Geo-Polymer Concrete Waste Based Recycle Able Polypropylene Matrix Composites

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ABSTRACT: ***Day by day the natural resources get exhausted. A significant number of natural resources are used by the building industries, which in turn creates a huge volume of industrial waste. In the past, several researchers have sought to make concrete environmentally friendly by using construction waste such as fly ash, building and demolition waste, etc. Civil building wastes is integrated as novel engineering composites into polymers for recycling. The present work investigated eco-friendly composites with recycled polypropylene (RPP) matrix combined with geo-polymer concrete waste particles, wither plain (GCW) or oleic acid (AGC) surface-modified composites. The waste particles of the geo-polymer concrete were combined with polymer powder to provide efficient dispersion between the different materials. An initial reactive extrusion processing followed by injection molding created the composites. These novel composites with a quantity of 20, 40 and 50 wt percent of GCW particles, both plain as-received and surface-modified, were tensile measures, statistically analyzed by ANOVA, as well as water absorption according to ASTM standards. Atomic-force microscopy has shown surface dispersion of nanoparticles. Scanning electron microscopy was used to conduct microstructural analysis. The results showed that these sustainable GCW particles integrated in the rPP matrix exhibit higher processability and less than 0.01 percent water absorption. Compared to the cool rPP, the rPP / AGC composites have a comparatively higher elastic frame, 629 MPa, with 529 MPa. Such properties indicate possible sustainable applications of waste materials in building construction.***

KEYWORDS: Geo-polymer waste, Recycled polypropylene, Eco-friendly composites, Water absorption.

INTRODUCTION

The need to minimize concrete environmental impacts was acknowledged in the Strategic Planning Council report. An abbreviated version of the study "Vision – 2030: A Vision for US Concrete Industry" was published in Concrete International March 2001. According to this report, the concrete technologist was confronted with the challenge of leading future development in away that protects the quality of the environment while projecting as the material of choice for con-structure. The public concern over climate change arising from the increased accumulation of global warming emissions must be handled responsibly. Eco-friendly Concretewas a groundbreaking trend in the concrete industry's history. It decreases the impact on the environment with a reduction in CO2 emission. Using eco-friendly Concrete will help us minimize a lot of waste of various products. Specific non-biodegradable goods can also be used to avoid the problem of disposal.

Several researchers have been doing studies on the need for eco-friendly concrete over the past three decades. Today's concrete industry was the largest user of natural resources, including water, sand, gravel, and crushed rock. So it is important to reorient the concrete industry by embracing environmentally friendly and more sustainable technologies. Many researchers found out that, in the 21st century, material conservation would be the new focus for concrete industry. The environmentally friendly concrete as concrete that uses the waste material as at least one of its components or its manufacturing process does not result in environmental degradation or has good performance and sustainability in the life cycle.

Most researchers are using additional cemented material and recycled aggregate to popular the environmental effects of concrete. The key factors responsible for growing interest in recycling concrete waste as an aggregate are environmental sustainability, the conservation of natural aggregate resources, the lack of waste disposal land and the rise in the cost of pre-disposal waste treatment. By replacing recycled materials with natural materials, the resource efficiency of the concrete industry could be greatly enhanced immediately. If properly collected, grounded, washed and sieved in a suitable industrial crushing facility, the building demolition rubble may become useful for more ambitious applications. The use of recycled aggregate as a substitute for natural aggregate would promote sustainability. Using RCA in new concrete production could create a greener environment and pave the way for sustainable construction.

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Many researchers have been attempting to substitute 100% of the coarse aggregate with recycled concrete aggregate. Some of them also tried to add mineral admixture to test the strength properties of concrete but there are no specific methods available for optimization when it comes to the mix design of concrete comprising broad parameters. The Taguchi method was used as an optimization technique for mix design. Taguchi developed a method to refine the research process with a view to increasing R&D efficiency and improving product quality while working for Electrical Communication Laboratories in Japan. While there, he first noticed the vast quantities of time and energy expended on research and testing, and came to believe that the cost of money in this field could be minimized by imaginative brainstorming. The consequence was a philosophy of design that "has created a specific and influential discipline of quality management which is different from conventional practices'.

The geo-polymer, formed from a chemical reaction of silica (SiO_2) and alumina (Al_2O_3), to form an inorganic polymer by geopolymerisation, is a revolutionary material developed to replace traditional cement in construction. In addition, due to their intrinsic characteristics such as fire resistance, hight durability and lower CO_2 emissions during the efficient circle, geopolymers have gained considerable attention compared to Portland cement. Geopolymers can be used in composite materials, too. The role of geopolymer fillers in the manufacture of hybrid composites, such as red mud, fly ash and asbestos tailings, was observed in research. A geopolymers may be used as a civil construction cement with additives such as sand and pebbles taking concrete. Geopolymer concrete can become waste during construction and after demolition, and could thus be recycled into a polymer matrix by addition as a second step. Another similar situation can occur with a PP product, which becomes a waste after operational life.

LITERATURE REVIEW

This study uses the Life Cycle Assessment approach to carry out a thorough environmental assessment of geopolymer concrete production. The literature indicates that the development of most modern geopolymer concrete forms has a slightly lower impact on global warming compared to standard concrete from the Ordinary Portland Cement (OPC). Although our findings support this, they also indicate that geopolymer concrete development has a higher impact on the environment in other categories of influence than global warming. It is because of the strong effects the sodium silicate solution causes. To be triggered, geopolymer concrete made from fly ashes or granulated blast furnace slags based on the sodium silicate solution need less [1].

A description of the developments in geopolymers resulting from alkaline activation of aluminosilicates is discussed along with possibilities for their use in construction. The properties of mortars / concrete made from geopolymeric binders are discussed in terms of fresh and hardened states, interfacial transition zone between aggregate and geopolymer, bonding with bars for reinforcing steel and resistance to elevated temperature. The resilience of the geopolymer pastes and concrete in various hostile conditions is demonstrated in terms of their degradation. CSIR-CBRI's R&D works on heat and ambient cured geopolymers are discussed briefly alongside the product innovations [2]. Recent advances have resulted in the development of geopolymer foam concrete, which combines the performance benefits and operational energy savings achievable by the use of lightweight foam concrete with the reduction of cradle-to-gate emissions achieved by the use of a fly ash-derived geopolymer binder. In order to provide a clearer understanding of the properties and possible large-scale benefits associated with the use of geopolymer foam concrete, this paper discusses some of the sustainability concerns currently facing the cement and concrete industry with regard to the use of foam concrete either based on ordinary Portland cement (OPC) or geopolymer binders [3].

The analysis results show that there is a broad variance in the measured financial and environmental "harm" of geopolymers, which may be beneficial or harmful depending on the location of the source, the source of energy and the mode of transport. Some case studies of geopolymer concrete mixes based on traditional Australian feedstocks show potential for a 44-64 percent reduction in greenhouse gas emissions while the financial costs are 7 percent lower than OPC to 39 percent higher [4]. Compared to OPC concrete, tensile strength growth was well associated with the compressive strength of the geopolymer concrete being treated with the ambient. Tensile strength estimates from compressive strength of ambient-curated geopolymer concrete using the codes ACI 318 and AS 3600 appear to be similar to those for OPC concrete. The estimates for heat-cured geopolymer concrete are more optimistic than for ambient-curated geopolymer concrete [5]. At different temperatures up to 1000, fly ash based geopolymer and ordinary portland cement (OPC) concrete cylinder specimens were exposed to heat °C, with a heating rate of the International Organization of Standards (ISO) standard 834. Beton compressive strength varied in the 39-58 range. MP. In terms of cracking, the geopolymer concrete specimens have been found to suffer less damage than the OPC concrete specimens after the fire exposures. For 800 and 1000 the OPC concrete cylinders were suffering extreme spalling. ° C concentrations, although the geopolymer concrete specimens did not spall [6]. This paper provides a description of the analysis performed to understand the effect of aggregate material on the geopolymer concrete's engineering properties. This paper also addresses the effect of other parameters on geopolymer concrete engineering properties such as curing temperature, curing time, ratio of sodium silicate to sodium hydroxide, ratio of alkali to fly ash and sodium hydroxide molarity.

Based on the analysis carried out, it could be concluded that a geopolymer concrete with a proper proportioning of the total aggregate content and the ratio of the fine aggregate to the total aggregate, along with the optimum values of other parameters, may have better engineering properties than the corresponding properties of ordinary cement concrete [7]. This research presents a report on the toughness of geopolymer concrete prepared using blended ash of pulverized fuel ash (PFA) and palm oil fuel ash (POFA) along with alkaline activators when exposed to 2 percent sulfuric acid solution for up to 18 months. Also, Ordinary Portland Cement (OPC) concrete was prepared as concrete power. The principal parameters analyzed were mass assessment, compressive power, degradation materials, and microstructural changes [8].

Nevertheless reinforced concrete structural elements are the most significant use of concrete in building construction. This study therefore aims to summarize and analyze the results published on the structural actions of geopolymer concrete members so as to provide a better understanding of the effects of these concrete in structural elements. Among the representatives of geopolymer concrete underlined in this study are reinforced concrete beams, columns, slabs and panels. It is found that there is usually no adverse impact of using geopolymer concrete as a structural component in terms of its load carrying capability, and good practice codes may be used to build the geopolym in a safe manner [9]. This paper focused on a analysis of geopolymer concrete based on fly ash which is ideal for atmospheric healing conditions. A small proportion of ordinary Portland cement (OPC) with low calcium fly ash has been added to improve geopolymer concrete curing instead of using elevated heat. Samples were cured in room conditions (about 23 °C and RH 65 ± 10 per cent) before they were tested. OPC inclusion as low as 5 percent of the overall binder decreased setting time to acceptable ranges and resulted in a marginal reduction in workability [10].

METHOD

The simple geopolymer concrete waste (GCW), an as-received material, was supplied by Lafarge Concreto Ltda., Brazil. COMBRARE Comercial Brasileirade Reciclagem Ltd. supplied recycled polypropylene (rPP) from goods molded by blow processing. Sigma Aldrich, Brazil, received the oleic acid (purity 99 per cent). Recycled PP composite was investigated, containing both plain as-received GCW particles and modified oleic acid surface (AGC) particles. The as-received GCW, as stated elsewhere, was crushed into particles smaller than 270 mesh and treated with oleic acid within 24 h. The changed AGC particles were distributed in a screw extruder to molten rPP matrix. The temperature profile was 180,190 and 200 C, starting from the feeding zone to the die, while the rotating rate of the screw was maintained at 6 rpm. The proportion of rPP / AGC generated corresponds to 80/20, 60/40, 50/50 (m / m per cent). A Battenfeld injection unit, Plus 35model, processed pellets of the modified compostes. The mixtures of the blend were made at 200 C. The water absorption and tensile properties were measured in accordance with ASTM C272 and ASTM D638 requirements, respectively. During the processing of the AGC specimens, the effect of the modifier fillers was observed, showing greater fluidity and low torque, as well as better molding and processing for the AGC composites, regardless of the amount processed. Instead of what was anticipated, a higher fluidity was acquired by the proportion of modified geopolymer concrete in the AGC compo polymer matrix. This effect can be explained by the plasticizing power of the oleic acid fixed on the surface of the hybrid fillers.

Atomic force microscopy (AFM) was performed to test the polymer composites' agglomerated and surface state. Water absorption assessment as per ASTM C272 has been performed to determine the percentage of water absorption in the rPP as well as in the composites rPP / GCW and rPP / AGC, taking into account the results of seven specimens for each. On a universal model 1185 Instron unit, traction tests as per ASTM D638 were performed. The elastic modulus (between 0.05 per cent and 0.25 per cent strains) of the rPP / AGC composites is measured at a crosshead speed of 5.105 mm / min, and tensile strength at the same crosshead speed. Analysis of variance (ANOVA) has been performed for statistical validation of the properties obtained from ten tensile-tested specimens of each composite type, including rPP (0 per cent AGC).

DISCUSSION

This paper presents the findings of forpure rPP water absorption samples, 0 per cent geopolymer concrete waste, as well as composites for bothrPP / GCW and rPP / AGC. According to these findings, all of the investigated materials absorbed virtually no quantity (0.01%) of water, which corroborates previous results. It also display no substantial impact of capillary water absorption by geopolymer concrete integrated in the PPmatrix, which reveals consistently embedded plain GCW and adjusted AGC in rPP.

Fraction of AGC Incorporation (wt %)	rPP/GCW	rPP/AGC
0	0.05	≤0.03
20	≤0.04	≤0.01
40	≤0.03	≤0.01
50	≤0.01	≤0.02

TABLE 1: Water absorption (wt %) of injection molded recycled polypropylene (rPP) composites incorporated with plain geopolymer concrete waste (GCW) and oleic acid modified geopolymer concrete waste (AGC).

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Fraction of AGC incorporation (wt %)	Tensile Strength (MPa)	Elastic Modulus (MPa)	Maximum Deformation (%)
0	34.5 ± 1.6	530.1 ± 33.9	50.7 ± 2.6
20	28.8 ± 1.4	540.1 ± 25.3	39.6 ± 3.6
40	24.0 ± 0.8	625.2 ± 31.2	30.6 ± 0.8
50	21.4 ± 0.9	615.6 ± 49.8	29.0 ± 1.2

TABLE 2: Tensile properties of recycled polypropylene (rPP) composites incorporated with oleic acid modified geopolymer concrete waste (AGC).

Increasing the elastic module is an indicator of strong matrix/fillers adhesion. As a result, the composites acquired suitable stiffness potential for applications in civil construction. Such findings support those already obtained for industrial wastes integrated in PP.

CONCLUSION

Eco-friendly composites of recycled polypropylene (rPP) matrix blended of 20, 40 and 50 wt per cent of geopolymersconcrete waste particles, both plain as-received (GCW) and surface-treated acid (AGC) have been manufactured and characterized for the first time. Initial extrusion accompanied by injection molding results in inrPP / AGC composites exhibiting greater fluidity in low-level associative associative composites. In all forms of rPP / GCW and rPP / AGC composites, including forpure rPP, virtually no water absorption (average 0.01 percent) was found. The integration of AGC particles above 20 wt percent greatly improves the elastic module of the rPP matrix. Moreover, this integration decreases the tensile strength and overall strain. SEM fratographs showed an efficient reduction of porosity from extrusion to injection molding during manufacturing, which supports null water absorption. Crackingafter molding, however, may be responsible for decreasing strength and strain. AFM shows evidence of rougher surface due to partial agglomeration in composite with large concentrations of AGC, which may support the reinforcement of the obtained steadiness.

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