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Review

Geopolymer concrete as sustainable material: A state of the art review

Furqan Farooq [a], Jin Xin [b], Muhammad Faisal Javed [a], Arslan Akbar [b], Muhammad Izhar Shah [a], Fahid Aslam [c], Rayed Alyousef [c]

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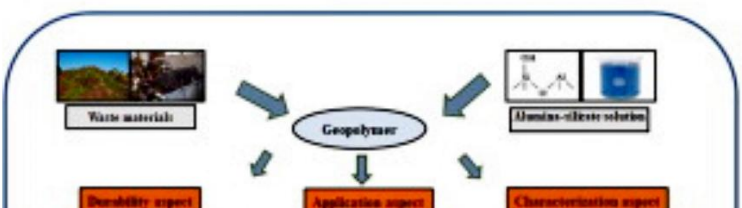
Highlights

- A comprehensive review of geopolymer concrete.
- Constituents of geopolymer concrete in detail.
- Characterization of geopolymer concrete.
- Properties of geopolymer concrete.
- Environmental impact of geopolymer concrete.

composite free from cement, made from various waste materials with a high amount of Al_2SiO_3 and Na_2SiO_3/NaOH (alkali-activated silica) is evolving as an eminent material for sustainability purposes. They are also preferred due to the lesser emission of greenhouse gases as compared to ordinary Portland cement (OPC). This paper aims at presenting a sustainable domain and state of the art review of GP composite. The properties of composites made from various geopolymeric waste binders are presented. Besides, the microstructure and chemical characterization of GP composites are also discussed. The durability of GP composite is also highlighted considering its deterioration in various aggressive environments. In the end, a global warming potential (GWP) assessment was conducted and the practical applications of GP composites in the building industry are also provided.

Graphical abstract



Introduction

Cementitious resources are extensively used as constructive materials in the development of the country's construction structural means. The cementitious concrete has an adamant effect on the greenhouse effect. From the environmental perceptive, the manufacturing of concrete produces 30% of carbon dioxide around the world [1]. Cement system (fine particles size) possess adamant adhesive binding ability in construction works. However, the production of cement emits carbon dioxide (CO_2) on a large scale [2]. CO_2 emission produces an obstinate effect in the environment, which results from the grinding of minerals, the burning of fossils, and raw material in the Kiln chamber [2]. Moreover, the cement industry as one unit generates high emissions of CO_2 [3], [4]. This emission vigorously affects the

emission vigorously affects the environmental condition and generates global warming, melting of ice in different regions. However, knowing its adverse side, cement utilization increases in the building construction industry around the globe. Cement binder productions vary in different countries around the world. The variation in cement production is due to the availability of resources/materials. The majority of the countries have their resources by which cement production and its need for construction is achieved. However, those countries which do not meet the criteria for cement production, have to import the resources to meet their needs [5], [6]. A recent survey conducted by the United States Geological Survey about the production of cement worldwide [8]. Stats result showed a drastic variation of cement production and emission of CO_2. The production of cement around the world in the year 2018 is shown in Fig. 1. The manufacturing of cement produces 4 billion tons of cement worldwide in which China covers half of the total emission and production of cement [8]. Ordinary Portland cement (OPC) adds adamantly to the earth's CO_2 emissions, the predictive value was about 1.45±0.20 Gt of CO_2, that is,

approximately 8% of the total anthropogenic CO_2 release [7]. Moreover, the CO_2 emission based on different countries is also shown in Fig. 2.

Manufacturing cement, directly or indirectly, emits gasses which has an adverse effect on the environment. The calcination process and burning of raw materials are classified as the main sources of gaseous emissions [10], [11]. Emission of CO_2 during cement manufacturing is an alarming situation around the world and hence measurement is needed to minimize CO_2 emissions [12].

The emission of CO_2 can be reduced by various approaches: (1) replacement of cement by secondary raw materials and secondary cementitious materials, (2) use of alternative fuel in clinker cement production, (3) use of alternative binder in the manufacturing of cement, (4) process-related emissions can be readily reduced by changing the manufacturing process as these emissions are higher than the energy-related emissions [13]. The emission of CO_2 can be significantly reduced by utilizing alternative binders and raw materials in the manufacturing process of cement. These