Possibilities of municipal waste recovery in geopolymers: A study

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Introduction

The aim of the paper is to create an overview of scientific works that have influenced and improved the properties of geopolymers through the use of municipal waste in order to reduce the amount of waste and its negative impact on the environment.

Authors	Types of Additives	Curing Regime	Primary Findings
Jin et al.	MSWI ash CaO and Cl rich	20 ± 3°C a 60 ± 3% relative humidity for 28 days	• Strength reached 36.1 MPa after leaching 2 000 ml of simulated acid rain at pH 3.0
Wongs et al.	MSWI ash CaO and SiO_2 rich	60°C for 24 h, subsequently for 7 to 28 days at 25 °C and 50% relative humidity	• the highest strength of 52.8 and 53 Mpa was achieved after 7 and 28 days by a sample containing 20% of ash
Tian et al.	MSWI ash CaO rich and coal ash with SiO_2 a Al_2O_3 content	60 °C for 6 h, then 7 days at room temperature	• during solidification of samples containing MSWI fly ash, it reacts with alkali to form H2 and subsequently creates cracks and causes low strength. This effect can be mitigated by optimizing the sodium hydroxide synthesis process
Xiao et al.	Glass powder from municipal waste containers	20 °C for 24 h; 3, 7, 14, 28 days afterwards at room temperature	• the highest strength of 34.5 MPa was achieved by a sample containing waste glass powder together with class C fly ash in a ratio of 1: 3
Hajimohammadi et al.	Fine separated waste glass powder	7, 14, 28 and 56 days at room temperature	• fine glass powder increases the alkalinity of the matrix, which helps a higher range of dissolution and responds better near the aggregates
Toniolo et al.	Fine waste sodium-calcium powder	60 °C for 48 h, then 7 to 28 days	• sodium-calcium glass shards are a viable substitute for commercial sodium silicate solutions
Aly et al.	Recycled crushed rubber from tires	28 to 60 days in water at room temperature	• the compressive strength was increasing up to 10% of the crushed rubber content limit
Long et al.	Recycled crushed rubber from tires	20 ± 2 °C and above 95% relative humidity for 3, 7 and 28 days	• crushed rubber has a negative effect on the static mechanical properties
Luhar et al.	Rubber fibres derived from tires	90 °C for 48 h, followed by 3, 7, 28, 90, 365 days at room temperature	• the compressive strength decreases by increasing the percentage of rubber fibres
Ganesh et al.	Fine powder from crushed PET bottles	Room temperature and before testing 1h at 200, 400, 600 and 800 °C	• compressive strength increased by 5.8% using 10% plastic powder
Posi et al.	Recycled packaging foam from electrical appliances	25 °C for 1 h and then cured at 25, 40 and 60 °C for 48 h	• foam volumes had significant effects on the strength, density and thermal properties of the geopolymer

According to the overview of scientific studies presented in the table, the conclusion of several facts related to the properties of geopolymer composites can be done. Ash from the municipal solid waste incineration have a positive effect on mechanical and physical properties. However, there are many differences between them due to the composition of the waste from which the ash originates. Siliceous waste glass also had a positive effect on the properties of geopolymers, but the main importance is in what form and amount it is added to the matrix. Recycled rubber granulates added to geopolymer composites in larger quantities had a negative effect on properties in most studies. The maximum amount of rubber crumb, with positive effect on the geopolymer composite, is approximately 10%. The addition of plastic waste powder also has a positive effect on the geopolymer only up to this percentage limit. In summary, it can be stated that municipal solid waste can be used in production of geopolymer composites. The usage of this waste will not only reduce costs but also allow the reuse of raw waste material that would be landfilled. Synthesized geopolymers together with municipal solid waste can be considered as way to improve and create a circular economy in individual countries of world.

Conclusion

Geopolymers are gaining more and more attention around the world thanks to their excellent properties, low energy consumption and CO2 production when compared to conventional concrete. The present overview study is contained of several research dealing with the synthesis of geopolymers and municipal solid waste such as fly ash from municipal waste incineration, glass waste material, recycled rubber granulate and plastic waste. The use of waste materials promotes recycling and reduces their amount which leads to creating new sustainable green materials. However, there are some limitations that can occur when synthesizing municipal waste due to their different chemical, physical and mineralogical properties, treatment and curing methods. Therefore, establishing a standard that would help to use geopolymer composites on a commercial scale would be necessary. Clearly, creating such a standard for certain types of municipal waste is not easy due to their very different chemical composition; hence it is necessary to focus on the given issue and seek solutions. Another important step is the creation of a cost-effective precursor geopolymer mixture, which would enable the greater use of municipal solid waste and thus reduce the environmental impact on the environment. The search for specific application possibilities of geopolymer composites created by using municipal solid waste will also help the future direction and use of geopolymer composites.