposal sites, the glass wastes are sorted such as green and black bottles, brown, glass for cathode ray, car windshields, colourless bottles and glass building materials (Harrison et al., 2020; Ling, 2012). Life span of glass differs and it depends on its types. However, there are limited glass recycling methods available in the market. The methods usually focus on recovery of the glass wastes. Glass recovery process includes crushing or melting process before it can be used. Commonly, the disposal areas do not classify glass wastes based on their properties. Consequently, this glass finally ends up to be reused for other limited purposes and some other end up in the landfill (Bhandari & Tajne, 2013; Aliabdo et al., 2016).

Glass is produced via a mixing process of certain materials soda silica, ash and CaCo3 (Neville, 2011). All these materials are melted with a high temperature before cooling down and forming a pretty translucent solid without any crystallization. When the glass turns into waste being crushed into a sand-like powder, it offers a similar property to natural sand (Shao et al., 2000; Du & Tan, 2014). Water absorption method is an efficient way to determine the moisture content of the specimens after casting. Specimen's quality can be identified based on its absorbency level (ASTM, 2013). This method closely related to the specimen's prosity level. It is important to stress that lesser absorbency level indicates a higher quality of the mortar. A high-quality mortar absorbs a minimum amount of water during the immersion process in a certain period of time. Besides that Nassar & Soroushian, 2011; Topçu & Canbaz, 2004 highlighted that the water absorption may reduce and lowering down the mortar cube, the volume of voids and results to low absorption of water due to the mortar.

Method

The automotive windscreen glass was obtained from nearby workshops in Terengganu, Malaysia (Ngah et al., 2021; Anisah et al., 2020). The Los Angeles machine was used to grind windscreen glass up to 5000 revolutions using 15 steel rod to produce the automotive windscreen glass waste (WGW). Figure 1 shows the flow of the preparation of WGW.

Figure 1 <Preparation of Automotive Windscreen Glass Waste (WGW)>

The study was carried out by 60 sample of mortar cube specimens with dimensions of 50mm x 50mm x50mm. The mortar mix proportion cement to sand (C:S) of 1:3 with water to cement (w/c) ratio 0.5. Three mix proportion were adopted comprising various percentages of WGW (10%, 20% and 30%) by weight of sand. The mortar cube specimens were water cured until the day of the compressive testing at 7, 14 and 28 days. The water absorption test was conducted in accordance to Water Absorption Test ASTM 1403-13 (2013). The water absorption was assessed using cube specimens of dimensions 50mm x 50mm x 50mm taken at 7, 14, and 28 days. Five replicates were used for each batch.

Results and Discussions

Results Figure 2 showed that the sample with 30% of replacement WGW in the mortar produced the lowest water absorption level as compared to other samples of mortar. This study has also discovered that the 30% of replacement WGW achieved the highest durability based on the degree of penetration of water into the mortar.

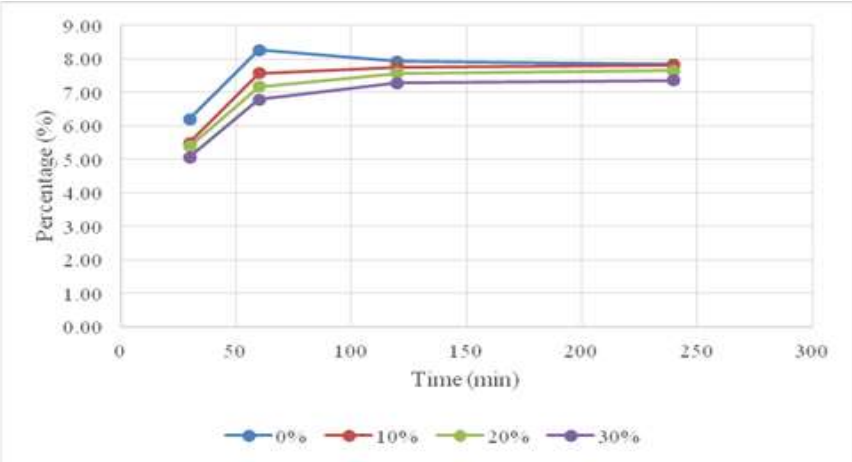

Figure 2 <Water Absorption Percentage of Glass Waste Mortar at 7 days of Curing>

Other than that, the table above also shows that the control sample obtains the highest water absorption during this test. The percentage of water absorption of other samples are below the control sample (0%). This implies that the absorption water level. This finding supports (Ngah et al., 2018; Harrison et al., 2020; Du & Tan, 2014) who discovered promising result as they incorporated fine glass particles in cement-based material such as mortar. These findings have supported the statement by (Omoniyi et al., 2014; Taha & Nounu, 2008) that replacement of glass waste can successfully reduce the amount of water absorption to the mortar and indirectly enhace the mortar's durability.

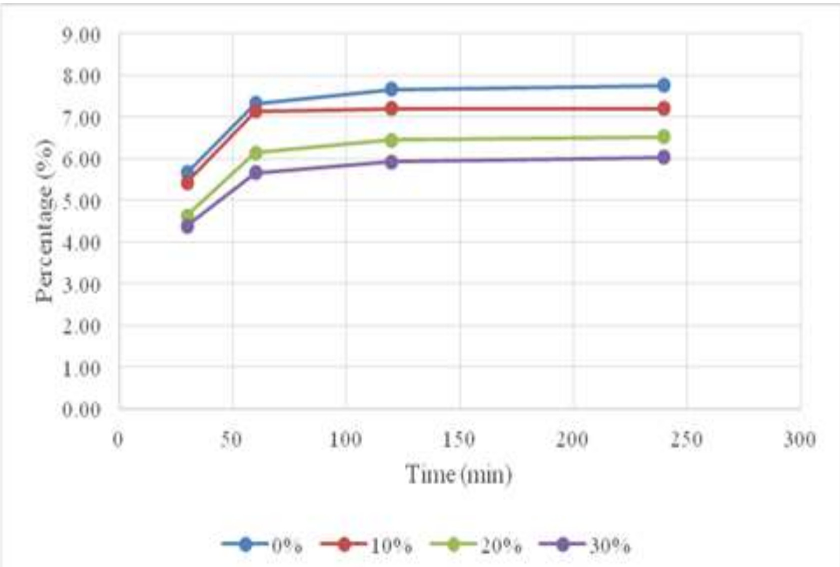

Figure 3 <Water Absorption Percentage of Glass Waste Mortar at 14 days of Curing>

Figure 4 showed that the result of water absorption of glass waste mortar after 14 days of curing. The pattern of the result were approximately the same as for 7 days curing. However result shows that, there are slightly reduction in the percentage of absorption due to the period of curing. (Cheng et al., 2018; Zidol et al., 2017).

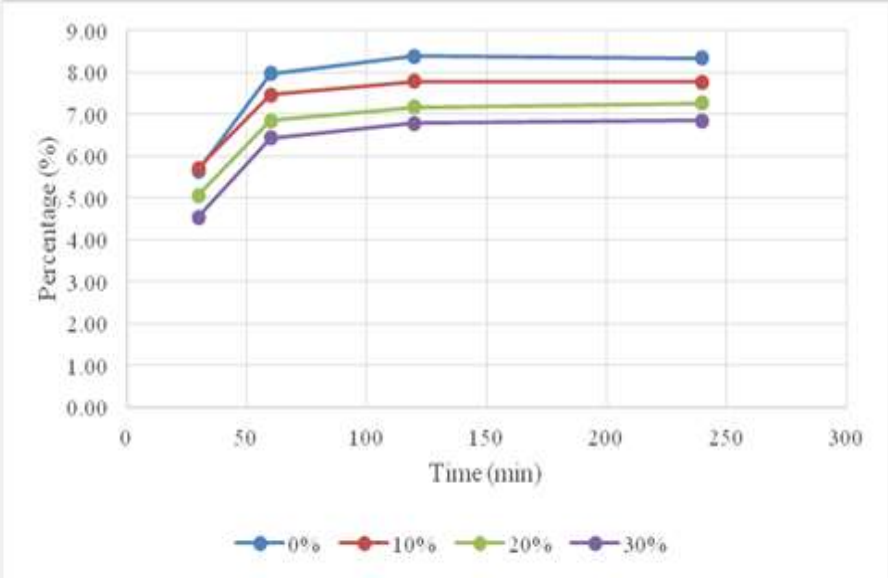

Figure 4 <Water Absorption Percentage of Glass Waste Mortar at 28 days of Curing>

The figure 4 shows the result of the curing period of the mortar samples taken at 28 days. The result showed nearly the same with the other two curing period for the testing the water absorption to the mortar samples. In this case, the result show that the mortar samples with 30% of glass waste replacement gave a better resistance to water absorption compared to other percentage of glass waste replacement mortar samples (10% and 20%) and also the control samples. It shows that, the mortar samples with 30% of glass waste replacement gave a lowest degree of water absorption. These findings agree with previous studies that glass particles enhance mortar performance (Harrison et al., 2020; Aliabdo et al., 2016).

This study has discovered that 30% substitution of WGW in mortar has obtained the lowest percentage of water absorption as compared to lower substitution percentage of mortar samples and control samples. This result has proven that mortar sample with the 30% replacement glass waste powder has successfully achieved the best water absorption as compared to other samples.

Conclusions

This study aims to investigate the relationship between the percentage of WGW and water absorption level of mortar. This study has demonstrated the effect of the WGW substitution on the mortar. Conclusions that can be made for this study. In the water absorption test, control sample has proven to achieve the highest percentage of water absorption as compared to other specimens with 10%,20% and 30% of WGW subtitution mortar. On top of that, the mortar with a higher percentage of WGW subtitution has helped to reduce the level of water absorption. This findings have proven that the subtitution of WGW in mortar helps to reduce the percentage of water absorption. Hence, durability of the mortar is enhanced. The higher percentage of WGW result to a lower water absorption level. This implies that the durability of the mortar is enhanced with a higher percentage of WGW. Substitution of sand with WGW can be considered as an environmental friendly effort towards Green Products. However, deeper investigations and studies need to be carried out to ensure it reliability and practicality. For furture studies, this study can be carried with more variables on the number of curing days and a higher percentage of glass waste replacement.

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