Detailed Overview of Geo-Polymer Concrete Fabrication Using RHA, GGBS and CRUMB RUBBER

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Abstract

Geo-polymer concrete is building materials that become popular in the past few years due to its significance that is eco-friendly or environment friendly. Geo-polymer concrete has significant advantages than standard concrete (PCC) are more long-lasting, requires little repair, saving a huge amount of money spent on repairing and maintaining of concrete based infrastructure, more resistive to corrosion and high compressive and tensile strength, it gains its full strength quickly and shrinks less than PCC. Geo-polymer concrete increases the life of structures up-to 10 years as compared to plain cement concrete. There are two main ingredients of geo-polymer concrete are source material and alkaline liquids. The source materials are those which have an alumina silicate should be rich in silicon (Si) and aluminum (Al). The alkaline liquids are soluble alkali metals that are sodium or potassium-based. This review deals use rice husk ash (RHA), crumb rubber (CR), and ground granulated blast furnace slag (GGBS) in the formation of geo-polymer concrete. RHA, CR, and GGBS all are the waste products, and difficult to dispose of, the use of all these waste will clear the environment. It also includes chemical composition, their properties, advantages and limitations of source materials.

Keywords: *Geopolymer Cement, Ordinary Portland cement, Technology, Properties*

Introduction

Geopolymer is inorganic materials that structure long-range, covalently fortified, non-crystalline systems. Economically created geopolymers might be utilized for fire and warmth safe coating and cement. Geopolymers can be grouped into two significant gatherings; unadulterated inorganic geopolymers and natural containing geopolymers of normally happening macromolecules (Usman and Pandian, 2014). The primary constituents of geopolymers in light of alumino-silicate ought to be rich in silicon (Si) and aluminum (Al). Usually, it would be side-effects, for example, flying debris, silica seethe, rice husk debris, GGBFS, red mud, and so on. The key unit inside a geopolymer structure is the tetrahedral complex comprising of Si or on the other hand, Al composed through covalent obligations of four oxygen's (Kishore and Gayathri, 2017; Kim et al., 2014). The geopolymer structure results from the cross-connecting between these tetrahedral, which prompts a 3-dimensional alumino-silicate to organize where the negative accuse related to tetrahedral aluminum is adjusted by a little cationic animal type, most ordinarily a soluble base metal cation (Amin and Abdelsalam, 2019; Kishanrao, 2013). The presentation of concrete is typically controlled by its quality and strength. For showing signs of improvement nature of cement, parameters like decrease of water substance; fine and coarse totals ought to be all around evaluated. Quality realizes up upon not just on reviewing of properties yet besides on better-restoring methods like steam relieving, encompassing. For instance, high basic arrangement content could essentially change the quality of the solid in fly debris based geopolymer concrete, aluminosilicate gel which is shaped from sodium hydroxide and sodium silicate prompt the silica and the alumina in the source materials. Physical and substance properties of geopolymer solid like quality, microstructure, and so forth, vary with the kind of relieving (Shoubi et al., 2013; Raijiwala and Patil, 2011).

Table 1: Influence of the particle size distribution of the binder phase on the compressive strength of GeoPC based on the type of poly (sialate) structure.

Types of GeoPC	Compressive strength Mpa	Fineness Major	Findings	References
RHA Based	35-61.5	BA: 15.7, 24.5 & 32.2 µm	BA gives rise to higher strength	Nauklong et al., 2016
FA Based	39-75	FA with fineness of 2700, 3900 & 4500cm2/g	Rise to optimum strength	Chindaprasirt et al., 2014
	15-45	FA 3 & 75 µm, RHA- 7 & 90 µm	Combination gives highest strength	Ye et al., 2016
RHA Based	34.5-43	RHA- 1,3 & 5 % retained on 325 sieve	Finer RHA gives the highest compressive strength	Ravat et al., 2017
	15-16	RHA- 100% passes on 150 µm	37.43 % increment on strength	Board, 2012

To meet present-day human advancement necessities utilization of normal sand has gotten high, in making cement and mortar. Results the gracefully and request of normal sand is exceptionally high. Use of normally happening waterway sand stores results from most calamity issues like a danger to condition, low laying zones during floods, vegetation, oceanic life gets upset, loosing of soil layers, level of water table gets diminishes sand with great diminishes which genuinely impacts horticulture and so on are a few models (Kishanrao, 2013; Mehta, 1992). Accessibility of characteristic sand with great quality is a major issue in creating nations like India. Specialist and Engineers have come out with their plans to diminish incompletely or completely substitution of waterway sand and utilize late bi-items, for example, M-sand (produced sand), robot silica or sand, stone smasher dust, sifted sand, rewarded and sieved residue expelled from repositories. An example has been made to utilize rice husk debris as income plate substitution of fly debris in various extent to examine the change in mechanical properties contrasting with conventional Geopolymer concrete, the goal of this paper is to learn about fly debris and rice husk debris geopolymer concrete (Mehta, 2002; Marais et al., 2017).

The necessity of geopolymer concrete:- Construction is one of the fast-growing fields worldwide. As per the present world statistics, every year around 260, 00, 00, 000 Tons of Cement is required. This quantity will be increased by 25% within a span of another 10 years. Since the Limestone is the main source material for the ordinary Portland cement an acute shortage of limestone may come after 25 to 50 years. Moreover while producing one ton of cement, approximately one ton of carbon dioxide will be emitted to the atmosphere, which is a major threat to the environment. In addition to the above huge quantity of energy is also required for the production of cement. Hence it is most essential to find an alternative binder. Cement production generated carbon dioxide, which pollutes the atmosphere. The Thermal Industry produces a waste called fly ash which is simply dumped on the earth, occupies larges areas. The wastewater from the Chemical Industries is discharged into the ground which contaminates groundwater. By producing Geopolymer Concrete all the above-mentioned issues shall be solved by rearranging them.Waste Fly Ash from Thermal Industry + Wastewater from Chemical Refineries = Geopolymer concrete. Since Geopolymer concrete doesn't use any cement, the production of cement shall be reduced and hence the pollution of the atmosphere by the emission of carbon dioxide shall also be minimized.

Rice husk ash:- Rice husk ash (RHA) is a carbon-neutral green product (Table 2) (Junaid et al., 2014) that is mostly used as ash for generating power (Ajay et al., 2012), or as boiler fuel for processing paddy with the volume between 20% and 25% of the rice paddy is an indigestible outer husk that is removed and burnt either in household stoves or in local power plants to produce steam for boiling rice (Sanjayan et al., 2015). In contrast, in the RHA-based GeoPC structures, the presence of sodium silicates with alkali-activated at elevated temperature can lead to producing new crystalline phases, for example, Na-feldspars, albite ($NaAlSi_3O_8$), and nepheline ($NaAlSiO_4$) contributing to higher thermal stability at elevated temperatures (Saravanan and Sivaraja, 2016). The crystalline silica content of RHA has received wide concern because of the potential hazards of inhaling this mineral (Sanjayan et al., 2015).

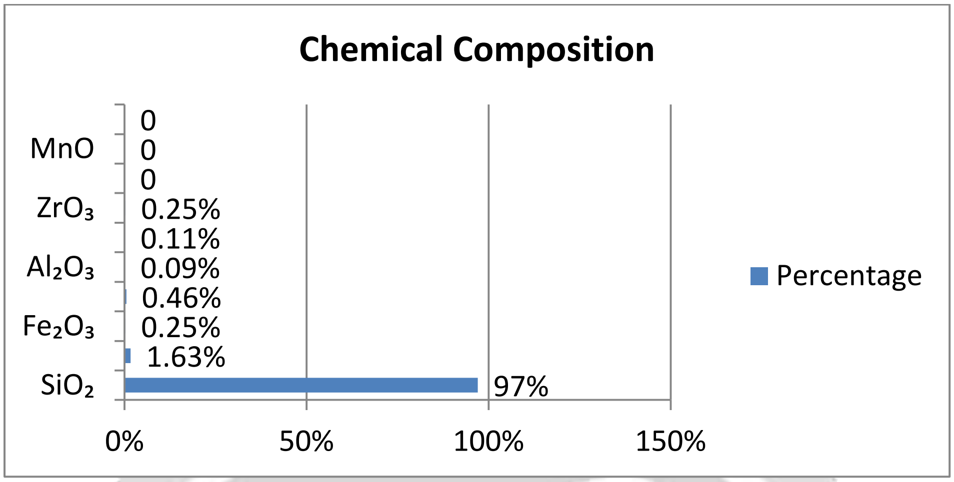

Figure 1: Chemical composition of Rice husk ash

RHA is approximately 25% by weight of rice husk when burnt in boilers. RHA is an excellent super pozzolan that can be utilized to produce mixes of special concrete (Saravanan and Sivaraja, 2016). This material may be applied as an alternative for cement in concrete production (He et al., 2013; Junaid et al., 2014; Saravanan and Sivaraja, 2016). Fine amorphous silica is increasingly being utilized in the manufacturing of special cement and low-permeability, high-strength and high-performance concrete mixes as well as in the construction of nuclear power plants, marine environments, and bridges (Board, 2012; Sanjayan et al., 2015). Most of the SFA or micro silica being sold in the market has been imported from Burma, China and Norway (Givi et al., 2010). In addition due to supply shortage, the price of silica fumes in India increased to almost US $500 per ton, which is far greater than the selling prices in China, Canada, and the US. The cement demand in India is also expected to reach approximately 550 Mt by 2020 with a shortfall of approximately 230 Mt (58%), and such increasing demand can be ascribed to the increasing number of infrastructural activities being conducted within the country (Singh et al., 2015). Given that RHA comprises about 18% rice husks, producing one ton of rice will generate approximately 45 kg of RHA, which has substantial pozzolanic properties, rich silica content (~95%), and high surface area. The amount, crystalline content and chemical composition of the produced silica strongly depend on furnace design and the burning temperatures. In GEOPC, it is reported that RHA blended concrete could lower the temperature influence that arises during the hydration of cement (Sangeetha, 2015). RHA blended concrete can improve the workability of concrete in comparison with OPC and could also raise the setting time of cement pastes. Moreover, RHA-based GeoPC can reduce concrete's total porosity, adjust its pore configuration, and considerably lower the permeability which permits the effect of dangerous ions contributing to the weakening of the concrete matrix (He et al., 2013; Givi et al., 2010). RHA cement increases the compressive strength and assists in improving the initial age mechanical and long-term strength characteristics of GeoPC pastes. Specifically, partial substitution of cement with RHA decreases the water diffusion into concrete by capillary action and effectively enhances the resistance of GeoPC to sulfate attack (Ajay et al., 2012; Saravanan and Sivaraja, 2016).

Table 2: Detail of specifications of RHA

Specifications of RHA	**% or size**
Humidity	Max. 2 %
Particle size	25 mm
Colour	Grey

Loss on ignition	Max. 4 %
pH	8

Ground granulated blast Slag:- Being a by-product of blast furnaces, Ground granulated blast slag (GGBS) is often utilized in iron production (Li and Zhao, 2003; Suresh and Nagaraju, 2015). This material can be obtained at temperatures of almost 1500 C and is fed with a cautiously controlled mixture of iron ore, coke, and limestone (Suresh and Nagaraju, 2015). The melted slag has a content of about 40% calcium oxide (CaO) and 30-40% silicon dioxide (SiO2), which is near to the chemical formation of OPC. When iron ore is reduced to iron, the residual materials create a slag that floats on top of the iron (Suresh and Nagaraju, 2015). This slag is regularly tapped off as a molten liquid and must be quenched quickly in large volumes of water to manufacture GGBS (Sahithi and Priyanka, 2015). This quenching process utilizes the cementitious properties of the slag and engenders granules comparable to coarse sand. The granulated slag is subsequently desiccated and ground to a fine powder. GGBS can replace the OPC content of concrete by 35-70% and exhibits excellent properties when finely ground and combined with other materials to formGeoPc. The glass particles of GGBS comprise Q0-type mono-silicates, which are comparable to those being applied in ordinary Portland cement clinker and dissolve upon activation by any medium (Amoudi, 1993). GGBS's glass content typically exceeds 85% of its total volume, while its specific gravity ranges from 2.7 to 2.90 (lower than that of ordinary Portland cement), and its bulk density varies between 1200 kg/m3 and 1300 kg/m3 (Ismaiel, 2014). The standard chemical composition of this material is presented in Table 7. The chemical composition of ordinary cement shows more similarities to that of GGBS than of other mineral admixtures, such as POFA concrete (Ismaiel, 2014).

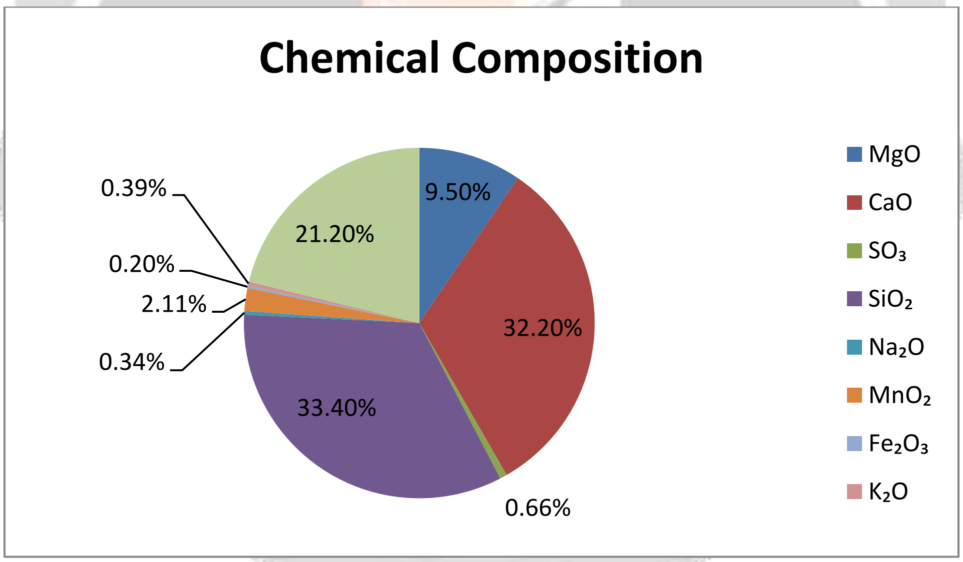

Figure 2: Chemical composition of GGBS

GGBS can be used for refining the pores and increasing the long term strength, sulfate, and alkali-silica reaction resistance of concrete as well as for reducing the water demand, permeability, and heat generation during the hydration process (Castel and Foster, 2015; Ismaiel, 2014; Suresh and Nagaraju, 2015). However, the addition of GGBS can influence the reaction, characteristics and PC matrix. The influence is varied based on the volume of GGBS added (5-50%). It is found that the reaction at 27 C is governed by the GGBS activation. The reaction at 27 C is contributed by precipitation and dissolution of CeSeH gel due to the alkali activation of GGBS (Li and Zhao, 2003; Sahithi and Priyanka, 2015). Moreover, in the production of GEOPC, the aluminum and silicon present in the GGBS are activated by a mixture of sodium silicate and sodium hydroxide solutions to produce the geopolymer paste that binds the aggregates (Islam et al., 2015). It may be deduced that the increased addition of GGBS can increase the ultrasonic pulse velocity, resistance to acid and compressive strength of GeoPC at all curing regimes (Sangeetha, 2015).

Crumb Rubber:- Rubbers utilized as a part of the generation of tires have distinctive constituents, yet the principle segment is vulcanized elastic. Amid the vulcanization procedure, elastic is warmed within the sight of sulfur, activating and accelerating agents. This procedure produces cross-interfaces in the individual particles of the polymers, which gives to the rubber an inflexible three-dimensional structure. The strength of the rubber is proportional to the number of such links. The cryogenic process is carried at very low temperatures (-87 C to 198 C). In this case, the rubber of the tyre is dipped into liquid nitrogen. At very low temperature, the rubber becomes very brittle and it can be easily pulled apart on a press, into the desired particle dimensions. These particles of crumb rubber have a lower specific surface than the once obtained by the grinding process. The use of binders modified with the rubber started in the 1940s (Mohammad et al., 2000).

Figure 3: Crumb Rubber

Table 3: Chemical Properties of Crumb Rubber

Sr. No	Major Rubber Components	Percentage
1	Natural Rubber Content	31
2	Carbon Black content	30
3	Rubber Hydrocarbon	25
4	Ash Content	4
5	Acetone extract	10