Green mortar: PET plastic and biochar as partial natural aggregate and cement replacements

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Introduction

The demand for various materials has only increased in recent years. Consequently, the amount of waste also increased. A lot of attention has recently been paid to plastic as one of the most commonly used materials in the packaging industry, on which the food industry is strongly dependent [1]. Due to the ever-increasing need for food, the intensity of agriculture also increases and contributes to increasing amounts of biomass waste [2].

Similar is in the construction sector where the increasing production of concrete as one of the most commonly used building materials has already been reflected in the local shortage of natural aggregates and where the biggest concern presents the production of cement due to carbon dioxide emissions.

Several studies highlighted the benefits of plastic waste in building materials as a natural aggregate replacement, especially in the improvement of mechanical properties [4-6]. In terms of biomass waste benefits, those wastes present the main feedstock for the production of biochar. While biochar is known to be a soil conditioner, some other benefits have been also presented regarding its use in building materials [7, 8].

In recent years, a special term has been used for concretes which uses waste materials as at least one of its components, i.e. green concrete. The main reasons for creating green concretes are to reduce greenhouse gas emissions natural resources consumption, and the use of waste materials. Therefore, the need to have green concrete is essential to meet future demands of key components for concrete production and at the same time reduce the amount of waste [9, 10].

The main purpose of this research was to determine the early-age properties of green mortars containing PET plastic particles as partial natural aggregate replacement and biochar as partial cement replacement.

Materials and Methods

Natural aggregate of 0/4 mm and ordinary Portland cement CEM I 42.5 N were used for plain mortar, while recycled PET plastic particles of 0/4 mm were used as partial natural aggregate replacement (5% of the volume) and wood waste biochar was used as partial ordinary Portland cement replacement (5% of the volume) in green mortar (Figure 1).

The fresh and early-age hardened plain and green mortar properties were determined to conform to Slovenian standards (SIST EN). For determination of hardened mortar properties, prism samples of 40 × 40 × 160 mm were tested 3, 7, and 28 days after moulding.

Figure 1. PET plastic particles and biochar are used in green mortar.

Results and Discussion

The flowability of investigated mortars was the same, while the fresh density of green mortar showed a decrease compared to plain mortar. Flexural and compressive strength tests of hardened mortars (Figure 2) showed that the presence of PET plastic particles and biochar in mortar did not significantly affect strength compared to plain mortar. It was found that the 3 and 7-day flexural strength of green mortar was comparable to plain mortar, while the 28-day flexural strength was slightly lower. The compressive strength of green mortar was also comparable to plain mortar.

Azhdarpour et al. (2016) [5] reported that using PET plastic particles 0-5% as partial aggregate replacement positively affects the strength compared to ordinary plain mortar, while replacement higher than 5 % could

decrease strength and modulus of elasticity. In addition, it was concluded by Rahmani et al. (2013) [5] that replacing aggregate in concrete with PET particles up to 10% is the best value with no significant effect on the strength of concrete.

Similar findings were presented in past studies for biochar-containing mortars where the importance of biochar dosage also played the most important role. It was found that biochar dosage of up to 24% by weight of cement increased the strength of composites [7]. Furthermore, the use of biochar and PET particles in mortar as partial replacements confirmed that despite using both at the same time deterioration the properties at suggested dosages were not determined.

Figure 2. Hardened plain mortar and green mortar.

Conclusions

To conclude, results showed the flowability of plain and green mortar was the same, while the fresh density of green mortar was slightly lower than the fresh density of plain mortar. Strength tests revealed the presence of recycled PET plastic particles and biochar as partial replacements for natural aggregate and cement in mortar did not contribute to significant deterioration of early-age strength compared to plain mortar. Overall, green mortar containing at the same time PET particles and biochar as partial aggregate and cement replacement has tremendous potential as a solution for multiple issues regarding increasing concrete production and the amount of waste.

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